A STUDY IN THE GROWTH OF TISSUES OF LAMBS AS EFFECTED BY ENVIRONMENTAL FACTORS

by

YOUSRI ALY MANSOUR

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ABSTRACT OF THESIS

In 1965 three levels (61, 107 and 144 g/day) of dietary DCP were fedin isocaloric diets (approx. 2·65 Mcal ME/day) to three groups of four Blackface wether lambs for 104 days before slaughter.

In 1966 three levels (2·04, 2·61 and 3·18 Mcal/day) of ME were fed in diets providing the same daily intake (approx. 90 g) of DCP to five groups of lambs three of which were slaughtered after 91 days on feed while the other two groups being fed at the lower daily energy intake levels were slaughtered after they had consumed the same total quantity of energy as the high daily energy intake group. These two groups were slaughtered after 112 and 140 days on feed.

At the start of each trial a representative group of lambs was slaughtered in order to estimate the body composition of the lambs on test. The response was taken as the gain in weight of the component over the estimated initial starting weight.

The body components were measured, the left side of each carcass was separated into retail joints, the fatty, muscle and bone tissue separated, weighed and chemically analysed and certain muscles individually removed and weighed.

It was shown that increasing the level of daily intake of DCP in isocaloric diets had only a small effect on live weight gain, but the body components were markedly effected. The gains in weight of S.E.B., carcass, gigot joint, kidney, pluck and blood were significantly increased. Bone tissue showed the greatest

response followed by muscle tissue while fatty tissue seemed to be retarded. Significant differential stimulation of some of the parts, individual muscles and chemical components of the body was found. The percentage of DM and EE in fatty and muscle tissues fell while that of CP detectably increased. Remarkable saving in the food required to produce a unit gain of live weight, carcass or muscle tissue was achieved due to increasing the level of protein.

In the second experiment (part a) raising the level of daily intake of ME significantly increased the gains in live weight, S.E.B. and carcass. Fatty tissue was most effected, followed by muscle, while bone tissue showed no noticeable response. The different joints and the individual muscles showed various responses to increasing the level of energy. Level of energy supply appeared to enhance protein deposition. The chemical composition of the carcass tissues was not noticeably altered. The efficiency of energy utilisation, energy retention and nitrogen retention was improved.

In the second experiment (part b) feeding similar quantities of ME at different levels of the daily intake had no detectable influence on live weight gain but had a marked effect on body components. Most of the measures of fat development were significantly decreased while those of bone tissue were slightly increased and those of muscle tissue showed no noticeable change. The chemical composition of the carcass tissue was markedly effected.

Feeding the same amount of energy at the medium level of the daily intake resulted in producing gains in empty body, carcass and muscle tissue with greater efficiency than if it had been fed the extreme rates.

It was concluded that wide variations in feeding regimes has a smaller effect on muscle development than fatty or bone tissues. The differential behaviour of the anatomical parts of the body to dietary regimes is mainly due to the differential tissue response. The gain in fresh weight of the body tissues does not indicate the changes which occur in the tissue. Composite measures such as live weight or carcass weight may not reflect the real effects of certain treatments. Discussion of the effect of plane of nutrition on body growth cannot be meaningful without reference to the level of intake of each nutrient since each has different functions for the development of different tissues.

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INTRODUCTION

In commercial meat production the efficient conversion of dietary components to saleable products must be considered in relation to the acceptability or relative value of the saleable product. Hence, a search must be made for those feeding regimes which can enhance carcass value as well as those regimes which achieve the required period to slaughter condition and economic conversion of food.

It has long been accepted by stocksmen and research workers that body components and carcass tissues grow at different rates relative to the whole or to each other. A natural sequence of events progresses from birth to maturity which makes the point of slaughter a major determinant of the composition of the carcass.

Although it has been appreciated that nutrition and other environmental factors can alter the growth pattern of both total and component body weights, the manner in which this is achieved is still a subject for debate. If restriction in nutrition does not effect all the components to the same degree then the factors which determine the particular degree of restriction need to be understood.

The further question arises as to whether these factors can be controlled in order to use them to advantage in improving the value of saleable carcass products.

Carcass value incorporates the favourable distribution of muscle tissue into the preferred joint areas as well as requiring

a suitable distribution of fat to enhance the eating, cooking and storing properties. Hence the carcass development must be studied on a joint and also tissue within joint basis in order to comprehend possible treatment effects.

In nutritional regimes the energy and protein components are closely combined. In this thesis the effect of energy and protein as separate dietary components were examined by holding one component level while increasing the level of the daily intake of the other. By combining the marginal increase of one dietary component with a carcass evaluation procedure the changes in the carcass which effect its value have been assessed.

REVIEW OF LITERATURE

The major objective in meat production is to convert animal feedingstuffs into acceptable edible meat products. Of the ingested nutrients only a proportion are utilised for carcass tissue production and of the latter only a proportion is saleable and edible product. However the value of a carcass not only depends upon the quantity of saleable meat and the suitability of it for consumer satisfaction but because of the variation in desirability (acceptability) of various areas of the carcass the proportion of these preferred areas in the carcass must also be considered. To add to the difficulty of appraising a carcass, edible meat is an admixture of muscle and fatty tissue while the most desirable proportion and distribution of each tissue is a matter of changing personal preference.

In order to assess the response of meat animals to production practices the tissue proportions, tissue distribution over the carcass and the tissue quality must be observed as the animal grows and develops. As nutrition is a major factor affecting the growth of body components the daily intake of dietary nutrients and the end products of digestion should also be considered if any control of the growth and development process is to be achieved.

Changes in body composition as the animal matures

It has generally been accepted (Hammond, 1932; McMeekan, 1940a,b,c and 1941; Wallace, 1948; Palsson and Verges, 1952a; Kidwell, 1955; Luitingh, 1962 and Butterfield 1963a,b) that

during the process of growth all organisms, except the most simple, only increase in size but also undergo changes in form due to differential growth rates of their constituent parts. Also qualitative changes generally occur. Palsson (1955) reviewed the work of many authors on growth and development of animals. He attributed the developmental changes, which occur as an animal grows, to a primary wave of growth from the cranium down the facial parts of the head and caudally to the lumbar region, and to a secondary wave from the distal parts of the limbs and the ventral region of the trunk terminating in the lumbar region. The lumbar region was described as the last part of the body to attain maximal growth rate and was, therefore, the latest maturing part of the body. This pattern is repeated by each of the major tissues which follow each other in the rate of development in the sequence of bone, muscle and fat. The various organs can exhibit marked differential growth. Palsson stated that the growth of the individual organs appeared to be related primarily to function. Those organs of most vital function to the life of the animal like the brain, eyes, lungs, kidneys, heart, oesophagus, abomasum and small intestines are relatively well developed at birth and consequently grow proportionately less in post-natal life than organs like the rumen and reticulum, which have an unimportant function until some time after birth when the lamb begins to eat fibrous foods. The thoracic organs as a whole are earlier maturing than the digestive tract. This concept has more recently been questioned by many

workers (Luitingh, 1962; Tulloh, 1963; Elsely et al., 1964; Berg and Butterfield, 1966, and Seebeck, 1968) on several grounds.

The use of considering growth in relation to the weight of the component at birth is dangerous because of the maternal influences and type of birth, secondly because during the first doubling of birthweight a considerable amount of differential growth takes place before finally settling down. Some authors (Berg and Butterfield, 1966) have demonstrated these rapid changes soon after birth. Because the head is well developed at birth its growth in relation to its initial weight must inevitably be small. On the contrary fatty tissue which is almost non existent at birth can only show a high percentage change in relation to its weight at birth.

Seebeck (1968) has pointed out the dangers of misinterpreting data based on slaughtering animals at different ages and different weights, particularly when they have been subjected to treatments which stimulate some components more than others.

Luitingh (1962) pointed out that the finding that the loin was the latest developing part results from the method of jointing which considered the dorsal and ventral parts of the loin together. It is only the abdominal regions which appear to make further growth after the skeletal muscles have tended to mature.

However with these deficiencies corrected the basic concepts at least in growth patterns include the immediate post natal phase.

The Concept of Differential Growth of Tissues

Studies concerned with the growth of carcass tissues (Hammond, 1932; McMeekan, 1940a; Wallace, 1948; and Palsson and Verges, 1952a) suggest that bone tissue is the first to mature, followed by muscle which is followed by fatty tissue. This concept has been more recently examined by Tulloh (1963), Elsley et al., (1964), Berg and Butterfield (1966) and Jackson (1967). Tulloh studied the allometric relationship between empty body weight and the weight of separated bone, fatty and muscle tissue of the carcass. The differential growth rate of each of these dissected carcass components indicated that as empty body weight increased the weight of each of the carcass components increased. The proportion of bone fell, that of fat increased and that of muscle remained almost constant. Fatty tissue showed the greatest variation from regression. Elsley et al. (1964) and Berg and Butterfield (1966) suggested that because fatty tissue was so effected by the level of nutrition, the growth of carcass tissues should be related to fat-free carcass or body weight. Both groups of workers studied the allometric relationship between the carcass tissues and the muscle plus bone content of the carcass showing that, over the weight range of the study, bone grew less fast than muscle plus bone, muscle slightly faster and fatty tissue faster than muscle plus bone. Jackson (1967) showed that in Blackface lambs growing from birth to maturity the muscle weight increased proportionally to the 1·36th power of bone weight and that this relationship held over

the entire range of observations. This close association of muscle growing differentially faster than bone would suggest at least some factors concerning growth common to both tissues. It seems likely then that bone stops growth at the same time as the muscle ceases growth but having grown at different rates throughout the period to maturity.

That fatty tissue grows, at least in the later stages of maturity, at a faster rate than muscle and bone has been shown by Tulloh (1963), Berg and Butterfield (1966), Elsley et al. (1964), and Callow (1947), but unfortunately fatty tissue is so influenced by plane of nutrition that the relationship with other tissues can only be approximated. It is acknowledged that fatty tissue continues to grow and increases in weight after muscles and bone tissue have ceased.

The Concept of Differential Growth of Parts

If tissues develop at different rates then it must be expected that parts of the carcass which have different tissue proportions will grow at different rates relative to each other. Hammond (1932), Palsson and Verges (1952a) and McMeekan (1940a) considering the total weight of sections of a carcass concluded that the loin section (dorsal and ventral parts) was the latest developing section. Most later studies take the loin to represent only the lumbar area and Luitingh (1962) questioned the theory that the lumbar area was the end point of these waves of growth. However, none of these studies considered the development

of individual tissues when the question arises as to whether a tissue in a certain part of the body grows at a different rate to the whole. Butterfield (1963b) studied the relative growth of the musculature of the ox by taking the weight of a muscle at birth in relation to total muscle in the carcass and compared it with the weight of the muscle in relation to total muscle at maturity. From this he classified muscles into those early developing which had at birth a weight relation to total carcass muscle that is greater than it was in adult life. In this classification were grouped the distal and proximal muscles of the forelimb and the distal muscles of the hind limb. Late developing muscles were taken as those muscles which at birth had a weight relation to total carcass muscle that was less than was found in the adult animal and which make rapid growth after birth. The predominant muscles in this category were the abdominal muscles and the proximal muscles of the hind leg. Following rapid growth in the first few months of life they thereafter were found to grow at rates similar to total muscle. Average developing muscles were those surrounding the spinal column and their proportion to the total muscle remained unchanged throughout their life. Unfortunately the animals used for this study differed widely in age, breed and nutritional history which makes the interpretation of the data into a growth theory highly dangerous. From this evidence it would appear that after the first few months of life muscle development takes place fairly uniformly over the carcass. This was in keeping with

the finding of Jackson (1968) who failed to show that the muscle of the hind leg of Blackface lambs grew from weaning to maturity at a different rate to that of the muscle in the whole carcass. With bone, Hammond (1932) McMeekan (1940a) and Palsson and Verges (1952a) have shown that the head and the feet of lambs are proportionally nearer to mature weight at birth than the other skeleton bones. Palsson and Verges (1952a), Joubert (1959) and Luitingh (1962) suggested the bones of the rib cage were the last to increase in weight. However in his studies of Blackface lambs growing from weaning to maturity Jackson (1968) failed to show that, in the carcass, the bone of the hind leg grew at a different rate to that of bone in the rest of the carcass.

Fatty tissue can be regarded as separate deposits with the perirenal fat, subcutaneous and intermuscular fat being of chief interest. Callow pointed out that in the later stages of fattening subcutaneous fatty tissue developed at a faster rate than intermuscular fat. Perirenal fat weight has been used as an indicator of total fatness but it appears to be well developed early in life and is noticeably more prominent in dairy breeds in contrast to beef breeds.

The work of Jackson (1968) showed that there may be a slight tendency for the fat in the hind limb to grow at a slower rate than the rest of the body carcass fat, but it was not considered that this difference was real or important.

Obviously those parts of the carcass which contain a high percentage of fatty tissue will appear to be growing at a faster rate than those with a low percentage of fatty tissue.

The Changes in Chemical Composition of the Tissues as the Animals Develop

The chief chemical components of the body - water, ether extract, fat-free dry matter and nitrogen - have been studied by many workers (Trowbridge et al., 1918 and 1919; Moulton et al., 1922; Armsby and Moulton, 1925; Kirton et al., 1959; Balley et al., 1960 and Lawrie, 1966). The concept put forward by Moulton (1923) suggests that, as the animal matured, a stage of chemical maturity was reached when the proportions of moisture, nitrogen and ash in the fat-free tissues become practically constant. Although mammals become chemically mature at different ages, the proportion of the total life span expended before they reach the stage of chemical maturity is approximately the same. Moulton has shown that animals are chemically mature after 4·0-4·5 per cent of the life span has been expended.

Wardrop (1963) summarised the work of many authors on the changes in the chemical composition of meat animals in post-natal life.

In general, the dry matter content of the carcass tissues increases with increasing maturity due to the increase in ether extract content of carcass tissues. Callow (1948) showed that ether extract in the fatty and muscle tissues increased as the level of the fatty tissue in the carcass increased.

(a) Changes in chemical composition of the muscle tissue with age.

The composition of muscle tissue varies with increasing animal age. In general, except water, there is an increase in most chemical components of muscles as the animal matures. The percentages of dry matter, ether extract and total nitrogen in the M. longissimus dorsi were found to be 22·04, 0·55 and 3·30 per cent respectively in a 12-day-old calf while in a 3-year-old steer the corresponding values are 25·89, 3·69 and 3·52 per cent (Lawrie, 1966). In pigs these values are 23·28, 2·85 and 3·71 per cent for dry matter, ether extract and total nitrogen respectively in the M. longissimus dorsi of 5-month-old animal while at 7 months old the percentages increased by 0·82, 1·11 and 0·16 per cent respectively (Lawrie et al., 1963). Moreover, different components were seen to reach mature values at different times. In the M. longissimus dorsi of bovine the myofibrillar and sarcoplasmic nitrogen reach 70-80 per cent of their mean adult value by birth and their subsequent rates of increase become asymptotic at about 5 months of age (Lawrie, 1966), whereas non-protein nitrogen does not attain its adult value until about one year old. The concentration of myoglobin increases rapidly until about 2 years old. On a fat-free basis, however, the moisture content remains fairly constant after 2 years old. The intramuscular fat (ether extract) appears to increase and moisture content on a whole tissue basis to decrease up to and beyond 40 months of age. In cattle the iodine number of the intramuscular fat falls very markedly (from 82·41 in 12-day-old calf to 56·50

at 3-year-old steer) with increasing age. While in the pigs the depression of the iodine number with age was relatively very small (57·4 to 55·4 at 5 and 7 months of age respectively). This fall has been attributed to the development of the rumen microflora which hydrogenate dietary fats. The percentages of collagen and elastin decrease as the animal matures (Wilson et al., 1954). This indicates that the connective tissue content of muscle is greater in young animals than in older ones. It is quite accepted that muscles from young animals is more tender than those from old ones which suggests differences in the nature of the connective tissue at different ages. Gross (1958) reported a higher concentration of "salt-soluble" collagen (a precursor of insoluble collagen) in young muscles. There is evidence that the connective tissue in the muscles of young animals may contain more reticulin (Boucek et al., 1961).

(b) Changes in chemical composition of fatty tissue with age

As the animal develops the percentage of dry matter in fatty tissue increases due to increase in its ether extract content. The percentage of ether extract in the fatty tissue increases as the animals become fatter (Callow, 1948). Hammond (1932) has shown that changes with age and with fatness are similar. It is expected therefore that the percentage of ether extract in fatty tissue increases with age. Callow (1962a) obtained higher values for ether extract in the fatty tissue of steers slaughtered at approximately 750 days of age than those slaughtered at 1068 days. However the animals in the first group

(750 days of age) were having concentrated diets while the other group was finished on grass. As the rate at which fat is deposited effects its composition (Callow, 1962a) the higher ether extract value in the fatty tissue of the steers which were fed a concentrated diet may largely be due to the effect of the type of the ration. The iodine number in these animals was lower in the young steers than in the older ones. It cannot be ruled out that this increase in the iodine number is due to the increase in the degree of maturity of the animals or due to the type of the ration.

Very little information is available regarding the effect of age on the proportion of nitrogen in the fatty tissue. Fat at first collects in the cytoplasm of the fatty cells as droplets which increase gradually until they fill most of the cell, therefore the percentage of nitrogen might decrease with increasing maturity.

(c) Changes in chemical composition of bone tissue with age

Compared with muscle and fatty tissue there is much less information concerned with proportional changes in the chemical components of the bone tissue as the animals develop. The major part of the skeleton of the embryo is first laid down in cartilage which undergoes gradual conversion into bone (ossification) during the development of the embryo and throughout the growth period of the young animal after birth. Thus the proportion of total ash is expected to increase with age.

The effect of level of nutrition on body composition

As has already been shown, the composition of an animal changes as it grows older and increases in size. These changes are generally considered from two aspects.

1) The increase in the weight of an animal or of any part of it, as it approaches mature size (the growth process as defined by Seebeck 1968).

2) The changes in the form of the animal resulting from differences in the relative growth rates of the component parts of the body (differentiation).

The rate changes of each process can be effected by environmental factors. In general nutrition is the most important factor determining the rate at which each process takes place.

Regarding the first aspect, the influence of plane of nutrition on gross live weight changes is not a complicated problem in comparison with the second one and data on this type can be found extensively in the literature. (Robinson, 1948; Wallace, 1948; and Garrett et al., 1959, with sheep: Robinson et al., 1964 and O'Grady, 1966 with pigs: and Waters, 1909; Eckles and Swett, 1918; Trowbridge et al., 1918; Moulton et al., 1922 and Hendrickson et al., 1965 with cattle). Although observations on total weight increases are straightforward they do not give an appreciation of the effect of feeding regimes on animal body components. The measurement of

the changes in each component part of the body in relation to each other or to the whole due to nutritional treatments is more difficult to observe and interpret. Because of this complexity different theories have been advanced to interpret the real effect of nutrition on body composition. It is pertinent to this review to discuss briefly the various ideas suggested to explain how body composition can be affected by certain feeding patterns. McMeekan (1940a,b,c) grew pigs along four pre-determined different growth curves representing different patterns of nutrition. These patterns were designated High-High, High-Low, Low-High and Low-Low., the words describing the plane of nutrition from birth to 16 weeks and 16 weeks to slaughter at 200 lb. respectively. From these experiments McMeekan pointed out that the relative development of different tissues and organs could be largely influenced by the plane of nutrition. Working with sheep Palsson and Verges (1952a,b) reached similar conclusions. As a result of these experiments the workers at Cambridge school advanced the hypothesis that:

a) Restricted nutrition penalized the growth of body components differentially in the reverse order of their maturity - late maturing tissues and parts being the most affected.

b) That those body components having their maximum growth intensity at the time of restriction were the most retarded (Palsson).

This hypothesis was questioned by Wallace (1948) who suggested that the apparent differential effect of the treatments on the relationships within the tissues was due to the fact that the comparison had been made at equal body weight rather than at equal tissue weight and if the data had been analysed on a within-tissue basis many of the treatment effects would disappear. However, this criticism by Wallace was rejected by Palsson and Verges (1952a,b). They plotted the bone of the head, lower jaw and pelvis against the total weight of skeleton, less the particular bone or bones in question, and demonstrated that there were significant differences in these relationships between the two extreme treatments. Even after adjustment for differences in bone weight (Fowler 1968) significant effects of treatments still occur. These results would indicate that some relationships within certain tissue components can be altered by nutrition.

However Wallace's suggestion was found support from the results of other workers. Wilson (1954) working with domestic fowl reported that the regression coefficients of total muscle dry matter, total dry matter and weight of skeleton on empty weight did not differ significantly in relation to the plane of nutrition. He also found that deposition of fat was not systematic and therefore should be excluded. Action was then taken to avoid any bias due to

differences in the amount of fat in the carcass. Wilson (1958) slaughtered East African dwarf goats when he estimated that they would have equal fat-free carcass weight. In this experiment Wilson did not demonstrate any obvious differential effects of the nutritional treatments on the growth of skeletal and muscle tissue. Fowler (1959) drew normal growth curves for the male pigs of McMeekan's experiments, plotting weights of individual bones against total skeleton weights. He found that when the values from pigs on different planes of nutrition were superimposed on the graph, they did not deviate largely from the normal curve. Elsley (1963) stated that pigs which were reared under different methods and slaughtered at equal live weight and same age had different carcass composition but similar bone/muscle ratio, demonstrating that the differences were mainly due to the variation in fat deposition between groups. The data of McMeekan (1940a,b,c) on pigs and of Palsson and Verges (1952a,b) on sheep had been re-analysed by Elsley et al., (1964) on a fat-free basis using the allometric equation. However different conclusions to those of the original authors were reported. The re-analysis of the data showed that the plane of nutrition has no effect on the total weight of bone or of muscle relative to the weight of bone plus muscle together. Apart from the weight of bone plus muscle in the head and neck, they found no evidence of a

relationship between the order of maturity of the joints as previously understood and their relative response to level of nutrition. The conclusion to be drawn from these results was that restricted nutrition caused a more or less uniform retardation of development except in so far as fatty tissue was concerned, which contrasted with the theory of the Cambridge school of workers.

The concept that comparison between nutritional treatments should be made on a fat-free body basis has also found some criticism. Subtraction of one component from the whole can only be justified if the absence of this component does not disturb the relationships between each of the other components and the weight of the whole less the weights of that component. Seebeck (1968) using McMeekan's data (1940) found that intermuscular fat effected muscle and bone in the carcass (at constant carcass weight) minus skin and total fat. With data on lambs intermuscular fat had a significant effect on muscle and bone in the carcass at constant jointed side (minus total fat) weight. He concluded that the relationship between the weight of the fat in the carcass and the composition of the remainder of the carcass should be examined before fat-free carcass weight is used as the independent variate.

Although Elsley and his colleagues suggested that it is ←

possible that some treatments could upset the balance between tissues (e.g. the severe restriction of nutrition as found by Pomeroy, 1941) the conclusion they made, that in choosing a feeding scale for any particular strain of animal no attention need be given to the relative proportion of bone to muscle but that the pattern of feeding should be aimed at producing carcasses of whatever fat content is desired, may not be completely justified. It is clear that the discrepancies between these hypothesis are mainly due to the way in which the data were interpreted. However the effect of the composition of the diet regarding this problem has not been discussed elsewhere. It is important in this respect to determine what is meant by restriction of nutrition. The animals in these trials rightly had different quantities of energy and protein but the chemical nature of this energy was not known. Both the level of energy and protein in the diet may effect body composition. Furthermore energy and protein from different sources may influence body composition differently as will be discussed later. If the low plane of nutrition was composed of a diet rich in protein then the growth of bone and muscle tissues may not be as greatly retarded as if the diet had been restricted in protein. Ignoring the level of energy and protein and the ratio of roughage to concentrate for each plane of feeding in these experiments has also cast doubt on the reliability

of these interpretations.

It is important that the relationships between body composition and the level of nutrition should be considered in the light of knowledge that the end products of digestion and the level of each ration component can effect the tissue response.

The chemical composition of carcass and carcass tissues as effected by the level of feeding

As the animal matures, considerable changes in the chemical composition occur but there is conflicting evidence as to whether the level of nutrition has also a marked effect on it. Callow (1958) with sheep, Callow and Searle (1956) with cattle, have shown that as the percentage of fatty tissue in the carcass increases the percentage of ether extract in fat increased. However, Callow (1962a) examined the effect of increasing level of nutrition on the percentage of ether extract in fatty tissue of various anatomical joints of steers. With the exception of a few joints level of nutrition was without significant effect on the ether extract concentration in fat. With the extracted fat from muscle tissues in these joints, similar results were also reported. The percentage of ether extract of muscle tissue as measured on the M. longissimus dorsi,

(McMeeken, 1940b,c, with pigs; Palsson and Verges, 1952a with sheep, and Callow, 1962a with cattle) increased with increasing level of feeding.

Dealing with the carcass as a whole Garrett et al. (1959) reported that lambs fed different daily intake levels of metabolizable energy and slaughtered at similar ages did not demonstrate any major effects on the chemical composition of the carcasses unlike steers which were considerably affected in their chemical composition with increasing level of dietary energy. Knight et al. (1960) working with lambs have shown that the ether extract/nitrogen ether extract/ash and ash/nitrogen ratios were altered by the level of nutrition. Babatunde et al. (1967) working with pigs found that groups put on limited feeding had significantly (except for ash per cent) higher proportions of protein, water and lower chemical fat in the carcass than full-fed groups.

The terms plane of nutrition and level of feeding were used to refer in most of these experiments to the quantity of food intake ignoring the level of each of the dietary constituents. High level of feeding generally means a higher proportion of concentrate foods which confounds a straight comparison between different levels of the same ration components. Since protein and energy of food have

different functions in the body, their effects on the animals tissues could be expected to be different. This may, in part, explain the discrepancies between these findings.

The effect of level of dietary protein on liveweight gain and body composition

Protein is the most abundant constituent, other than water, of the organs and soft structures of the animal body. A continuous supply of protein forming ingredients is needed for the build up of proteinacious tissues, enzyme actions, hormones and tissue repair. The question of how dietary protein is allocated to the various demands and whether increasing the amount fed daily would effect the amount of protein stored has not been extensively studied particularly with sheep.

The early work of Hogan and Pilcher (1933); Forbes et al. (1935a, 1935b); Hogan et al. (1935) and Johnson et al. (1936) with rats have shown that increasing the percentage of dietary protein in isocaloric diets increased total gains, protein stored, water and energy gains and decreased gain in fat. Hamilton (1939) reported that increasing the percentage of dietary protein had no effect on the rate

of gain of rats but effected the composition of the gains. Diets containing low proportion of protein produced gain having less protein and more fat than those having a higher percentage of protein. Allison et al. (1962) stated that the relationship between nitrogen intake and body weight gain in rats is curvilinear but may be considered as linear at the lower nitrogen intakes.

Several experiments have been carried out to investigate the effect of increasing the level of dietary protein on live weight gain and carcass composition of pigs. Bowland and Berg (1959) have shown that high protein rations resulted in leaner carcasses. Morgan et al. (1959) fed two levels of dietary protein and similar amounts of TDN. They reported that pigs on low protein level had more total body fat and backfat and less lean than those fed high protein level. Holme (1961) summarised the work of many authors. He stated that some experiments have shown that variations in level of dietary protein have only a small effect on the leanness or fatness of the carcass, while others suggest that dietary protein levels can have a marked effect on the carcass composition. He attributed the apparent discrepancies of the findings mainly to the various methods used to measure the effect of dietary protein. The recent work of Robinson et al. (1964) and Robinson and Lewis (1964) have shown that dietary protein level had no significant

effect on rate of live weight gain but had a marked effect on the composition of carcasses. They found a graded increase on lean content and a decrease in fat content as the protein level of the diet was increased from 11-19% (constant level of energy, same live weight but different ages). Holme et al. (1965) reported that variations in level of dietary protein had little effect on growth rate but had a noticeable influence on carcass composition. Cooke (1967) studied the effect of increasing the level of dietary protein at different levels of energy on the carcass composition of pigs. He found that as the level of dietary protein was increased the lean proportion of the carcasses increased steadily whereas the rate of growth fell off beyond a certain point. This conclusion has been confirmed at the different levels of dietary energy.

Work with steers (Haskins et al. 1967 and Fontenot and Kelly, 1967) have shown that dietary protein levels significantly effected live weight gains.

On the other hand, dietary protein above a certain level was found to depress growth rate. Forbes et al. (1938) reported that the rates of gain of rats decreased as the percentage of dietary protein increased above 25 per cent. Preston et al. (1960) fed 4 levels of crude protein

in diets approximately having the same caloric value to early-weaned calves. They found that nitrogen retention increases as the crude protein in the dry matter of the diet reached 20% and then fell at the higher levels. Similar results on pigs were obtained by Jones et al. (1961). Robinson et al. (1964) have shown that growth rate was depressed when pigs fed levels of crude protein higher than 20 per cent. Fontenot and Kelly (1967) reported that cattle fed 12·9 per cent protein had higher daily gain than those fed 17 per cent or 9·2 per cent protein.

The optimal protein requirement of the diet, however, cannot be considered in isolation from those for carbohydrates and fats. It is well known in poultry meat production that the energy:protein ratio is of great importance (Combs, 1961). The possibility of interaction between these nutrients in the rations of pigs has been examined by Kennington et al. (1958); Bowland and Berg (1959) and Robinson et al. (1964). They reported that protein and energy exert their influence independently of each other. Cooke (1967) found that as the energy level was raised at a particular dietary protein level the lean content of the carcass fell but not the quantity of lean produced per day. Kielanowski (1966b, 1968) has shown that the daily deposition of protein increased when increasing the level of energy supply of pigs. These findings emphasise

the necessity of studying the growth characteristics of animals in relation to individual food nutrients levels as well as to overall nutrient concentration.

There is a lack of information on protein: energy ratio in the diets of lambs and its effect upon growth rate and carcass composition. Preston et al. (1965) reported that the ratio of 22 g digestible protein/1000 Kcal digestible energy resulted in maximal gain in wether lambs. They pointed out that this ratio may well represent the optimal ratio for growing-finishing sheep and cattle. Ørskov and Andrews (1968) 'unpublished paper' fed different concentrations of crude protein at different levels of feeding. They reported that optimum protein content of the ration increased with increasing levels of feeding and decreased as the weight of the lambs increased.

The effect of source of nitrogen on the growth of ruminants

It is quite accepted that the utilization of dietary protein by non-ruminants depends largely on the amino acid composition of the protein. In ruminants the case is simple and quality of protein may not be important. However several reports have shown that all nitrogen sources may

not be of equal value to the ruminant animal. Woods et al. (1962) pointed out that cottonseed meal was inferior to either sesame or soyabean oil meal as a protein supplement for growing lambs. Theurer et al. (1968) have shown that soyabean meal was superior to corn gluten meal as a nitrogen source in semi purified diet for promoting lambs growth, but was not superior in natural diets. In both semi purified and natural diets urea was inferior to soyabean meal or corn gluten meal.

Although the effect of source of nitrogen on body composition has not been extensively studied, the present evidence suggest that the source of dietary nitrogen should be taken into consideration in studies concerning protein level effect on body composition.

The effect of the level of energy on body composition

A considerable amount of work can be found in the literature regarding the effect of high and low plane of nutrition on body composition. Little is known about the distinctive actions of food nutrients on growth and development of farm animals. The question of how marginal increases in energy intake are utilised is a complex problem. In the light of the present knowledge it is accepted that

energy is used for body maintenance and tissue building and the surplus is deposited in body fat reserves.

Cooke (1967) has shown that, in pigs, increases in energy above a certain level did not effect the quantity of lean produced per day but the lean content of the carcass fell. Protein synthesis depends largely on the energy supply at least to a certain level. The amount of energy required for the synthesis of one gram protein was shown to be 7·5 Kcal metabolizable energy (Kielanowski, 1966a). The composition of bone tissue was also seen to be influenced by level of energy. Ash percentage of the skeleton of sheep decreased with increasing level of dietary energy (Benzie et al. 1960).

Experiments concerning the high and low level of nutrition have generally used rations which differed in concentrate to roughage ratio and also in protein level. Dietary protein may effect body composition in a different way to that of energy. Moreover, energy from different sources may effect body composition differently. For instance, two diets have the same caloric value but made up from different components may not necessarily show similar effects on animals. The discovery of rumen VFA throws a light on many problems regarding the efficiency

of energy utilization and the relationship of diet composition and body composition.

THE EFFICIENCY OF FEED UTILISATION

The concentration of rumen volatile fatty acids as effected by the composition of feeds

The major volatile fatty acids (VFA) produced in the rumen are acetic, propionic and butyric acids (Phillipson, 1942 and Bath and Rook, 1963). The amounts and relative proportions of these acids are influenced by the composition and physical form of the diet. Varying the concentrate: roughage ratio has been reported to alter rumen acids levels. Stoddard et al. (1949), Tyznick and Allen (1951) and Balch et al. (1955) have shown that roughages favour the production of high proportions of acetic acid and less proportions of propionic and butyric acids. McClymont (1951) found no marked change in the proportion of acetic acid in the rumen when different ratios of roughage to concentrates were fed. Balch and Rowland (1957) reported that, when a diet of hay alone was given to dairy cows, the proportions of VFA in the rumen were acetic 70%, propionic 18% and butyric 10%, when a diet of 2 lb. of hay and 24 lb. of concentrate, the proportion was 41%, 38% and 9% for acetic, pripionic and butyric acids respectively. They also found that, replacing long hay by finely ground hay decreased the ratio of acetic

to propionic acid. Brown et al. (1958) show that the molar percentage of acetate decreased from 60 to 40, whereas per cent propionate increased from 20 to 40 when the per cent concentrate in the diet increased from 20 to 80. Raun et al. (1962) working with lambs, obtained narrower acetic/propionic ratio and higher butyric when the diet contained high proportion of concentrates. Rhodes and Woods (1962) reported that a long hay ration produces narrower acetate to propionate ratios than ground mixed rations, and rations containing a high level of concentrates depressed the proportion of acetic and raised the proportion of propionic acid.

Donefer et al. (1963) working with sheep, fed 5 pelleted rations consisting of different ratios of alfalfa: barley. They obtained low molar proportion of acetic acid and high proportion of butyric acid when the level of barley was increased. These results have also been confirmed by Bath and Rook (1963) and by Weiss et al. (1967). Vidal et al. (1967) fed 4 different ratios of hay:grain to sheep. They reported that as the grain was increased the molar percentage of acetic and butyric decreased while propionic increased.

The effect of increasing the level of feeding upon the production of VFA has been studied by Bath and Rook (1963)

who reported that when the dry matter intake was increased there was an increase in the concentration of the total VFA. They pointed out that the molar proportion of acetic and propionic acids has also been effected by the level of intake. Raising the level of intake of a diet containing hay and concentrates resulted in a decrease in the molar proportion of acetic acid with a corresponding increase in n-butyric, however these changes were small when hay was fed alone.

In general, it is clear that increasing the molar percentage of propionic acid at the expense of acetic acid is associated with high concentrate rations.

Influence of rumen volatile fatty acids on live weight gain and carcass composition

Carroll and Hungate (1954) have shown that the energy absorbed as volatile fatty acids can contribute as much as 70% of the energy requirements of the ruminant. Experiments have shown that the proportions of rumen VFA play an important role in determining the net utilization of metabolizable energy, particularly for production purposes (Armstrong et al., 1957a,b, 1958 and Armstrong and Blaxter, 1957a, 1957b). When the energy of mixtures of VFA is used for maintenance, composition of the mixture has very little

effect and all the acids are utilized with the same efficiency but at production levels the relative efficiency of VFA have been shown to alter. Armstrong and Blaxter (1957a,b) and Armstrong et al. (1957a) demonstrated with sheep that the heat increment of added acetic acid was greater than that of added propionic or butyric acid. Blaxter (1960) pointed out that the number of Kcal of fat synthesised per 100 Kcal of VFA dissimilated in the order acetic acid< propionic<butyric<lactic<glucose. The calorific value of the fat synthesised from acetic is only 30% of the calories supplied, with butyric 62% and with hexose about 70%. This indicates that propionate is more efficient than acetate as an energy source for lipogenesis.

Several experiments have been carried out to investigate whether changes in the amount and relative proportions of VFA would be reflected in changes in body gain and carcass characteristics. Armstrong (1960) working with sheep, showed that when the diet contained a high proportion of acetic acid and low proportion of propionic acid, the net energy value was less in comparison with diets which had a low proportion of acetate and high proportion of propionic acid. Shaw et al. (1960) reported that rations which favoured the production of propionic acid rather than the production of acetic acid, increased

live weight gain of steers by 22%. Putman et al. (1965) found a relationship between VFA concentration and average daily gains when bulls were fed and managed similarly. Richard and Ternauth (1965) reported that there was a response in live weight gain of the lambs to propionic acid supplement. Weiss et al. (1967) working with steers reported that animals had similar daily level intake of digestible energy and different proportions of VFA varied in carcass fat and protein. They found that carcass weight dressing percentage, carcass grade and carcass fat were negatively associated with the ratio of acetic to propionic acid.

Other experiments have shown conflicting results. Essig et al. (1959) found no differences in daily gain, carcass grade and dressing percentage between lambs fed similar energy level intake and various ratios of VFA. Rook et al. (1960) working with heifers reported that propionic acid tended to give lower values for empty body weight increments than either acetic or butyric acid. Raun et al. (1962) working with lambs found no correlation between the ratio of acetic to propionic acid and daily live weight gain. Despite these findings it is evident that when comparing different nutritional regimes the effect of VFA should be taken into consideration when interpreting the findings.

The efficiency of feed utilization in relation to the level of nutrition

A high plane of nutrition may be regarded as allowing full expression of the growth potential of the animals organs, tissues, and parts. If the nutrition is not restricting then the growth of the organ or tissue can be expected to be effected by endocrine and other physiological limitations. A high plane of nutrition may be necessary for maximum growth of muscle, bone and fatty tissue. Above a certain level the energy nutrients are surplus and are stored in the fatty tissue or excreted while excess protein is broken down and used as an energy source. Below this level the time taken to reach a given weight or condition is prolonged with an increasing requirement for maintenance. In animal production we are usually interested in the levels of feeding which lie between these limits. The level given to an animal depends upon many considerations. The most important is the efficiency with which food is converted into useful products and the value of these products. Feed may be utilised more efficiently when it is fed at higher levels than at lower levels of intake. The increased physiological efficiency resulting from high planes of nutrition has been shown by Watson (1943) with beef cattle. This indicates that marked savings in feed consumed per unit gain may be achieved by keeping an animal on a high plane of nutrition. However, conflicting results concerning the relationship between the level of nutrition and the efficiency of food conversion have been reported. Blaxter and Graham (1955) have demonstrated that a very high plane of nutrition may accelerate

the rate of passage of faeces, giving reduced digestibility and resulting in more food being consumed per unit of live weight gain. The metabolic rates of animals have been shown to be increased by high level of feeding. Hansson (1956) found that the rate of breathing and heart beat increased as the level of nutrition was raised during rearing. Regarding the level of protein, it has been shown by Maynard and Loosli (1962) that increasing the dietary protein intake in the diets of rats and chickens improved the efficiency of utilization. While protein in excess of what the body can use is broken down and used as a source of energy, adding expense and also adding to the difficulty of excreting the surplus nitrogen with its associated effect on animal health.

Net energy and energy retention as effected by the level of feeding

The net energy of a food is that energy which is available to the animal for useful purposes, i.e. for body maintenance and for the different forms of production. It is determined by deducting the heat increment of a food from its metabolizable energy. While energy retention is defined as the energy stored in or lost from the body as products of lactation or pregnancy. It is determined as the difference between the metabolizable energy of the food and the heat production (a combination of basal metabolism, heat increment and heat produced by activity). The effect of the level of intake on energy retention has been reviewed and discussed extensively by Blaxter (1956). Early work by Armsby and Fries (1903, 1905) showed that the amount of energy retained differs

according to the level of feeding. Further studies (Armsby and Fries, 1915) show that this relationship is linear, hence the nutritive value per unit of feed is constant irrespective of the level of feeding. The work on cattle by Forbes et al. (1928, 1930) demonstrated that the relationship between energy retention and the level of intake is curvilinear. This result has been confirmed by Mitchell and Hamilton (1932) and Blaxter and Graham (1955) with sheep. Blaxter (1956) reviewed the work of many authors, found that they all agree that the relationship between energy retention and energy intake is curvilinear. However, Forbes et al. (1928, 1930) and Marston (1948) suggested an intermediate proposal for interpreting this relationship. They suggested that this relationship should be regarded as linear above maintenance and curvilinear below maintenance. Kriss (1943) reported that the utilization of the metabolizable energy of a diet for body increase is not greatly effected by the feeding levels within fairly wide limits above maintenance. Blaxter and Graham (1955) consider that the relationship is curvilinear above and below maintenance and the assumption of the linearity of the relationship between energy retention and the level of metabolizable energy intake is incorrect. Garrett et al. (1959) reported that the relationship between energy intake and energy retention in lambs is best expressed as a linear rather than exponential function while the opposite is the case in steers. Jenkinson et al. (1967) working with pigs have shown that the relationship between energy retention and energy intake was linear above maintenance. Graham et al. (1959) reported that at

very high nutritional levels, warm conditions in a calorimeter could lead to increases in body temperature and this results in the acceleration of metabolism and consequently a fall in the net energy value of the food. Blaxter and Wainman (1961) pointed out that net energy per unit of food declines with increasing intake. McDonald et al. (1966) pointed out that at feeding levels between maintenance and maximum appetite, metabolizable energy is used for fattening with constant efficiency. However, the discrepancies between these results are mainly due to the way in which they are presented. // Since oxidative processes at maintenance and below maintenance are more efficient processes than is the synthesis of fat (Armstrong et al., 1957a, and Blaxter and Wainman, 1961). It would be expected that when feed intake ranged from zero to maximum attainable a change of slope of the curve relating energy retention to metabolizable energy intake would happen. Relating energy retention to food intake (gross energy) rather than to metabolizable energy intake would include any curvilinearity due to a decline in the metabolizable energy of unit food with increasing feeding level.

The effect of the level of feeding and percentage of crude protein in food on the apparent digestibility of crude protein

Hale et al. (1940) reported that the digestibility of crude protein (CP) decreased as the level of alfalfa hay was increased. Truter and Lauw (1950) found that sheep put on three levels (maintenance, one and a half times maintenance and twice maintenance) of equal parts by weight of hay and crushed maize, showed a depression in the apparent digestibility of CP by increasing the

level of feed intake. However, Watson et al. (1949a) in a study of the effect of plane of nutrition on the digestibility of linseed meal, reported that plane of nutrition had no effect on the digestibility of protein.

Several workers, Mitchell (1942), Glover et al. (1957), McDonald and Purves (1957), Holter and Reid (1959), Topps (1962), Bredon et al. (1963), Butterworth (1963), Milford and Minson (1965) have reported a close relationship between the percentage of crude protein in the diet and the apparent digestibility of crude protein. Standish and Bowland (1967) working with pigs, showed that the apparent digestibility of nitrogen increases with increasing dietary protein percentage from 12% to 20%. O'Shea and Maguire (1967) reported that, as the percentage of dietary crude protein increased the apparent digestibility of CP was increased when 49 different feedstuffs (ranged from 7-70% CP) used in ruminant feeding were examined. Anderson and Lamb (1967) studied the effect of the level of CP in the diet on its digestibility in various types of diets of hay alone and of different ratios of mixture of concentrate forages fed at two levels of feeding (slightly above maintenance and ad libitum). They found in all cases that, as the percentage of crude protein in the diet increased the percentage of digestible protein also increased.

This brief review shows that the digestibility of crude protein is markedly affected by the percentage of crude protein in the food. The higher the percentage of CP in the diet the greater the percentage of digestible crude protein in the food.

The effect of the level of feeding on the apparent digestibility of energy

Investigations into the digestibility of dietary energy at different levels of nutrition have shown varying results. Some rations show a definite decline in the digestibility with increasing intake while others do not.

The digestibility of concentrates and of mixed roughage/concentrate rations decreases with increasing level of feeding (Forbes et al., 1930; Watson et al., 1949a,b; Truter and Lauw, 1950 and Anderson et al., 1959). With hay alone, however, (Watson et al., 1935) found no change in the digestibility when the amount fed to steers was increased from 4·5 to 9 kilograms per day. Lauw (1944) working with sheep, found no effect on the digestibility of lucerne hay by increasing the level of intake.

Raymond et al. (1955) studied withsheep the effect of the level of herbages intake on digestibility. They found that dry matter digestibility decreased slightly when intake was increased from 80-100 units. In a study (Reid, 1956) of the relationship between feed input and milk output by dairy cows, it appeared that with mixed rations and grain containing roughages the faecal loss of energy was minimal at a level of intake approximately equivalent to maintenance and these losses increase markedly with increasing intake. The digestibility of roughage feeds not containing grain does not decline as the level of intake increases. Working with sheep (Blaxter et al., 1956) has shown that the physical nature of food can effect its digestibility. When long grass was fed at

600 gms and 1500 gms per day the apparent digestibilities were 80·3% and 79·4% respectively. When they were in the form of medium ground and cubes the digestibilities were 76·9% and 69·9% respectively. When they were finely ground and cubed the digestibilities were 75·9% and 65·9%.

Anderson et al. (1959) carried out a series of 33 digestibility trials to investigate the influence of the level of intake of forages and mixed rations on the digestibility. They reported that the digestibilities of fresh green forages and of hay by lambs and steers respectively were not affected by the level of intake. The digestibilities of mixed rations showed varying results. Some showed a marked decrease while others did not appear to be affected by increasing the level of feeding. The work on non-ruminant animals (Forbes et al., 1946 with rats, and Zivkovic and Bowland, 1963, and Jenkinson et al., 1967 with pigs) has shown that the level of feed intake has no effect on the percentage digestibility of energy of food.

Garrett et al. (1959) working with sheep added three levels of concentrates to a maintenance ration of pelleted hay to provide 15, 30 and 45% of the total air dry feed, found no detectable decline in the digestibility at the higher levels of intake. Armstrong (1964) reported that as the levels of grass intake increased the faecal loss was also increased. The changes in the apparent digestibility of energy on increasing levels of feeding have been measured by Blaxter (1961). He derived a formula to estimate the depression in the apparent digestibility of energy by increasing

food intake from maintenance to twice maintenance (ΔA). This equation was as follows:- $\Delta A = 11{\cdot}9 - 0{\cdot}119\ Am$ where Am is the apparent digestibility of energy determined at maintenance. Similar equation has been derived by Armstrong (1964)

$\Delta A = 10{\cdot}1 - 0{\cdot}111\ Am.$

In general, the effect of the level of intake on the digestibility seems to be associated with the concentration of the diet, low-concentrate rations are less effected by the level of feeding than the high concentrate ration. The effect of the level of feeding in mixed diets has not been fully confirmed.

CARCASS EVALUATION PROCEDURES

The relationships of parts, tissues and carcass measurements to the composition of the whole carcass

Numerous experiments have shown close relationships between the physical or chemical composition of some parts of the carcass and the composition of the whole carcass. Many attempts have been made to use these relationships in carcass evaluation. The early work on sheep by Palsson (1939) showed that the leg and loin reflect carcass composition most accurately and particularly the bone content of the carcass. He considered that these two parts typified the whole carcass in rate of development since the leg is an early developing region while the loin is late developing. Hankins (1947) obtained a high degree of correlation between the composition of the nine-rib cut (4th-12th rib) and the composition of the carcass. Barton and Kirton (1958) reported a close relationship between loin and fat content of the carcass. They also showed that muscle and bone content of the carcass was more related to the leg. More recent work (Field et al., 1962, 1963) found that the fat, lean and bone in the rib joint were highly correlated to that in the whole carcass. Khandekar et al. (1965a) reported that the weight of fat, muscle and bone in the half carcass can be predicted with a high degree of accuracy from the weight of the respective tissues either in the leg or in the loin joints. Timon and Bichard (1965a) obtained high correlation coefficients between fat, lean and bone in either the loin or best-neck (7-12 rib joint) and in the carcass, they

found that the leg and the shoulder joints had the highest correlation with the bone content of the carcass. When two joints were combined they gave better relationship than did either joint considered separately. This last conclusion is also in agreement with Palsson (1939) and Barton and Kirton (1960). Similar results have been reported by (Hopper, 1944; Hankins and Howe, 1946; Cole et al., 1960b; Kennick and England, 1960; and Taylor et al., 1961) on cattle, and by (Hankins and Ellis, 1934; McMeekan, 1941 and Adam and Smith, 1966) on pigs.

The physiological relationship of certain muscles to total carcass muscling has been investigated by many workers. Ament et al. (1962) and Orme et al. (1962), working with lambs, reported a close relationship between some individual muscle weight and the total lean weight in the carcass. Orme et al. (1960) and Butterfield (1962, 1963a, 1965), working with beef carcasses, found that individual muscles and muscle groups were closely related to the total muscle weight in the carcass and suggested the use of muscle weight in the estimation of total muscle. Similar results have been obtained by (McMeekan, 1941 and Topel et al., 1965) on pigs. However, Christian and Orme (1962) working with swine reported that none of the individual muscles studied were closely related with per cent of lean cuts. The reports on the relationship between area of eye muscle and muscle development have shown conflicting results. Palsson (1939), Branaman (1940), George (1940), McMeekan (1941), Fredeen et al., (1955), Zobrisky et al. (1959), Balley et al. (1961), Ament et al. (1962) and Field et al. (1962)

reported strong relationship between area of the cut surface of longissimus dorsi muscle and the weight of lean in the carcass. On the contrary, several workers have found opposing results. Walker and McMeekan (1944), Cole et al. (1960a,b), Magee et al. (1960) and Goll et al. (1961) pointed out that only a small per cent of the variation in total lean is associated with the loin eye area measurements.

The relationship between fat thickness measurements and body composition has been investigated by Ament et al. (1962) on lambs. They found that fat-thickness at the 12th rib was not closely associated with total or per cent fat, within groups slaughtered at different weights and ages, while average values were closely related to average fat content for each group. Engelman et al. (1950), Henning and Evans (1963) and Buck et al. (1962) reported that back-fat thickness was closely related to carcass muscling of pigs. However Bowman et al. (1962) and Topel et al. (1965) found opposing results. They attributed these discrepancies to the way in which the values for lean cuts was expressed, whether it is a percentage or absolute weights.

Studies on the chemical composition of the carcass (Hopper, 1944 and Hankins and Howe, 1946 with beef carcasses) demonstrated that the relationship between some chemical and dissectible components of the carcass is statistically close. Kirton and Barton (1962) and Ulyatt and Barton (1963) have drawn a similar conclusion with sheep.

In spite of the strong relationships between the composition of some parts and the same composition in the whole carcass it has been seen that these relationships can be affected by different treatments and the validity of using such criteria as measures of response to some treatments in in question. McMeekan (1940b,c), Pomeroy (1941), Wallace (1948) and Palsson and Verges (1952a) demonstrated that nutritional treatments at any age from the late foetal stages to maturity not only effect growth in general but also effects the tissues differentially. Preston and Gee (1957) and Kirton and Barton (1958b) in a study of the effects of hexoestrol and thyroxine respectively, on the carcass composition in sheep have shown that there was a differential response evoked in the leg and the loin joints by hormone treatment. Harrington (1962) working with pigs carcasses found that different feeding regimes significantly affected various carcass relationships. Butterfield (1963b) working with steers, pointed out that the relationship of some individual muscles to total muscle can be altered by nutritional treatments. Timon and Bichard (1965a) working with sheep, found that year to year differences (sampling variance) may also effect carcass relationships.

The reliability of methods of carcass evaluation

It can be misleading to consider a particular treatment to be superior only because the animals had heavier live weight responses. It has been demonstrated that live weight is an inadequate measure of response to certain feeding regimes. Meyer et al. (1960) have shown that variation in rumen "fill" at the final

weighing of groups of cattle fed for 90 days, found to account for up to 0·3 lb per head of the daily gain. Macfarlane et al. (1956) reported that sheep deprived of water in a tropical environment may lose 23% of their body weight and 45% of their extra-cellular fluid volume. Since water has no energy value, body weight may be misleading when estimating body energy reserves.

An accurate assessment of the body and/or carcass composition of the experimental animals is essential. Apart from the difficult and expensive method of complete carcass dissection and analysis, there is no generally acceptable method of carcass evaluation. This absence of an agreed criterion has led to the use of a variety of methods and made it very difficult to compare the results of different workers. The use of the external body measurements either on the live animal or on the carcass found to be insensitive indices of carcass composition (Bratzler, 1958, and Butterfield, 1963b). The usefulness of the natural potassium (K^{40}) and sodium for predicting the composition of live animals and their carcasses has been reviewed and discussed by Kirton (1963) indicating that this method is not sufficiently accurate for use in meat production and nutritional experiments. The variation in K^{40} resulting from the differences in gut "fill" (Blater and Rook, 1956; Hyden, 1961 and Kirton et al. (1963) limit the use of this method. Lawrie and Pomeroy (1963) have shown that individual muscles differ in their sodium and potassium contents. Investigations on the usefulness of the specific gravity determinations in predicting lamb carcass composition have shown extremely variable results (Barton and Kirton, 1956; Kirton and Barton, 1958a; Garrett et al., 1959;

Kirton and Barton, 1962; Field et al., 1963; Timon and Bichard, 1965b,c and Khandekar et al., 1965b) suggest that little confidence could be placed in specific gravity determinations as a reflection of real individual differences or small treatment differences. Numerous workers have reported close relationships between the composition of some joints and the same composition in the whole carcass suggesting the possibility of using such criteria for estimating carcass composition. However the general application of such criteria is limited since these relationships were shown to be altered by different treatments. Timon and Bichard (1965c) stated that the increased experimental variation resulting from the use of a prediction equation can be compensated for by an increase in treatment group size. However the invalidity of this concept has been mathematically proved by Conniffe and Moran (1968) 'unpublished paper'. Other methods have been suggested for determining carcass composition such as the relationship between creatinine excretion and muscle content of the carcass, the radiographical (X-ray) techniques and tissue probes to evaluate fatness in live animals. In general reports on these techniques suggest that they have considerable limitations either in terms of accuracy and/or practical application.

The well established fact of the differential stimulations of body components to certain feeding regimes emphasises the necessity of studying each component separately. Hammond (1932), Palsson (1939), Hankins (1947), Garrett et al. (1959), Kirton et al. (1962) and Timon (1963) have shown that the most accurate information on

the composition of lamb carcasses may be obtained by either complete physical dissection and/or chemical analysis. This technique is naturally somewhat tedious and expensive. However these disadvantages can be partially overcome by using one side of the carcass to evaluate the whole carcass.

The accuracy of carcass appraisals based on one side

Time and expense involved in obtaining reliable data are the most limiting factors in meat production studies. If reliable data can be obtained from a single side of the carcass, a real saving in labour and commercial value of the remaining side would result. Butler et al. (1956), Harrington and Pomeroy (1959) and Brungardt and Bray (1963) reported significant differences in some carcass measurements between the left and right side in beef carcasses and attributed these differences to the cutting technique. Lasley and Kline (1957) working with swine carcasses showed that differences between the weight of the sides and between side differences in weights of the cuts could be attributed to errors in splitting and cutting the carcasses. Carpenter et al.,(1961) found that the fat content of three anatomical locations of the right and left longissimus in pork carcasses to be similar. Breidenstein et al. (1964) working with swine found differences between some muscles from left and right sides of about 8% with no indication of bilateral asymmetry. Kirton et al. (1962) working with lambs reported that the weight of two sides of 20 frozen carcasses were similar while right sides had heavier forequarters

and lighter loins than the opposite sides. They attributed the differences in forequarter weight between sides to the way in which the brisket (sternum) was split. The differences between left and right sides of lamb carcasses were reported to be of a random nature (Carroll and O'Carroll, 1964). They also showed that only the bone tissue of the carcass can be predicted with less efficiency from one side. This last conclusion is in agreement with the results of Field et al. (1963) on lambs who found that the low correlation between bone in the carcass and bone in the loin was due to inaccuracies in splitting the carcass. Concerning the chemical composition, Kirton et al. (1962) reported that the mean percentage composition of the two sides of lamb carcasses were similar (except the loin in the left sides had significantly more protein percentage than the loin in the right sides) when the leg, loin, 9, 10, 11 rib and fore joints were analysed for water, fat and protein. Ulyatt and Barton (1963) working with ewe carcasses found no detectable relationship between ash weight in the loin from one side and dissectible bone in the loin from the other. Martin and Doornenbal (1967) working with swine carcasses showed that half-carcass analysis were satisfactory for chemical analysis per cent except for ash particularly in the ham. These differences in the chemical composition of loin or ham may be a reflection of the variation in bone content of these joints due to splitting errors.

In general most of the authors agree that the differences in composition between the two sides of the carcass are mainly due to technical inaccuracies and carcasses could be evaluated from one side with a high degree of reliability when the same side is always used (Lasley and Kline, 1957) and split carefully.

The limitation of part carcass analysis

Regardless of the accuracy with which a part of a carcass can be used to predict the composition of the whole carcass the information concerning the composition of the carcass is of limited value in the commercial assessment of the carcass. Separable fatty, muscle and bone tissue gives more precise information than chemical fat, protein and ash as the chemical fat of the fatty tissue is confounded with that of the muscle tissue. The same applies to the protein value.

However, for commercial evaluation the distribution of fatty and muscle tissue over the carcass into the high priced regions and in such a way as to enhance the desirability of the edible meat is required. For this information there is at present no known satisfactory method of estimation.



MATERIALS AND METHODS

Animals

The experiments were conducted in two consecutive years. The protein experiment (Experiment I) was started in December 1965 and finished in March 1966, while the energy experiment (Experiment II) started in December 1966 and finished in April 1967.

In both experiments animals from the same source were used. Wether lambs were taken shortly after weaning from the Edinburgh School of Agriculture's Castlelaw flock of Blackface sheep. The flock is run on traditional lines and is a mountain breed used for utilising the natural herbage of upland areas in Scotland. The flock records show a ewe liveweight at first mating (18 months of age) of 100 lb which increases to 120-130 lb at four years of age.

Of the wether lambs at weaning in September (16-20 weeks) about 30% can be sold for immediate slaughter or after a short fattening period while the remainder require a further period of both growth and fattening. It is this class of animal which has been used in this study. Because the Scottish Blackface breed is the most numerous in Scotland, large numbers of lambs of this type are available each year. Other mountain breeds produce similar type of lambs which require to be removed from the hill for their final growth and fattening.

EXPERIMENTAL PROCEDURE

The technique used for the assessment of the response of the animals to a particular feeding regime was to estimate the composition of the animals at the start of the experiment by slaughtering a representative group of lambs at this point, and also the slaughter procedure and carcass analysis was common to all the animals used in both experiments.

Slaughter procedure

The slaughter procedure was that evolved by Jackson, at the Edinburgh School of Agriculture, which was used to study environmental influences on growth and development in lambs. The procedure is more elaborate than the trials required but the additional data can be used for further studies:

Food was withheld from the animals 15 hours before slaughter in an effort to reduce variation in rumen contents.

Water was permitted.

The animals were weighed at the end of this period which was about two hours before slaughter. All animals on the trial had the same treatment to this point.

The animals for slaughter were taken in a van to a slaughterhouse five miles away. They were rested for one hour before slaughter in a special block.

The lamb was (i) stunned by cap and bolt pistol,

(ii) bled by cutting the throat - the blood caught, sampled and weighed.

(iii) The pelt (fleece + skin) was removed and weighed.

(iv) The feet were removed and weighed (fore-feet removed by cutting between the proximal edge of the metacarpus and the distal edge of the carpal bones, hind feet between the proximal edge of the metatarsal bone and the distal edge of the tarsal bones).

(v) The digestive tract (from the oesophagus to the anus) was removed complete with contents. No attempt was made to sub-divide the tract although this is possible. The total tract was weighed, caul fat, mesenteric fat and glandular material was removed and weighed, the gut emptied and weighed and the gut 'fill' weight obtained by subtraction.

(vi) The internal body organs (pluck) consisting of the trachea, lungs, heart, liver, spleen, thyroid, diaphragm and adrenals were weighed together to give a total pluck weight.

(vii) The head was removed and weighed. The removal of the head was by disarticulating at the atlanto occipital joint.

(viii) The warm carcass was weighed.

(ix) The carcass was left for twenty-four hours to chill in

a commercial cooling plant. On removal it was weighed.

(x) The carcass was split medially down the centre of the vertebral column. The left side of the animal was removed for carcass analysis.

Carcass Analysis

1. The half carcass was hung in a refrigerator at a temperature fluctuating between 0°C and 4°C.

2. The carcass was dissected in a cool damp atmosphere.

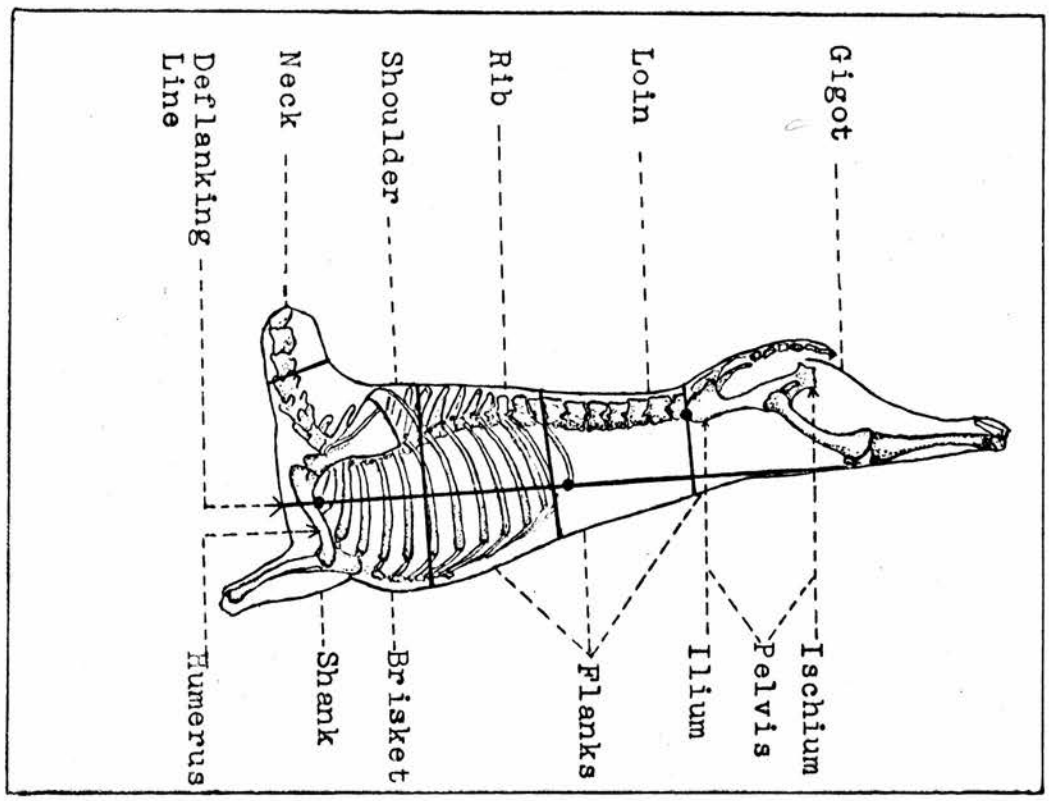
3. The carcass was first cut into four major retail cuts and seven secondary cuts as indicated in Figure A by using anatomical check points approximating to the commercial cutting procedure of the Edinburgh district.

Prime		Secondary
Shoulder	-	Neck
	-	Brisket
	-	Shank
Rib	-	Rib flank
Loin	-	Loin flank
Gigot	-	Gigot flank
		Kidney, perirenal fat and pelvic fat.

Jointing procedure

1. The kidney, kidney fat and pelvic fat were removed first. The sublumbar, perirenal and pelvic fat were removed by cleaning the surface of the psoas muscles and the sacrosciatic ligament.

Fig. A. The jointing procedure and the skeletal check points



Fat protruding from behind the M. transversus abdominis was left with the loin joint.

The kidney was separated from the perirenal fat, ureter and blood vessels by a cut at the renal hilus.

2. The gigot. This joint was removed by cutting at right angles to the vertebral column with the knife skirting the lateral projection of the ilium - the tuber coxae. The cut separates the 5th and 6th lumbar vertebrae.

(a) The small piece of flank remaining on this joint was removed. It consists mainly of the posterior part of the M. rectus abdominis and is removed by cutting through the lateral edge of this muscles sheath close to the ventral edge of the M. obliquus internus abdominis and continuing back to trim the cod fat overlying the M. gracilis back to a point level with the anterior edge of the symphysis pubis.

3. The dividing line of the primary and secondary cuts. Before removing any more cuts a line was marked to indicate the point of removal of the flank, breast and shank cuts. It is referred to as the deflanking line.

The anterior point was taken by seeking internally the anterior point of the ventral end of the first rib at the costo chondral junction and the posterior point by seeking the lower end of the 13th rib where it joins the costal arch. These two points are joined by a straight line which is projected back over the loin region. The ventral areas were removed after the shoulder, loin and rib cuts had been separated.

4. The shoulder. This joint was removed by cutting between the 5th and 6th ribs, keeping the knife skirting the 6th rib and projecting dorsally to the vertebral column between thoracic vertebrae 5 and 6 and sawing through the spinous process of vertebra 5 and then cutting ventrally through the sternum.

The shank and brisket (or breast) were removed by sawing along the previously marked deflanking line.

The brisket is separated from the shank by cutting through the axilla leaving the major part of the Mm. pectoralis attached to the brisket.

The neck was removed from the shoulder by sawing at right angles through the vertebral column between the 3rd and 4th cervical vertebrae, keeping the saw at right angles to the line of the vertebral column at that point.

5. The loin. This joint was separated from the remaining rib section by cutting through between the 12th and 13th ribs (the knife crowding the 12th rib) the cut projected dorsally through the vertebral column. Because of the angle of the rib the knife must travel slightly forward. The cut was projected ventrally through the flank.

The flank was removed by cutting across the previously marked deflanking line.

6. The rib. This joint was the remaining section 6 - 12th ribs.

The flank was removed by sawing across the ribs along the previously marked deflanking line.

Carcass Measurements

A cross section of M. longissimus dorsi was exposed at the 12th rib and the following measurements taken:-

(a) The area of the cross section by tracing round the area and estimating the area by polar planimeter method.

(b) The longest axis of the cross section was measured by ruler. (Width of M. longissimus dorsi).

(c) The thickness of fat cover over the M. longissimus dorsi at the 12th rib was taken as the mean of three measures taken at points perpendicular to the longest axis of the cross section at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the way along it.

(d) The visible fat deposits in the cross section of the M. longissimus dorsi at the 12th rib were counted and classified into those larger than 2 square millimeters and those less than 2 square millimeters.

Physical Separation

Each primary and secondary joint was separated into fatty, muscle and bone tissue and weighed separately. Tendon and cartilage were added to bone tissue.

Individual Muscle Dissection

Each joint was separated in such a way as to remove certain individual muscles which were weighed separately.

The following muscles were separated from the various joints:-

Joint	Muscle or part of:
Gigot	M. obliquus internus abdominis (part).
	M. gastrocnemius.
	M. semitendinosus.

Joint	Muscle or part of:
Gigot (contd.)	M. semimembranosus.
	M. quadriceps femoris.
	M. gluteus medius
	M. extensor digitorum longus.
Loin	M. obliquus internus abdominis (part).
	M. transversus abdominis (part).
	M. longissimus dorsi (part).
	M. psoas major (part).
Rib	M. longissimus dorsi (part)
	M. transversus abdominis (part)
	Mm. pectoralis profundus et superficialis (part).
Shoulder	M. biceps brachii (part)
	M. brachialis (part).
	M. supraspinatus.
	M. infraspinatus.
	Mm. pectoralis profundus et superficialis (part).
Shank	M. biceps brachii (part)
	M. brachialis (part).
	M. extensor carpi radialis
Brisket	Mm. pectoralis profundus et superficialis (part).

The M. obliquus internus abdominis and M. transversus abdominis were weighed and recorded together.

The individual muscle dissection technique is described in Appendix I.

After the individual muscles had been removed and weighed the rest of the tissues were separated into fatty, muscle and bone tissues and treated as previously reported.

Chemical Analysis

The chemical analysis was made for moisture, nitrogen and ether extract. The methods used are described in Appendix II. Analysis was made on:-

(i) a central core of the M. longissimus dorsi from the 10-12th rib sections.

(ii) a strip of subcutaneous fat taken between the 10th and 12th rib sections.

(iii) a sample of lean from the minced and mixed dissected lean of:-

(a) gigot

(b) shoulder

(c) loin + rib

(d) the secondary cuts.

(iv) a sample of fat from the minced and mixed separable fat from:-

(a) gigot

(b) shoulder

(c) loin + rib

(d) the secondary cuts

(v) the minced and mixed internal body organs constituting the pluck, digestive tract and caul fat.

The reliability of the methods of chemical analysis

Samples from each of the primary and the secondary cuts of the fatty and muscle tissue and also a sample from the gut was taken for determination of dry matter, ether extract and crude protein in order to test the reliability of the method of sampling and chemical analysis. Ten determinations were run on each of the samples and the results are presented in Appendix II while Table 1 shows the means, standard deviation and the coefficient of variation of the percentage composition of the samples as determined by repeating the analysis.

Table 1

The means, standard deviation (S.D.) and the coefficient of variations (C.V.) of the percentages of the chemical composition of carcass tissues of Blackface wether lambs.

Samples	DM %			EE %			CP %		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Fatty tissue in primary cuts	77·02	0·99	1·28	69·40	0·68	0·98	6·53	0·22	3·31
Fatty tissue in secondary cuts	80·93	0·73	0·90	73·06	1·05	1·45	6·73	0·20	2·93
Muscle tissue in primary cuts	28·75	0·70	2·43	7·54	0·36	4·73	17·79	0·16	0·90
Muscle tissue in secondary cuts	31·47	0·51	1·62	10·62	0·56	5·31	17·87	0·39	2·16
Gut	35·38	0·25	0·70	20·89	0·46	2·22	10·54	0·06	0·54

The results show that the methods employed give repeatable results with the extremely heterogeneous samples.

Energy determinations

The caloric value of the muscle and fatty tissues of the joints and carcass was determined from the chemical components of the animals concerned. The remainder of the body components were determined directly by calorimeter.

Calorimeter determinations

These were made by the bomb calorimeter method for

(a) the ether extract of the fatty and muscle tissues of the various joints of the carcass and the combined offal component,

(b) the fat free residue of the fatty and muscle tissues of the various joints of the carcass and the combined offal component as derived from the chemical analysis.

(c) the blood. A sample of 50 ml was taken on bleeding at slaughter. To prevent clotting 300 mg of sodium citrate was added (Bell et al., 1963).

(d) the pelt. A sample of approximately 100 square inches of the skin + fleece from the right shoulder was removed. The sample was cut into small pieces and dried at 100°C for twenty-four hours and milled through a 2 mm sieve and stored in a screw-topped bottle before taking a carefully mixed sample for energy determination.

(e) the bone of the carcass. A large machine was used for grinding and this caused difficulty in obtaining satisfactory grinding of individual samples. It was decided therefore to take samples from each group of lambs rather than individual animals. Samples were dried at 90°C for twenty-four hours, ground in a mortar and stored in a screw-topped bottle awaiting determination.

(f) the head of the animal. As with the bone of the carcass the heads from the animals from each feeding group were ground together to give a composite sample. The head included horns and tongue. The sample was treated similarly to bone.

(g) the feet. The four feet of the animals of each feeding group were milled together to give a composite sample which was treated similarly to that for bone. The gross energy value was taken as the average of several determinations for each component.

Estimation of body composition of pretest animals

The body composition of the animals at the start of the feeding trial was estimated from the observations on the initial slaughter group. Body components were regressed with liveweight at slaughter. Since all the animals were weighed at the same time the body components of the treatment groups of animals could be predicted so long as there was a significant relationship. In cases where the relationship between live weight and body component was not significant at the 5 per cent level of probability then the mean weight of the component in the initial slaughter group was used as representing the initial weight of that component in the experimental animals.

The gain in weight of body components

The gain in weight of body components was calculated as the difference between the actual weight of the component at the end of the trial and the estimated weight of the component at the start of the trial.

The percentage prime cuts

The prime cuts were taken as a percentage of cold carcass weight. The calculation was

$$100 \left(\frac{\text{(wt. of gigot (prime) + wt. of shoulder (prime) + wt. of loin (prime) + wt. of rib (prime)}}{\text{cold carcass wt.}} \right)$$

The standard empty body weight

The standard empty body weight referred to as 'S.E.B.' was the sum of the weight of warm carcass, head, blood, feet, pluck, empty digestive tract and caul fat. To equate with preslaughter liveweight the addition of pelt weight, gut fill and a discrepance figure is required.

Calculation of metabolizable energy of the rations

The metabolizable energy content of the rations fed were estimated from the equation.

$$ME = \text{gross energy} - \left(\text{(Heat of combustion of faeces} + \text{Heat of combustion of urine} + \text{Heat of combustion of fermentation gases)} \right)$$

The gross energy of the food, faeces and urine were determined by bomb calorimeter. The heat of combustion of methane was estimated by the formula given by Blaxter and Clapperton (1965).

CH_4 (Kcals/100 Kcals) = 1·30 + 0·112 D - L (0·050D - 2·37)

where D is the apparent digestibility of the diet at maintenance level of feeding

L is the feeding level as a multiple of the maintenance level.

$$\text{Feeding level (L)} = \frac{\text{amount of ME consumed}}{\text{amount of ME required when energy retention is zero}}$$

Amount of ME consumed was calculated by multiplying digested energy by 0·82 A.R.C. 1965, p.233).

The ME requirements for maintenance were computed from the calculating tables of the fasting metabolism (A.R.C. 1965, p.254).

The predictive values of D (apparent digestibility at maintenance) were estimated from the regression of apparent digestibility on feeding level, (Blaxter, 1962).

Statistical methods

The experiment was designed so that the gain in weight in body components could be regressed with the graduated levels of daily intake of digestible crude protein or metabolisable energy to demonstrate the response of the animals to the treatments. The coefficients of regression were tested for differences from zero (Snedecor, 1956). Differences between groups, accounting for initial liveweight, were tested by analysis of variance, the form of which was suggested by Finney D.J. (personal communication) and is shown in Appendix II.

Regression was also used to predict the body components of the treatment groups from the relationship of the body components with liveweight derived from the representative initial slaughter group. Where no significant relationship existed the mean weight of the component of the group was used.

The standard error of means was calculated by the procedure given by Snedecor (1956).

Units

In order to facilitate the use of regression in interpreting

the data the treatments were converted to units as follows:-

1 unit DCP = 61 grams.

1 unit ME = 2041 Kcal.

1 unit time = 91 days.

E X P E R I M E N T I

EXPERIMENT I

THE EFFECT OF LEVEL OF DIETARY PROTEIN ON BODY AND CARCASS COMPOSITION OF BLACKFACE WETHER LAMBS

The experiment was designed to establish whether an increase in the daily intake of dietary protein while keeping the energy constant, would produce observable qualitative and quantitative changes in the developing body and carcass components.

PROCEDURE

Animals

Eighteen Blackface wether lambs were taken from a group which had been running on pasture for 8 weeks after weaning in September. The lambs were the medium to small lambs in the flock which required a period of further fattening. The heaviest lamb and the lightest lamb of this group were added to the initial slaughter group. The remaining 16 lambs were grouped in fours by weight. The lambs from each weight group were allocated at random to one of the following treatment groups:

I = Initial slaughter group - slaughtered at the start of the experiment.

L = Group fed low level of protein in constant energy diet (61 g DCP)

M = Group fed medium level of protein in constant energy diet. (107 g DCP)

H = Group fed high level of protein in constant energy diet (144 g DCP)

Table 2

The fasted liveweight (kg) of the Blackface wether lambs at the start of the experiment allocated to the treatment groups

	Initial Slaughter	Protein Level Low	Medium	High
	25·42	-	-	-
	26·33	25·88	25·42	25·42
	27·69	27·24	26·33	28·15
	28·15	29·06	29·51	27·69
	29·51	30·42	30·87	33·69
	33·60	-	-	-
Mean	28·45	28·15	28·03	28·60

Table 2 shows the number and liveweight of the animals in each group. The 6 animals in the initial slaughter group were used to assess the composition of the animals in the feeding groups at the start of the trial. The initial slaughter group were treated as previously described.

The remaining 12 animals were randomly allocated to individual feeding pens, bedded on straw litter and given water troughs, feeding boxes and hay nets. The animals were fed twice daily. At 9 a.m. the total hay and half the concentrates

was given. At 4 p.m. the remainder of the concentrates was fed.

Feeding trial

The feeding trial commenced on 2 December, the lambs being introduced to their diets slowly over the first 14 days. The trial lasted 104 days.

Three foodstuffs only were used, hay (long), bruised barley and soyabean meal with added minerals and vitamins. The foodstuffs fed represented three practical approaches to the fattening of these lambs. To a basal allowance of hay (1½ lb) was added 1 lb. of bruised barley for the low protein diet, ¾ lb of barley and ¼ lb of soyabean meal for the medium protein diet and ½ lb of bruised barley and ½ lb of soyabean meal for the high protein diet.

Table 3 shows the composition of the three rations.

Table 3

The weight (g) of the daily intake of ration components of the three groups of Blackface lambs fed isocaloric diets of different DCP content

Ingredient	Protein level					
	Low		Medium		High	
	Wt.	% DM	Wt.	% DM	Wt.	% DM
Hay	681	60·1	681	59·6	681	59·3
Bruised barley	454	38·6	341	28·8	227	19·1
Soyabean meal	-	0	114	10·3	227	20·3
Mineral mixture*	12·5	1·32	12·5	1·30	12·5	1·30

* The daily intake of mineral mixture was the same for each group and was as follows:

Component	Daily amount
Vit. A.	2,000 I·U
Vit. D.	500 I·U
NaCl.	2 grms
K.I.	0·2 m.grms
CoSO4	0·72 m.grms
Limestone flour	10 grms

Feed residues were collected separately for each animal and reintroduced to the same animal as appetite improved. All lambs consumed the total amount of feed that they had been allocated.

Table 4 gives the daily intake of Digestible Crude Protein (g) and Metabolizable Energy (Kcals) for the three groups of lambs.

Table 4

The daily intake of Digestible Crude Protein (g) and Metabolizable Energy (Kcals) for the three groups of Blackface wether lambs

Level of protein	DCP grm	ME Kcals
Low	61	2,629
Medium	107	2,671
High	144	2,660

It was fortunate that in selecting these rations the metabolizable energy content did not vary as the soyabean meal was substituted for the bruised barley. The digestible crude protein and metabolizable energy values were determined by digestibility trials.

Digestibility trials

Nine Blackface wether lambs of similar size and age to the experimental animals were used to determine the digestibility of the three rations. The animals were housed as a group for a period of two weeks before being placed in the individual digestibility crates. During this period they were fed a diet of 2 lb of hay. On being placed in the metabolism crates 1 lb of concentrate mixture (¾lb bruised barley and ¼lb soya-bean meal) was introduced over the first week. At the end of this week the diets were changed to the actual experimental diets for a three day preliminary period before the digestibility trial commenced.

The experimental diets were fed for a ten day experimental period.

The initial weight of the animals on the trial was the mean of three consecutive daily weighing before the trial commenced. The weights are shown in Table 5.

Table 5

The initial liveweight (kg) of lambs used for the determination of the digestibility of the three experimental rations

Treatment		
Low	Medium	High
31·78	29·96	25·88
30·42	30·42	28·15
32·69	29·06	28·51

The equipment used for the feeding and collection of urine and faeces was that described by McDonald (1958). Faeces and urine were collected for a ten day feeding period. During the collection period the faeces were stored in a tin in the deep freeze awaiting sampling and analysis. The urine was collected by means of an attached funnel and tube to a collecting bottle. The daily collection of urine was transferred to a large container. The urine was acidified daily by 25 ml of sulphuric acid 25%.

Following the collection period the faeces were mixed and quartered into a laboratory sample. Representative samples were taken for the dry matter determinations and these dried samples were ground in a mill (1 mm sieve) and stored in screw topped glass bottles awaiting chemical analysis. Samples of fresh material were taken for Kjeldahl nitrogen determination.

The urine container was well shaken and the volume of the urine was measured. Samples were taken for nitrogen determinations.

At the end of the feeding period the lambs were weighed. The food residues were weighed, dried and analysed.

The rations fed were those as given in Table 3 and the components were representative of the feeds used in the main feeding trial. The total food for the feeding trial was set aside at the start of the trial and the food for the digestibility trial was taken as a representative sample of it from different portions of the whole. Samples of hay, barley and soyabean meal were removed for dry matter determination and these dried samples were ground and stored for chemical analysis.

The feeding routine followed that of the main trial except that both the hay and concentrate part of the diet were given in two equal parts at 9 a.m. and 4 p.m. whereas in the main trial all the hay was fed at 9 a.m.

The mean values of the coefficients of digestibility of crude protein and energy and their standard errors are given for the three experimental diets in Table 6. The mean digestibilities of crude protein were higher at the higher levels of protein intake. The differences were highly significant ($p < 0{\cdot}01$) between diet L (low level of protein) and all other diets. The difference between diet M (medium level of protein) and diet H (high level of protein) did not reach significant levels at 5%. The mean digestibilities of energy were similar for all diets.

Table 6

The mean values and standard errors of the digestibilities of crude protein and energy for the three lambs on each of the experimental rations

Diets	Crude protein Digestibility %	Energy Digestibility %
L	69·23 ± 3·98	58·60 ± 2·39
M	75·49 ± 0·88	59·22 ± 0·47
H	79·84 ± 1·05	58·86 ± 1·55

The digestibility of crude protein (percentage) of the diets was closely related to the percentage of crude protein in the dry

matter. The correlation coefficient "r" between these two variables was +0·884. The regression equation which describes the relationship was found to be:

$$Y = 35{\cdot}52 + 2{\cdot}44X \text{ (S.E. of b } = \pm 0{\cdot}487)$$

where Y is the digestibility of crude protein and X is the percentage of crude protein in the dry matter of the food. This equation shows that as the percentage of crude protein in the dry matter increased the digestibility of the crude protein also increased. This result confirms the reports of many authors (Mitchell, 1942; McDonald and Purves, 1957; Topps, 1962; Milford and Minson, 1965 and Anderson and Lamb, 1967). There appeared to be no apparent relationship between the percentage of crude protein in the ration and the digestibility of energy.

The caloric value of extracted fat and fat free dry matter

The caloric value of the ether extract and of the fat free dry matter (ether extracted residues) was determined on samples taken from different joints. The results are presented in Table 7. The mean caloric values for fat and fat free dry matter were used to calculate the caloric value of the carcass and digestive tract from the chemical analysis.

Table 7

The caloric value (Kcal/g) of ether extract (EE) and of fat free dry matter (FFDM) of samples taken from various joints of Blackface wether lambs

Energy value of Fat (EE)	
Joint	Kcal/g
Gigot	9·44
"	9·22
Rib + Loin	9·36
" "	9·22
" "	9·29
Shoulder	9·41
"	9·36
Secondary cuts	9·42
" "	9·28
Gut	9·35
Mean	9·34
S.E. of mean	± 0·02

Energy value of (FFDM)	
Joint	Kcal/g
Rib + Loin	5·47
Gigot	5·42
Secondary cuts	5·45
Shoulder	5·40
M.l.d.*	5·45
Gut	5·30
Mean	5·42
S.E. of mean	± 0·03

* M. longissimus dorsi in the rib area.

The caloric values of the samples of ether extract and fat free dry matter from the various joints did not differ greatly from each other so that the mean value of all the samples was used in determining the caloric value of the different joints from their chemical analysis.

The mean value for ether extract (9·34 Kcal/g) is in close agreement with the value 9·354 Kcal/g given by Garrett et al. (1959) for sheep, and the value 9·367 Kcal/g given by Blaxter and Rook (1953) for cattle, but is less (1·68%) than the value 9·50 Kcal/g given by Armsby (1917) and by Milford (1961).

The caloric value of protein has been shown to be dependent upon the nitrogen content (Blaxter and Rook, 1953) and for comparative purposes the values given should be adjusted to a standard 16% nitrogen content of the protein. In dealing with fat free dry matter the protein value can also vary due to variation in ash content.

The mean caloric value of the fat free dry matter of the joints and gut of the Blackface lambs was 5·42 Kcal/g. The average percentage protein was 86·7 which is intermediate between the value 80·7% reported by Garrett et al. (1959) and 90% given by Bate-smith (1942).

Correcting the mean value of 5·42 Kcal/g for fat free dry matter to 90% protein value increases the caloric value to 6·23 Kcals/g. This is greater than the value of 5·70 Kcals/g reported by Armsby (1917) and the value 5·57 Kcals/g given by Garrett et al. (1959) - both with sheep. Blaxter and Rook (1953) reported a

lower value (5·322 Kcals/g) for purified protein. Milford (1961) estimated the caloric value of fat free organic matter as 5·58 Kcals/g. In view of these differences, which may be explained by analytical technique, greater accuracy could be expected from using the values as determined in the experiment (Table 7).

The estimation of the composition of the body and carcass of the treatment groups from the representative initial slaughter group

Because of the variation in liveweight of the lambs in each group those components which showed a strong relationship ($p < 0·05$) with liveweight (Table 8) were estimated by fitting the liveweight into the estimating equation derived from the initial slaughter group.

Table 8

The correlation coefficients "r", the regression equation and the standard error of the regression coefficient "b" of the significant relationships between liveweight and body components of the initial slaughter group

Components	Regression equation	S.E. of "b"	"r"
S.E.B.	Y = 1·97 + 0·562X	±0·091	+0·952
Gut "fill"	Y = 0·261X - 0·83	±0·092	+0·818
Warm carcass	Y = 0·16 + 0·384X	±0·111	+0·866
Muscle tissue	Y = 0·110X - 0·01	±0·034	+0·854
Gigot	Y = 0·47 + 0·047X	±0·011	+0·916
Shoulder	Y = 0·071X - 0·04	±0·019	+0·890
Muscle (gigot)	Y = 0·25 + 0·034X	±0·011	+0·825
Muscle (shoulder)	Y = 0·054X - 0·43	±0·013	+0·896
Brisket	Y = 0·014X - 0·17	±0·003	+0·880
Shank	Y = 0·013X - 0·07	±0·004	+0·849
M.quadriceps femoris	Y = 0·07 + 0·006X	±0·002	+0·852

X = liveweight (kg)

Those components not showing a significant relationship with liveweight were estimated by using the mean weight of that component derived from the initial slaughter group.

RESULTS
of
EXPERIMENT I

RESULTS

The effect of level of dietary digestible crude protein on liveweight

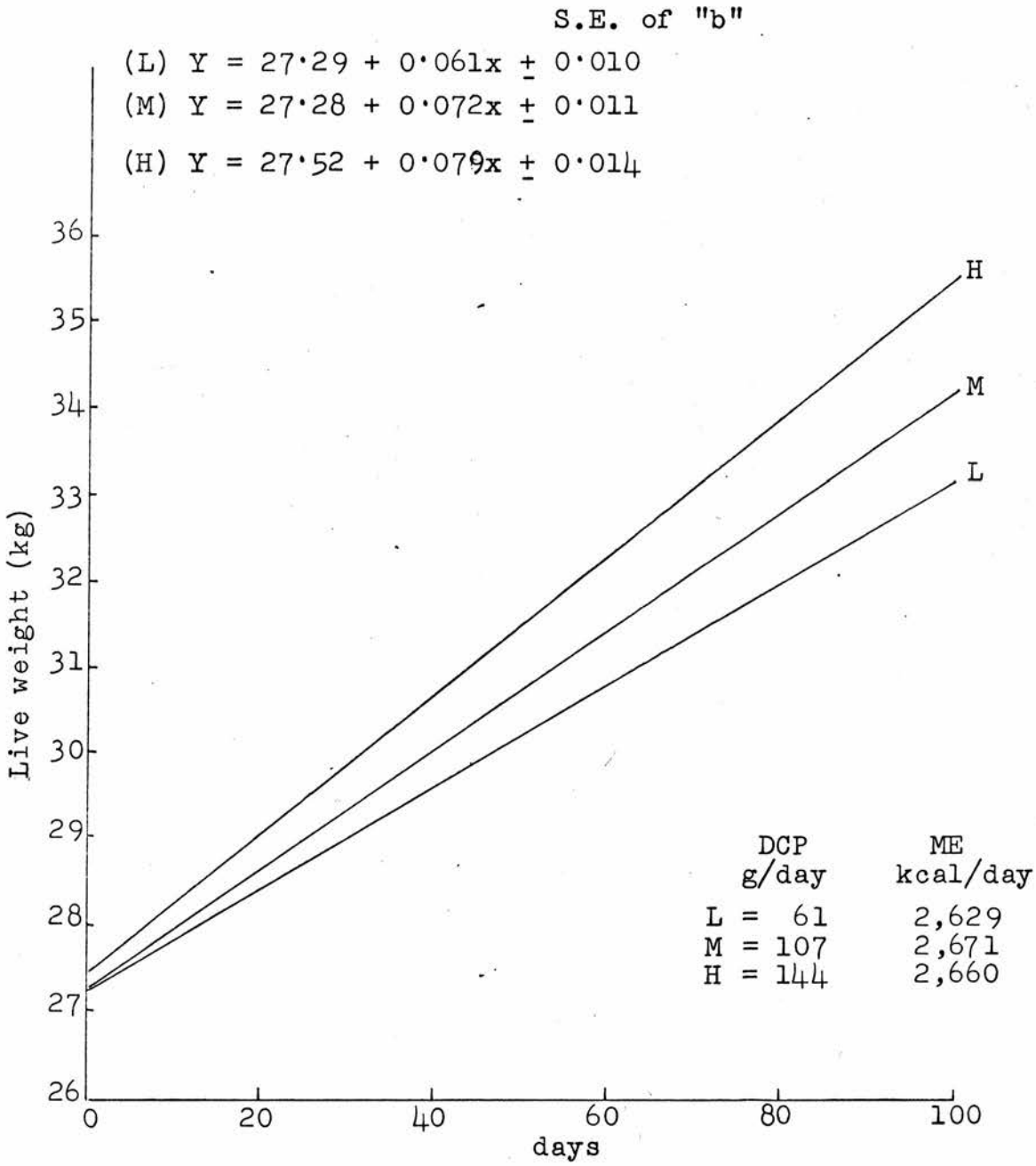
Substantial fluctuations can occur in the weight of animals over short periods thus increasing the variation in individual weights. To overcome this the regression of liveweight on time (number of days fed) was used to study the liveweight response of animals to the different feeding regimes. The linear regression fits the data well accounting for 92-94 per cent of the variation in liveweights for the three groups of lambs.

Figure 1 shows that there was an increase in liveweight (kg) with increase in daily level of DCP intake (g). Lambs on treatment H (144 g of DCP) tended to increase in liveweight faster than those on treatment L (61 g of DCP) with treatment M (107 g of DCP) intermediate. None of these differences were significant at the 5 per cent level of probability. The differences, although small, show that an increase by 1 kg liveweight over 104 days feeding might be expected from an increment of approximately 40 g DCP in daily intake.

The effect of level of dietary digestible crude protein on gain in weight of liveweight components

Liveweight, being a composite measure, can be split into a number of component parts. The first partition of liveweight was made into pelt, alimentary tract "fill" and the residue can be regarded as the standard empty body weight - hereafter being

Fig. 1. The linear relationship between live weight and number of days fed in B.F. wether lambs which had different levels of daily intake of DCP and similar levels of daily intake of ME



referred to as S.E.B. The pelt, containing skin and fleece together, was taken for convenience. As the skin was of little interest to this study, removing the pelt removed the variation due to length of fleece and avoided the necessity for close shaving. The experiment was so designed that the relationship between the body components and levels of daily intake of protein could be assessed by regression wherever practicable. Analysis of variance was also used. Any statement concerning statistical significance pertains to the 5 per cent or less level of probability. Due to variations in initial liveweight within groups, the animals were blocked into three groups by weight, light, medium and heavy.

In the graphical presentation the intact line refers to significant response, the broken line (—— · —— · ——) to non-significant, while the broken line (—— —— ——) indicates the possibility of a trend.

Figures 2A show the effect of various daily intake levels of DCP on the increase in liveweight when the daily intake of metabolizable energy was similar for each group of lambs. There was a tendency for the gain in liveweight to increase as the daily intake of DCP increased. Of the components of liveweight, the figures 2A and 2B show that as the daily intake of DCP increased the increase in gain of the S.E.B. weight was significantly ($p < 0{\cdot}05$) increased while the gain in pelt weight tended to increase and the alimentary tract "fill" tended to decrease but neither reached significance. The regression equations for these relationships are shown on the graphs. The

Fig. 2A. The effect of level of dietary DCP on gain in weight of live weight components of B.F. wether lambs

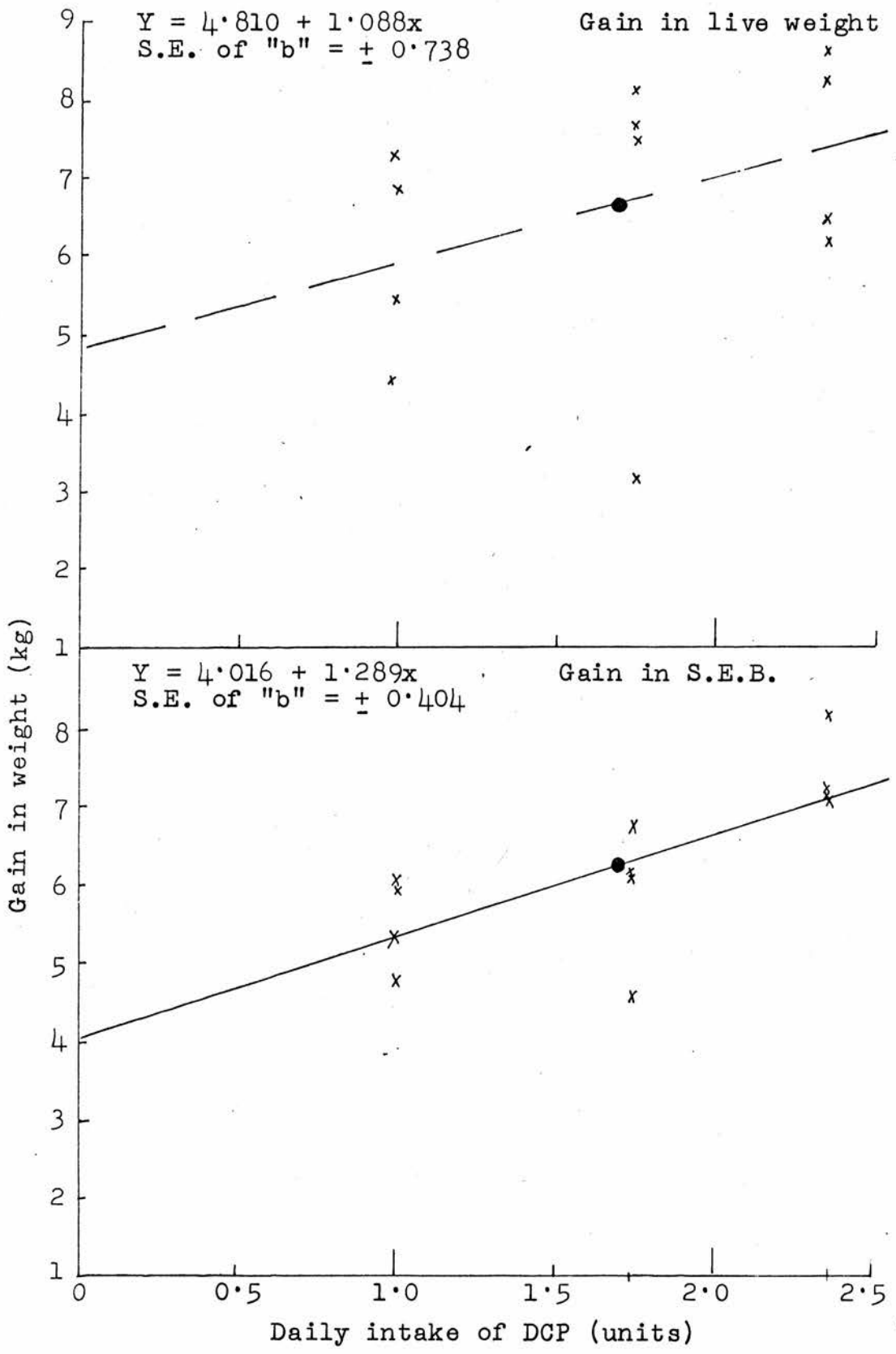
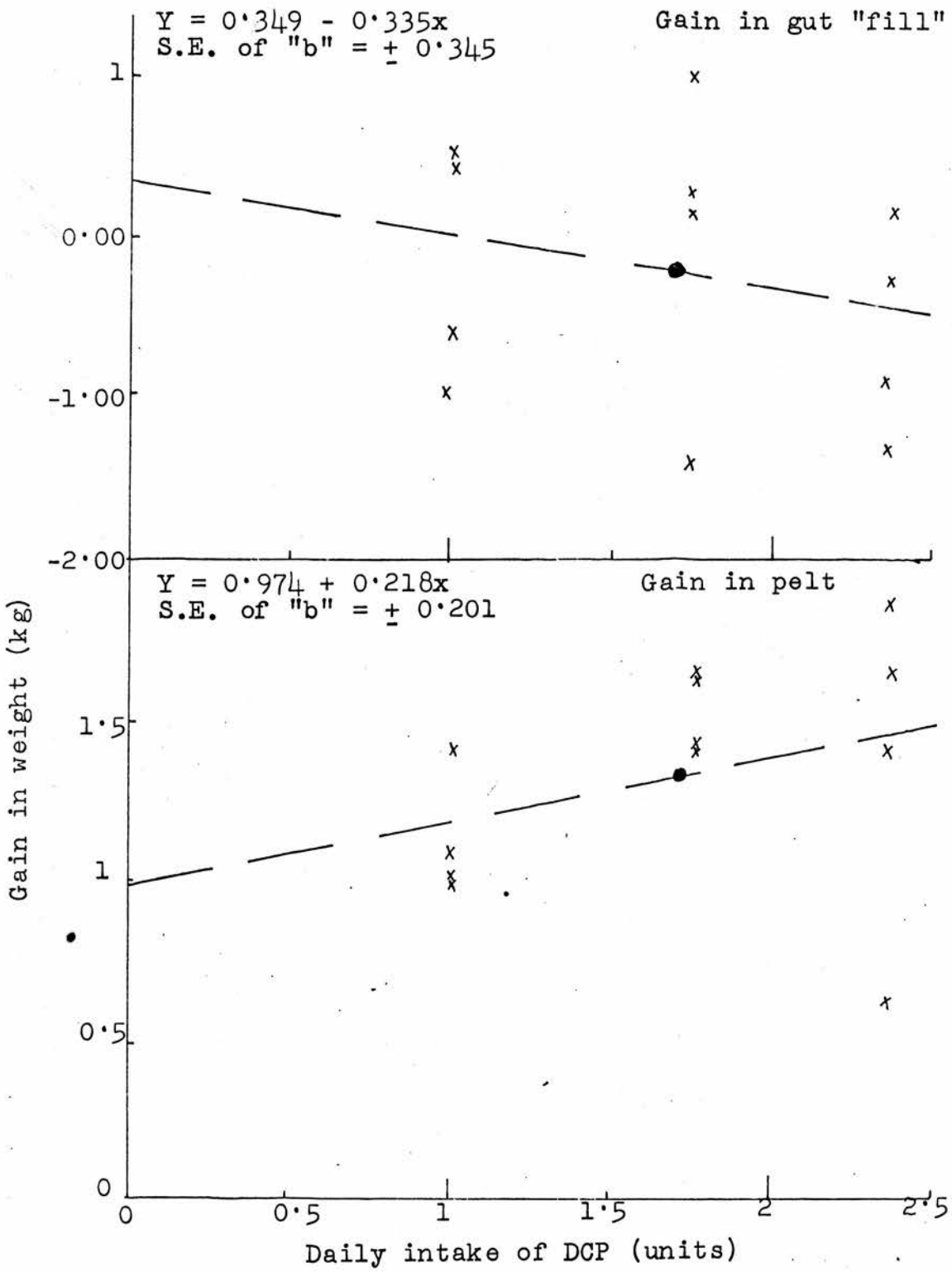


Fig. 2B. The effect of level of dietary DCP on gain in weight of live weight components of B.F. wether lambs



data suggests that for each additional unit of protein increase at the constant energy level reported, S.E.B. might be expected to increase its weight gain by 1·29 kg in 104 days. The data shows that the large standard error associated with "fill" make liveweight a less sensitive measure of response to certain feeding regimes than S.E.B.

On comparing the differences between groups the analysis of variance (Appendix III) for S.E.B. shows that there was a significant difference ($p < 0·05$) between group H (high level of protein) and both the other groups. The difference between group L and group M did not reach significance at the 5 per cent level of probability. The differences between groups for liveweight gain, pelt and "fill" did not reach significance at the $p < 0·05$ level.

The effect of level of dietary digestible crude protein on gain in weight of standard empty body components

The standard empty body weight was split into the components of warm carcass, blood, feet, head, pluck, alimentary tract (gut) and caul fat weights. The pluck weight included liver, heart, lungs, trachea and spleen weights.

The figures 3A, 3B and 3C show the effect of increasing levels of DCP on these components. The gain in weight of warm carcass ($p < 0·05$), blood ($p < 0·05$) and pluck ($p < 0·01$) increased significantly with the increasing level of DCP. The gain in weight of feet, head and gut showed a slight tendency

to increase and the caul fat to decrease as the daily intake of DCP was increased but these relationships did not reach significance at the $p < 0{\cdot}05$ level.

The regression equations of the relationship of these S.E.B. components with the levels of protein intake show that, at the levels of protein used, for each unit of protein increase at the constant energy level reported, warm carcass might be expected to increase its weight gain by 0·91 kg over 104 days while blood could be expected to increase its weight gain by 0·16 kg, and pluck weight increase by 0·14 kg.

On testing differences between groups the analysis of variance (Appendix III) for warm carcass, blood and pluck show significant differences. The analysis of variance for warm carcass shows that the H group increased significantly more than either of the other two groups. Also the difference in gain in blood between group H and either of the other groups was significantly greater ($p < 0{\cdot}05$). The analysis of variance for pluck shows that the differences between groups H and L was highly significant ($p < 0{\cdot}01$) while that between groups H and M was significant at the $p < 0{\cdot}05$ level. L and M did not differ significantly (at 5 per cent level) in warm carcass, blood and pluck. The differences between groups for feet, head, gut and caul fat did not reach significance at the $p < 0{\cdot}05$ level.

Fig. 3A. The effect of level of dietary DCP on gain in weight of standard empty body components of B.F. wether lambs

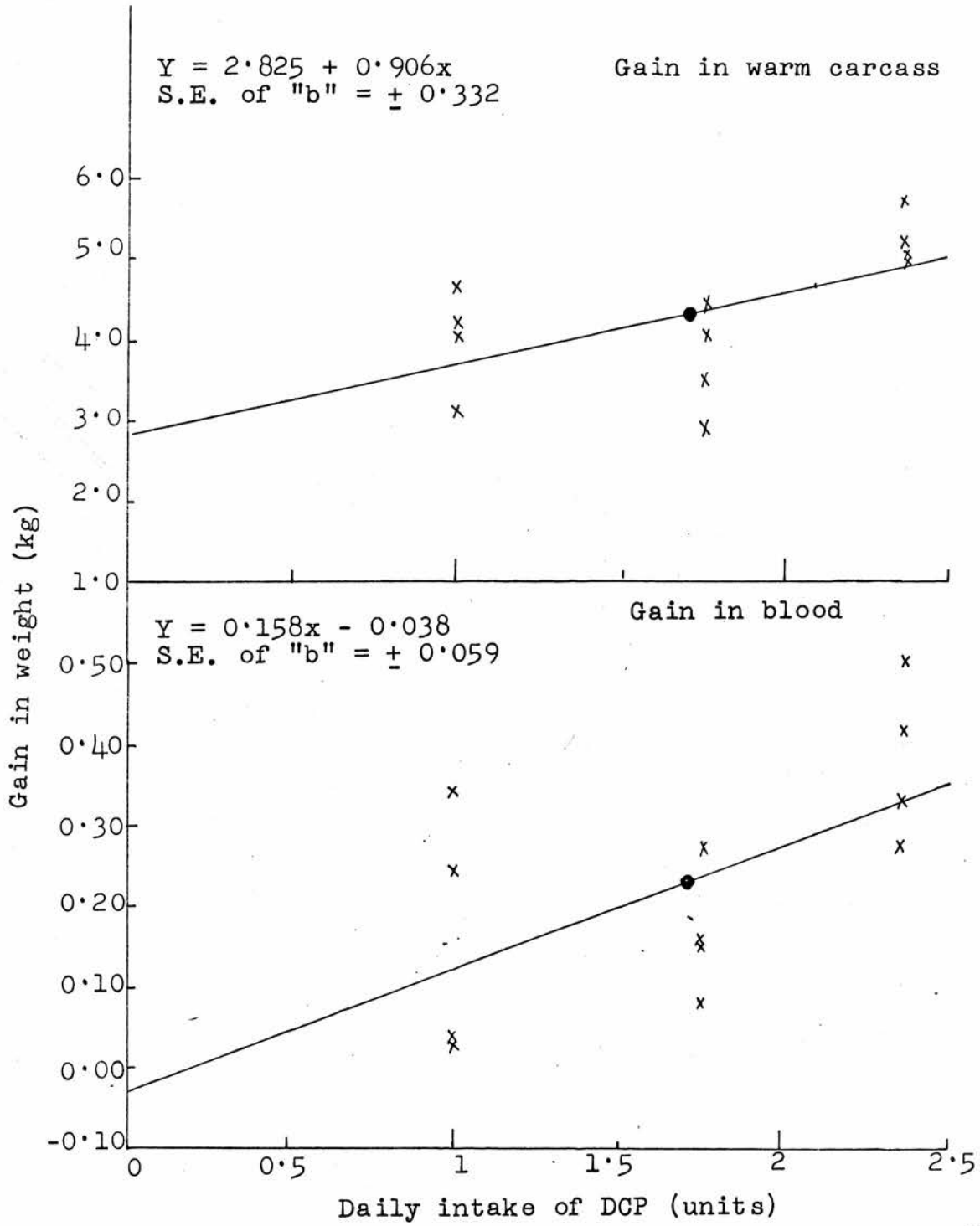


Fig. 3B. The effect of level of dietary DCP on gain in weight of standard empty body components of B.F. wether lambs

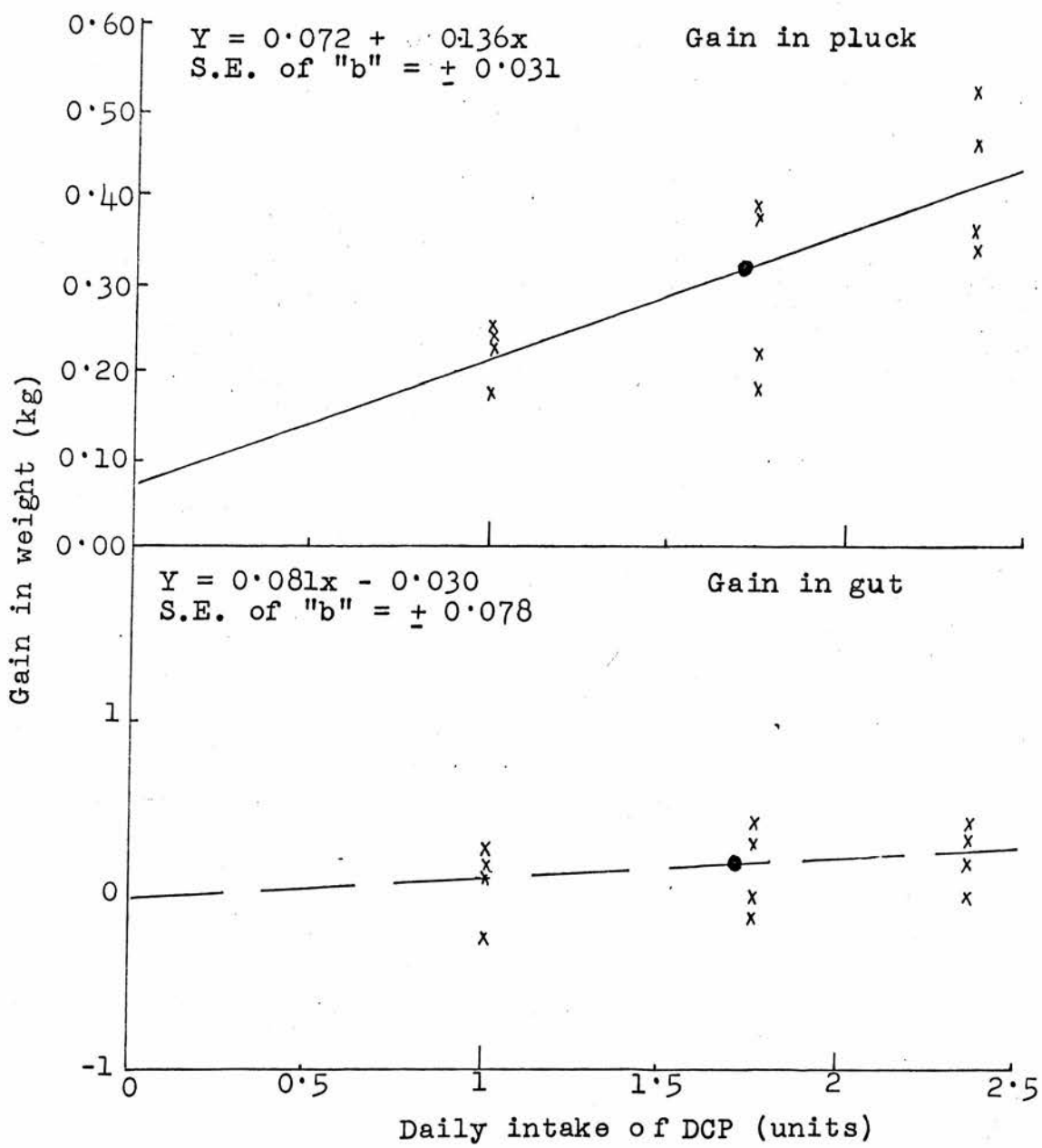
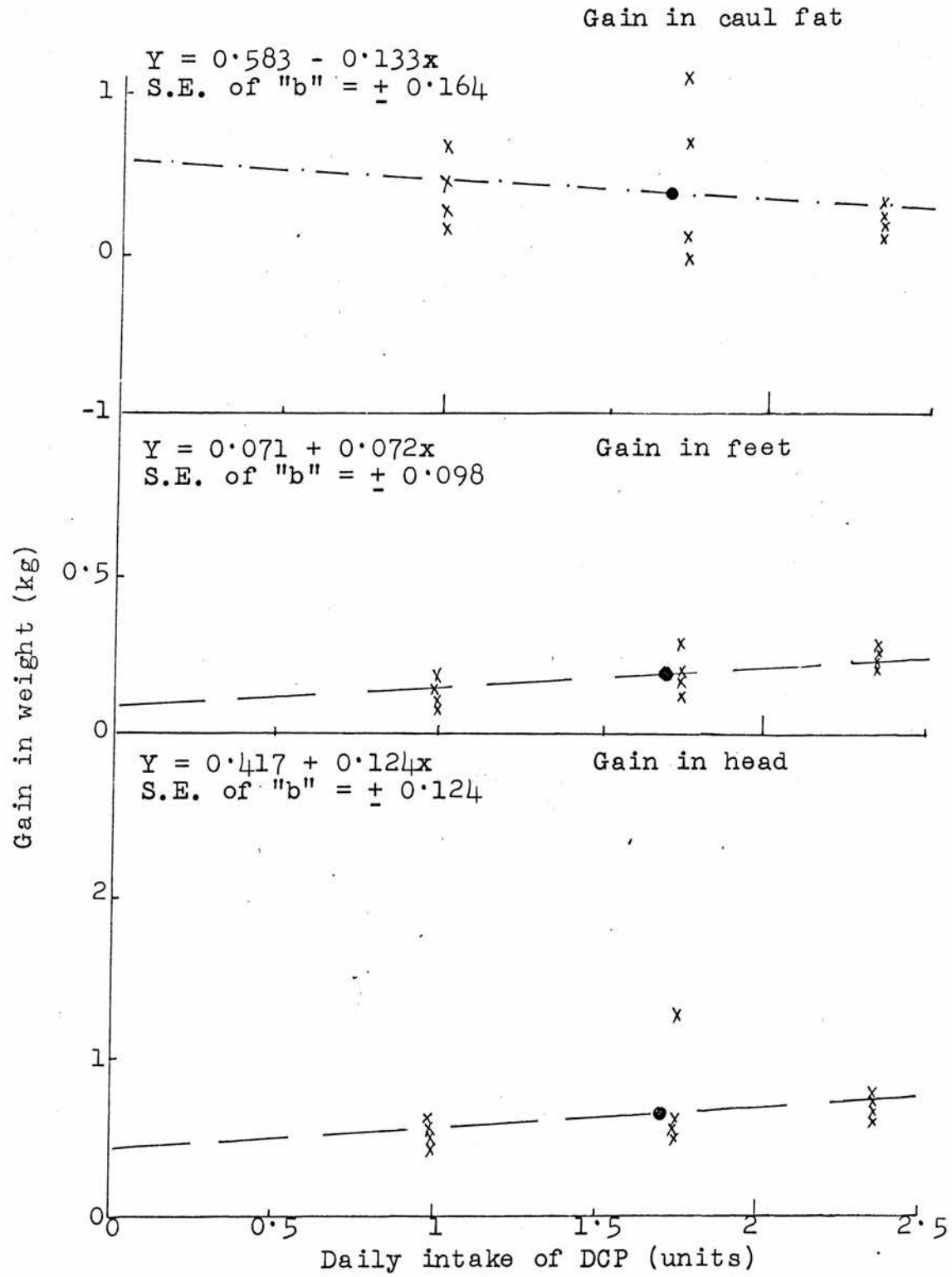


Fig. 3C. The effect of level of dietary DCP on gain in weight of standard empty body components of B.F. wether lambs



The effect of level of dietary digestible crude protein on gain in weight of major tissues in the carcass

Each primary and secondary joint was separated into fatty tissue, muscle and bone. The total fatty tissue in a half carcass was the sum of the fatty tissue in these joints. Likewise the total muscle and total bone in the half carcass were the sum of these tissues respectively separated from each joint.

The figures 4A and 4B show that as the daily intake of DCP increased the gain in bone tissue was significantly increased and there was an indication that muscle tissue was also increased but not significantly so at the 5% level of probability. The gain in weight of fatty tissue tended to decrease as the level of daily DCP increased but the variability of the data reduced the confidence that can be placed on it.

The regression equations show that, at the level of protein used and type of animal used for each unit of protein increase while the energy was kept constant, bone tissue might be expected to increase its weight gain by 0·21 kg within a period of 104 days. If the effect was real the gain in weight of muscle tissue over this period was similar to that of bone (0·27 kg).

The analysis of variance (Appendix III) for bone tissue reveals a significant difference ($p < 0·05$) between the group fed the highest level of daily intake of DCP and those fed low and medium levels of DCP. The differences between groups for fatty and muscle tissues failed to reach significance at the $p < 0·05$ level.

Fig. 4A. The effect of level of dietary DCP on gain in weight of the major tissues in the carcass of B.F. wether lambs

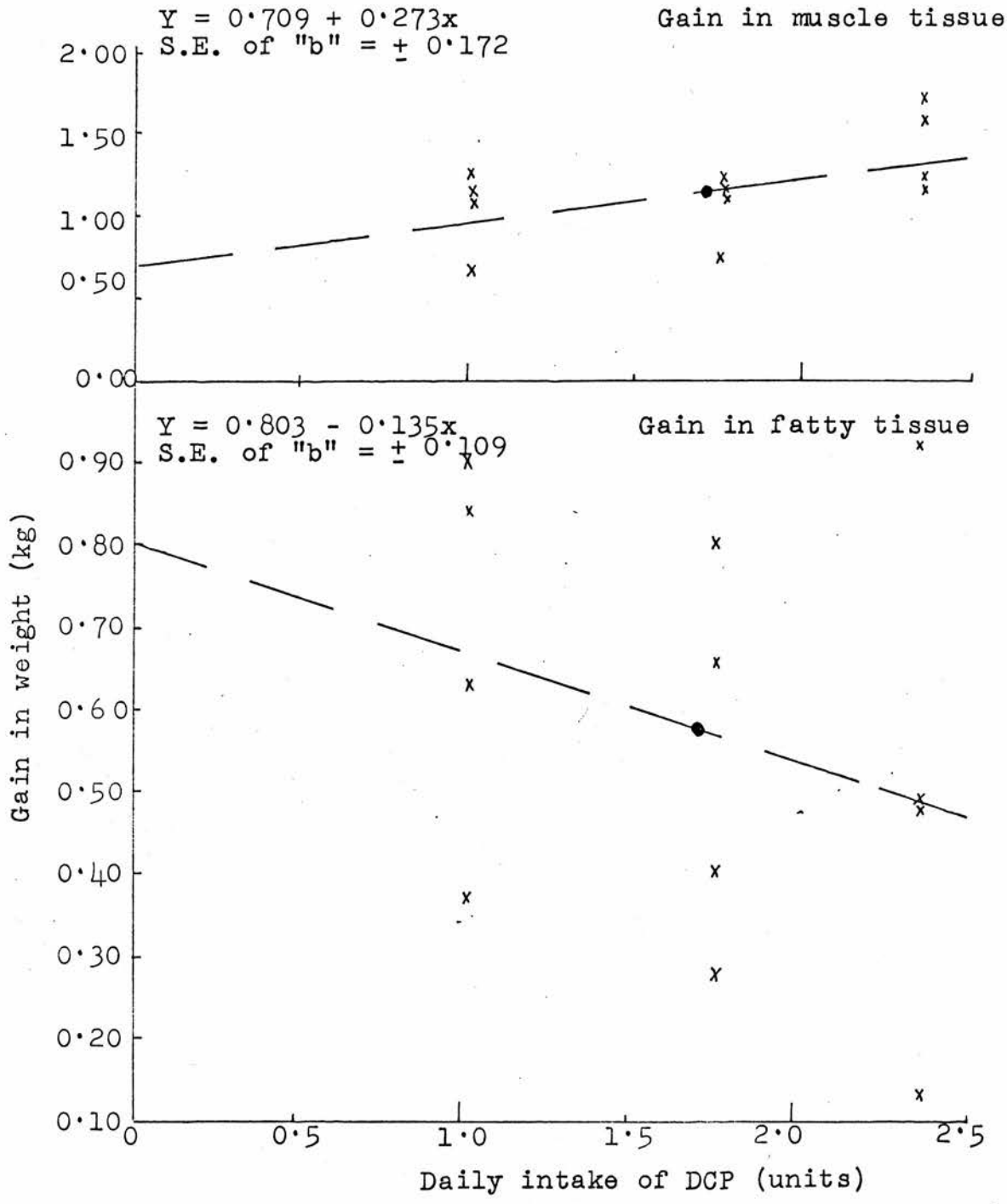
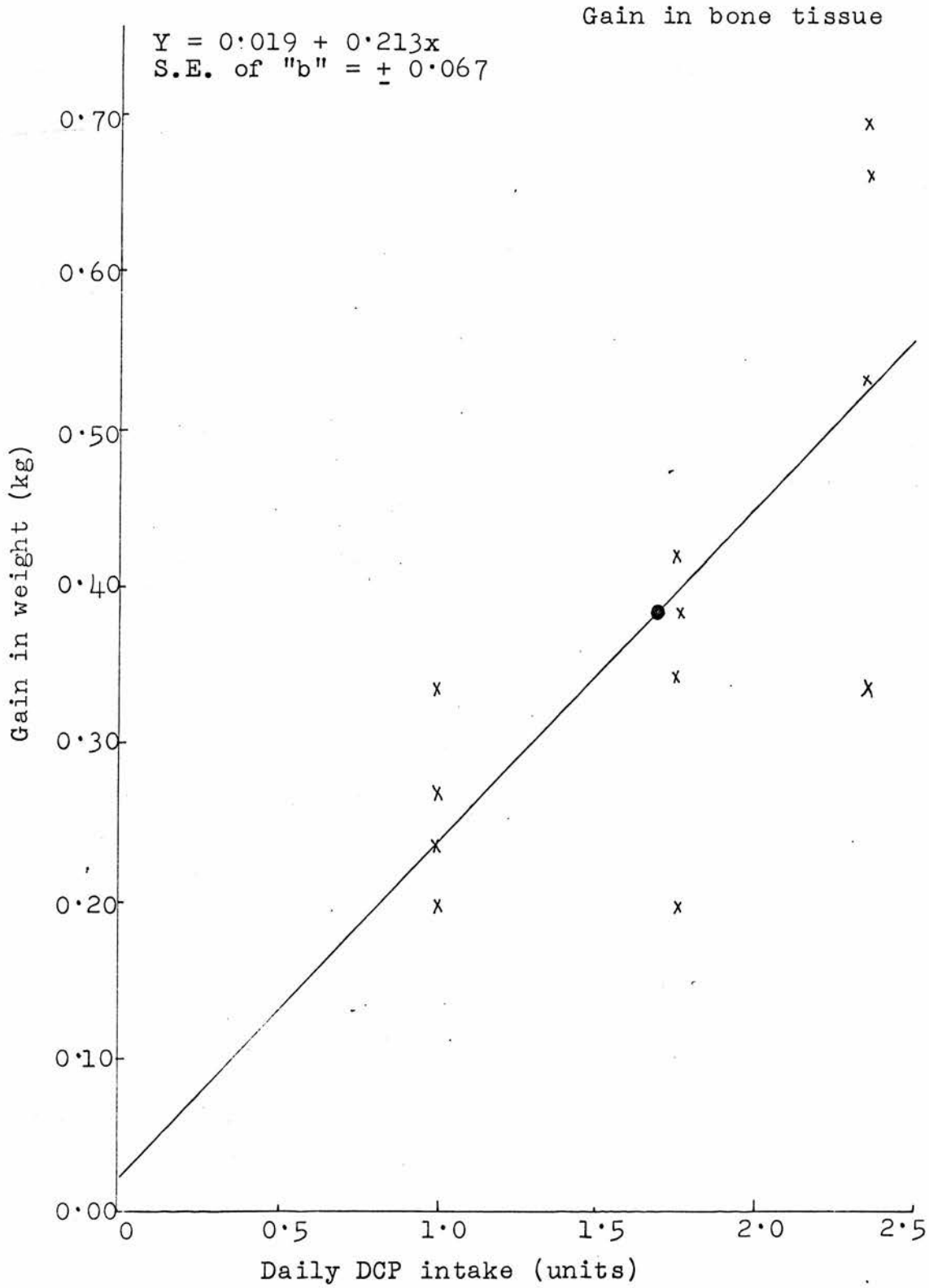


Fig. 4B. The effect of level of dietary DCP on gain in weight of the major tissues in the carcass of B.F. wether lambs



The effect of level of dietary digestible crude protein on gain in weight of the retail cuts

The carcass was cut into four major retail cuts (gigot, shoulder, loin and rib) and seven secondary cuts (brisket, neck, shank, gigot flank, loin flank, rib flank and kidney and surrounding fat.

The figures 5A, 5B and 5C, show the effect of increasing daily intake of DCP on these components. The gain in weight of gigot joint increased significantly ($p < 0.05$) as the daily intake of DCP increased. The gain in weight of shoulder and decrease in gain of the kidney and perirenal fat approached significance at the $p < 0.05$ level. Increasing daily DCP intake showed no major effect on the gain in weight of loin, rib, kidney, brisket, shank, neck, gigot flank, loin flank and rib flank.

The regression equations of the relationship of these components with daily DCP intake show that, for each unit of protein increase, gigot joint might be expected to increase its weight gain by 0·17 kg,over a period of 104 days.

On comparing the differences between groups the analysis of variance (Appendix III) for gigot joint shows that there was a highly significant ($p < 0.01$) difference between groups H and M, while that between groups H and L was significant at the 5 per cent level. The differences between groups for the rest of the retail cuts reported did not reach significant level at the $p < 0.05$ level.

Fig. 5A. The effect of level of dietary DCP on gain in weight of the retail cuts of B.F. wether lambs

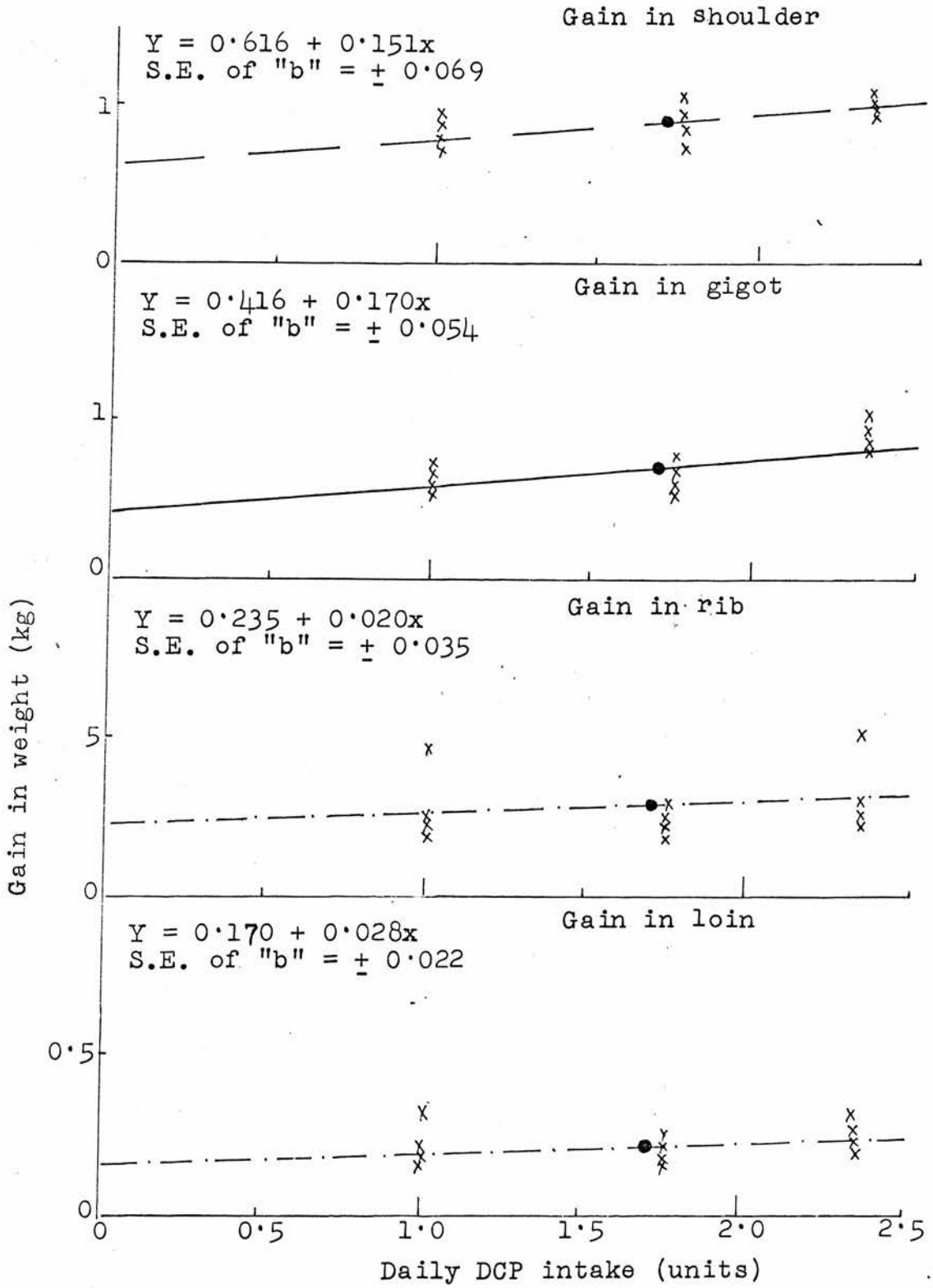


Fig. 5B. The effect of level of dietary DCP on gain in weight of the retail cuts of B.F. wether lambs

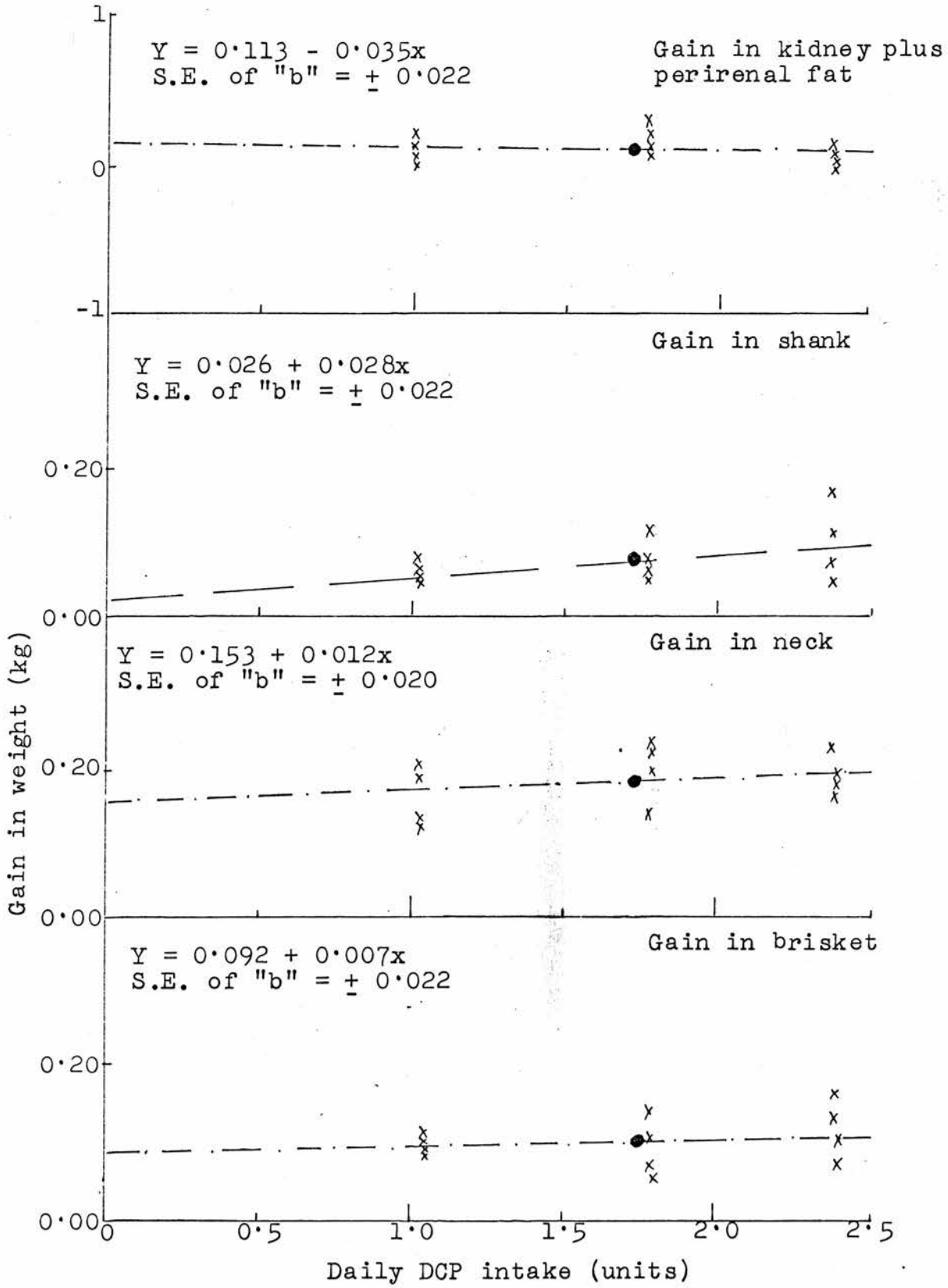
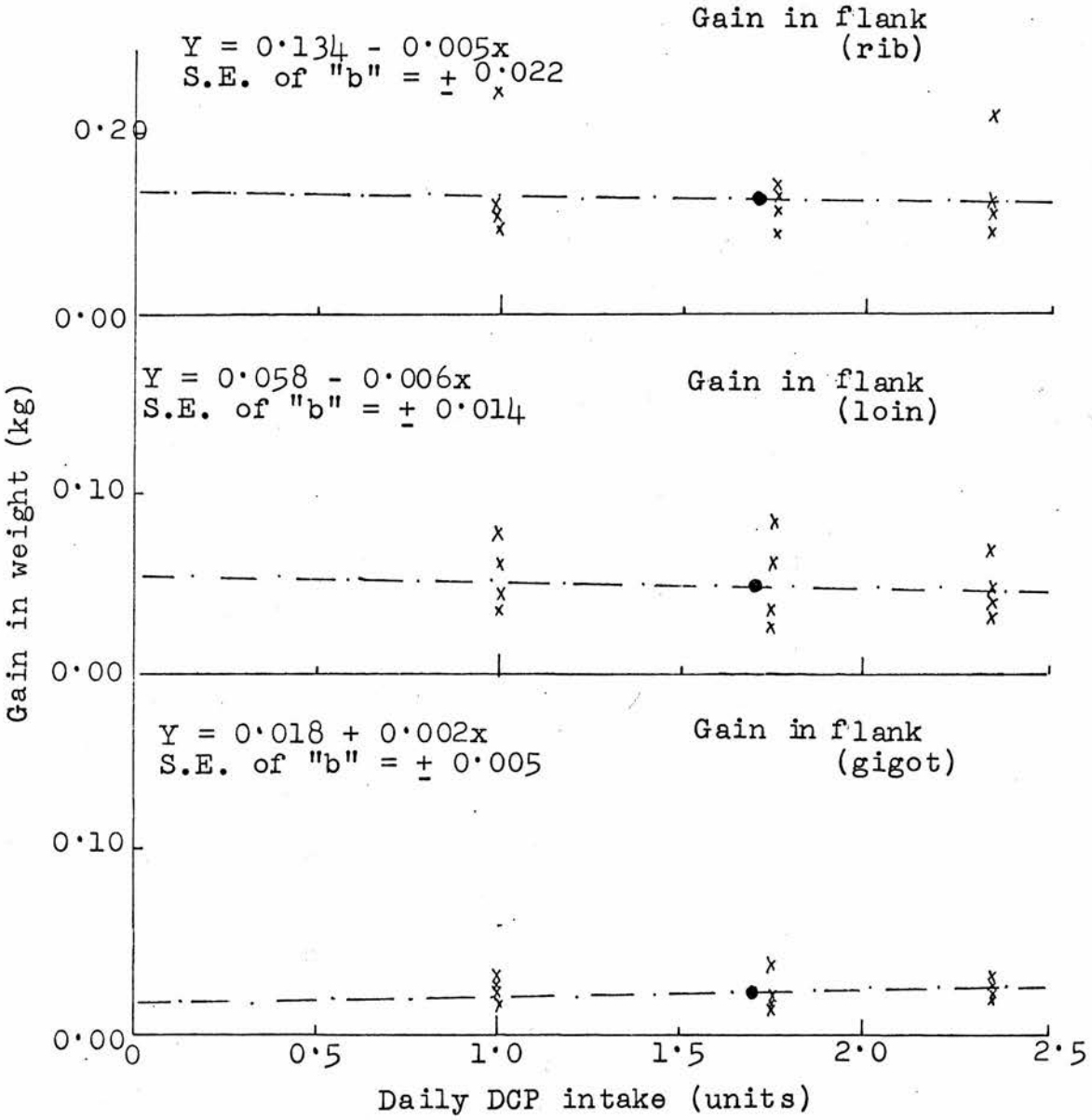


Fig. 5C. The effect of level of dietary DCP on gain in weight of the retail cuts of B.F. wether lambs



The effect of level of dietary protein on changes in the weight of major tissues in the retail cuts

Each primary and secondary joint was separated into fatty tissue, muscle and bone.

Muscle: Figures 6A, 6B, 6C and 6D, show that with increasing level of DCP intake, muscle tissue in gigot joint and in kidney increased in weight significantly ($p < 0{\cdot}05$ and $p < 0{\cdot}01$ respectively) while muscle in shoulder tended to increase in weight but did not reach significance at the 5 per cent level. The gain in weight of muscle in loin and rib joints showed only small positive changes with increasing level of DCP.

Bone: The gain in weight of bone tissue in the gigot, shoulder and loin increased significantly ($p < 0{\cdot}05$, $p < 0{\cdot}01$ and $p < 0{\cdot}05$ respectively), while bone in the rib showed a tendency to increase in weight with increasing level of DCP but this relationship failed to reach significance at the $p < 0{\cdot}05$ level.

Fat: There was a tendency for fatty tissue in the gigot, shoulder, loin and kidney joints to be decreased in weight by increasing level of DCP but these relationships did not reach significant levels at $p < 0{\cdot}05$. The gain in weight of fat in the rib joint showed no certain relationship with levels of DCP but again had a slight negative suggestion.

The regression equations expressing these relationships show that, for each unit of protein increase, muscle tissue in gigot and kidney might be expected to increase its weight gain by 0·13 kg and 0·01 kg respectively, within a period of 104 days.

Fig. 6A. The effect of level of dietary DCP on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

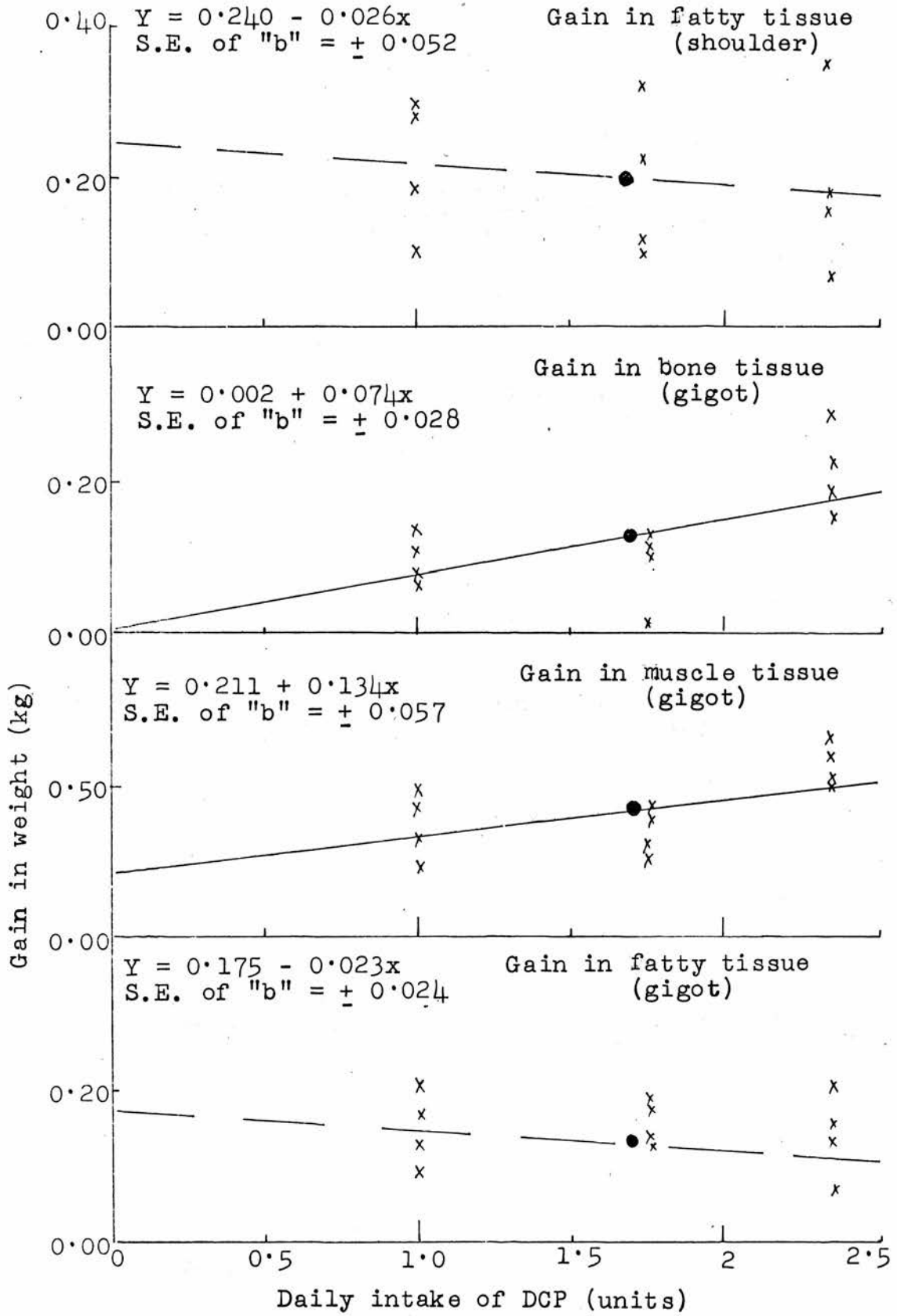


Fig. 6B. The effect of level of dietary DCP on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

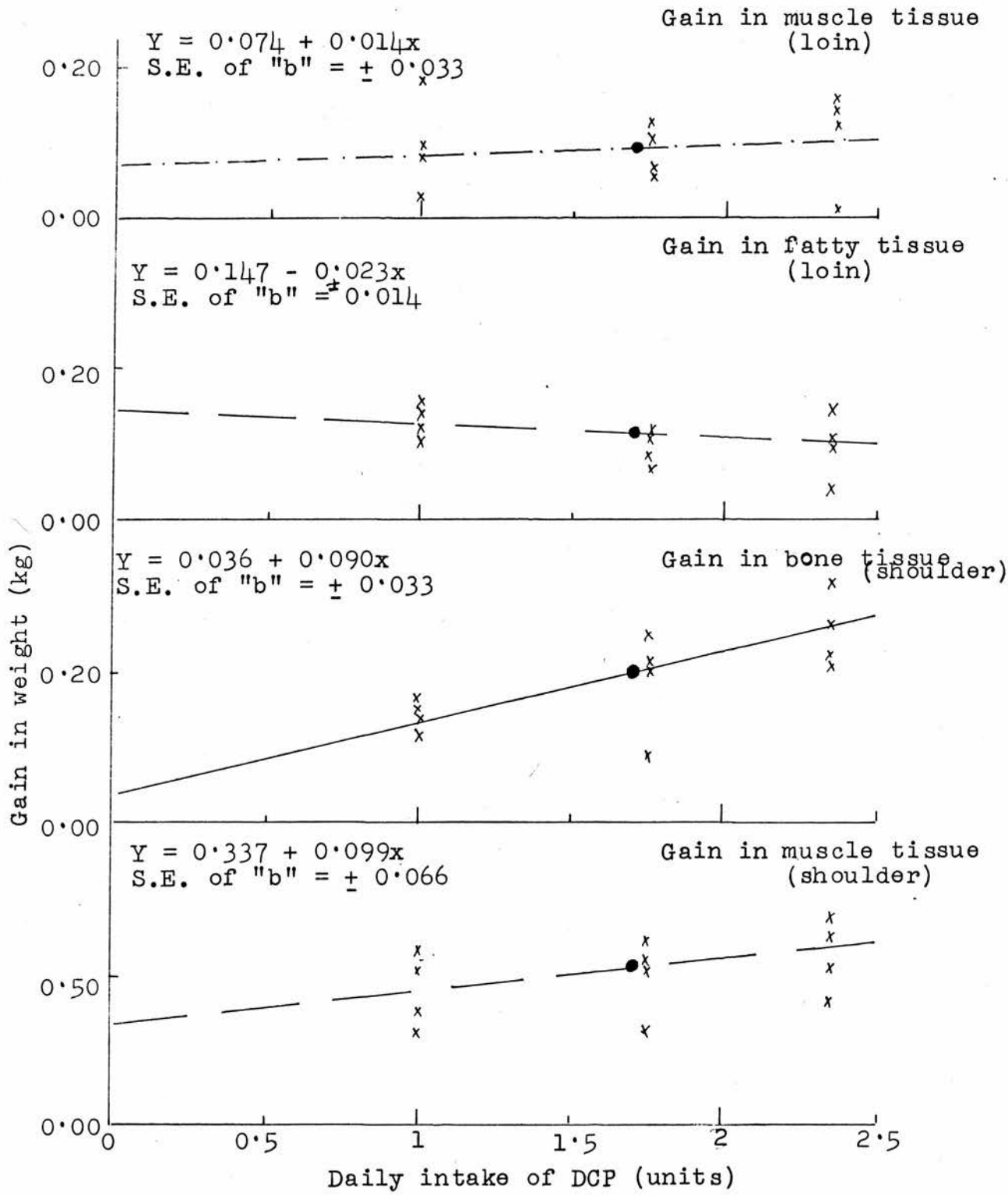


Fig. 6C. The effect of level of dietary DCP on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

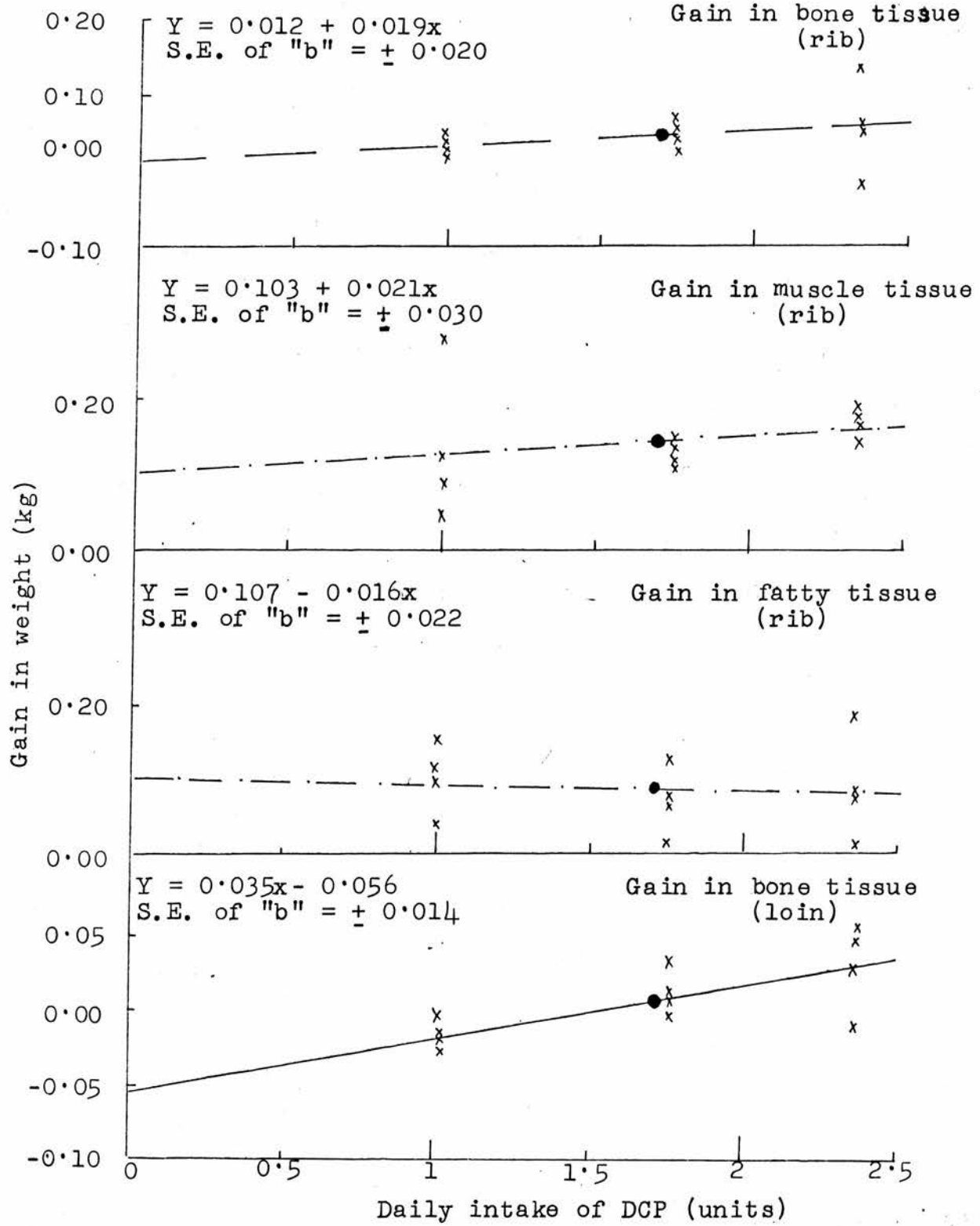
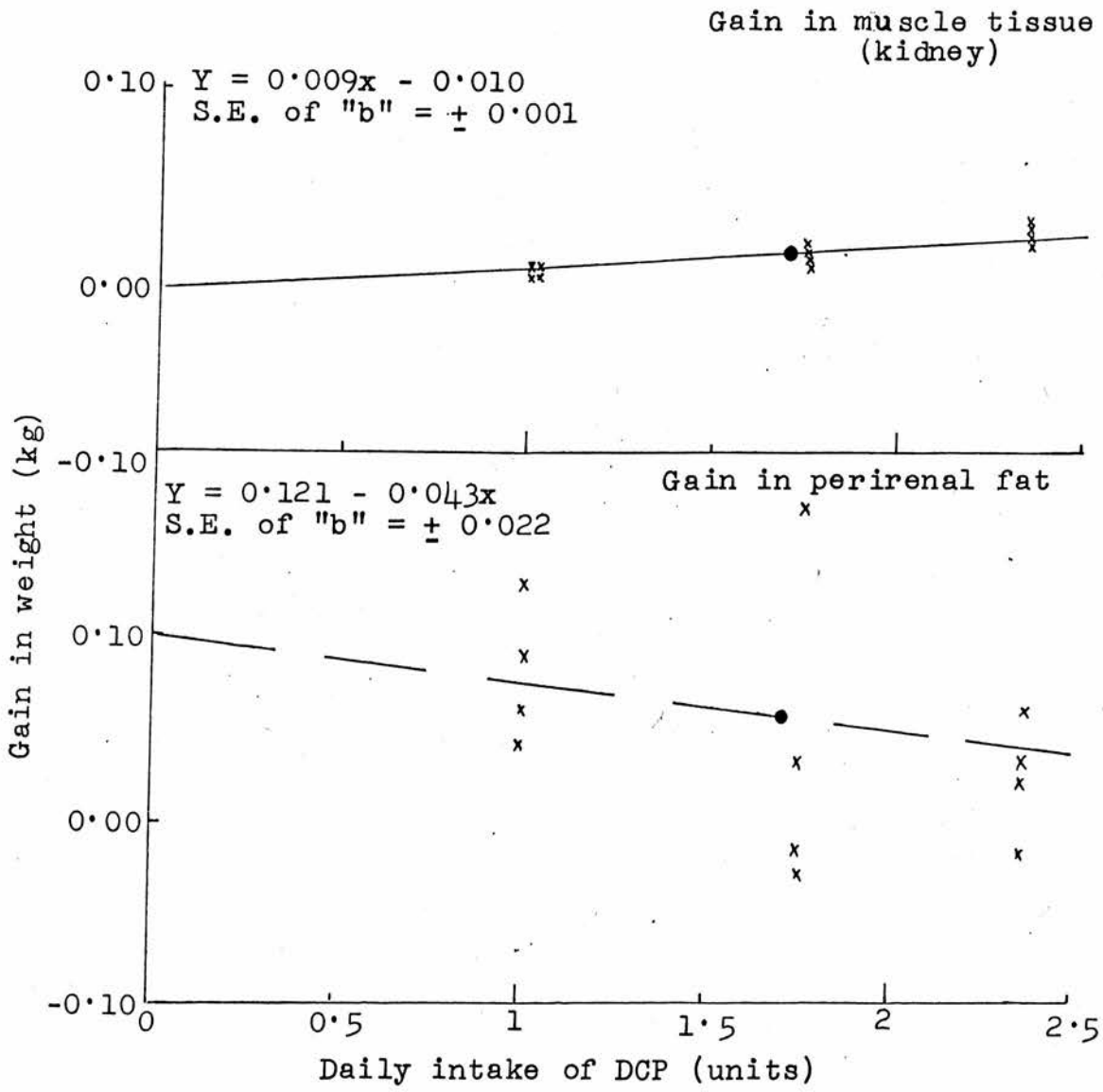


Fig. 6D. The effect of level of dietary DCP on gain in weight of the major tissues in the retail cuts of B.F. wether lambs



Bone tissue in gigot, shoulder and loin might be expected to increase its weight gain by 0·07 kg, 0·09 kg and 0·04 kg respectively in the same period.

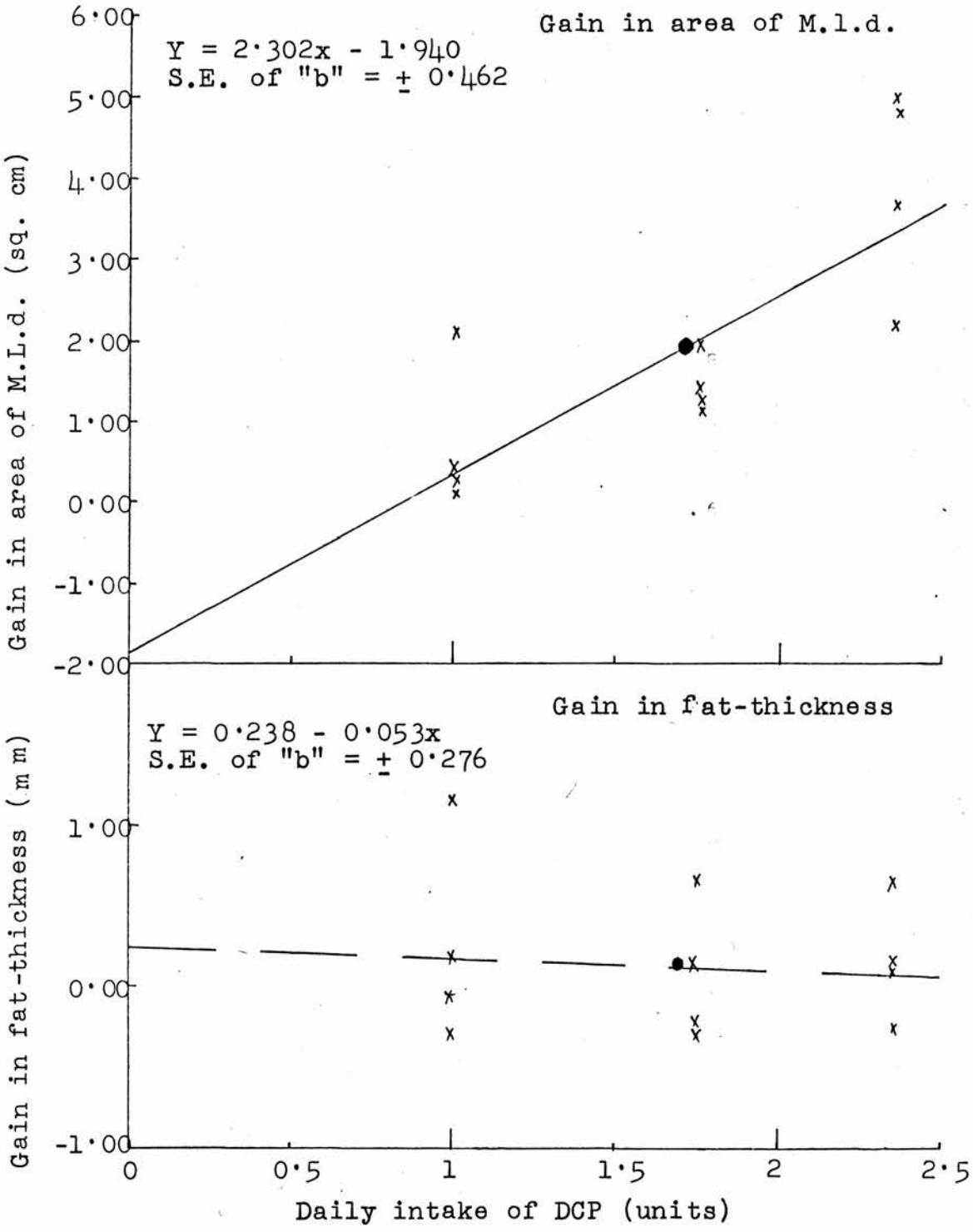
The analysis of variance (Appendix III) for muscle tissue in gigot and kidney joints shows that there were significant differences $p < 0·05$ between group H and both the other groups. The gain in weight of bone tissue in gigot was significantly ($p < 0·05$) greater in the H group than either of the other two groups. The difference in the bone in the shoulder joint was highly significant ($p < 0·01$) between groups H and L while that between groups H and M did not reach significance at the 5 per cent probability level. The differences between the two groups of low and medium levels of DCP for muscle tissue in gigot and kidney and for bone tissue in gigot and shoulder failed to reach significance at the 5 per cent level. The analysis of variance for the rest of the components reported in this section showed no significant ($p < 0·05$) differences between groups.

The effect of level of dietary protein on the increase of carcass measurements

The area of M. longissimus dorsi at the 12th rib and the thickness of fat that covers this muscle at the 12th rib were recorded.

The figure 7 shows that, as the daily intake of DCP increased, the area of M. longissimus dorsi increased, while the gain in fat-thickness tended to decrease. The increase in area of M. longissimus dorsi at the 12th rib was highly significant ($p < 0·01$).

Fig. 7. The effect of level of dietary DCP on the increase of carcass measurements of B.F. wether lambs



The regression equation shows that the area of M. longissimus dorsi might be expected to be increased by 2·30 square cm when the level of protein increased by one unit.

The analysis of variance (Appendix III) for the area of M. longissimus dorsi at the 12th rib shows that there was a highly significant difference ($p < 0·01$) between the group fed a high level of DCP and those fed low and medium levels, although the difference between the latter groups did not reach significance at $p < 0·05$ level. There was no significant difference ($p < 0·05$) between the groups for fat-thickness.

The effect of level of dietary digestible crude protein on gain in weight of individual muscles

Certain individual muscles from the various joints of the carcass were removed and weighed separately.

The figures 8A, 8B, 8C, 8D, 8E, 8F and 8G show the effect of level of daily intake of DCP on the changes in weight of these individual muscles. The gain in weight of M. extensor digitorum longus and of M. extensor carpi radialis were highly significant ($p < 0·01$) while those of M. gastrocnemius, M. quadriceps femoris, M. longissimus dorsi in rib area, M. infraspinatis and M. supraspinatis reached significance at the 5 per cent level of probability. Of the nine other muscles tested (M. obliquus internus abdominis + M. transversus abdominis, M. semitendinosus, M. semimembranosus, M. gluteus medius, M. psoas major, M. longissimus dorsi in loin area, M. biceps brachii, Mm. pectoralis profundus et superficialis and M. brachialis) only one (M. brachialis) showed no tendency to

Fig. 8A. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

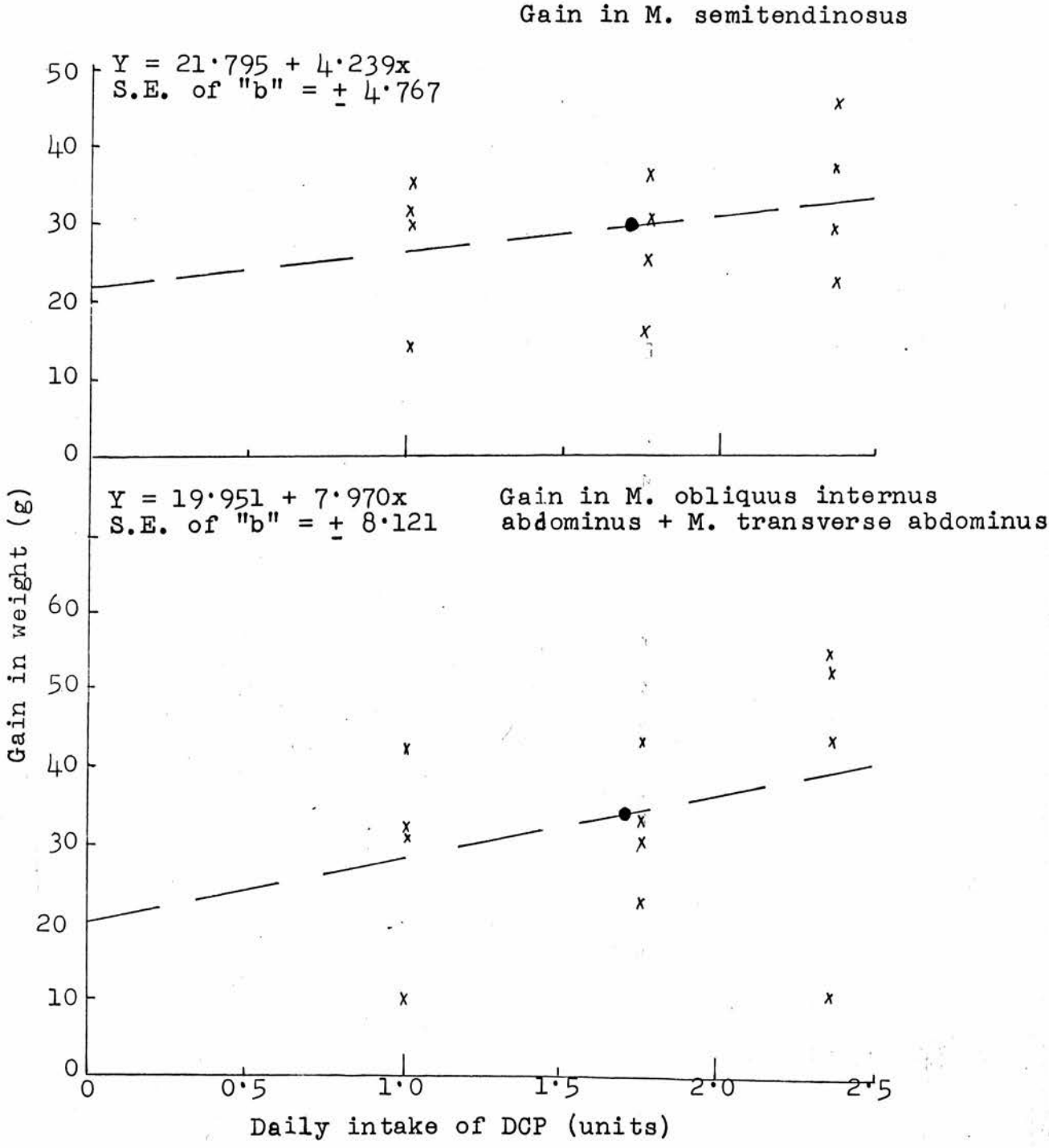


Fig. 8B. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

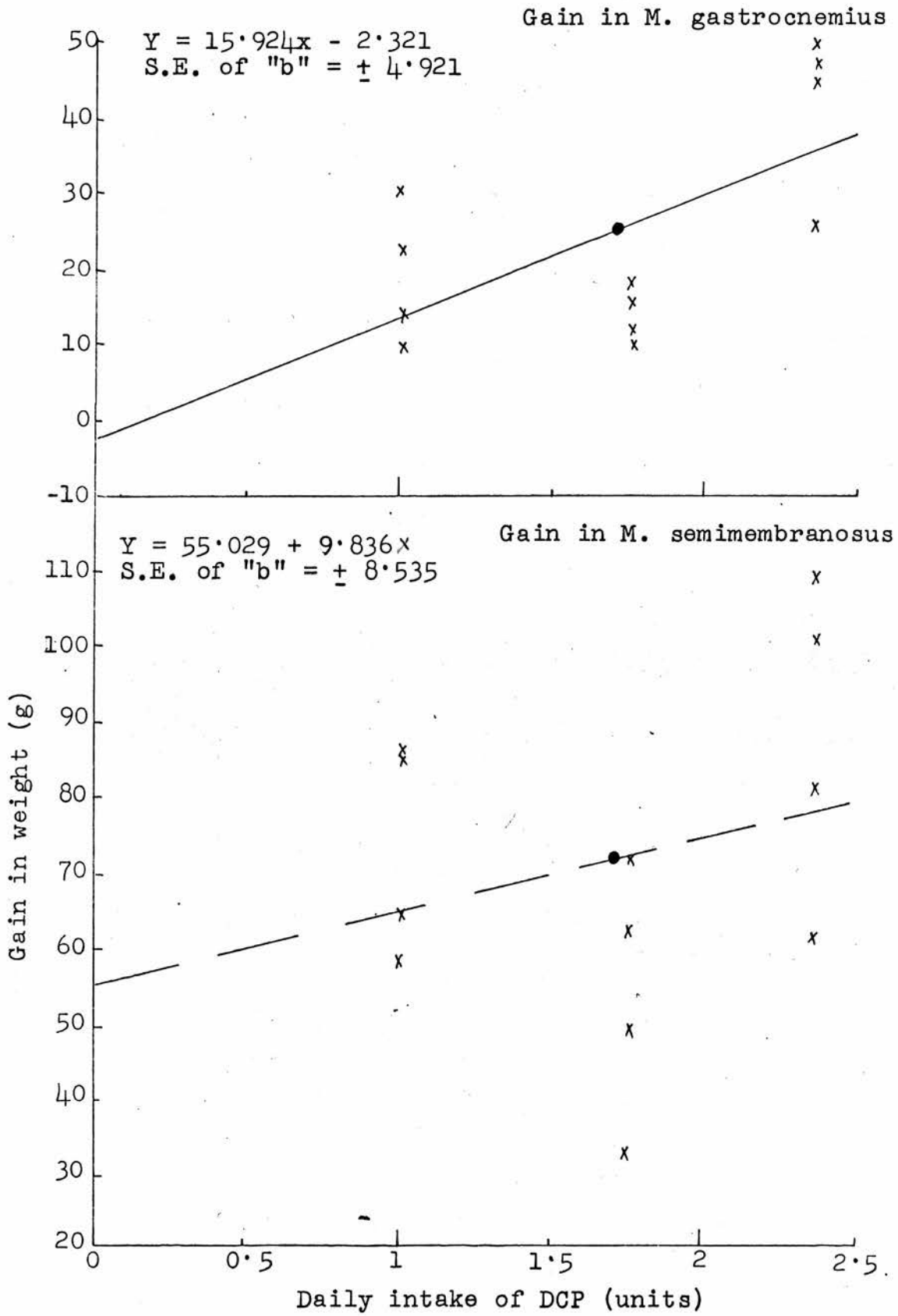


Fig. 8C. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

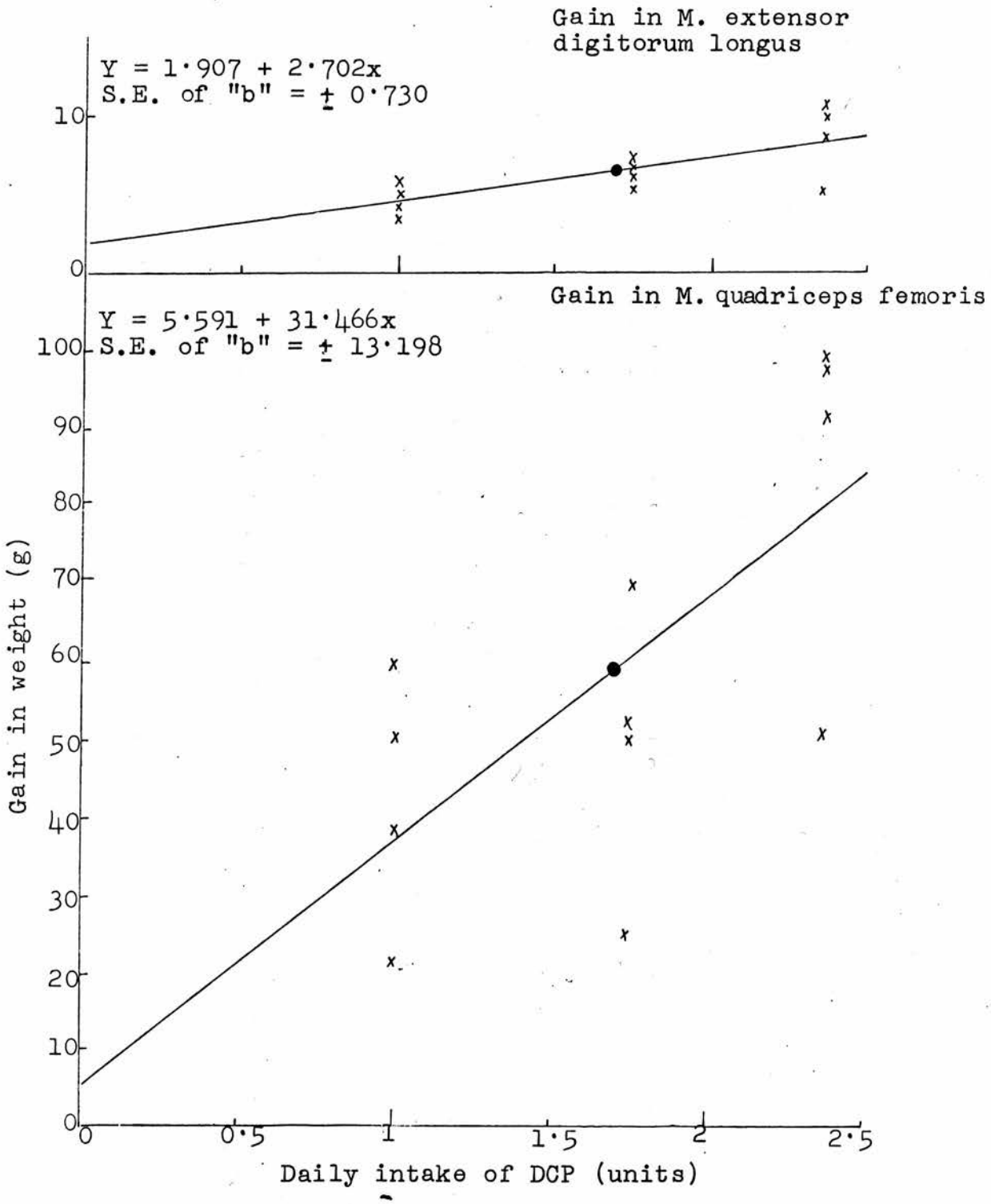


Fig. 8D. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

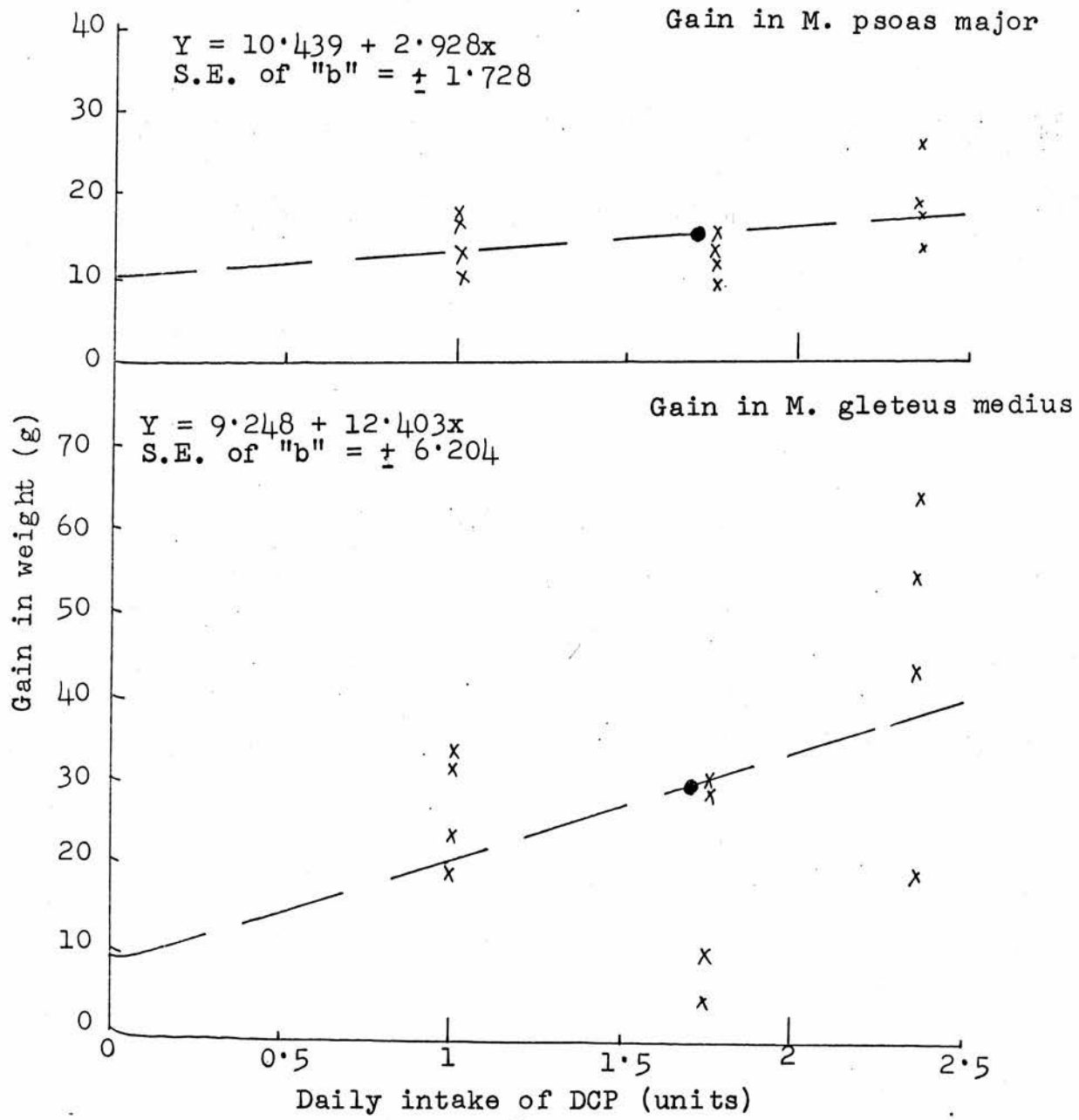


Fig. 8E. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

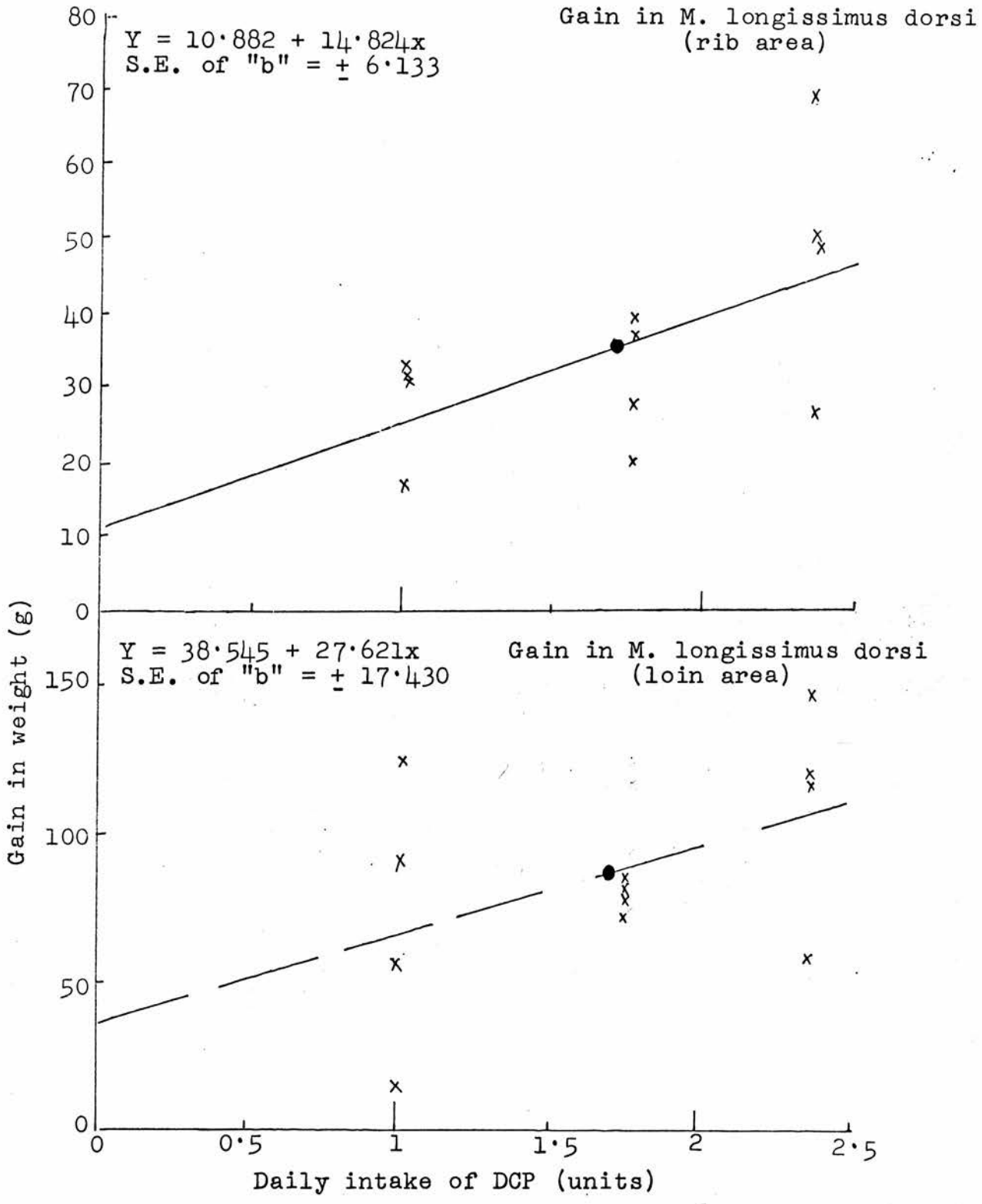


Fig. 8F. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs

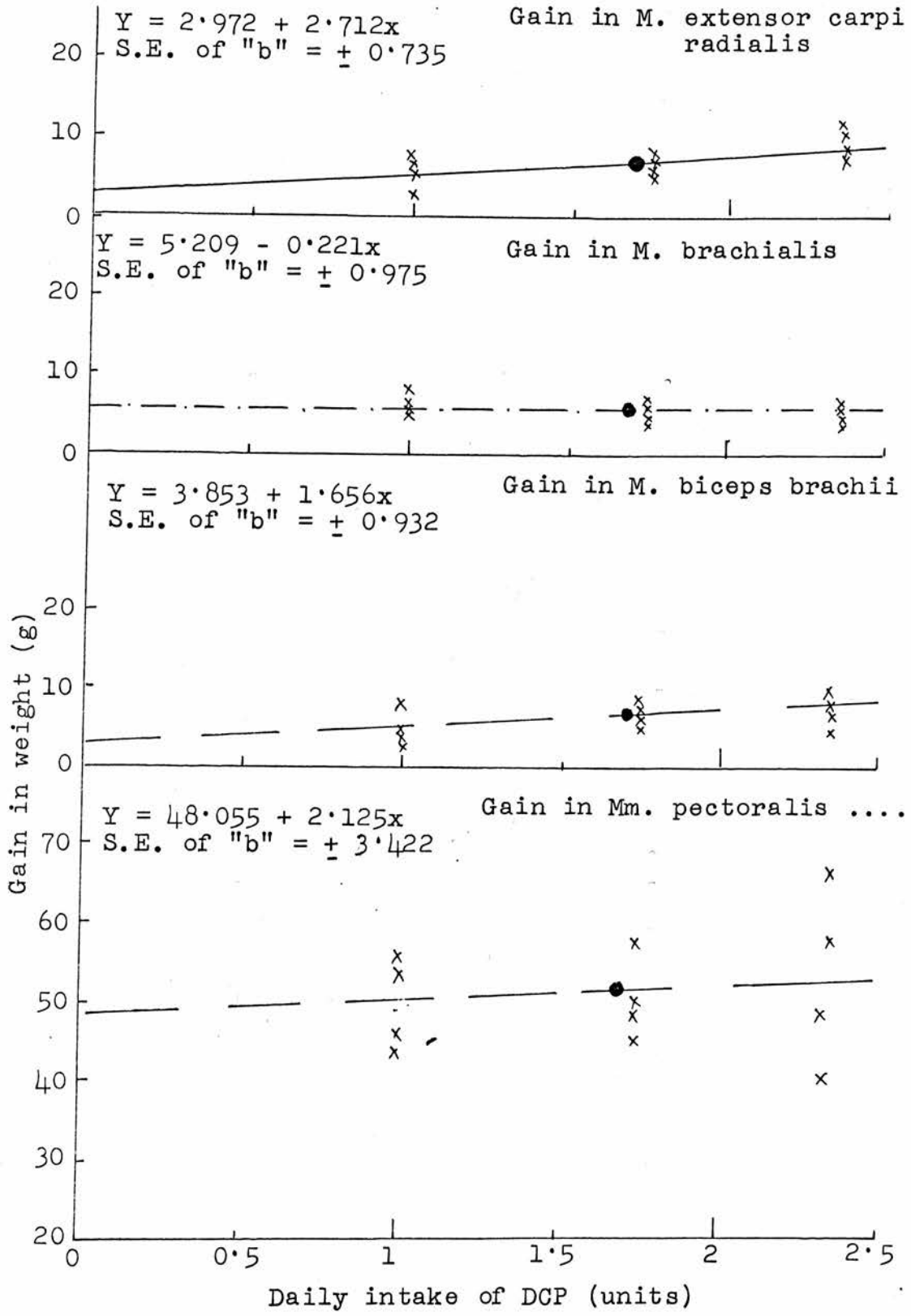
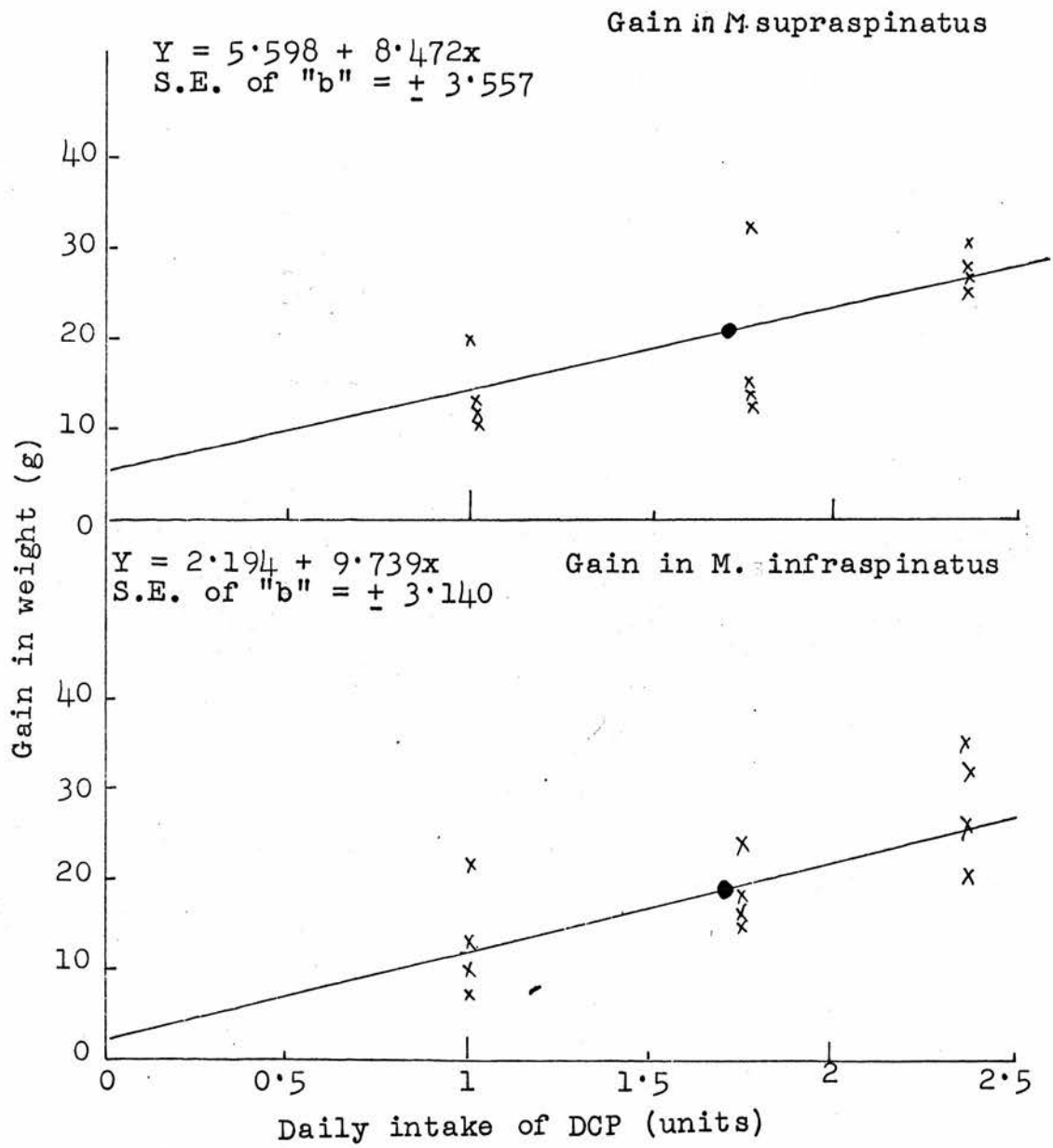


Fig. 8G. The effect of level of dietary DCP on gain in weight of individual muscles of B.F. wether lambs



increase as the level of daily DCP was increased.

The regression equations of these relationships show that for each unit of protein increase, M. gastrocnemius, M. quadriceps femoris, M. longissimus dorsi in the rib area, M. infraspinatis, M. supraspinatis, M. extensor digitorum longus and M. extensor carpi radialis, might be expected to increase in gain in weight by 16 g, 31 g, 15 g, 10 g, 8 g, 3 g, and 3 g respectively over a period of 104 days.

On comparing the differences in gain in weight between groups, the analysis of variance (Appendix III) for M. gastrocnemius and M. infraspinatis shows that there were significant differences ($p < 0{\cdot}01$ and $p < 0{\cdot}05$ respectively) between that group of lambs with the highest daily intake of DCP and both the other groups. The analysis of variance for M. extensor digitorum longus showed similar results to that for M. extensor carpi radialis. In both muscles the H group was significantly greater ($p < 0{\cdot}01$ and $p < 0{\cdot}05$) than either the L or M groups respectively. The gain in weight in M. gluteus medius in the H group was significantly ($p < 0{\cdot}05$) greater than either of the other two groups. Groups L and M did not differ significantly ($p < 0{\cdot}05$) in M. gastrocnemius, M. gluteus medius, M. extensor digitorum longus, M. extensor carpi radialis and M. infraspinatis. The differences in gain in weights between groups for the other individual muscles reported did not reach significance at the 5 per cent level of probability.

The effect of level of dietary digestible crude protein in changes in chemical composition of the carcass tissues

Chemical determinations were made on samples of carcass tissues for dry matter, ether extract and crude protein. Because of the possible variations occurring in level of separation, samples of muscle from the centre of the M. longissimus dorsi at the 12th rib and of fatty tissue overlying the 12th rib were used as indications of these tissue changes (Appendix VI).

(a) Dry matter: Figure 9 shows that as the level of daily intake of DCP increased, the percentage of dry matter in the fatty and muscle tissues fell. While these relationships did not reach significance at the 5 per cent level of probability both were approaching significance.

(b) Ether extract: Figure 10 shows that, with increasing levels of daily intake of DCP, the percentage of ether extract in the fatty tissue and in the muscle tissue tended to decrease, the relationships approaching but not actually reaching significance at the 5 per cent level.

(c) Crude protein: Figure 11 shows the effect of increasing the level of daily intake of DCP on the percentage of crude protein in the carcass tissues. As the level of daily intake of DCP increased, the percentage of crude protein in the muscle tissue significantly ($p < 0{\cdot}05$) increased while the percentage of crude protein in the fatty tissue increased with increasing level of DCP but just failed to reach significance at the

Fig. 9. The effect of level of dietary DCP on the percentage of dry matter in carcass tissues of B.F. wether lambs

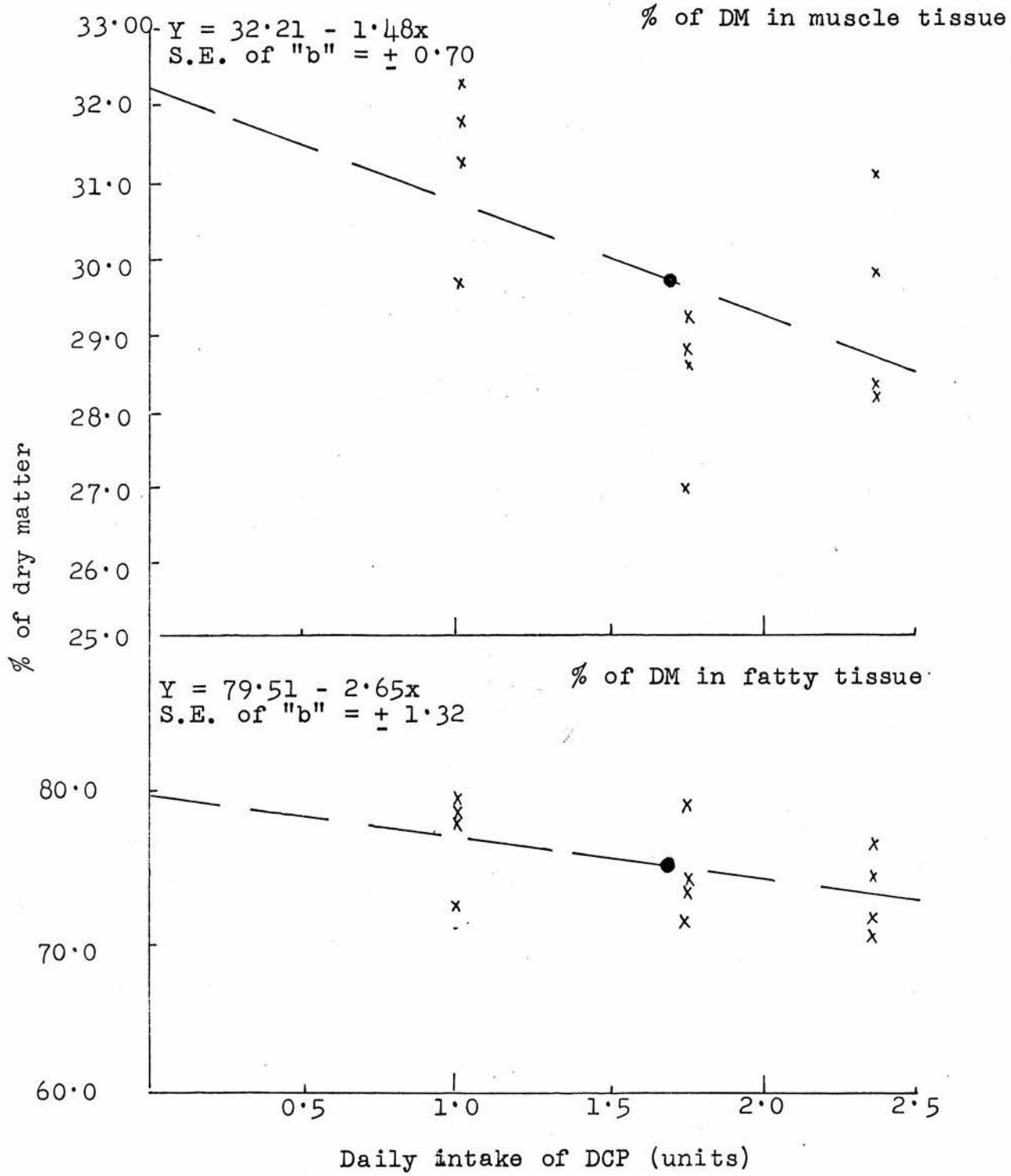


Fig. 10. The effect of level of dietary DCP on the percentage of ether extract in carcass tissues of B.F. wether lambs

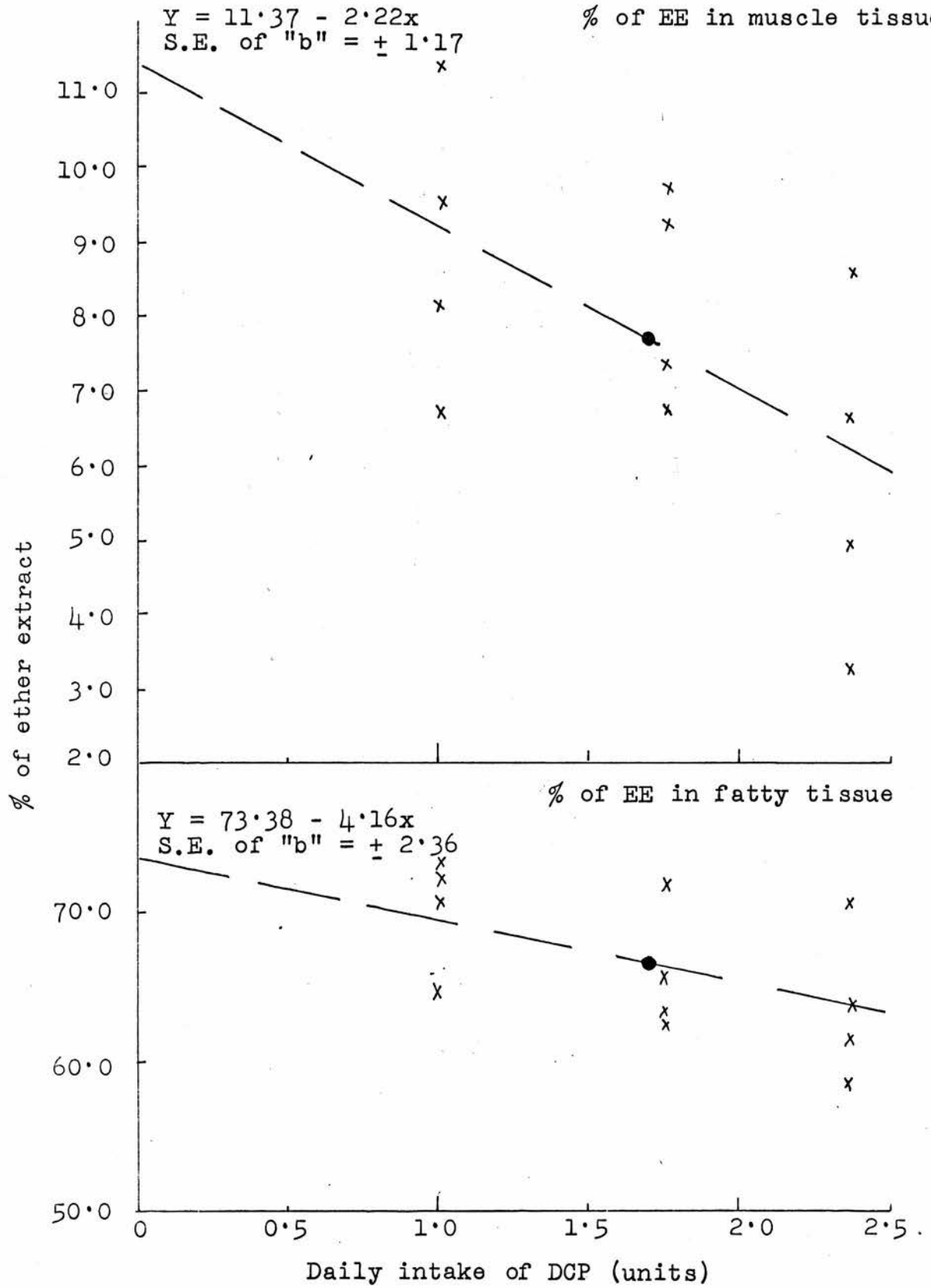
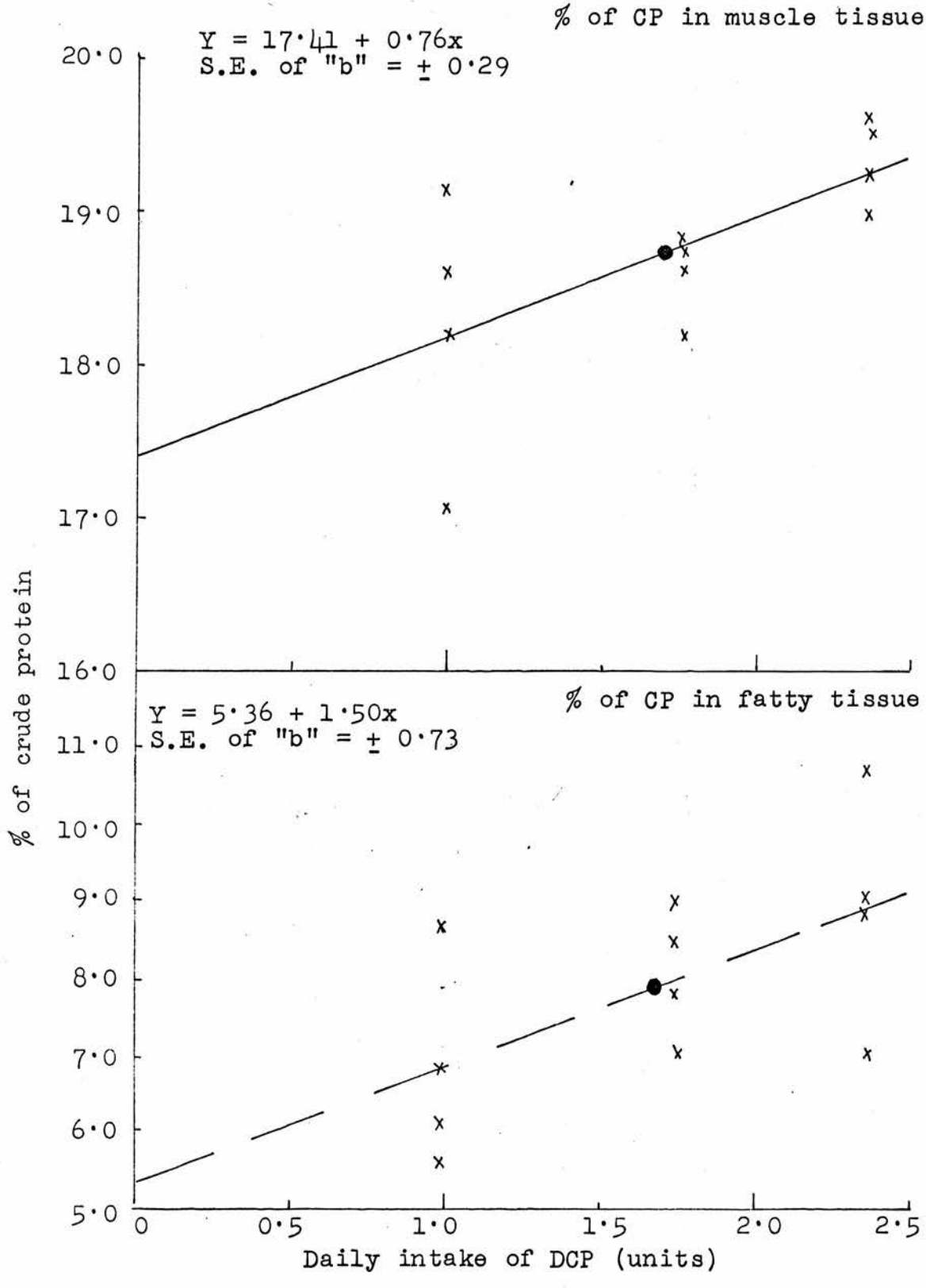


Fig. 11. The effect of level of dietary DCP on the percentage of crude protein in carcass tissues of B.F. wether lambs



$p < 0{\cdot}05$ level of probability.

The regression coefficients of these relationships show that crude protein percentage in muscle tissue might be expected to increase by 0·76 per cent over 104 days when the level of DCP increased by one unit.

The analysis of variance (Appendix III) for the percentages of dry matter, ether extract and crude protein in fatty and in muscle tissues shows no significant ($p < 0{\cdot}05$) differences between groups.

The effect of level of dietary protein on changes in weight of the chemical components of carcass tissues

Chemical determinations were made on samples of the carcass tissues for dry matter, ether extract, and crude protein.

(a) Dry matter: Figure 12 shows the effect of increasing the level of DCP intake on the gain in dry matter weight of the fatty and muscle tissues. The gain in dry matter weight of the fatty tissue tended to decrease with an increasing intake of DCP but this relationship was not significant ($p < 0{\cdot}05$) while the gain in dry matter weight of the muscle tissue showed no tendency to increase with an increasing daily intake of DCP.

(b) Ether extract: Figure 13 shows that as the level of dietary protein was increased there was a tendency for the gain in weight of ether extract of both the fatty and muscle tissues to be decreased, although the trend was not significant at the 5 per cent level of probability.

(c) Crude protein: Figure 14 shows that as the daily intake of DCP increased, gain in weight of crude protein in the fatty tissue and in the muscle tissue of the carcass increased significantly ($p < 0{\cdot}05$ and $p < 0{\cdot}01$ respectively).

The regression coefficients of these relationships show, that for each unit of DCP increase, crude protein in the fatty tissue and in the muscle could be expected, over the 104 day period, to increase its weight gain by 0·011 kg and 0·099 kg respectively.

The analysis of variance (Appendix III) for the gain in weight of crude protein in the muscle tissue shows that group H was highly significantly ($p < 0{\cdot}01$) increased more than either of the other two groups. The differences, between groups for dry matter and ether extract in fatty and muscle tissues, and for crude protein in fatty tissue, were not significant at the ($p < 0{\cdot}05$) level.

<u>The effect of level of dietary protein on the gain of gross energy in the carcass tissues</u>

The total gross energy in fatty tissue and in muscle was

Fig. 12. The effect of level of dietary DCP on gain in weight of the dry matter in carcass tissues of B.F. wether lambs

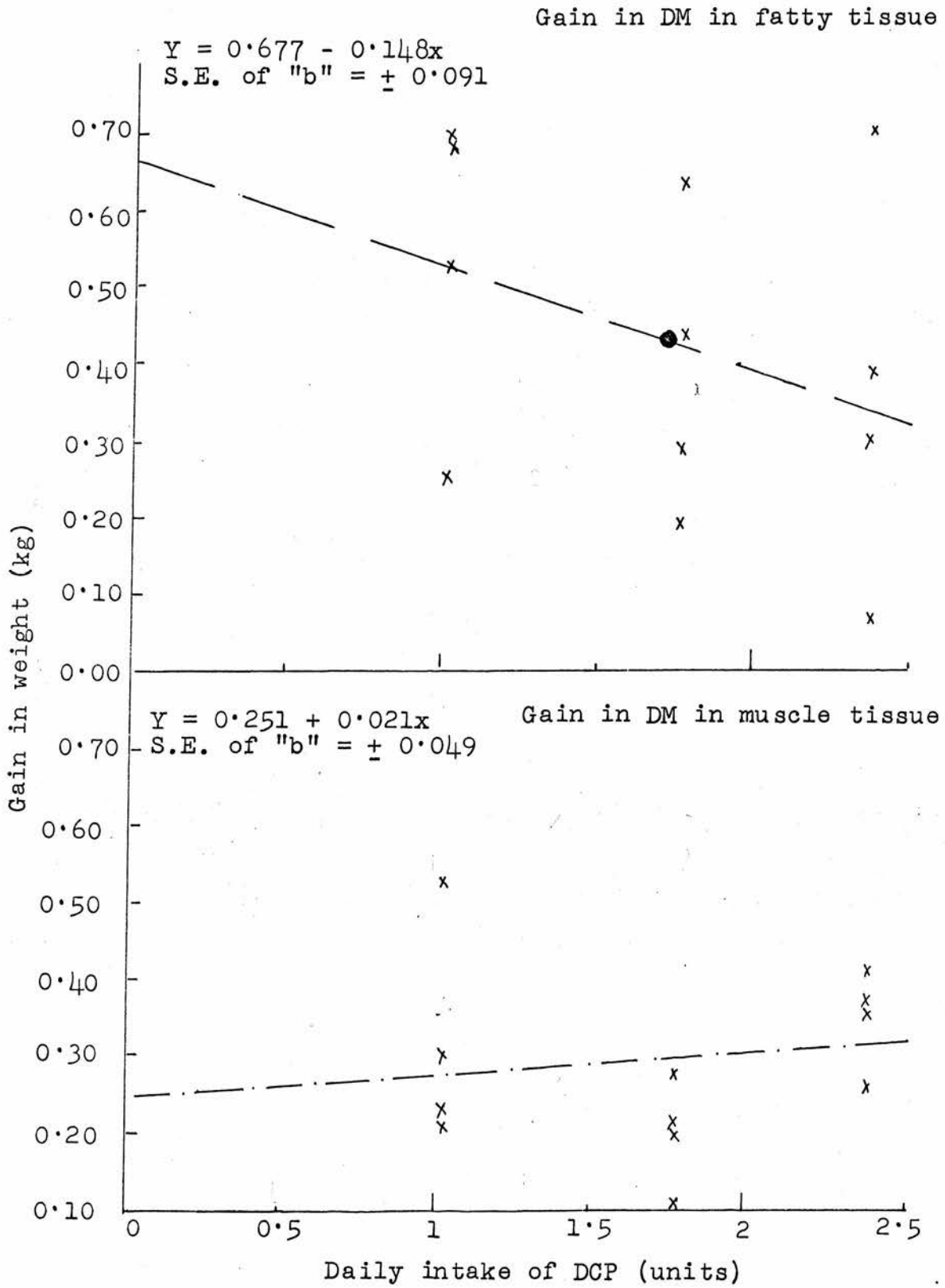


Fig. 13. The effect of level of dietary DCP on gain in weight of the ether extract in carcass tissues of B.F. wether lambs

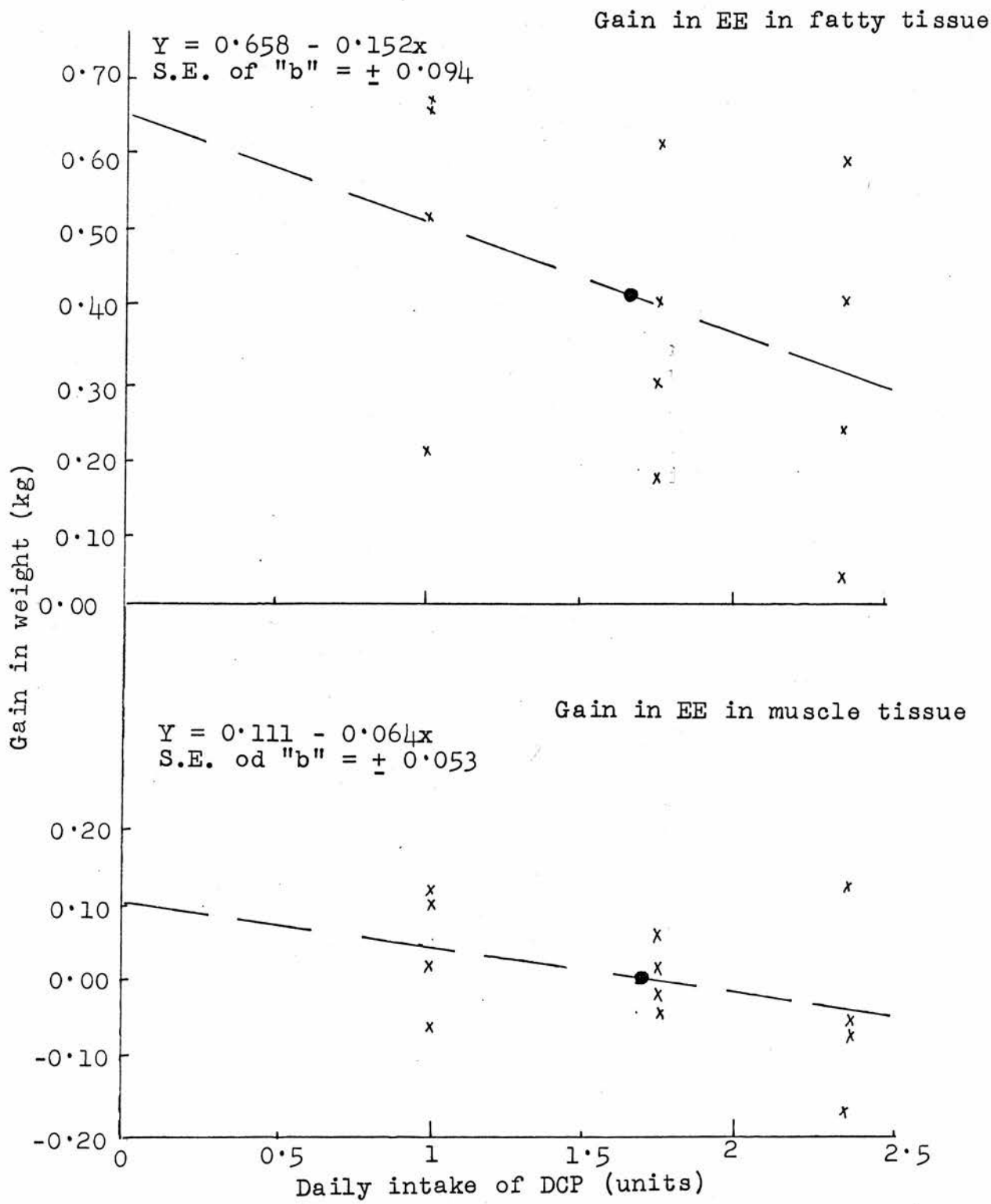
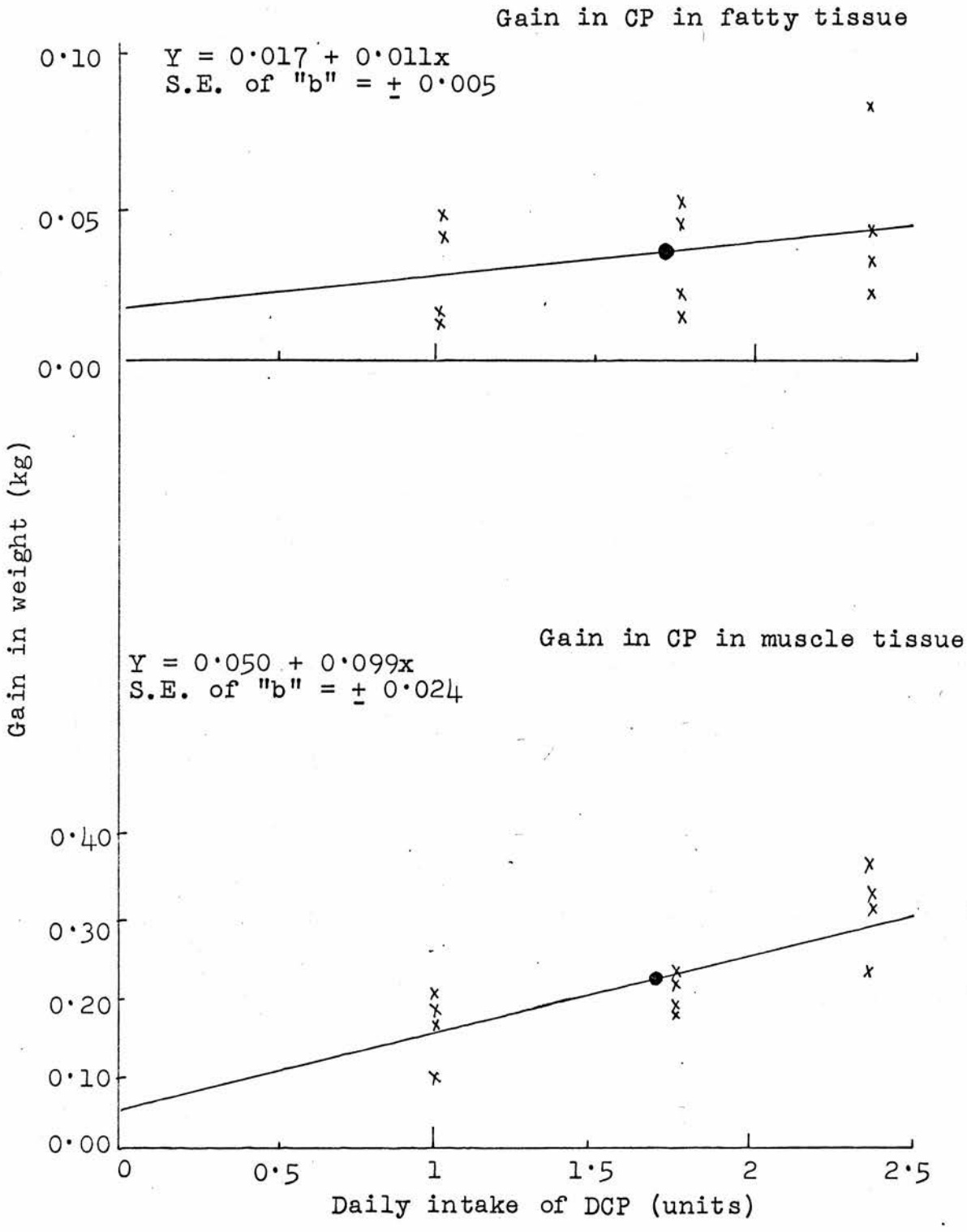


Fig. 14. The effect of level of dietary DCP on gain in weight of crude protein in carcass tissues of B.F. wether lambs

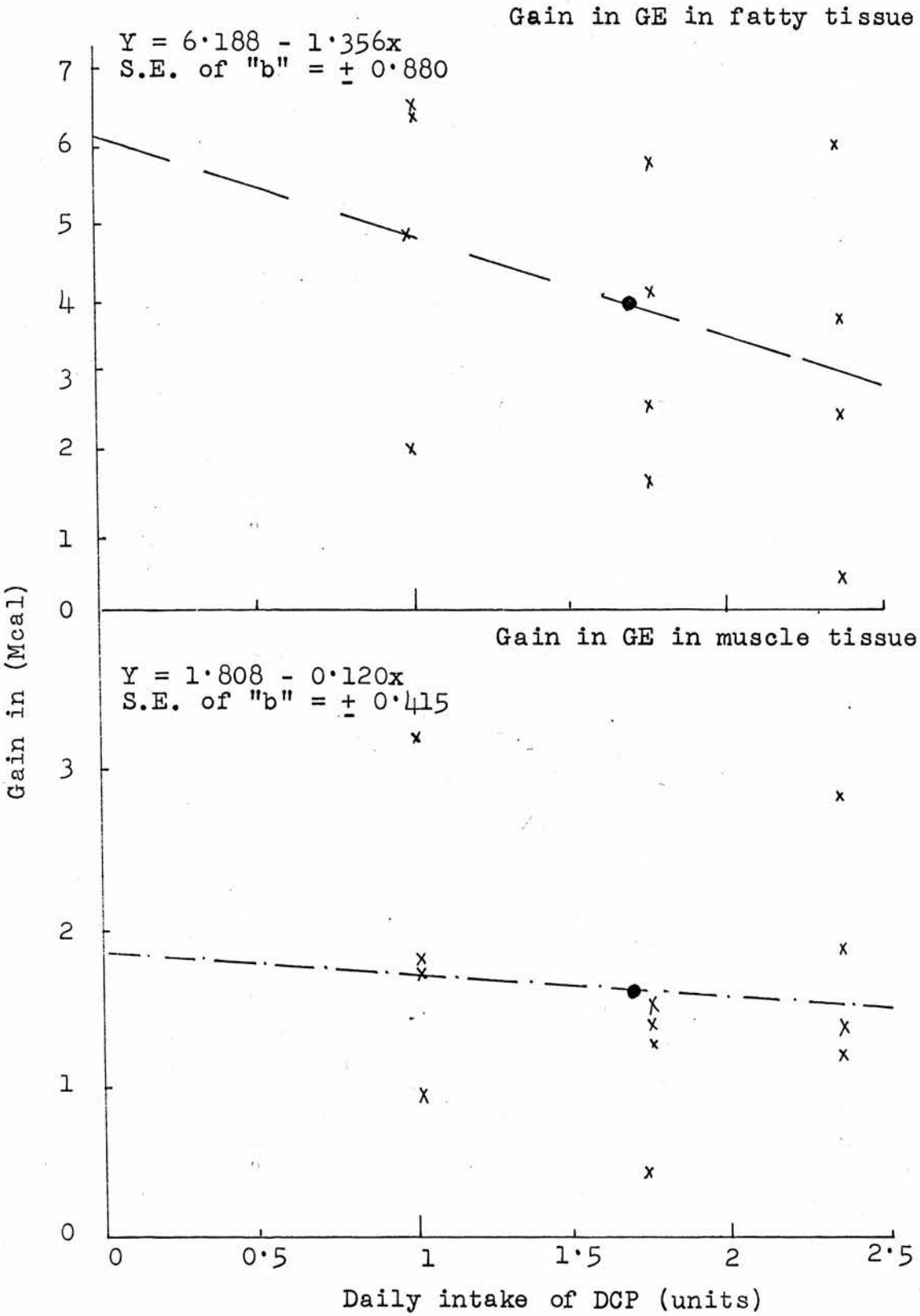


calculated by using values derived from the determinations of the caloric values for ether extract and for fat free dry matter extracted from the actual tissues of the experimental animals. (see method section). The weight of ether extract and weight of fat-free dry matter in the carcass were multiplied by the mean caloric values (see Table 7).

Figure 15 shows that when the level of protein intake of the isocaloric diet increased, there was a slight tendency for the gross energy in fatty tissue to decrease but not significantly so over the period of the experiment. The data shows that increasing the level of daily intake of DCP had no noticeable effect on the gain of gross energy in the muscle tissue.

The analysis of variance (Appendix III) for gross energy in fatty and in muscle tissues shows no significant ($p < 0{\cdot}05$) differences between groups.

Fig. 15. The effect of level of dietary DCP on gain in the gross energy (Mcal) of carcass tissues of B.F. wether lambs



D I S C U S S I O N

of

E X P E R I M E N T I

DISCUSSION

The effect of different daily intakes of digestible crude protein on the growth and development of lambs which have been given equal daily intakes of energy has not been extensively studied. This makes the findings of this trial of particular interest despite the limited number of animals involved.

The results showed the responses of the major body components to raising the level of DCP in isocaloric rations. The results were presented in graphical form in order to illustrate the strength of the response by the regression line and also the variability of the individual observations. With the small numbers used reliance on the significance of the regression coefficient or the between group differences limits the interpretation of the data. A review of the general pattern of the responses would appear to be more informative.

To assist in this collation Table 16 and Table 17 are presented. Table 16 classifies the responses in two ways. Firstly those which are significant from those approaching significance at the 5% level of probability from those non-significant. Secondly the classification of those responses which appear prominent and important from those which are small and unimportant with an intermediate group which falls between these two categories.

Table 16. The responses of body components to increasing levels of dietary protein in isocaloric diet classified on biological and statistical grounds.

	Significant*		Doubt		Non-significant	
Important response	S.E.B.	+	L.wt.	+	Fatty Tissue	-
	Warm carcass	+	Muscle tissue	+	EE in muscle	-
	Blood	+	Shoulder	+		
	Pluck	+	Muscle(shoulder)	+		
	Bone tissue	+	M.l.d.(loin)	+		
	Gigot	+	% CP in fat	+		
	Muscle (gigot)	+	DM in fat	-		
	Bone (gigot)	+	EE in fat	-		
	Bone (shoulder)	+	GE in fat	-		
	M. gastrocnemius	+				
	M. quadriceps femoris	+				
	M.l.d.(rib)	+				
	M. infraspinatus	+				
	% CP in muscle	+				
	CP in fat	+				
	CP in muscle	+				
Possible response	Muscle(kidney)	+	Feet	+	Pelt	+
	M. extensor digitorum	+	Kidney+perirenal fat	-	Head	+
	M.extensor corpi radialis	+	Fat (loin)	-	Caul fat	-
	M.supraspinatus	+	Perirenal fat	-	Neck	+
			M.gluteus medius	+	Shank	+
			M.psoas major	+	Fat (gigot)	-
			% DM in fat	-		
			% DM in muscle	-		
			% EE in fat	-		
			% EE in muscle	-		
Trivial response	Bone (loin)	+	M.biceps brachii	+	Gut	+
	Area of M.l.d.	+	Gut "fill"	-	Loin	+
					Rib	+
					Brisket	+-
					Flanks	+-
					Fat(shoulder	-
					Muscle(loin)	+
					Fat (rib)	-
					Muscle(rib)	+
					Bone (rib)	+
					Fat-thickness	-
					M. obliquus	+
					M.semitendinosus	+
					M.semimembranosus	+
					M.pectoralis	+
					M. brachialis	+-
					DM in muscle	+
					GE in muscle	-

* $P < 0{\cdot}05$
+ Positive response
- Negative response
+- No response

This classification shows that the gains in weight of some body components were significantly stimulated while the other showed only a minor response. Within the significantly stimulated components the magnitude of change ranged from appreciable (considered of probable commercial importance, e.g. warm carcass, bone tissue, gigot and muscle in the gigot) to trivial (components, although showing significant responses, having changes which were small and could be regarded as unimportant e.g. area of M.l.d. The variation in these measures was small.) The response of some body components to increasing level of dietary protein were noticeable but failed to reach significance at the 5 per cent level of probability, e.g. muscle tissue in the carcass, l.wt. and shoulder cut. This may be due to the big variation associated with these measures or to the limited number of the animals involved. However, under these experimental conditions there is still doubt as to whether such components can be stimulated by dietary protein. This will require further investigation.

The second table (17) is placed in the Appendix (III) and shows the regression coefficient with its standard error and the "F" value of the treatment effect on the groups along with the regression coefficient ("b") expressed as a percentage of the initial wt. of the component, thus giving an indication of the percentage response of the component. The responses of the individual tissues is the key to understanding the response of the composite organs and parts which were studied.

The major positive response was in bone tissue. The bone tissue of the carcass had a pronounced response to increasing the level of DCP while keeping the energy level constant. The head and feet (cannons) which are principally bony parts showed a lower response but none the less both were positive and definite.

Evidence from the literature has shown that restricting the dietary protein has a noticeable influence on the development of bone tissue. El-Maraghi et al. (1965) stated that bone rarefaction or osteoporosis in animals and humans were found to be associated with deficiencies of protein or calcium or both. Platt and Stewart (1962) reported that in the prevention or treatment of osteoporosis an increase in the protein value of the diet may be as important as, or more important than, supplementation with calcium. El-Maraghi et al. (1965) found that an increased intake of protein in the diets of rats, even when unaccompanied by extra intake of calories, led to the production of bones with a higher total weight of ash and increased radiographic densities and higher values for weight of ash/CM^3 of bone. Zeman (1967) reported that restricted dietary protein levels for rats during pregnancy depressed skeletal development of the offspring as evidenced by the decreased crown-rump length. It has been shown by McCance et al. (1942) and Mellander (1955) that low-protein diets depressed calcium absorption. However, in the experiment here described, lambs in different groups were given similar amount of calcium. It is suggested, therefore, that the decrease in the gain in weight of bone tissue in the low-protein level group of

lambs may be associated with a depression in calcium absorption.

It cannot be ruled out, however, that the experimental animals may have started the trial with a degree of osteoporosis which resulted in the accelerated growth of the bone tissue. The lambs had been reared on their mothers and had been run on low ground pasture before the trial commenced which make the supposition unlikely but unfortunately the histological and chemical status of the bones was not examined at the start of the experiment.

That the bone of the carcass showed a greater percentage response to increasing DCP at the levels used than did the head and the feet could be expected from the fact that these latter components are nearer to mature size at birth and have a high impetus for growth soon after birth. Similarly under the hypothesis put forward by Hammond (1932), Wallace (1948) and Palsson and Verges (1952a), that the most actively growing part at that time would be more stimulated or retarded by increasing or restricting the diet components, then different areas of the carcass bone might be differentially effected. Bone tissue in the gigot and the shoulder areas were strongly effected while bone in the rib and bone in the loin showed a smaller but quite definite response. Whether this reflects the different growth impetus of the spine as opposed to the limb bones at this time is an interesting point which cannot be ascertained from the present data. However the difference does indicate the possibility of a differential response to the increasing level of DCP.

The response of muscle tissue to increasing levels of DCP in isocaloric rations was not as high as bone tissue in the carcass

but in all observations of muscle tissue the response was positive. Total muscle tissue in the carcass did not respond significantly although the percentage response was about eight percentage - approximately half that of bone tissue in the carcass. The reason why muscle tissue did not respond as strongly as bone tissue may be due to the restriction of energy which has been shown to have little effect on bone development but may be important in muscle development.

Although the total muscle in the carcass failed to reach significance the muscle in the gigot joint and certain muscles in the gigot, spinal and shoulder regions reached or approached significance and made important responses. The kidney and muscles in the distal part of the limbs made significant but smaller responses while the area of the muscle longissimus dorsi and muscle in the loin and rib and the ventral muscles made only trivial responses.

The tendency for the gain in muscle tissue in the carcass to increase in weight gain as the daily level of protein increased in the energy constant diet is in agreement with the findings of Robinson and Lewis (1964) who showed that increasing the crude protein content from 11 to 19% produced a graded increase in the carcass lean content of pigs. Similar results were reported by Bowland and Berg (1959) and Aunan et al.(1961). Waldern (1964) has reviewed the work of many authors regarding the effect of dietary protein level on lean content of pig carcasses and suggests, in general, that at a constant energy level, the lean content of the carcass increases as the level of dietary protein was increased. Cooke (1967) has shown that, as the level of dietary protein was raised, the lean proportion in the pig carcasses appeared to increase steadily whereas the rate of growth fell off beyond a

certain point. This conclusion has been confirmed at different levels of energy.

Butterfield (1963a,b) has classified the muscles of the ox into early, average, late and very late developing on the basis of their proportional weight at birth to that at maturity. He indicated that the late developing abdominal muscles showed greatest response to restricted feeding and subsequent recovery. In the trial being reported with the exception of M. brachialis it was the muscles classified by Butterfield as early developing which showed the greatest response, significant at the 95 per cent level of possibility, i.e. M. extensor digitorum longus, M. extensor carpi radialis, M. gastrocnemius, M. infraspinatus and M. supraspinatus. The late developing muscles, i.e. M. transversus abdominis, M. gluteus medius, M. quadriceps femoris, M. semimembranosus and M. semitendinosus were less effected by protein level. The muscles of the spinal column (M. longissimus dorsi and M. psoas major) which were classified as average developing by Butterfield showed a tendency to increase in gain with increasing daily protein similar to the classified late developing muscles.

The question of why some muscles responded more than others cannot be completely answered on the basis of early and late maturing concept of individual muscles. It is well known that the various muscles of an animal differ considerably in the chemical composition, histology, shape, size and function (Lawrie and Pomeroy, 1963; Lawrie et al., 1964; Ramsbottom and Strandine, 1948; Goldspink, 1962a,b,c; Hammond, 1932; McDonald and Slen, 1959 and Joubert, 1956). For instance the nitrogen distribution, e.g. sarcoplasmic

nitrogen, myofibrillar nitrogen, stroma nitrogen and non-protein nitrogen differ between individual muscles (Lawrie, 1966) and this, together with differences in total nitrogen, reflects both quantitative and qualitative differences in the protein of different muscles. These extremely different characteristics of individual muscles effect their response to certain feeding regimes. There is evidence that particular food proteins go differentially into the various body proteins (Needham, 1964); for instance egg protein goes extensively into plasma proteins and beef protein into haemoglobin. Because of the similarity of the respective amino acid compositions between egg proteins and plasma protein and between beef proteins and haemoglobin, one might expect that feeding certain amounts of particular amino acids the muscles with high content of similar amino acids to those fed would respond more than those that have a lower proportion of these amino acids.

If the responses of individual muscles to certain feeding regime were related directly to their order of development then it would be expected that those muscles with the highest growth intensity at that time would be most effected. When interpreting the results on the basis of Butterfield's concept of order of growth it would appear that the responses of most of the individual muscles tested were not closely related to their order of development. However, the order of the relative development of muscles as suggested by Butterfield (1963a) cannot be completely accepted. The animals used for his study differed widely in age, breed and nutritional history which makes the interpretation of the data into a growth theory unreliable. Evidence that muscle development takes place fairly uniformly over the carcass after the first few months of life

must also be considered. Jackson (1968) found that the rate of development of the muscles of the hind leg of Blackface lambs grew from weaning to maturity was not different from that of the muscle in the whole carcass.

These findings suggest that the responses of individual muscles to certain feeding treatments depend on the characteristics of the muscle and the nature of the diet and the degree of similarity between the two rather than the order of development of the muscles. Unfortunately in this study neither the muscles nor the rations were critically examined particularly for their amino acid composition. This would be worthy of further study.

Muscle tissue was not the only component high in protein content to be expected to respond to higher intakes of dietary protein. The blood and pluck made important and significant responses while the alimentary tract made only a trivial and non-significance response. The response of the pelt was noticeable but nonsignificant and considering its high protein content this finding was not in keeping with what might have been expected.

The increased gain in weight of blood as the daily intake of protein was increased could have been expected if the protein had a direct effect on protein containing tissues. Blood contains 95% crude protein in the dry matter (Milford, 1961). The response to the three protein levels used indicated that the ceiling of protein intake had not been reached for increasing blood weight. It might be expected that blood volume would be closely related to the quantity of muscle and bone tissues in the body.

The pluck was also significantly effected by the level of daily dietary protein. Hamilton (1939), Allison et al. (1962) and Zeman

(1967) found that decreasing the nitrogen intake for rats had a pronounced effect of restricting the development of the liver. Since the liver constitutes a high proportion of the pluck it could be responsible, at least in some measure, for the increase in gain in pluck weight. The other two major components of the pluck weight are the heart and the lungs. Zeman (1967) has shown that the heart was more resistant to protein deficiency than the liver. The lungs, composed of epithelial, connective and muscle tissue, may be expected to respond differently to liver and heart tissue but unfortunately these weights were not recorded separately.

The non-protein constituents in the wool have been shown by Hudson (1954) to represent not more than 1 per cent. Milford (1961) has shown that the crude protein value of the skin plus fleece ranged in lambs from 80-88 per cent. In the present study the pelt was a combination of fleece plus skin and although the separate observation was not made, the pelt could be expected to contain a high proportion of protein. If the action of increasing the daily intake of DCP is an overall effect on all protein containing tissues, then it would be expected that the pelt would be effected. While in the present study the effect did not reach statistical significance ($p < 0{\cdot}05$), increasing the daily intake of DCP did have a marked effect on the gain in weight of the pelt.

Fatty tissue, both of the carcass and that surrounding the internal body organs, gave a negative response. In terms of percentage reduction in response with increasing levels of DCP most of the observations were large and important but due to the inherent variability of fatty tissue few of these achieved significance at the 5 per cent level of probability. The percentage reduction in fatty tissue response was as high as the positive response of bone tissue. The caul fat was even more reduced as was the kidney fat.

Fatty tissue of the loin was also noticeably effected as was fat in the rib, gigot and shoulder joints, to a lesser extent. Fat thickness was not greatly effected by the treatment.

The associated tendency for the gain in weight of fatty tissue in the carcass to decrease with increasing daily intake of protein and having a constant daily energy supply suggests an alteration in the processes of digestion and resulting digestion products. The studies of Forbes et al. (1935b), Hogan et al. (1935), Johnson et al. (1936) and Hamilton (1939) have shown that rats fed high dietary protein levels in equicaloric diets gained less fat than those fed low dietary protein levels. Robinson and Lewis (1964) and Holme et al. (1965) have shown similar results with pigs.

These findings suggest that when protein intake limits muscle and bone development the surplus energy is retained in the fatty tissues. When protein intake is increased the energy is used to service the building of muscle and bone tissues with a reduction in gain of fatty tissue. Protein synthesis from its constituent amino acids is energetically expensive. Kielanowski (1966a) stated that the energy cost of protein deposition is about 7·5 Kcal metabolizable energy per 1 g protein deposited. It has been observed (Kielanowski, 1966b) that a greater protein deposition was frequently accompanied by a higher maintenance cost.

The recent work by Hunter (1968) showed that growth hormone mobilised stored energy by increasing the release of non-esterified fatty acids from adipose tissue to service the synthesis of protein. There is evidence that dietary protein enhances the secretion of growth hormone. It may be that increasing the level of dietary protein resulted in an increase in growth hormone level in the body.

These basic effects of increasing the daily dietary intake of protein while keeping the supply of energy constant have a compound effect on the composite carcass and body measurement. The positive response of bone and to a lesser extent muscle offset the negative response of fatty tissue to give the warm carcass an important and significant positive response. Added to this, the response of blood, feet, head and pluck more than offset the decline in response in caul fat to indicate that S.E.B. responded significantly to the increasing protein level. The small but negative response of gut "fill" reduced the response as measured by live weight, to one of doubtful significance and perhaps doubtful importance. This emphasises the difficulties of interpreting responses of composite measures for composite measures may contain positively and negatively stimulated components which misinterpret the real effects of certain treatments. The lack of significant of live weight response to dietary protein has been shown by other workers to occur in pigs (Robinson and Lewis, 1964 and Holme et al., 1965) although the carcass composition in these experiments was markedly effected.

On balance the positive response of the bone and muscle tissue outweighed the negative response of fatty tissue to modify the response of the retail cuts. The gigot joints achieved, while the shoulder joints approached, significance at the 5 per cent level. Both showed noticeable responses as did the foreshank and negatively, the kidney plus perirenal fat. The other joints of loin, rib, brisket, neck and flank showed no noticeable stimulation to protein level of the diet. These findings can be partially explained by the differential stimulation of the tissues. It has been shown that bone and muscle tissues were more stimulated than fatty tissue hence one would expect those joints with a high proportion of muscle and

bone to be increased more than those with a high proportion of fat. The shank has a high proportion of muscle and bone; the gigot has a small quantity of fatty tissue while the loin, rib, brisket and flank have a high proportion of fatty tissue. The neck has a high proportion of bone which does not appear to have been stimulated as total carcass bone and which seems to behave similarly to the bone of head and feet. However the great variability in the separation of the joint makes this supposition unreliable. The tendency for the shoulder to increase in gain as the daily intake of protein was increased may also be due to the tissue proportions which are similar to those of the carcass as a whole. This explanation ignores any genuine differential stimulation of anatomical areas as opposed to differential stimulation of the tissues.

If there was a differential stimulation of parts of the carcass it would be expected from the hypothesis of Hammond (1932) and Wallace (1948) that those parts actively growing at the time would be most effected. In the final fattening phase the late developing parts would be most effected. Hammond (1932), Walker and McMeekan (1944) and Palsson (1955) supposed the lumbar region to be the latest developing area but their lumbar region (loin) combined a section of the body from the dorsal to the ventral region which misled the interpretation of the findings. Butterfield (1963b) showed that in the musculature of the ox the distal muscles of the legs were early maturing while the abdominal area was the last to develop. If protein had effected parts differentially it would be expected that the flank and the proximal areas of the legs would be most effected. However, if dietary protein acts by decreasing fat deposition then the flank would not be shown to make its expected late

developing gain. By stimulating bone and muscle tissue, particularly in the proximal region of the legs, then the shoulder and gigot would be expected to be increased more than the others. This does not explain the increase in the shank which should have been an early developing part with reduced growth impetus in the later stages. The findings suggest that the differential tissue response is the most dominant factor in explaining the demonstrated differential response in the retail joints and that it is not sensible to discuss differential growth of parts of the carcass without reference to the tissue proportions.

Considering the major tissues of the retail cuts showed that they generally followed a similar pattern to the tissues totalled in the half carcass. Gain in bone tissue in the gigot, shoulder and loin was significantly increased while bone in the rib joint tended to increase but did not reach significance. The strong relationship between the bone in each joint and total bone has been reported by many workers (Barton and Kirton, 1958; Khandekar et al., 1965a, and Timon and Bichard, 1965a).

Gain in muscle tissue in the gigot was greatly stimulated by the increased daily intake of protein while that in the shoulder showed a noticeable but non-significant increase. The gain in muscle tissue in the rib and loin joints were only slightly increased by raising the daily level of protein. The finding that the loin was less stimulated than the gigot over this fattening phase is at variance with Hammond's theory of centripetal growth unless this phase of growth can be regarded as only leading up to the final phase. With equal daily energy intake the allocation of nutrients for muscle development seems to go to the gigot and the shoulder region.

Butterfield (1963b), however, found no evidence that the centripetal waves of growth terminated in the loin or lumbar region and suggested that the late developing muscles appear to be centred in the abdominal region. The abdominal muscles may, however, have an individual pattern of behaviour because of their loose nature and their close association with impregnated fatty tissue.

The gain in fatty tissue in the retail cuts show that the level of dietary protein has only a small differential effect. The fatty tissue of the perirenal fat, loin and gigot joints relatively showed the greatest reduction in gain to increasing daily intakes of protein. This is in accordance with the findings of Holme et al. (1965) who found that in pigs the percentage of separable fat in leg and loin decreased as the level of dietary protein increased. The gain in weight of fatty tissue in the shoulder and rib joints, caul fat and fat thickness over the 12th rib showed only slight response to the dietary protein level.

In order to understand the mode of action of protein stimulation the chemical analysis of the tissues was undertaken. The percentage dry matter in the fatty and muscle tissue tended to decline with increasing intakes of dietary protein both approaching significance. This fell due to the decline in the percentage of ether extract in both tissues was interesting. The actual C.P. in the muscle and fatty tissue did increase with the increasing levels of dietary protein and this was offset by the reduced response of ether extract. The gross energy in the fatty tissue declined while the gross energy of the muscle tissue showed little change. These findings are in keeping with the results of other workers. Holme et al. (1965) found that the percentage of ether

extract in the loin and leg muscles decreased as the level of dietary protein was increased. Wagner et al. (1963) have shown that the nitrogen content of the muscle tissue of pigs increased while intramuscular fat decreased as the level of dietary protein was increased. The results show that gain in fresh weight of the body tissues does not reflect the changes which may be taking place within the tissues.

On examination of the actual gain in these components shows that gain in dry matter was reduced in the fatty tissue as the daily level of protein increased while the dry matter gain in muscle tissue showed no noticeable trend. In muscle tissue the gain in weight of the crude protein (significant $p < 0.05$) offset the reduction in gain of ether extract but in fatty tissue the greater reduction in gain of ether extract could not be compensated for by the smaller increase in crude protein in the fatty tissue. The increase in gain of crude protein in the muscle tissue was also associated with the greater increase in moisture which led to the increased gain in weight of total fresh muscle tissue.

The associating of ether extract, particularly in the muscle tissue, with eating - cooking quality of meat has been pointed out by many workers (Cover et al., 1956 and Cook, 1963). Whether other factors such as tenderness and juiciness have been effected by increasing the daily intake of protein was not examined but could be of major interest for consumer acceptance studies.

It can be concluded that dietary protein stimulated bone and to a smaller extent effects muscle production while at the same energy level more energy is needed to service the protein and less is available for fatty tissue production. These changes are

the major factors in explaining the differences in response of the various body components and organs. However there still remains a possibility of distribution changes.

E X P E R I M E N T II

EXPERIMENT II

THE EFFECT OF LEVEL OF DIETARY ENERGY ON BODY COMPOSITION OF BLACKFACE WETHER LAMBS

The experiment was designed to study the effect of level of daily intake of energy in two parts.

Part (a) looked at the effect of three levels of daily dietary energy on the body composition of lambs slaughtered after equal days on feed.

Part (b) looked at the effect on body composition of feeding three levels of daily energy to animals which were slaughtered after they had consumed equal amount of energy and hence fed for different number of days.

PROCEDURE

Animals

In 1966, twenty-five Blackface wether lambs of the same type and weight as used in Experiment I were taken after weaning and run on lowground pasture till November 21st. Because of the high variation in gut "fill" of animals in the protein experiment, in this trial, an attempt was made to standardise gut "fill" by feeding a standard diet for 10 days before the actual feeding trial commenced. This diet included the components of the experimental rations providing 1,638 Kcal of metabolizable energy daily and 100 g of digestible crude protein daily. On December 1st the lambs were split into four groups of lambs in order of their weight with the one lamb remaining (the heaviest) to be allocated to the initial

slaughter group. The lambs in each weight group were allocated at random to one of six treatment groups. This gave one group of five lambs (initial slaughter group) and five groups of four lambs for the feeding trial.

The groups were given the following treatments:-

Group I - Initial slaughter group (5 lambs) from which to predict the body composition of the other lambs at the start of the trial.

Group A - Four lambs fed a ration of low daily intake of dietary energy and slaughtered after 91 days.

Group B - Four lambs fed a ration providing a medium daily intake of dietary energy and slaughtered after 91 days.

Group C - Four lambs fed a ration providing a high daily intake of dietary energy and slaughtered after 91 days.

Group D - Four lambs fed the same daily rations as group A but fed for 140 days before slaughter.

Group E - Four lambs fed the same daily ration as group B but were slaughtered after 112 days.

Table 9 shows the liveweight of the lambs at the start of the experiment.

TABLE 9

The fasted liveweight (kg) of the lambs at the start of the experiment allocated to the prescribed feeding regimes

Initial	Groups A	B	C	D	E
35·41	-	-	-	- -	-
31·78	30·87	31·78	32·69	31·33	31·33
29·51	29·51	30·42	30·87	29·96	30·42
28·60	28·60	28·15	29·06	29·96	29·51
25·88	25·88	24·97	27·24	28·15	26·33
Mean 30·24	28·72	28·83	29·97	29·85	29·40

The initial slaughter group were taken away after weighing and the slaughter procedure (as described previously) was operated. The remaining lambs were individually penned and fed their experimental rations. The trial started on the 1st December, 1966.

Feeding trial

The four main sources of feeding stuffs were chopped hay (2-3"), bruised barley, soyabean meal and molassine meal. The chopped hay was weighed out separately into plastic bags. The concentrates were mixed together into the three different mixes and were weighed out daily as required.

The rations were formulated to keep the daily intake of Digestible Crude Protein constant for all groups while giving three different levels of dietary energy daily.

Table 10 shows the composition of the rations - rations D and E duplicating rations A and B respectively.

TABLE 10

The composition of the rations fed to the five groups of Blackface lambs expressed as percentage dry matter

Ingredient	Treatment				
	A	B	C	D	E
Chopped hay	16·9	13·8	11·5	16·9	13·8
Molassine meal	16·9	13·8	11·5	16·9	13·8
Bruised barley	47·0	60·4	71·1	47·0	60·4
Soyabean meal	16·9	9·9	4·3	16·9	9·9
Mineral mixture*	2·4	2·0	1·6	2·4	2·0

* The daily intake of mineral mixture was the same for each group and was as follows:

Component	Daily amount
Vit A	2,000 iu
Vit D	500 iu
NaCl	2 grms
KI	0·2 mg
$CoSO_4$	0·72 mg
Limestone flour	14 grms

The rations gave the daily intakes of metabolizable energy and digestible crude protein as shown in Table 11.

TABLE 11

The daily intake of metabolizable energy and digestible crude protein of the groups of lambs

Treatment	ME Kcal	DCP
A	2040	92
B	2610	92
C	3185	85
D	2040	92
E	2610	92

The total quantity of ME fed to groups C, D and E was approximately 289 Mcals.

The daily intake of metabolizable energy and the digestible crude protein of the three rations were determined by digestibility trials similar to those reported for the protein experiment.

The daily rations were fed in two equal parts - half at 9 am and half at 4 pm. Feed residues were collected separately and reintroduced to the animal gradually. All lambs consumed the total amount of feed estimated for it over the period and as near as possible to the daily level decided for it as variation in appetite would allow.

The animals were weighed at two weekly intervals.

Digestibility of the diets used for varying the daily intake of energy

The mean values of the coefficients of digestibility of energy and crude protein and their standard errors are given for the three experimental diets in Table 12. The mean digestibilities of crude protein were lower at the higher levels of energy intake. The differences were highly significant ($p < 0{\cdot}01$) between diet (high level of energy) and all other diets. The difference between diet A (low level of energy) and diet B (medium level of energy) did not reach significant levels at 5%. The mean digestibilities of energy were similar for all diets.

TABLE 12

The mean values and standard errors of the digestibilities of energy and crude protein for the groups of three lambs on each of the experimental diets

Diets	Energy Digestibility %	Crude protein Digestibility %
A	66·24 ± 0·71	76·91 ± 0·84
B	68·27 ± 0·53	74·63 + 0·62
C	68·28 ± 1·31	67·57 ∓ 0·33

There was a high and negative correlation between the level of feeding (expressed as a multiple of the maintenance level) and the digestibility of crude protein (percentage) of the rations. The correlation coefficient "r" of this relationship was -0·753.

The regression equation which describes the relationship was found to be:

% digestible crude protein = 109·32 - 15·57 L

where L is the energy level as a multiple of probable maintenance requirement 65 Kcals/Kg $W^{0.73}$ (W = fasted liveweight). The standard error of the regression coefficient "b" was ± 5·15. The equation shows that as the level of energy increased the digestibility of crude protein (%) decreased. Hale et al. (1940) and Truter and Lauw (1950) reported that the apparent digestibility of crude protein decreased as the plane of nutrition was increased.

The digestibility of dietary energy showed no relationship with the levels of energy intake. This result is in close agreement with that obtained by Garrett et al. (1959) with lambs, Hill and Anderson (1958) with chicks, Forbes et al. (1946) with rats and Zivkovic and Bowland (1963) and Jenkinson et al. (1967) with pigs.

The caloric value of extracted fat and fat free dry matter

The caloric value of the ether extract and of the fat free dry matter (ether extracted residues) was determined on samples taken from the different groups. The results are given in Table 13.

TABLE 13

The caloric value (Kcal/g) of ether extract (EE) and of fat free dry matter (FFDM) of samples taken from the different groups of Blackface wether lambs

Energy value of Fat (EE)		Energy value of (FFDM)	
Group	Kcal/g	Group	Kcal/g
Initial	9·25	Initial	5·26
"	9·37	"	5·26
"	9·56	A	5·31
A	9·33	"	5·26
"	9·37	B	5·28
B	9·17	C	5·25
C	9·18	E	5·21
E	9·30		
"	9·14		
Intermuscular fat	9·10		
Mean	9·28	Mean	5·26
S.E. of mean	±0·04	S.E. of mean	±0·01

The caloric values of the samples of (EE) and (FFDM) shown in Table 13 did not differ greatly from each other so that the mean value of all the samples was used in determining the caloric value of the different joints from their chemical analysis. The mean value for ether extract (9·28 Kcal/g) was 0·64 per cent less than the value (9·34 Kcal/g) found in Experiment I while the mean value for FFDM (5·26 Kcal/g) was 2·95 per cent less than its corresponding value (5·42 Kcal/g).

The determination of the caloric value for head, feet, bone and blood

TABLE 14

The caloric values for head, feet, bone, blood and pelt for different groups of Blackface wether lambs fed different levels of ME (Kcal/g dry matter).

Groups	Head	Feet	Bone	Blood	Pelt
Initial	5·09	4·82	4·68	5·56	5·55
A	4·72	4·57	4·58	5·69	5·73
B	5·29	4·90	4·56	5·67	5·50
C	5·03	4·45	4·54	5·62	5·50
E	4·69	4·76	4·52	5·37	5·55
D	4·76	4·66	4·58	5·54	5·65
Mean	4·93	4·69	4·58	5·58	5·58
S.E. of mean	±0·10	±0·07	±0·02	±0·05	±0·04

Table 14 shows the caloric values of the body components as determined from composite samples from each group of lambs. For head, feet and carcass bone the group value was used in determinations of total gross energy of each group but in blood and pelt, because of the lack of variation between groups, the mean of all the determinations for these components was used.

The estimation of the composition of the body and carcass of the treatment groups from the representative initial slaughter group

Because of the variation in liveweight of the lambs in each group those components which showed a strong relationship ($p < 0·05$) with liveweight (Table 15) were estimated by fitting the liveweight into the estimating equation derived from the initial slaughter group.

TABLE 15

The correlation coefficient, regression equations and standard errors of regression coefficient of the significant relationships between liveweight (kg) and body components (kg) of the initial group

Components	Regression equation	S.E. of "b"	"r"
S.E.B.	Y = 0·751X - 0·19	±0·107	+0·971
Warm carcass	Y = 0·554X - 2·53	±0·113	+0·943
Pluck	Y = 0·052X - 0·18	±0·004	+0·993
Muscle tissue	Y = 0·139X - 0·23	±0·018	+0·975
Bone tissue	Y = 0·43 + 0·033X	±0·011	+0·879
Gigot	Y = 0·091X - 0·39	±0·018	+0·946
Shoulder	Y = 0·097X - 0·42	±0·020	+0·940
Muscle (gigot)	Y = 0·057X - 0·19	±0·008	+0·961
Muscle (shoulder)	Y = 0·055X - 0·24	±0·011	+0·946
Bone (rib)	Y = 0·008X - 0·02	±0·002	+0·883
M. quadriceps femoris	Y = 0·012X - 0·06	±0·002	+0·953

X = liveweight (kg)

Those components not showing a significant relationship with liveweight were estimated by using the mean weight of that component derived from the initial slaughter group.

RESULTS

of

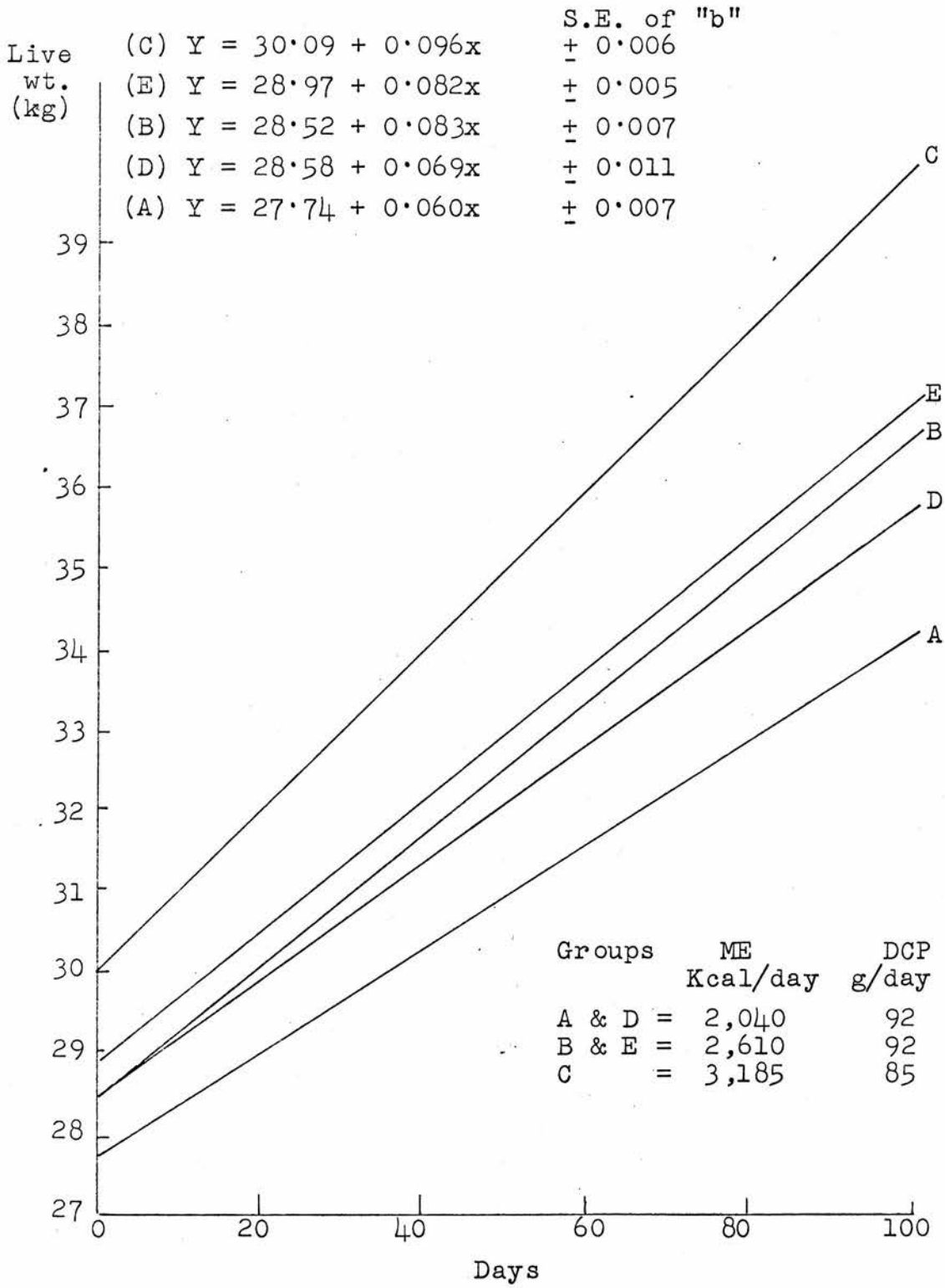
EXPERIMENT II

RESULTS

The effect of level of daily intake of metabolizable energy on live weight

Increasing the daily intake of metabolizable energy had a significant effect on the live weight gain of the groups of lambs. The regression coefficients (Figure 1) of live weight increasing with time (no. of days) indicated that there was a significantly ($p < 0{\cdot}05$) greater increase in live weight of animals fed the highest daily intake of energy (group C = 3,185 Kcal/ME) than those fed the low daily level of energy (groups A and D = 2,040 Kcal/ME). The intermediate levels of daily energy intake (groups B and E 2,610 Kcal/ME) were intermediate in response but the differences with the extreme treatments did not reach significance at the 5 per cent level of probability. There were small differences in the gains of live weight of the groups fed similar levels of energy but neither of these approached significance at the 5 per cent level. The high level of daily energy intake (group C) might be expected to increase live weight by 9·6 kg, the intermediate level (groups B and E) 8·3 kg and the low level (groups A and D) between 6·0 - 6·9 kg per 100 days.

Fig. 1. The linear relationship between live weight (kg) and number of days fed in B.F. wether lambs which had different levels of daily intake of ME and similar levels of daily intake of DCP



PART (a)

THE EFFECT OF LEVEL OF DAILY INTAKE OF METABOLIZABLE ENERGY ON BODY COMPOSITION AND CARCASS CHARACTERISTICS OF BLACKFACE WETHER LAMBS SLAUGHTERED AFTER EQUAL DAYS ON FEED

The effect of level of daily intake of dietary ME on gain in weight of live weight components

Figures 2a and 2b show the effect of increasing the daily intake of metabolizable energy on the gain in weight of live weight components. As the daily ME intake increased the gain in weight of live weight and of S.E.B. increased significantly ($p < 0{\cdot}05$). The gain in pelt tended to increase in weight with increasing level of daily intake of ME and while this relationship did not reach significance at the 5 per cent level it was approaching significance at this level. There was no definite increase on the gain in weight of the alimentary tract "fill" as the daily intake of ME increased.

The regression coefficients of the rate of increase of these body components with the increase of daily ME intake are shown on the graphs. The data suggests that for each unit of ME increase at the constant level of DCP reported, live weight and S.E.B. might be expected to increase their weight gains by 6·49kg and 5·05 kg respectively over a feeding period of 91 days.

On comparing the differences between groups the analysis of variance (Appendix IV) for live weight and for S.E.B. were similar. In both these body components, the C group of lambs (high level of

Fig. 2a. The effect of level of dietary ME on gain in weight of live weight components of B.F. wether lambs

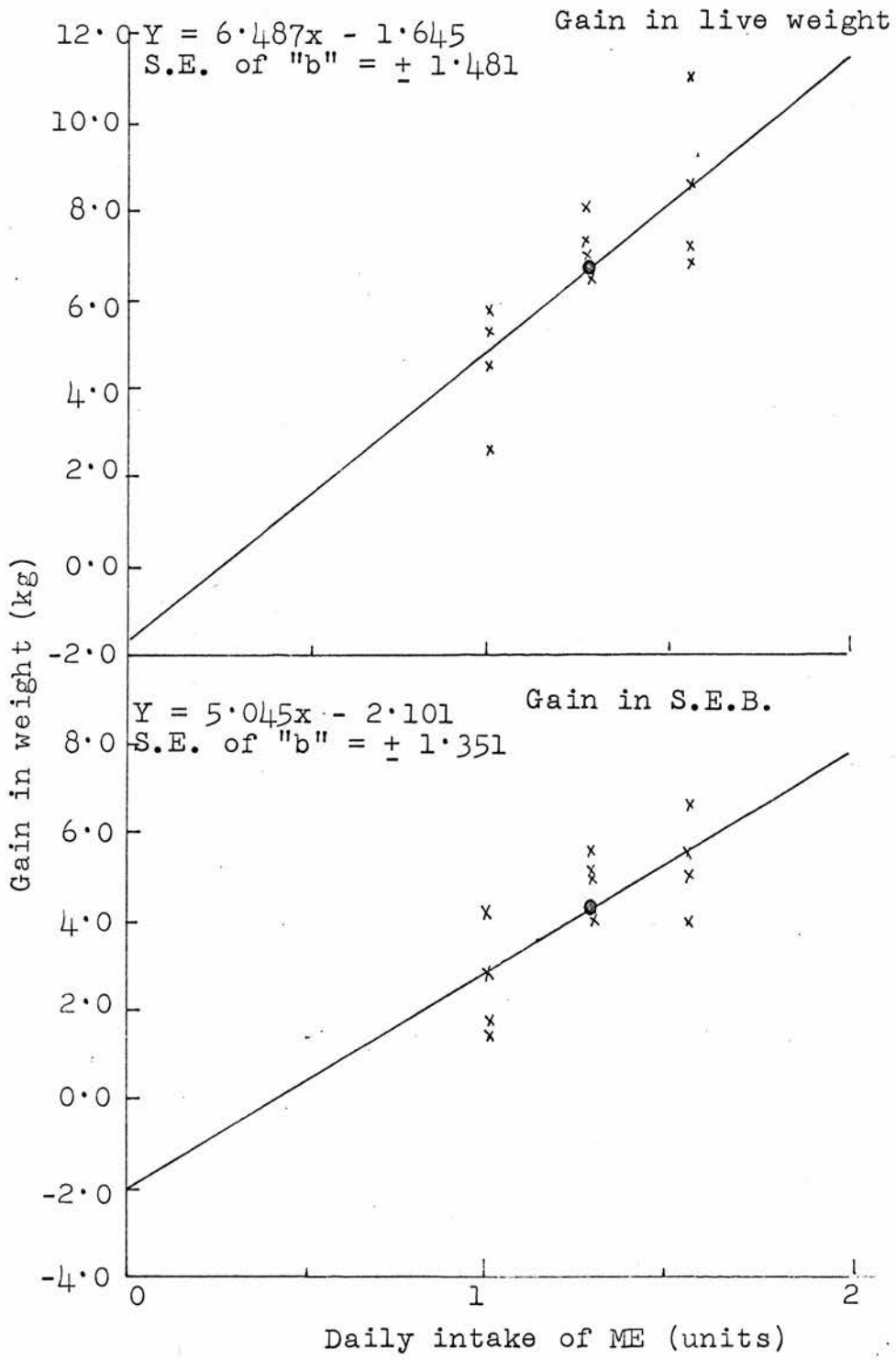
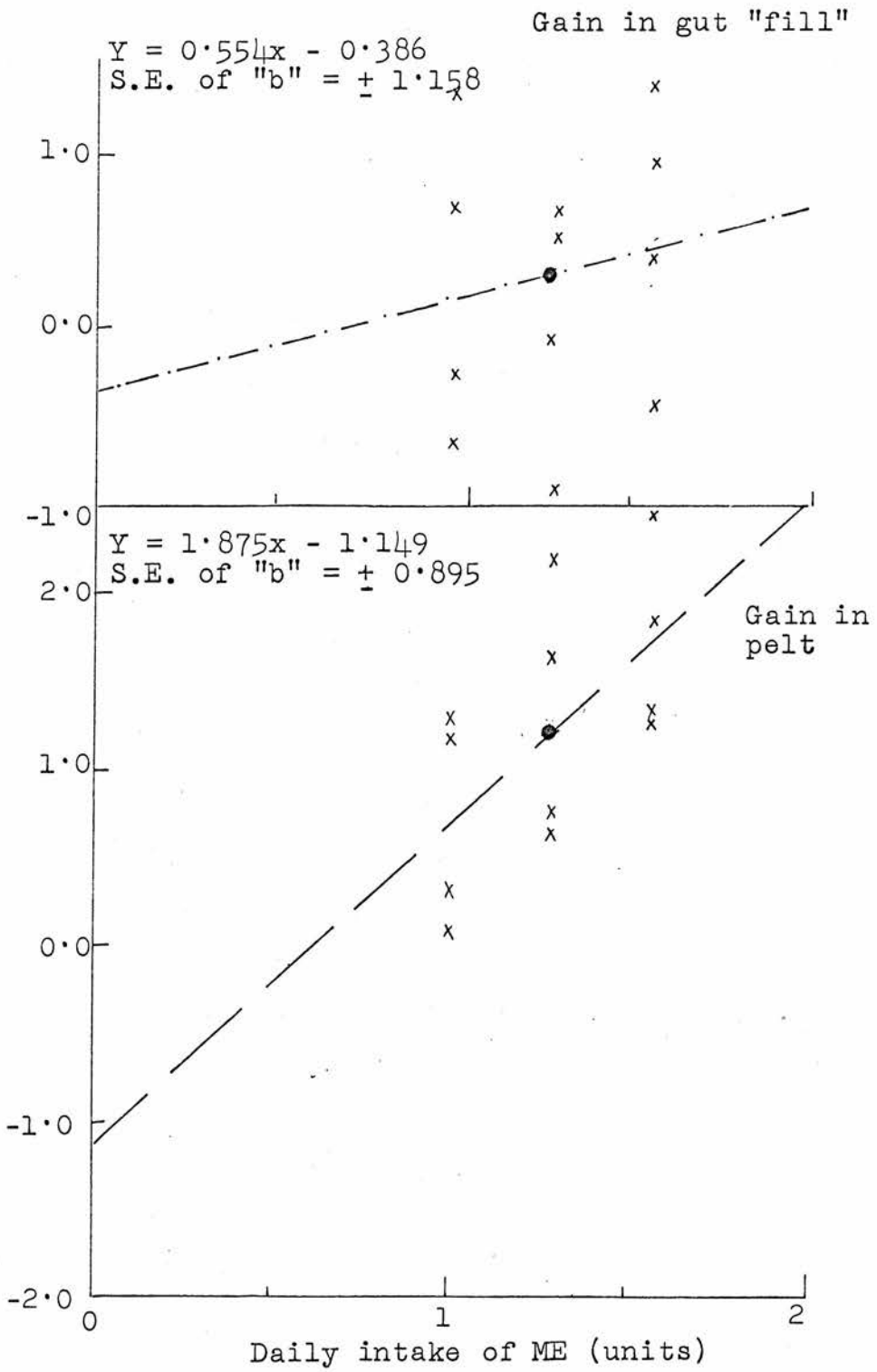


Fig. 2b. The effect of level of dietary ME on gain in weight of live weight components of B.F. wether lambs



ME) was significantly ($p < 0{\cdot}05$) greater than the A group (low level of ME). The differences between groups B (medium level of ME) and A were significant at the 5 per cent level of probability. Groups C and B did not differ significantly at the 5 per cent level. The differences between groups for pelt and "fill" did not reach significance at the $p < 0{\cdot}05$ level.

The effect of level of dietary ME on gain in weight of standard empty body components

Figures 3a, 3b and 3c show that as the daily level of ME increased the gains in weight of warm carcass and caul fat were also increased significantly ($p < 0{\cdot}01$ and $p < 0{\cdot}05$ respectively). There was a tendency for the gain in blood to be increased in weight with increasing level of daily ME intake but this relationship did not reach significance at the $p < 0{\cdot}05$ level. Increasing the daily intake of ME showed no noticeable effect on the gain in weight of feet, head, pluck and "gut".

The regression equations of the relationships of these S.E.B. components with level of ME intake show that, at the level of energy used, for each unit of energy increase gain in weight in warm carcass and in caul fat might be expected to increase by 3·98 kg and 0·83 kg respectively over a period of 91 days.

On testing differences between groups the analysis of variance (Appendix IV) for warm carcass showed a highly significant ($p < 0{\cdot}01$)

Fig. 3a. The effect of level of dietary ME on gain in weight of standard empty body components of B.F. wether lambs

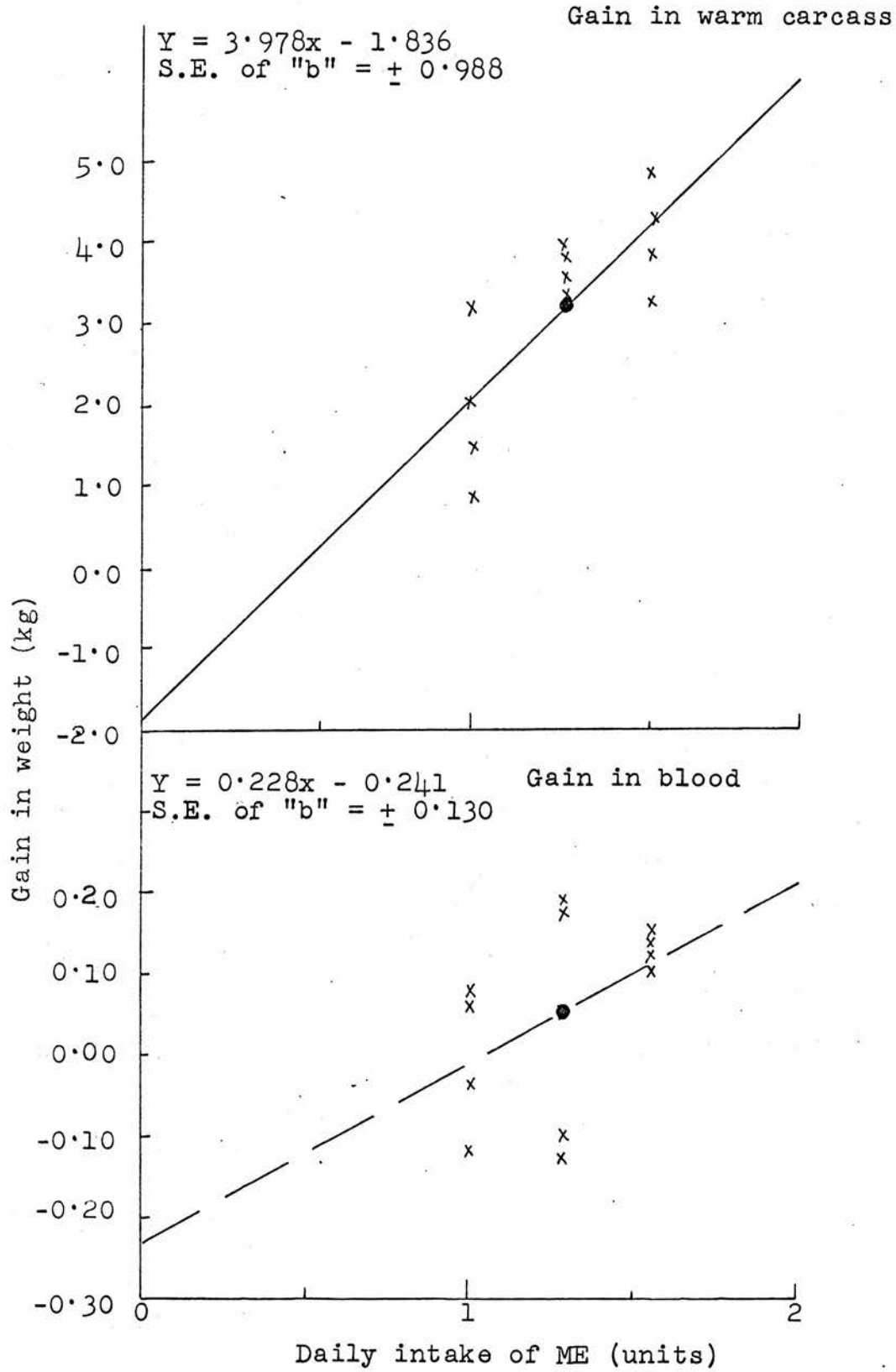


Fig. 3b. The effect of level of dietary ME on gain in weight of standard empty body components of B.F. wether lambs

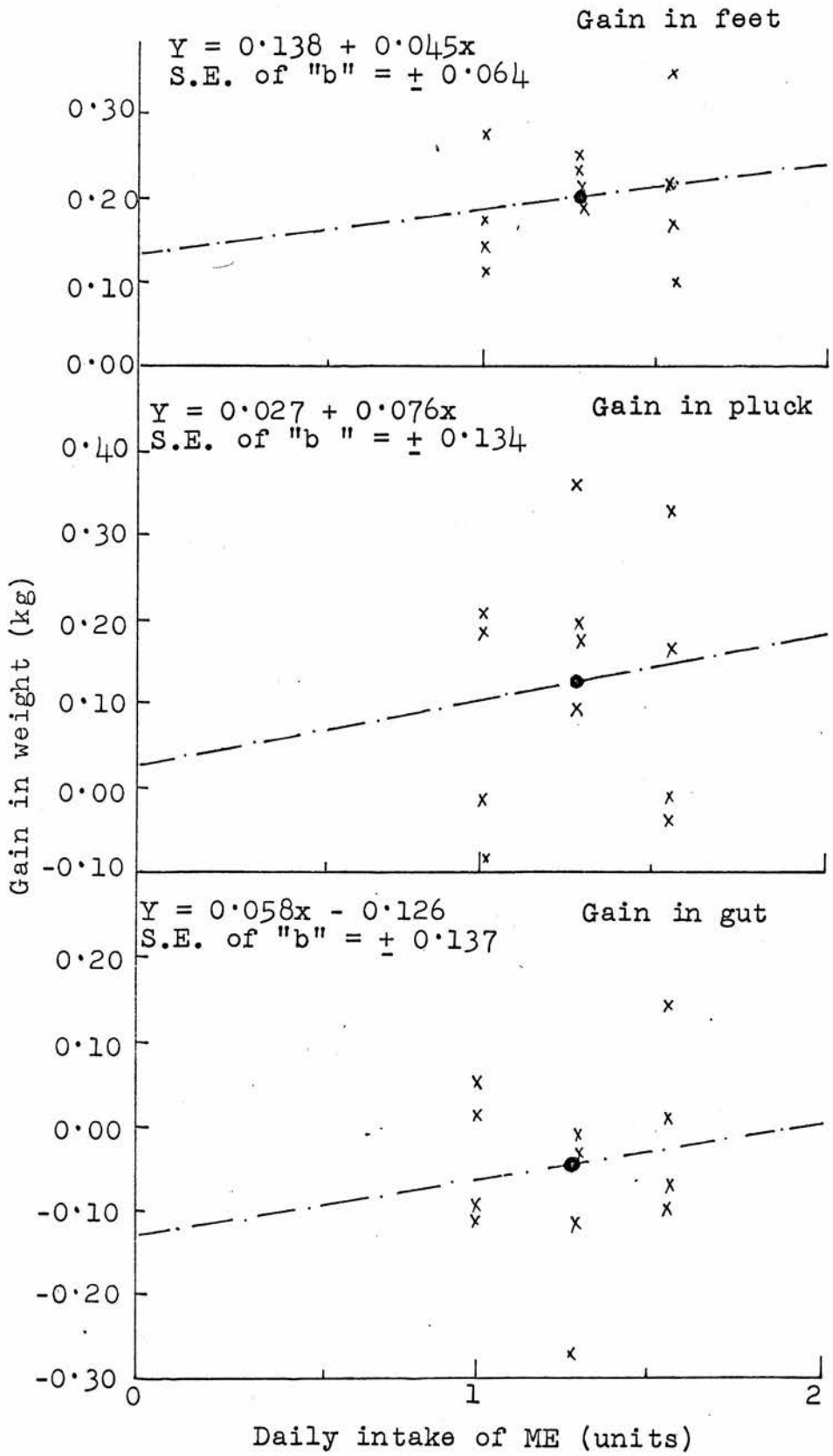
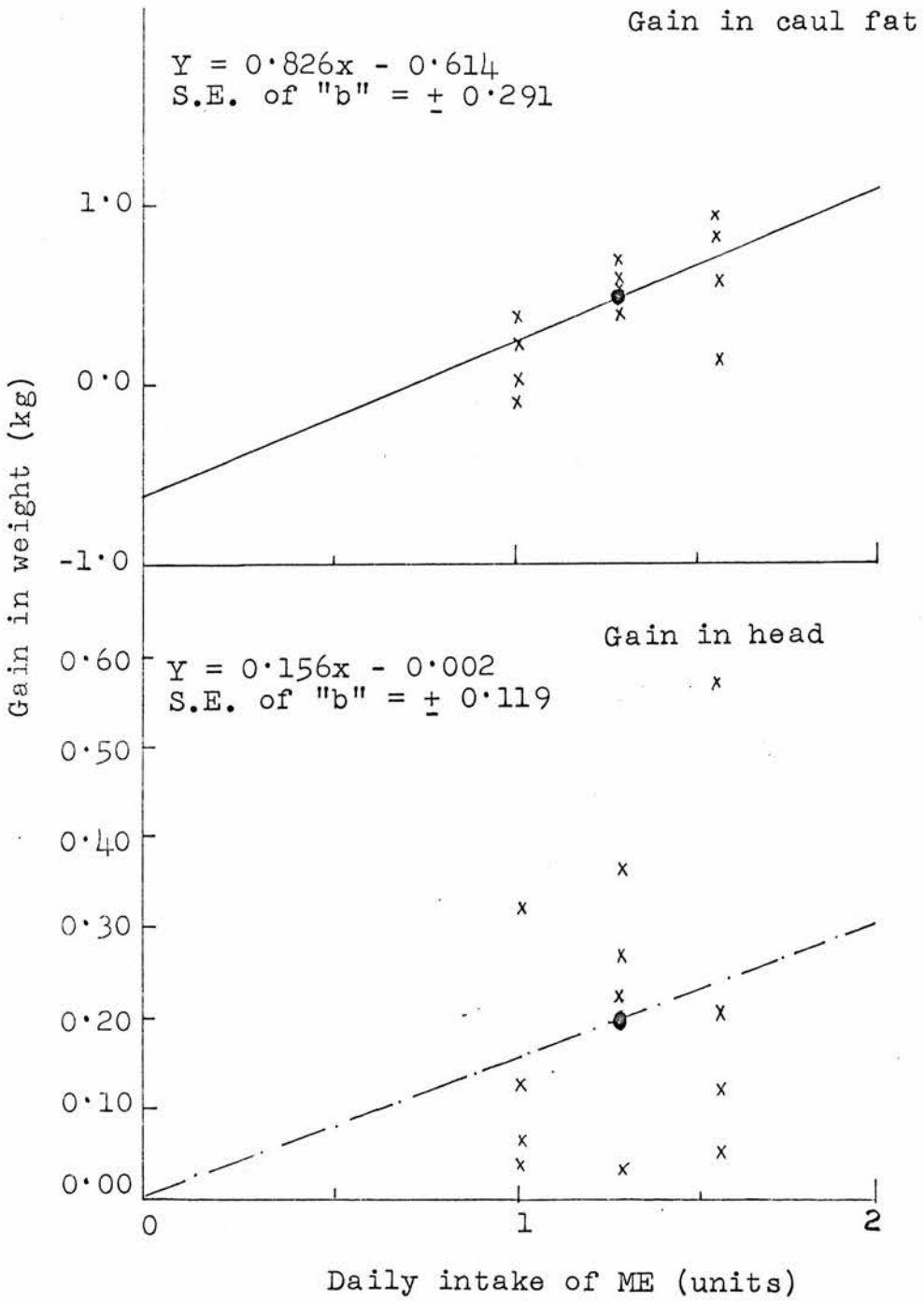


Fig. 3c. The effect of level of dietary ME on gain in weight of standard empty body components of B.F. wether lambs



difference between groups C and A and between groups B and A while the difference between groups C and B did not reach significance at the 5 per cent level of probability. The differences between groups for the rest of the S.E.B. components reported failed to reach significance at the $p < 0{\cdot}05$ level.

The effect of level of daily intake of ME on the gain in weight of the major tissues in the carcass

As in Experiment I the total fatty tissue in a half carcass was the sum of the fatty tissue in the retail cuts. Likewise the total muscle and total bone in the half carcass were the sum of these tissues respectively separated from each of the retail cuts.

Figures 4a and 4b show that as the level of daily intake of ME increased, the gain in weight of fatty tissue was significantly ($p < 0{\cdot}05$) increased while the gain in muscle tissue tended to increase but did not reach significance at the 5 per cent level. There appeared to be no relationship between the gain in weight in bone tissue and level of daily intake of ME.

The regression equations show that, under these experimental conditions, for each unit of ME increase, fatty tissue might be expected to increase its weight gain by 1·14 kg over a period of 91 days.

The analysis of variance (Appendix IV) shows that the gain in weight of fatty tissue in the C group was significantly ($p < 0{\cdot}05$) greater than that for the A group. Groups B and A differed significantly ($p < 0{\cdot}05$) in the gain in weight of fatty tissue.

Fig. 4a. The effect of level of dietary ME on gain in weight of the major tissues in the carcass of B.F. wether lambs

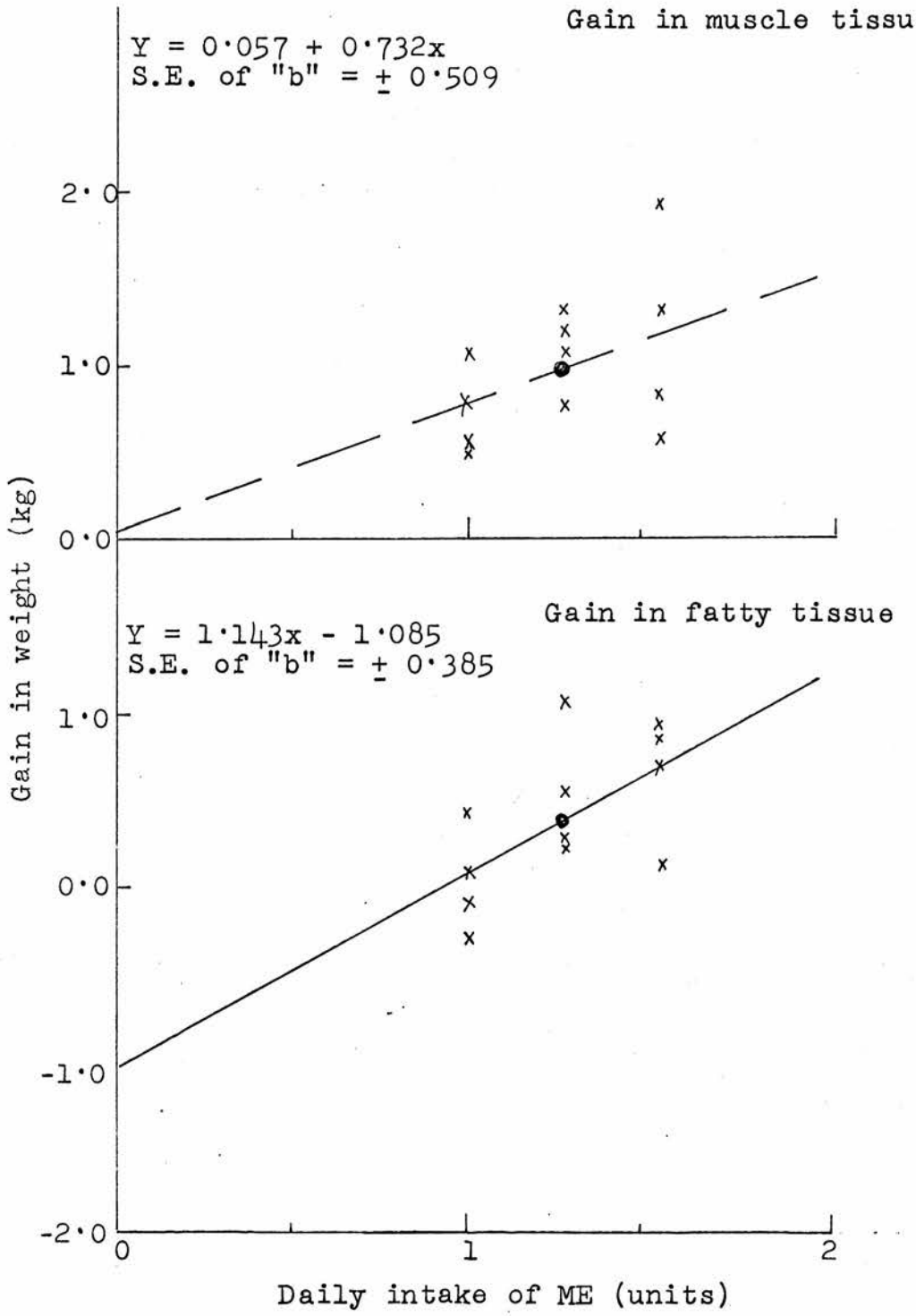
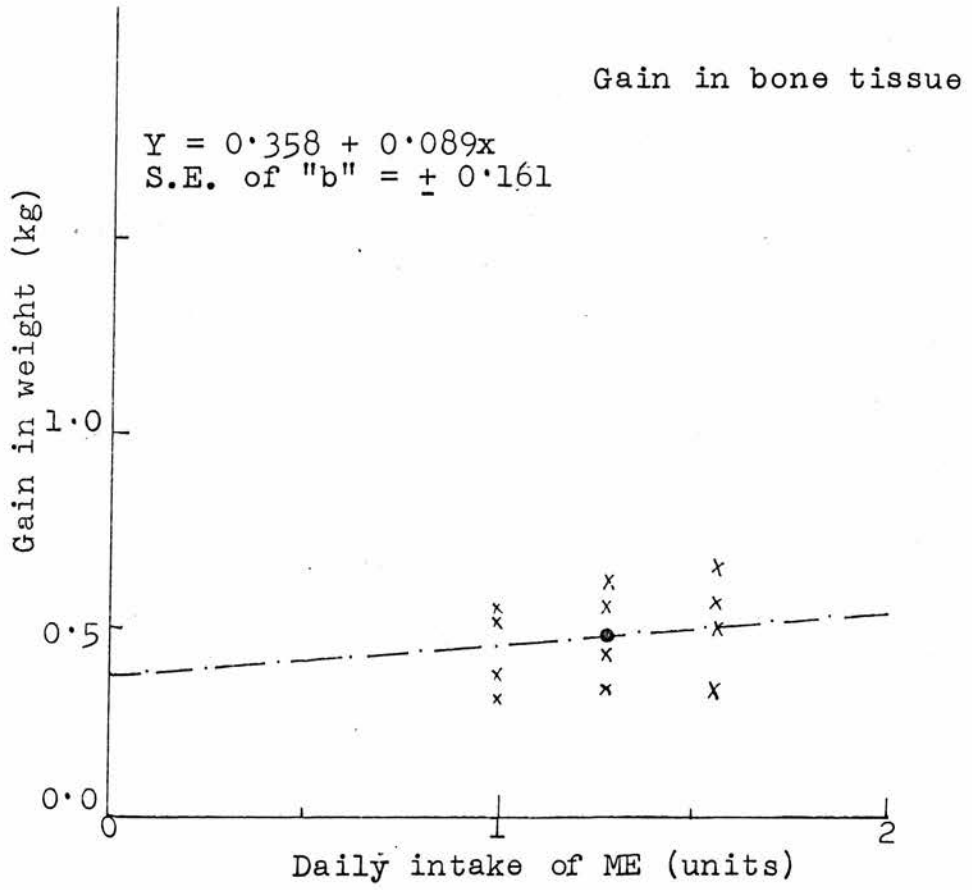


Fig. 4b. The effect of level of dietary ME on gain in weight of the major tissues in the carcass of B.F. wether lambs



There was no significant ($p < 0{\cdot}05$) differences in the gain in weight of fatty tissue between groups C and B. The differences between groups for muscle and bone tissues did not reach the significance at 5 per cent level./

The effect of level of daily intake of ME on gain in weight of the retail cuts

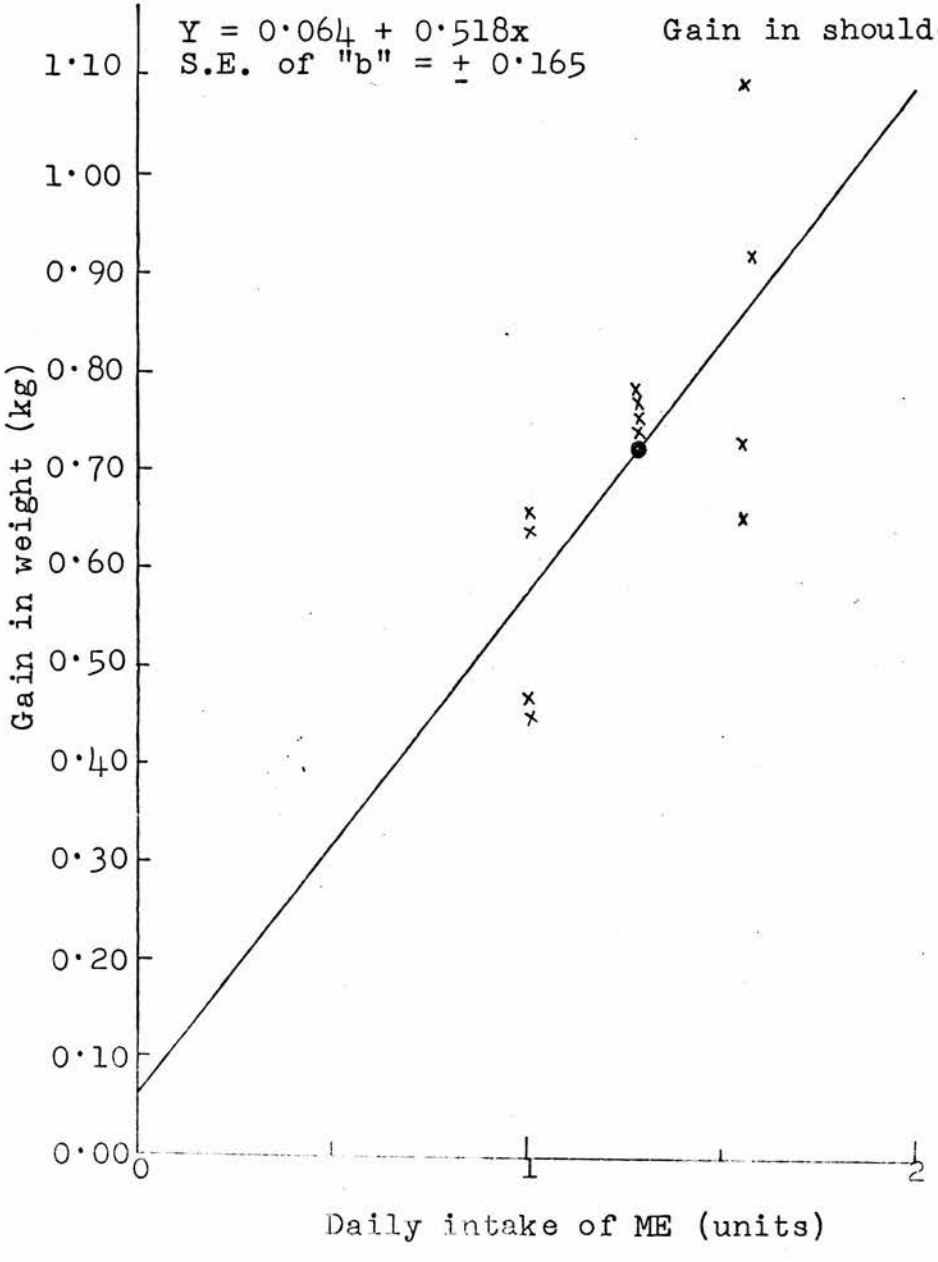
The carcass was cut into four primary and seven secondary cuts (see Methods section).

Primary cuts: Figures 5a and 5b show the effect of increasing the level of daily intake of ME on the gain in weight of these components when the daily intake of DCP was approximately the same for each group of lambs. The gain in weight of shoulder and loin joints and in rib joint increased significantly ($p < 0{\cdot}05$ and $p < 0{\cdot}01$ respectively) as the level of daily intake of ME was increased, while the gain in gigot joint tended to increase in weight but just failed to reach significance at the $p < 0{\cdot}05$ level.

The regression equations of these relationships show that for each unit of ME increase, the joints shoulder, loin and rib might be expected to increase its weight gain by 0·52 kg, 0·50 kg, and 0·46 kg respectively over a period of 91 days.

On testing the differences between groups, the analysis of variance (Appendix IV) shows that in both shoulder and loin joints, the differences between groups C and A and between B and A were significant at 5 per cent level while the difference between groups C and B was not significant at the $p < 0{\cdot}05$ level. The gain in weight in rib joint in the C group was highly significantly ($p < 0{\cdot}01$)

Fig. 5a. The effect of level of dietary ME on gain in weight of the retail cuts of B.F. wether lambs



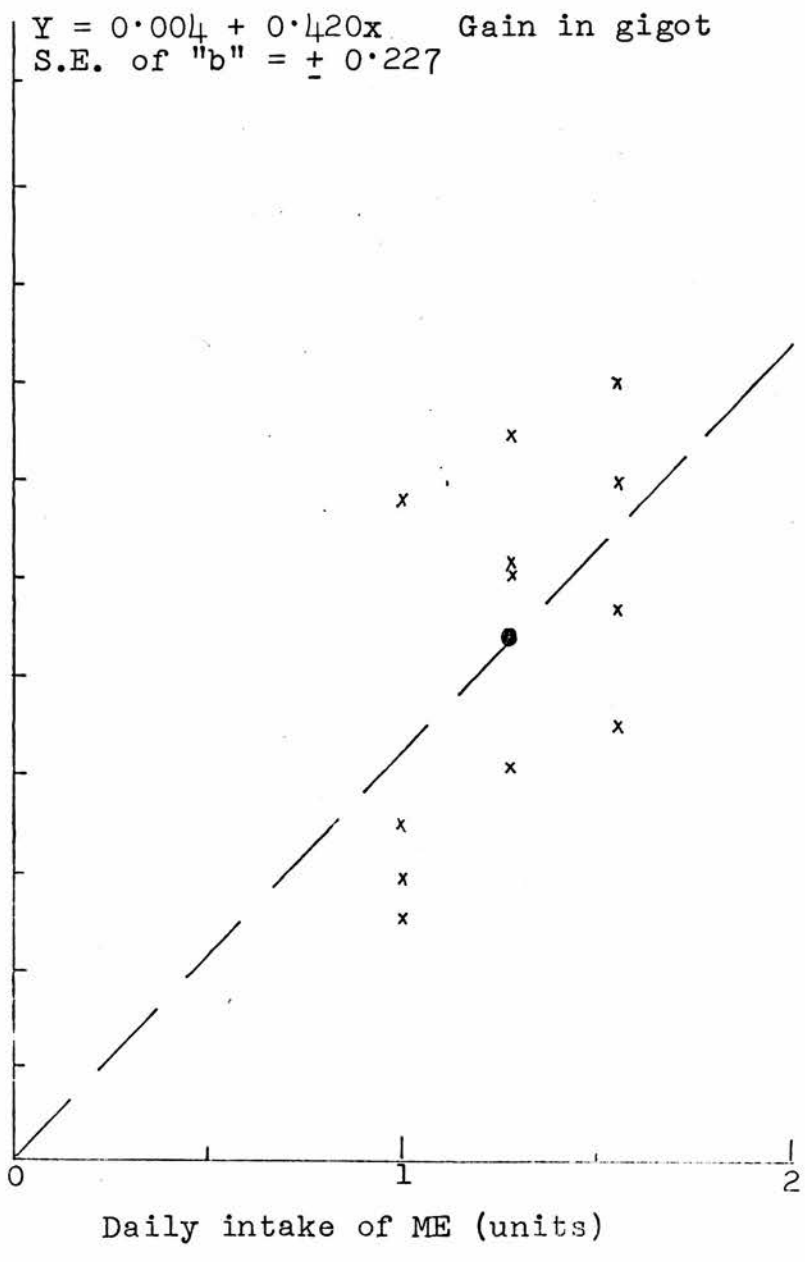
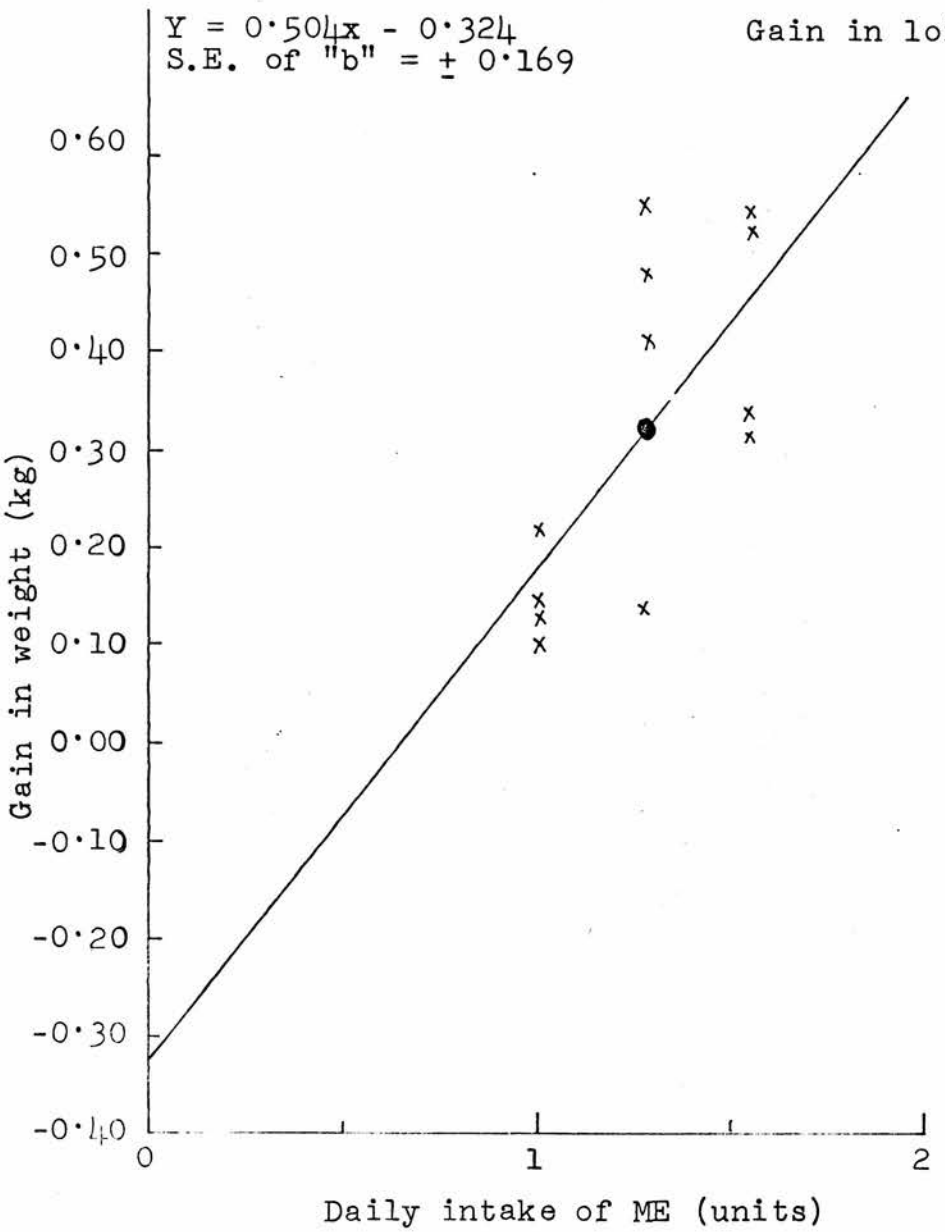
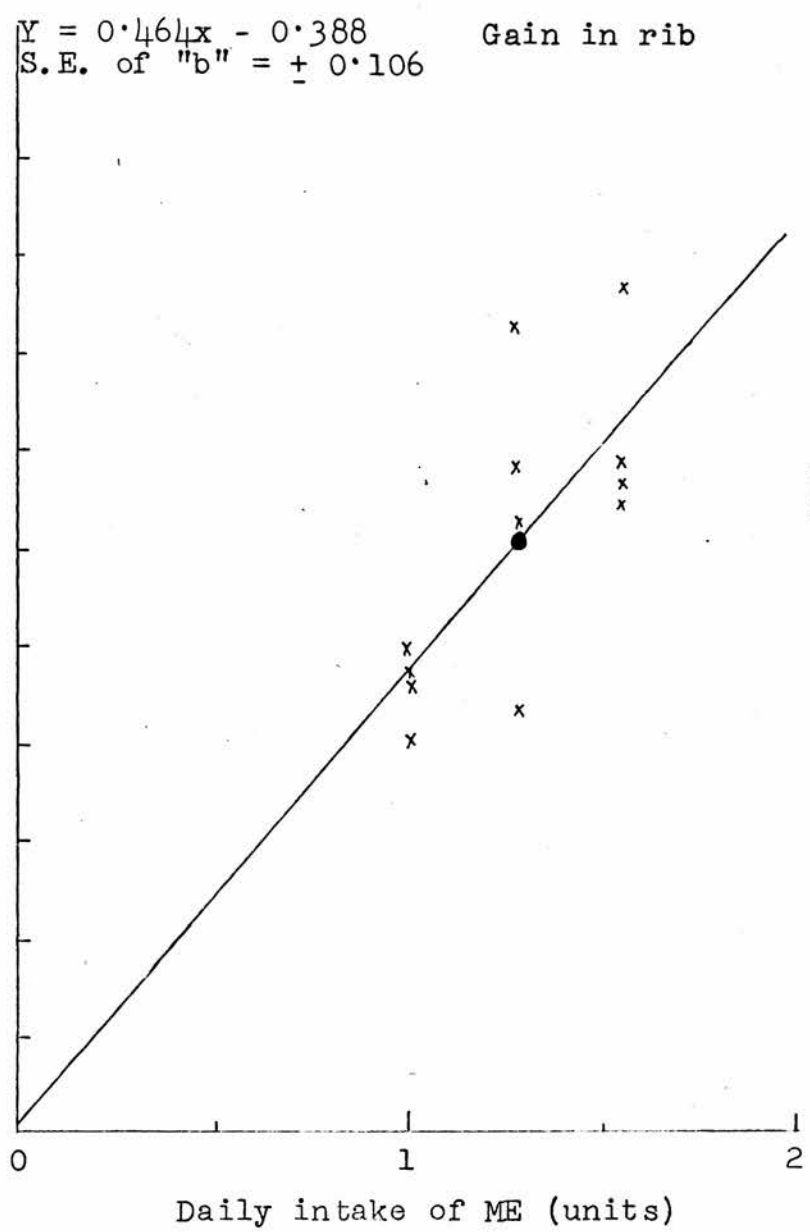


Fig. 5b. The effect of level of dietary ME on gain in weight of the retail cuts of B.F. wether lambs





greater than that for group A while the difference between the B and A groups was significant at 5 per cent level. Groups C and B did not differ significantly ($p < 0{\cdot}05$) in the gain in weight of rib joint.

Secondary cuts: Figures 5c and 5d show that as the daily intake of level of ME increased the gain in weight in flank (of rib) was highly significantly ($p < 0{\cdot}01$) increased. There was a tendency for the gain in shank, brisket and flank (of loin and of gigot) joints to be increased in weight with increasing level of daily intake of ME. The gain in weight in neck, kidney plus perirenal fat joints showed no relationship with levels of ME.

The regression equations show that, for each unit of ME increase, flank (of rib) might be expected to increase its weight gain by 0·17 kg in 91 days.

The analysis of variance for the gain in weight in flank (of rib) reveals significant ($p < 0{\cdot}01$ and $p < 0{\cdot}05$) differences between groups C and A and groups B and A respectively. Groups C and B did not differ significantly ($p < 0{\cdot}05$) in gain in weight of flank (of rib). The differences between groups for the rest of the secondary cuts reported did not reach significance at the 5 per cent level.

<u>The effect of level of daily intake of ME on gain in weight of the major tissues in the retail cuts</u>

Each primary and secondary joint was separated into fatty tissue muscle and bone.

Fig. 5c. The effect of level of dietary ME on gain in weight of the retail cuts of B.F. wether lambs

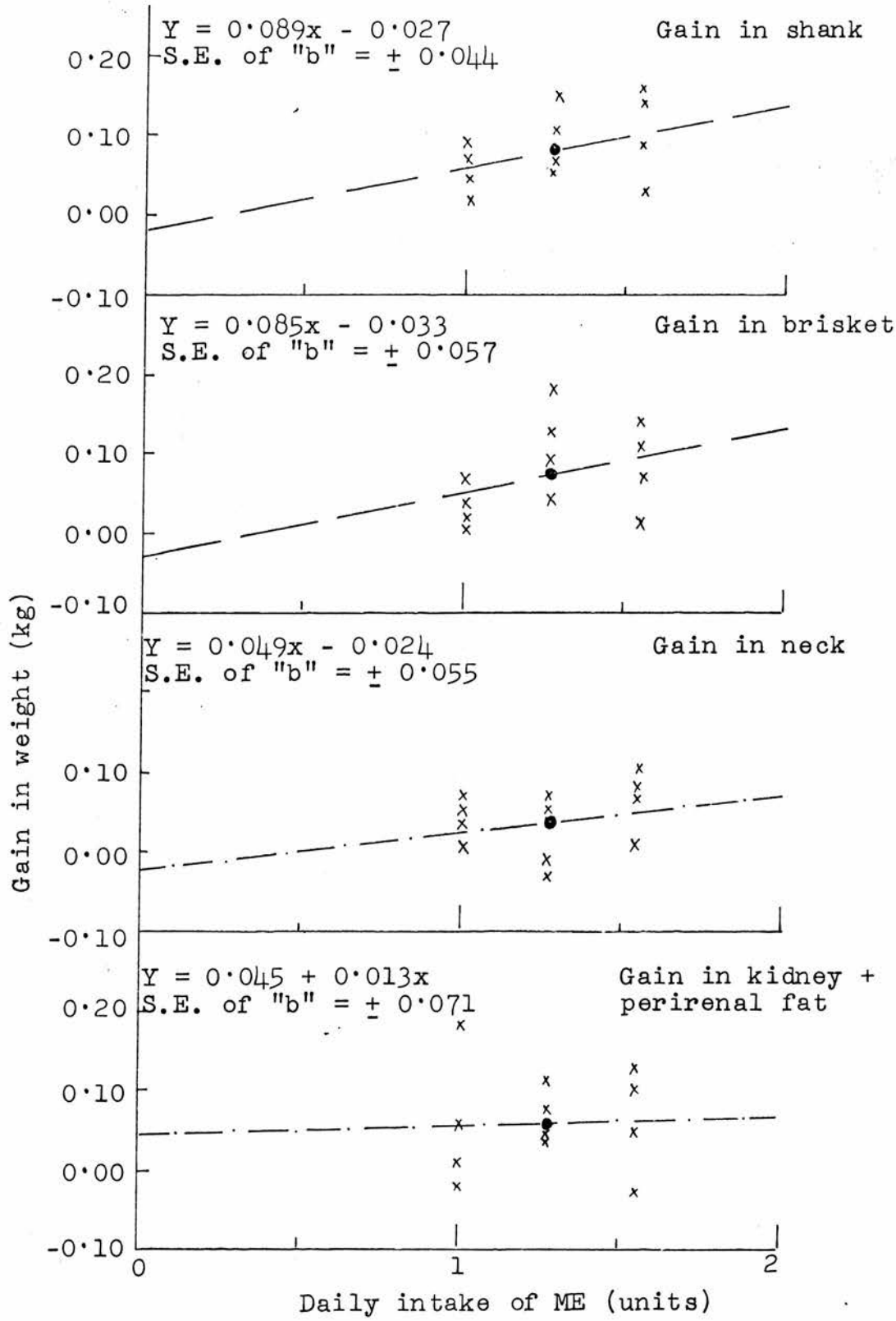
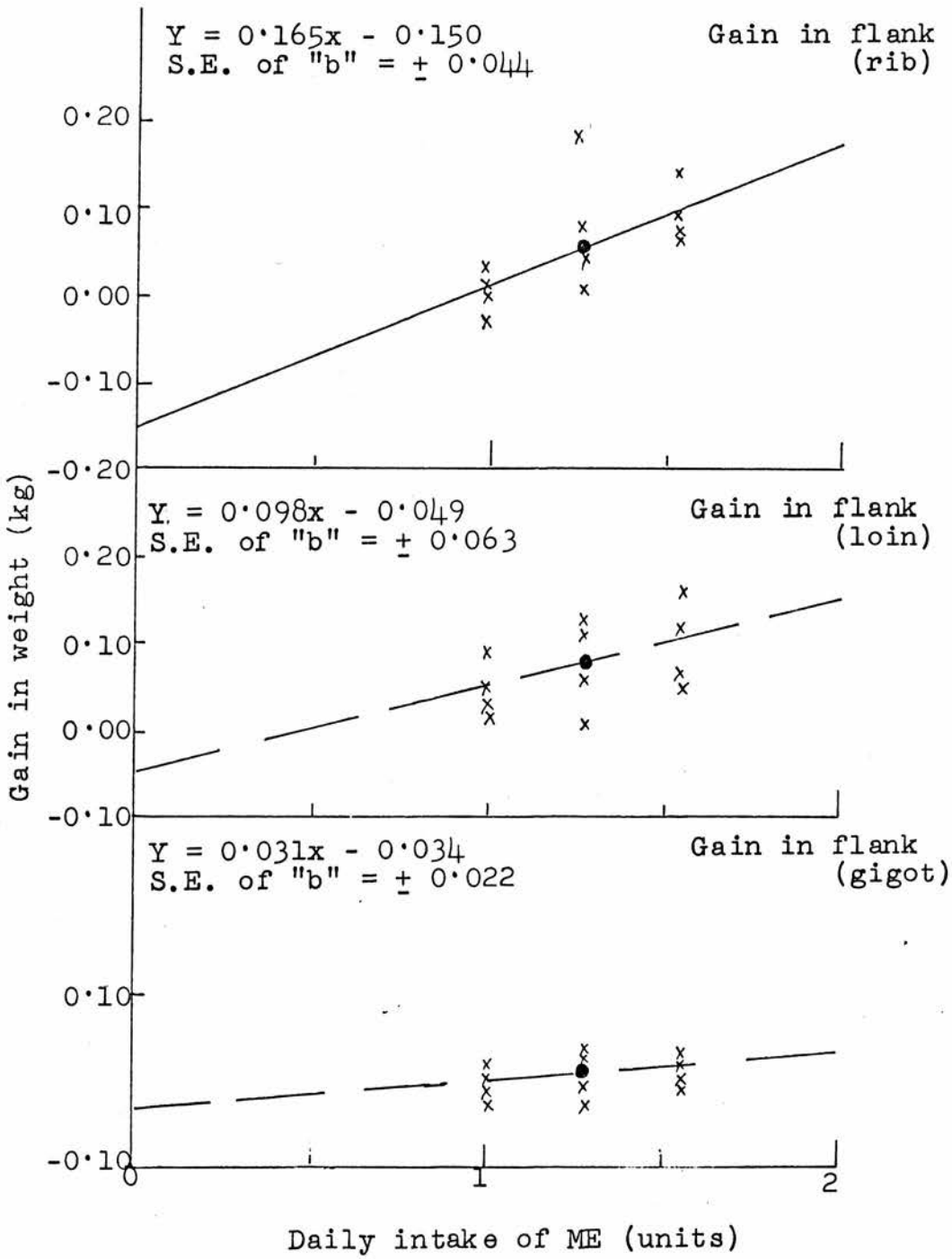


Fig. 5d. The effect of level of dietary ME on gain in weight of the retail cuts of B.F. wether lambs



Figures 6a, 6b, 6c, 6d and 6e show the effect of increasing level of daily intake of ME on the gain in weight of these components when the daily intake of digestible crude protein was approximately the same for each group of lambs.

Fat: As the daily intake of ME increased, the gain in weight of fatty tissue in shoulder, gigot and rib joints and in loin joint was significantly ($p < 0{\cdot}05$ and $p < 0{\cdot}01$ respectively) increased while the gain in weight of perirenal fat showed no relationship with levels of ME.

Muscle: There was a tendency for the gain in muscle tissue in the shoulder, loin and rib to be increased in weight by increasing level of daily ME intake but these relationships failed to reach significance at the 5 per cent level. The gain in weight of muscle tissue in the gigot and in the kidney showed no relationships with levels of ME.

Bone: The gain in weight of bone tissue in the gigot and rib tended to increase with increasing levels of ME but did not reach the 5 per cent level. The shoulder and loin joints showed no noticeable change in gain in weight of bone tissue as the level of ME intake was increased.

The regression equations expressing these relationships show that, for each unit of energy increase fatty tissue in the shoulder, gigot, loin and rib joints might be expected to increase its weight gain by 0·36 kg, 0·29 kg and 0·25 kg respectively over a period of 91 days.

Fig. 6a. The effect of level of dietary ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

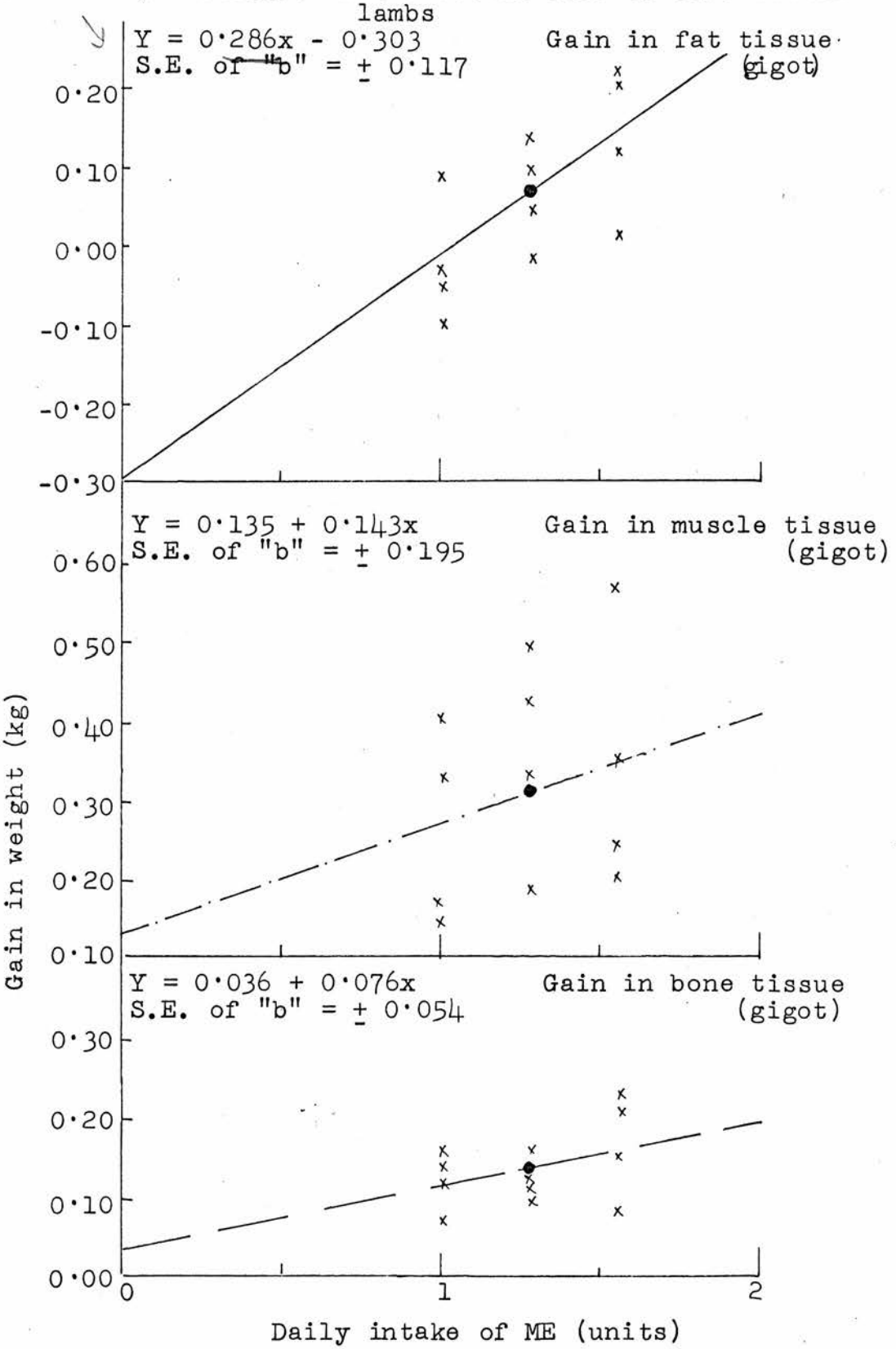


Fig. 6b. The effect of level of dietary ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

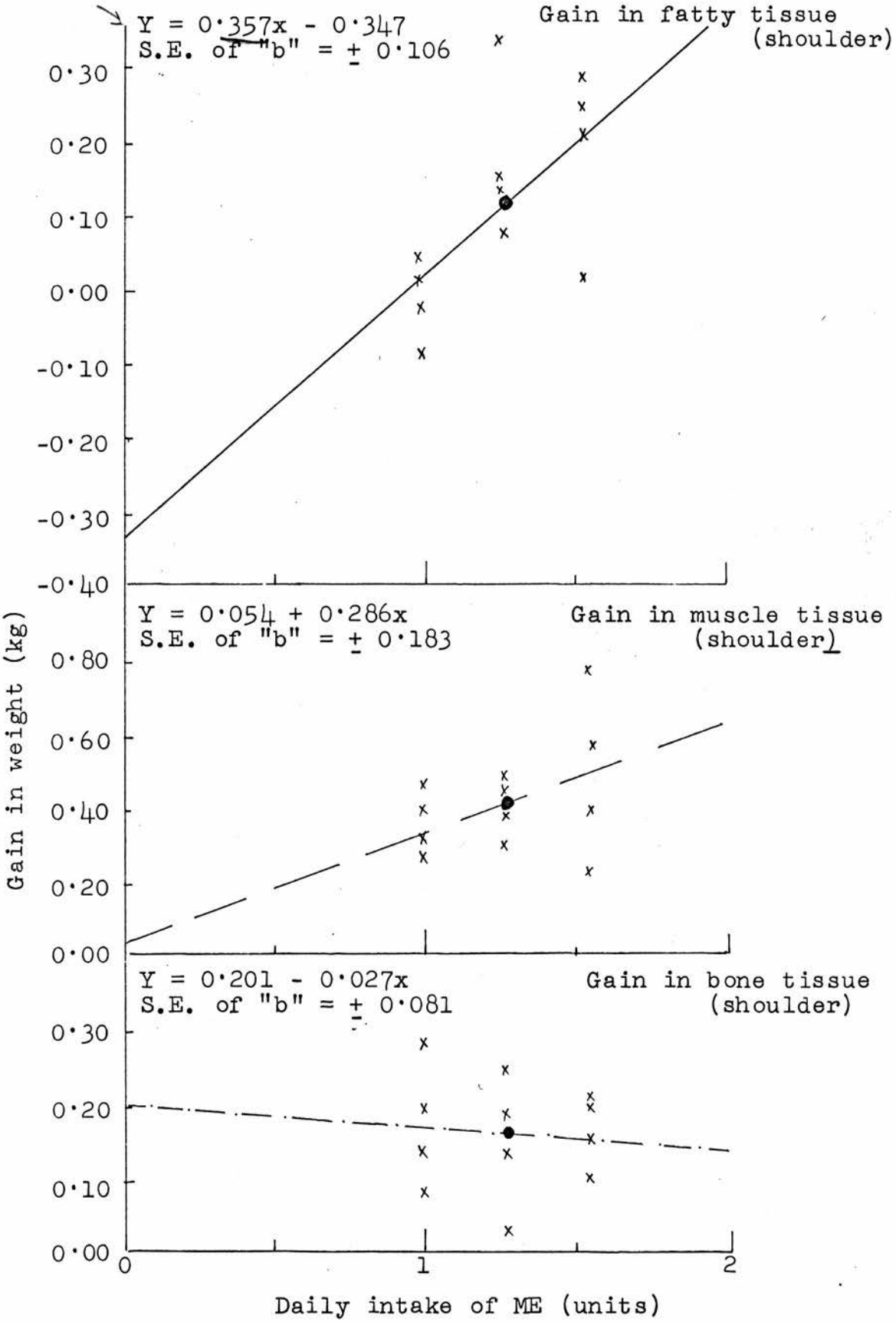


Fig. 6c. The effect of level of dietary ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

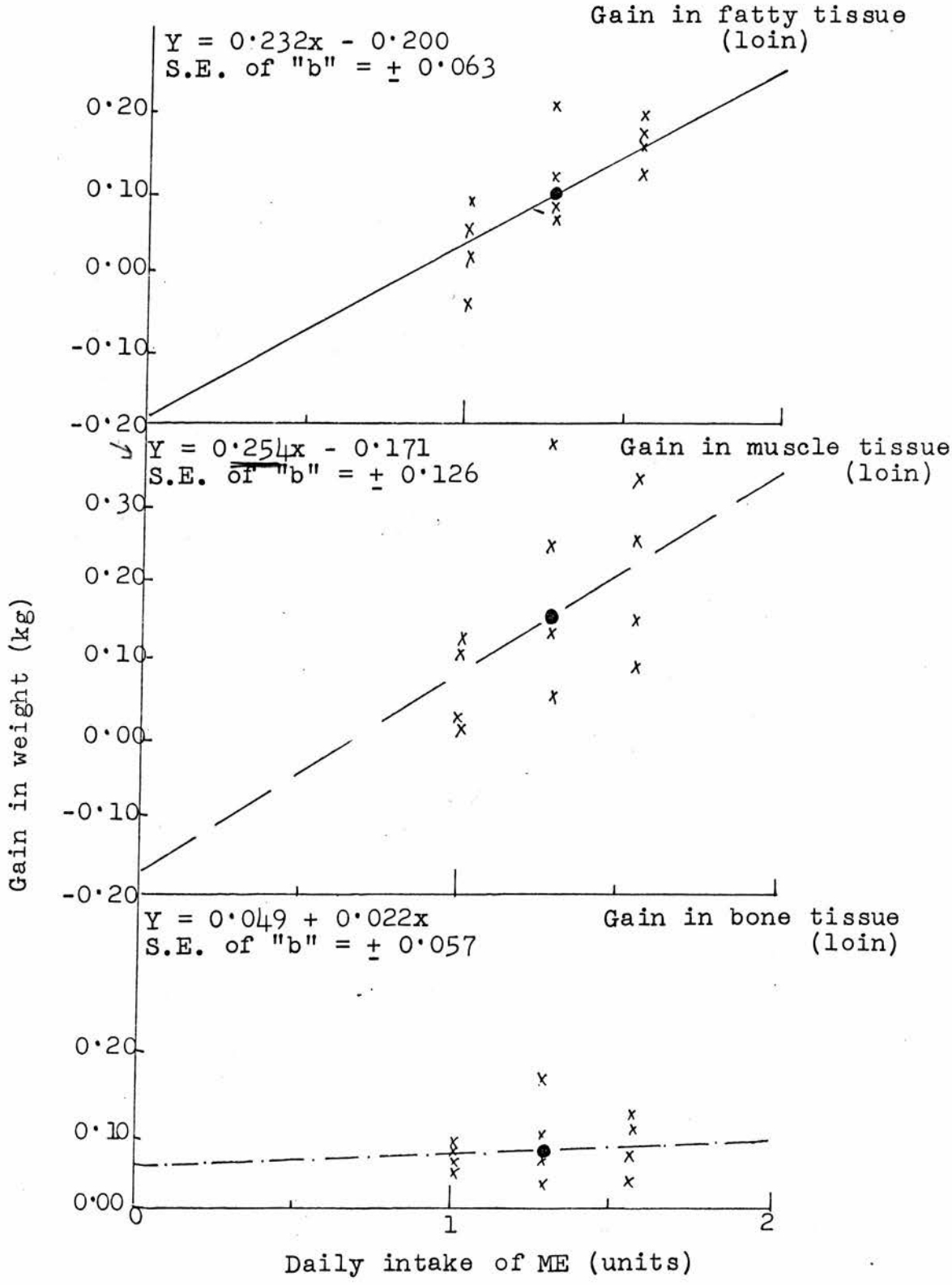


Fig. 6d. The effect of level of dietary ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

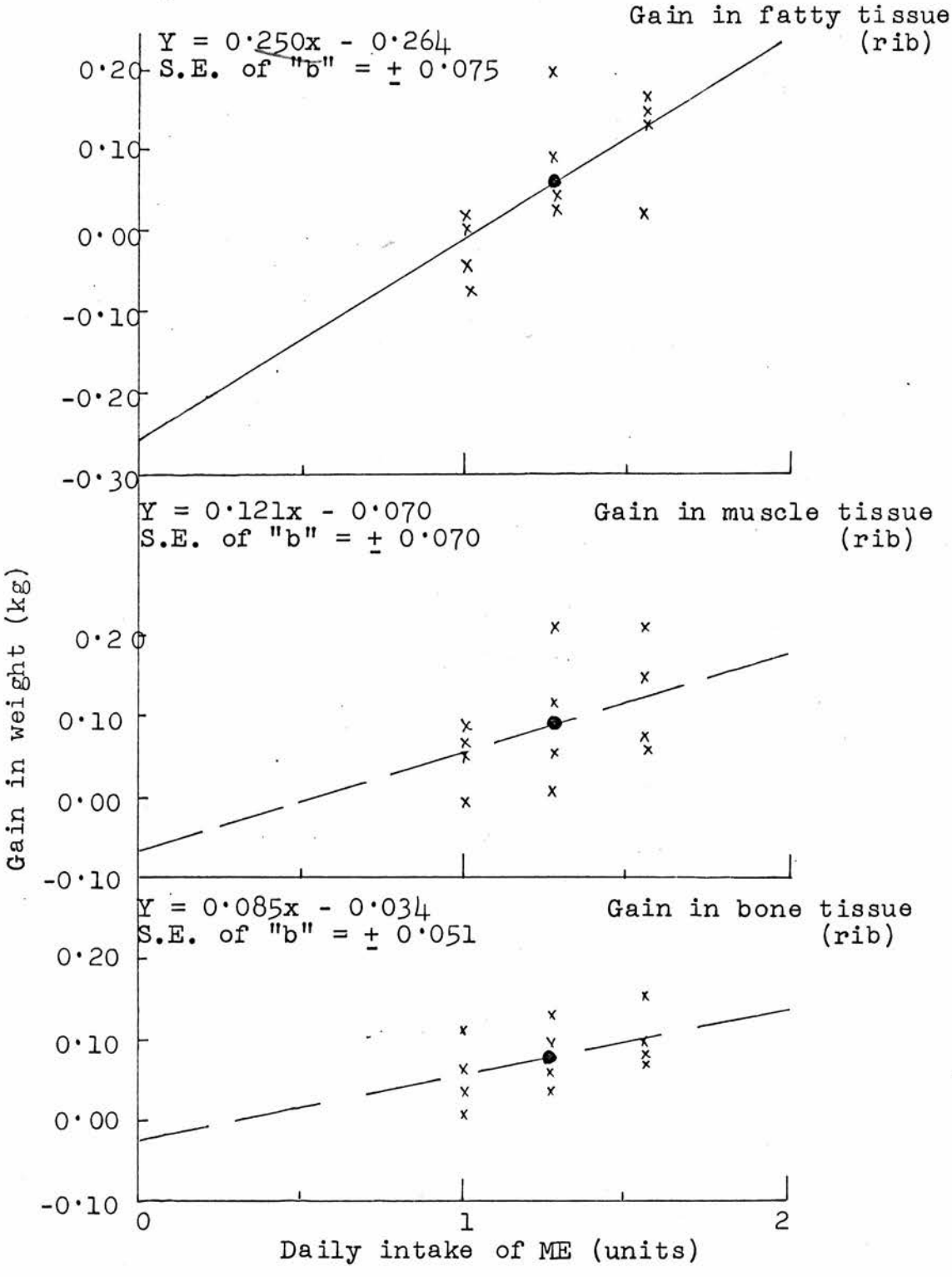
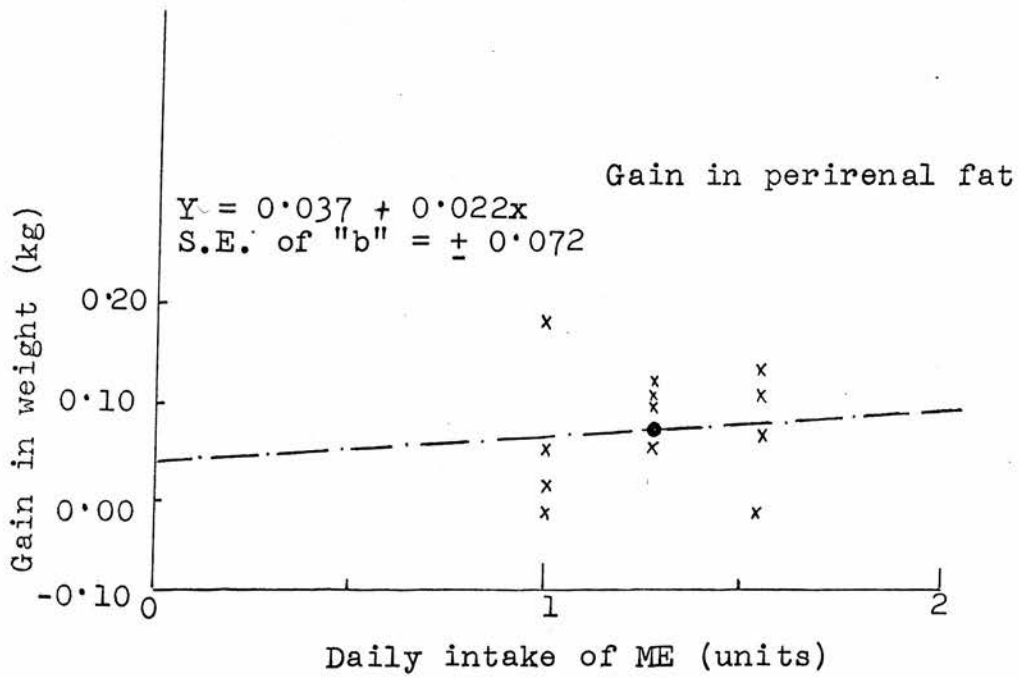


Fig. 6e. The effect of level of dietary ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs



On testing differences between groups the analysis of variance (Appendix IV) for gain in weight of fatty tissue in the shoulder and rib joints showed a significant ($p < 0{\cdot}05$) difference between the C group of lambs and A group and between groups B and A, while groups C and B did not differ significantly at the 5 per cent level. The differences in gain in weight of fatty tissue in loin were significant ($p < 0{\cdot}01$ and $p < 0{\cdot}05$) between groups C and A and between groups B and A respectively while that between C and B was not significant at the 5 per cent level. The analysis of variance for the rest of the components reported in this section showed no significant ($p < 0{\cdot}05$) differences between groups.

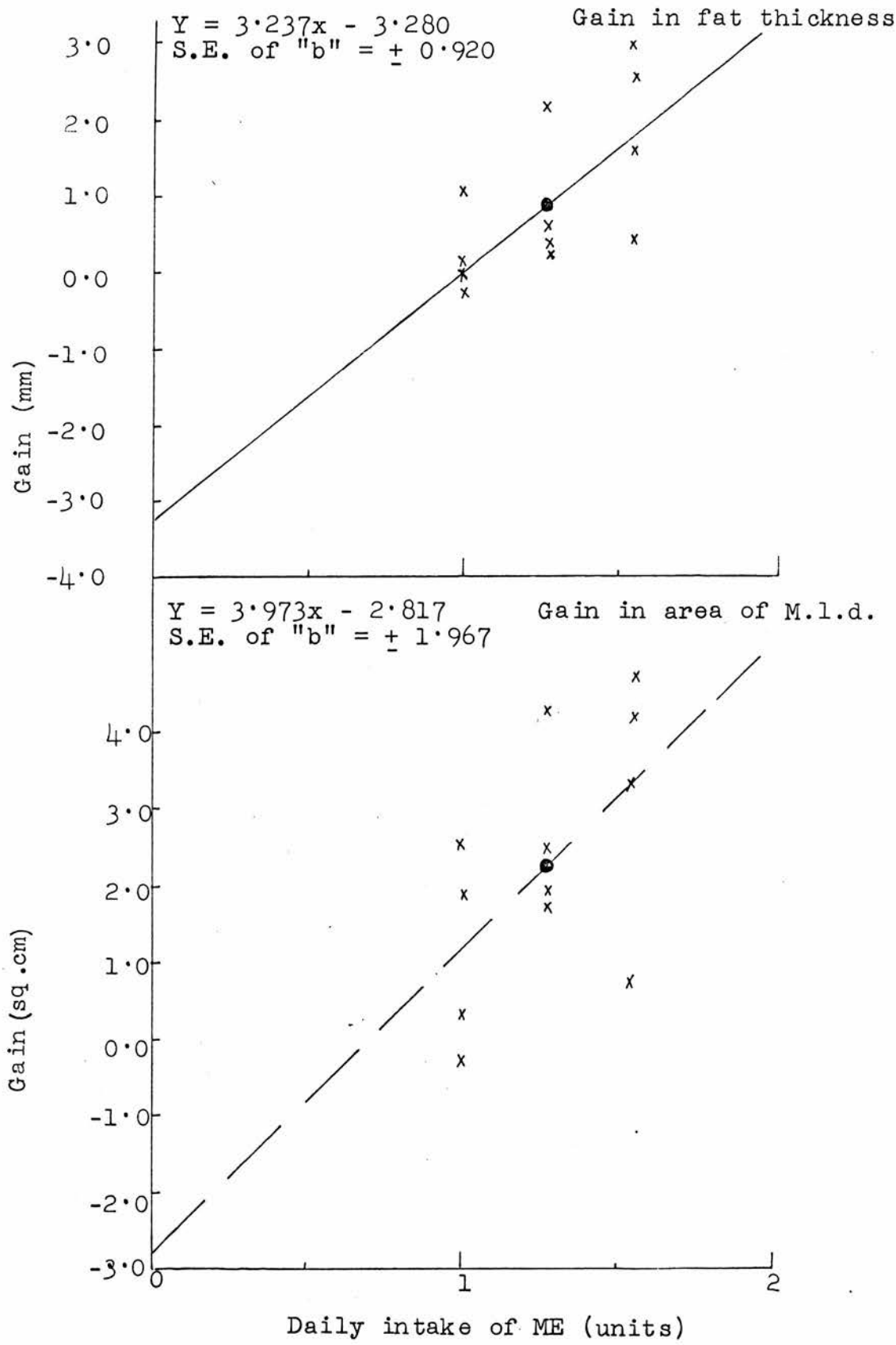
The effect of level of daily intake ME on the increase of carcass measurements

Fat-thickness over the M. longissimus dorsi at the 12th rib and the area of that muscle at the same rib were recorded.

Figure 7 shows that, as the level of daily intake of ME increased, fat-thickness over the 12th rib was highly significantly ($p < 0{\cdot}01$) increased while the gain in the area of M. longissimus dorsi tended to increase but was not significant at the 5 per cent level.

The regression equation shows that for each unit of ME increase the fat-thickness over the M.l.d. at the 12th rib might be expected to increase by 3·24 mm in a period of 91 days.

Fig. 7. The effect of level of dietary ME on the increase of carcass measurements of B.F. wether lambs



The analysis of variance (Appendix IV) for the fat-thickness shows that there was a highly significant ($p < 0{\cdot}01$) difference between groups C and A. The differences between the other groups did not reach significance at the 5 per cent level. There was no significant ($p < 0{\cdot}05$) difference between groups for the area of M. longissimus dorsi at the 12th rib.

The effect of level of daily intake of ME on gain in weight of individual muscles

Representative muscles from the various joints of the carcass were removed and recorded separately.

Figures 8a, 8b, 8c, 8d, 8e, 8f, 8g and 8h show the influence of increasing daily intake of ME on the gain in weight of these individual muscles. The gains in weight of M. obliquus internus abdominis + M. transversus abdominis, M. brachialis and M. biceps brachii were highly significant ($p < 0{\cdot}01$) while that of M. longissimus dorsi (loin area) reached significance at the 5 per cent level of probability. Of the 12 other muscles tested, i.e. M. gastrocnemius, M. semitendinosus, M. semimembranosus, M. quadriceps femoris, M. gluteus medius, M. extensor digitorum longus, M. psoas major, M. longissimus dorsi (rib) area, Mm. pectoralis profundus et superficialis, M. supraspinatis, M. infraspinatis and M. extensor carpi radialis only two muscles, (M. gluteus medius and M. extensor carpi radialis) showed no tendency to increase in weight with increasing level of daily intake of ME while the rest tended to increase.

Fig. 8a. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

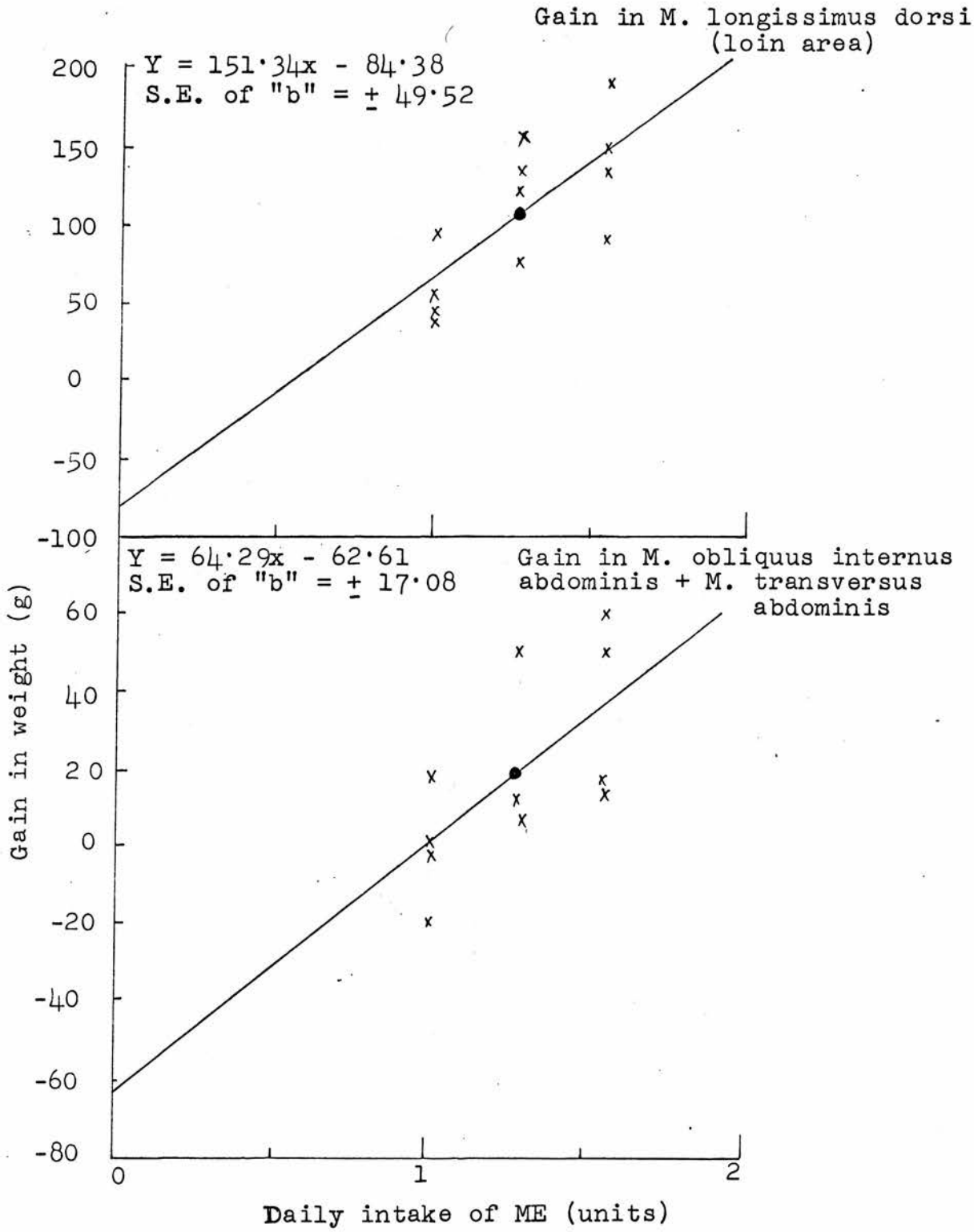


Fig. 8b. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

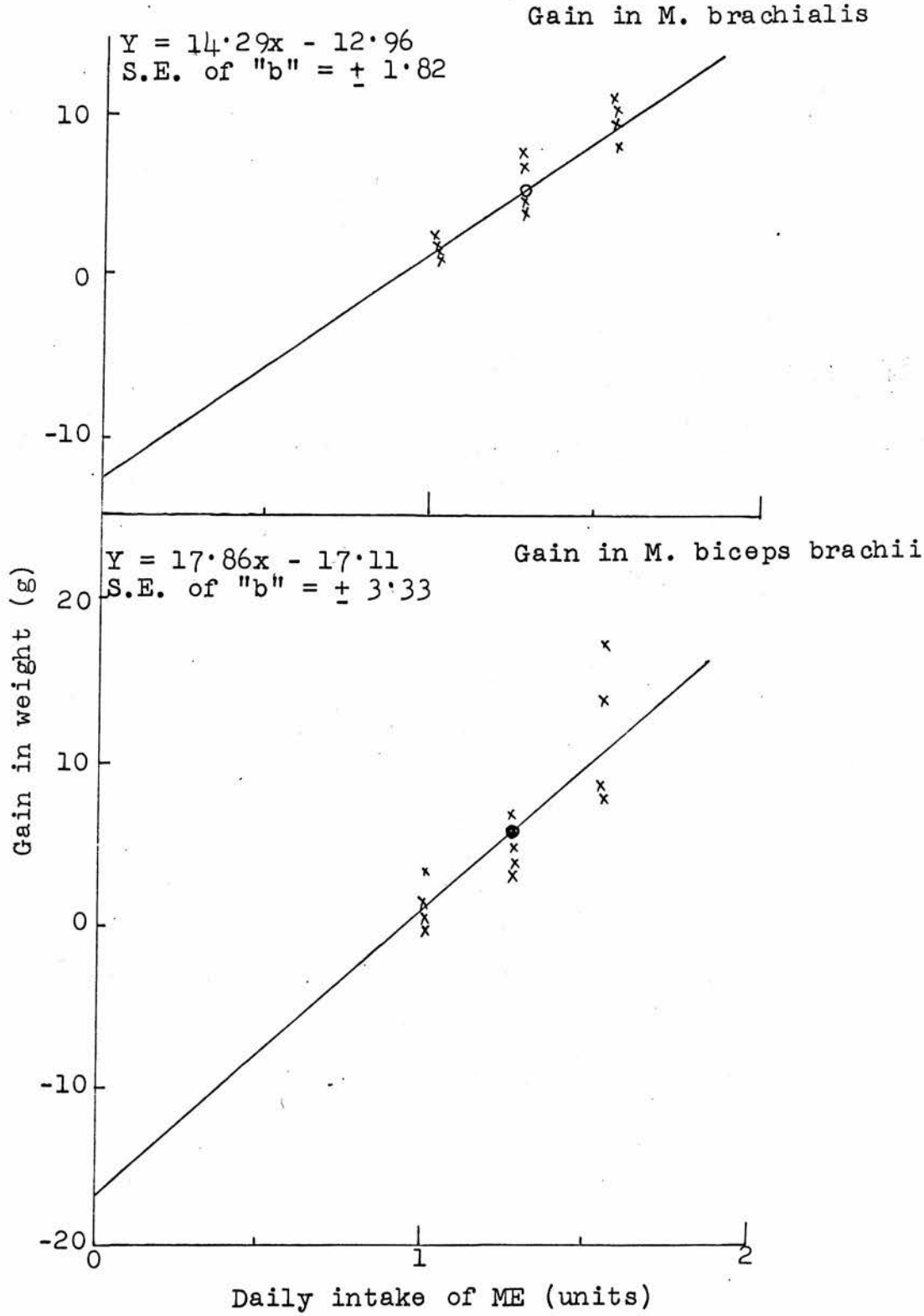


Fig. 8c. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

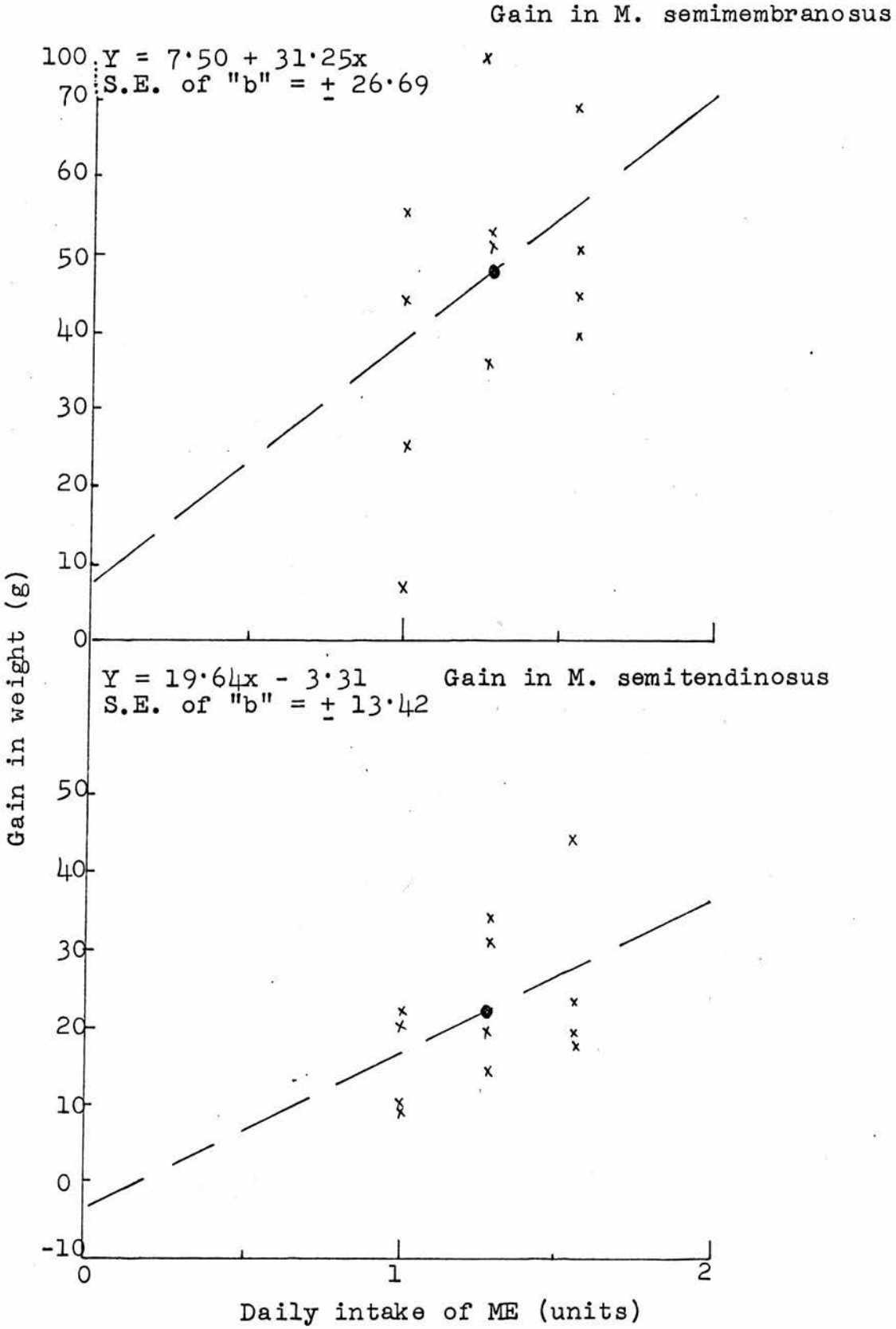


Fig. 8d. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

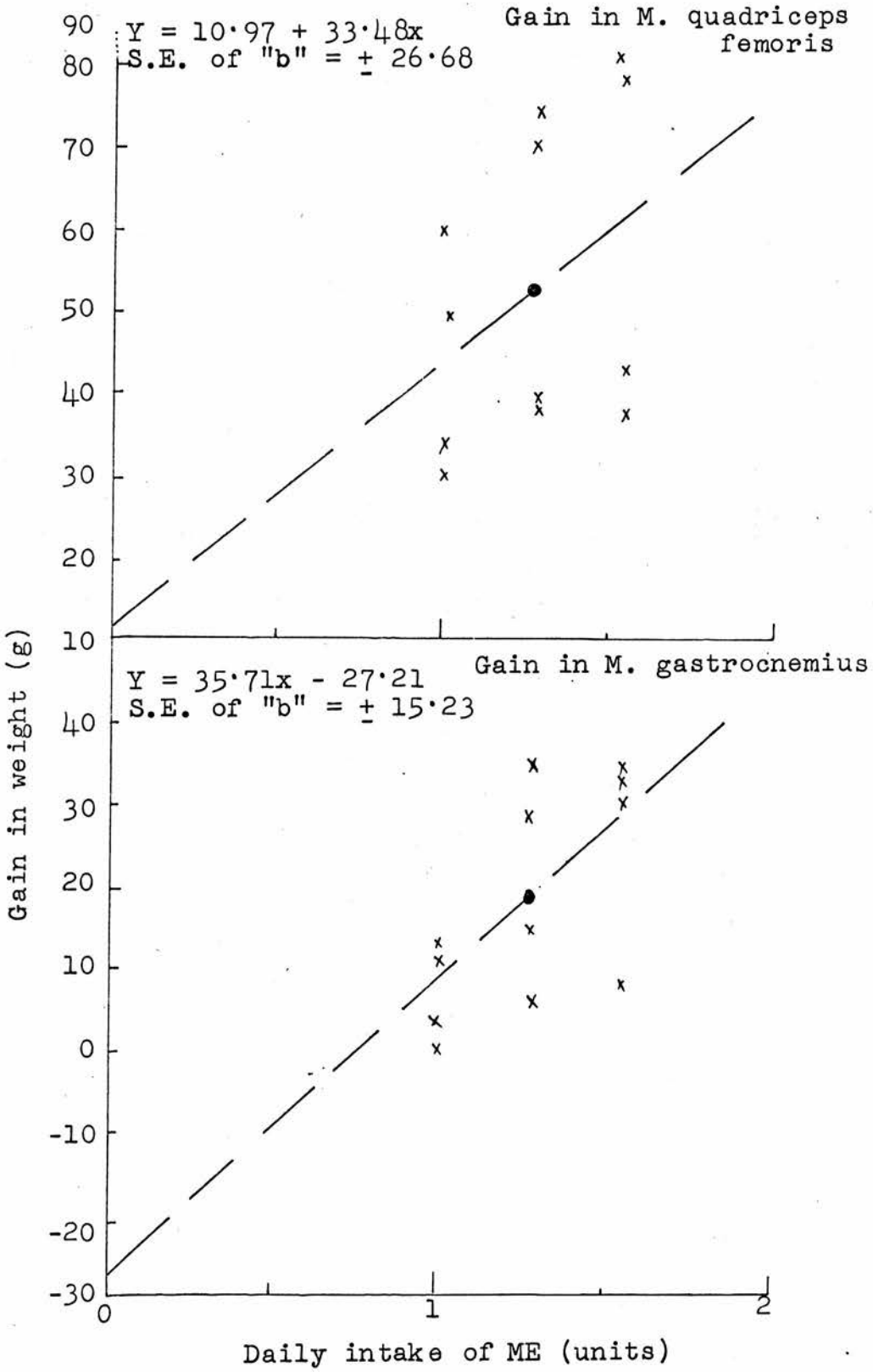


Fig. 8e. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

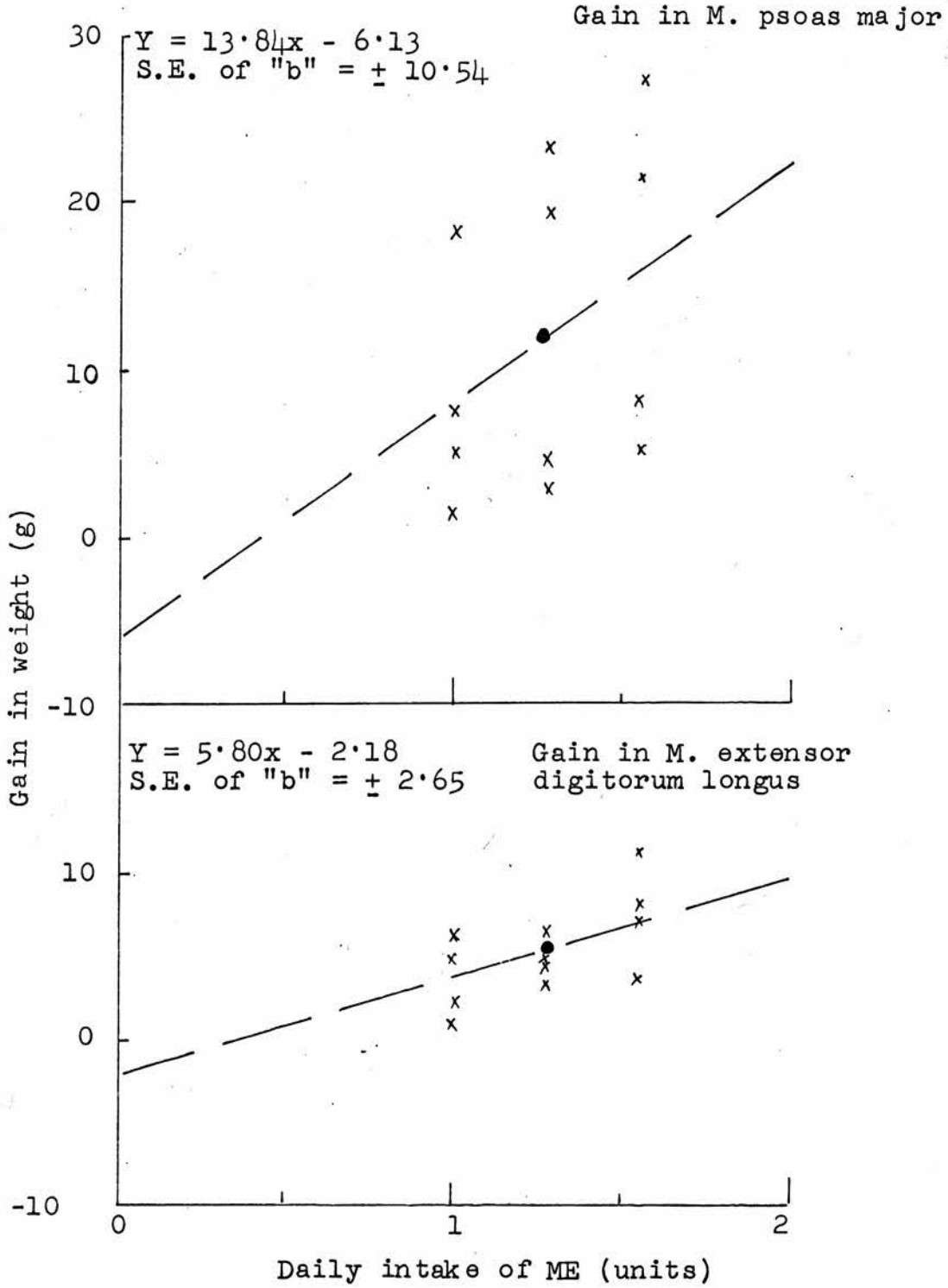


Fig. 8f. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

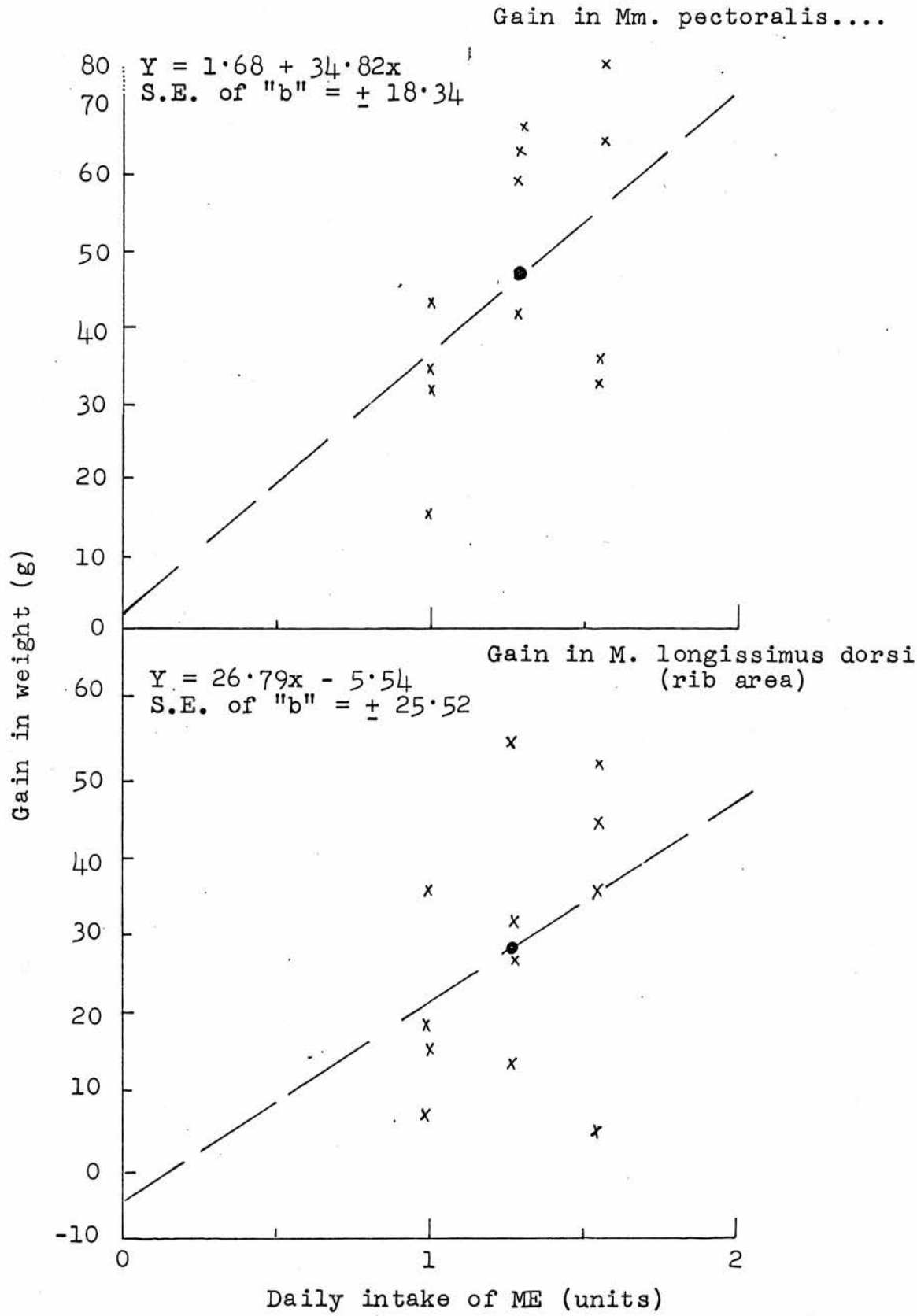


Fig. 8g. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs

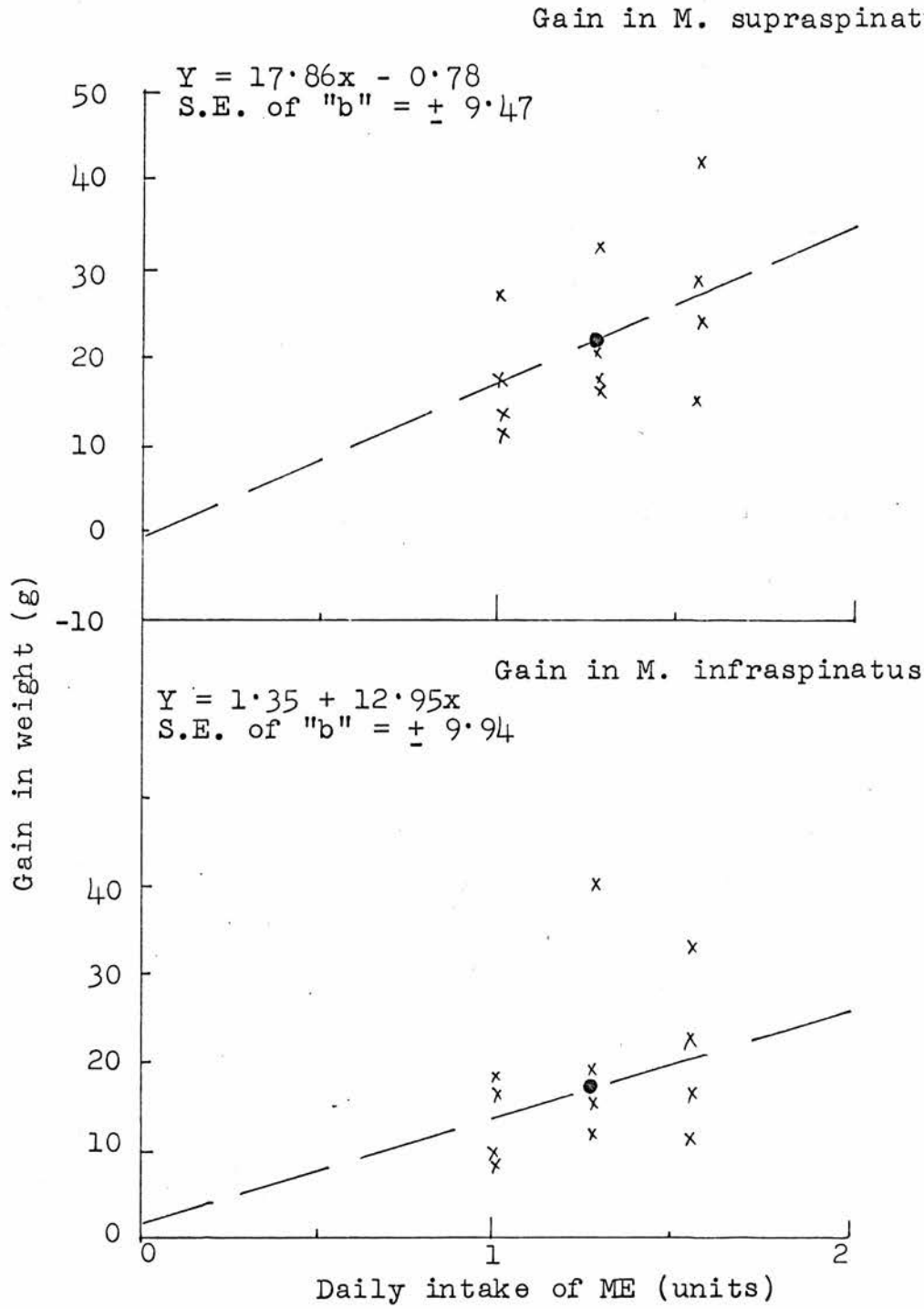
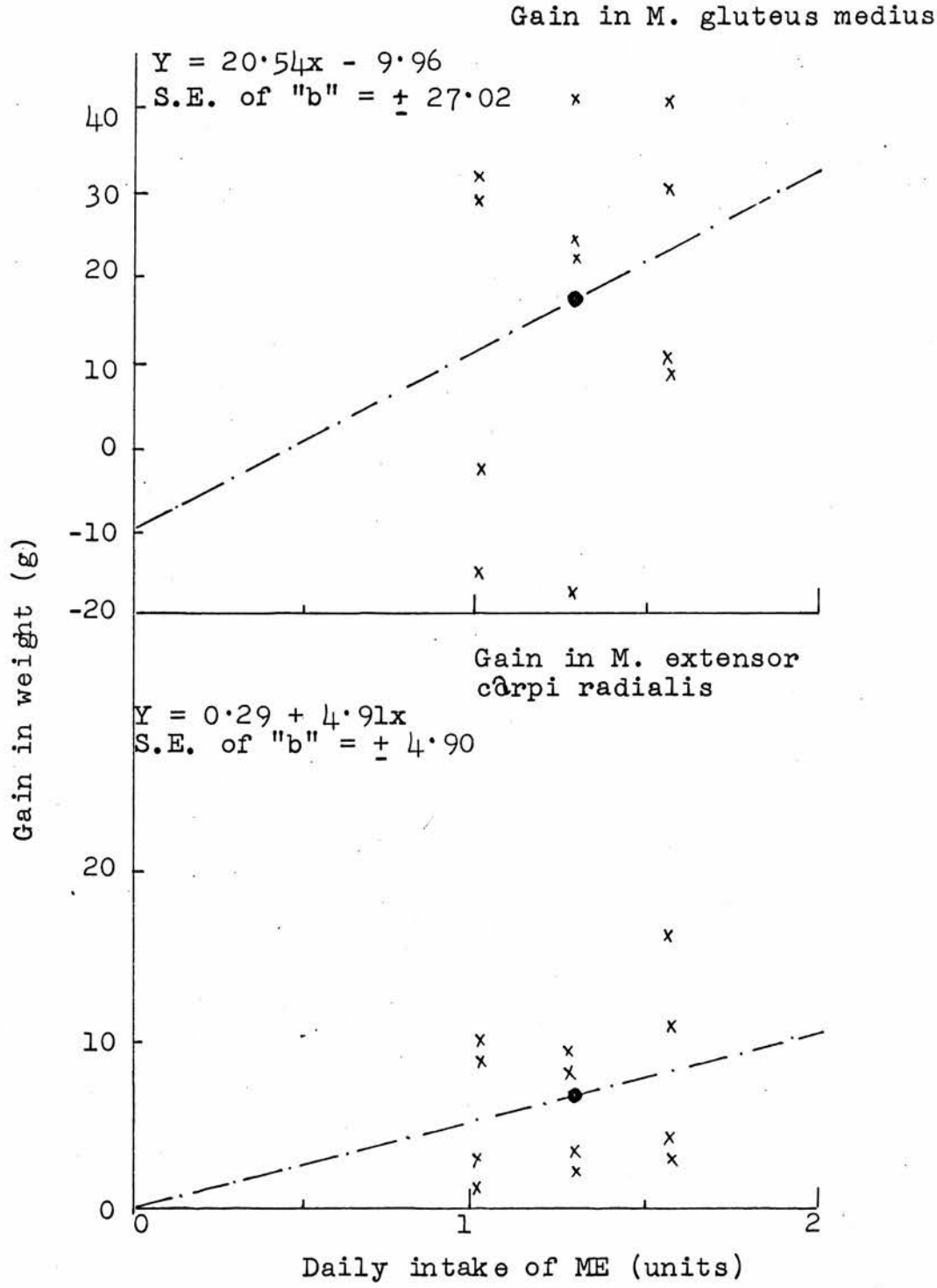


Fig. 8h. The effect of level of dietary ME on the gain in weight of individual muscles of B.F. wether lambs



The regression equations expressing these relationships show that, for each unit of ME increase, M. longissimus dorsi (loin area), M. obliquus internus abdominis + M. transversus abdominis, M. brachialis and M. biceps brachii might be expected to increase in gain in weight by 151 g, 64 g, 14 g and 18 g respectively over a period of 91 days.

On testing differences between groups the analysis of variance (Appendix IV) for the gain in weight of M. longissimus dorsi (in loin area), M. obliquus internus abdominis + M. transversus abdominis, M. brachialis and M. biceps femoris showed significant differences between groups. In these four individual muscles there was no significant ($p < 0{\cdot}05$) difference between the C and B groups. Groups C and A differed significantly ($p < 0{\cdot}01$) in gain in weight of M. obliquus internus abdominis + M. transversus abdominis, M. biceps brachii and M. brachialis, while that of M. longissimus dorsi (loin area) was significant at the 5 per cent level. The differences between groups B and A for M. obliquus internus abdominis + M. transversus abdominis and M. longissimus dorsi were significant at the $p < 0{\cdot}05$ level while that of M. brachialis was reached significance at the 1 per cent level. Groups B and A showed no significant ($p < 0{\cdot}05$) difference for the gain in weight of M. biceps brachii. The analysis of variance for the rest of the individual muscles reported showed no significant ($p < 0{\cdot}05$) differences between groups.

The effect of level of daily intake of ME on changes in chemical composition of the carcass tissues

Chemical determinations were made on samples of carcass tissues for dry matter, ether extract and crude protein.

(a) Dry matter: Figure 9 shows that the percentage of dry matter in fatty and muscle tissues showed no detectable change as the level of daily intake of ME was increased.

The analysis of variance (Appendix IV) showed that there were no significant ($p < 0{\cdot}05$) differences between groups for the percentage of dry matter in both tissues.

(b) Ether extract: Figure 10 shows that as the level of daily intake of ME increased the percentage of ether extract in fatty tissue tended to increase, although this relationship did not reach significance at the 5 per cent level of probability. The percentage of ether extract in the muscle tissue showed no relationship with levels of daily intake of ME.

The analysis of variance for ether extract in both tissues failed to reveal significant ($p < 0{\cdot}05$) differences between groups.

(c) Crude protein: Figure 11 shows the influence of increasing level of daily ME intake, while holding the daily intake of DCP approximately the same for each group of lambs, on the percentage of crude protein in fatty and muscle tissues.

The regression lines show no noticeable change in the percentages of crude protein in both tissues as the daily intake of ME was increased.

Fig. 9. The effect of level of dietary ME on the percentage of dry matter in carcass tissues of B.F. wether lambs

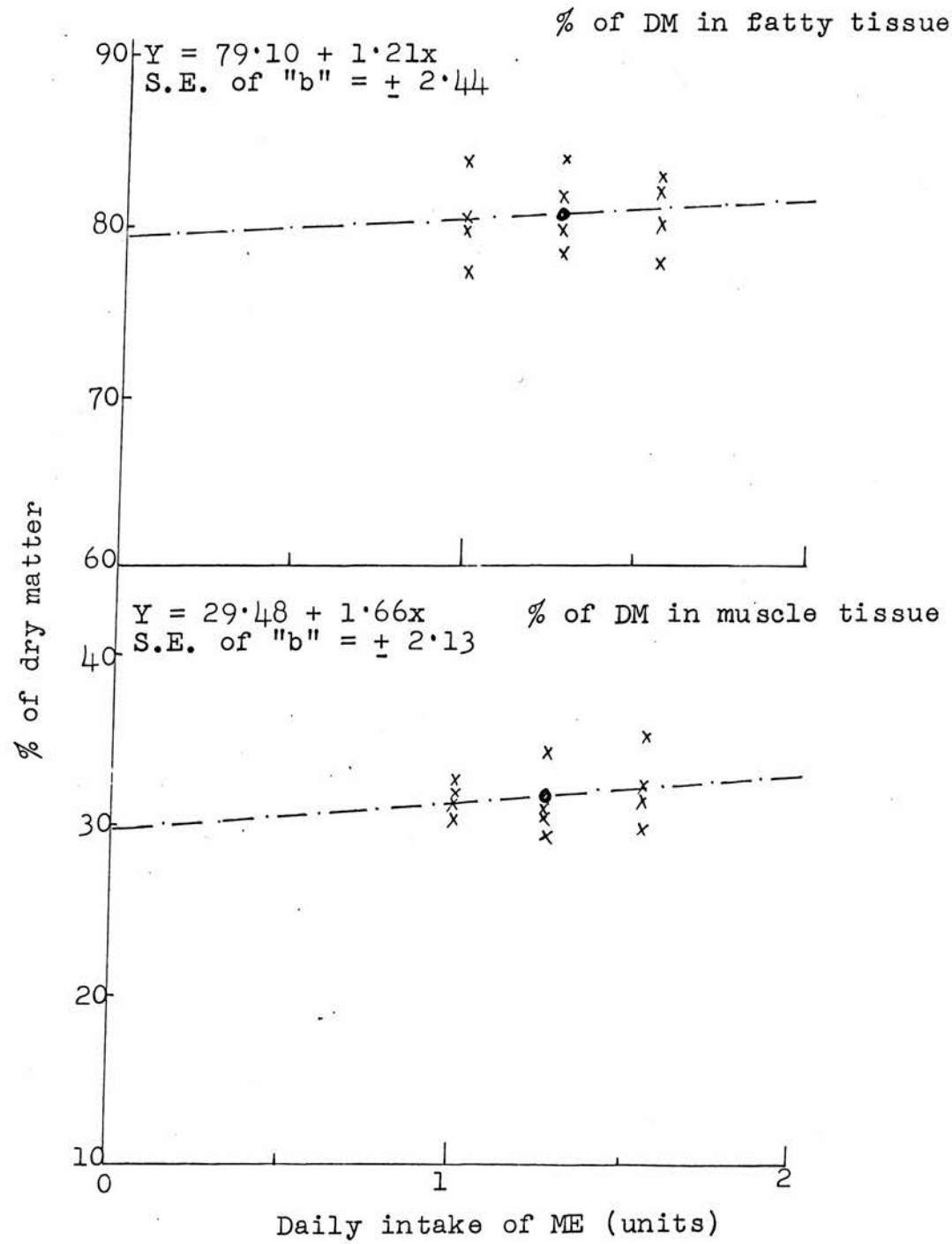


Fig. 10. The effect of level of ME on the percentage of ether extract in carcass tissues of B.F. wether lambs

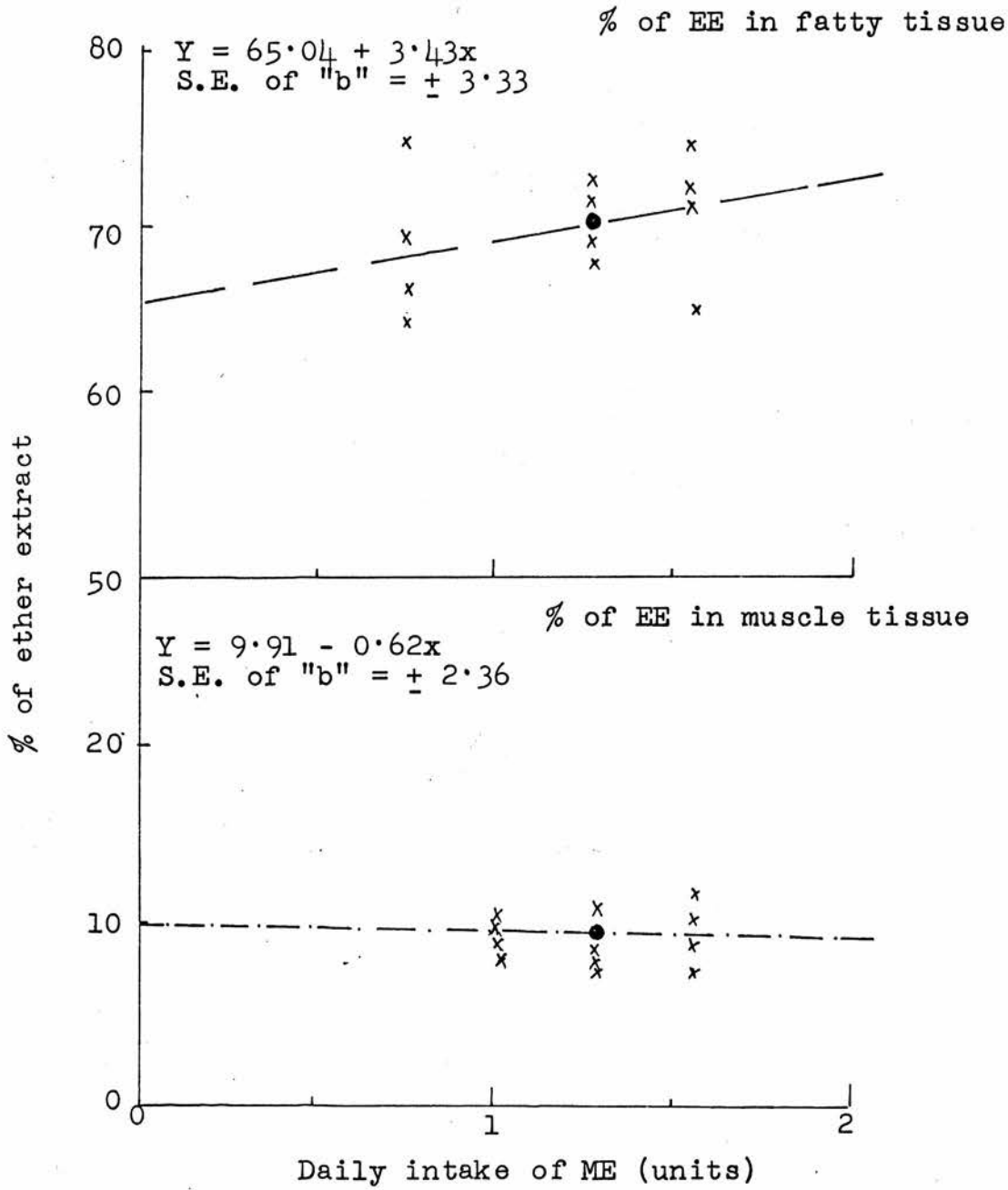
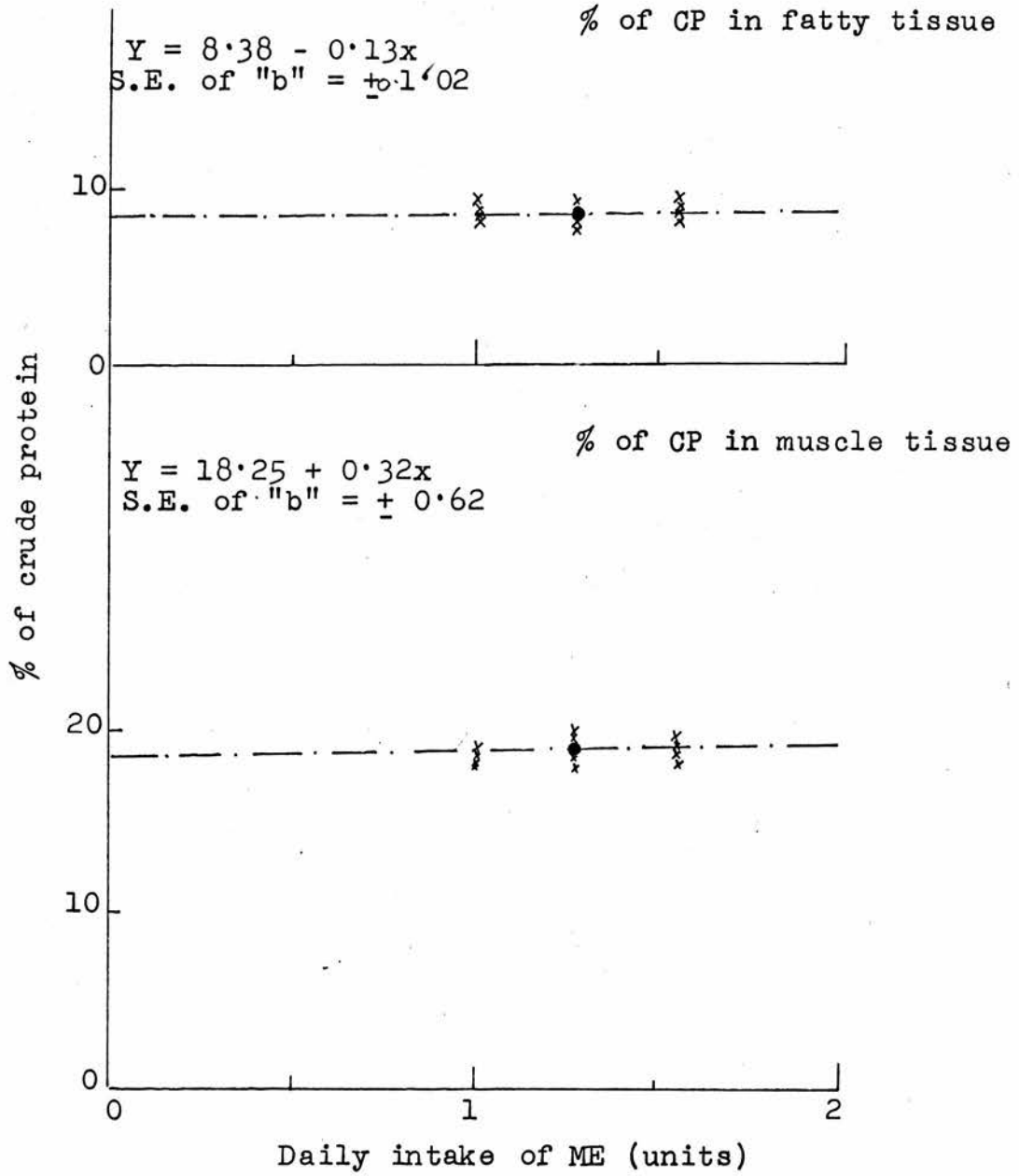


Fig. 11. The effect of level of ME on the percentage of crude protein in carcass tissues of B.F. wether lambs



There was no significant ($p < 0{\cdot}05$) difference between groups for the crude protein per cent in both the tissues studied.

The effect of level of daily intake of ME on gain in weight of the chemical components of carcass tissues

(a) Dry matter: Figures 12a and 12b show the effect of increasing the level of daily intake of ME on the gain in weight of dry matter in fatty tissue, muscle and bone. The gain in dry matter weight in fatty tissue was significantly ($p < 0{\cdot}05$) increased while the gain in weight of dry matter in muscle tissue tended to increase, but did not reach significance at the 5 per cent level, as the daily level of ME was increased. There was a slight increase in the gain in dry matter in bone tissue but was not significant at the 5 per cent level.

The regression equation shows that, for each unit of energy increase, dry matter in fatty tissue might be expected to increase its weight gain by 0·93 kg over a period of 91 days.

The analysis of variance (Appendix IV) for the gain in weight of dry matter in these tissues showed no significant ($p < 0{\cdot}05$) differences between groups.

(b) Ether extract: Figure 13 shows that as the level of daily dietary ME increased, the gain in weight of ether extract in fatty tissue was significantly ($p < 0{\cdot}05$) increased. The gain in weight of ether extract in the muscle tissue increased as the level of ME increased but the relationship failed to reach significance at the 5% level of probability.

Fig. 12a. The effect of level of dietary ME on gain in weight of the dry matter in carcass tissues of B.F. wether lambs

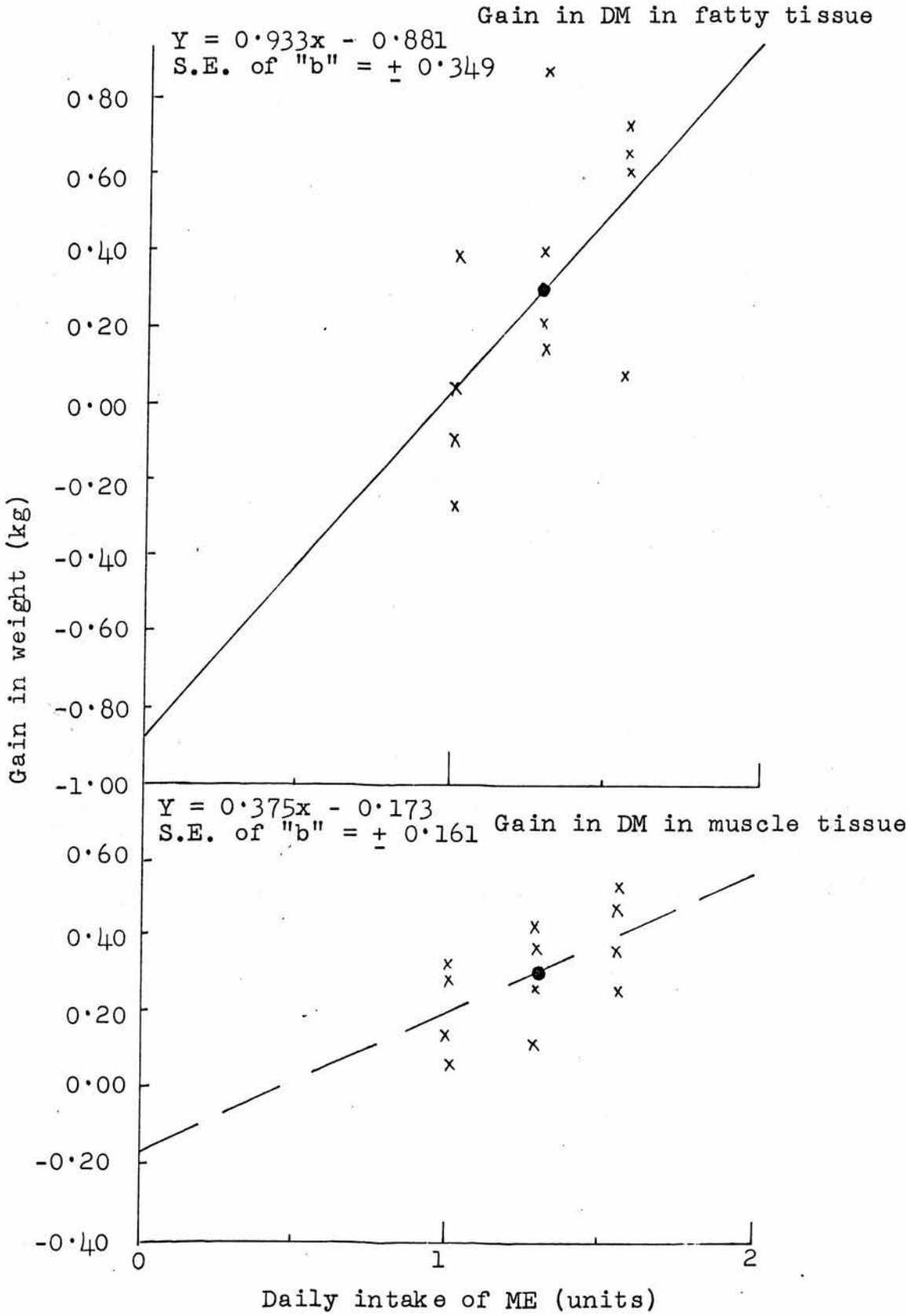


Fig. 12b. The effect of level of dietary ME on gain in weight of the dry matter in carcass tissues of B.F. wether lambs

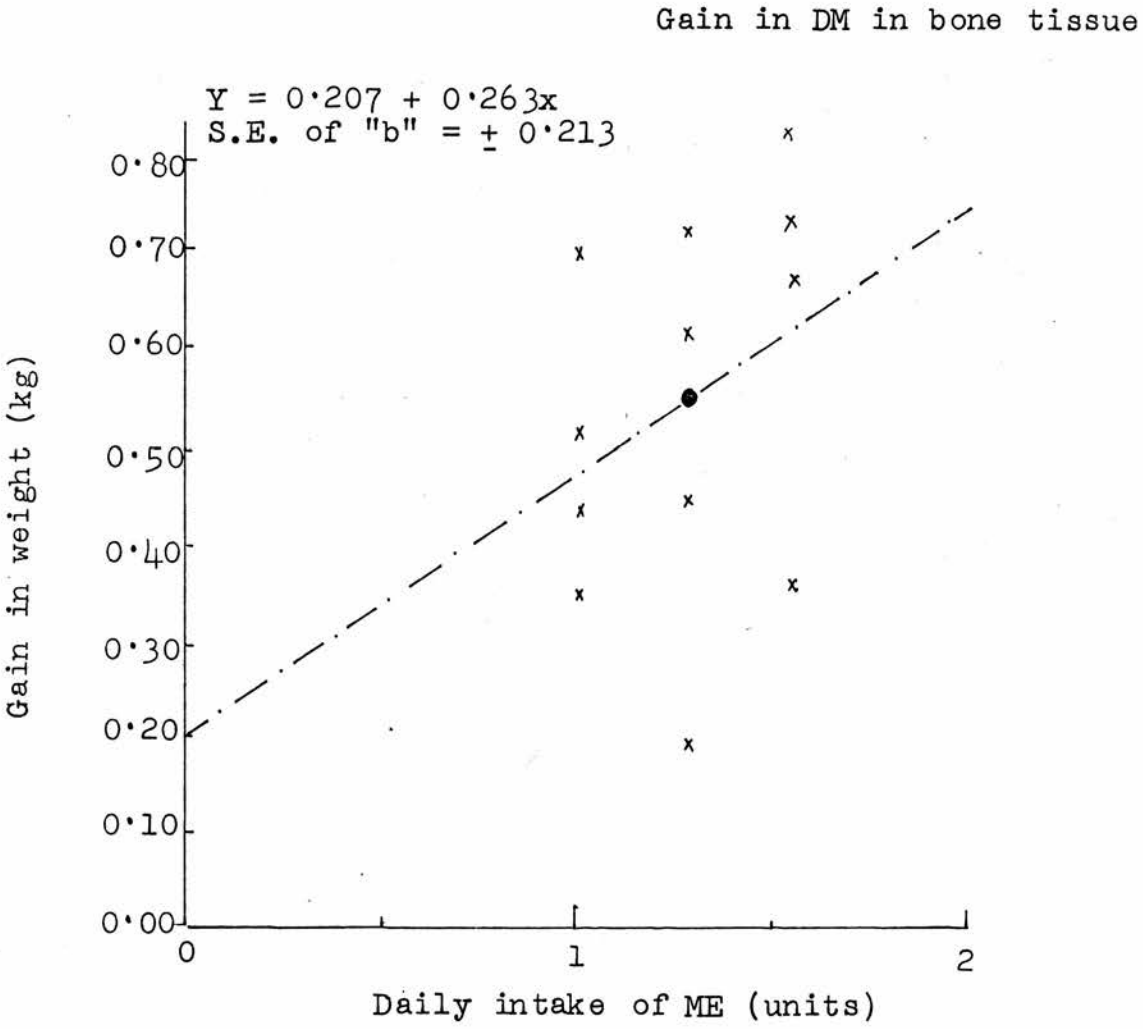
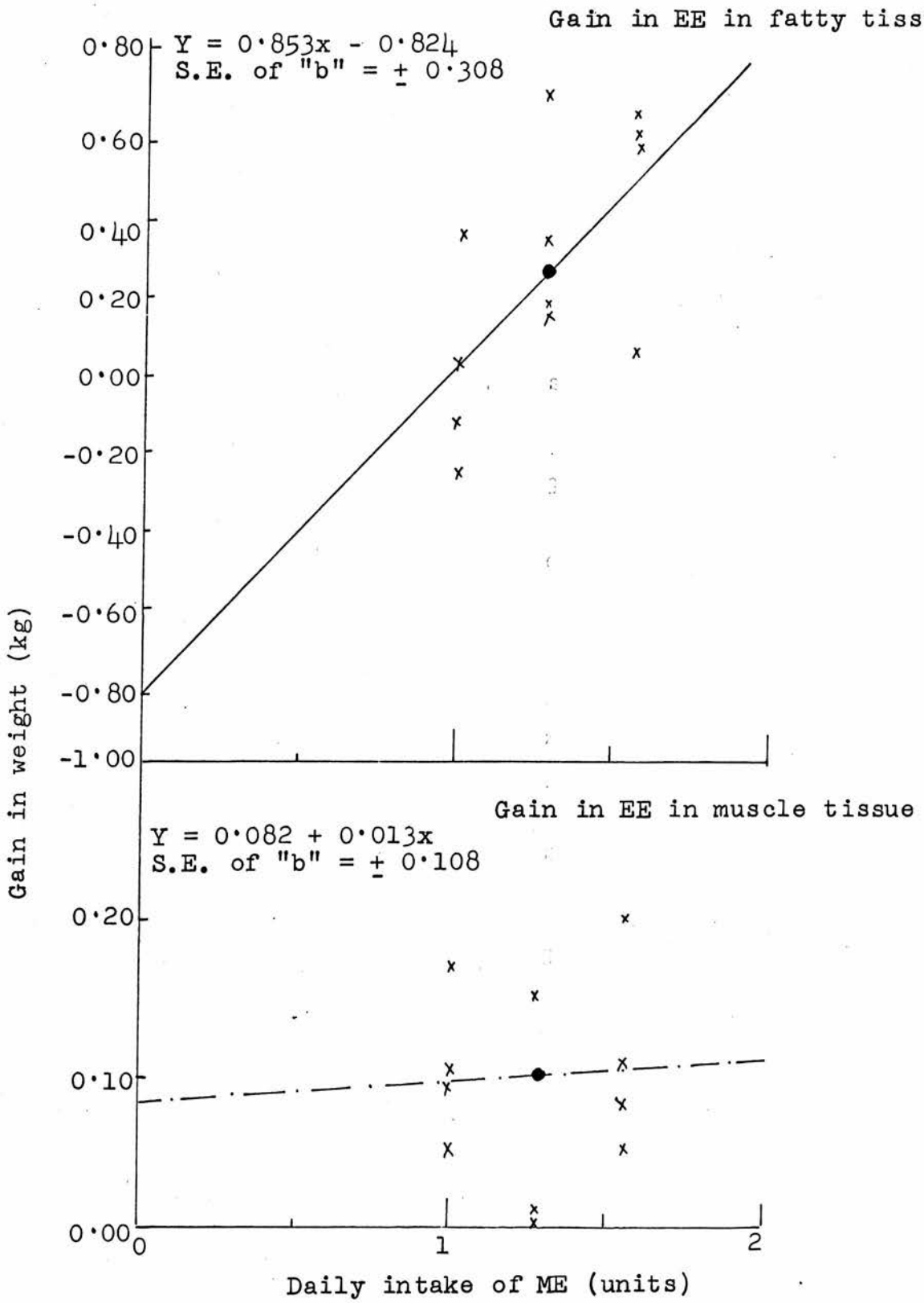


Fig. 13. The effect of level of dietary ME on gain in weight of the ether extract in carcass tissues of B.F. wether lambs



The regression equation of the relationship of ether extract in fatty tissue with level of the daily intake of ME shows that, for each unit of ME increase, the gain in weight of ether extract might be expected to be increased by 0·85 kg within 91 days.

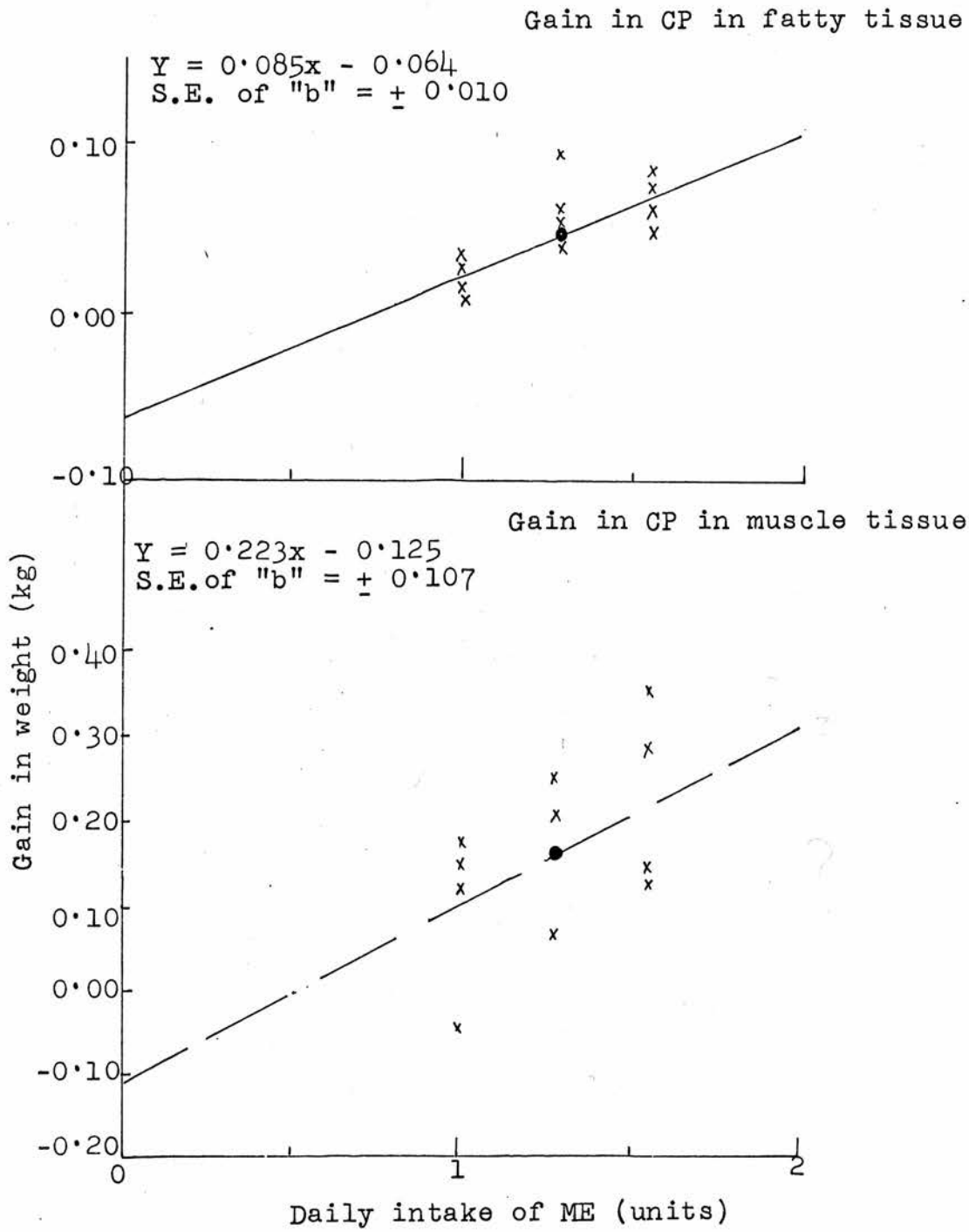
The analysis of variance for the gain in weight of ether extract in these tissues failed to reveal significant ($p < 0·05$) differences between groups.

(c) Crude protein: Figure 14 shows that, with increasing the level of daily ME intake, the gain in weight of crude protein in the fatty tissue was highly significantly ($p < 0·01$) increased while the gain in crude protein in muscle tissue tended to increase in weight but did not reach significance at the 5 per cent level.

The regression equations expressing these relationships show that, for each unit of ME increase at the constant DCP level reported, the gain in weight of crude protein in the fatty tissue might be expected to be increased by 0·09 kg over a period of 91 days.

On testing differences between groups, the analysis of variance for the gain in weight of crude protein in fatty tissue showed that the A group of lambs differs significantly ($p < 0·01$) from either of the other two groups. There was no significant ($p < 0·05$) difference between the C and B groups of lambs. The differences between groups for the gain in weight of crude protein in muscle tissue did not reach significance at the 5 per cent level of probability.

Fig. 14. The effect of level of ME on gain in weight of crude protein in carcass tissues of B.F. wether lambs



The effect of level of daily intake of ME on the gain of gross energy in the carcass tissues

The total gross energy in fatty tissue, muscle and bone has been calculated. The weight of ether extract and weight of fat free dry matter in fatty and muscle tissues and the weight of dry matter in bone tissue were multiplied by the mean caloric values of EE, FFDM and the caloric value of g bone.

Figures 15a and 15b show the influence of increasing the level of daily intake of ME, when the level of daily DCP intake was kept approximately the same for each group of lambs, on the gain of gross energy in the carcass tissues. The gain in gross energy in fatty tissue was significantly ($p < 0{\cdot}05$) increased, while the gain in gross energy in muscle and bone tissues tended to increase but failed to reach significance at the 5 per cent level.

The regression equations of these relationships show that, for each unit of ME increase, the gain in gross energy in fatty tissue, might be expected to be increased by 8·50 Mcal, over a period of 91 days.

The analysis of variance (Appendix IV) revealed no significant ($p < 0{\cdot}05$) differences between groups for the gain in gross energy in the carcass tissues.

The effect of level of daily intake of ME on gain in weight of the dry matter of live weight components - pelt, blood, feet and head

Dry matter determination was made on samples of pelt, blood, feet and head, (Appendix VII).

Figures 16a and 16b show the effect of increasing level of daily intake of ME on the gain in weight of these components. The

Fig. 15a. The effect of level of dietary ME on gain in the gross energy (Mcal) of carcass tissues of B.F. wether lambs

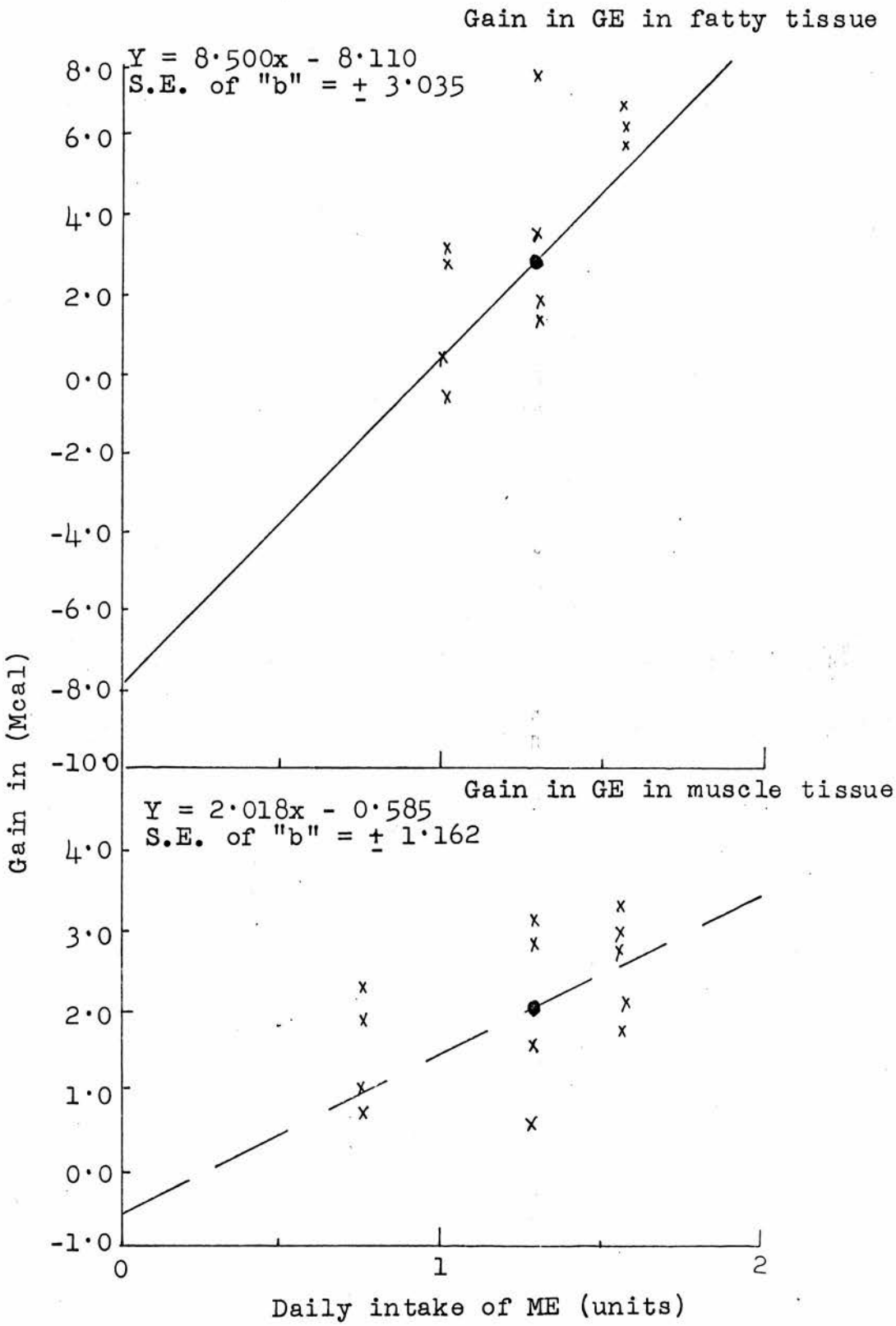


Fig. 15b. The effect of level of dietary ME on gain in the gross energy (Mcal) of carcass tissues of B.F. wether lambs

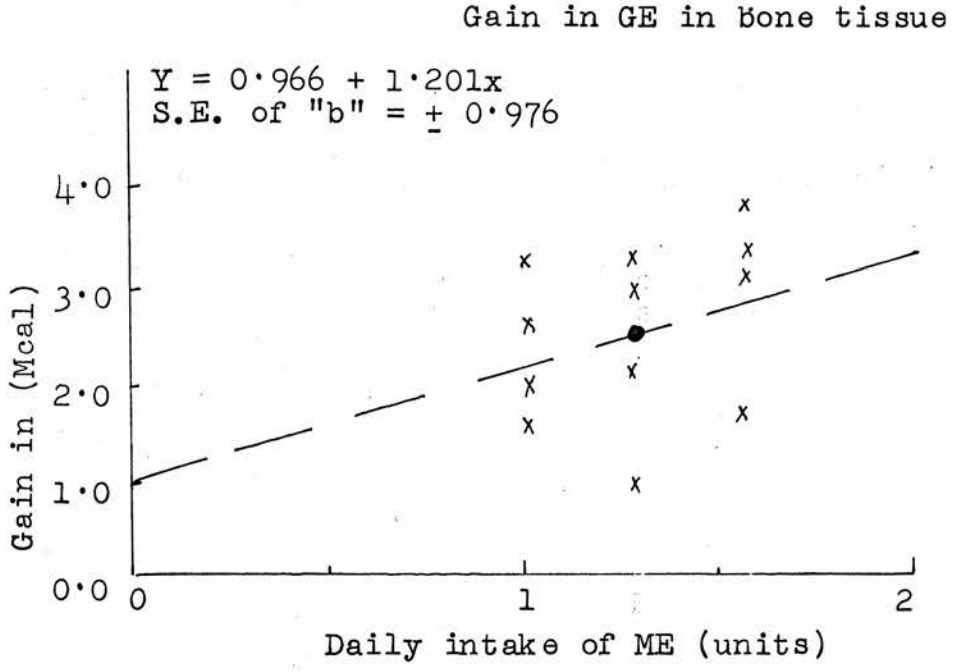


Fig. 16a. The effect of level of dietary ME on gain in weight of the dry matter of live weight components of B.F. wether lambs

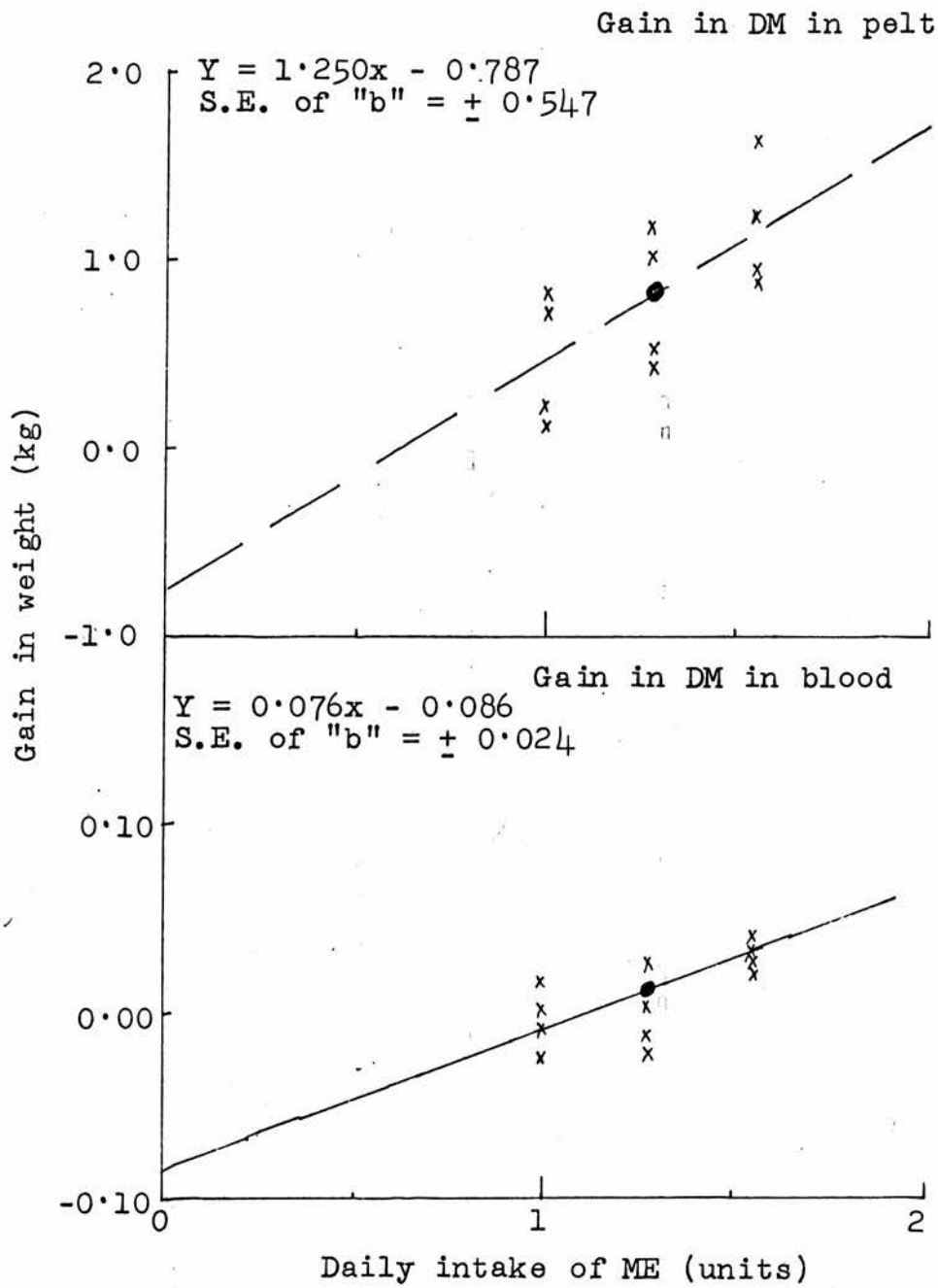
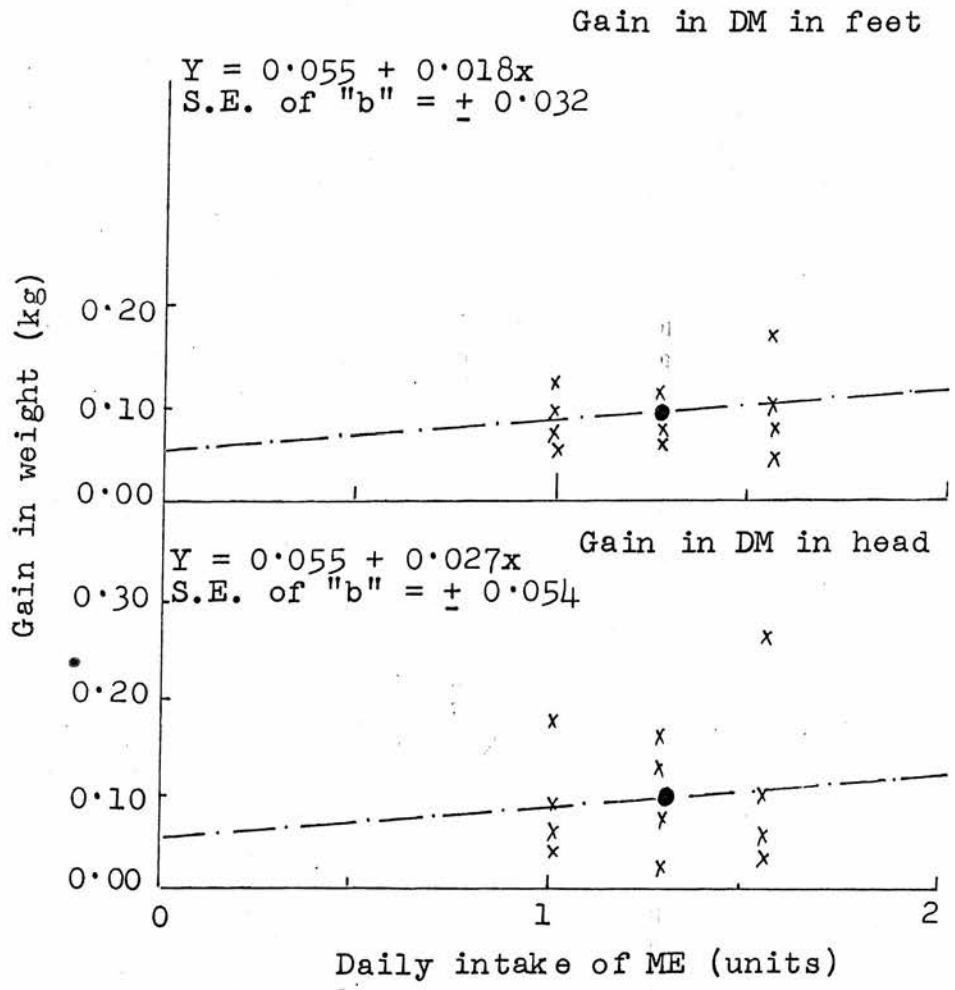


Fig. 16b. The effect of level of dietary ME on gain in weight of the dry matter of live weight components of B.F. wether lambs



gain in weight in dry matter in blood was significantly ($p < 0{\cdot}05$) increased while the gain in dry matter in pelt tended to increase in weight but was not significant at the 5 per cent level. The gain in weight of the dry matter in feet and head showed no relationship with levels of ME.

The regression equations expressing these relationships show that, for each unit of ME increase, the dry matter in the blood might be expected to increase in weight gain by 0·08 kg within a period of 91 days.

The analysis of variance (Appendix IV) for the gain in dry matter in blood shows that there was a significant ($p < 0{\cdot}05$) difference between group C and either of the other two groups. Groups B and A did not differ significantly ($p < 0{\cdot}05$) in the gain in weight of the dry matter in blood. The differences between groups for the gain in weight of dry matter in pelt, feet and head failed to reach significance at the 5 per cent level.

<u>The effect of level of daily intake of ME on gain in gross energy of live weight components pelt, blood, feet and head</u>

The total gross energy in pelt, blood, feet and head was calculated by multiplying the weight of the dry matter of these components by the caloric values of these components determined by the bomb calorimeter (Methods section - Table 14).

Figures 17a and 17b show that as the level of daily intake of ME increased, the gain in gross energy in blood was significantly ($p < 0{\cdot}05$) increased, while the gain in gross energy in the pelt tended to increase although this relationship did not reach

Fig. 17a. The effect of level of dietary ME on gain in gross energy of live weight components of B.F. wether lambs

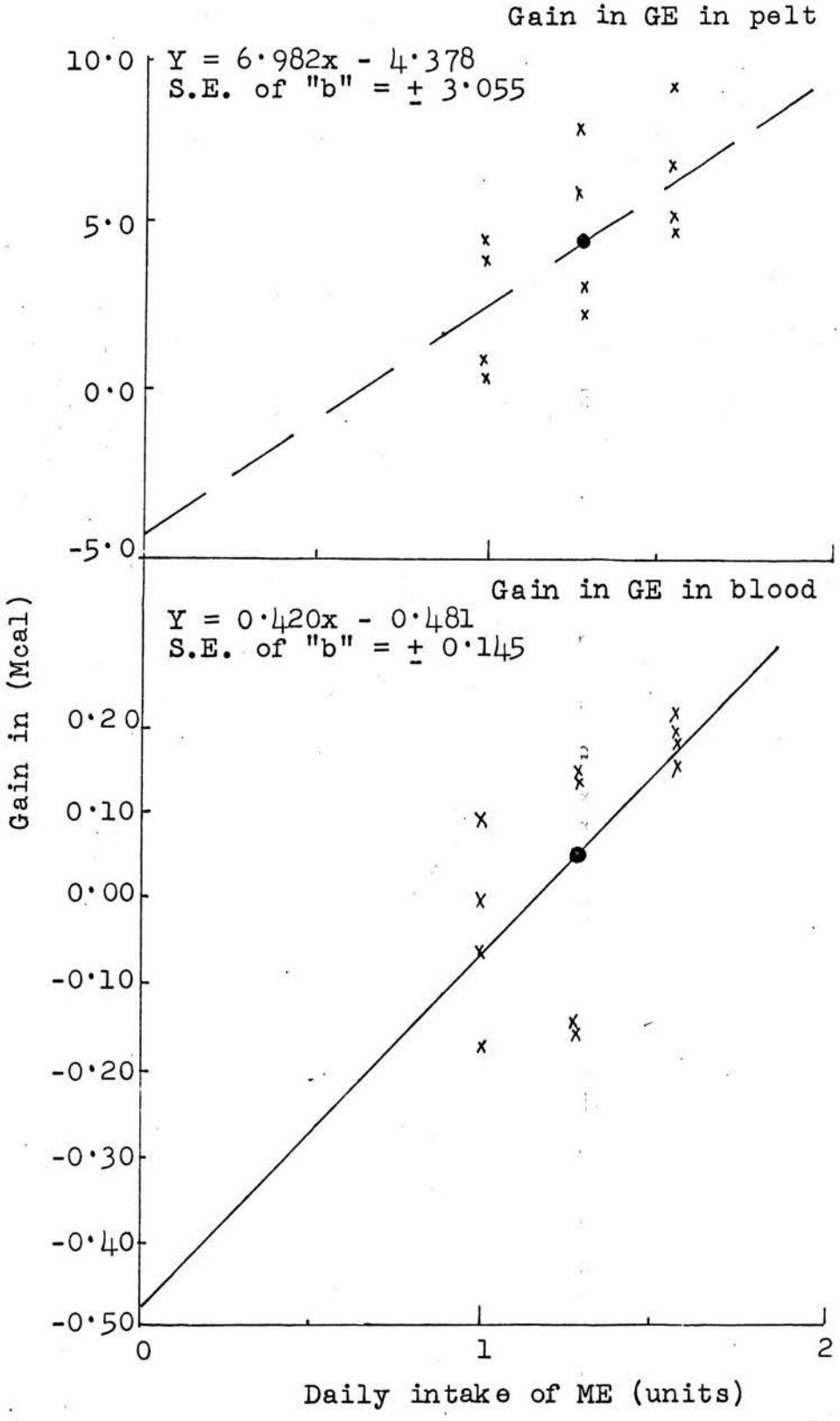
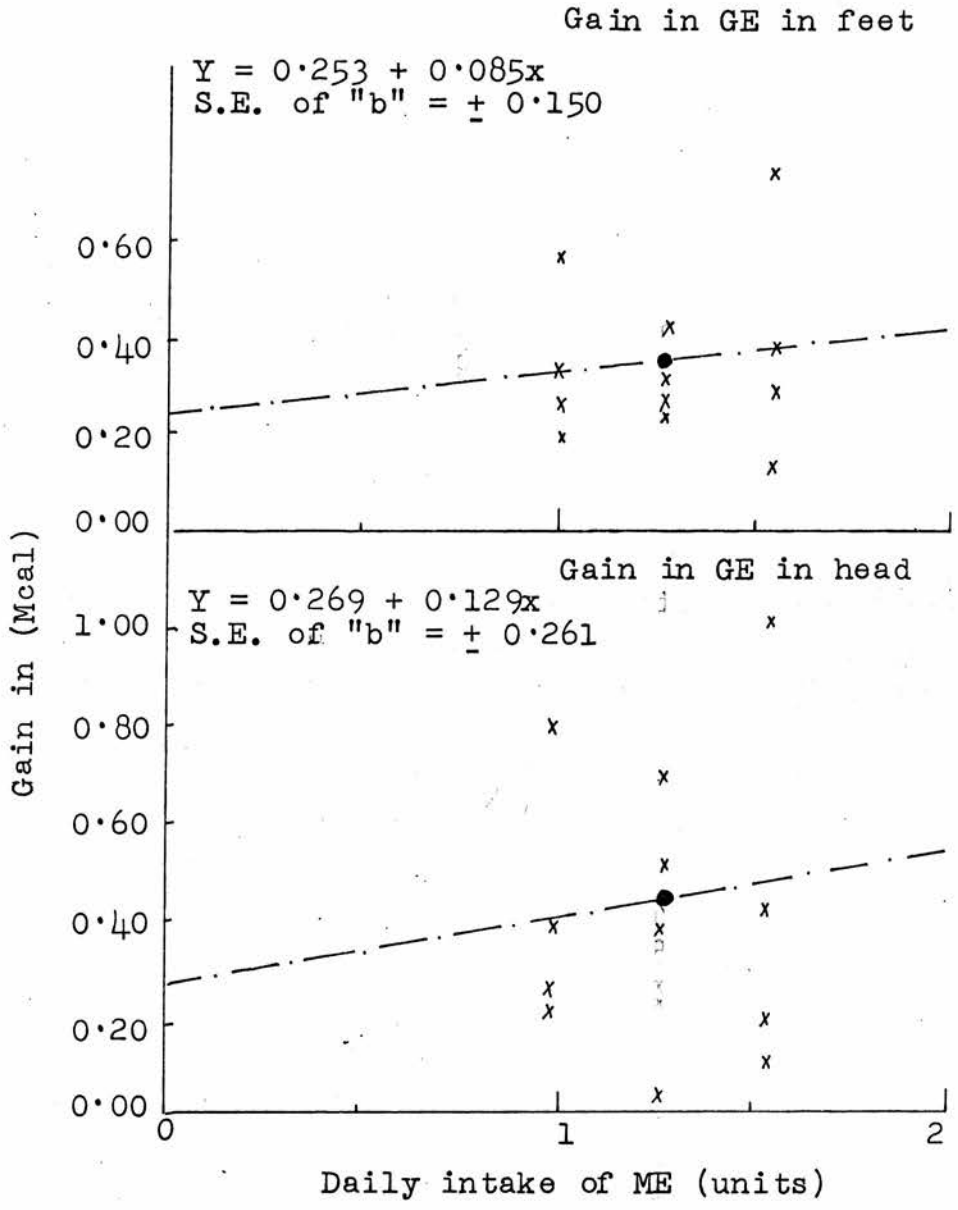


Fig. 17b. The effect of level of dietary ME on gain in gross energy of live weight components of B.F. wether lambs.



significance at the 5 per cent level. The gain in gross energy in the feet and head showed no noticeable change with increasing levels of ME.

The regression equations of the relationship of level of daily ME intake with the gain in gross energy show that, for each unit of ME increase, the gain in gross energy in blood might be expected to be increased by 0·42 Mcal over a feeding period of 91 days.

On testing differences between groups, the analysis of variance (Appendix IV) for the gain in gross energy in blood shows that the C group of lambs differed significantly ($p < 0·05$) from either of the other two groups. There was no significant ($p < 0·05$) difference between groups B and A. The differences between groups for the gain in gross energy in pelt, feet and head did not reach significance at the 5 per cent level.

D I S C U S S I O N

of

E X P E R I M E N T II part (a)

DISCUSSION

The rate of production of body tissues in growing animals depends on the level of available food nutrients and on the stimulus for growth. Most of the experiments carried out on the relationship between level of feeding and growth and development of animals have been concentrated on the differences in the quantitative plane of nutrition without reference to the qualitative differences. It was the aim of the study to investigate the influence of different levels of metabolizable energy on body composition and carcass characteristics of lambs when the daily intake of DCP was approximately the same for each group of lambs.

Table 18. Classifies the responses of the various components in the same manner as in Experiment I produced the following types of responses.

	Significant*		Doubtful		Non-significant	
Important response	L.wt.	+	Gigot	+		
	S.E.B.	+	Muscle tissue (shoulder)	+		
	warm carcass	+	Muscle tissue (loin)	+		
	Caul fat	+	M.gastrocnemius	+		
	Fatty tissue	+	Pelt	+		
	Shoulder	+				
	Loin	+				
	Rib	+				
	Fatty tissue(gigot)	+				
	Fatty tissue(shoulder)	+				
	Fatty tissue (loin)	+				
	Fat thickness(rib)	+				
	M.l.d. (loin area)	+				
	M.obliquus Internus	+				
	M. brachialis	+				
	M. biceps brachii	+				
	DM in fat	+				
	EE in fat	+				
	CP in fat	+				
	GE in fat	+				
	GE in blood	+				
Possible response	Flank (rib)	+	Blood	+	Muscle tissue (gigot)	+
			Muscle tissue	+	M. quadriceps	+
			Flank (loin)	+	M.l.d. (rib)	+
			Muscle tissue(rib)	+	M. gluteus medius	+
			Area of M.l.d.	+	DM in bone	+
			M.semimembranosus	+	GE in muscle	+
			M.semitendinosus	+	GE in bone	+
			M. psoas major	+		
			M. pectoralis	+		
			M.supraspinatus	+		
			% EE in fat	+		
			DM in muscle	+		
			CP in muscle	+		
			DM in pelt	+		
			GE in pelt	+		
Trivial response			kidney + perirenal fat	+	Gut "fill"	+
			Shank	+	Feet + Pluck	+
			Brisket	+	Gut + Head	+
			Bone tissue(rib)	+	Bone tissue +- Neck	+
			M.extensor digitorum	+	Flank (gigot)	+
			M.infraspinatus	+	Bone tissue(gigot)	+
					Bone tissue(shoulder)	+-
					Bone tissue(loin)	+
					Perirenal fat	+-
					M.extensor corpi	+
					% DM in fat	+-
					% DM in muscle	+-
					% CP in fat	+-
					% CP in muscle	+-
					EE in muscle	+-
					muscle in kidney	+-

* $p < 0.05$ + Positive response +- No response

The results show that when the daily intake of DCP was constant, increasing the level of dietary metabolizable energy had a significant effect on increasing the gain of liveweight, S.E.B., warm carcass, caul fat, fatty tissue in the carcass, the four prime cuts of the carcass (shoulder, gigot, loin and rib) and indicated significant differential stimulation of some of the parts, tissues and chemical components of the carcass. Most of the measures of fat development significantly increased in gain as the level of daily dietary ME was increased unlike those of bone tissue, which showed no noticeable response. Those of muscle tissue development responded intermediately. The chemical composition of the carcass tissues was not noticeably altered by the treatments.

In the Appendix (IV) Table 19 the response is expressed as a percentage of the initial weight of the component along with the regression coefficient, the standard error of the regression coefficient and the "F" value for the between group comparisons.

The main effect of increasing the daily intake of dietary metabolizable energy, while keeping the daily intake of DCP the same for each group, was to stimulate the development of fatty tissue and those components which contained a high proportion of fatty tissue. Fatty tissue in the carcass and caul fat were almost doubled during the feeding period by increasing by one unit the daily energy intake. Fatty tissue in the gigot and shoulder gave similar response while fatty tissue in the loin and rib region and fat thickness at the 12th rib exceeded this response. Perirenal fat however gave a surprisingly small response which may indicate that this specialised fat deposit was little effected during this period of development.

That fatty tissue in the carcass was markedly effected by increasing the level of ME is in close agreement with the results of plane of nutrition experiments (McMeekan, 1940b,c, with pigs; Palsson and Verges, 1952a, with lambs; Wilson, 1952, with fowl and 1958, 1960, with goats; and Luitingh, 1962, with cattle). This was to be expected since the energy surplus to requirements is stored in this tissue. The results indicated however that fatty tissue over the various parts of the carcass was not equally effected. McMeekan (1940b) and Palsson and Verges (1952a) have suggested that in the growing animals, level of nutrition does not only effect individual organs and tissues of the body differentially but also, within a tissue, some parts are effected proportionally more than others. It is generally accepted that the fatty tissue of the body develops in the order of kidney fat, followed by intermuscular fat and then subcutaneous fat. The gain in weight of fatty tissue in the loin showed the greatest stimulation to levels of dietary energy. The relationship between the gain in weight of fat in the loin and level of daily intake of ME was highly significant at the $p < 0{\cdot}01$ level of probability. This finding is in close agreement with the results of Palsson and Verges (1952a) that the fat of the loin was most effected by the level of feeding. The gains in weight of the fatty tissue in the shoulder, gigot and rib joints showed similar response to levels of dietary energy and were significant at the 5 per cent level of probability. McMeekan (1940b) reported that the rate of growth of fatty tissue in the shoulder and leg were similar. The gain in weight of the perirenal fat was not effected by the level of dietary ME. However this part of fatty tissue was described to

be early developing and therefore expected to be less effected by nutritional levels. The gain in fat thickness (mm) over the 12th rib was highly significantly increased. Palsson and Verges (1952a) with lambs and Luitingh (1962) with cattle, obtained comparable results indicating that subcutaneous fat in the loin was most effected by the plane of nutrition.

The response of the muscle tissue to increasing the level of energy in diets which have similar contents of dietary DCP was positive but not significant. At the levels used the extra energy encouraged the utilisation of the available DCP for muscle development at least to a moderate extent. Although the response of muscle tissue in the carcass was not significant at the 5 per cent level of probability some parts of it showed a positive and important response while others reached significant levels. Muscle tissue in the shoulder and loin area had an important but non-significant response while the muscles longissimus dorsi in the loin area, M. obliquus internus abdominis + M. transversus abdominis in the abdominal region and M. biceps brachii, M. brachialis and M. gastrocnemius of the distal parts of the limb gave significant responses. Muscle tissue in the gigot and certain individual muscles e.g. M. semitendinosus, M. semimembranosus and M. quadriceps femoris showed only a small response which was not significant. These findings are in good agreement with those of Palsson and Verges (1952a) who found that muscle tissue of the leg and thigh were least effected by level of feeding while those of the shoulder and lumbar regions were most effected. The gain in weight of

kidney (early developing part) was not effected by increasing levels of dietary ME at constant daily DCP intake. It is interesting to note that the gain in weight of muscle tissue in the gigot and kidney joints which showed little response to level of dietary ME at constant daily intake of DCP showed the greatest response to increasing the levels of dietary DCP at constant daily intake of ME. This result suggests that level of dietary protein had a distinctly different action in stimulating the growth of parts of the body to that of energy.

The significant increase in the gain in weight of M. obliquus internus abdominis + M. transversus abdominis was in accordance with the findings of Butterfield (1963b) that the late developing abdominal muscles showed greatest response to restricted feeding and subsequent recovery. The gain in weight of M. longissimus dorsi in the loin area was more effected by the level of daily intake of ME than that portion in the rib area. Hammond (1932) and Palsson (1955) reported that the lumbar portion of M. longissimus dorsi is later developing than the thoracic part. It was surprising to find that most of the individual muscles which showed the greatest stimulation to dietary protein levels were least effected by the dietary ME levels.

Growth and development of individual muscles of the animals is a subject that has not been fully studied and this makes the interpretation of these findings more difficult. Further investigations to explain the differential effects of nutritional treatments upon the development of the individual muscles are needed.

It cannot be stated whether these effects of nutritional treatments are related to the order of development of the individual muscles or to the qualitative differences that occur between muscles.

Other components having a high proportion of protein showed a positive and important response to level of energy. Of these pelt and blood were the most noticeable while pluck and alimentary tract responses were trivial. The response of pelt may be due to the increase in fat content of the skin or simply to the increase in weight of the live body. Jackson (1961) found a high correlation (r = 0·982) between the fleece weight and the weight gains of sheep. As pelt was not critically examined the contribution of these factors cannot be assessed. The response of blood tissue to level of energy failed to reach significance although the response was appreciable. Comparing these results with those of Experiment I it appears that the weight of blood is more effected by dietary protein level than dietary energy level. While the body weight increased with increasing daily intakes of energy, it might be expected that blood weight would also increase.

The results of Palsson and Verges (1952a) show that the lambs on a high level of nutrition had heavier liver, heart, lungs and spleen than those fed low level of feeding. Our experiment reports that there was no detectable increase in the gain in weight of the pluck (includes liver, heart, lungs and spleen) in lambs fed different levels of daily intake of energy at constant level of DCP.

However, Palsson and Verges used animals which were treated from the third month of foetal life and taken over their entire life-time. Unfortunately the protein content, as well as the level of energy, differed between the treatments which made a direct comparison with these results impossible. In the study being reported the level of daily intake of DCP was approximately equal for each group of lambs. Since dietary protein levels were found to effect the gain in weight of the pluck (Experiment I) it may be suggested that the development of these organs was more related to the amount of protein in the ration rather than the level of dietary energy.

As protein level was constant for each group of animals it was expected that those body components, which depend largely on protein for their growth, would be equally effected. The results showed that there is strong evidence that protein deposition at least in some body components can be enhanced by increasing energy supply. Protein synthesis from its constituent amino acids is energetically expensive (Kielanowski, 1966a).

Bone tissue was not noticeably effected by increasing the level of dietary energy. Considering the various parts of the skeleton (with the exception of bone in the rib area which showed moderate response) increasing the level of energy, at constant protein intake, did not demonstrate any major differential effects on those parts. In all observations of bone tissue there was no significant nor important responses. The bony structions of head

and feet showed similar responses to that of total carcass bone. Other experiments have shown that restriction of energy supply was without detectable influence on bone growth. Benzie et al. (1960) have shown that supplements of dietary energy (starch) had a marked overall effect on live weight increase, but none on the deposition of minerals in the skeleton of Blackface wethers as a whole, the percentage of ash fell in almost all of the axial skeleton and in many regions of the appendicular skeleton. In the mandible the provision of extra dietary energy resulted in a smaller bone in which the percentage of ash had not been reduced. Hendrickson et al. (1965) found that restriction in energy supply for steers had no effect on carcass bone. The bone in the rib area which showed a moderate response can be explained on the basis of the early and late maturing concept. Many workers have demonstrated that the bone in the ribs represents the latest maturing bones of the body (Palsson and Verges, 1952a, with lambs; Joubert, 1959 and Luitingh, 1962, with cattle) and in consequence most effected by the level of nutritive supply. Palsson and Verges (1959a) have shown that the bone of the loin area attained its maximum rate of growth in the late stages of post-natal life. According to the early and late maturing concept it would be expected that this part of the skeleton would be greatly effected by the plane of nutrition. The results of the trial being reported showed that the gain in weight of bone tissue in the loin area was not noticeably effected by increasing the level of daily intake

of ME. Butterfield (1963b) quoted the work of Walker on steers and showed that the development of the lumbar vertebrae was not greatly different from that of the total bone. Hammond (1932), Palsson (1939) and Wallace (1948) found that the number of vertebrae in the lumbar region of sheep was extremely variable. It has been noticed during the dissection of our animals that an extra rib may be present and also in some lambs an extra lumbar vertebra. These added variants could influence the results concerning the rib and loin sections. This point should be accounted for in future investigations.

Overall these tissue responses effected the composite components. Warm carcass weight, standard empty body weight and live weight were all significantly increased by the increasing levels of metabolizable energy. Gut "fill" appeared to increase as the daily energy increased but no certainty can be placed on this response. The significant increase in the gain of liveweight found in this study was in agreement with the findings of many others (Robinson, 1948; Wallace, 1948; Palsson and Verges, 1952a, and Garrett et al., 1959, on sheep; McMeeken, 1940b,c; O'Grady, 1966, on pigs; Wilson, 1952 on poultry; and Eckles and Swett, 1918; Trowbridge et al., 1918; Moulton et al., 1922; Luitingh, 1962 and Hendrickson et al.,

1965, on cattle).

The dressed carcass was more effected than the organs and offal parts with the exception of the abdominal fats. These results were in close agreement with those of McMeekan (1940b) and Palsson and Verges (1952a).

Of the joints the shoulder, loin and rib increased significantly while gigot also gave an important response but which failed to reach significance at the 5% level of probability. The brisket, flank and shank joints make positive responses but are extremely variable. The response of the kidney and peri-renal fat was extremely small but still positive. As the tissues were differentially stimulated it was expected that those joints possessing a high proportion of fatty tissue would gain at a faster rate than those with a low proportion.

The concept put forward by Hammond (1952), Wallace (1948) and Palsson and Verges (1952a) that increasing the level of nutrition most effected the part which was developing at that time was demonstrated for tissues. The late developing fatty tissue showed greatest response, but this was to be expected as physiologically the surplus energy was being stored in this tissue. The concept was extended to cover parts of the carcass. In this trial the rib, loin and shoulder cuts were the commercial primal cuts and were not comparable to Hammond's or Palsson and Verges' joints of loin, rib, shoulder which were total sections of the carcass with the

ventral flank areas attached. The significant gains in the shoulder, rib, loin and flank (rib) and the tendency to gain in the joints of gigot, brisket, shank and loin flank would suggest that the subcutaneous fat has been most stimulated. The kidney plus perirenal fat showed no response to increase in dietary ME which was a most surprising finding. Palsson and Verges (1952a) showed that the shoulder of sheep was more effected by the plane of nutrition than was the hind leg (gigot). The flank showed a large response to increasing food level. The flank has been described by Butterfield (1963b) and Luitingh (1962) as late developing and effected most by plane of nutrition.

That the neck was not effected by the plane of nutrition is in contradiction to the findings of Palsson and Verges (1952a) who reported this joint to be more effected than either leg or shoulder on lambs. Whether this contradiction can be accounted for by the fact that in the lambs of the present trial, treatments only differed from weaning time when the development of the neck should be well advanced is not possible to resolve. Considering the tissue composition alone the neck would not be expected to respond greatly to increased levels of ME.

The chemical components indicated the type of response. The ether extract, crude protein and hence dry matter in the fatty tissue showed a large and significant response to increasing the daily intake of dietary energy but on a percentage basis the response was small and trivial. This is surprising - more fatty tissue but no change in the composition.

In muscle tissue the increase in dry matter was more due to the increase in crude protein than to the ether extract component. On a percentage basis the ether extract declined in the muscle tissue while the percentage CP did not appear to change. The increase in muscle tissue was not due to an increase in fat within the muscle but to a greater retention of protein.

It appears that when the dietary DCP was constant for each group of lambs the gain in weight of ether extract in muscle tissue was similar irrespective of level of dietary energy. This was contrary to what might have been expected from the response in fatty tissue and also the response to increasing daily protein level when energy was kept constant. As the ether extract in the muscle tissue may be an important component of carcass quality, this process requires further study.

These findings show that raising the level of energy supply at constant DCP intake, had no major influence on the chemical composition of the carcass tissues. The results were in good agreement with those obtained by Garrett et al. (1959) with sheep who found that the chemical composition of the carcass tissues was not greatly effected by the level of nutrition.

The increased gains in weight of crude protein in both fatty and muscle tissues of the carcass with increasing level of daily intake of metabolizable energy of lambs had similar quantities of daily DCP intake, may indicate that level of dietary energy enhanced protein deposition. The dependence of protein deposition on the level of energy intake has been shown by Kielanowski (1968). He pointed out that the daily deposition of protein depends largely on the energy supply "plane of nutrition" in addition to the individual abilities of the animals to deposit more or less protein and to the quality of food. The nitrogen balance in pigs weighing from 30 - 90 kg. liveweight increased in response to higher plane of nutrition.

The gain in dry matter and gross energy in bone tissue showed only a slight increase. The gross energy of fatty tissue increased noticeably while that of muscle tissue

increased only marginally. Similar results were obtained by Garrett et al. (1959) who found that theenergy retention in the fatty tissue of the lambs increased with increasing daily intake of ME.

The conclusion to be drawn was that increasing the level of dietary ME at constant daily intake of DCP had a marked effect on fat development in the body, except the perirenal fat, while there was no marked influence on bone growth. In general muscle tissue in the carcass gave only a small response although some measures of muscle development did demonstrate an important response.

R E S U L T S

of

E X P E R I M E N T II part (b)

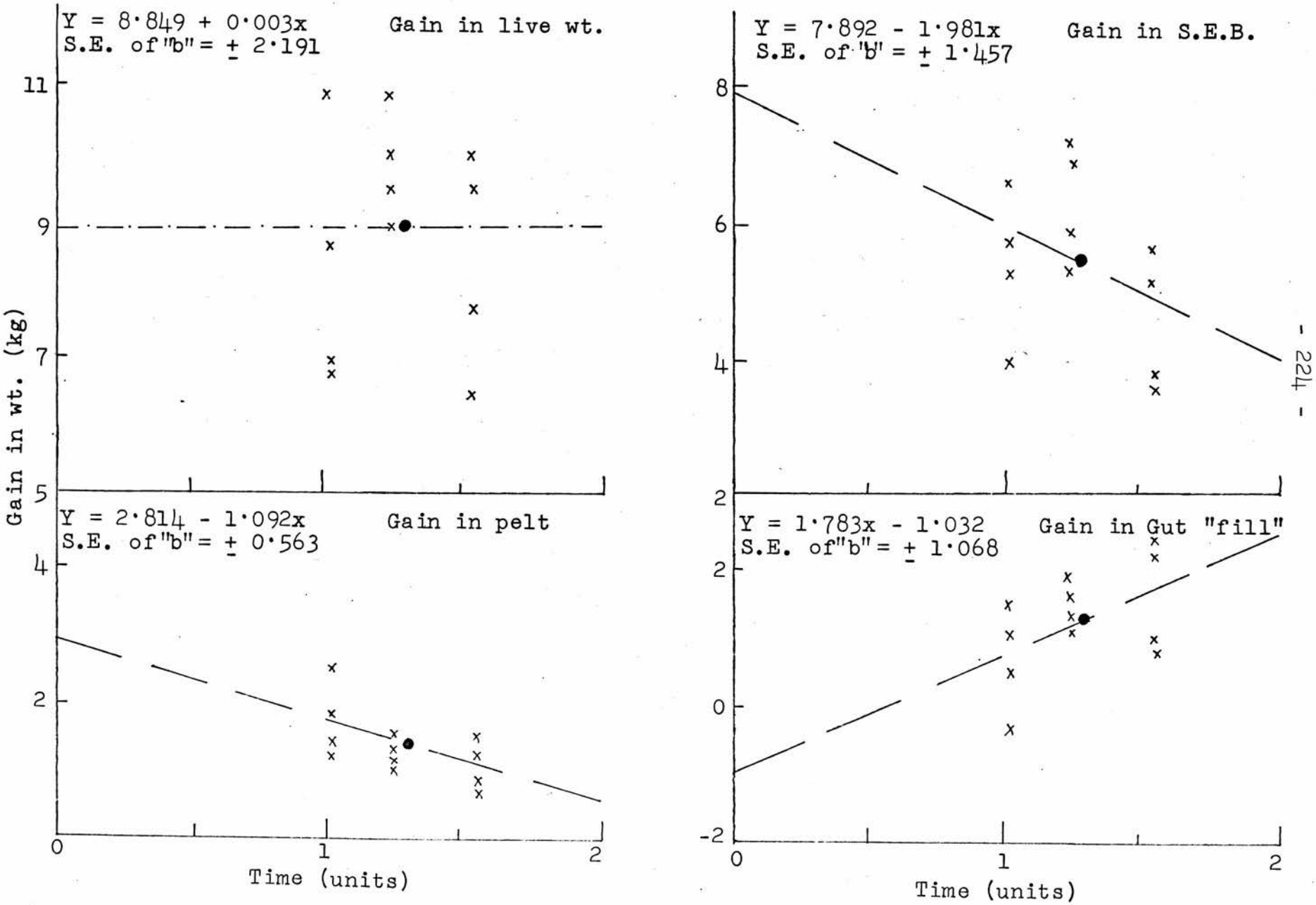
PART (b)

THE EFFECT OF LEVEL OF DAILY INTAKE OF METABOLIZABLE ENERGY ON BODY COMPOSITION AND CARCASS CHARACTERISTICS OF GROUPS OF BLACKFACE WETHER LAMBS WHICH WERE SLAUGHTERED AFTER DIFFERENT NUMBER OF DAYS ON THE FEED SO THAT EACH CONSUMED SIMILAR TOTAL QUANTITIES OF METABOLIZABLE ENERGY

The effect of restricting the daily intake of a given quantity of ME on gain in weight of live weight components

Figure 1 shows the effect of increasing daily dietary metabolizable energy levels on the gain in weight of live-weight, S.E.B., pelt and alimentary trace "fill" of groups of lambs which have been fed the same total quantity of metabolizable energy but over different lengths of feeding periods. The gain in weight of the S.E.B. and pelt tended to decrease, while the gain in weight of gut "fill" showed a tendency to increase as the days taken to feed the quantity of ME increased but these relationships did not reach significance at the 5 per cent level. When fed the same total energy the gain in liveweight showed no significant ($p < 0{\cdot}05$) increase in weight due to the daily dietary ME intake.

Fig. 1. The effect of restricting the daily intake of a given quantity of ME on gain in weight of live wt. components of B.F. wether lambs



On testing differences between groups the analysis of variance (Appendix V) for the gain in weight of these body components showed no significant ($p < 0{\cdot}05$) differences between groups.

The effect of restricting the daily intake of a given quantity of ME on gain in weight of standard empty body components

Figures 2^{I} and 2^{II} show that, as the time taken to feed the same quantity of ME increased, the gain in head was significantly ($p < 0{\cdot}05$) increased in weight while the gain in weight of caul fat was decreased significantly at the 5 per cent level. The gain in weight of warm carcass, blood, feet, pluck and gut showed no relationship with the time taken to feed the same quantity of ME at different daily intake levels.

The regression equations of these relationships show that, as the days to feed the quantity of energy increased by one unit, the gain in weight of head might be expected to increase by 0·42 kg, while the gain in weight of caul fat decrease by 1·08 kg.

The analysis of variance (Appendix V) for the gain in weight of head and caul fat showed significant differences between groups. The gain in weight of head in the D group of lambs (fed for 140 days) was significantly ($p < 0{\cdot}05$ and $p < 0{\cdot}01$) greater than the C group (fed for 91 days) and the E group (fed for 112 days) respectively. The E and C groups of lambs did not differ significantly ($p < 0{\cdot}05$) in the gain in weight of head. There was a significant ($p < 0{\cdot}05$) difference between groups D and C in the gain in weight of caul fat while the differences between the other groups were not significant at the 5 per cent level. The analysis

Fig. 2[I]. The effect of restricting the daily intake of a given quantity of ME on gain in weight of S.E.B. components of B.F. wether lambs.

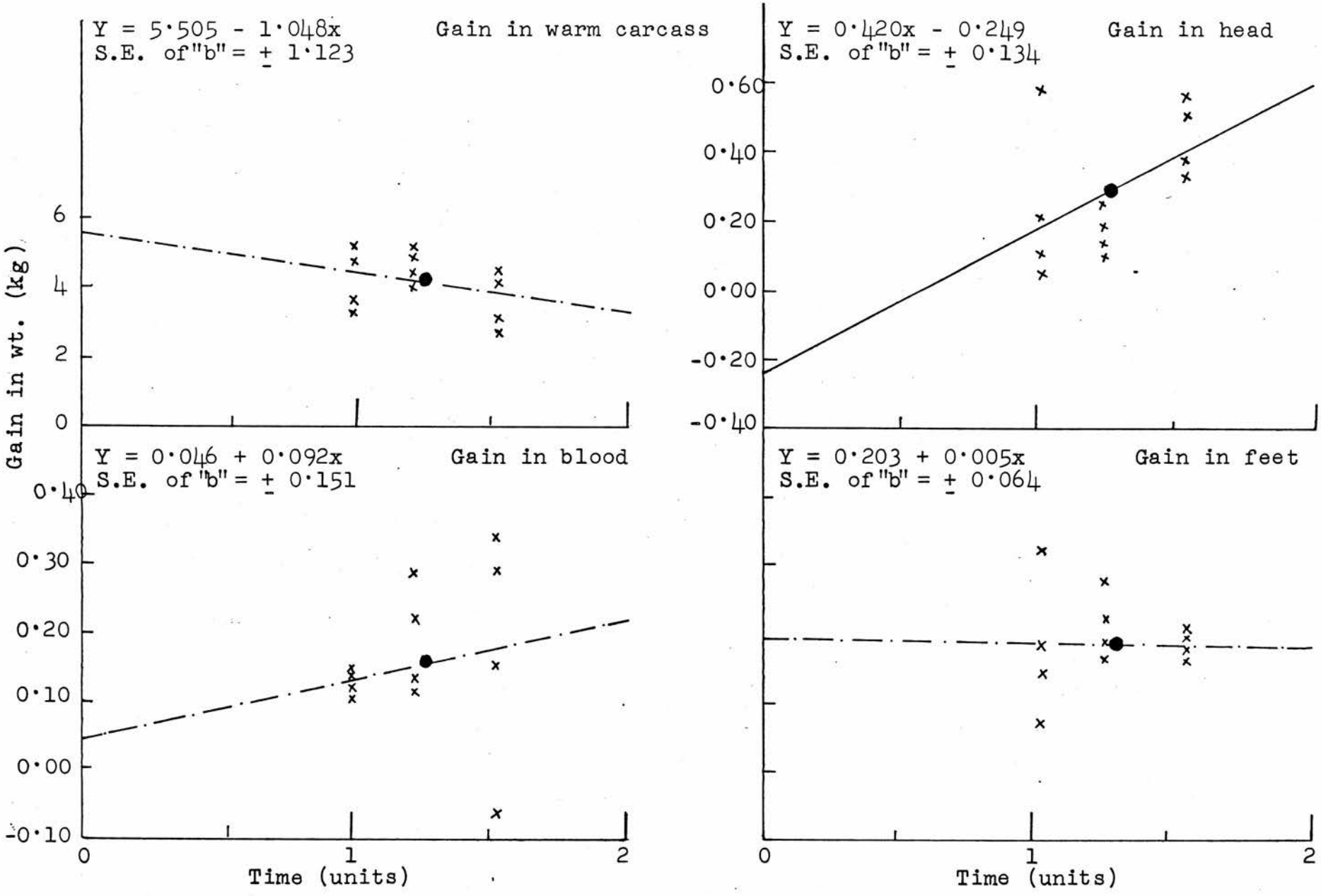
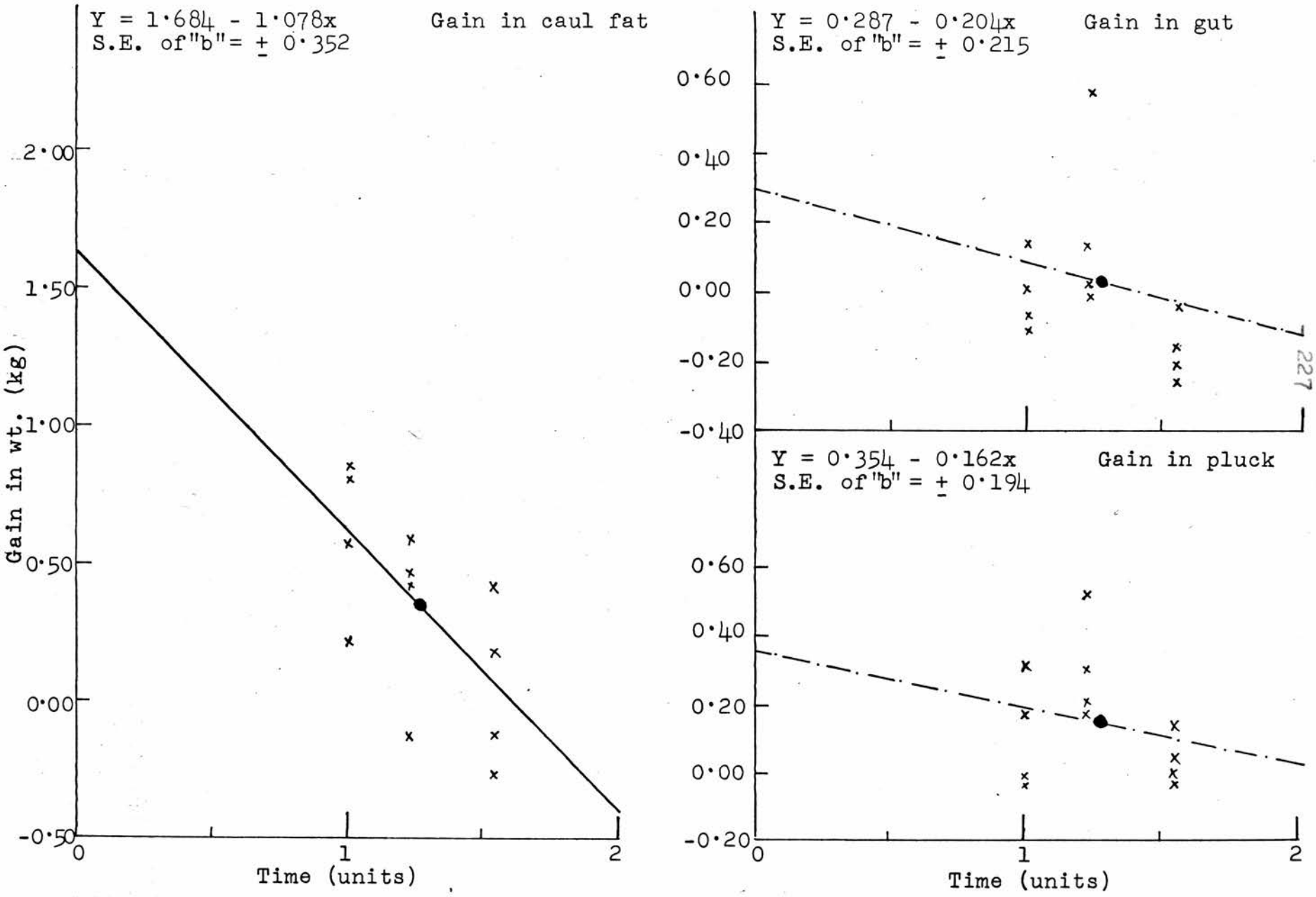


Fig. 2^{II}. The effect of restricting the daily intake of a given quantity of ME on gain in weight of S.E.B. components of B.F. wether lambs



of variance for the gain in weight in the rest of the S.E.B. components reported, showed no differences between groups at the 5 per cent level of probability.

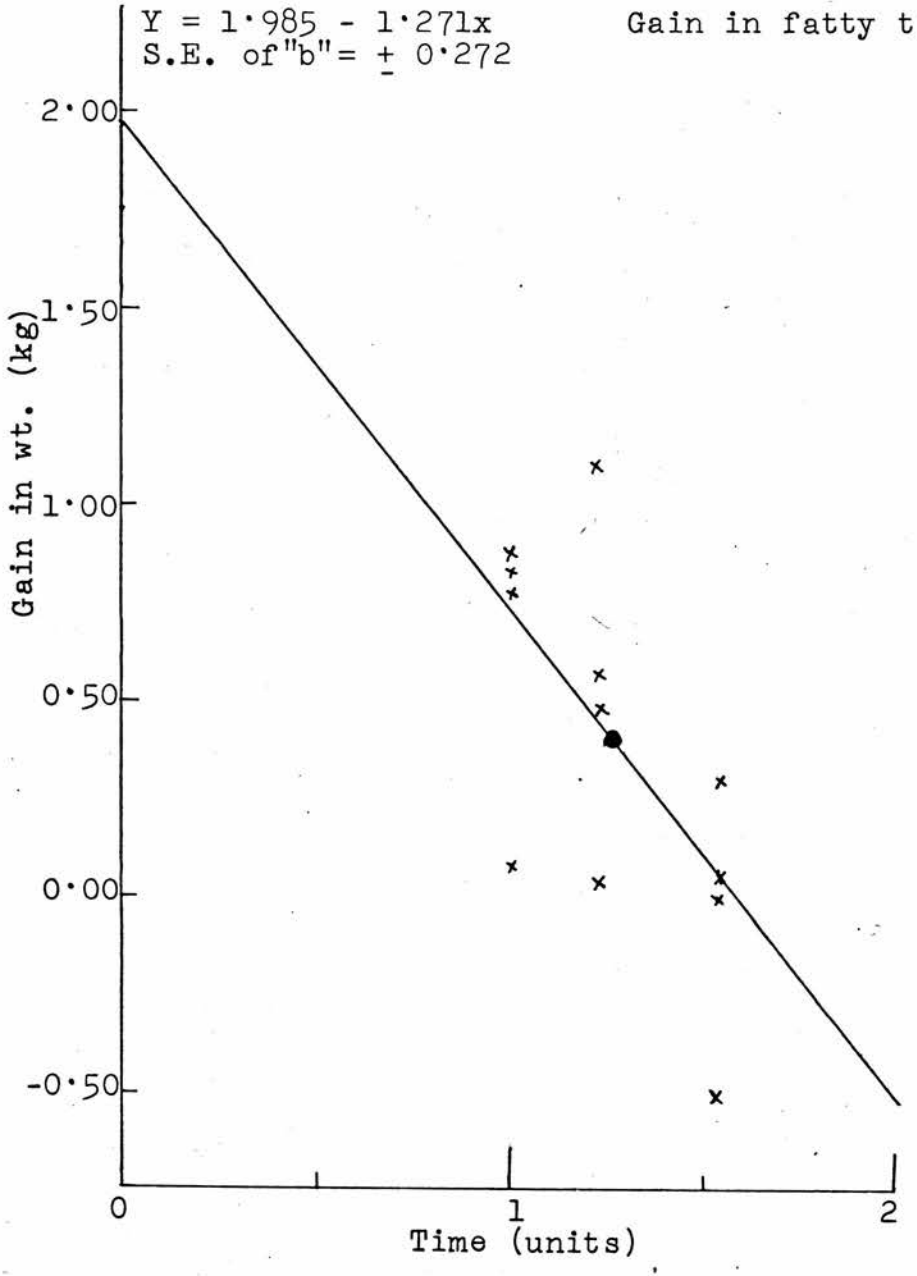
The effect of restricting the daily intake of a given quantity of ME on the gain in weight of the major tissues in the carcass

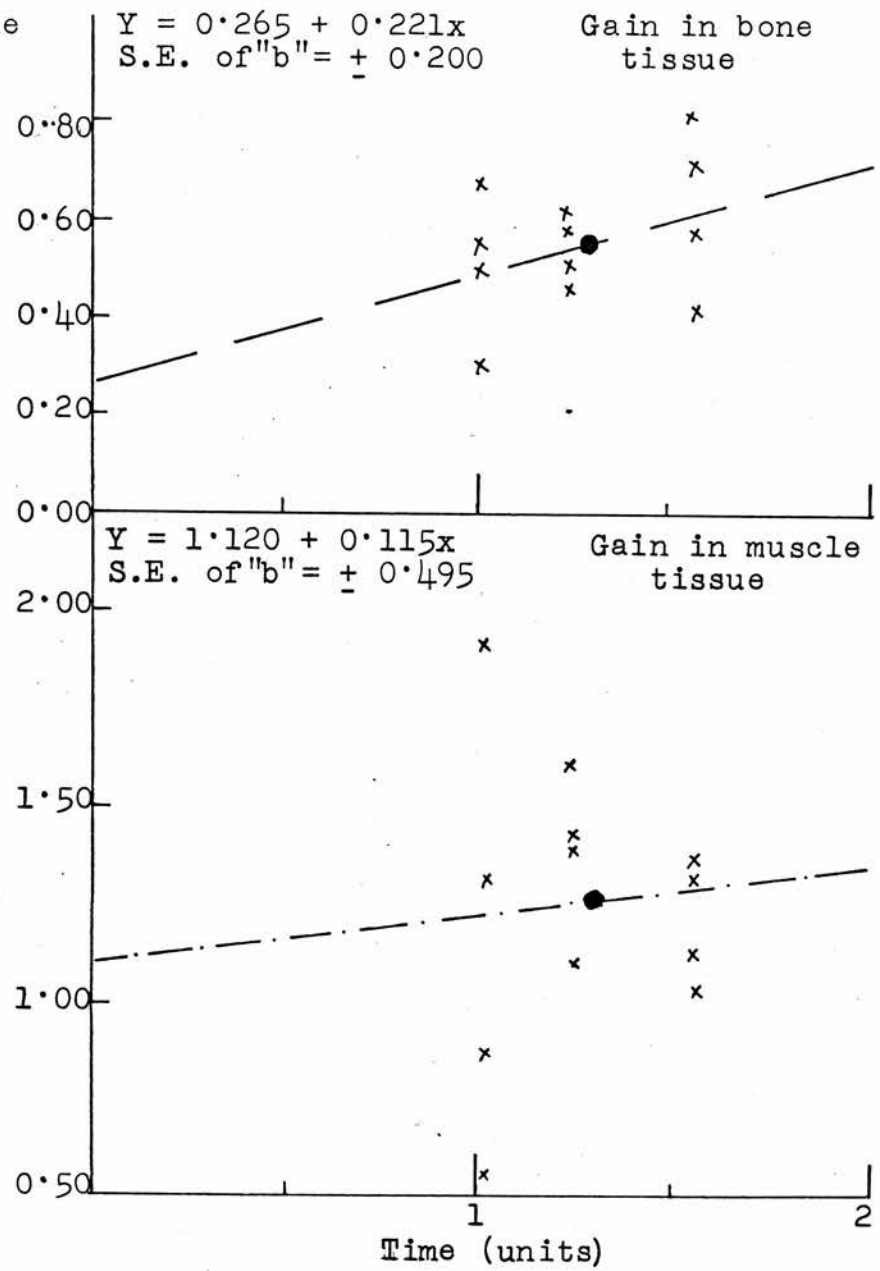
Figure 3 shows that, as the time taken to feed equal amounts of ME, at different daily intake levels, increased, the gain in weight in fatty tissue was highly significantly ($p < 0{\cdot}01$) decreased, while the gain in bone tissue tended to increase in weight but did not reach significance at the 5 per cent level. The gain in weight in muscle tissue showed no noticeable change as the days taken to feed the quantity of energy increased.

Under these experimental conditions, the regression equations expressing these relationships show that, as the days taken to feed the quantity of ME increased by one unit, the gain in weight of fatty tissue might be expected to decrease by 1·27 kg.

The analysis of variance (Appendix V) for the gain in weight of fatty tissue showed that group D differs significantly ($p < 0{\cdot}01$) from either the C or E groups, while the difference between the last two groups did not reach significance at the $p < 0{\cdot}05$ level. The differences between groups for the gain in weight in bone and muscle tissues were not significant at the 5 per cent level.

Fig. 3. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of the major tissues in the carcass of B.F. wether lambs





The effect of restricting the daily intake of a given quantity of ME on gain in weight of the retail cuts

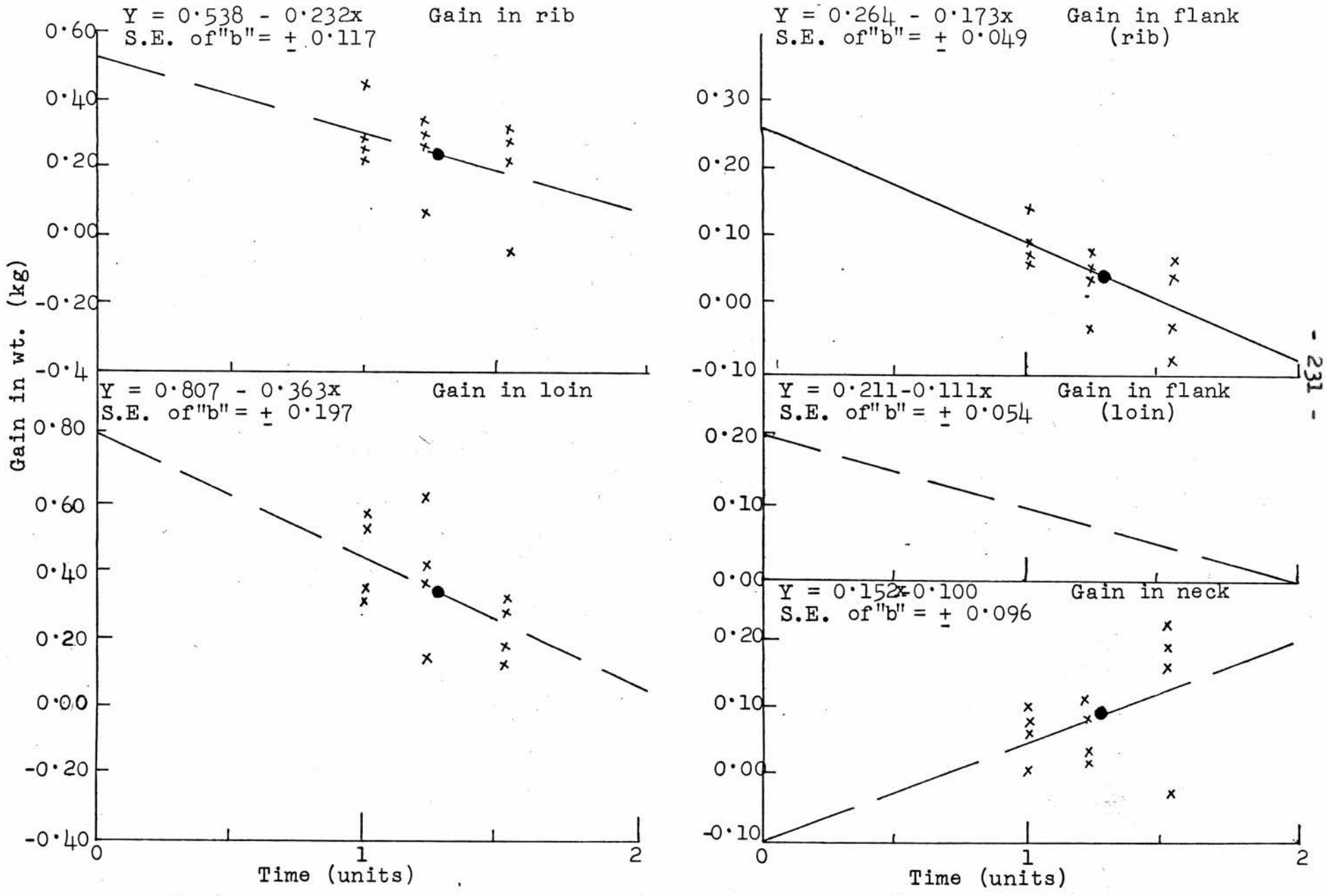
When it was clear that the gain in weight of components showed no detectable change with the time taken to feed equal quantities of metabolizable energy at different daily intake levels, the statistical analysis was not carried out. The points representing the gains in weight of these components for each animal in the different groups of lambs have been shown on graphs (Appendix VI).

The primary cuts: Figure 4 and Figure 1 (Appendix VI) show the effect of time taken to feed similar amounts of ME at different daily intake levels on the changes in gain in weight of the primary and secondary cuts. As the time taken to feed the same quantity of energy increased, the gain in weight of the rib and loin tended to decrease, although these relationships did not reach significance at the 5 per cent level. There appeared to be no relationship between the gain in weight of gigot and shoulder and the number of days required to feed equal amounts of ME.

The analysis of variance (Appendix V) for the gain in weight of these primary cuts failed to reveal significant ($p < 0{\cdot}05$) differences between groups.

The secondary cuts: The regression lines expressing the relationships of the gain in weight of the secondary cuts with the number of days needed to feed equal quantity of ME, show

Fig. 4. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of the retail cuts of B.F. wether lambs



that the gain in weight in flank (of rib) decreased significantly ($p < 0{\cdot}01$) as the time taken to feed the same quantity of ME increased. The gain in weight of flank (of loin) showed a tendency to decrease and the gain in neck tended to increase in weight, but these relationships did not reach significance at the 5 per cent level. The gain in weight of flank (of gigot), brisket, kidney plus perirenal fat and shank showed no relationship with the time taken to feed the same quantity of energy.

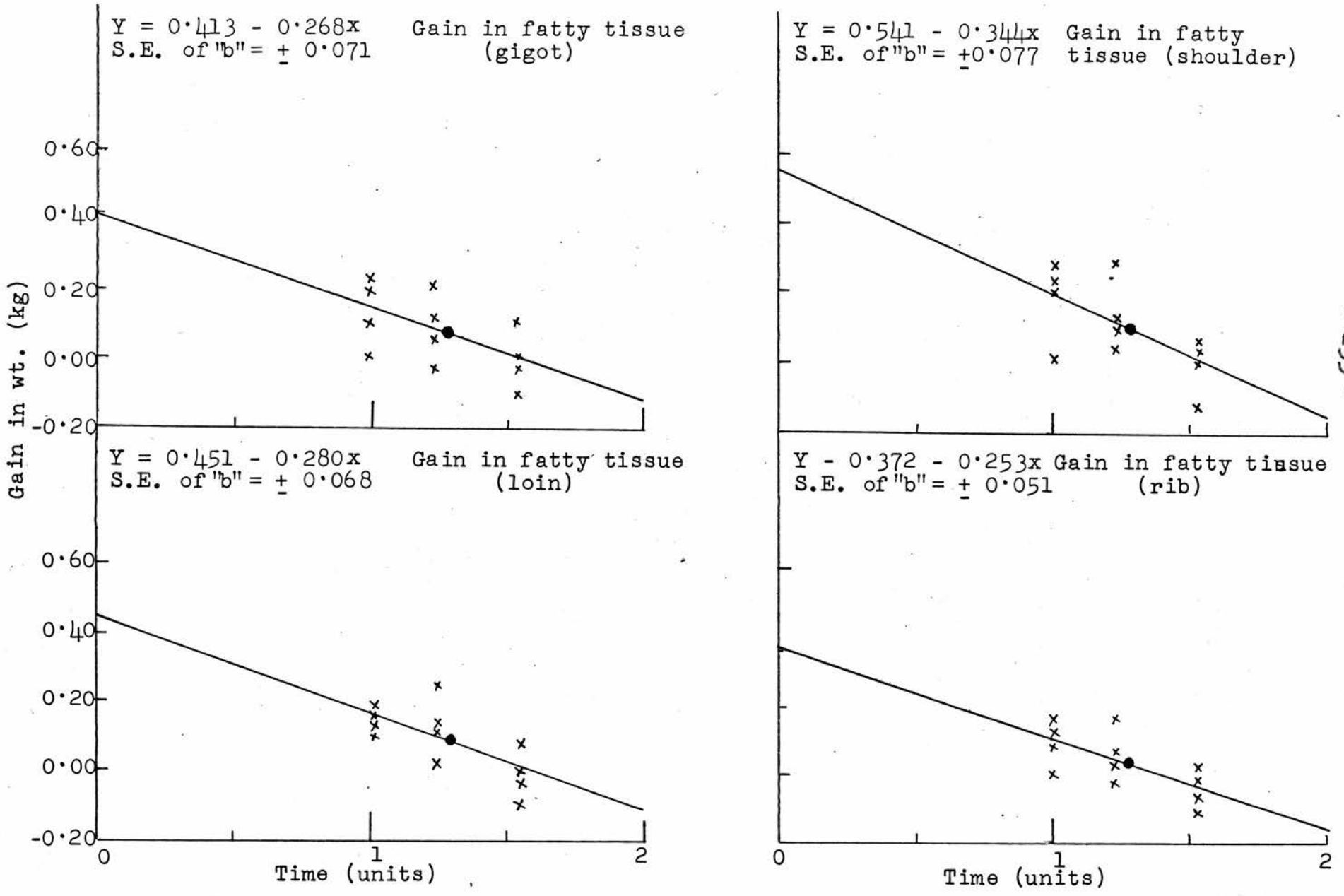
The regression equations of these relationships show that, as the days to feed the quantity of ME increased by one unit, the gain in weight in flank (rib) might be expected to decrease by 0·17 kg.

The analysis of variance for the gain in weight of flank (rib) shows that the C group of lambs differed significantly ($p < 0{\cdot}01$ and $p < 0{\cdot}05$) from the D and E groups respectively. There was no significant ($p < 0{\cdot}05$) difference between D and E groups. The differences between groups for the gain in weight in the rest of the secondary cuts reported, did not reach significance at the 5 per cent level.

<u>The effect of restricting the daily intake of a given quantity of ME on gain in weight of the major tissues in the retail cuts</u>

Figure 5 and the Figures 2 and 3 (Appendix VI) show the influence of increasing daily dietary metabolizable energy levels on the gain in weight of these tissues in groups of lambs slaughtered on a different number of days after they had consumed

Fig.5. The effect of restricting the daily intake of a given quantity of ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs



similar quantities of metabolizable energy.

Fat: The gain in weight of fatty tissue in gigot, shoulder, loin and rib joints all decreased significantly ($p < 0{\cdot}01$) as the time taken to feed the same quantity of ME was increased, while the gain in weight of perirenal fat showed no noticeable change.

Muscle: The gain in weight of muscle tissue in every joint reported in this section (except that of the shoulder was slightly increased) showed no relationship with number of days required to feed equal amounts of energy.

Bone: The gain in weight of bone tissue showed similar response to that of the gain in weight of muscle tissue although there was a slight increase in the gain in weight of bone tissue in the shoulder joint but did not reach significance at the 5 per cent level.

The regression equations of these relationships show that as the days taken to feed the quantity of energy increased by one unit, the gain in weight of fatty tissue in gigot, shoulder, loin and rib might be expected to decrease by 0·27 kg, 0·34 kg, 0·28 kg and 0·25 kg respectively.

The analysis of variance (Appendix V) for the gain in weight of fatty tissue shows that the differances between the C and D groups of lambs for the gain in weight of fatty tissue in gigot, shoulder, loin and rib were highly significant ($p < 0{\cdot}01$). The gains in weight of fatty tissue in shoulder, loin and rib were highly significantly ($p < 0{\cdot}01$) greater in the E group than in the D group, while that of the gigot reached significance at the 5 per cent level.

The analysis of variance revealed no significant ($p < 0.05$) differences between C and E groups in the gain in weight of fatty tissue in these joints studied. The differences between groups for the gain in weight of muscle and bone tissues in these joints reported did not reach significance at the 5 per cent level of probability.

The effect of restricting the daily intake of a given quantity of ME on the increase of carcass measurements

Figure 6 and Figure 3 (Appendix VI) show that, as the time taken to feed equal amounts of ME at different daily intake levels increased, fat-thickness over the 12th rib tended to decrease, although this relationship did not reach significance at the 5 per cent level. The gain in the area of M. longissimus dorsi at the 12th rib showed no noticeable change.

On testing differences between groups, the analysis of variance (Appendix V) for these two measurements failed to reveal significant differences at the 5 per cent level.

The effect of restricting the daily intake of a given quantity of ME on gain in weight of individual muscles

Figure 7 and the Figures 4, 5 and 6 (Appendix VI) show the influence of the time taken to feed equal quantities of energy at different daily intake levels on the gain in weight of these individual muscles. The gain in weight of M. obliquus internus

Fig.6. The effect of restricting the daily intake of a given quantity of ME on the increase in fat-thickness over the 12th rib of B.F. wether lambs

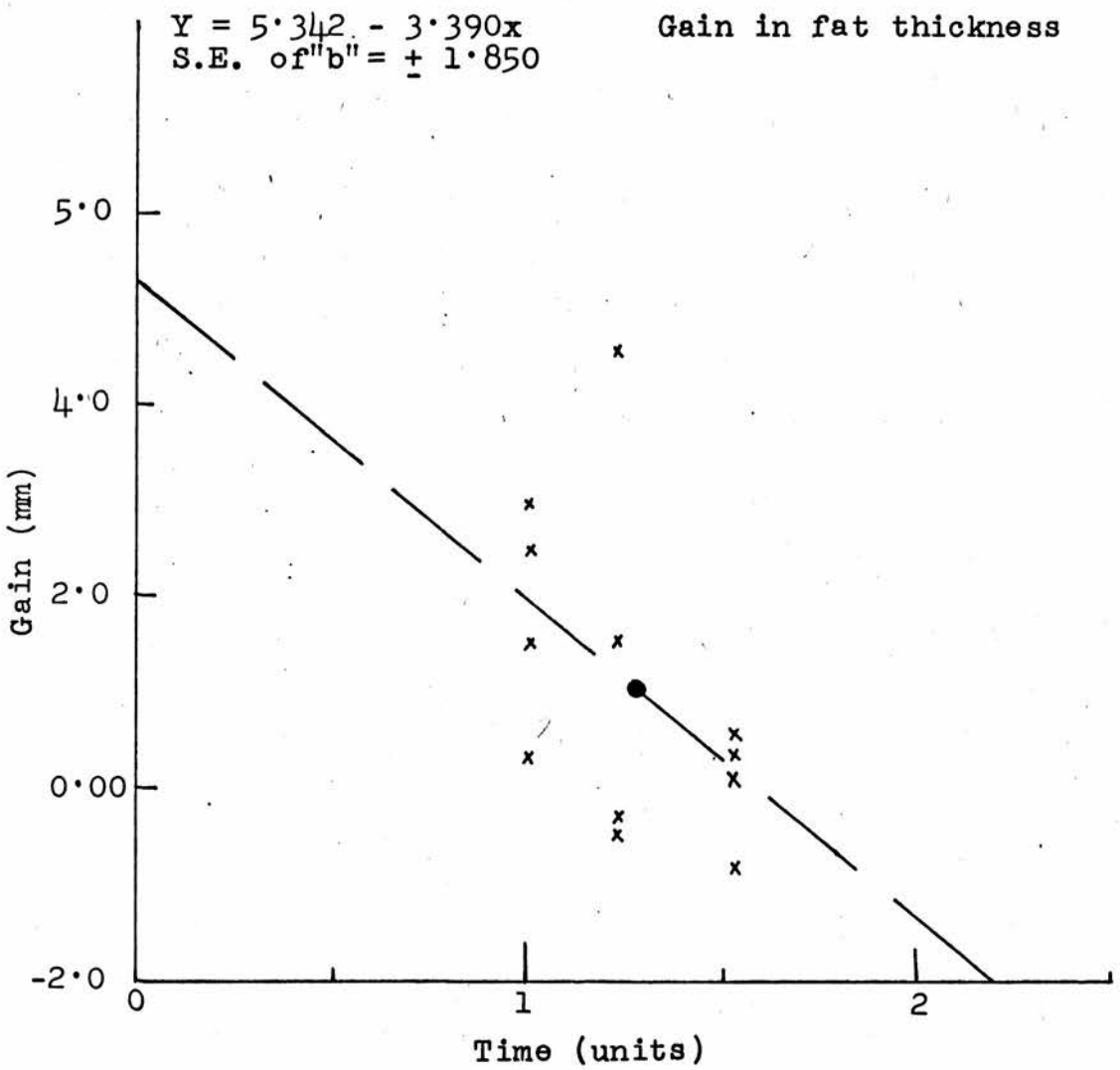
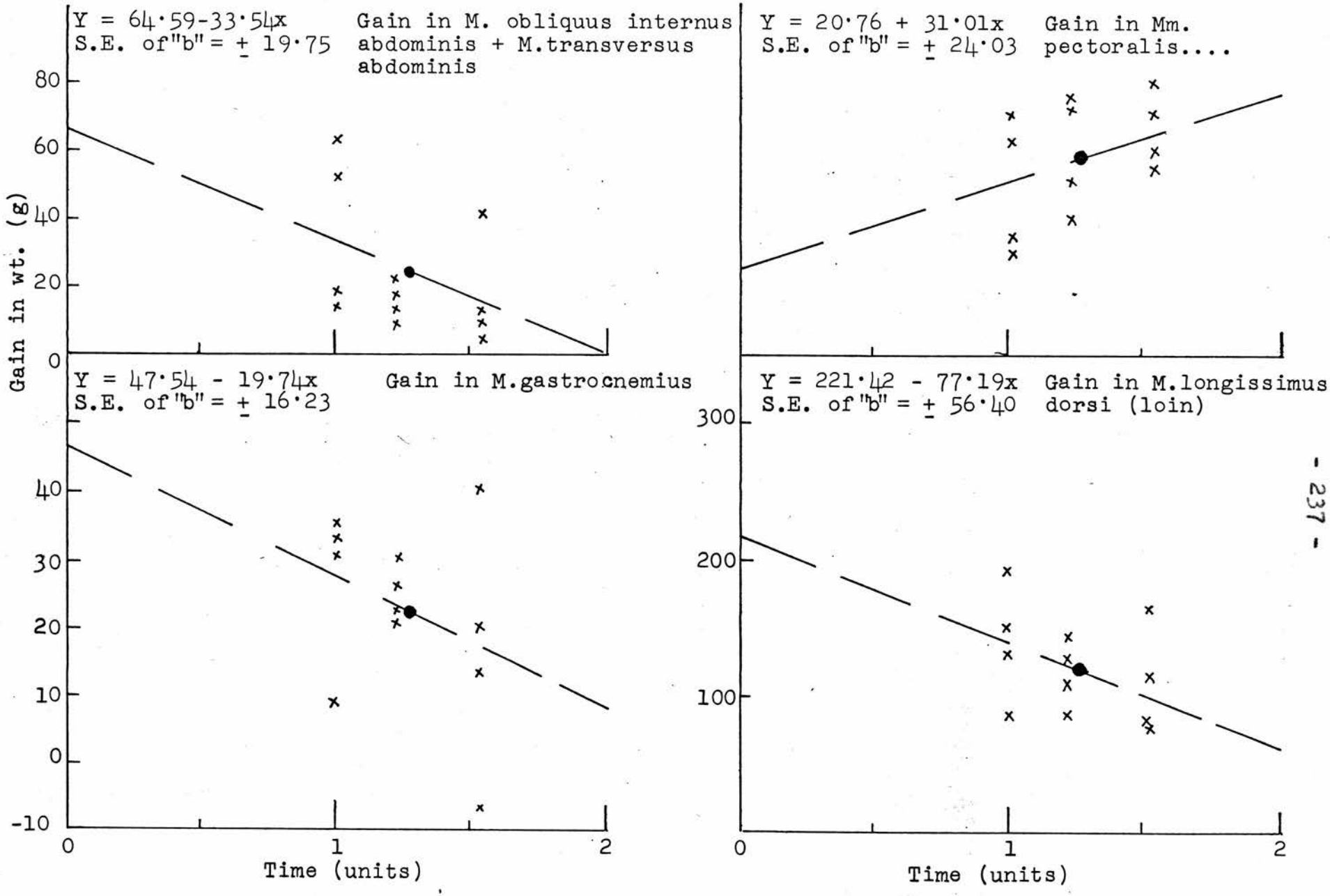


Fig.7. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of individual muscles of B.F. wether lambs



abdominis + M. transversus abdominis, M. gastrocnemius and M. longissimus dorsi in the loin area tended to decrease, while that of Mm. pectoralis profundus et superficialis tended to increase as the time taken to feed the same quantity of ME increased but none of these relationships reached significance at the 5 per cent level. The gain in weight of the other individual muscles tested (see graphs 4, 5 and 6 - Appendix VI) showed no detectable relationship with the time taken to feed the same quantity of ME.

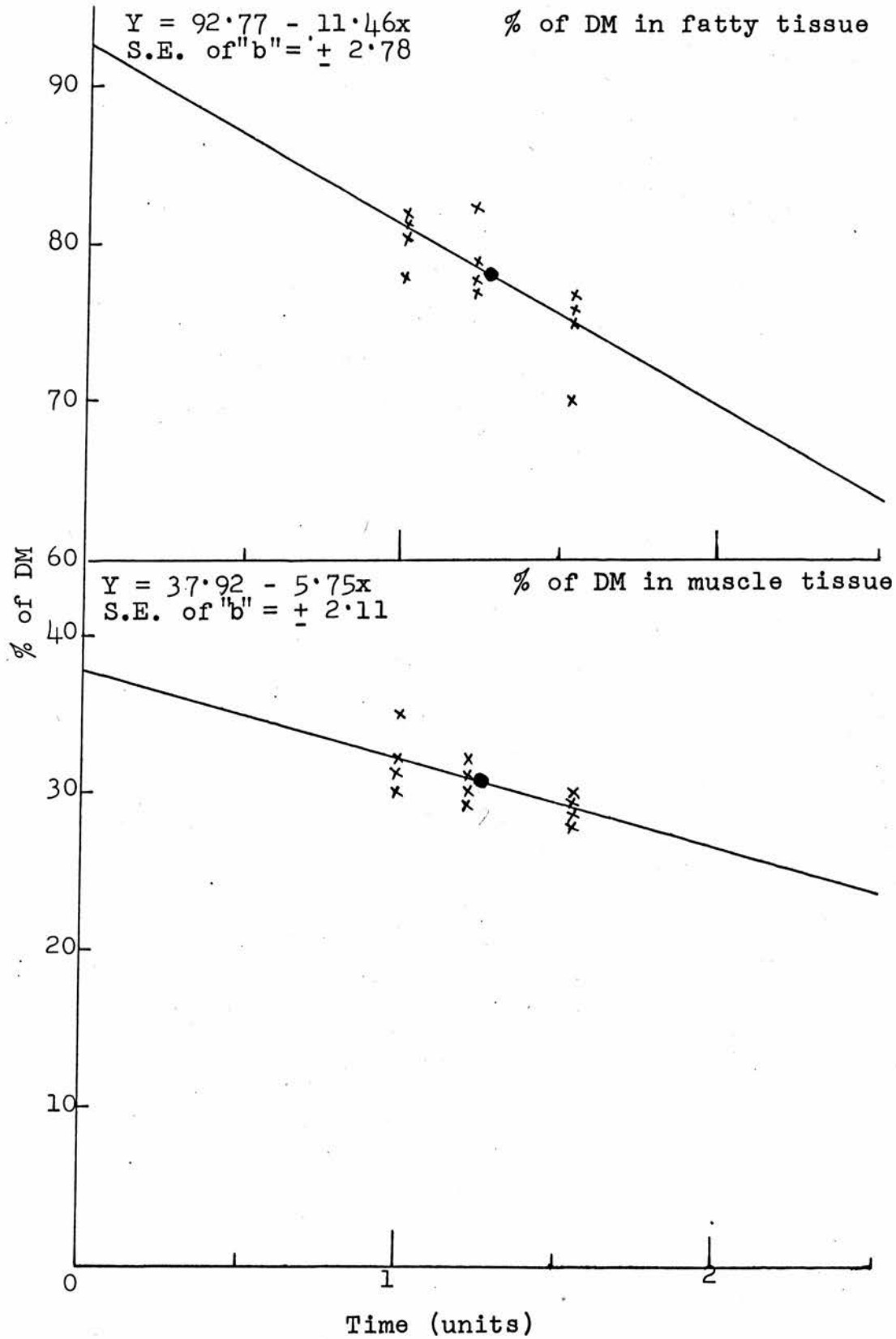
On testing differences between groups, the analysis of variance (Appendix V) for the gain in weight of all individual muscles reported, revealed no significant differences at the $p < 0{\cdot}05$ level.

The effect of restricting the daily intake of a given quantity of ME on changes in chemical composition of the carcass tissues

(a) Dry matter: Figure 8 shows that as the time taken to feed the same quantity of metabolizable energy increased, the percentage of dry matter in fatty and muscle tissues significantly ($p < 0{\cdot}01$ and $p < 0{\cdot}05$ respectively) decreased.

The regression equations of these relationships show that, as

Fig.8. The effect of restricting the daily intake of a given quantity of MF on the % of DM in the carcass tissues of B.F. wether lambs



the time taken to feed the quantity of energy increasedby one unit, the dry matter percentage in fatty and muscle tissues might be expected to decrease by 11·46 per cent and 5·75 per cent respectively.

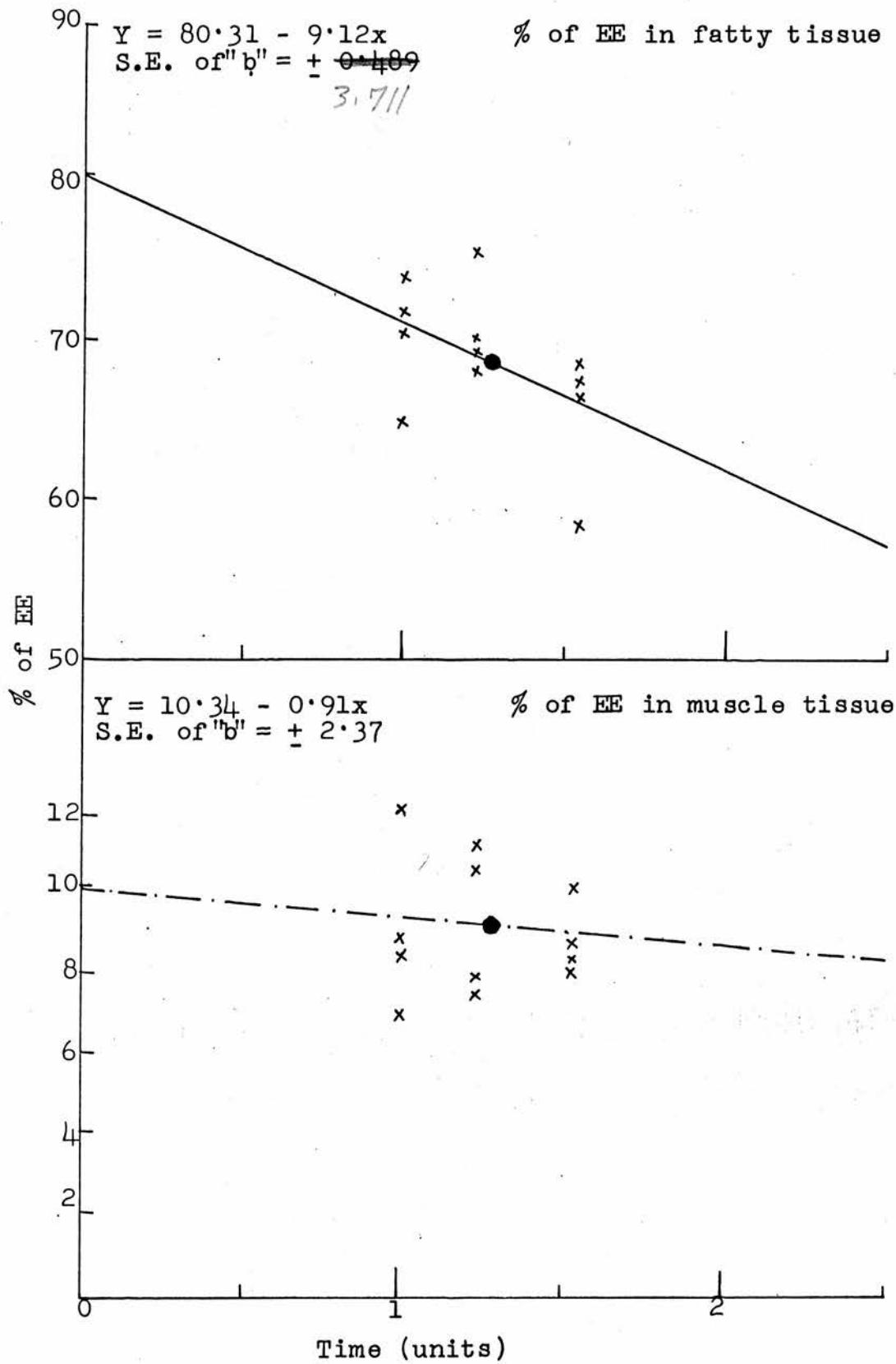
The analysis of variance (Appendix V) for the percentage of dry matter in fatty tissue revealed significant ($p < 0·01$ and $p < 0·05$) differences between group D and both the C and E groups respectively. The differences between the C and E groups did not reach significance at the 5 per cent level. The differences between groups for the percentage of dry matter in muscle tissue failed to reach significance at the $p < 0·05$ level.

(b) Ether extract: Figure 9 shows that as the time taken to feed similar amounts of ME increased, the percentage of ether extract in fatty tissue significantly ($p < 0·01$) decreased, while the percentage of ether extract in muscle tissue showed no detectable change.

The regression equation of the percentage of ether extract in fatty tissue shows that for each unit increase in the time taken to feed the same quantity of ME, the percentage of ether extract in fatty tissue might be expected to decrease by 9·12 per cent.

The analysis of variance for the percentage of ether extract in fatty tissue shows that there was a highly significant ($p < 0·01$) difference between the D group of lambs and either of the other two groups. Groups E and C did not differ significantly at the 5 per cent level. The differences between groups for the percentage of ether extract in muscle tissue did not reach significance at the 5 per cent level. The differences between groups for the

Fig.9. The effect of restricting the daily intake of a given quantity of ME on the % of EE in the carcass tissues of B.F. wether lambs



percentage of ether extract in muscle tissue did not reach significance at the 5 per cent level.

(c) Crude protein: Figure 10 shows the effect of the time taken to feed equal amounts of ME at different daily intake levels on the percentage of crude protein in fatty and muscle tissues. In both tissues there was no detectable change in the percentage of crude protein due to the time taken to consume the same quantity of ME.

The analysis of variance failed to reveal significant ($p < 0{\cdot}05$) differences between groups for the percentage of crude protein in both tissues.

<u>The effect of restricting the daily intake of a given quantity of ME on gain in weight of the chemical components of carcass tissues and live weight components - pelt, blood, feet and head</u>.

(a) Dry matter: Figure 11 and the Figures 7 and 8 (Appendix VI) show the effect of the time taken to feed similar quantities of metabolizable energy on the gain in weight of the dry matter of these components in groups of lambs fed different daily intake levels and slaughtered on a different number of days. The gain in weight of dry matter in fatty tissue was significantly ($p < 0{\cdot}01$) decreased as the time taken to feed the same quantity of energy increased. The gain in weight of dry matter in muscle tissue tended to decrease while that of bone tissue showed a tendency for increase, but none of these reached significance at the 5 per cent level. The gain in dry matter in the head was significantly ($p < 0{\cdot}05$) increased in weight as the time taken to feed equal

Fig.10. The effect of restricting the daily intake of a given quantity of ME on the % of CP in the carcass tissues of B.F. wether lambs

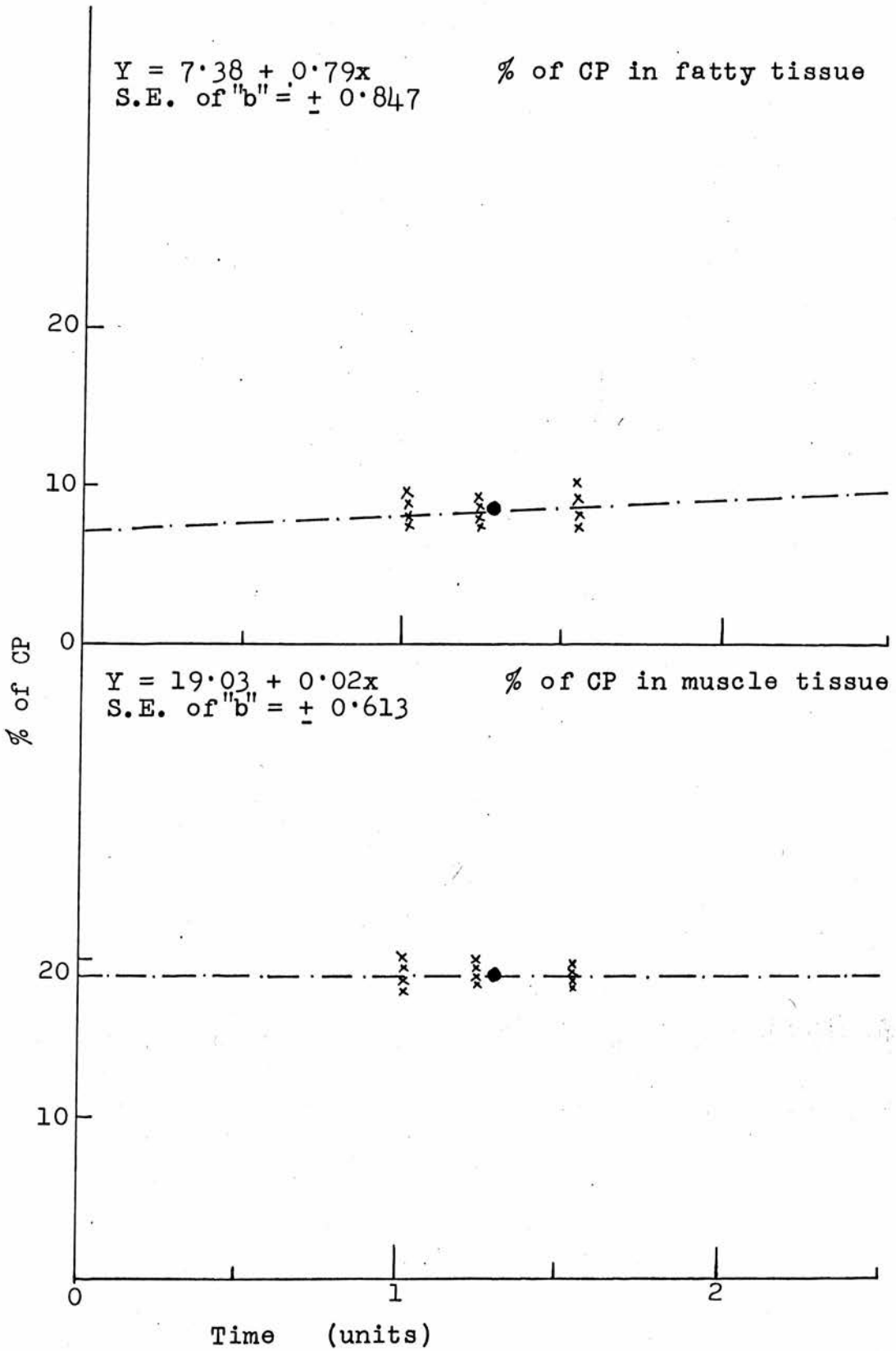
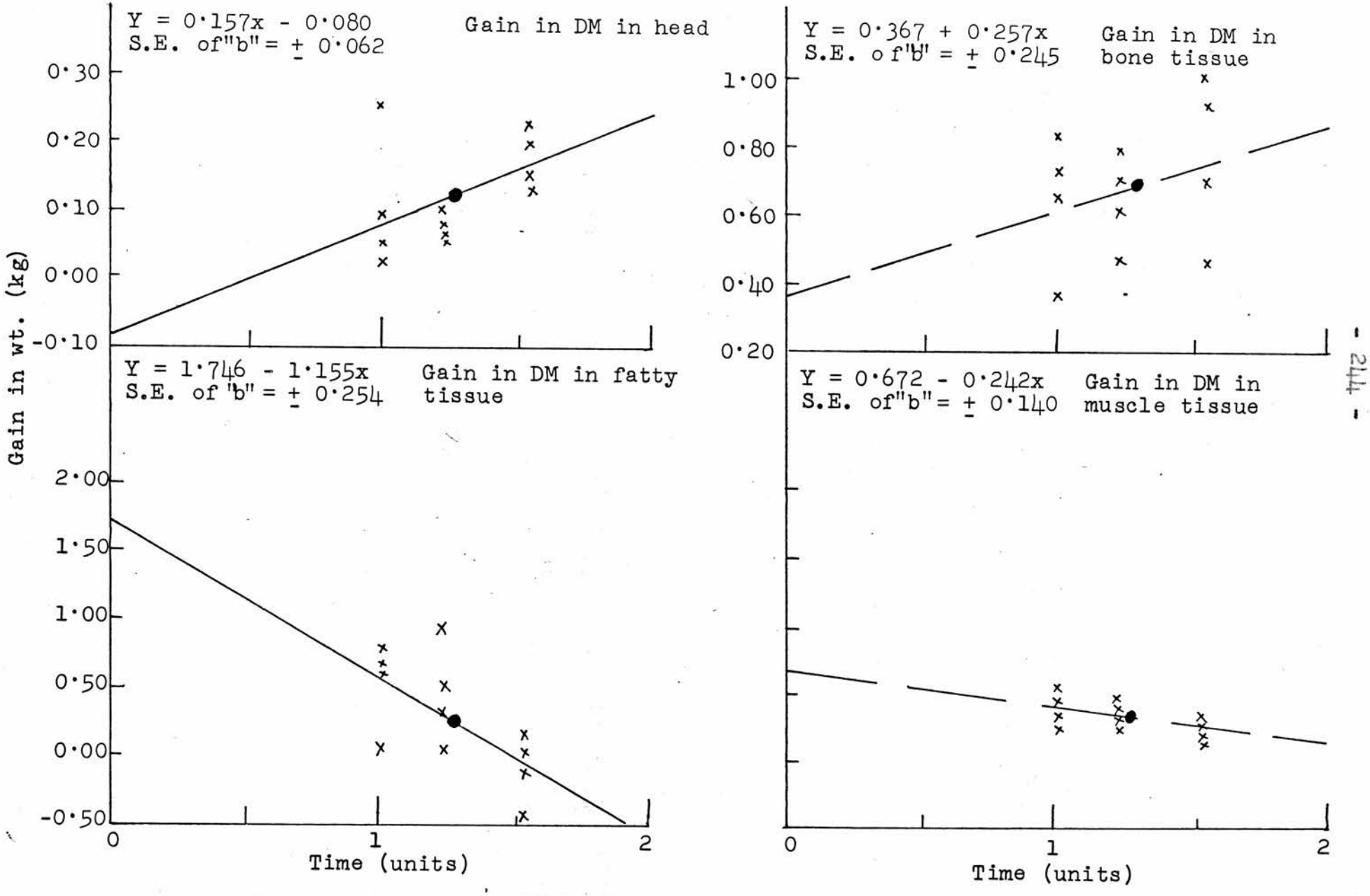


Fig.11. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of DM of body components of B.F. wether lambs



amounts of energy was increased. There appeared to be no detectable relationship between the gain in weight of dry matter in blood, feet and pelt and the number of days needed to feed equal amounts of metabolizable energy.

The data suggests that for each unit increase in the time taken to feed an equal quantity of ME the gain in weight of dry matter in fatty tissue might be expected to decrease by 1·16 kg.

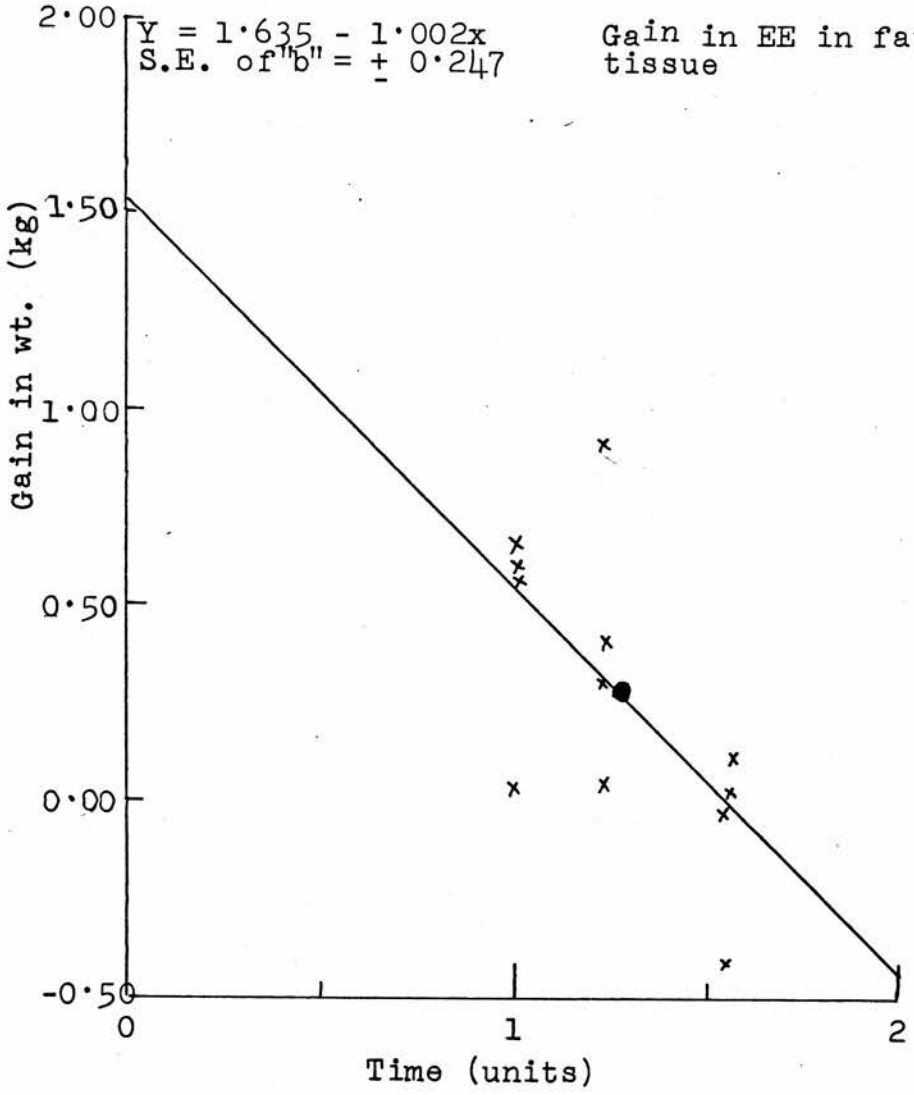
The differences between group D and either of the other two groups (Appendix V) for the gain in weight of dry matter in fatty tissue and in head, were significant at the 1 per cent and 5 per cent levels respectively. Groups E and C did not differ significantly ($p < 0·05$) in the gain in weight of dry matter in fatty tissue and head.

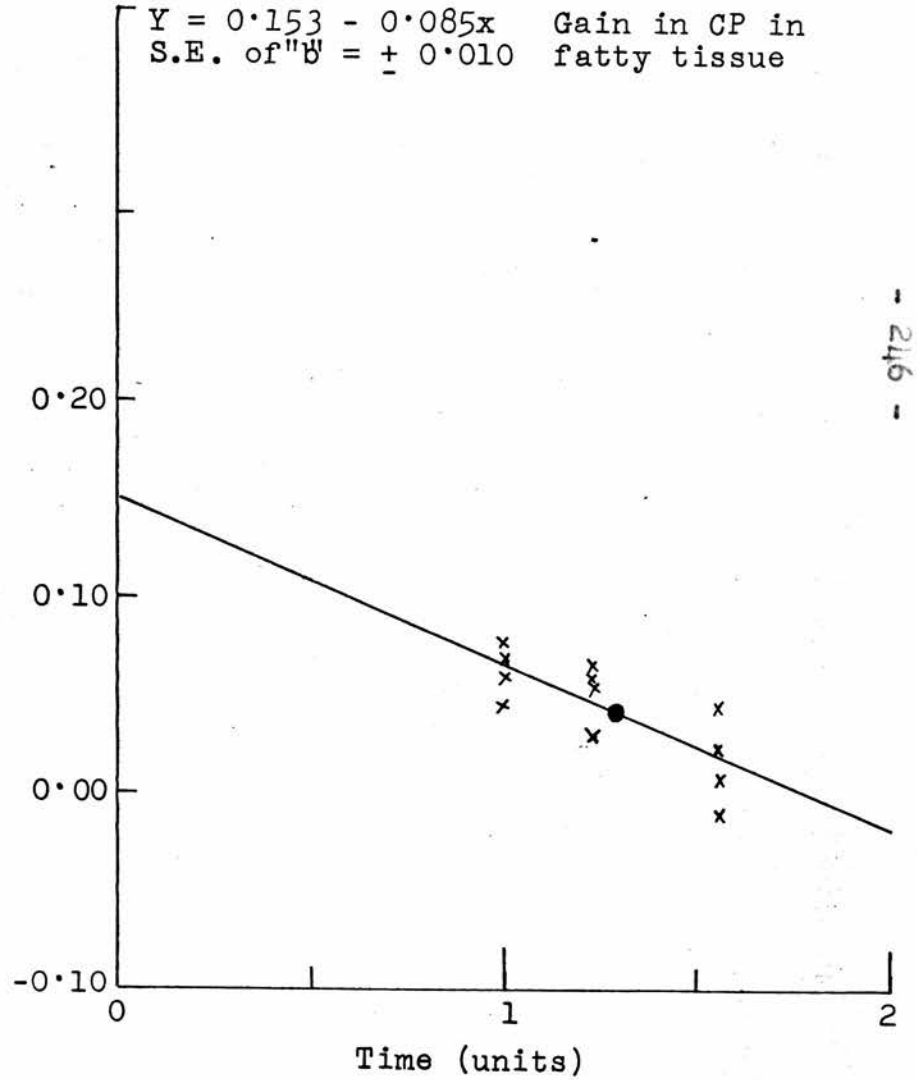
The analysis of variance for the gain in weight of dry matter in the rest of the components tested showed no significant ($p < 0·05$) differences between groups.

(b) Ether extract: Figure 12 and Figure 7 (Appendix VI) show that, as the time taken to feed equal amounts of metabolizable energy increased, the gain in weight of ether extract in fatty tissue was significantly ($p < 0·01$) decreased while the gain in weight of ether extract in muscle tissue showed no noticeable change.

The regression equations expressing these relationships suggest that the gain in weight of ether extract in fatty tissue might be expected to be decreased by 1·00 kg when the time taken to feed the same quantity of energy increased by one unit.

Fig.12. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of chemical components of the carcass tissues of B.F. wether lambs





The analysis of variance for the gain in weight of ether extract in fatty tissue shows that the D group of lambs differs significantly ($p < 0{\cdot}01$) from either of the other two groups. The difference between the E and C groups did not reach significance at the 5 per cent level. The differences between groups for the gain in weight of ether extract in muscle tissue did not reach significance at the $p < 0{\cdot}05$ level.

(c) Crude protein: Figure 12 and Figure 7 (Appendix VI) show the effect of the time taken to feed similar quantities of energy at different daily intake levels on the gain in weight of crude protein in fatty and muscle tissues. There was a significant ($p < 0{\cdot}01$) decrease in the gain in weight of crude protein in fatty tissue while the gain in weight of crude protein in muscle tissue showed no noticeable change with the number of days required to feed the same quantity of ME.

The data suggests that, as the time taken to feed the same quantity of ME increased by one unit, the gain in weight of crude protein in fatty tissue might be expected to decrease by 0·09 kg.

The analysis of variance for the gain in weight of crude protein in fatty tissue shows that the D group of lambs differs significantly ($p < 0{\cdot}01$) from either of the other two groups while the difference between the E and C groups did not reach significance at the 5 per cent level. There were no significant ($p < 0{\cdot}05$) differences between groups for the gain in weight of crude protein in muscle tissue.

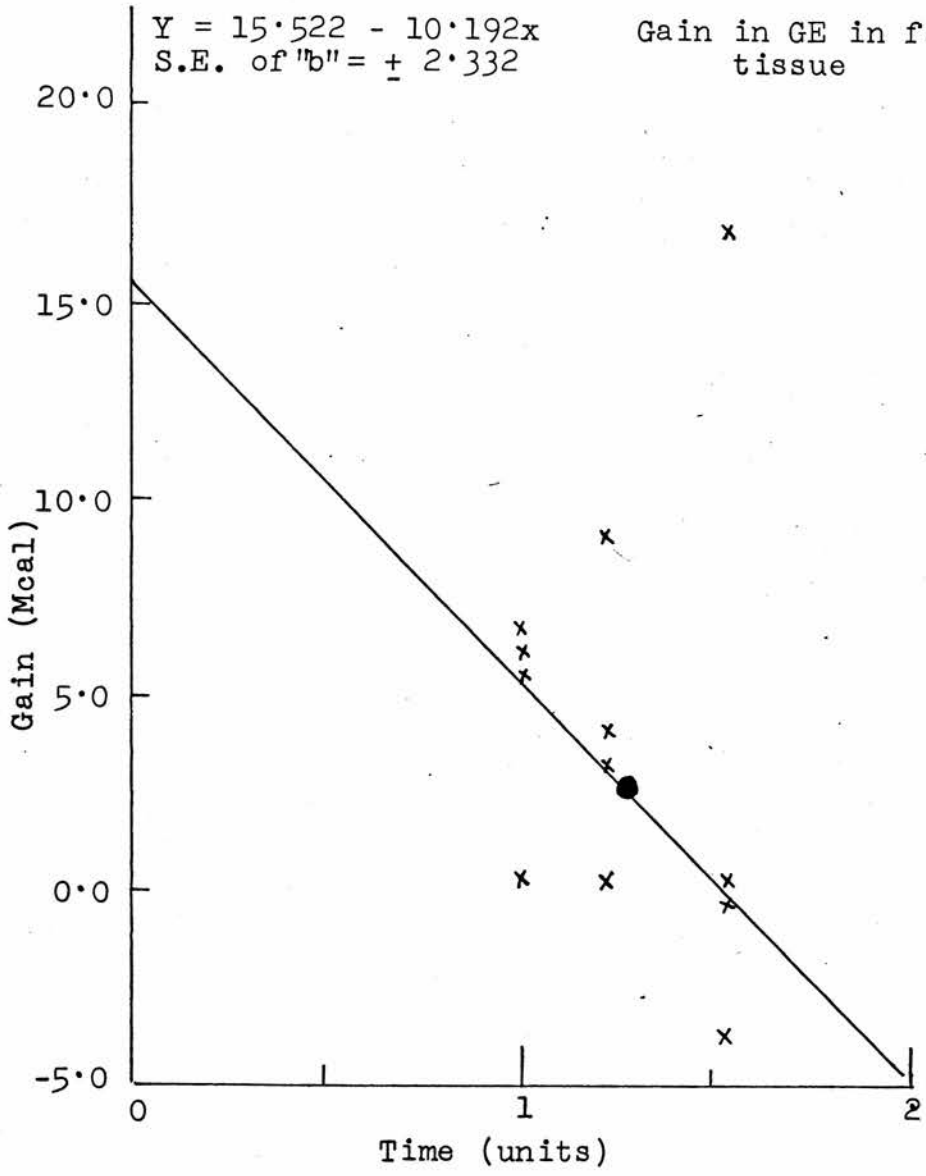
The effect of restricting the daily intake of a given quantity of ME on gain of gross energy in the carcass tissues and live weight components - pelt, blood, feet and head

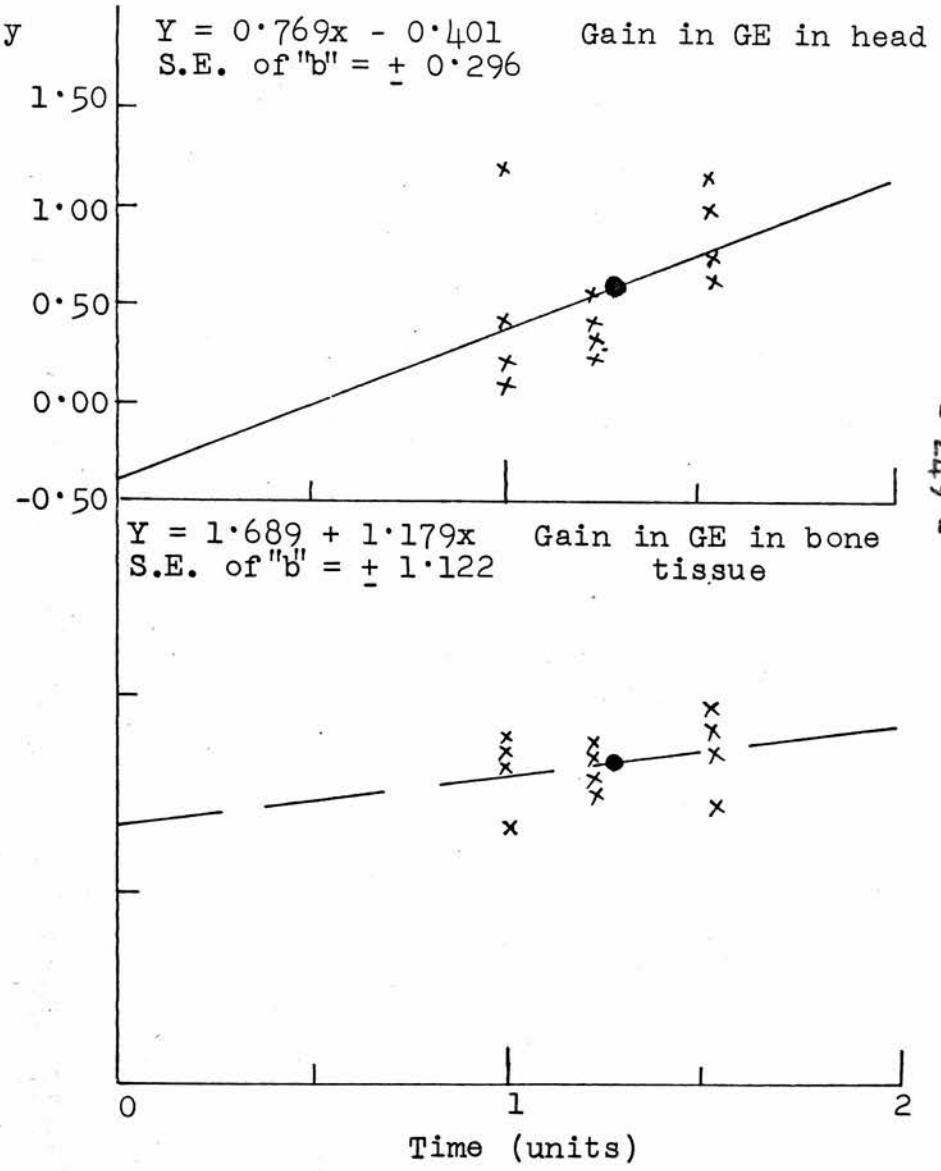
Figure 13 and the Figures 7 and 8 (Appendix VI) show the influence of different daily intake levels of the dietary metabolizable energy on the gain of gross energy in the carcass tissues and body components of groups of lambs slaughtered on different number of days after they had consumed similar quantities of ME. The gain in gross energy in fatty tissue was significantly ($p < 0{\cdot}01$) decreased while that of head was significantly ($p < 0{\cdot}05$) increased as the time taken to feed the same quantity of energy was increased. There was a small tendency for increase in the gain of gross energy in bone tissue but did not reach significance at the 5 per cent level. The gain in gross energy in muscle tissue, blood, feet and pelt showed no detectable relationship with the time taken to feed the same quantity of metabolizable energy.

The regression equations of these relationships show that, as the time taken to feed equal amounts of ME increase by one unit, the gain in gross energy in fatty tissue might be expected to decrease by 10·19 Mcal while that of head could be expected to increase by 0·77 Mcal.

On testing differences between groups the analysis of variance (Appendix V) for the gain in gross energy in fatty tissue shows that the D group of lambs differs significantly ($p < 0{\cdot}01$) from either of the other two groups, while that of head, the differences between the D group and either of the other two groups reached significance at the 5 per cent level. In these two components

Fig. 13. The effect of restricting the daily intake of a given quantity of ME on gain in GE of body components of B.F. wether lambs





(fatty tissue and head) group E did not differ significantly ($p < 0{\cdot}05$) from group C. The differences between groups for the gain in gross energy in muscle and bone tissues and in pelt, feet and blood did not reach significance at the 5 per cent level.

D I S C U S S I O N

of

E X P E R I M E N T II part (b)

DISCUSSION

Numerous experiments investigating the effect of level of feeding on animals slaughtered at similar ages or similar live-weights are to be found in the literature. Very little information has been reported on the influence of level of dietary metabolizable energy on the physical and chemical composition of groups of lambs fed similar quantities of ME and slaughtered after different number of days on trial.

Before discussing the results of this experiment certain factors need to be considered.

(a) The maintenance costs: It is accepted that lowering the level of food intake restricts the growth rate and increases the time needed to reach a given weight or size with the possible consequence of an increase in the total maintenance requirements. On the other hand increasing the level of feeding can enhance the energy costs of work of digestion (Kielanowski, 1966b) and consequently greater daily energy maintenance costs may be expected. Energy maintenance costs were higher in pigs fed on a higher level of nutrition.

(b) Protein intake: The rations were arranged so that the daily intake of DCP was similar. However as the groups of animals were fed over a different number of days in order to consume the same quantity of ME then the groups which had the longest feeding period were fed a greater amount of protein.

(c) Changes in body proportions with age: Hammond (1932) and Palsson and Verges (1952a) have shown that as an animal matures the

different anatomical regions and tissues of the body grow differentially to each other. It is to be expected that groups slaughtered at different ages or at different degrees of maturity will differ from each other because of this natural differential growth.

(d) Diet composition: Rations having the same energy and protein values but made up of different components can have different effects on the body organs tissue response (Jackson, 1959). In this trial the ration components differed slightly in the fibre content and in energy source and in roughage to concentrate ratio. Armstrong et al. (1957a,b, 1958) and Armstrong and Blaxter (1957a,b) have shown that the proportion of rumen VFA (acetic, propionic and butyric) is an important factor in determining the net utilization of metabolizable energy particularly for production purposes. The amount and the relative proportions of VFA were seen to be largely associated with the level of feed intake and the roughage:concentrate ration in the diet. Bath and Rook (1963) reported that increasing the level of dry matter intake of a mixed diet containing hay and concentrates, increased the concentration of the total VFA and decreased the proportion of acetic acid and increased the proportion of n-butyric. Numerous workers (Stoddard et al., 1949; Tyznich and Allen, 1951; Balch et al., 1955; Brown et al., 1958; and Vidal et al., 1967) have shown that high concentrate rations increase the proportion of the propionic acid at the expense of acetic acid.

Armstrong and Blaxter (1957a, 1957b), Armstrong et al. (1957a, b) and Blaxter (1960) have shown that propionate is more efficient

than acetate as an energy source for lypogenesis. It would be expected, therefore, that the diets of the same caloric value but producing different proportions of VFA when utilized for growth could produce different tissue responses. Weiss et al. (1967) have shown that steers which had similar daily intake of digestible energy and different proportions of VFA varied in carcass fat and protein. They found that carcass fat was negatively associated with the ratio of acetic to propionic acid. Shaw et al. (1960) with steers and Richard & Ternauth (1965) with lambs, reported that there was a response in liveweight gain to higher proportions of propionic acid. However, conflicting views regarding this subject have also been reported. Essig et al. (1959) found no differences in the daily gain, carcass grade and dressing percentage between lambs fed similar energy level intake and various ratios of VFA. Raun et al. (1962) working with lambs found no correlation between the ratio of acetic to propionic acid and daily liveweight gain. Liveweight, however, may not reflect the real effect of these treatments.

Although attempts have not been made to determine the proportions of VFA in the experiment being reported, the results of previous reported workers may indicate possible happenings which may help in the interpretation of the findings. The differences in roughage to concentrate ratios in the diets used were small but may partially contribute to the differences in response noted between the different groups.

The responses of body components of lambs which had similar total quantities of ME at different levels of daily intake were presented in the Table 20.

Table 20. The responses of body components of Blackface wether lambs fed similar total quantities of ME at different lengths of feeding period.

	Significant*		Doubt		Non-significant	
Important responses	Caul fat	-	Pelt	-	Gut "fill"	+
	Fatty tissue	-	Fat-thickness	-		
	Fat (shoulder)	-				
	Fat (loin)	-				
	Fat (rib)	-				
	% DM in fat	-				
	% EE in fat	-				
	DM in fat	-				
	EE in fat	-				
	CP in fat	-				
	GE in fat	-				
Possible responses	Flank of rib	-	S.E.B.	-	M.l.d. (loin)	-
	% DM in muscle	-	Loin	-	DM in bone	+
	Head	+	Rib	-	DM in muscle	-
	DM in head	+	Flank of loin	-	Bone in shoulder	+
	GE in head	+	Neck	+	Bone tissue	+
			M. obliquus...	-		
Trivial responses	Fat (gigot)	-	M. gastroc...	-	Live wt.	+-
			GE in bone	+	Warm carcass	-
					Blood	+
					Feet	+-
					Gut	-
					Pluck	-
					Muscle tissue	+-
					M. pectoralis....	+
					% EE in muscle	-
					% CP in muscle	+-
					% CP in fat	+
					The rest of the component showed little response and were presented in Appendix (VI)	

* $p < 0{\cdot}05$

\+ Positive response

\- Negative response

+- No response

In the Appendix V Table 21 shows the regression coefficient with its standard error and the "F" value of the treatment on the groups along with the regression coefficient "b" expressed as a percentage of the initial weight of the component, thus giving an indication of the percentage response of the component.

The main effects of restricting the daily intake of energy for lambs slaughtered after they had consumed equal quantities of metabolizable energy was on fatty tissue. With certain exceptions all measures of fat development were markedly depleted with increasing the time to feed the quantity of energy. The fatty tissue in the carcass, caul fat and fat in the prime cuts all showed significant and appreciable reduction. The fat cover over the M. longissimus dorsi at the 12th rib also showed a pronounced decrease but failed to reach significance at the 5 per cent level of probability. It was surprising that perirenal fat has not been noticeably effected.

By feeding the quantity of energy over different number of days the amount of energy allocated for maintenance can be expected to increase with time at the expense of that allocated for production. The reduction in gain in weight of fatty tissue may be mainly due to this fact although, as has already been stated, the composition of the diets can also effect the amount of fat deposited in the body. In this trial it was not

possible to separate these effects.

Muscle was the only tissue which showed negligible response to the treatments. In general within the same tissue the various parts of it gave similar responses to the tissue as a whole. The differences between groups for the gains in weight of muscle tissue in the four anatomical joints (gigot shoulder, loin, rib and kidney) can be considered of a random nature and none of these components showed an important change. The various individual muscles tested also gave a similar trend, although the M. obliquus internus abdominis plus M. transversus abdominis and M. longissimus dorsi in the loin area were moderately reduced but non-significantly.

It has been reported that level of energy supply is a determinant factor in protein synthesis (Kielanowski, 1968). It was expected therefore that those lambs on high level of energy (group C) should deposit more protein than either of the other two groups (E and D) which were receiving lower levels of ME. However the last two groups had consumed more total protein intake since they were fed over a longer period at similar daily intake of DCP. Therefore these two factors were working against each other to give similar quantities of muscle development over the feeding period.

The tendency for the gain in M. obliquus internus abdominis plus M. transversus abdominis to decrease in weight

may be attributed to a decrease in the gain in weight of its fat content. These muscles may differ in their behaviour from the rest of the muscles because of loose nature and their close association with impregnated fatty tissue. It is possible that pronounced gain in weight of these muscles may largely be associated with the degree of fat deposition in the carcass and in consequence level of nutrition. If this assumption is true then the finding of Butterfield (1963b) that the centripetal waves of growth of muscles terminate in the abdominal region requires re-examining. The big response of these abdominal muscles to restricted feeding and subsequent recovery, shown by Butterfield, could be mainly due to changes in fat content of these muscles. Obviously in future studies the chemical analysis for these muscles is necessary to elucidate the problem. The decreased gain in weight of M. longissimus dorsi in the loin area may also be attributed to a decrease in its fat content. Evidence from the literature has shown a strong relationship between the ether extract in M. longissimus dorsi and that of the carcass. As the ether extract in the whole carcass tended to decrease this supposition cannot be ruled out.

The pluck, blood and gut responded similarly to the muscle tissue in the carcass. As previously shown the growth of these components depends largely on the level of protein rather

than the energy level. Wardrop and Coombe (1960) reported that the rumen, which is the latest developing part of the alimentary tract, has its maximum growth rate between birth and 9 weeks of age and that the level of nutrition before or after this age had less effect on its growth rate than during this period (Palsson and Verges 1952a). In this study the experiment was started after the animals had passed this stage.

The negative response of pelt to the treatment was noticeable but did not reach significance at the 5 per cent level. The pelt was measured as skin plus fleece. As the gain in weight of most of the measures of fat development decreased as the time taken to consume the same amount of ME was increased, the tendency for the gain in weight of pelt to decrease could be a reflection of the decrease in its fat content. Another possible contributing factor to the decrease in gain in weight of pelt was the mechanical loss in wool. The longer the time for the animal to stay on the trial the greater the chance to lose more wool mechanically. However the chemical analysis for pelt has shown that neither of these assumptions are likely. When the gain in pelt was expressed in terms of gain in dry matter, differences between groups tended to disappear, indicating that the decrease in gain in pelt weight was mainly due to variations in moisture content

of the pelt between the groups of lambs. Those lambs which were last to be slaughtered had the least moisture in their pelts. This decrease in the moisture content of the pelt of lambs last to be killed may be attributed to higher loss in moisture through evaporation from the wool and may not be a direct treatment effect. However, as the animals were treated similarly during the feeding period and the slaughtering routine, this supposition seems unlikely. Measurements made on fresh weight of some body components may not reflect the real effect of certain treatments on these components.

The significant reduction in caul fat exceeded the significant increase in gain in weight of the head and this caused the S.E.B. to show a noticeable negative response. The responses of carcass, blood, pluck, gut and feet were negligible. In addition to this the decreased gain in weight of the S.E.B. and pelt and the increase in gain in weight of gut "fill" compensated to make the gain in liveweight similar for each group of animals. Again this emphasises that in animal nutrition and meat production studies, liveweight is an inadequate measure of response to reveal differences between certain treatments. The positive increase in gain in weight of gut "fill" was noticeable although it did not reach significant levels. If the increase in gain in weight of gut "fill" is genuine it may be due to differences in the composition of the

diets. Wardrop (1960) quoted the work of Blaxter (1952) reporting that calves of the same age and liveweight and put on diets of milk and hay had similar stomach weight but those fed hay had larger volume due to stretching of the walls. The fact that the gain in weight of gut in this experiment showed no detectable change does not rule out the possibility of an increase in gut volume. Although the roughage to concentrate ratios were not of a large magnitude, they were corresponding with the gain in weight of gut "fill".

Bone tissue in the carcass showed a small and non-significant response, while other parts of the skeleton were markedly effected. The gain in weight of the head, a predominantly bony part, was significantly increased. Apart from the bone in the shoulder joint, which showed a moderate response, there were no major changes in the gains in weight of bone tissue in the gigot, loin, rib and feet.

If the response of the skeleton is genuine (considering the number of lambs involved and the period of the experiment) the differences in the ages of animals may be largely responsible for it. At the stage of maturity of the lambs in this experiment some bones of lambs can be expected to be still developing (Jackson, 1967) and the level of energy does not appear to effect the daily deposition of bone, (Experiment II). The head has long been regarded (Hammond, 1932; Wallace, 1948 and Palsson, 1955) as an early maturing part of the body which

consequently achieves the major part of its growth in the early stages of life. The increased gain in weight in head may be attributed to an increase in the weight of the horns as the animal gets older. Hammond (1932) reported that in some breeds the cranium develops and forms horns in later life. The Blackface sheep is one of these breeds which develop horns. It may be that horn increase is independent of level of nutrition and can be considered as a function of time. No evidence has been found to support this finding. Hammond (1932) reported that the scapula even in the adult animals has an upper edge of cartilage in which bone can be deposited. As the animals were slaughtered at different ages, it would be expected that those lambs killed later have heavier scapula than earlier killed lambs. Unfortunately the weight of the scapula was not recorded separately.

The responses of the anatomical parts of the carcass would appear to be largely associated with the tissue proportions of these parts particularly as far as the proportion of fatty tissue is concerned. With the exception of a few cases, the areas where fat is usually deposited, such as the abdominal region, (i.e. flank of rib and of loin) and the dorsal region of the trunk, (i.e. the loin and rib cuts) were decreased in gain in weight as the time taken to feed the quantity of ME was increased while differences between groups for the gains in weight of the rest of the joints (except neck) can be

neglected. The brisket and kidney plus perirenal fat are joints having a high proportion of fat, were expected to decrease in weight gain but showed no detectable change. This may be a result of the particular period of development over which the trial took place. The fat in these regions covers organs vital to the life of the animal, i.e. kidney and thoracic organs and it is important in regulating the surrounding temperature. Both deposits seem to be more resistant to wide variations in plane of nutrition. Palsson and Verges (1952a) have shown that perirenal fat intermuscular fat and subcutaneous fat develop in that order. According to previous theories, perirenal fat can be expected to be less effected by level of nutrition than total fat. The finding reported in the first part of this experiment that increasing the level of daily intake of ME has a negligible effect on the gain in weight of perirenal fat in lambs slaughtered at the same age is in accordance with that found in the experiment being reported. The gain in weight in gigot and shank were not noticeably altered due to treatments. The gigot has a small amount of fatty tissue and the shank is almost composed of bone and muscle. Since the gain in weight of muscle and bone tissues showed no detectable change in comparison with fatty tissue, it is expected therefore that those parts with high proportions of muscle and bone would behave similarly to the total bone and muscle in the carcass. The tissue proportion in the shoulder were similar to those of the carcass as a whole and both showed no noticeable relationship with number of days required to feed the quantity of energy. The neck, having a high proportion of bone, showed a similar response to that of the total bone in the carcass.

It may be concluded that the various responses of most of the

anatomical areas of the carcass is a function of tissue proportion and could be best explained on this basis rather than the order of development of these regions. Thus the differential stimulation of the anatomical parts of the animal cannot be discussed in isolation from the tissue proportion in these parts.

The main chemical components of fatty and muscle tissues are the crude protein, ether extract and ash. Tissues responded in one or more of these chemical components to the treatments. In this experiment the ether extract percentage in fatty tissue was significantly reduced while the percentage of crude protein showed a trivial response and this noticeably reduced the percentage of the dry matter. These findings are in keeping with those of Callow (1947) who found that the fatty tissue of lean carcass contains much more water and less chemical fat than the fatty tissue of a moderately fat or fat carcass.

The percentage of dry matter in muscle tissue was significantly decreased while those of ether extract and crude protein showed no noticeable changes. This was unexpected because of the strong relationship between the percentage of EE and the percentage of DM (Garrett et al., 1959, with sheep and Jenkinson et al., 1967, with pigs). As ash is a component of dry matter, as the proportions of ether extract and crude protein were not largely altered the findings suggest that the decreased dry matter percentage in muscle tissue can be attributed to a decrease in the ash percentage in this tissue. Because no attempt has been made to determine the percentage of ash in this study, this makes the assumption unreliable. It is worth noting that the big variation associated with the percentage of EE in muscle tissue masked any change which might have been present due to treatments.

Dealing with the actual gains in these components showed that the chemical components (DM, EE and CP) of fatty tissue were all highly significantly decreased in the gain in weight as the time taken to feed the quantity of ME was increased. While the percentage of DM and EE in fatty tissue were decreased and that of CP remained nearly constant for each group of lambs and while the gain in weight of fresh fatty tissue was highly significantly decreased, these findings were not unexpected. The gain in weight of DM in muscle tissue tended to decrease.

Varying daily dietary energy intake for lambs which had similar quantities of ME failed to show any major effect on the gain in weight of ether extract and crude protein in muscle tissue of the carcass. The gains in weight of the dry matter in bone tissue, showed a similar pattern to that on fresh basis indicating no detectable changes in the percentage of moisture in this component due to treatments.

The gain in gross energy in fatty tissue was highly significantly decreased. This was expected as the gains in weight of EE and CP in this tissue were both highly significantly decreased. The gain in gross energy in muscle tissue showed no noticeable change, this also was expected since the differences between groups for the gain in weight of EE and CP in this tissue were negligible. The gains in gross energy in bone tissue showed a similar trend to the gains in weight of dry matter in this component. However, the number of Kcal of gross energy per one gram dry matter of bone tissue was found to be similar for each group of lambs.

G E N E R A L
D I S C U S S I O N

GENERAL DISCUSSION

Taken in consideration with the more recent published findings the three trials being reported add to the understanding of the growth responses of meat producing animals and contribute to the clarification of previously held concepts of growth and development.

The growth period of the Blackface wether lambs studied in this trial was similar in each of the trials and covered the period from soon after weaning of lambs which required a period of growth and fattening before marketing. From previous studies (Jackson, unpublished data) adult wethers reach approximately twice the live weight of those at the start of the trial and approximately twice the weight of muscle and bone tissues. Hence, while the lambs had passed their initial phase of development they still had a considerable amount of growth potential left before reaching mature weight of muscle and bone. The growth and development responses of lambs of this class to nutritional regimes has considerable practical and commercial importance.

The trials attempted to separate the dietary components of energy and protein and to study the responses of body components to each nutrient. The gain in weight of each component over its predicted weight at the start of the trial was taken as the response and an increasing response to increasing the daily nutrient intake was looked for so that the target components could be identified for each nutrient.

In order to interpret the findings the trials must be looked

at together. Separately the responses are difficult to assess. The fact that one essential nutrient has been kept constant means that the response to a marginal increase in the other nutrient may only be possible if the constant nutrient is not limiting. Also a response cannot be expected from those tissues that have previously satisfied their requirements by priority claim on the nutrients or have no growth response left. So the responding components may be regarded as those which have an unsatisfied requirement for the marginal nutrient which have not been prevented from growth by the level at which the alternative nutrient has been held constant. Responses must be considered with these thoughts in mind.

In this study the response of components has been regarded as linear but there is evidence that this is not so. In the protein trial, of the positive responses, the response between the two lower levels of protein intake is in most cases less than that between the two higher levels of protein. One relevant factor may be that the major source of protein in the lower levels was from hay and barley while at the higher level soyabean meal, which has a different amino acid composition, was predominant. Amino acids from soyabean meal may be more conducive to tissue growth. Many workers have shown that all nitrogen sources may not be of equal value to the ruminant animal. Woods et al. (1962) found that cottonseed meal was inferior to either sesame or soyabean meal as a protein supplement for growing lambs. Theurer et al. (1968) have shown that soyabean meal was superior to corn gluten meal as a nitrogen source in semi purified diet for promoting lambs growth, but was not superior in natural diets. In both semi purified and natural diets urea was inferior to soyabean meal or corn gluten meal. It may also be conjectured that the first level of protein did not supply all the protein requirements for body activities

other than tissue growth and that this requirement had to be further met from the second level. It may also be that higher levels of protein intake are more effectively utilised as has been seen from digestibility studies and efficiency of feed conversion. It would not appear that a ceiling to response had been reached at the highest level of protein feed, at least in the responding components.

It would seem that in the protein trial the energy supplied was more than was required to service the restricted protein intake. As the protein level increased more energy was required to service the protein and less was available for fat storage. Increasing the level of protein increased the demand for energy. Alternatively by Hunter's hypothesis (1968) more fatty tissue has been utilised and less or the same amount was being deposited.

In the energy trial there appeared to be a greater response to the first increment of energy than to the second increment. This may be due to the previously discussed level of nutrition effect or that at the higher intensities of fat storage the weight increment of fat becomes energetically more expensive. Having a constant protein intake a ceiling of muscle growth may have been achieved between the two higher intake levels of energy - hence the response to the second increment can be expected to be smaller.

The results have demonstrated the different effects that energy and protein have in body growth.

Carcass tissues: A marginal increase in protein without increasing the energy level allowed only a small response in growth of muscle tissue but allowed a considerable response in bone tissue.

It would seem that bone tissue was restricted by the low level of protein and was not restricted by the energy level. In the energy experiment bone growth was not effected by the energy level and it might appear that bone has a high priority for energy for growth. Increase in bone weight can also be due to mineral

deposition effecting the density of the bone. It has been shown that increasing the protein intake also effects the minerals intake (McCance et al., 1942; Mellander, 1955 and El-Maraghi et al., 1965). Increases in starch have been shown to restrict mineralisation (Benzie et al., 1960). So in bone growth, protein seems to play the major role with energy level not effective in increasing bone weight, at least at the levels used in this trial. Increasing the protein level while keeping the energy level constant had only a small effect on muscle development. The higher of the two increments gave the greater response. Increasing the energy intake with the same level of protein also increased muscle development but again only slightly. Muscle development requires energy and increasing energy can increase muscle growth to a certain point. Increasing protein intake appears to demand energy for its utilization and therefore leaves less energy available for storage. However, there would appear to be a limit to the rate of muscle development over which increasing the level of protein or energy have little effect. Cooke (1967) has shown that the lean proportion in pig carcasses increased steadily with increasing level of dietary protein to a certain point. He found that muscle development did not increase when increasing the level of digestible energy. This may be because, at the levels used, growth had reached a ceiling. Kielanowski (1968) has shown that the daily deposition of protein increased with increasing level of energy in the diets of pigs. It may also be possible that for protein storage energy has to be presented in a certain form to be readily available. It was

surprising that the ether extract in muscle tissue did not increase with increasing level of energy. Fatty tissue in the carcass was effected by increasing the level of protein by removing some of the energy available for fat storage or from fat storage. There was an increase in the percentage of crude protein in the fatty tissue as a result of fatty tissue increasing its gain in crude protein and with a reduction in gain of ether extract. However, an increase in the energy intake at similar protein levels gave a big increase in fatty tissue. The ether extract in fatty tissue also tended to increase with increasing level of energy, which is in keeping with the findings of Callow (1948). The results indicated that rapid fattening can be achieved by curtailing the protein intake.

Standard empty body components: The S.E.B. was increased by both protein and energy but for entirely different reasons. The response in the S.E.B. to increasing level of dietary protein is in the carcass, blood, pluck, pelt, feet, head and gut, while the response in the S.E.B. to increasing level of dietary energy is in the carcass, caul fat, blood and pelt. It would appear that protein has more overall effects on body components than energy.

Carcass: // As previously shown protein and energy have different effects on carcass tissues - protein stimulating bone, energy stimulating fatty tissue while muscle tissue responded to both nutrients. Hence carcass weight can be increased by either dietary protein and energy but for the different reasons. If protein effects body components in a different way to that of energy then composite measures such as the S.E.B. or carcass when taken as

measures of response to certain treatments can mask the real effects of these treatments.

Head and feet: The head and feet behaved like carcass bone but to a less pronounced degree to increased intakes of protein while these parts were not effected by the energy levels used. Protein stimulated the bone growth in the carcass. The head and feet appear to achieve the major part of their growth earlier than the rest of the skeleton (Hammond, 1932; Palsson and Verges, 1952a) therefore they appear to have a reduced response to the protein supply than the bone of the carcass at this stage of their development. Energy level was without detectable influence on the growth of carcass bone at the levels used and it would be interesting to know at what level energy restriction would become effective.

Pelt: Pelt showed a tendency to increase with both protein and energy very much as muscle tissue responded. Pelt contains wool which is composed almost entirely of protein (Maynard and Loosli, 1962, and Hudson, 1954) hence a substantial amount of protein may be required for its growth. Because pelt was taken as skin plus wool it cannot be stated whether the effect of energy on pelt growth is due to increases in fat content of the skin or to greater deposition of protein in wool due to raising the energy supply or both.

Blood: Blood weight increased significantly with increasing level of dietary protein but only showed a tendency to increase with the increased energy intake. There is evidence from this study that blood weight might relate to the lean mass of the body (muscle plus bone tissues). Luitingh (1962) has shown that blood tissue

tended to increase proportionally to the body.

Pluck: Raising the level of dietary protein significantly increased the gain in weight of pluck while with dietary energy pluck showed no noticeable response. Evidence that the increase in pluck weight with increasing protein was largely due to its effect on liver weight has been presented by Hamilton (1939), Allison et al. (1962) and Zeman (1967) who have shown the effect of the level of nitrogen intake on the growth of liver in rats.

Gut: The weight of gut tended to increase with increasing the protein level and like pluck showed no response to energy. If protein has an overall effect on the protein containing tissues, gut would have been expected to increase also.

Caul fat: The responses of the fatty tissue surrounding the alimentary tract to dietary protein and energy levels were similar to that of total carcass fat.

Retail cuts: The differences in tissue composition of the carcass retail joints suggest that the difference in response to the level of dietary protein and energy will occur. The gigot was significantly increased by protein level but showed only a slight response to energy level. The muscle and bone tissue of the gigot responded significantly to the level of protein while the fatty tissue of the gigot responded to increasing energy. The loin cut did not respond to protein but showed a significant response to

increasing the level of energy. The bone tissue positively and to a lesser extent fatty tissue negatively responded to protein while fatty tissue and to a lesser extent muscle tissue responded to energy increase. The rib joint did not show any detectable response to increasing protein but was significantly increased by the increased energy level. Bone, in the rib only, showed a slight tendency to increase while muscle and fatty tissues showed no response to increasing protein level. However the fatty tissue in the rib and to a lesser extent the muscle and bone tissues responded to energy level.

Carcass characteristics: Of the secondary cuts only the kidney and to a lesser extent perirenal fat and shank responded to protein level while the flank of the rib and to a lesser extent shank, brisket and flank of loin responded to energy level. Neck did not appear to be effected by either nutrients. The area of M. longissimus dorsi at the 12th rib was significantly increased while fat-thickness at the 12th rib tended to decrease with increasing level of protein. However, with energy level the opposite was the case. Fat-thickness significantly responded while the area of M. longissimus dorsi only showed a slight tendency to increase. It was apparent that most of the tissues, organs and parts of the body which responded more to increasing the level of protein than to energy level have in their chemical composition a high percentage of protein. Marginal increases in energy intake at the same level of protein seem to have no major effect on the growth of these components (except muscle tissue). The findings

show that protein effects growth of organs, tissues and parts of the body differently from energy. Thus diets which vary in energy content as well as protein content, as in the plane of nutrition experiments, are expected to effect body components differently from those which vary in one nutrient only and having the other nutrient constant. If protein and energy exert their influences on growth of body components independently of each other then raising the level of both nutrients (protein and energy) in a diet is expected to stimulate both types of components which showed responses to protein and energy. For instance the gigot significantly responded to protein and not to the energy while the loin significantly responded to energy but not to protein. If this is genuine, then an increase in level of protein accompanied by an increase in the level of energy would be expected to stimulate both joints and in this case the differential responses of the joints to the level of nutrition might not be apparent. It may be that the discrepancies in the results of the experiments regarding the differential effects of plane of nutrition on body components may in part be attributed to this factor.

Differential Tissue Response

The work of McMeekan (1940b,c) and Palsson and Verges (1952a) has shown that in the developing animals the level of nutrition does not only effect organs and tissues of the body differentially but also, within a tissue, some parts are effected proportionally more than others. However the question arises as to whether the effect of the dietary protein or energy to the tissues is equal over all parts of the carcass.

Bone tissue: It has been seen that bone tissue was increased significantly in the gigot, shoulder and loin joints while showing only a slight tendency to increase in rib, head and feet with increasing level of protein. The head and feet are proportionally better developed at birth than the rest of the skeleton. The rib appeared to respond less to increased protein level. If this is genuine it may be that the growth impetus for this bony region occurs at a later stage of maturity. There is evidence to show that the ribs represent the latest maturing bones of the body (Palsson and Verges, 1952a, with lambs, and Joubert, 1959 and Luidingh, 1962, with cattle). Compared with protein level, energy level has been seen to have less differential effects on bone growth in the various parts of the body. Bone in gigot and in rib responded slightly to energy level while there was no noticeable response in bone of loin, shoulder, feet and head.

Muscle tissue: The differential effects of either protein or energy on muscle tissue development was in general more pronounced than on bone or fatty tissues. The muscle tissue in the gigot and in the kidney was strongly effected, muscle tissue in the shoulder was partially effected while muscle tissue in loin and rib showed no noticeable response to increased protein level. Of the individual muscles the early developing muscles, e.g. M. extensor digitorum longus, M. extensor carpi radialis, M. gastrocnemius, M. infraspinatus and M. supraspinatus responded to increasing protein level as well as M. quadriceps femoris and M. longissimus dorsi (rib area) which are regarded as late and average developing ones. While the

abdominal muscles, the M. biceps brachii, M. semitendinosus, M. semimembranosus and M. gluteus medius were less noticeably effected. M. brachialis did not appear to be effected by increasing the level of protein. Energy appeared to effect muscle tissue in the shoulder, loin and rib joints more than in gigot or kidney joints. The abdominal muscles, M. longissimus dorsi (in loin area) the muscles of the fore shank, i.e. M. brachialis and M. biceps brachii responded more to energy level than the rest of the individual muscles tested. The M. gluteus medius and M. extensor carpi radialis showed no noticeable response to energy level. The other muscles tested responded intermediately. Reference has already been made to the extreme variation between the individual muscles of the body either anatomically, chemically or physiologically which make the explanation of these different responses very difficult without information regarding the anatomy or/and chemical composition of these muscles. However, the data strongly suggest that the responses of the individual muscles tested to either of the nutrients were not the same. These results apply only to a particular stage of development.

Fatty tissue: The response of the fatty tissue over the different parts of the carcass to increasing level of protein was not the same. The perirenal fat, fatty tissue in the gigot, shoulder and loin joints, fat-thickness over the 12th rib caul fat and the ether extract of muscle tissue all tended to show a reduced increase as the protein level was increased, while fatty tissue in the rib joint did not respond to the increased level of protein. With increasing energy level caul fat, fatty tissue in the gigot, shoulder, rib and loin joints and fat-thickness were significantly effected by energy level. Perirenal fat and the chemical fat of muscle tissue showed no noticeable

response to energy level. It would appear that at this stage of maturity the surplus energy went fairly equally over the subcutaneous fat layers of the carcass while the perirenal fat and the chemical fat of muscle tissue showed little effect.

In general the results show that the various parts of a tissue responded differentially to either level of protein or energy. The differential effects of plane of nutrition on growth of body components have been reported by many workers (Robertson, 1923, with cats; Child, 1939, with insects; McMeekan, 1940b,c, with pigs; Hammond, 1943, and Palsson and Verges, 1952a, with sheep; Wilson, 1952, with poultry and Butterfield, 1963b, with cattle). In hexoestrol implantation studies in lambs, Preston and Gee (1957) have shown that the leg joint was significantly heavier while the loin was lighter in treated lambs. This finding is in agreement with the protein stimulation studies. Kirton and Barton (1958b) reported that ewes subjected to L-thyroxine showed differential responses in the different regions of the carcass. Other hormones have differential effect on the growth of muscles. Growth hormone preferentially stimulates the growth of M. quadriceps, M. supraspinatus and diaphragm (Greenbaum and Young, 1953) "cited by Lawrie, 1966". If the response of individual joints to particular feeding regimes is likely to vary then studies using a sample joint to predict the composition of the whole carcass is not valid. The relationship of each joint to the whole must be determined for each treatment.

The conclusion to be made was that varying the levels of dietary protein or energy not only effect tissues and organs of the body differently but also within a tissue some parts were influenced more than others. This is in close agreement with the theory that

plane of nutrition effects the growth of body components differentially but disagrees with theory that the response is related to their order of development. If the responses of body components to certain feeding regime are closely related to their order of maturity, as suggested by the workers at the Cambridge school one would have expected that increasing the level of protein in the constant energy diet would effect the growth of fatty tissue more than muscle and muscle more than bone tissue. In our experiment the opposite was the case. The bone tissue showed the greatest response than muscle and fat. This can be attributed to the fact that the growth of bone depends largely on the level of protein and not on the level of dietary energy. Increasing the protein supply stimulates the growth of bone. The findings suggest that the responses of body tissues is more related to the composition of the ration than the order of maturing of these tissues. Thus the concept put forward by McMeekan (1940) and Palsson and Verges (1952a) that restricted nutrition effect the growth of body tissue differentially in the reverse order of their maturity cannot be meaningful without determining what is meant by restriction of nutrition. If the low plane of nutrition was composed of a diet rich in protein then the growth of bone tissue may not be as greatly retarded as if the diet has been restricted in protein. Alternatively, a high protein and low energy diet would stimulate bone growth more than muscle while a high energy and medium protein diet would stimulate muscle growth more than bone hence disrupt the normal relationships between these two carcass components.

That body components responded differentially to either dietary protein and energy levels was not in keeping with the findings of Elsley et al. (1964) and Wilson (1958) that restricted nutrition causes a more or less uniform retardation of development except in so far as fatty tissue was concerned. The results of the present study showed that the relationship between bone and muscle tissue can be altered by certain nutritional treatments. Thus the conclusion that has been made by Elsley et al. (1964) that in choosing a feeding scale for any particular strain of animal no attention need be given to the relative proportion of bone to muscle. They suggested that the pattern of feeding should be aimed at producing carcasses of whatever fat content is desired but this cannot be completely justified for two reasons. Firstly, the use of fat-free carcass weight as an independent variate can only be justified if the absence of fatty tissue does not disturb the relationships between each of the other components and the weight of the whole less the weight of the components. Seebeck (1968) using the same data of Elsley et al. (1964) found evidence that this relationship existed. Secondly, the data of Elsley and his colleagues were obtained from animals fed different quantities of energy but the chemical nature of this energy and the level of protein at each plane was not known. Energy as well as protein from different sources may effect body growth differently, as has already been indicated.

The feeding of equal quantities of energy over different number of days

The question arises if by feeding the same amounts of energy on different levels of intake feed can be utilised with better efficiency at the lower levels and whether the carcass components can be effected by extending the time required to feed the quantity of energy.

Carcass tissues: Feeding similar quantities of energy over longer time was seen to increase the bone tissue although the increase was small. The previous trial indicated that bone continued growing at the same daily rate so that the longer the feeding time the greater proportion of carcass bone and head. Feet could also be expected to increase but the trial showed that this part did not show any noticeable change.

Muscle tissue: Muscle tissue appeared not to be effected by extending the feeding period indicating that the longer number of days to slaughter compensated for the muscle growing at a slower daily rate on reduced daily energy intake. Although there is a small increase in muscle tissue when the quantity of energy was fed on 112 days rather than 91 or 140 days. However these differences did not reach significance at the 5 per cent level of probability.

Fatty tissue: Fat was the only tissue which was largely effected by the treatment. As the time taken to feed the quantity of energy increased fatty tissue was significantly decreased in weight.

The energy required for maintenance as well as the composition of the diets were suggested as contributing factors to this reduction in fat.

Retail cuts: The rib flank, and to a lesser extent, rib, loin and loin flank joints decreased while the gigot, shoulder, brisket, shank and kidney plus perirenal fat were not effected. The neck joint seemed to react similarly to the head which increased over the longer period of feeding. The dissection of these joints showed that the fatty tissue of all the prime cuts, caul fat and fat-thickness over the 12th rib significantly decreased while muscle and bone tissues in the shoulder were slightly increased. Muscle and bone tissues in gigot, loin and rib joints were not effected by extending the feeding period. Also the area of eye muscle showed no noticeable change.

Of the individual muscles, those muscles which may have high proportion of fat such as the abdominal muscles and the M. longissimus dorsi tended to be reduced in the groups fed longer. Only the Mm. pectoralis profundus et superficialis tended to increase. However the rest of the individual muscles tested behaved similarly to the total muscle tissue in the carcass.

Chemical composition of the carcass tissues: The percentage of dry matter and ether extract in the fatty tissue were reduced significantly with increasing the time to feed the quantity of energy. With muscle tissue the longer fed groups had more moisture percentage. It is surprising that the decreased dry matter per cent in muscle

tissue was not associated with decrease in the per cent of ether extract. The percentage of crude protein in both tissues seemed not to be effected by extending the feeding period.

It may be concluded that feeding similar quantities of energy appeared to produce carcasses with less fat, slightly more bone and similar muscle tissue in the lambs which have the quantity of energy fed over a longer period.

Feed utilisation

It is important in meat production to balance the efficiency of feed utilisation with the desirability of the saleable product. As meat is sold by weight the amount of feed required to produce a unit of weight gain effects the costs of production and is a useful economic parameter. This is a measure of economic efficiency as opposed to the efficiency of energy or protein retention which is a measure of the biological efficiency of the physiological processes. The proportion of energy retained in various components such as the standard empty body or carcass or muscle tissue can have economic importance.

In the trials being reported the number of treatments was too small to give precision to the response curve or line. Nevertheless the data does indicate several important points.

The level of nutrition and the efficiency of energy utilisation

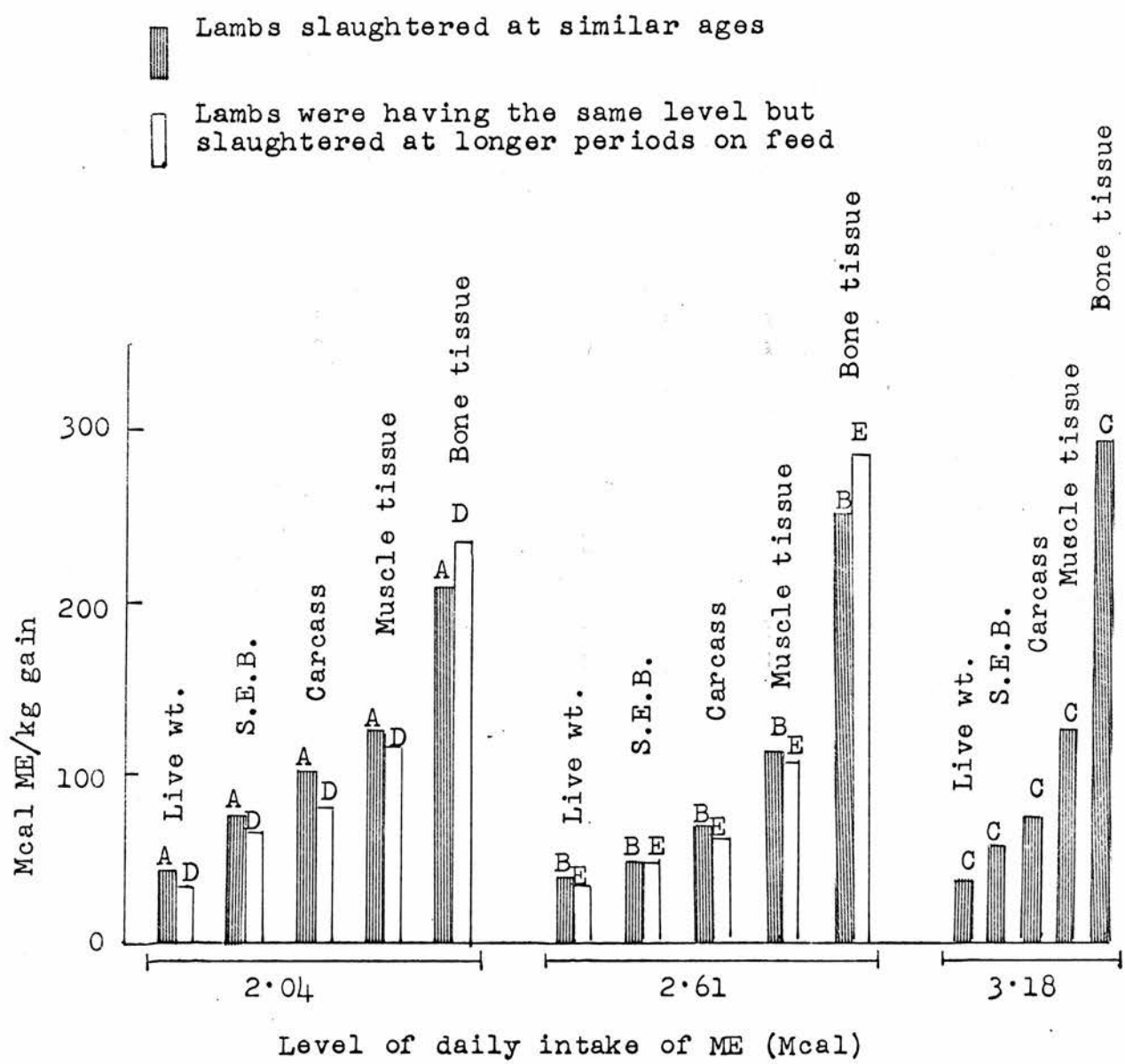
The quantity of dietary metabolizable energy (Mcal)/kg gain was taken as a measure of the energy utilisation, while energy retention was expressed as Mcal diet ME/Mcal retained. Table 22 gives the amount of metabilizable energy in the different rations

Table 22. The effect of level of daily intake of metabolizable energy on the efficiency of energy utilisation and retention in Blackface wether lambs

	Groups				
	A	B	C	E	D
Level of ME (Mcal/day)	2·04	2·61	3·18	2·61	2·04
Length of feeding period (days)	91	91	91	112	140
Mcal ME/kg gain:					
Live weight	40	34	35	30	34
S.E.B.	72	46	54	46	65
Carcass	100	62	71	60	79
Muscle tissue	124	110	125	104	116
Bone tissue	209	249	292	281	233
Fatty tissue	-	237	228	261	-
Mcal ME/Mcal ER:					
S.E.B.	17	10	9	10	26
Carcass	37	18	17	18	47
Muscle tissue	64	61	56	52	74
Bone tissue	82	104	98	97	82
Fatty tissue	-	32	31	36	-
Mcal ME/Mcal ER (over maintenance):					
S.E.B.	8	6	6	6	12
Carcass	18	11	11	10	21
Muscle tissue	31	37	37	31	33
Bone tissue	40	62	65	57	36
Fatty tissue	-	19	20	21	-
Daily ER (Kcal)	121	264	338	250	78

taken to produce a kilogram of gain and to retain one Mcal energy in certain components. Each value is the mean of four animals. Figure 1a shows the relationship between the level of daily intake of ME and the amount of energy taken to produce a unit of gain. In general, over the levels of ME used, the data suggests that an improvement in the efficiency of energy utilisation resulted from increasing the daily intake of energy. The results are in keeping with the findings of Watson (1943) with beef cattle, who showed that the efficiency of feed conversion increased with increasing

Fig. ia. The relationship between level of ME and the efficiency of energy utilisation (Mcal/kg gain)



plane of nutrition. Fontenot and Kelly (1967) working with steers, have shown that feed efficiency increased with energy level. Cooke et al. (1968) 'unpublished paper' have shown that increasing the energy intake for pigs resulted in a linear increase in efficiency of feed conversion. In the experiment being reported, raising the level of daily intake of ME from 2·04 Mcal/day to 2·61 Mcal/day resulted in a reduction in the quantities of ME required to produce one kg gain of liveweight, S.E.B., carcass and muscle tissue by 15, 36, 38 and 11 per cent respectively, while increasing energy level from 2·04 to 3·18 Mcal ME/day these values were only 13, 25, 29 and 1 per cent indicating that energy was utilised with maximal efficiency when fed at about the level of 2·61 Mcal/day. Over that level the efficiency of energy use appeared to decline. The findings show that a considerable saving in the quantity of energy required to produce a unit of gain can be achieved by adopting the most suitable level of feeding. The decline in the efficiency of energy conversion over the level of 2·61 Mcal/day may be attributed to a limitation in protein supply at the 3·18 level. However, the data does not show whether the diet can be utilised with greater efficiency if the level of protein was raised above the level used. In terms of weight gain there is an indication that increasing the level of protein in isocaloric diets (Experiment I) improved the efficiency of energy utilisation for weight of product formation.

Bone tissue behaves differently to the rest of the components. As the level of energy increased by about 0·6 Mcal ME/day the amount of energy required to produce a kilogram of gain of bone tissue

increased by approximately 18 per cent. This was due to the fact that no gain in bone growth resulted from the increase in energy intake. Muscle responded slightly to increasing the daily energy level while fatty tissue was noticeably effected.

These responses have in the past been erroneously interpreted. Restrictions of food intake have been thought to effect most severely those tissues of the carcass which were most actively growing at the time. This assumed that the use of the nutrient was the same for each tissue. It is now appreciated that energy has little effect on bone growth, that bone grows even at low daily intake levels. Muscle growth is only slightly effected by the extra energy but fatty tissue growth is totally dependent on it. The effect of restricting energy is going to have no effect on bone but a large effect on fatty tissue neither of which is related to their impulsion to grow. One would expect this response up to the cessation of growth. Because one is feeding more energy with no extra gain in bone weight, then the ratio feed:bone weight is seen to deteriorate but this is a function of the feeding level and not the earliness of maturity of bone.

It is of interest to note that at the energy level of 2·04 Mcal ME/day feeding efficiency in terms of Mcal ME/kg gain of live-weight, S.E.B., carcass and muscle tissue improved as the animals matured (Group A and D in the figure ia). While with bone tissue the efficiency declined. This pattern is repeated (although on a smaller scale due to the small differences in ages) when energy was fed at the level of 2·61 Mcal ME/day (groups B and E). These

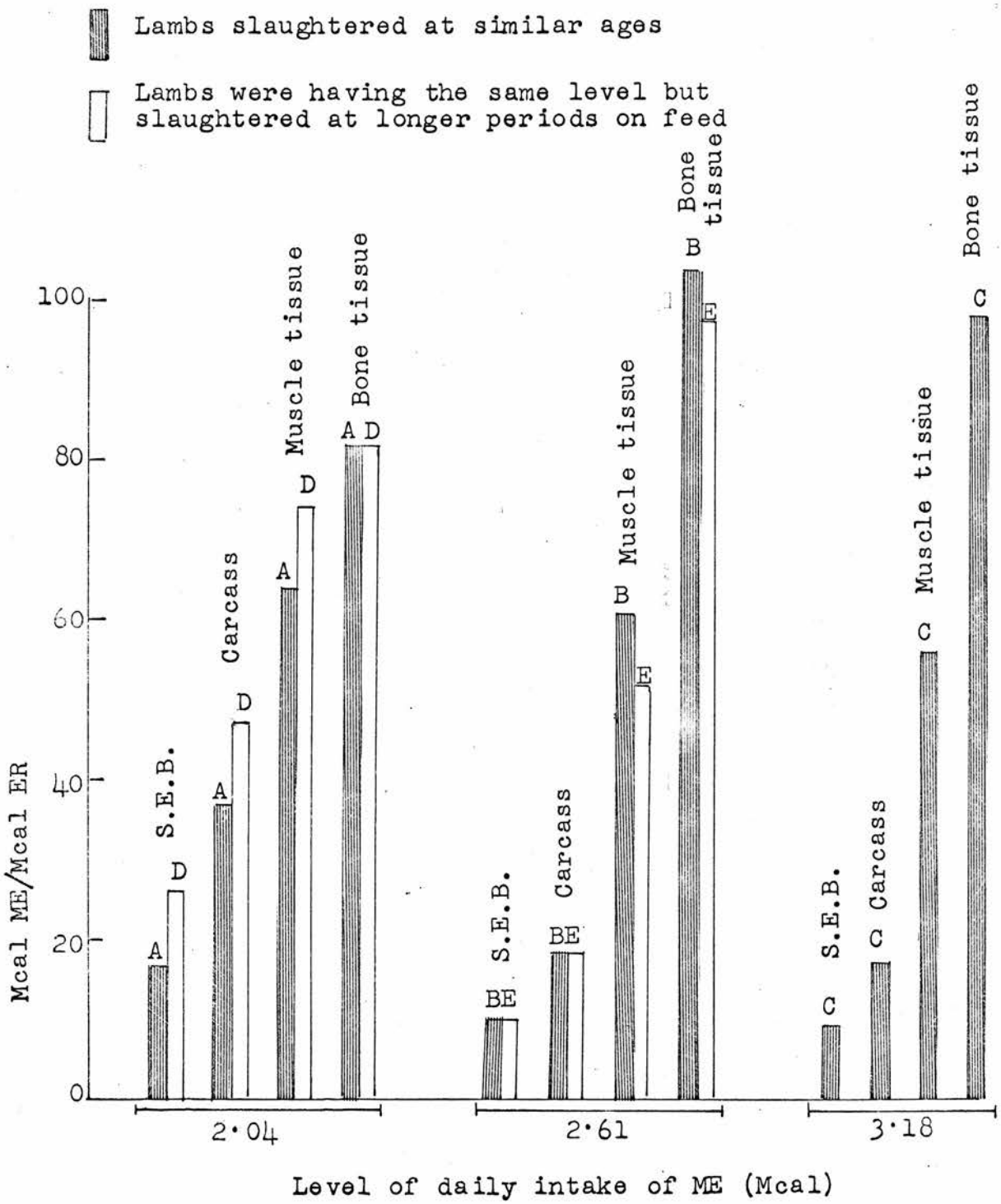
findings would indicate that at earlier stages of growth in the trial the utilisation of feed energy for bone growth was better than at the later stages while the opposite was the case with muscle tissue. The data suggests that, at the same daily energy level, the better was the use of feed for muscle growth the longer the animals were on the trial particularly at the low level of feeding.. This is a puzzling finding.

When the lambs consumed similar quantities of energy but at different levels of daily intake, the efficiency with which energy can be utilised in promoting gains in the liveweight, S.E.B., carcass and muscle tissue improved by feeding the quantity of energy in a period of 112 days rather than 91 or 140 days. The results show that feeding the quantity of energy at 2·61 Mcal ME/day instead of 3·18 Mcal ME/day resulted in a decrease in the amount of energy required to produce a unit gain in muscle and an increase in the quantity required for producing a unit weight of fat. Thus a unit of muscle tissue can be produced more economically if the same amount of feed was fed at 2·61 Mcal/day rather than 3·18 Mcal/day while the opposite is the case with fatty tissue. Since fat has less commercial value than muscle and only a certain amount of it is required, then the level of 2·61 Mcal ME/day when fed with 92 g of DCP would appear to give the maximal efficiency of energy conversion and approximately achieves the minimal cost of producing a unit gain in muscle tissue. In the groups which were slaughtered at the same number of days on the trial (A, B and C) this level has again shown an improvement over the extreme levels.

The efficiency of energy retention as effected by the level of dietary metabolizable energy

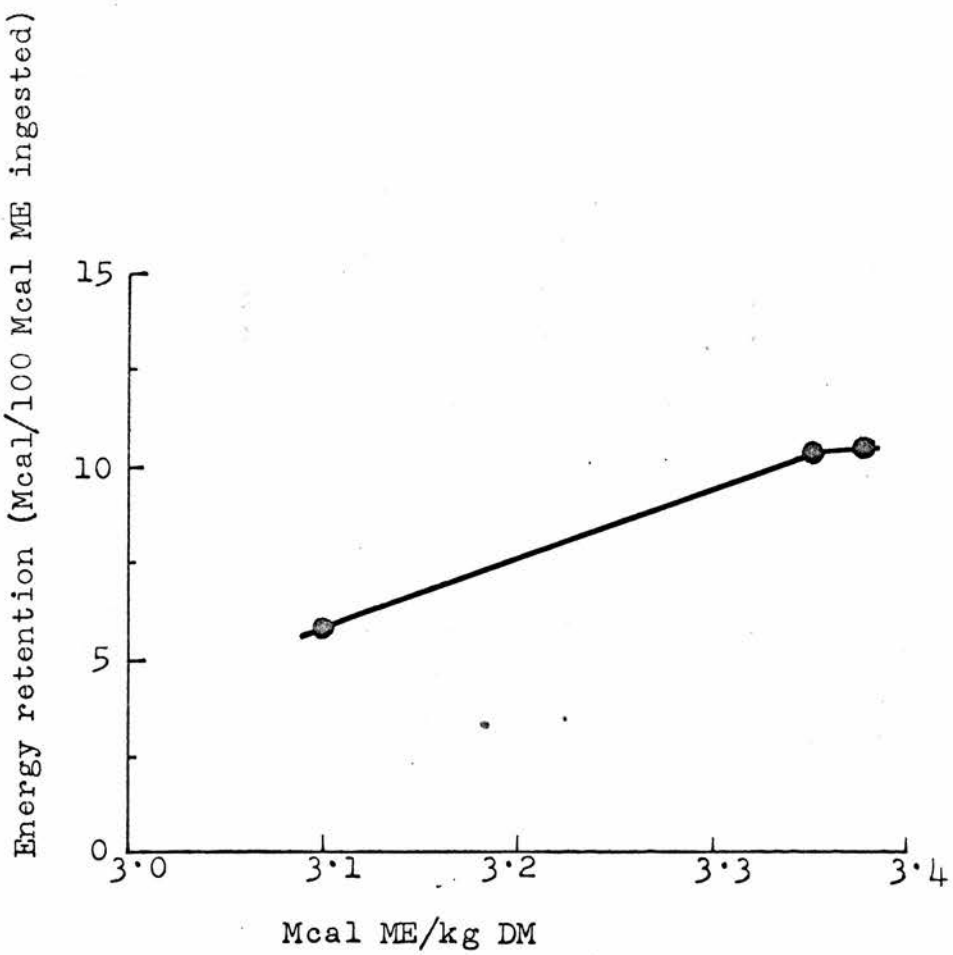
Investigations concerning the relationship between level of energy intake and energy retention have shown extremely conflicting results. It appears from the review of literature that there are two opposing views regarding the relationship. The first showed that the relationship between energy intake and energy retention was linear (Armsby and Fries, 1915, and Jenkinson et al., 1967), hence the nutritive value per unit of feed was constant irrespective of the level of feeding. The opposite view (Forbes et al., 1928, 1930; Mitchell et al., 1932; Marston, 1948; Blaxter and Graham, 1955; Blaxter, 1956 and Blaxter and Wainman, 1961) consider that this relationship is curvilinear hence, the net energy per unit of feed declines with increasing intake. This contradiction is largely due to the levels of feeding which were used and the compositinn of these diets. Also these workers have used different species of animals and there is evidence that this relationship differs with species. Garrett et al. (1959) have reported that the relationship between energy intake and energy retention is best expressed as linear with sheep and exponentially with cattle. In this study the efficiency of energy retention was expressed in terms of Mcal of ME/Mcal ER. The figure ib shows the relationship between the amount of metabolisable energy (Mcal) from the different rations required to retain one Mcal of energy in various body components. As the level of the daily intake of ME increased the numbers of Mcals of ME needed to retain one Mcal in the S.E.B., carcass and muscle tissue decreased while that of bone tissue increased. This

Fig. ib. The relationship between daily intake of ME and the efficiency of energy retention (Mcal ME/Mcal ER)



improvement in the efficiency of energy retention was more prominent as the level of ME increased from 2·04 Mcal/day to 2·61 Mcal/day than from 2·61 to 3·18 Mcal/day which indicated a curvilinear relationship between the level of energy and the efficiency of energy retention. It is not known whether this improvement is due to raising the level of energy or to the composition of the diet or both. There is evidence that the efficiency in which metabolizable energy is used for body gain is not effected by the level of feeding, hence the amount of energy required to retain unit of energy is constant regardless of the amount of energy ingested. It has been reported by the A.R.C. (1965) and Lofgreen and Garrett (1968) that the efficiency with which the ME of a diet is used to maintain animals increases as the concentration of the diet increases. This improvement is more pronounced when the energy is utilised for growth and fattening./ In the experiment being reported it has been found that as the concentration of the diet in terms of Mcal ME/kg dry matter increased, the amount of energy retained per 100 Mcal ME ingested also increased (Figure ic). Blaxter (1967) 'unpublished paper' has shown that an increase in the ME of feed by a fifth from 50 to 60 per cent resulted in an economy of feed for maintenance of 4 per cent and an economy of feed for the production of unit gain by 15 per cent. Also this improvement in the efficiency of energy retention can be attributed to the proportions of VFA. It has been mentioned previously that increasing the percentage of concentrates in the diet results in an increase in the proportion of propionic

Fig. ic. The relationship between diet concentration (Mcal ME/Kg DM) and the efficiency of energy retention (Mcal/100 Mcal ME)



acid at the expense of acetic acid. Since propionate is more efficient than acetate as an energy source, at least for fat synthesis, thus it would be expected that a high concentrated ration would be utilised more efficiently than rations with a high proportion of roughage. Moreover it is possible that with concentrated feed more carbohydrate escapes fermentation and is absorbed as glucose (McDonald et al., 1966). In this experiment it should be noted that the proportion of the concentrates increased as the level of feeding was increased. The findings may suggest that in studies concerning the level of feeding and energy retention the composition of the diet should be taken into consideration. In fact one of the most important reasons contributing to the discrepancies in the results regarding the level of feeding and energy retantion may be due to the composition of the diet at each level of feeding particularly in relation to roughage to concentrate ratio. As the proportion of concentrates was increased with increasing level of feeding it was expected therefore that the C diet would utilise more efficiently than the B diet but the improvement in the efficiency was very small in comparison with the improvement which occurred from increasing the energy level from 2·04 to 2·61 Mcal/day.

With lambs fed 2·04 Mcal ME/day the amount of energy required to retain one Mcal in S.E.B., carcass and muscle tissue increased as the animals were longer on the feed, while with bone tissue the efficiency was similar for the different slaughter ages. However in the figure ia the amount of energy needed to produce one

kg of gain of fresh material in S.E.B., carcass and muscle tissue decreased as the feeding period was extended. This would suggest that the moisture contents of the lambs in group D (older age) might be higher than that of group A (younger). The chemical analysis confirms this conclusion. Brody (1945) has shown that the maintenance requirements of the animal per unit of feed ingested is greater in large animals than in the small ones. Therefore the amount of energy for production per unit feed is smaller in the D group than in the A group of lambs. At the level of 2·61 Mcal ME/day the variation in the efficiency due to age differences tended to be smaller.

Dealing with lambs consuming similar quantities of ME but on different levels of daily intake Figure ib shows that apart from bone tissue there was a general depression in the efficiency of energy retention in terms of Mcal ME/Mcal ER as the time taken to feed the quantity of energy was increased. It is worth noting that ration E (2·61 Mcal/day) was utilised with greater efficiency in producing muscle tissue than either of the other two rations which is in agreement with the efficiency of energy utilisation as expressed in terms of Mcal ME/kg gain of muscle.

The decline in the efficiency of energy retention resulting from feeding the quantity of energy at lower levels of intake can be attributed to two relevant factors. Firstly, while the lambs were fed similar quantities of the metabolizable energy they may not have produced similar quantities of each of the VFA's. Animals fed similar quantities of energy but made up from different feeds

are not necessarily equally effected. Weiss et al. (1967) found that steers had similar daily levels of digestible energy but different proportions of rumen VFA varied in their fat and protein contents. Secondly, the lambs were slaughtered at different ages, the longer the period of feeding the higher the quantity of ME required for maintenance and the smaller the quantity for producing gains. However when the total quantity of ME estimated to be used to maintain the animals was subtracted from the total energy ingested the results were similar to that described before deducting the maintenance allowance, indicating a real difference between diets in their efficiency to produce gains in the body. It is worth noting that the decline in the efficiency due to increasing the number of days to consume the quantity of energy was only pronounced when the animals had the same quantity of ME in a period over 112 days. In fact better use (although only slightly) of the quantity of energy ingested can be made if it is fed over a period of 112 days rather than 91 days particularly for producing muscle tissue.

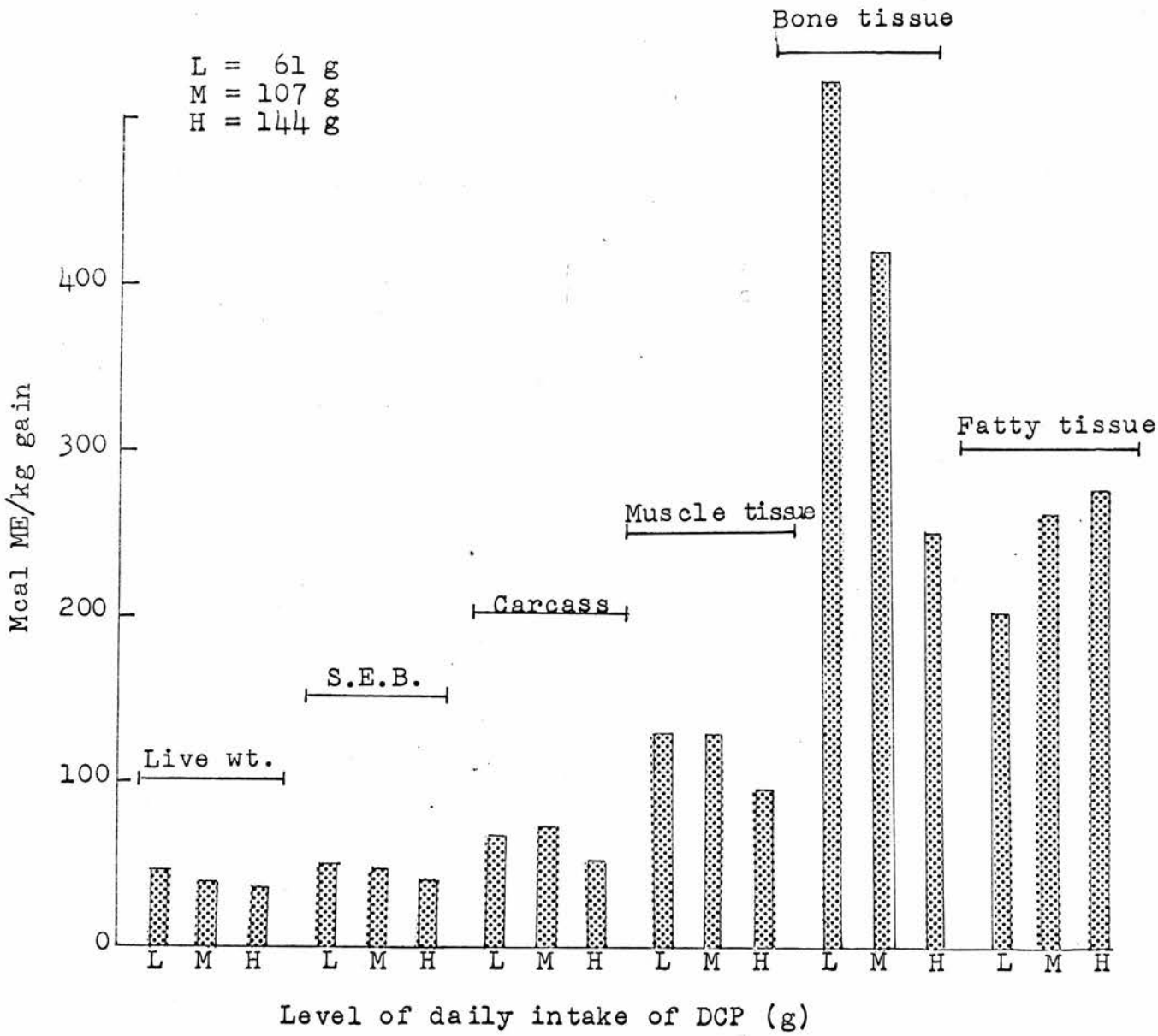
From these results it may be concluded that dietary energy could be utilised in producing gains in empty body, carcass or muscle tissue with greater efficiency if the lambs are fed at the daily rate of 2·61 Mcal ME and 92 g of DCP rather than the levels of 2·04 or 3·18 Mcal/day at the same level of DCP. Whereas feed energy can be used with slightly greater efficiency in retaining energy in these components when the lambs were fed the highest level of intake. When the same quantity of metabolizable energy was fed

at the level of 2·61 Mcal/day it can be utilised with greater efficiency in producing gains in empty body, carcass and muscle tissue or in retaining energy in these components than if it is given at the other levels.

Effect of the level of dietary DCP in isocaloric diets on the efficiency of energy utilisation

The protein:energy ratio and its effect on the efficiency of feed utilisation in poultry feeding is now familiar knowledge. There is evidence (Maynard and Loosli, 1962) that higher protein levels result in greater feed economy. Protein is essential for the growth of rumen microorganisms which play an important role in the utilisation of carbohydrates. Little information is available on the effect of the level of protein in ruminants diets on the efficiency of feed conversion. Figure iia shows the relationship between the level of daily intake of DCP and the amounts of metabolizable energy required to produce a kg of gain in some body components. The results (Table 23) show that with the exception of fatty tissue, there was a marked saving in the amount of feed required to produce a unit gain in liveweight, S.E.B., carcass, muscle tissue and bone tissue as the level of the daily intake of protein was increased. However this improvement was more noticeable from the medium to higher level of protein intake. McDonald et al. (1966) have shown that carbohydrate diets were utilised more efficiently for fattening than protein diets. Other workers have shown that raising the level of dietary protein resulted in better feed efficiency. Holme et al. (1965) found that pigs were growing

Fig. iia. The relationship between level of dietary DCP and the efficiency of energy utilisation (Mcal/kg gain)



at similar rates, the efficiency of feed conversion (lb feed/lb gain) improved with increasing level of dietary protein at least up to certain level. Similar results were obtained by Fontenot and Kelly (1967) with steers. Cooke et al. (1968) 'unpublished paper' have shown that increasing the level of dietary protein to certain limits increased efficiency of feed conversion in pigs. The data of the protein experiment indicated that the use to which feed energy is put is different with the different levels of protein intake.

TABLE 23

The effect of level of dietary protein in the efficiency of energy utilisation and retention in Blackface wether lambs

	Groups		
	L	M	H
Level of DCP (g/day)	61	107	144
Length of feeding period (days)	104	104	104
Mcal ME/kg gain:			
Liveweight	46	41	38
S.E.B.	49	48	38
Carcass	68	74	52
Muscle tissue	131	131	98
Bone tissue	525	421	251
Fatty tissue	201	262	277
Mcal ME/Mcal ER:			
S.E.B.	10	12	13
Carcass	16	23	22
Muscle tissue	71	124	95
Bone tissue	95	95	95
Fatty tissue	27	39	44

The induced tissue response decides whether the total food intake is more effectively used for a particular purpose. Bone is increased and while not retaining additional energy it is seen to improve its efficiency at the higher protein levels. Less energy

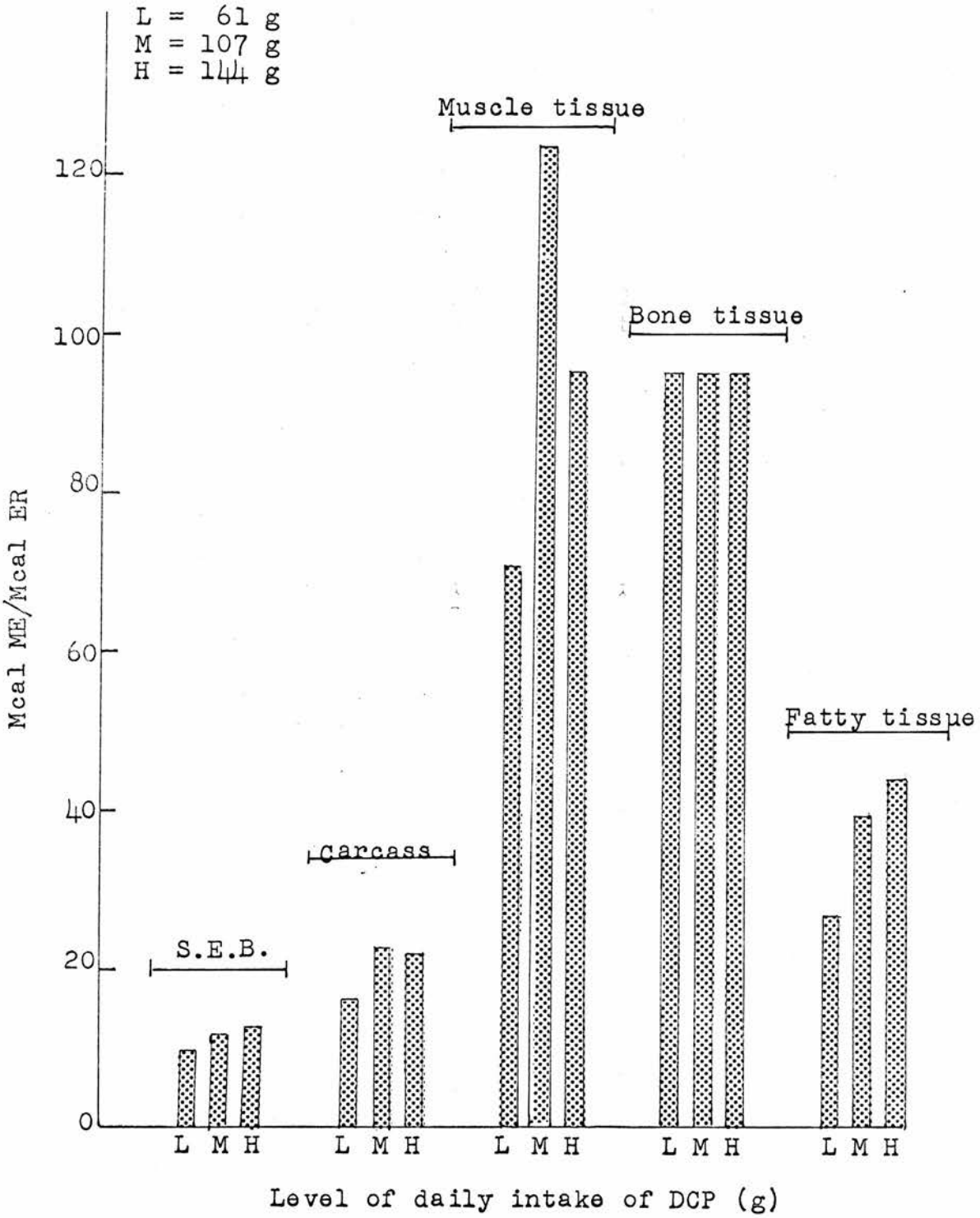
is available for fat deposition at the higher protein intake - hence the small response of fatty tissue growth made the food utilisation for fatty tissue production poorer at the higher levels of protein intake.

The effect of the level of dietary DCP in isocaloric diets on the efficiency of energy retention

When the efficiency of energy retention is expressed in terms of Mcal ME/Mcal ER (Figure iib) the amounts of energy required to retain one Mcal in the S.E.B., carcass, muscle tissue and fatty tissue increased with increasing level of DCP. This was expected as the lambs in group L were fatter than the lambs in group M and those fatter than in group H. This indicated that animals could have heavier weight but less caloric content than others which have lighter weight, depending on the proportion of the different tissues in the body. Fowler (1968) 'unpublished paper' has shown that the efficiency of energy retention was positively related to the fat content of the carcass.

The data showed that the energy was utilised with equal efficiency, irrespective of the level of DCP, to retain calories in bone tissue, while it was utilised with greater efficiency to produce fresh gain in bone as the level of DCP increased, suggesting that bone produced from the diets rich in protein has higher mineral contents than bone produced from diets relatively poor in protein (assuming that the percentage of dry matter in bone tissue is constant for each group).

Fig. iib. The relationship between level of dietary DCP and the efficiency of energy retention (Mcal ME/Mcal ER)



The effect of the level of dietary ME on the efficiency of nitrogen retention

Figure iiia shows the relationship between the level of daily intake of metabolizable energy and the amount of nitrogen retained in certain body components per 100 g of nitrogen intake. The results (Table 24) show that there was a marked improvement in the efficiency of nitrogen retention due to increasing the level of daily intake of energy. The percentage of nitrogen retention in muscle and fatty tissue and in gut plus pluck increased as the level of ME was increased. The results are in keeping with the findings of Kielanowski (1968) who found that the nitrogen balance in pigs increased in response to higher level of feeding.

The data show that when lambs had similar total quantities of ME but on different levels of intake (groups C, E and D) the amount of nitrogen retained per 100 g nitrogen intake was also associated with the level in which the quantity of energy was fed. The highest nitrogen retention was achieved when the quantity of energy was fed at the highest level of energy intake. Although nitrogen was retained with approximately equal efficiency at the highest two levels of energy suggesting that the optimal nitrogen retention at least in the components tested, can be obtained when the same amount of energy is fed at the level of 2·61 Mcal/day and 92 g of DCP daily. It is not known whether an improvement in the efficiency of nitrogen retention can be achieved if the level of 3·18 Mcal ME/day was fed with higher level of protein.

Feeding lambs on the same energy level and slaughtered at

Fig. iiia. The relationship between level of ME and efficiency of nitrogen retention

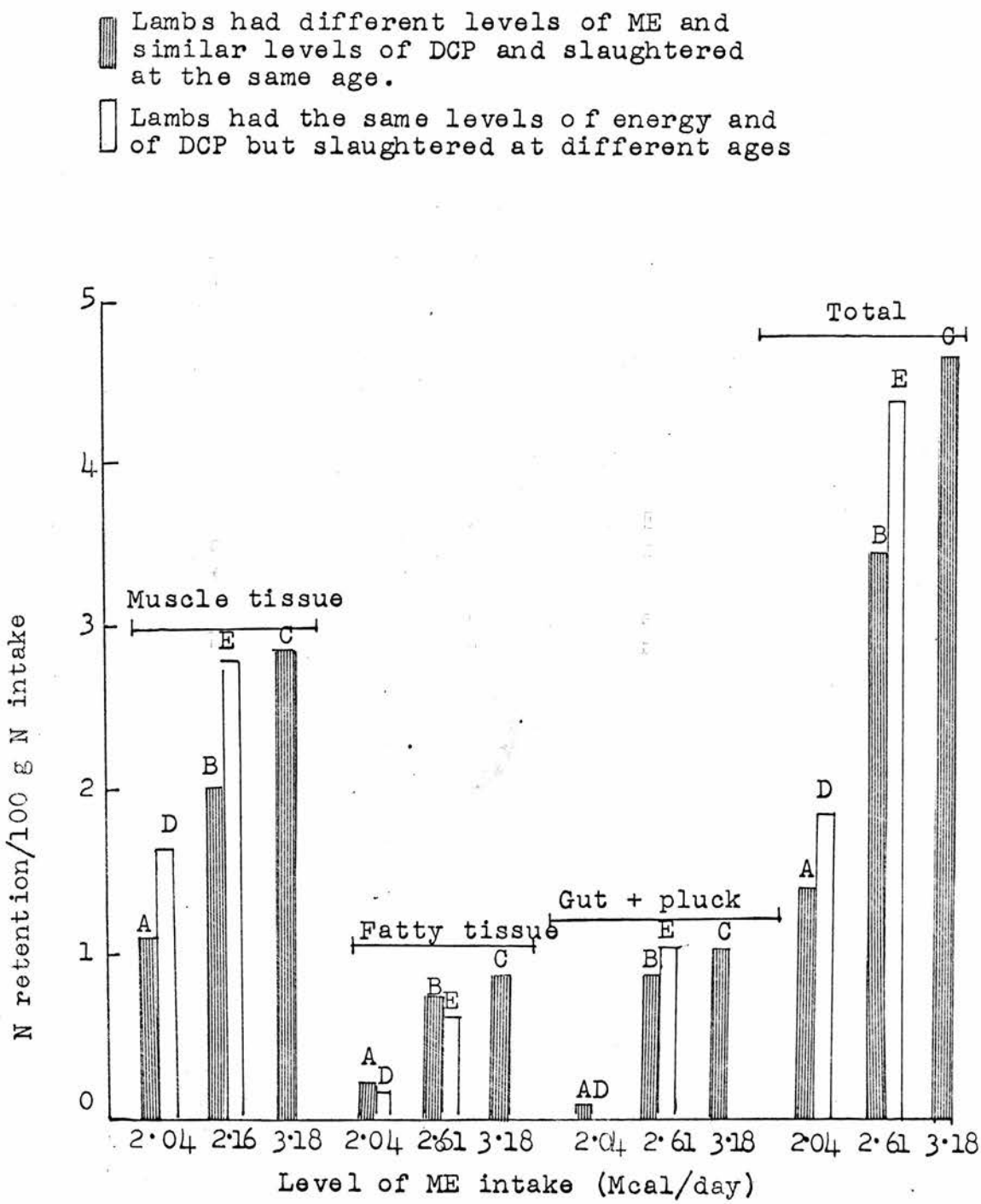


TABLE 24

The effect of level of ME on the efficiency of nitrogen retention in Blackface wether lambs

	Groups				
	A	B	C	E	D
N retention/100 g N intake:					
Muscle tissue	1·14	1·97	2·84	2·75	1·69
Fatty tissue	0·18	0·69	0·81	0·56	0·14
Gut plus Pluck	0·05	0·81	0·99	1·06	0·00
Total	1·37	3·47	4·64	4·37	1·82

different degrees of maturity (groups A and D and groups B and E) resulted in marked improvement in the efficiency of nitrogen retention at the later slaughter dates. The small amount of data suggests that nitrogen can be utilised with greater efficiency at least in muscle tissue if the lambs are slaughtered at the later stage of maturity. As the animal matures the percentage of nitrogen in muscle tissue increases (Lawrie, 1966). In this experiment lambs slaughtered at older ages (groups D and E) had higher nitrogen percentage in muscle tissue than those fed on the same level of feeding but slaughtered earlier (groups A and B respectively).

The effect of the level of dietary DCP in isocaloric diets on the efficiency of nitrogen retention

The efficiency of nitrogen retention was seen to vary with varying level of dietary protein (Figure iiib). The data (Table 25) shows that nitrogen of food can be utilised more efficiently when the level of protein in the diets was 61 g DCP per day while

Fig. iiib. The relationship between level of DCP in isocaloric diets and efficiency of nitrogen retention

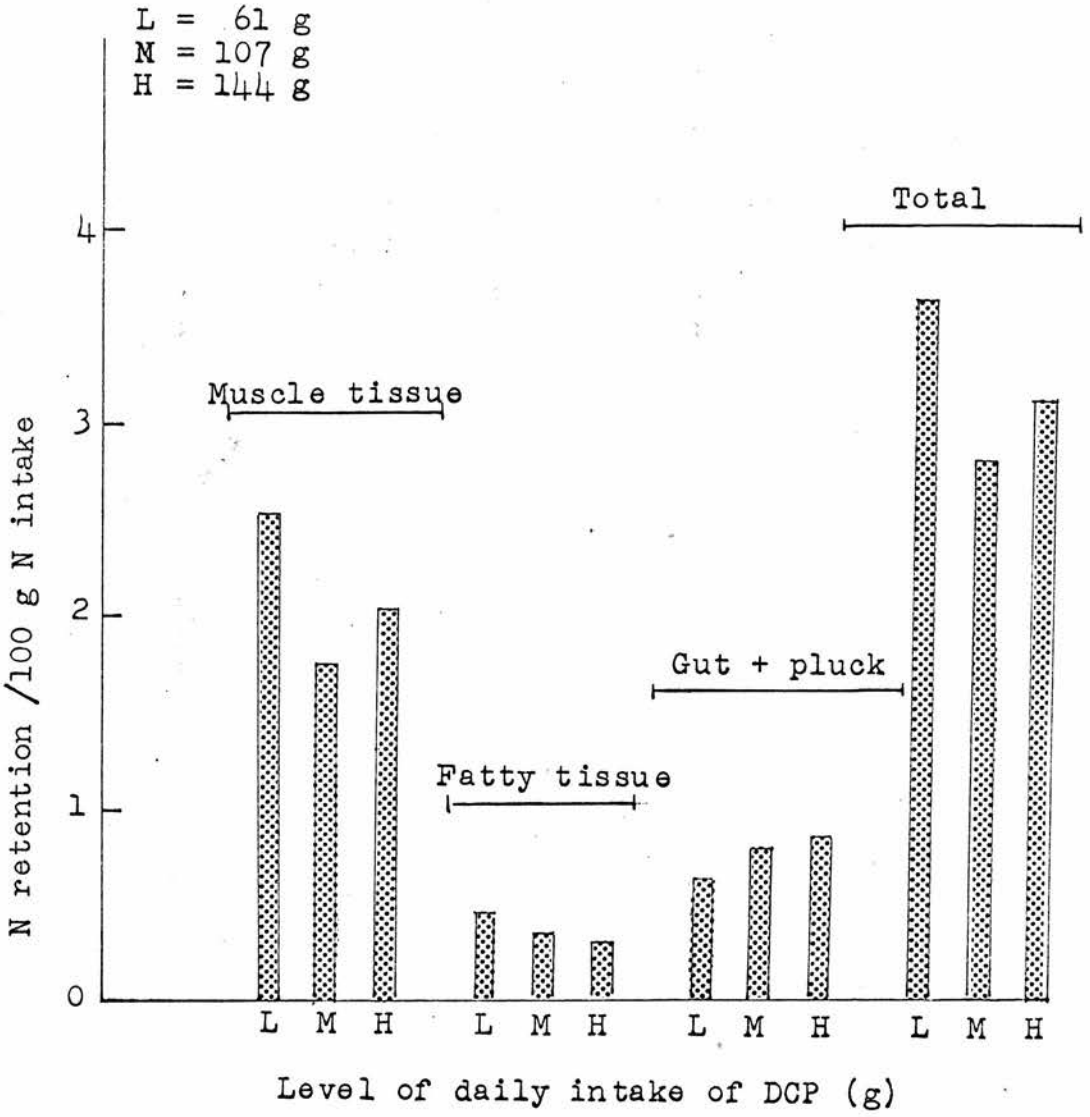


TABLE 25.

The effect of level of dietary DCP on the efficiency of nitrogen retention in Blackface wether lambs

	Groups		
	L	M	H
N retention/100 g N intake:			
Muscle tissue	2·59	1·66	2·02
Fatty tissue	0·43	0·34	0·28
Gut plus Pluck	0·60	0·76	0·83
Total	3·62	2·76	3·14

the efficiency declined at the level of 107 g DCP and improved again by raising the level of daily intake of DCP to 144 g. As shown previously in the figure iiia the amount of nitrogen retained per 100 g nitrogen intake increased as the level of energy supply was increased. An adequate supply of energy is therefore necessary for the retention of the excess nitrogen. If the efficiency of nitrogen retention depends on the level of energy then feeding high quantities of nitrogen without adequate supply of energy to enable this nitrogen to be retained then the efficiency might therefore be expected to decline. The diets in this experiment were isocaloric which may suggest that at the higher levels of nitrogen intake the energy was insufficient to retain the nitrogen with greater efficiency. If this assumption is genuine one would have expected that nitrogen at the medium level would be utilised more efficiently than nitrogen at the highest level of intake. However, the results show the opposite. The efficiency of nitrogen retention was higher at the highest level of nitrogen intake than at the medium level. As the protein was supplied from different sources in different

proportions it may be suggested that these differences in the nitrogen efficiency between M and H diets are due to qualitative differences in dietary protein. The amount of soyabean meal was higher and that of barley was lower in the H diet than in the M diet which may suggest that soyabean nitrogen is utilised with greater efficiency than nitrogen from barley.

Commercial and academic considerations

Despite the scale of the trials, the findings consider the effects of practical diets on hill bred store lambs and taken in conjunction with other work add to the understanding of the growth, production and development process.

The major point arising from this study is that the energy and protein components of the ration effect tissue growth in different ways. Higher daily energy leads to more rapid fatty tissue increase, in slightly more protein retained in the muscle tissue but no more intramuscular fat and no bone increase. Higher protein stimulates increase in bone weight, increases slightly the muscle development and in isocaloric rations retards the fatty tissue development. So for rapid fattening a low protein, high energy diet should be used but for muscle development and low fat deposition a high protein, medium energy diet should be used.

As a result of this differential tissue response it can be seen that the feeding regime effects retail joints differentially because of the differences in tissue composition of these joints. Also the demonstrated differential responses of the various parts

of the tissue to the feeding treatments will effect the differential growth of the retail joints. Protein stimulated carcass bone more than head, bone of the gigot joint more than of the rib, reduced fatty tissue in the carcass more than caul fat and increased muscle in the distal regions of the limbs more than the spinal region. Energy stimulated bone of the gigot and rib joints more than carcass bone, increased carcass fat more than perirenal fat and stimulated muscle in the spinal region more than the hind limbs. However, many of these differences were only of academic importance showing that the tissue in certain areas of the body was effected differentially to the same tissue in other areas and none of these differences appeared to have commercial significance under the condition of these trials.

Because of the inability to define the characteristics of the carcass which enhance its value due to the wide variation in consumer demands no assessment has been attempted to relate feed input to carcass value. If lean meat is the objective then food is best utilised around the medium range of energy and the highest protein inputs for the type of lambs used. If quality of lean meat is indicated by the chemical fat of the muscle tissue it was disappointing to find that increasing the energy over the range used had no effect. If the nitrogen content of muscle tissue effects its quality it was interesting to find that increasing protein level enhances lean meat quality.

The value of carcasses is effected by the amount of fat and bone trim, although in lambs most of the joints are sold with the bone

in. The increase in bone weight by high protein feeding is of deteriment to the value of the carcass because it is not compensated adequately by increased muscle development. Excess fat is trimmed from the perirenal deposits, loin area (if excessive), breast and flank areas. However, excess fat deposition is considered a waste of food material but as energy is utilised with better efficiency at the higher levels of input the surplus fat must be weighed against this overall saving in feed conversion. Fatty tissue from high energy diets has more chemical fat than fatty tissue from low energy diets.

Of practical and academic importance is the limitation of using the fresh weight of the body tissues or the live weight to assess the response of the carcass and body components. The weight of a tissue increases due to increase in one or more of its chemical components. The rate of increase in these chemical components can be altered by certain nutritional treatments. The increase in gain in weight of muscle tissue with increasing dietary protein was resulted from increases in water and nitrogen contents of the tissue. With increasing energy muscle tissue increased in weight due to increasing the weights of nitrogen and probably the ash content.

Using composite measures such as live weight or carcass weight introduces dangers of erroneous interpretation of the real effect of feeding regimes. As these measures contain components which vary considerably in their composition and functions different responses to particular feeding regimes can be expected, hence the importance of studying each component separately.

With more knowledge and understanding it will be possible to give greater control over the production of meat so that identifiable market demands can be satisfied. It is hoped that this thesis has contributed to this end.

SUMMARY

Two experiments were conducted in consecutive years to study the growth response of individually fed Blackface wether lambs to the protein and to the energy components of the diet.

In 1965 three levels (61, 107 and 144 g/day) of dietary DCP were fed in isocaloric diets (approx. 2·65 Mcal ME/day) to three groups of four Blackface wether lambs for 104 days before slaughter.

In 1966 three levels (2·04, 2·61 and 3·18 Mcal/day) of ME were fed in diets providing the same daily intake (approx. 90 g) of DCP to five groups of lambs three of which were slaughtered after 91 days on feed while the other two groups being fed at the lower daily energy intake levels were slaughtered after they had consumed the same total quantity of energy as the high daily energy intake group. These two groups were slaughtered after 112 and 140 days on feed.

At the start of each trial a representative group of lambs was slaughtered in order to estimate the body composition of the lambs on test. The response was taken as the gain in weight of the component over the estimated initial starting weight.

The body components were measured, the left side of each carcass was separated into retail joints, the fatty, muscle and bone tissue separated, weighed and chemically analysed and certain muscles individually removed and weighed.

The physical responses have been considered in relation to the current theories of growth and development and the efficiency

of feed utilisation discussed in the light of modern knowledge.

In the first trial it was shown that:

1. When the energy level was kept constant for each group of lambs increasing the level of dietary protein had only a small effect on increasing live weight gain while its various components were markedly effected.

2. Of the live weight components, the gain in weight of S.E.B. was significantly increased, pelt tended to increase while gut "fill" tended to decrease.

3. Of the S.E.B. components the gains in weight of the carcass, blood and pluck showed a significant response to increasing the level of dietary protein. The gains in weight of feet, head and gut showed a small response while that of caul fat was not detectably effected.

4. The carcass tissues did not show equal response to increased levels of dietary protein. The gain in weight of bone tissue was significantly ($p < \cdot 05$) increased while that of muscle tissue showed only a slight tendency to increase and the growth of fatty tissues seems to be retarded.

5. Of the prime cuts, the gain in weight of the gigot was most effected followed by that of the shoulder. There appeared to be no relationship between the gains in weight of loin and rib and the level of dietary protein. The shank tended to increase in weight while the rest of the secondary cuts, i.e. neck, brisket, flanks and kidney plus perirenal fat were not noticeably effected by the treatments.

6. Of the major tissues of these anatomical areas, the gains in weight of muscle tissue in the gigot and the kidney were significantly increased and that of the shoulder tended to increase while those of loin and rib showed no noticeable response. Bone tissue in the gigot, shoulder and loin all significantly increased while that of rib showed a tendency to increase. With fatty tissue the gains in weight in gigot, shoulder, loin and perirenal fat showed a tendency to decrease but none reached significance at the 5 per cent level of probability.

7. Of the carcass characteristics the response of fat-thickness over the M. longissimus dorsi at the 12th rib was similar to that of the total fatty tissue of the carcass. The area of M. longissimus dorsi at the same location was markedly increased.

8. The gains in weight of the individual muscles responded differentially to increasing the level of dietary protein. The M. extensor digitorum longus, M. extensor carpi radialis, M. gastrocnemius, M. quadriceps femoris, M. longissimus dorsi (in the rib area), M. infraspinatus and M. supraspinatus were most effected while M. brachialis showed no detectable response. The rest of the individual muscles tested responded similarly to the total muscle tissue of the carcass.

9. The chemical composition of the carcass tissues was also effected by the level of dietary protein. The percentages of DM and EE in fatty and muscle tissues fell with increasing the daily level of DCP. The percentage of CP in muscle tissue was markedly increased while that of fatty tissue showed a tendency to increase.

10. Raising the level of dietary DCP in isocaloric diets showed no noticeable influence on the amount of energy retained in the muscle and fatty tissues of the carcass.

11. The efficiency of energy utilisation expressed as Mcal ME/kg gain of live weight, S.E.B., carcass and muscle tissue was improved with increasing the level of dietary protein. While the amount of energy required to retain one Mcal energy as S.E.B., carcass, muscle or fatty tissue increased. The efficiency of nitrogen retention in terms of g N retention (in muscle and fatty tissues and in gut plus pluck) per 100 g N intake declined as the level of protein increased. It was suggested that qualitative differences in the protein effected the efficiency of nitrogen utilisation.

12. The results suggest that at this stage of development the level of 144 g DCP and 2·65 Mcal ME per day produced carcasses with more bone and muscle and less fat content and was more efficient converting energy into saleable product.

In the second experiment (part a) it was shown that:

1. Raising the level of the daily intake of metabolizable energy, when the daily intake of DCP was similar for each group of lambs, significantly increased the gains in weight of live weight and S.E.B. while the gain in weight of pelt tended to increase and that of gut "fill" showed no noticeable change.

2. Of the S.E.B. components the gains in weight of carcass and caul fat were noticeably increased, while that of the blood tissue showed a tendency to increase. There was no noticeable response

in the gains in weight of feet, head, pluck and gut to the increasing level of dietary energy.

3. The major tissues of the carcass exhibited varied responses to the increasing energy level. The gain in weight of fatty tissue was most effected and that of bone tissue was relatively uneffected while muscle tissue was shown to respond intermediately. It was indicated that the level of energy supply influenced protein deposition.

4. Of the prime cuts only the gain in weight of gigot showed no significant response to level of dietary energy. Of the secondary cuts the gain in weight of the flank of the rib joint was most effected followed by the brisket, flanks of loin and of gigot joints. The neck and kidney plus perirenal fat showed no detectable response to increasing the level of energy.

5. On examination of the gains in weight of the major tissues in these retail cuts, it was found that fatty tissue in all the prime cuts was greatly increased while the perirenal fat was not noticeably altered. There was a detectable increase in the gains in weight of muscle tissue in the shoulder, loin and rib joints while increasing the level of dietary energy was without major effects on muscle tissue of the gigot and kidney. With bone tissue, apart from a slight increase in the gain in weight of the bone in the gigot and rib, there appeared to be no relationship between energy level and the growth of bone tissue in the various parts of the body.

6. The responses of the carcass measurements (area of M. longissimus dorsi and fat-thickness) to energy level was similar

to that of the weight of total muscle and fatty tissue of the carcass.

7. Individual muscles responded differentially to energy level. The gains in weight of M. obliquus internus abdominis + M. transversus abdominis, M. brachialis, M. biceps brachii and M. longissimus dorsi (in the loin area) were most effected while M. gluteus medius and M. extensor carpi radialis were least effected by the treatments. The rest of the individual muscles tested responded similarly to the energy level as did the total muscle tissue of the carcass. It was suggested that the anatomical, chemical or physiological variations in the various muscles of the body could be responsible for these different responses. Further study on this tissue is required.

8. Apart from a small increase in the percentage of EE in the fatty tissue the chemical composition of the carcass tissues showed no major changes due to increasing the level of dietary energy.

9. The efficiency of energy utilisation (Mcal/kg) gain in live weight, S.E.B., carcass and muscle tissue improved with increasing the level of energy supply. The efficiency of energy retention (Mcal ME/Mcal ER) in the empty body, carcass and muscle tissue also improved. There was a marked improvement in the efficiency of nitrogen retention with increasing the level of dietary energy.

10. It was shown that energy was utilised with the greatest efficiency in producing gains in empty body carcass or muscle tissue at the daily rate of 2·61 Mcal ME and 92 g DCP.

In the second experiment (part b) it was shown that:

1. When groups of lambs consumed similar quantities of ME at different levels of the daily intake, live weight gains were practically the same for each group of lambs, although body components were markedly effected particularly as far as fatty tissue was concerned. The S.E.B. and pelt tended to decrease while gut "fill" tended to increase as the time taken to feed the quantity of energy was increased.

2. Of the S.E.B. components the gain in weight of head was markedly increased and that of caul fat decreased. The rest of the components of the S.E.B. showed no noticeable changes.

3. The gain in weight of the carcass showed no noticeable change due to treatments although the major tissues were effected in opposing ways. The gain in weight of fatty tissue was greatly decreased and that of bone tended to increase while muscle tissue showed no noticeable response. This illustrates the masking of information that occurs when composite measures are used.

4. Feeding a given quantity of energy over a different number of days was found to effect the various anatomical parts of the body unequally. With certain exceptions, the areas where fat is usually deposited such as the flanks, loin and rib were decreased in gain in weight. The fat covering organs vital to the life of the animal, i.e.perirenal fat and the fat in the thoracic area appeared to be more resistent to wide variations in level of energy supply.

5. Examining the responses of the major tissues of the retail cuts, it seemed that these generally followed a similar pattern to

that of the responses of the total major tissues of the carcass, i.e. the gain in weight of fatty tissue was markedly decreased while differences in the gains in weight of muscle and bone tissues, in most of the joints were not pronounced.

6. Apart from a small decrease in the gains in weight of M. obliquus internus abdominis + M. transversus abdominis and M. longissimus dorsi (in the loin area) there was no detectable changes in the gains in weight of the rest of the individual muscles tested. It was noticed that the muscles which may have a high proportion of fat because of their close association with impregnated fatty tissue, such as the abdominal muscles, responded noticeably to level of dietary energy.

7. The percentage of DM in the fatty and muscle tissues fell with increasing days on feed and the percentage of EE in the fatty tissue also noticeably decreased. The percentage of CP in both tissues showed no noticeable changes. It seemed that there was no relationship between the percentage of EE in the muscle tissue and the level at which the quantity of energy was fed.

8. The same quantity of food can be utilised with greater efficiency in producing gains in empty body, carcass and muscle tissue or in retaining energy in these components when fed at the level of daily intake of 2·61 Mcal rather than the other levels. The highest nitrogen retention was obtained when the quantity of energy was fed at the highest level of energy intake.

It was concluded, that under the conditions of the experiments being reported, that:

(a) The most valuable saleable carcass tissue "muscle" was only

effected to a small extent by wide variations in nutritional treatments. Bone was significantly effected by higher daily protein intake but not by increased energy intake while fatty tissue was significantly increased by higher energy levels but tended to be retarded by higher protein intakes fed in isocaloric diets.

(b) The requirement of the various tissues for different dietary components for their growth and development has been demonstrated. The differential tissue response is the most dominant factor in explaining the differential behaviour of parts of the carcass to dietary regimes. Differential growth of parts cannot be sensibly discussed without reference to the tissue proportions of these parts.

(c) Within tissues a differential response has been demonstrated in bone, muscle and fatty tissues to the dietary regimes.

(d) The gain in fresh weight of the body tissues does not indicate the changes which occur in the tissue. Some diets increase fresh weight by adding crude protein and water while others add ether extract or ash.

(e) Erroneous interpretation of the findings would have been made if composite measures such as live weight or carcass weight had been used. The loss of information essential to the understanding of the proper functioning of each treatment by using composite measures makes detailed investigation essential.

(f) Discussion of the effect of plane of nutrition cannot be meaningful without reference to the daily level of intake of each ration component since each has different functions for the different tissues.

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A P P E N D I X

APPENDIX I

INDIVIDUAL MUSCLE DISSECTION

The method of jointing did cut across some of the muscles which were to be dissected out so that the complete muscle had to be removed from two or more joints. The muscles were dissected out in the order in which they are described.

1. M. obliquus internus abdominis together with M. transversus abdominis.

These two muscles are so closely attached that it was decided to take them out together and use them as representing the abdominal region.

These muscles range over four of the retail cuts. The M. obliquus internus abdominis originates from the lumbo dorsal fascia, the tuber coxae and the adjacent part of the inguinal ligament. The insertion is by an aponeurosis which blends with the M. obliquus externus abdominis near the linea alba.

The muscle was separated from the aponeurosis along the edge of the tendinous sheet. The M. obliquus internus abdominis is partly in the gigot cut and partly in the loin primary which overflows into the flank section of the loin. The M. transversus abdominis is partly in the loin cut with small sections in the loin and rib flanks. It arises from the ventral ends or cartilages of the asternal ribs meeting the costal attachment of the diaphragm and from the transverse processes of the lumbar vertebrae by the deep layer of the lumbo dorsal fascia. It is

inserted to the linea alba and xiphoid cartilage. Where it is contiguous with the transverse thoracic muscle a cut is made along the line of the costal arch to separate them.

2. M. semitendinosus

After removing the fat cover over the gigot the semitendinosus muscle is exposed. It was filleted out from between the M. semimembranosus and the M. biceps femoris. Its origin is from the tuber ischii and it is attached to the crest of the tibia. The muscle was cleaned from the bone surface and removed along its attachment to the M. biceps femoris near its origin.

3. M. semimembranosus

The M. semimembranosus is exposed by removing M. gracilis. Its origin is the ventral aspect of the tuber ischii and pelvic symphysis behind that of the gracilis muscle. The insertion is by a short tendon to the medial epicondyle of the femur to a small tubercle beneath the medial articular margin of the tibia and to the intermuscular septum between it and the lower part of the M. adductor femoris.

4. Mm. gastrocnemius et plantaris (M. plantaris = M. flexor digitorum superficialis).

Removed from the distal end of the femur and the tendo Achillis severed on the edge of the tuber calcis. The M. plantaris rises between the two heads of the gastrocnemius and its tendon has an intimate association with the tendon of gastrocnemius. The two muscles are considered together.

5. M. quadriceps femoris

This muscle is comprised of four different heads arranged around the lateral, anterior and medial borders of the femur. The muscles, M. vastus lateralis, M. vastus medialis, M. vastus intermedius have their origins in the appropriate aspects of the femur while the fourth muscle M. rectus femoris has its origin in a fossa anterior to the acetabulum. The insertions are on to the patella and the point of removal of the muscle is by cutting the patellar ligament distal to the patella.

6. M. gluteus medius.

The main origin is from the gluteal surface and coxal tuber of the ilium. It is inserted into the greater trochanter and trochanteric crest of the femur. It must be noted that the deep gluteal - M. gluteus profundus - lies close to the middle gluteal and is inserted into the neck of the femur beneath that of the middle gluteal.

7. M. extensor digitorum longus

The muscle has a strong tendon of origin arising in the extensor fossa at the distal end of the femur. This is cut and the muscle removed along with the M. peroneus tertius from the insertion on the tibia. Once removed the overlying M. peroneus tertius is separated.

8. M. psoas major

The M. psoas major was filleted out of the loin section by crowding the knife down the transverse processes and bodies of the

lumbar vertebrae. The section was taken from the origin at the 12th rib to the point of separation of the gigot from the loin area - at a point skirting the tuber coxae.

9. M. longissimus dorsi

The M. longissimus dorsi was removed from the loin and rib areas by filleting away from the spinous processes of the vertebral column and the ribs. The complication of the origin and insertion made the muscle difficult to remove in its entirety. However, the section from the anterior edge of the 6th rib to the point of detachment of the gigot - at the tuber coxae - could be removed cleanly and made an important contribution to the evaluation of the muscle.

10. M. biceps brachii

Due to the cutting method the M. biceps brachii was cut in two and had to be removed, part from the shoulder joint and part from the fore shank. The muscle arises from the tuber scapulae by a rounded tendon which is cut as close to the bone as possible. The tendon passes through the bicipital groove of the humerus and is inserted into the medial tuberosity of the radius, the interosseus ligament between the radius and the ulna and the fascia over the fore-arm which is attached to the M. extensor carpi radialis.

11. M. brachialis

This muscle is also removed in two sections. The muscle arises from the proximal third of the posterior surface of the humerus, deep to the lateral head of the triceps muscle and is inserted into the medial tuberosity of the radius and the inter-

osseous ligament between the radius and ulna. It pursues a course in the musculo spiral groove of the shaft of the humerus.

12. M. extensor carpi radialis

This muscle has three points of origin, the lateral condyloid crest of the humerus, the coronoid fossa and the deep fascia of the arm and fore-arm and the intermuscular septum between this muscle and the medial digital extensor muscle. Its insertion is into the metacarpal tuberosity on the dorsolateral surface.

13. Mm. pectoralis profundus et superficialis

These muscles were taken together and were contained in the breast and the scapular region of the shoulder. To reach the pectoral muscle on the shoulder one has to reflect the M. brachiocephalicus so as to gain access to the anterior part of the scapular region. The origin of the cranial section is from the first sternal segment and the insertion is into the medial collateral ligament of the elbow joint and the fascia over the medial and lateral surfaces of the fore-arm. The caudal section has its origin from the 2nd to the 6th sternal segments and runs back to the sternal end of the 10th rib. It unites above with the M. latissimus dorsi. Its insertion is into the fascia over the cranial border of the medial surface of the long head of the triceps brachii muscle, the medial tuberosity of the humerus, the crest of the humerus between the M. biceps brachii and the coracobrachialis muscle, the anterior edge of the lateral tuberosity of the humerus and the tendon of insertion of the supraspinatus muscle.

14. M. supraspinatis

This muscle is readily removed by scraping the muscle from the supraspinous fossa of the scapula. The origin is from the fossa, the spine, the lower part of the cartilage of the scapula and the proximal part of the cranial border of the scapula. The insertion is to the cranial part of the greater tuberosity of the humerus and to a strong tendinous cord - the transverse humeral ligament - which bridges the bicipital groove.

15. M. infraspinatis

This muscle occupies the infraspinous fossa of the scapula and extends beyond its posterior limit. The origin is from the infraspinous fossa and the scapular cartilage and the insertion is to the medial surface of the posterior part of the greater tuberosity of the humerus and to the lateral aspect of the greater tuberosity of the humerus lateral to the supraspinatus muscle.

The muscle is covered by a strong aponeurosis which is associated with the attachment of the deltoid muscle to the scapula. The deltoid muscle is in two parts which are removed before taking out the infraspinatus muscle.

A P P E N D I X II

Methods of chemical analysis

APPENDIX II

THE CHEMICAL ANALYSIS OF CARCASS TISSUES

Chemical determinations were made on the samples of tissue for dry matter, ether extract, crude protein and gross energy.

The general procedure was to take separate samples of separable muscle from the joints (gigot, loin plus rib, shoulder and combined secondary cuts) and a sample from the M. longissimus dorsi at the 10th - 12th rib section. Samples of separable fatty tissue were taken from each of the aforementioned joints and also from the subcutaneous fat layer covering the 10th - 12th rib section. The offal (heart, lungs, liver etc.) was mixed with the emptied alimentary tract and caul fat to give a composite sample from the internal body organs.

In some of the trials the major cuts were taken as a composite sample.

Preparation

Offal. After the emptying of the digestive tract the entire tract along with the pluck (lungs, liver, pancreas, spleen etc.) and caul fat were minced and mixed three times to get a homogenous sample. Difficulty was experienced with the trachea so this was excluded. A sample of 400 - 500 grams was taken and placed in a polipot container with sealed top and stored in a deep-freeze cabinet until the chemical analysis could be conducted.

Secondary cuts. The separable muscle tissue from the flank of gigot, loin and rib cuts, the neck, shank and kidney were minced

and mixed together before a sample was taken and placed in a sealed pot and stored in the deep-freeze to await analysis.

The separable fatty tissue from the secondary cuts was treated in the same way.

Prime cuts. The separable muscle tissue of each of the prime cuts of shoulder, loin plus rib and gigot was taken separately, minced, mixed, sampled and stored in the deep-freeze until chemical analysis was conducted.

The separable fatty tissue from each prime joint was also treated this way.

Storage time

No sample was stored in the deep-freeze for more than two months. The chemical analysis was done systematically so that samples of the same tissue from the same joint of the animals from all the treatment groups were analysed at any one time.

Method of Analysis

The samples were removed from the deep-freeze cabinet to allow the dry ice to disappear.

After mixing, triplicate samples of 2 - 3 grams were weighed in aluminium dishes 4·5 cm in diameter and 6 mm in height. Care was taken to minimise moisture loss by exposing to the air as little as possible.

Determinations were made for dry matter, ether extract and crude protein in that order.

Dry Matter

The samples were dried in an oven at 90 - 100°C for approximately 17 hours, removed and then weighed.

Ether Extract

The moisture free samples from the dry matter determination were taken, the aluminium dish carefully folded over the dried sample and placed in a Soxhlet thimble. Petroleum ether (boiling point 40° - 60°C) was used. The sample was left to extract for eight hours, dried in the oven as for dry matter and then weighed.

Crude Protein

The ether extracted residue was taken and transferred from the aluminium dish to a Kjeldahl flask. The nitrogen content was determined by the Macro-kjeldahl method (A.O.A.C., 1956).

The nitrogen content x6·25 was taken as the crude protein content.

The percentage of dry matter in the fatty and muscle tissues of the carcass and in gut plus pluck taken as repeated aliquots of the same sample

Sample No.	Fat		Lean		Gut * + Pluck
	Prime	Secondary	Prime	Secondary	
1	78·10	81·05	29·64	30·71	35·55
2	79·07	82·07	28·68	31·45	35·39
3	76·98	80·84	27·81	31·81	35·43
4	76·90	80·38	28·17	31·53	35·30
5	76·99	80·06	28·23	31·89	35·02
6	76·34	80·00	28·77	30·79	35·71
7	76·95	81·75	29·82	30·89	35·75
8	77·02	80·57	28·02	31·61	35·13
9	75·42	80·85	29·01	32·15	35·40
10	76·41	81·79	29·35	31·91	35·11
$\bar{x}$	77·02	80·93	28·75	31·47	35·38

* Pluck (included the liver, heart, lungs and spleen)

Gut (included the four stomachs + intestine + caul fat)

The percentage of ether extract in the fatty and muscle tissues of the carcass and in gut plus pluck taken as repeated aliquots of the same sample

Sample No.	Fat		Lean		Gut * + Pluck
	Prime	Secondary	Prime	Secondary	
1	68·93	71·42	7·18	10·13	21·34
2	70·27	70·04	7·85	10·71	20·69
3	70·06	72·99	7·08	10·00	20·37
4	69·67	73·47	7·95	10·70	21·48
5	69·29	72·48	7·15	11·48	20·59
6	68·57	72·67	7·53	10·39	21·57
7	69·26	72·70	7·97	10·39	21·25
8	70·44	72·94	7·40	11·55	20·63
9	68·62	73·36	7·92	10·00	20·41
10	68·88	73·24	7·34	10·97	20·57
$\bar{X}$	69·40	72·53	7·54	10·63	20·89

* Pluck (included the liver, heart, lungs and spleen)

Gut (included the four stomachs + intestine + caul fat)

The percentage of crude protein in the fatty and muscle tissues of the carcass and in gut plus pluck taken as repeated aliquots of the same sample

Sample No.	Fat		Lean		Gut * + Pluck
	Prime	Secondary	Prime	Secondary	
1	6·25	6·92	17·75	17·73	10·39
2	6·21	6·70	17·97	18·03	10·71
3	6·39	6·90	17·88	18·13	10·70
4	6·40	6·79	17·56	17·51	10·47
5	6·70	6·90	17·68	17·29	10·60
6	6·88	6·77	17·56	17·49	10·54
7	6·65	6·32	17·97	17·60	10·52
8	6·71	6·51	17·71	18·25	10·40
9	6·59	6·85	17·87	18·34	10·59
10	6·50	6·59	17·95	18·30	10·50
$\bar{x}$	6·53	6·73	17·79	17·87	10·54

* Pluck (included the liver, heart, lungs and spleen)

Gut (included the four stomachs + intestine + caul fat)

The form in which the analysis of regression and of variance was carried out (example)

Blocks (init. wt.)	A	B	C	Totals
I	4·54	6·36	6·81	17·71
II	(2·72 (5·90	6·81 6·81	6·81) 8·62)	37·67
III	5·45	8·17	10·90	24·52
Totals	18·61	28·15		79·90
				$\bar{y}$=6·658

Analysis of variance

Source	d.f.	s.s.	m.s.	F
Blocks	2	9·4621		
Regression	1	26·3901	26·3901	19·194
Deviations from regression	1	0·8627		
Groups	2	27·2528	13·6264	9·911
Error	7	9·6241	1·3749	
Total	11	46·3390		

Adjustment for mean = 532·0008

Total s.s. = 578·3398 - 532·0008 = 46·3390

Blocks s.s. = 304·9581 + 236·5048 = 9·4621

Groups s.s. = 559·2536 - 532·0008 = 27·2528

Regression s.s. = -5·2108 + 9·2792 = 4·0684

$= \frac{(4·0684)^2}{0·6272} = 26·3901$

Error ss. = 9·6241/7 = 1·3749 (m.s. of error)

"b" $= \frac{4·0684}{0·6272} = 6·487$

S.E. of "b" $= \frac{1·3749}{0·6272} = \pm 1·481$

APPENDIX III

The analysis of variance for results of Experiment I

Table 17. The regression coefficients "b" with its standard error, the "F" value and the value of "b" expressed as a percentage of the initial weight of the component of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric rations.

Body components	"F"	"b"	S.E. of "b"	"b" as % of the initial
Live weight	2.17	1·088	± 0·738	3.82
S.E.B.	10·17	1·289	± 0·404	7·18
Warm carcass	7·42	0·906	± 0·332	8·18
Pelt	1·16	0·218	± 0·201	10·69
Gut "fill"	0·94	-0·335	± 0·345	5·08
Blood	7·26	0·158	± 0·059	14·63
Feet	5·36	0·072	± 0·098	12·63
Head	1·00	0·124	± 0·124	8·92
Pluck	17·20	0·136	± 0·031	12·36
Gut	1·07	0·081	± 0·078	3·86
Caul fat	0·66	-0·133	± 0·164	21·11
Major tissues				
Fatty tissue	1·51	-0·135	± 0·109	16·07
Muscle tissue	2·53	0·273	± 0·172	8·75
Bone tissue	10·10	0·213	± 0·067	17·04
Retail cuts				
Gigot	9·97	0·170	± 0·054	9·39
Shoulder	4·82	0·151	± 0·069	7·63
Loin	1·71	0·028	± 0·022	4·18
Rib	0·34	0·020	± 0·035	3·08
Kidney + Perirenal fat	2·30	-0·035	± 0·022	20·59
Brisket	0·12	0·007	± 0·022	3·04
Neck	0·46	0·012	± 0·020	7·50
Shank	0·71	0·028	± 0·022	9·33
Flank (gigot)	0·11	0·002	± 0·005	4·00
Flank (loin)	0·17	0·006	± 0·014	6·00
Flank (rib)	0·06	0·005	± 0·022	2·00

[Contd.

Table 17 [Contd.]

Body components	"F"	"b"	S.E. of "b"	"b" as % of the initial
Tissues in the retail cuts				
Fat (gigot)	0·95	-0·023	± 0·024	10·95
Muscle (gigot)	5·68	0·134	± 0·057	10·98
Bone (gigot)	7·18	0·074	± 0·028	20·00
Fat (shoulder	2·60	-0·026	± 0·052	8·97
Muscle (shoulder)	2·20	0·099	± 0·066	8·92
Bone (shoulder)	12·91	0·090	± 0·033	16·36
Fat (loin)	2·38	-0·023	± 0·014	25·56
Muscle (loin)	0·17	0·014	± 0·033	3·33
Bone (loin)	7·67	0·056	± 0·014	3·50
Fat (rib)	0·53	-0·016	± 0·022	12·31
Muscle (rib)	0·49	0·021	± 0·030	6·36
Bone (rib)	0·87	0·019	± 0·020	10·00
Perirenal fat	3·72	-0·043	± 0·022	33·08
Muscle (kidney)	30·00	0·009	± 0·001	22·50
Carcass Measurements				
Area of M.l.d.	24·86	2·302	± 0·462	2·62
Fat-thickness	0·04	-0·053	± 0·276	2·90
Individual muscles				
M. obliquus	0·96	7·970	± 8·121	6·87
M. semitendinosus	0·79	4·239	± 4·767	8·65
M. semimembranosus	1·33	9·836	± 8·535	6·39
M. gastrocnemius	10·46	15·924	± 4·921	18·10
M. quadriceps femoris	5·68	31·466	±13·198	13·28
M. gluteus medius	4·00	12·403	± 6·204	11·59
M. extensor digitorum....	13·67	2·702	± 0·730	12·87
M. psoas major	2·87	2·928	± 1·728	9·45
M.l.d. (loin)	2·51	27·621	±17·430	15·97
M.l.d. (rib)	5·84	14·824	± 6·133	18·76

[Contd.

Table 17 [Contd.]

Body components	"F"	"b"	S.E. of "b"	"b" as % of the initial
Individual muscles [Contd.]				
M. pectoralis	0·39	2·125	± 3·422	2·41
M. biceps brachii	3·17	1·656	± 0·932	8·72
M. brachialis	0·05	0·221	± 0·975	1·70
M. extensor carpi	13·65	2·712	± 0·735	11·79
M. infraspinatus	9·62	9·739	± 3·140	13·16
M. supraspinatus	5·68	8·472	± 3·557	10·59
Chemical composition				
% DM in fatty tissue	4·04	-2·65	± 1·30	3·53
% DM in muscle tissue	4·43	-1·48	± 0·70	4·77
% EE in fatty tissue	3·11	-4·16	± 2·36	6·50
% EE in muscle tissue	3·62	-2·22	± 1·17	22·2
% CP in fatty tissue	4·18	1·50	± 0·73	1·72
% CP in muscle tissue	6·66	0·76	± 0·29	4·13
Chemical components				
DM in fatty tissue	2·61	-0·148	± 0·091	22·77
DM in muscle tissue	0·19	0·021	± 0·049	2·19
EE in fatty tissue	2·65	-0·152	± 0·094	27·14
EE in muscle tissue	1·43	-0·064	± 0·053	20·65
CP in fatty tissue	5·88	0·011	± 0·005	15·71
CP in muscle tissue	16·46	0·099	± 0·024	17·07
GE in fatty tissue	2·38	-1·356	± 0·880	23·79
GE in muscle tissue	0·08	0·120	± 0·415	1·88

"F" at 5 per cent level with $n_1 = 1$ $n_2 = 7$ = 5·59

"F" at 1 per cent level with $n_1 = 1$ $n_2 = 7$ = 12·25

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		S.E.B.+	
Source	s.s.	m.s.	F
Blocks	0·5206	0·2603	
Regression	6·1575	6·1575	10·173*
Deviation from Regression	1·4046		
Groups	7·5621	3·7811	5·247*
Error	4·2374	0·6053	
Total	12·3201		

* Significant at $p < 0·05$

+ L.S.D. between groups means = 1·31 (p·05).

+ L.S.D. between groups means = 1·94 (p·01).

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		Warm carcass+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·2441	0·1221	
Regression	1	3·0462	3·0462	7·424*
Deviation from Regression	1	2·5514		
Groups	2	5·5976	2·7988	6·821*
Error	7	2·8718	0·4103	
Total	11	8·7135		

* Significant at $p < 0·05$

+ L.S.D. between groups means = 1·05 (p·05).

+ L.S.D. between groups means = 1·56 (p·01).

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Components	Blood+		
Source	s.s.	m.s.	F
Blocks	0·0372	0·0186	
Regression	0·0929	0·929	7·259*
Deviation from Regression	0·0406		
Groups	0·1335	0·0668	5·219*
Error	0·0896	0·0128	
Total	0·2603		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 0·19 (p·05).

+ L.S.D. between groups means = 0·28 (p·01).

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		Pluck+		
Source	d.f.	s.s.	ms.	F
Blocks	2	0·0338	0·0169	
Regression	1	0·0688	0·0688	17·200**
Deviation from Regression	1	0·0042		
Groups	2	0·0730	0·0365	9·125*
Error	7	0·0279	0·0040	
Total	11	0·1347		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 0·01 (p·05).

\+ L.S.D. between groups means = 0·15 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		Bone tissue[+]			Gigot[++]		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·0133	0·0067		0·0134	0·0067	
Regression	1	0·1686	0·1686	10·096*	0·1067	0·1067	9·972*
Deviation from Regression	1	0·0195			0·1084		
Groups	2	0·1881	0·0941	5·635*	0·2151	0·1076	10·056**
Error	7	0·1171	0·0167		0·746	0·0107	
Total	11	0·3185			0·3031		

* Significant at p<0·05.

** Significant at p<0·01.

\+ L.S.D. between groups means = 0·22 (p·05)

\+ L.S.D. between groups means = 0·32 (p·01).

++ L.S.D. between groups means
= 0·17 (p·05)
= 0·26 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Components	Muscle (gigot)+		
Source	s.s.	m.s.	F
Blocks	0·0043	0·0022	
Regression	0·0664	0·0664	5·675*
Deviation from Regression	0·0491		
Groups	0·1155	0·0578	4·940*
Error	0·0117		
Total	0·2014		

* Significant at $p < 0·05$.

\+ L.S.D. between groups means = 0·18 (p·05).

\+ L.S.D. between groups means = 0·27 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		Bone (gigot)+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·0032	0·0016	
Regression	1	0·0201	0·0201	7·179*
Deviation from Regression	1	0·0180		
Groups	2	0·0381	0·0191	6·821*
Error	7	0·0194	0·0028	
Total	11	0·0607		

* Significant at $p < 0·05$.

\+ L.S.D. between groups means = 0·09 (p·05).

\+ L.S.D. between groups means = 0·13 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	Bone (shoulder)+		
Source	s.s.	m.s.	F
Blocks	0·0085	0·0043	
Regression	0·0297	0·0297	12·913**
Deviation from Regression	0·0006		
Groups	0·0303	0·0152	6·609*
Error	0·0160	0·0023	
Total	0·0548		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 0·08 (p·05).

\+ L.S.D. between groups means = 0·12 (p·01).

The analyais of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	Muscle (kidney)+		
Source	s.s.	m.s.	F
Blocks	0·00000		
Regression	0·00030	0·00030	30·000**
Deviation from Regression	0·00010		
Groups	0·00040	0·00020	20·000**
Error	0·00010	0·00001	
Total	0·0005		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 0·005 (p·05).

+ L.S.D. between groups means = 0·007 (p·01).

The analysis of variance of the gains in carcass measurements of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		Area of M.l.d. (sq.cm.)+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	3·3702	1·6851	
Regression	1	19·6460	19·6960	24·856**
Deviation from Regression	1	3·2534		
Groups	2	22·8994	11·4497	14·486**
Error	7	5·5327	0·7904	
Total	11	31·8023		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 1·49 (p·05).

+ L.S.D. between groups means = 2·20 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	M. gastrocnemius+		
Source	s.s.	m.s.	F
Blocks	131·58	65·79	
Regression	940·49	940·49	10·464*
Deviation from Regression	923·01		
Groups	1863·50	931·75	10·367*
Error	629·17	89·88	
Total	2624·25		

* Significant at $p < 0·05$.

+ L.S.D. between groups means= 15·85 (p·05).

+ L.S.D. between groups means= 23·48 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	M. quadriceps femoris			
Source	d.f.	s.s.	m.s.	F
Blocks	2	11·42	5·71	
Regression	1	3672·05	3672·05	5·681*
Deviation from Regression	1	707·12		
Groups	2	4379·17	2139·58	3·310
Error	7	4524·33	646·33	
Total	11	8914·92		

* Significant at $p < 0·05$.

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		M. extensor digitorum longus+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	13·67	6·84	
Regression	1	27·07	27·07	13·672**
Deviation from Regression	1	4·43		
Groups	2	31·50	15·75	7·955*
Error	7	13·83	1·98	
Total	11	59·00		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 2·35 (p·05).

\+ L.S.D. between groups means = 3·48 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	M. extensor carpi radialis[+]		
Source	s.s.	m.s.	F
Blocks	36·75	18·38	
Regression	27·29	27·29	13·645**
Deviation from Regression	2·88		
Groups	30·17	15·09	7·545*
Error	14·00	2·00	
Total	80·92		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 2·37 (p·05).

\+ L.S.D. between groups means = 7·50 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Components		M. infrospinatus+			M. supraspinatus		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	170·25	85·13		75·17	37·59	
Regression	1	351·77	351·77	9·619*	266·18	266·18	5·675*
Deviation from Regression	1	50·23			40·32		
Groups	2	402·00	201·00	5·496*	306·50	153·25	3·268
Error	7	256·00	36·57		328·33	46·90	
Total	11	828·25			710·00		

* Significant at $p<0·05$

+ L.S.D. between groups means = 10·11 (p·05)

+ L.S.D. between groups means = 14·96 (p·01)

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		% DM in fatty tissue			% DM in muscle tissue+		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	52·04	26·02		0·43	0·22	
Regression	1	26·05	26·05	4·04	8·10	8·10	4·43
Deviation from Regression	1	2·09			9·26		
Groups	2	28·14	14·07	2·18	17·36	8·68	4·74*
Error	7	45·16	6·45		12·78	1·83	
Total	11	125·74			30·57		

* Significant at $p<0·05$

\+ L.S.D. between groups means = 2·27 (p·05)

L.S.D. between groups means = 3·36 (p·01)

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	% EE in fatty tissue				% EE in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	100·51	50·26		0·68	0·34	
Regression	1	64·28	64·28	3·11	18·22	18·22	3·62
Deviation from Regression	1	0·08			2·92		
Groups	2	64·36	32·18	1·55	21·14	10·57	2·10
Error	7	144·91	20·70		35·26	5·04	
Total	11	309·78			57·08		

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components	% CP in fatty tissue				% CP in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	3·52	1·76		0·89	0·45	
Regression	1	8·31	8·31	4·18	2·13	2·13	6·66*
Deviation from Regression	1	0·12			0·28		
Groups	2	8·43	4·22	2·12	2·41	1·21	3·78
Error	7	13·90	1·99		2·22	0·32	
Total	11	25·85			5·52		

* Significant at $p<0·05$

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		CP in fatty tissue			CP in muscle tissue+		
Source	d.f.	s.s.	m.s.	F	ss.	m.s.	F
Blocks	2	0·0034	0·0017		0·0067	0·0034	
Regression	1	0·0005	0·0005	5·882*	0·0362	0·0362	16·455**
Deviation from Regression	1	0·0000			0·0079		
Groups	2	0·0005	0·0003	0·375	0·0441	0·0221	10·045**
Error	7	0·0006	0·0008		0·0152	0·0022	
Total	11	0·0045			0·0660		

* Significant at p<0·05

** Significant at p<0·01

\+ L.S.D. between groups means = 0·078 (p·05)

\+ L.S.D. between groups means = 0·115 (p·01)

The analysis of variance of the gains in GE (Mcal) of the carcass tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Components		GE in fatty tissue			GE in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	21·9545	10·9773		1·0977	0·5489	
Regression	1	6·8148	6·8148	2·375	0·0532	0·0532	0·083
Deviation from Regression	1	0·5233			1·4162		
Groups	2	7·3381	3·6691	1·279	1·4694	0·7347	1·151
Error	7	20·0873	2·8696		4·4676	0·6382	
Total	11	49·3799			7·0347		

A P P E N D I X IV

The analysis of variance for results of Experiment II - part (a)

Table 19. The regression coefficient "b" with its standard error, the "F" value for the between group comparisons and the value of "b" expressed as a percentage of the initial weight of the components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of DCP.

Body components	F	"b"	S.E. of "b"	"b" as % of the initial
Liveweight	19·19	6·487	± 1·481	21·45
S.E.B.	13·94	5·045	± 1·351	22·40
Warm carcass	16·20	3·978	± 0·988	27·97
Pelt	4·39	1·875	± 0·895	59·90
Gut "fill"	0·02	0·554	± 1·158	13·10
Blood	3·07	0·228	± 0·130	17·54
Feet	0·50	0·045	± 0·064	6·92
Head	1·72	0·156	± 0·119	7·88
Pluck	0·03	0·076	± 0·134	5·47
Gut	0·18	0·058	± 0·137	2·82
Caul fat	8·07	0·826	± 0·291	92·81
Major tissues				
Fatty tissue	8·81	1·143	± 0·385	86·59
Muscle tissue	2·07	0·732	± 0·509	18·44
Bone tissue	0·31	0·089	± 0·161	6·22
Gigot	3·43	0·420	± 0·227	17·80
Shoulder	9·89	0·518	± 0·165	20·64
Loin	8·97	0·504	± 0·169	63·00
Rib	19·31	0·464	± 0·106	50·99
Kidney + Perirenal fat	0·03	0·013	± 0·071	7·22
Brisket	2·25	0·085	± 0·057	27·42
Neck	0·79	0·049	± 0·055	19·60
Shank	4·17	0·089	± 0·044	24·72
Flank (gigot)	2·00	0·031	± 0·022	38·75
Flank (loin)	2·44	0·098	± 0·063	70·00
Flank (rib)	14·25	0·165	± 0·044	41·25

[Contd.

Table 19. [Contd.]

Body components	F	"b"	S.E. of "b"	"b" as % of the initial
Tissues in the retail cuts				
Fat (gigot)	5·89	0·286	± 0·117	79·44
Muscle (gigot)	0·54	0·143	± 0·195	9·35
Bone (gigot)	2·00	0·076	± 0·054	16·88
Fat (shoulder)	11·27	0·357	± 0·106	79·33
Muscle (shoulder)	2·43	0·286	± 0·183	20·14
Bone (shoulder)	0·12	-0·027	± 0·081	4·44
Fat (loin)	13·52	0·232	± 0·063	136·47
Muscle (loin)	4·06	0·254	± 0·126	52·92
Bone (loin)	0·15	0·022	± 0·057	15·71
Fat (rib)	11·20	0·250	± 0·075	125·00
Muscle (rib)	2·94	0·121	± 0·070	25·21
Bone (rib)	2·81	0·085	± 0·051	38·64
Perirenal fat	0·10	0·022	± 0·072	16·92
Carcass Measurements				
Area of M.l.d.	4·08	3·973	± 1·967	42·86
Fat-thickness	12·37	3·237	± 0·920	132·12
M. obliquus	14·17	64·29	±17·08	41·21
M. semitendinosus	2·14	19·64	±13·42	29·76
M. semimembranosus	1·37	31·25	±26·69	15·47
M. gastrocnemius	5·50	35·71	±15·23	32·76
M. quadriceps femoris	1·58	33·48	±26·68	11·43
M. gluteus medius	0·58	20·54	±27·02	15·21
M. extensor digitorum....	4·48	5·80	± 2·65	22·30
M. psoas major	1·73	13·84	±10·54	32·19
M.l.d. (loin)	9·34	151·34	±49·52	80·93
M.l.d. (rib)	1·10	26·79	±25·52	27·06
M. pectoralis	3·60	34·82	±18·34	30·28
M. biceps brachii	28·77	17·86	± 3·33	81·18

[Contd.

Table 19. [Contd.]

Body co mponents	F	"b"	S.E. of "b"	"b" as % of the initial
Carcass measurements [Contd.]				
M. brachialis	61·79	14·29	± 1·82	95·27
M. extensor carpi....	1·01	4·91	± 4·90	16·93
M. infraspinatus	1·70	12·95	± 9·94	15·06
M. supraspinatus	3·56	17·86	± 9·47	20·30
Chemical composition				
% DM in fat	0·24	1·21	± 2·44	1·51
% DM in muscle	0·61	1·66	± 2·13	5·35
% EE in fat	1·06	3·43	± 3·33	5·04
% EE in muscle	0·07	-0·62	± 2·36	6·89
% CP in fat	0·02	-0·13	± 1·02	1·86
% CP in muscle	0·23	0·32	± 0·62	1·68
Chemical components				
DM in fat	7·17	0·933	± 0·349	88·02
DM in muscle	5·44	0·375	± 0·161	32·05
DM in bone	1·53	0·263	± 0·213	15·56
EE in fat	7·66	0·853	± 0·308	92·72
EE in muscle	0·01	0·013	± 0·108	4·48
CP in fat	64·29	0·085	± 0·010	94·44
CP in muscle	4·35	0·223	± 0·107	29·73
GE in fat	7·85	8·500	± 3·035	92·19
GE in muscle	3·02	2·018	± 1·162	27·49
GE in bone	1·52	1·201	± 0·976	15·54
DM in pelt	5·22	1·250	± 0·547	66·84
DM in blood	9·00	0·076	± 0·024	30·40
DM in feet	0·33	0·018	± 0·032	5·00
DM in head	0·28	0·027	± 0·054	3·10

[Contd.

Table 19. [Contd.]

Body components	F	"b"	S.E. of "b"	"b" as % of the initial
Chemical components [Contd.]				
GE in pelt	5·23	6·982	± 3·055	67·07
GE in blood	8·44	0·420	± 0·145	30·00
GE in feet	0·32	0·085	± 0·150	5·03
GE in head	0·25	0·129	± 0·261	3·00

"F" at 5 per cent level with $n_1 = 1$ $n_2 = 7$ = 5·59

"F" at 1 per cent level with $n_1 = 1$ $n_2 = 7$ = 12·25

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Live wt.			S.E.B.		
Source	d.f.	s.s. +	m.s.	F	s.s.	m.s. ++	F
Blocks	2	9·4621	4·7311		2·1363	1·0687	
Regression	1	26·3901	26·3901	19·194**	15·9612	15·9612	13·944**
Deviation from Regression	1	0·8627			3·4962		
Groups	2	27·2528	13·6264	9·911**	19·4574	9·7287	8·499*
Error	7	9·6241	1·3749		8·0128	1·1447	
Total	11	46·3390			29·6065		

* Significant at p<0·05
** Significant at p<0·01
\+ L.S.D. between groups means = 1·96(p·05)
\+ L.S.D. between groups means = 2·90(p·01)

++ L.S.D. between groups means = 1·79(p·05)
= 2·65(p·01)

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Warm carcass+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·6737	0·3368	
Regression	1	9·9235	9·9235	16·204**
Deviation from Regression	1	1·8760		
Groups	2	11·7995	5·8998	9·634**
Error	7	4·2869	0·6124	
Total	11	16·7601		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 1·31 (p·05).

+ L.S.D. between groups means = 1·93 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Fatty tissue+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·4616	0·2308	
Regression	1	0·8192	0·8192	8·809*
Deviation from Regression	1	0·1041		
Groups	2	0·9233	0·4617	4·965*
Error	7	0·6513	0·0930	
Total	11	2·0362		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 0·51 (p·05).

+ L.S.D. between groups means = 0·75 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Shoulder+			Loin++		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·0513	0·0257		0·0375	0·0188	
Regression	1	0·1682	0·1682	9·894*	0·1596	0·1596	8·966*
Deviation from Regression	1	0·0141			0·0287		
Groups	2	0·1823	0·0912	5·365*	0·1883	0·0942	5·292*
Error	7	0·1193	0·0170		0·1249	0·0178	
Total	11	0·3529			0·3507		

* Significant at $p<0·05$

\+ L.S.D. between groups means = 0·22 (p·05)

\+ L.S.D. between groups means = 0·32 (p·01)

++ L.S.D. between groups means
= 0·22 (p·05)
= 0·33 (p·01)

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Rib+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·0708	0·0354	
Regression	1	0·1352	0·1352	19·314**
Deviation from Regression	1	0·0081		
Groups	2	0·1433	0·0717	10·423**
Error	7	0·0490	0·0070	
Total	11	0·2631		

** Significant at $p < 0·01$

\+ L.S.D. between groups means= 0·14 (p·05).

\+ L.S.D. between groups means= 0·21 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	Flank (rib)+		
Source	s.s.	m.s.	F
Blocks	0·0441	0·0221	
Regression	0·0171	0·0171	14·250**
Deviation from Regression	0·0022		
Groups	0·0193	0·0097	8·083*
Error	0·0085	0·0012	
Total	0·0441		

* Significant at $p < 0·05$

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 0·06 (p·05).

\+ L.S.D. between groups means = 0·08 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	Fat (shoulder)+		
Source	s.s.	m.s.	F
Blocks	0·0506	0·0253	
Regression	0·0800	0·0800	11·268*
Deviation from Regression	0·0224		
Groups	0·1024	0·0512	7·211*
Error	0·0498	0·0071	
Total	0·2028		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 0·14 (p·05).

+ L.S.D. between groups means = 0·21 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Fat (loin)+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·0079	0·0040	
Regression	1	0·0338	0·0338	13·520**
Deviation from Regression	1	0·0021		
Groups	2	0·0359	0·0180	7·200*
Error	7	0·0173	0·0025	
Total	11	0·0611		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 0·09 (p·05).

\+ L.S.D. between groups means = 0·13 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	Fat (rib)+		
Source	s.s.	m.s.	F
Blocks	0·0139	0·0070	
Regression	0·0392	0·0392	11·200*
Deviation from Regression	0·0060		
Groups	0·0452	0·0226	6·457*
Error	0·0248	0·0035	
Total	0·0839		

* Significant at $p < 0·05$

+ L.S.D. between groups means = 0·10 (p·05).

+ L.S.D. between groups means = 0·15 (p·01).

The analysis of variance of the gains in carcass measurements of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	Fat - thickness (mm.)+		
Source	s.s.	m.s.	F
Blocks	4·8906	2·4453	
Regression	6·5703	6·5703	12·366**
Deviation from Regression	0·2109		
Groups	6·7812	3·3906	6·382*
Error	3·7188	0·5313	
Total	15·3906		

* Significant at $p < 0·05$.

** Significant at $p < 0·01$.

\+ L.S.D. between groups means = 1·22 (p·05).

\+ L.S.D. between groups means = 1·82 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		M. obliquus ... plus[+] M. transversus		
Source	d.f.	s.s.	m.s.	F
Blocks	2	2377·83	1188·92	
Regression	1	2592·00	2592·00	14·173**
Deviation from Regression	1	112·67		
Groups	2	2704·67	1352·33	7·395*
Error	7	1280·17	182·88	
Total	11	6362·67		

* Significant at $p < 0·05$

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 22·61 (p·05)

\+ L.S.D. between groups means = 33·46 (p·01)

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		M.l.d. (loin)+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	198·00	99·00	
Regression	1	14365·13	14365·13	9·342*
Deviation from Regression	1	1520·04		
Groups	2	15885·17	7942·59	5·165*
Error	7	10763·50	1537·64	
Total	11	26846·67		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 65·57 (p·05).

+ L.S.D. between groups means = 97·02 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	M. biceps brachii+		
Source	s.s.	m.s.	F
Blocks	37·58	18·79	
Regression	200·00	200·00	28·767**
Deviation from Regression	6·00		
Groups	206·00	103·00	14·820**
Error	48·67	6·95	
Total	292·25		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 4·41 (p·05).

+ L.S.D. between groups means = 6·52 (p·01).

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		M. brachialis[+]		
Source	d.f.	s.s.	m.s.	F
Blocks	2	6·00	3·00	
Regression	1	128·00	128·00	61·794**
Deviation from Regression	1	0·17		
Groups	2	128·17	64·09	30·961**
Error	7	14·50	2·07	
Total	11	148·67		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 2·41 (p·05).

+ L.S.D. between groups means = 3·56 (p·01).

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	% DM in fatty tissue				% DM in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	29·19	14·50		11·04	5·52	
Regression	1	0·92	0·92	0·24	1·72	1·72	0·61
Deviation from Regression	1	0·00			1·08		
Groups	2	0·92	0·46	0·12	2·80	1·40	0·49
Error	7	26·22	3·75		19·96	2·85	
Total	11	56·33			33·80		

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	% EE in fatty tissue				% EE in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	73·05	36·53		4·60	2·30	
Regression	1	7·37	7·37	1·06	0·24	0·24	0·07
Deviation from Regression	1	0·17			2·68		
Groups	2	7·54	3·77	0·542	2·92	1·46	0·418
Error	7	48·63	6·95		24·40	3·49	
Total	11	129·21			31·92		

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		% CP in fatty tissue			% CP in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·92	0·46		0·21	0·11	
Regression	1	0·01	0·01	0·02	0·06	0·06	0·23
Deviation from Regression	1	0·36			0·00		
Groups	2	0·37	0·19	0·30	0·06	0·03	0·13
Error	7	4·41	0·63		1·68	0·24	
Total	11	5·70			1·95		

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		DM in fatty tissue			DM in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·4002	0·2001		0·0390	0·0295	
Regression	1	0·5460	0·5460	7·165*	0·0882	0·0882	5·444
Deviation from Regression	1	0·0630			0·0001		
Groups	2	0·6090	0·3045	3·996	0·0883	0·0442	2·728
Error	7	0·5336	0·0762		0·1132	0·0162	
Total	11	1·5428			0·2405		

* Significant at $p<0·05$

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		DM in bone tissue		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·1641	0·0821	
Regression	1	0·0435	0·0435	1·532
Deviation from Regression	1	0·0145		
Groups	2	0·0580	0·0290	1·021
Error	7	0·1986	0·0284	
Total	11	0·4207		

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		EE in fatty tissue			EE in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·3631	0·1816		0·0080	0·0040	
Regression	1	0·4560	0·4560	7·664*	0·0001	0·0001	0·014
Deviation from Regression	1	0·0408			0·0012		
Groups	2	0·4968	0·2484	4·175	0·0013	0·0007	0·096
Error	7	0·4163	0·0595		0·0508	0·0073	
Total	11	1·2762			0·0601		

* Significant at $p<0·05$

The analysis of variance of the gains in weight (kg) of chemical components of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		CP in fatty tissue+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·0017	0·0009	
Regression	1	0·0045	0·0023	64·286**
Deviation from Regression	1	0·0010		
Groups	2	0·0055	0·0028	40·000**
Error	7	0·0005	0·0007	
Total	11	0·0077		

** Significant at p < 0·01

+ L.S.D. between groups means = 0·01 (p·05)

+ L.S.D. between groups means = 0·02 (p·01)

The analysis of variance of the gains in GE (Mcal) of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		GE in fatty tissue			GE in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	32·3253	16·1627		1·6019	0·8010	
Regression	1	45·3152	45·3152	7·851*	2·5538	2·5538	3·017
Deviation from Regression	1	4·8600			0·0205		
Groups	2	50·1752	25·0876	4·347	2·5743	1·2872	1·521
Error	7	40·4015	5·7716		5·9246	0·8464	
Total	11	122·9020			10·1008		

* Significant at $p<0·05$

The analysis of variance of the gains in GE (Mcal) of the carcass tissues of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		GE in bone tissue		
Source	d.f.	s.s.	m.s.	F
Blocks	2	3·4609	1·7305	
Regression	1	0·9045	0·9045	1·515
Deviation from Regression	1	0·3061		
Groups	2	1·2106	0·6053	1·014
Error	7	4·1804	0·5972	
Total	11	8·8159		

The analysis of variance of the gains in weight (kg) in DM of live weight components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components	Blood[+]		
Source	s.s.	m.s.	F
Blocks	0·0021	0·0011	
Regression	0·0036	0·0036	9·000*
Deviation from Regression	0·0007		
Groups	0·0043	0·0022	5·500*
Error	0·0029	0·0004	
Total	0·0093		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 0·03 (p·05).

+ L.S.D. between groups means = 0·05 (p·01).

The analysis of variance of the gains in GE (Mcal) of live weight components of Blackface wether lambs fed different levels of daily intake of ME and similar levels of daily intake of DCP

Components		Blood+	
Source	s.s.	m.s.	F
Blocks	0·0609	0·305	
Regression	0·1105	0·1105	8·435*
Deviation from Regression	0·0228		
Groups	0·1333	0·0667	5·092*
Error	0·0917	0·0131	
Total	0·2859		

* Significant at $p < 0·05$.

+ L.S.D. between groups means = 0·19 (p·05).

+ L.S.D. betweenn groups means = 0·28 (p·01).

A P P E N D I X V

The analysis of variance for results of Experiment II - part (b)

Table 21. The regression coefficient "b" with the SE and the "F" value of the treatments on the groups along with the regression coefficient expressed as a percentage of the initial weight of the components of Blackface wether lambs fed similar total quantities of ME at different levels of daily intake.

Component	"F"	"b"	S.E. of "b"	"b" as % of the initial
Liveweight	0·016	0·003	± 2·191	0·10
S.E.B.·	1·848	-1·981	± 1·457	8·80
Warm carcass	0·871	-1·048	± 1·123	7·37
Pelt	3·761	-1·092	± 0·563	34·89
Gut "fill"	2·789	1·783	± 1·068	42·15
Blood	0·368	0·092	± 0·151	7·08
Feet	0·001	0·005	± 0·064	0·77
Head	9·838	0·420	± 0·134	21·21
Pluck	0·692	-0·162	± 0·194	11·65
Gut	0·897	-0·204	± 0·215	9·90
Caul fat	9·403	-1·078	± 0·352	121·12
Fatty tissue	21·804	-1·271	± 0·272	96·29
Muscle tissue	0·054	0·115	± 0·495	2·90
Bone tissue	1·232	0·221	± 0·200	15·45
Loin	3·377	-0·363	± 0·197	45·38
Rib	3·938	-0·232	± 0·117	25·49
Flank (loin)	4·235	-0·111	± 0·054	79·29
Flank (rib)	12·571	-0·173	± 0·049	43·25
Neck	2·500	0·152	± 0·096	60·80
Fat (gigot)	14·586	-0·268	± 0·071	74·44
Fat (shoulder)	19·829	-0·344	± 0·077	76·44
Fat (loin)	16·963	-0·280	± 0·068	164·71
Fat (rib)	25·067	-0·253	± 0·051	126·50
Fat-thickness	3·387	-3·390	± 1·850	138·37
M. obliquus	2·887	-33·54	±19·75	21·50

Table 21 (Contd.)

Component	"F"	"b"	S.E. of "b"	"b" as % of the initial
M. gastrocnemius	1·480	-19·74	±16·23	18·11
M. pectoralis	1·665	31·01	±24·03	26·97
M.l.d. (loin)	0·187	-77·19	±56·40	41·28
% DM in fat	17·01	-11·46	± 2·78	14·33
% DM in muscle	7·46	-5·75	± 2·11	18·85
% EE in fat	347·8	-9·12	± 3·711	13·41
% EE in muscle	0·15	-0·91	± 2·37	10·46
% CP in fat	0·86	0·79	± 0·847	10·87
% CP in muscle	0·00	0·02	± 0·613	0·11
DM in fat	20·724	-1·155	± 0·254	108·96
DM in muscle	2·991	-0·242	± 0·140	20·68
DM in bone	1·103	0·257	± 0·245	15·21
DM in head	6·545	0·157	± 0·062	18·05
EE in fat	16·528	-1·002	± 0·247	108·91
CP in fat	43·000	-0·085	± 0·010	94·44
GE in fat	19·100	-10·192	± 2·332	110·54
GE in bone	1·105	1·179	± 1·122	15·25
GE in head	6·732	0·769	± 0·296	17·88

"F" at 5 per cent level with $n_1 = 1$ $n_2 = 7$ = 5·59

"F" at 1 per cent level with $n_1 = 1$ $n_2 = 7$ = 12·25

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Live weight			S.E.B.		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	1·8679	0·9340		0·1452	0·0726	
Regression	1	0·5856	0·5856	0·016	2·2978	2·2978	1·848
Deviation from Regression	1	5·7039			5·3467		
Groups	2	6·2893	3·1447	1·119	7·6445	3·8223	3·075
Error	7	19·6777	2·8111		8·7016	1·2431	
Total	11	27·8349			16·4913		

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components	Pelt		
Source	s.s.	m.s.	F
Blocks	0·4842	0·2421	
Regression	0·6977	0·6977	3·761
Deviation from Regression	0·0152		
Groups	0·7129	0·3565	1·922
Error	1·2981	0·1855	
Total	2·4952		

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Gut "fill"		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·0870	0·0435	
Regression	1	1·8612	1·8612	2·789
Deviation from Regression	1	0·4333		
Groups	2	2·2945	1·1473	1·719
Error	7	4·6716	0·6674	
Total	11	7·0531		

The analysis of variance of the gains in weight (kg) of live weight components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components	Head[+]		
Source	s.s.	m.s.	F
Blocks	0·1452	0·0726	
Regression	0·1033	0·1033	9·838*
Deviation from Regression	0·0685		
Groups	0·1718	0·0859	8·181*
Error	0·0736	0·0105	
Total	0·3906		

* Significant at $p < 0·05$.

\+ L.S.D. between groups means = 0·17 (p·05).

\+ L.S.D. between groups means = 0·26 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Fatty tissue[+]		
Source	d.f.	s.s.	m.s.	F
Blocks	2	1·0762	0·5381	
Regression	1	0·9463	0·9463	21·804**
Deviation from Regression	1	0·1318		
Groups	2	1·0781	0·5391	12·42**
Error	7	0·3036	0·0434	
Total	11	2·4579		

** Significant at $p < 0·01$.

+ L.S.D. between groups means = 0·35 (p·05).

+ L.S.D. between groups means = 0·51 (p·01).

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake.

Components	Loin		
Source	s.s.	m.s.	F
Blocks	0·0341	0·0171	
Regression	0·0770	0·0770	3·377
Deviation from Regression	0·0096		
Groups	0·0826	0·0413	1·811
Error	0·1595	0·0228	
Total	0·2762		

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Rib		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·1029	0·0515	
Regression	1	0·0315	0·0315	3·938
Deviation from Regression	1	0·0025		
Groups	2	0·0340	0·0170	2·125
Error	7	0·0560	0·0080	
Total	11	0·1929		

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components	Flank (rib)+		
Source	s.s.	m.s.	F
Blocks	0·0155	0·0078	
Regression	0·0176	0·0176	12·571**
Deviation from Regression	0·0009		
Groups	0·0185	0·0093	6·643*
Error	0·0101	0·0014	

* Significant at $p < 0·05$

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 0·06 (p·05)

\+ L.S.D. between groups means = 0·09 (p·01)

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Fat (gigot)+			Fat (shoulder)++		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·0657	0·0329		0·0832	0·0416	
Regression	1	0·0423	0·0423	14·586**	0·0694	0·0694	19·829**
Deviation from Regression	1	0·0029			0·0056		
Groups	2	0·0452	0·0226	7·793*	0·0750	0·0375	10·714**
Error	7	0·0202	0·0029		0·0244	0·0035	
Total	11	0·1311			0·1826		

* Significant at $p < 0·05$

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 0·09 (p·05)

\+ L.S.D. between groups means = 0·14 (p·01)

++ L.S.D. between groups means

= 0·10 (p·05)

= 0·15 (p·01)

The analysis of variance of the gains in weight (kg) of carcass components of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		Fat (loin)+			Fat (rib) ++		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·0292	0·0146		0·0375	0·0188	
Regression	1	0·0458	0·0458	16·963**	0·0376	0·0376	25·067**
Deviation from Regression	1	0·0061			0·0017		
Groups	2	0·0519	0·0250	9·630**	0·0393	0·0197	13·133**
Error	7	0·0191	0·0027		0·0103	0·0015	
Total	11	0·1002			0·0871		

** Significant at $p < 0·01$

+ L.S.D. between groups means = 0·09 (p·05)
+ L.S.D. between groups means = 0·13 (p·01)

++ L.S.D. between groups means
= 0·07 (p·05)
= 0·10 (p·01)

The analysis of variance of the gain in fat-thickness (mm) of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Source	d.f.	s.s.	m.s.	F
Blocks	2	8·7657	4·3829	
Regression	1	6·7285	6·7285	3·387
Deviation from Regression	1	0·1569		
Groups	2	6·8854	3·4427	1·733
Error	7	13·9062	1·9866	
Total	11	29·5573		

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		M. obliquus .... plus M. transversus			M. gastrocnemius		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	989·83	494·92		596·50	298·25	
Regression	1	658·69	658·69	2·885	228·20	228·20	1·480
Deviation from Regression	1	385·98			12·47		
Groups	2	1044·67	522·34	2·288	240·67	120·34	0·780
Error	7	1598·17	228·31		1079·50	154·21	
Total	11	3632·67			1916·67		

The analysis of variance of the gains in weight (g) of individual muscles in half-carcass of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		M.l.d. (loin)			Mm. pectoralis		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	73·50	36·75		179·00	89·50	
Regression	1	348·88	348·88	0·187	563·16	563·16	1·665
Deviation from Regression	1	2072·29			31·51		
Groups	2	2421·17	1210·59	0·650	594·67	297·34	0·879
Error	7	13039·00	1862·71		2368·00	338·29	
Total	11	15533·67			3141·67		

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components	% DM in fatty tissue[+]				% DM in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	46·84	23·42		2·17	1·09	
Regression	1	76·89	76·89	17·01**	19·39	19·39	7·46*
Deviation from Regression	1	1·91			0·20		
Groups	2	78·80	39·40	8·72*	19·59	9·80	3·77
Error	7	31·65	4·52		18·21	2·60	
Total	11	157·29			39·97		

* Significant at $p < 0·05$

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 3·55 (p·05)

\+ L.S.D. between groups means = 5·26 (p·01)

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		% EE in fatty tissue+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	109·26	54·63	
Regression	1	48·69	48·69	347·78**
Deviation from Regression	1	14·46		
Groups	2	63·15	31·58	225·57**
Error	7	0·97	0·14	
Total	11	173·38		

** Significant at $p < 0·01$

+ L.S.D. between groups means = 0·63 (p·05).

+ L.S.D. between groups means = 0·93 (p·01).

The analysis of variance of the chemical composition of carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components	% CP in fatty tissue				% CP in muscle tissue		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	6·39	3·20		0·51	0·26	
Regression	1	0·36	0·36	0·86	0·00	0·00	0·00
Deviation from Regression	1	0·29			1·67		
Groups	2	0·65	0·33	0·79	1·67	0·84	3·82
Error	7	2·96	0·42		1·51	0·22	
Total	11	10·00			3·69		

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		DM in fatty tissue+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	0·8028	0·4014	
Regression	1	0·7813	0·7813	20·724**
Deviation from Regression	1	0·0920		
Groups	2	0·8733	0·4367	11·584**
Error	7	0·2640	0·0377	
Total	11	1·9401		

** Significant at $p < 0·01$

+ L.S.D. between groups means = 0·32 (p·05)

+ L.S.D. between groups means = 0·48 (p·01)

The analysis of variance of the gains in weight (kg) in chemical components of the carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		EE in fatty tissue[+]			CP in fatty tissue[++]		
Source	d.f.	s.s.	m.s.	F	s.s.	m.s.	F
Blocks	2	0·7283	0·3642		0·0033	0·0017	
Regression	1	0·5884	0·5884	16·528**	0·0043	0·0043	43·000**
Deviation from Regression	1	0·0929			0·0006		
Groups	2	0·6813	0·3407	9·570**	0·0049	0·0025	25·00**
Error	7	0·2495	0·0356		0·0005	0·0001	
Total	11	1·6591			0·0087		

** Significant at p < 0·01

+ L.S.D. between groups means = 0·31 (p·05)

+ L.S.D. between groups means = 0·47 (p·01)

++ L.S.D. between groups means
= 0·01 (p·05)
= 0·02 (p·01)

The analysis of variance of the gains in GE (Mcal) of the carcass tissues of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Components		GE in fatty tissue+		
Source	d.f.	s.s.	m.s.	F
Blocks	2	66·5228	33·2614	
Regression	1	50·8254	60·8254	19·100**
Deviation from Regression	1	7·7431		
Groups	2	68·5685	34·2843	10·766**
Error	7	22·2913	3·1845	
Total	11	157·3826		

** Significant at $p < 0·01$

\+ L.S.D. between groups means = 2·98 (p·05)

\+ L.S.D. between groups means = 4·42 (p·01)

The analysis of variance of the gain in weight (kg) in DM of head of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Source	d.f.	s.s.	ms.	F
Blocks	2	0·0270	0·0135	
Regression	1	0·0144	0·0144	6·545*
Deviation from Regression	1	0·0105		
Groups	2	0·0249	0·0125	5·682*
Error	7	0·0151	0·0022	
Total	11	0·0670		

* Significant at $p < 0·05$

L.S.D. between groups means = 0·08 (p·05)

L.S.D. between groups means = 0·12 (p·01)

The analysis of variance of the gain in GE (Mcal) of head of Blackface wether lambs fed similar total quantities of ME on different levels of daily intake

Source	d.f.	s.s.	m.s.	F
Blocks	2	0·6518	0·3259	
Regression	1	0·3467	0·3467	6·732*
Deviation from Regression	1	0·2584		
Groups	2	0·6051	0·3026	5·876*
Error	7	0·3603	0·0515	
Total	11	1·6172		

* Significant at $p < 0·05$

L.S.D. between groups means = 0·38 (p·05)

L.S.D. between groups means = 0·56 (p·01)

A P P E N D I X VI

Graphs pertaining to Experiment II - part (b)

Fig. 1. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of the retail cuts of B.F. wether lambs

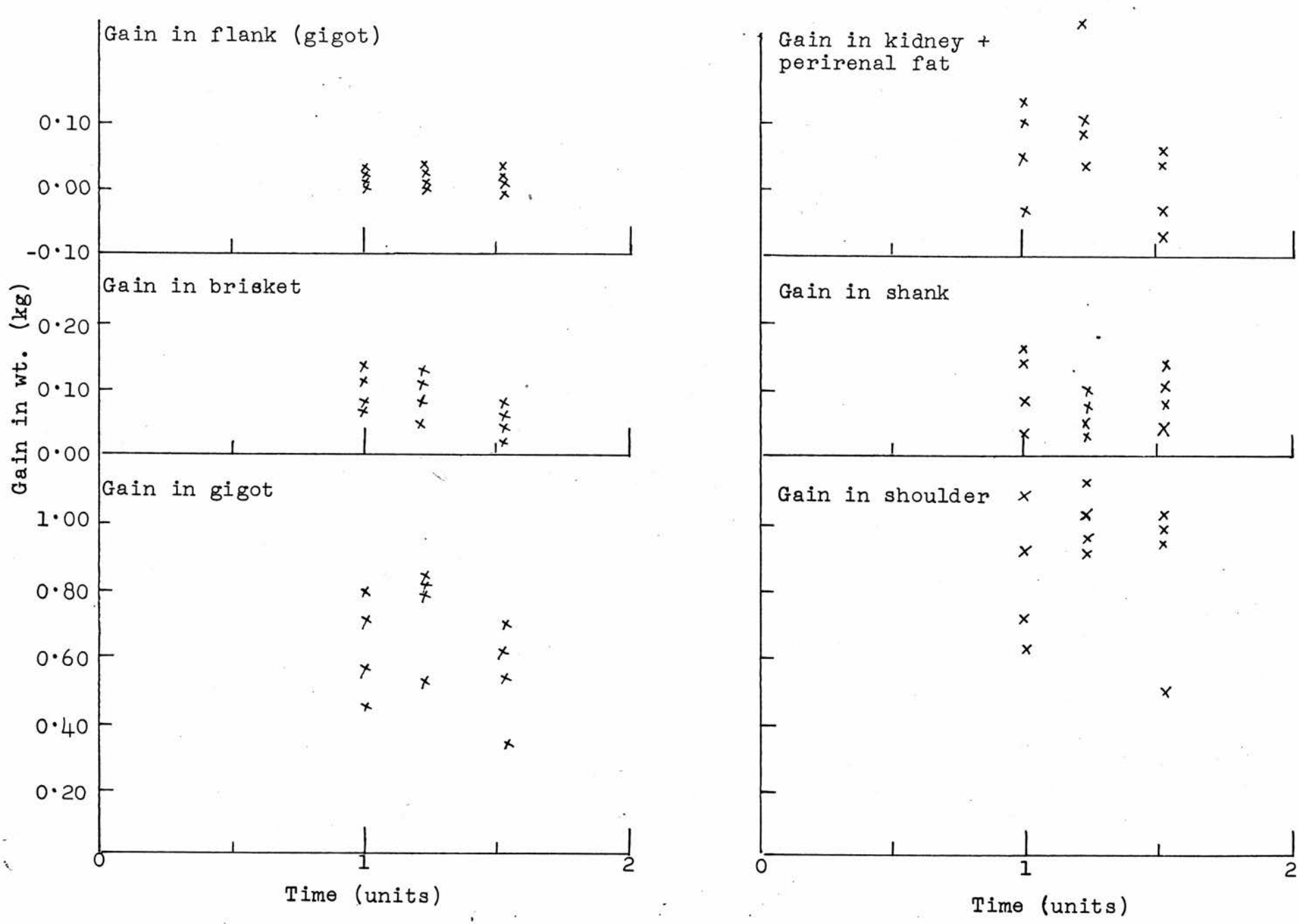


Fig. 2. The effect of restricting the daily intake of a given quantity of ME on gain in weight of the major tissues in the retail cuts of B.F. wether lambs

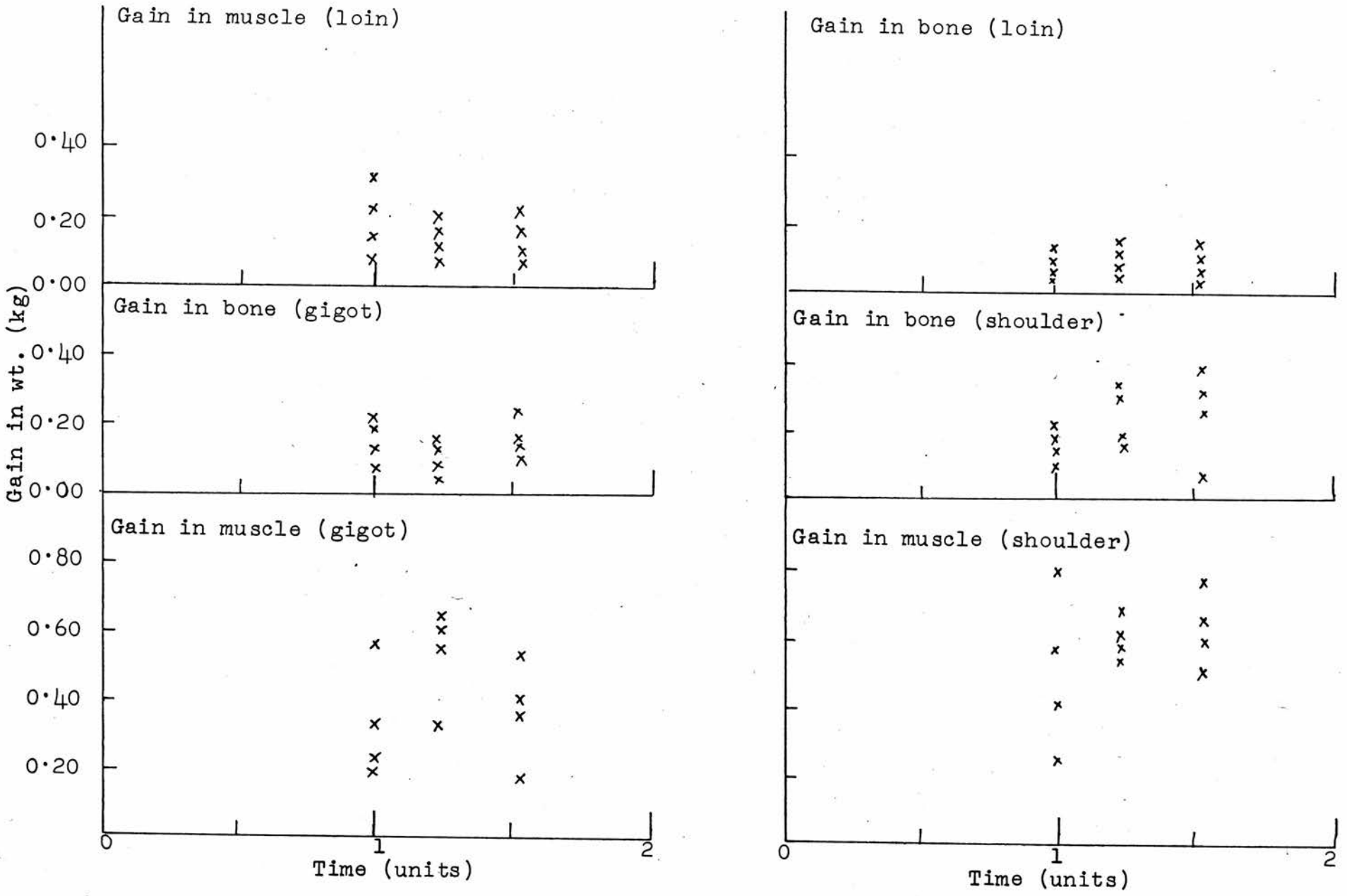


Fig.3. The effect of restricting the daily intake of a given quantity of ME on gain in weight of carcass components of B.F. wether lambs

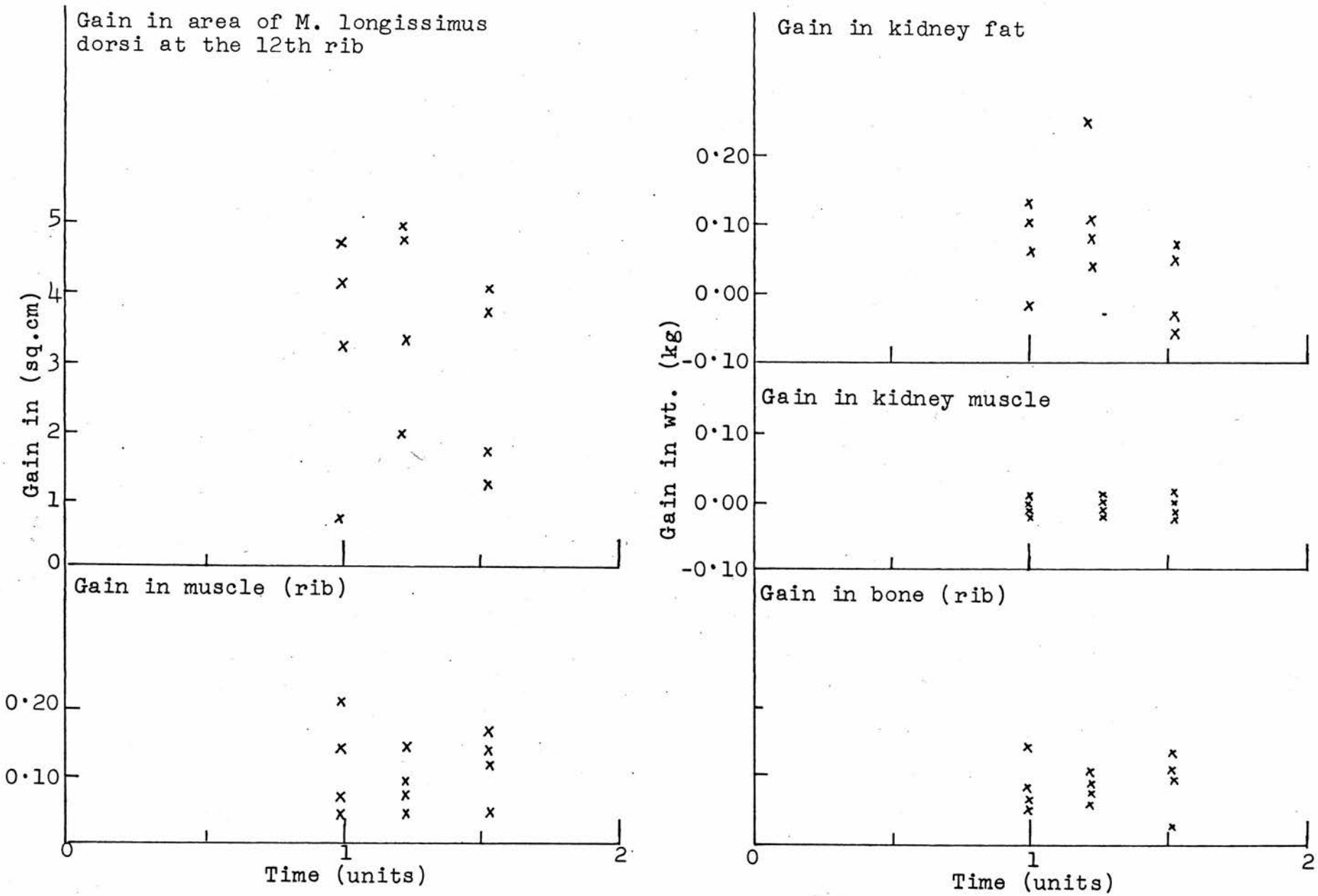


Fig. 4. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of individuals of B.F. wether lambs

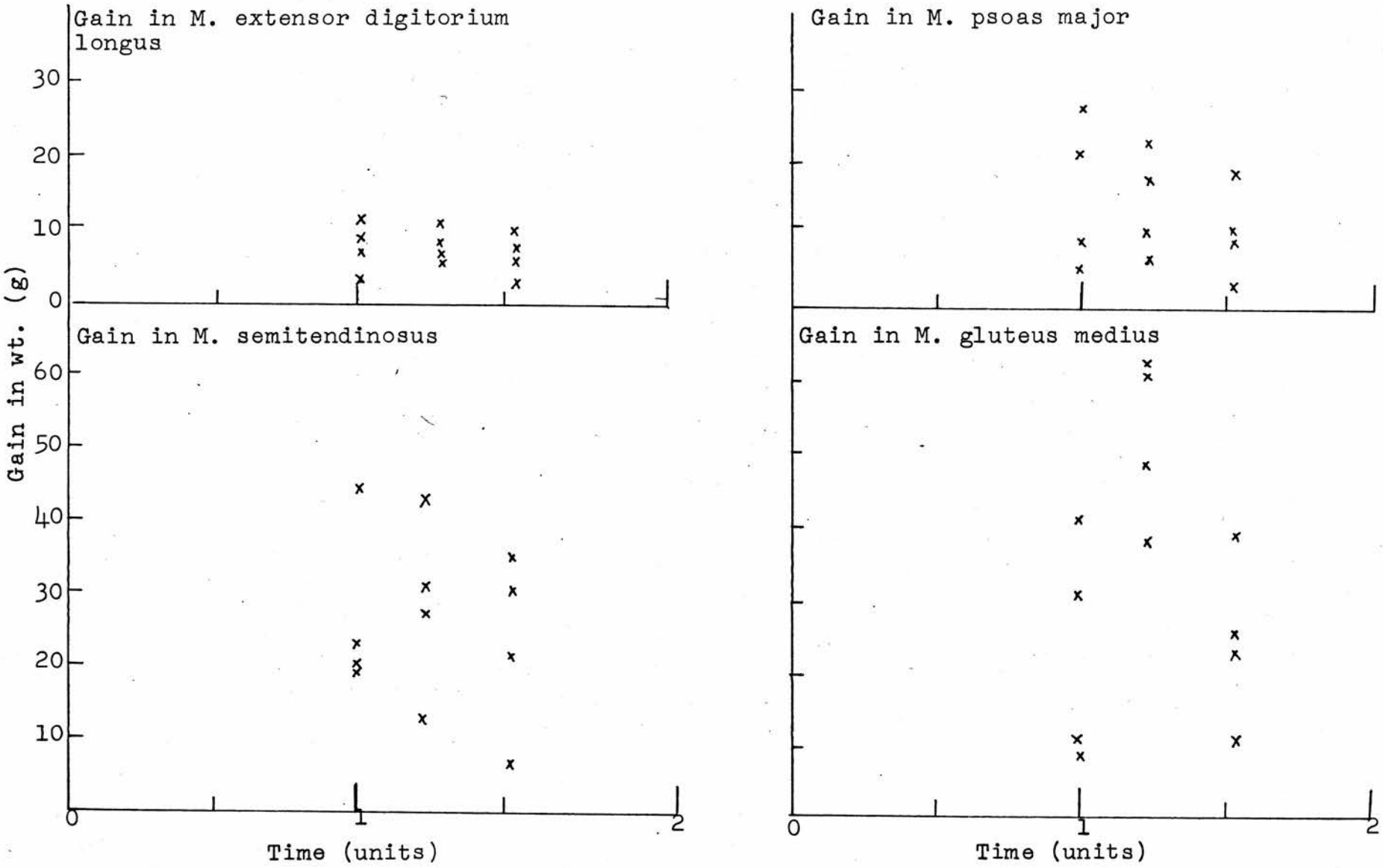


Fig. 5. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of individual muscles of B.F. wether lambs

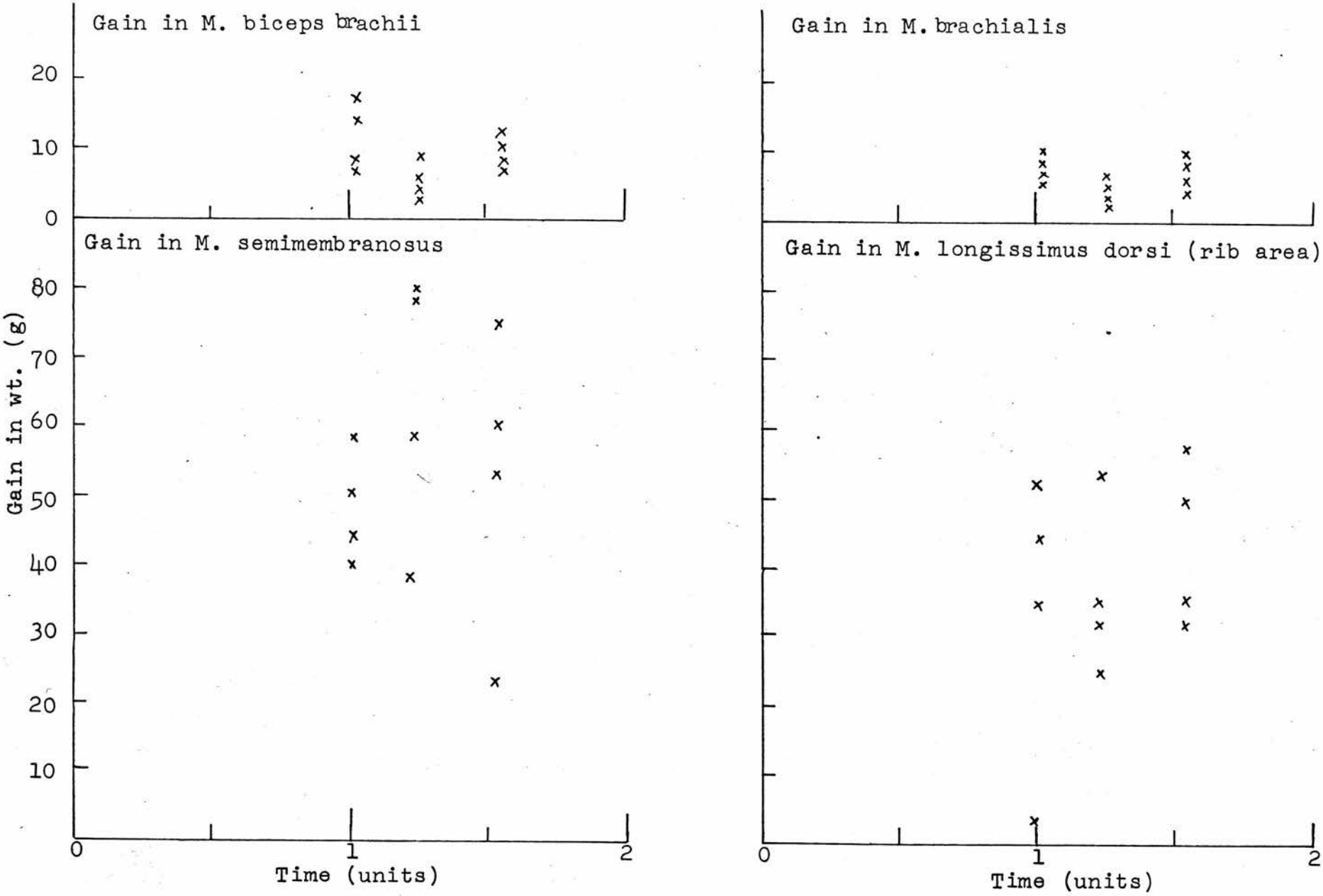


Fig. 6. The effect of restricting the daily intake of a given quantity of ME on the gain in weight of individual muscles of B.F. wether lambs

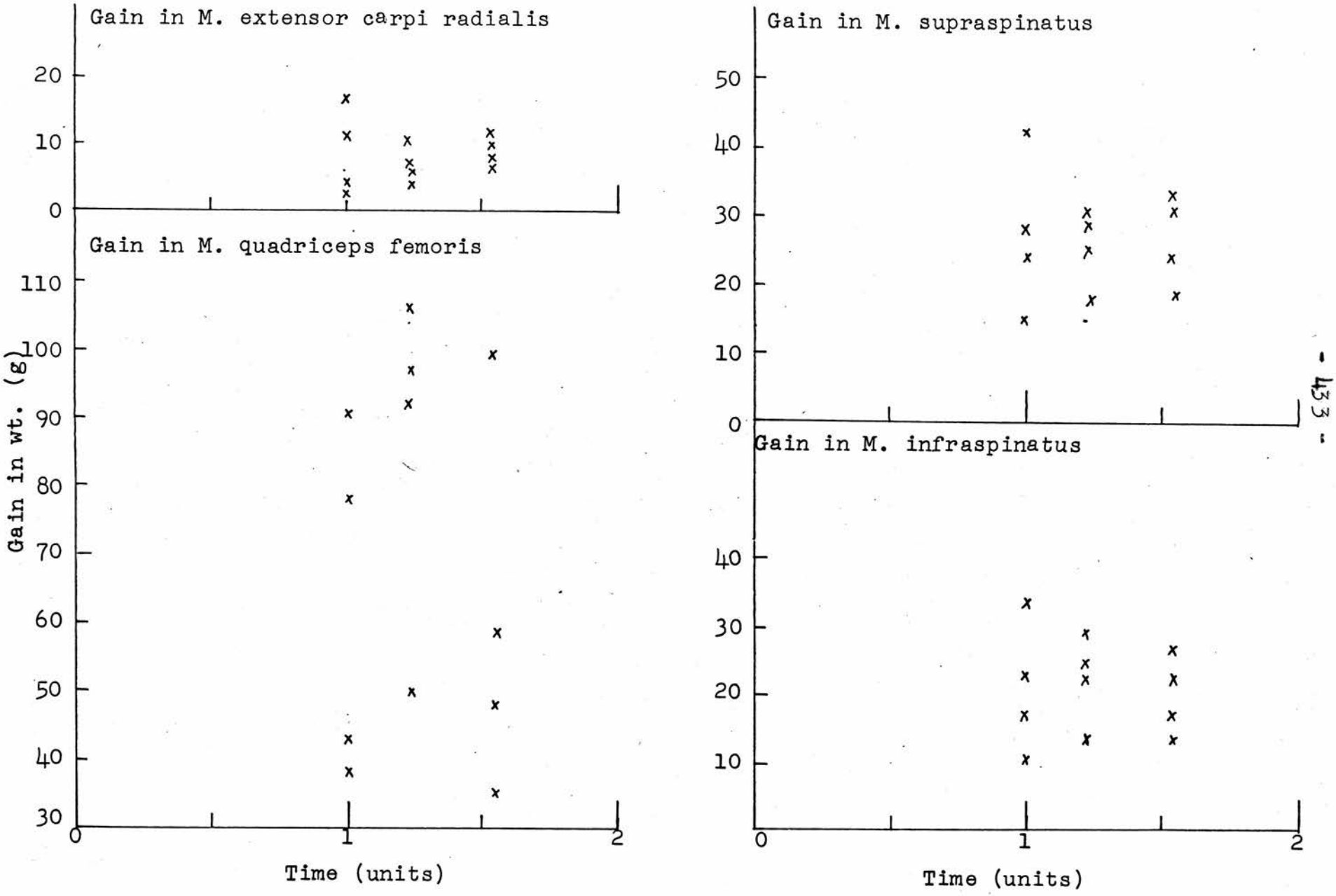


Fig. 7. The effect of restricting the daily intake of a given quantity of ME on gain in weight of chemical components in body components of B.F. wether lambs

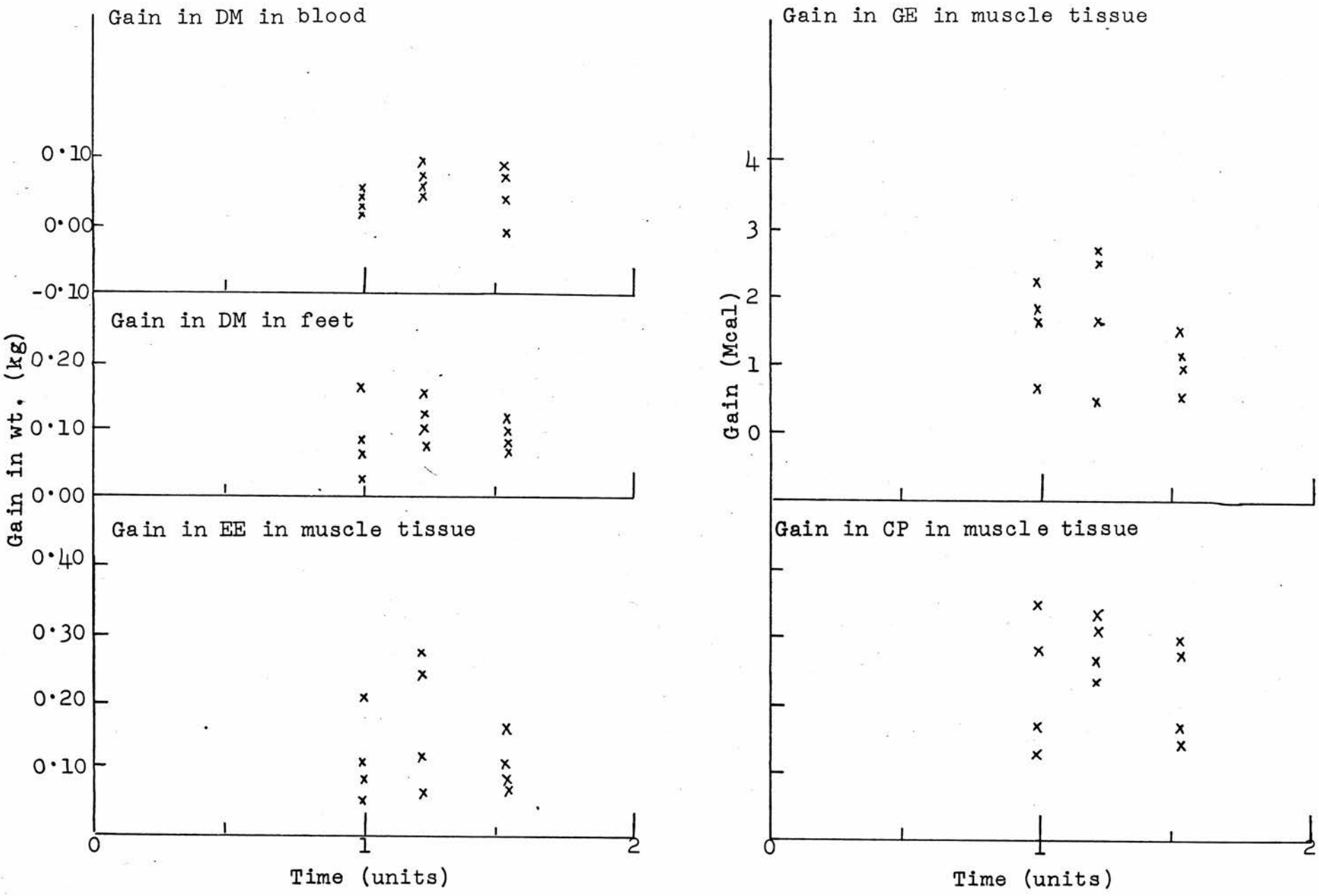
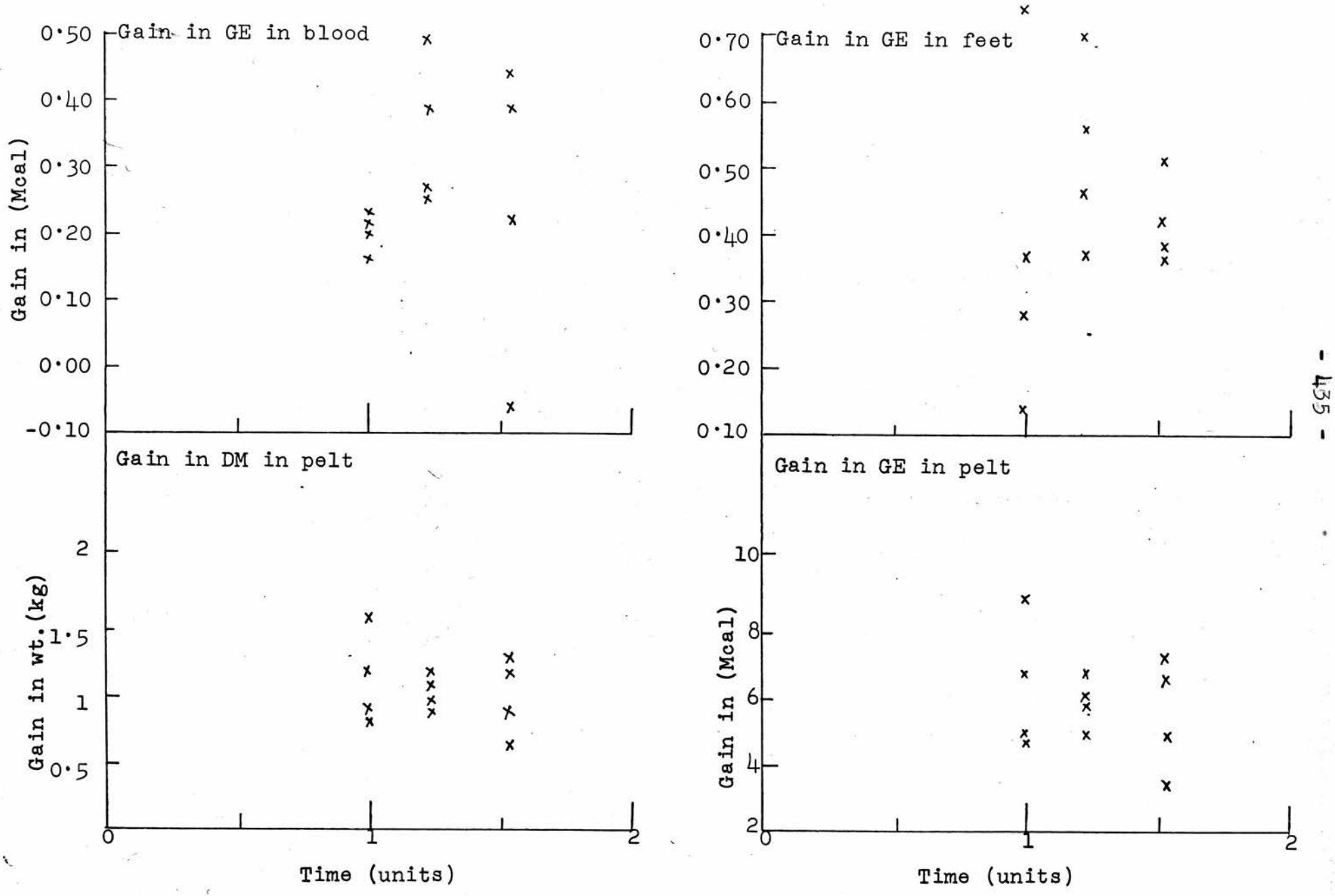


Fig.8. The effect of restricting the daily intake of a given quantity of ME on gain in weight of chemical components of live wt. components of B.F. wether lambs



A P P E N D I X VII

Data pertaining to Experiment I

The chemical composition of the foodstuffs used in the protein level experiment (fresh basis)

%	Foodstuff		
	Soyabean meal	Bruised barley	Hay
Dry matter	86·47	80·86	83·80
Crude protein	45·72	11·31	7·39
Ether extract	0·86	2·12	1·04
Crude fibre	3·48	3·78	29·91
Total ash	5·65	2·63	6·75

Each figure is the mean value of three determinations.

The percentage digestibility for the diets used in the protein level experiment

Components	Diets											
	L				M				H			
	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
DM	67·55	73·05	63·74	68·11	70·24	72·67	68·87	70·59	73·88	67·88	68·70	70·15
CP	62·38	65·77	52·53	60·23	75·55	76·97	73·94	75·49	81·83	79·43	78·25	79·84
OM	68·70	74·96	65·52	69·73	71·55	74·58	70·40	72·18	75·40	69·08	69·90	71·46
ME	58·39	62·83	54·57	58·60	59·03	60·12	58·51	59·22	61·94	57·51	57·12	58·86

The analysis of variance of the percentage of digestible crude protein in the diets of experiment I

Source	d.f.	s.s.	m.s.	F
Treatments	2	636	318	26·50**
Replicates	2	59	30	2·50
Error	4	47	12	
Total	8	742		

** Significant at $p < 0·01$

L.S.D. between treatments means = 7·86 (p·05)

L.S.D. between treatments means = 13·03 (p·01)

The analysis of variance of the percentage of metabolizable energy in the diets of experiment I

Source	d.f.	s.s.	m.s.	F
Treatments	2	1	0·5	0·07 N.S.
Replicates	2	22	11·0	1·57
Error	4	28	7·0	
Total	8	51		

N.S. non-significant at $p < 0{\cdot}05$

Experiment I

Initial slaughter lambs slaughter data (kg)

Live wt. components	Lamb No.					
	0483	0569	B258	R70	B260	0579
Live wt. (starved)	27·70	28·15	26·33	29·51	33·60	25·42
Pelt	2·27	2·05	2·27	2·61	2·95	2·50
Gut "fill"	6·94	6·78	6·07	7·31	7·48	5·00
S.E.B.	17·18	18·45	16·68	17·75	21·14	16·55
Components of S.E.B:						
Warm carcass	10·44	11·80	10·44	10·44	13·39	9·99
Blood	1·13	1·03	1·02	1·18	1·13	1·01
Feet	0·53	0·50	0·53	0·63	0·69	0·56
Head	1·36	1·36	1·36	1·30	1·59	1·36
Pluck	1·05	1·06	0·96	1·26	1·20	1·09
Gut	2·20	1·96	1·63	2·43	2·48	1·93
Caul fat	0·48	0·74	0·76	0·51	0·66	0·62
Retail cuts:						
Gigot	1·78	1·87	1·72	1·76	2·07	1·65
Shoulder	1·81	1·96	1·92	1·92	2·43	1·82
Loin	0·62	0·75	0·64	0·60	0·79	0·64
Rib	0·63	0·76	0·59	0·64	0·70	0·61
Kidney plus perirenal fat	0·12	0·21	0·17	0·17	0·23	0·13
Brisket	0·23	0·18	0·20	0·25	0·31	0·21
Neck	0·12	0·14	0·20	0·16	0·21	0·14
Shank	0·31	0·24	0·28	0·32	0·38	0·28
Flank (gigot)	0·04	0·05	0·05	0·05	0·05	0·05
Flank (loin)	0·09	0·14	0·08	0·10	0·10	0·07
Flank (rib)	0·25	0·30	0·23	0·24	0·25	0·22
Major tissues (in ½ carcass):						
Fatty tissue	0·82	1·02	1·09	0·66	0·93	0·53
Muscle tissue	3·01	3·26	2·68	2·99	3·78	2·99
Bone tissue	1·07	1·16	1·20	1·37	1·45	1·27

Experiment I

Initial slaughter lambs slaughter data (kg)

Live wt. components	Lamb No.					
	0483	0569	B258	R70	B260	0579
Major tissues in the retail cuts:						
Fat (gigot)	0·18	0·22	0·26	0·18	0·23	0·16
Muscle (")	1·24	1·27	1·08	1·18	1·41	1·15
Bone (")	0·34	0·36	0·37	0·39	0·42	0·33
Fat (shoulder)	0·26	0·31	0·37	0·29	0·34	0·20
Muscle (")	1·08	1·12	0·97	1·02	1·44	1·01
Bone (")	0·45	0·46	0·55	0·59	0·63	0·59
Fat (loin)	0·07	0·12	0·16	0·04	0·10	0·04
Muscle (")	0·42	0·47	0·32	0·39	0·49	0·42
Bone (")	0·12	0·15	0·15	0·15	0·19	0·17
Fat (rib)	0·22	0·20	1·15	0·03	0·11	0·04
Muscle (")	0·23	0·36	0·30	0·37	0·37	0·37
Bone (")	0·17	0·19	0·14	0·23	0·21	0·19
Fat (kidney)	0·09	0·18	0·14	0·13	0·16	0·09
Muscle (")	0·03	0·04	0·03	0·04	0·06	0·04
Carcass measurements:						
Area of M.l.d. (sq.cm)(i)	8·10	10·10	6·63	8·47	11·18	8·19
Fat thickness (mm)(ii)	2·0	2·5	3·0	1·0	1·5	1·0

(i) Area of M. longissimus dorsi at the 12th rib.

(ii) Fat thickness over M. longissimus dorsi at the 12th rib.

Experiment I.

Initial slaughter lambs slaughter data (g)

Individual muscles	Lamb No.					
	0483	0569	B258	R70	B260	0579
M. obliquus internus abdominis + M. transversus abdominis	122	118	90	118	130	115
M. semitendinosus	47	48	49	40	62	47
M. semimembranosus	155	182	143	136	170	140
M. gastrocnemius	90	88	74	85	100	90
M. quadriceps femoris	234	249	213	235	265	228
M. gluteus medius	98	115	90	98	115	125
M. extensor digitorum longus	20	20	15	21	27	20
M. psoas major	32	36	30	31	31	28
M. longissimus dorsi (loin)	182	191	156	147	207	155
M. " " (rib)	82	90	79	71	81	71
Mm. pectoralis profundus et superficialis	90	97	74	74	110	85
M. biceps brachii	17	19	15	17	23	20
M. brachialis	13	14	12	14	13	13
M. extensor carpi radialis	21	22	18	25	30	24
M. infraspinatus	70	75	85	65	76	70
M. supraspinatus	90	88	73	69	80	80

Percentage of DM in the muscle and fatty tissues of various parts of the initial slaughter group of Blackface wether lambs

Lamb No.	Muscle tissue				Fatty tissue				(i) M.l.d.	Gut + Pluck
	Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
0483	28·56	30·81	31·11	34·36	80·50	63·60	71·12	76·93	25·94	30·75
0569	30·23	33·04	31·01	32·46	81·88	72·43	73·83	82·20	27·40	33·30
B258	27·12	37·18	30·47	35·28	83·24	79·44	77·03	82·40	27·21	42·08
R70	26·50	29·66	28·74	29·36	78·19	71·40	76·22	81·94	30·62	27·08
B260	26·87	31·08	28·71	30·48	69·25	63·63	70·53	79·52	25·24	28·59
0579	28·79	30·72	31·41	33·94	70·34	71·40	63·27	79·52	24·05	30·22
Mean	28·01	32·08	30·24	32·65	77·23	70·32	72·00	80·42	26·74	32·00

(i) M. longissimus dorsi (in rib area)

Percentage of EE in the muscle and fatty tissues of various parts of the initial slaughter group of Blackface wether lambs

Lamb No.	Muscle tissue				Fatty tissue				(i) M.l.d.	Gut + Pluck
	Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
0483	7·81	9·15	10·99	10·82	67·25	48·57	61·78	69·69	1·06	17·13
0569	10·70	13·33	11·73	12·27	73·25	62·18	62·84	75·61	3·06	20·31
B258	5·98	17·09	10·45	14·56	75·23	66·98	66·26	75·44	2·66	26·43
R70	4·75	9·38	9·88	10·23	69·48	52·85	68·03	75·15	4·16	12·03
B260	5·53	10·27	9·06	10·33	57·34	52·70	60·79	72·28	1·57	14·61
0579	7·29	9·50	11·15	12·32	55·82	56·87	50·38	68·51	1·80	15·66
Mean	7·01	11·45	10·54	11·76	66·40	56·69	61·68	72·78	2·39	17·70

(i) M. longissimus dorsi (in rib area)

Percentage of CP in the muscle and fatty tissues of various parts of the initial slaughter group of Blackface wether lambs

Lamb No.	Muscle tissue				Fatty tissue				(i) M.l.d.	Gut + Pluck
	Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
0483	19·16	18·98	17·93	19·65	10·01	11·53	7·97	7·64	22·13	10·90
0569	17·77	17·95	17·61	18·58	9·16	8·98	8·81	6·41	21·51	10·23
B258	19·19	18·04	17·52	19·09	7·39	8·33	7·56	6·29	22·67	9·74
R70	17·62	17·62	17·45	17·64	7·06	12·25	7·24	6·14	19·80	11·53
B260	18·69	18·59	17·94	18·25	9·93	11·32	8·12	8·14	21·81	10·20
0579	18·15	18·24	17·00	17·99	9·50	10·83	11·08	7·81	20·50	10·75
Mean	18·43	18·24	17·58	18·53	8·85	10·54	8·46	7·07	21·40	10·56

(i) M. longissimus dorsi (in rib area)

The caloric values* (Kcal/100 g fresh matter) of the muscle and fatty tissues of various parts of the initial slaughter group

Lamb No.	Muscle tissue				Fatty tissue				M.l.d.(i)	Gut + Pluck
	Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
0483	185·42	202·86	211·70	228·65	699·94	535·10	627·65	690·15	144·75	233·81
0569	205·79	231·33	214·06	224·03	730·93	636·32	646·50	741·92	160·50	260·11
B258	170·43	268·51	206·11	248·29	766·86	693·12	677·24	742·33	157·90	331·68
R70	162·26	197·53	194·30	199·23	696·15	594·16	679·79	738·70	202·50	193·93
B260	167·31	208·71	191·12	205·69	600·11	551·46	620·57	714·34	142·95	212·23
0579	184·62	203·74	213·95	232·88	600·06	609·92	540·41	699·55	137·41	225·18
Mean	179·29	218·75	205·21	223·06	682·35	603·35	632·02	721·20	157·68	242·83

* Calculated from the chemical composition (fat-free dry matter and ether extract) of these components
The caloric value for 1 g fat-free dry matter = 5·42 Kcal
The caloric value for 1 g ether extract = 9·34 Kcal

(i) M. longissimus dorsi (in rib area)

Experiment I

The chemical components of the fatty and muscle tissues in half-carcass of the initial slaughter group

Lamb No.	Fatty tissue				Muscle tissue			
	DM (kg)	EE (kg)	CP (kg)	GE (Mcal)	DM (kg)	EE (kg)	CP (kg)	GE (Mcal)
0483	0·60	0·50	0·08	5·19	0·93	0·29	0·57	6·13
0569	0·80	0·70	0·08	7·12	1·14	0·42	0·65	7·82
B258	0·89	0·78	0·09	7·90	0·83	0·29	0·50	5·64
R70	0·52	0·46	0·05	4·65	0·83	0·23	0·52	5·50
B260	0·68	0·59	0·09	5·98	1·09	0·31	0·70	7·12
0579	0·39	0·33	0·05	3·34	0·92	0·29	0·54	6·12
Mean	0·65	0·56	0·07	5·70	0·96	0·31	0·58	6·39

Experiment I

Live weight data (kg) of Blackface wether lambs fed different levels of daily intake of digestible crude protein and similar levels of daily intake of metabolisable energy

Group	Date	2/12/65	22/12/65	19/1/65	16/2/65	17/3/66
	Lamb No.					
L	B234	25·88	25·88	26·79	28·60	32·69
	B259	27·24	27·24	30·87	33·60	34·50
	B257	29·06	28·60	29·06	31·78	33·14
	R82	30·42	29·96	30·87	34·96	35·87
	Mean	28·15	27·92	29·40	32·24	34·05
M	0481	25·42	26·33	29·06	31·78	33·60
	0482	26·33	26·79	27·24	32·69	34·05
	0670	29·51	31·78	32·69	36·32	37·23
	0664	30·87	27·24	30·42	33·60	34·05
	Mean	28·03	28·04	29·85	33·60	34·73
H	0590	25·42	25·42	26·79	31·78	34·05
	R7	28·15	28·15	30·87	30·87	34·50
	R235	27·69	27·24	30·87	34·50	35·87
	0480	33·14	31·78	35·41	39·95	39·50
	Mean	28·60	28·15	30·98	34·28	35·98

Final and Initial weights (kg) and gains in weight of live wt. components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in iso-caloric diets.

Group	Lamb No.	Live wt.			S.E.B.			Warm carcass			Pelt		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	32·69	25·88	6·81	21·85	16·51	5·34	14·30	10·10	4·20	3·52	2·44	1·08
	B259	34·50	27·24	7·26	23·23	17·28	5·95	14·71	10·62	4·09	3·41	"	0·97
	B257	33·14	29·06	4·08	22·99	18·30	4·69	14·41	11·32	3·09	3·86	"	1·42
	R82	35·87	30·42	5·45	25·19	19·07	6·12	16·57	11·84	4·73	3·41	"	0·97
	Mean	34·05	28·15	5·90	23·32	17·79	5·53	15·00	10·97	4·03	3·55	"	1·11
M	0481	33·60	25·42	8·18	22·96	16·26	6·70	14·39	9·92	4·47	3·86	"	1·42
	0482	34·05	26·33	7·72	22·75	16·77	5·98	14·41	10·27	4·14	4·09	"	1·65
	0670	37·23	29·51	7·72	24·54	18·55	5·99	15·02	11·49	3·53	4·09	"	1·65
	0664	34·05	30·87	3·18	23·75	19·32	4·43	14·87	12·01	2·86	3·86	"	1·42
	Mean	34·73	28·03	6·70	23·54	17·72	5·78	14·67	10·92	3·75	3·97	"	1·53
H	0590	34·05	25·42	8·63	23·35	16·26	7·09	15·08	9·92	5·16	3·86	"	1·42
	R7	34·50	28·15	6·35	24·92	17·79	7·13	16·21	10·97	5·24	3·06	"	0·62
	R235	35·87	27·69	8·18	25·59	17·53	8·06	16·49	10·79	5·70	4·09	"	1·65
	0480	39·50	33·14	6·36	27·59	20·59	7·00	18·06	12·89	5·17	4·31	"	1·87
	Mean	35·98	28·60	7·38	25·36	18·04	7·32	16·46	11·14	5·32	3·83	"	1·39

Final and Initial weights (kg) and gains in weight of live wt. components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in iso-caloric diets.

Group	Lamb No.	Gut "fill"			Blood			Feet			Head		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	6·50	5·92	0·58	1·11	1·08	0·03	0·72	0·57	0·15	1·82	1·39	0·43
	B259	6·89	6·28	0·61	1·32	"	0·24	0·76	"	0·19	1·86	"	1·47
	B257	5·77	6·75	-0·98	1·10	"	0·02	0·66	"	0·09	1·93	"	0·54
	R82	6·50	7·11	-0·61	1·42	"	0·34	0·70	"	0·13	1·93	"	0·54
	Mean	6·41	6·52	-0·11	1·24	"	0·16	0·71	"	0·14	1·88	"	0·49
M	0481	5·98	5·80	0·18	4·22	"	0·14	0·75	"	0·18	1·95	"	0·56
	0482	6·33	6·04	0·29	1·22	"	0·14	0·78	"	0·21	1·93	"	0·54
	0670	7·91	6·87	1·04	1·35	"	0·27	0·87	"	0·30	2·68	"	1·29
	0664	5·78	7·23	-1·45	1·15	"	0·07	0·69	"	0·12	1·93	"	0·54
	Mean	6·50	6·49	0·01	1·23	"	0·15	0·77	"	0·20	2·12	"	0·73
H	0590	5·96	5·80	0·16	1·35	"	0·27	0·77	"	0·20	1·95	"	0·56
	R7	6·28	6·52	-0·24	1·50	"	0·42	0·76	"	0·19	1·95	"	0·56
	R235	5·50	6·40	-0·90	1·41	"	0·33	0·86	"	0·29	2·13	"	0·74
	0480	6·49	7·82	-1·33	1·58	"	0·50	0·84	"	0·27	2·15	"	0·76
	Mean	6·06	6·63	-0·57	1·46	"	0·38	0·81	"	0·24	2·05	"	0·66

Final and Initial weights (kg) and gains in weight of live wt. components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Pluck			Gut			Caul fat		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	1·27	1·10	0·17	1·85	2·10	-0·25	0·79	0·63	0·16
	B259	1·35	"	0·25	2·33	"	0·23	0·96	"	0·27
	B257	1·32	"	0·22	2·27	"	0·17	1·31	"	0·68
	R82	1·34	"	0·24	2·16	"	0·06	1·08	"	0·45
	Mean	1·32	"	0·22	2·15	"	0·05	1·02	"	0·39
M	0481	1·27	"	0·17	2·04	"	-0·06	1·35	"	0·72
	0482	1·31	"	0·21	2·49	"	0·39	0·62	"	-0·01
	0670	1·47	"	0·37	2·40	"	0·30	0·75	"	0·12
	0664	1·48	"	0·38	1·91	"	-0·19	1·73	"	1·10
	Mean	1·38	"	0·28	2·21	"	0·11	1·11	"	0·48
H	0590	1·44	"	0·34	2·08	"	-0·02	0·68	"	0·05
	R7	1·43	"	0·33	2·27	"	0·17	0·80	"	0·17
	R235	1·55	"	0·45	2·31	"	0·21	0·85	"	0·22
	0480	1·61	"	0·51	2·39	"	0·29	0·98	"	0·35
	Mean	1·51	"	0·41	2·26	"	0·16	0·83	"	0·20

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Group	Lamb No.	Total fat			Total muscle			Total bone			Gigot		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	1·20	0·84	0·36	3·97	2·84	1·13	1·52	1·25	0·27	2·42	1·69	0·73
	B259	1·47	"	0·63	4·12	2·99	1·13	1·59	"	0·34	2·41	1·75	0·66
	B257	1·68	"	0·84	3·72	3·19	0·53	1·48	"	0·23	2·36	1·84	0·52
	R82	1·74	"	0·90	4·71	3·34	1·37	1·44	"	0·19	2·58	1·90	0·68
	Mean	1·52	"	0·68	4·13	3·09	1·04	1·51	"	0·26	2·44	1·79	0·65
M	0481	1·50	"	0·66	3·99	2·79	1·20	1·44	"	0·19	2·14	1·66	0·48
	0482	1·24	"	0·40	4·06	2·89	1·17	1·59	"	0·34	2·43	1·71	0·72
	0670	1·11	"	0·27	4·40	3·24	1·16	1·67	"	0·42	2·47	1·86	0·61
	0664	1·64	"	0·80	4·09	3·39	0·70	1·63	"	0·38	2·42	1·92	0·50
	Mean	1·37	"	0·53	4·14	3·07	1·06	1·58	"	0·33	2·37	1·79	0·58
H	0590	1·31	"	0·47	4·01	2·79	1·22	1·78	"	0·53	2·48	1·66	0·82
	R7	1·33	"	0·49	4·69	3·09	1·60	1·57	"	0·32	2·69	1·79	0·90
	R235	0·96	"	0·12	4·78	3·04	1·74	1·91	"	0·66	2·79	1·77	1·02
	0480	1·77	"	0·93	4·77	3·64	1·13	1·95	"	0·70	2·85	2·03	0·82
	Mean	1·34	"	0·50	4·56	3·15	1·42	1·80	"	0·55	2·70	1·81	0·89

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Group	Lamb No.	Shoulder			Loin			Rib			Kidney and perirenal fat		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	2·45	1·80	0·65	0·85	0·67	0·18	0·83	0·65	0·18	0·21	0·17	0·04
	B259	2·81	1·89	0·92	0·86	"	0·19	0·88	"	0·23	0·27	"	0·10
	B257	2·71	2·02	0·69	0·82	"	0·15	0·85	"	0·20	0·22	"	0·05
	R82	2·98	2·12	0·86	0·98	"	0·31	1·12	"	0·47	0·30	"	0·13
	Mean	2·74	1·96	0·78	0·88	"	0·21	0·92	"	0·27	0·25	"	0·08
M	0481	2·80	1·76	1·04	0·89	"	0·22	0·93	"	0·28	0·21	"	0·04
	0482	2·70	1·83	0·87	0·83	"	0·16	0·84	"	0·19	0·14	"	-0·03
	0670	2·88	2·06	0·82	0·85	"	0·18	0·86	"	0·21	0·16	"	-0·01
	0664	2·83	2·15	0·68	0·88	"	0·21	0·92	"	0·27	0·35	"	0·18
	Mean	2·80	1·95	0·85	0·86	"	0·19	0·89	"	0·24	0·22	"	0·05
H	0590	2·67	1·76	0·91	0·84	"	0·17	0·92	"	0·27	0·22	"	0·05
	R7	2·97	1·96	1·01	0·91	"	0·24	0·87	"	0·22	0·20	"	0·03
	R235	2·95	1·93	1·02	0·93	"	0·26	0·86	"	0·21	0·15	"	-0·02
	0480	3·32	2·31	1·01	0·99	"	0·32	1·15	"	0·50	0·24	"	0·07
	Mean	2·98	1·99	0·99	0·92	"	0·25	0·95	"	0·30	0·20	"	0·03

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Group	Lamb No.	Brisket			Neck			Shank			Flank (gigot)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	0·29	0·19	0·10	0·28	0·16	0·12	0·28	0·27	0·01	0·07	0·05	0·02
	B259	0·30	0·21	0·09	0·36	"	0·20	0·34	0·28	0·06	0·06	"	0·01
	B257	0·37	0·24	0·13	0·29	"	0·13	0·37	0·31	0·06	0·08	"	0·03
	R82	0·35	0·26	0·09	0·34	"	0·18	0·41	0·33	0·08	0·07	"	0·02
	Mean	0·33	0·23	0·10	0·32	"	0·16	0·35	0·30	0·05	0·07	"	0·02
M	0481	0·34	0·19	0·15	0·39	"	0·23	0·31	0·26	0·05	0·06	"	0·01
	0482	0·27	0·20	0·07	0·29	"	0·13	0·38	0·27	0·11	0·06	"	0·01
	0670	0·35	0·24	0·11	0·34	"	0·18	0·42	0·31	0·11	0·08	"	0·02
	0664	0·30	0·26	0·04	0·39	"	0·23	0·37	0·33	0·04	0·09	"	0·04
	Mean	0·32	0·22	0·10	0·35	"	0·19	0·37	0·28	0·08	0·07	"	0·02
H	0590	0·26	0·19	0·07	0·31	"	0·15	0·36	0·26	0·10	0·07	"	0·02
	R7	0·31	0·22	0·09	0·32	"	0·16	0·34	0·30	0·04	0·07	"	0·02
	R235	0·38	0·22	0·16	0·32	"	0·16	0·45	0·29	0·16	0·07	"	0·02
	0480	0·42	0·29	0·13	0·38	"	0·22	0·42	0·36	0·06	0·08	"	0·03
	Mean	0·34	0·23	0·11	0·33	"	0·17	0·39	0·30	0·09	0·07	"	0·02

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

	Lamb No.	Flank (loin)			Flank (rib)			Fat (gigot)			Muscle (gigot)		
		Final	Init-	Gain	Final	Ini-	Gain	Final	Ini-	Gain	Final	Ini-	Gain
L	B234	0·13	0·10	0·03	0·34	0·25	0·09	0·29	0·21	0·08	1·62	1·13	0·49
	B259	0·14	"	0·04	0·35	"	0·10	0·34	"	0·13	1·54	1·18	0·36
	B257	0·18	"	0·08	0·35	"	0·10	0·42	"	0·21	1·47	1·24	0·23
	R82	0·16	"	0·06	0·50	"	0·25	0·38	"	0·17	1·74	1·28	0·46
	Mean	0·15	"	0·05	0·39	"	0·14	0·36	"	0·15	1·59	1·21	0·38
M	0481	0·18	"	0·08	0·39	"	0·14	0·33	"	0·12	1·42	1·11	0·31
	0482	0·13	"	0·03	0·33	"	0·08	0·38	"	0·17	1·57	1·15	0·42
	0670	0·16	"	0·06	0·37	"	0·12	0·33	"	0·12	1·65	1·25	0·40
	0664	0·12	"	0·02	0·36	"	0·11	0·37	"	0·16	1·58	1·30	0·28
	Mean	0·15	"	0·05	0·36	"	0·11	0·35	"	0·14	1·56	1·20	0·36
H	0590	0·14	"	0·04	0·36	"	0·11	0·32	"	0·11	1·60	1·11	0·49
	R7	0·13	"	0·03	0·33	"	0·08	0·34	"	0·13	1·84	1·21	0·63
	R235	0·17	"	0·07	0·36	"	0·11	0·25	"	0·04	1·88	1·19	0·69
	0480	0·14	"	0·04	0·47	"	0·22	0·39	"	0·18	1·87	1·38	0·49
	Mean	0·15	"	0·05	0·38	"	0·13	0·33	"	0·12	1·80	1·22	0·58

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

	Lamb No.	Bone (gigot)			Fat (shoulder)			Muscle (shoulder)			Bone (shoulder)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	0·48	0·37	0·11	0·39	0·29	0·10	1·35	0·97	0·38	0·68	0·55	0·13
	B259	0·51	"	0·14	0·47	"	0·18	1·62	1·04	0·58	0·71	"	0·16
	B257	0·45	"	0·08	0·59	"	0·30	1·43	1·14	0·29	0·66	"	0·11
	R82	0·44	"	0·07	0·58	"	0·29	1·72	1·21	0·51	0·67	"	0·12
	Mean	0·47	"	0·10	0·51	"	0·22	1·53	1·09	0·44	0·68	"	0·13
M	0481	0·38	"	0·01	0·61	"	0·32	1·55	0·94	0·61	0·63	"	0·08
	0482	0·46	"	0·09	0·40	"	0·11	1·54	0·99	0·55	0·75	"	0·20
	0670	0·48	"	0·11	0·38	"	0·09	1·69	1·16	0·53	0·80	"	0·25
	0664	0·46	"	0·09	0·51	"	0·22	1·55	1·24	0·31	0·75	"	0·20
	Mean	0·45	"	0·08	0·48	"	0·19	1·58	1·08	0·50	0·73	"	0·18
H	0590	0·55	"	0·18	0·44	"	0·15	1·46	0·94	0·52	0·77	"	0·22
	R7	0·50	"	0·13	0·46	"	0·17	1·74	1·09	0·65	0·76	"	0·21
	R235	0·66	"	0·29	0·35	"	0·06	1·78	1·07	0·71	0·81	"	0·26
	0480	0·59	"	0·22	0·64	"	0·35	1·78	1·36	0·42	0·87	"	0·32
	Mean	0·57	"	0·20	0·47	"	0·18	1·69	1·11	1·58	0·80	"	0·25

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Group	Lamb No.	Fat (loin)			Muscle (loin)			Bone (loin)			Fat (rib)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	0·19	0·09	0·10	0·51	0·42	0·09	0·14	0·16	-0·02	0·16	0·13	-0·03
	B259	0·21	"	0·12	0·50	"	0·08	0·15	"	-0·01	0·23	"	0·10
	B257	0·24	"	0·15	0·43	"	0·01	0·14	"	-0·02	0·24	"	0·11
	R82	0·24	"	0·15	0·61	"	0·19	0·12	"	-0·04	0·28	"	0·15
	Mean	0·22	"	0·13	0·51	"	0·09	0·14	"	-0·02	0·23	"	0·10
M	0481	0·20	"	0·11	0·52	"	0·10	0·17	"	0·01	0·20	"	0·07
	0482	0·18	"	0·09	0·48	"	0·06	0·07	"	0·01	0·19	"	0·06
	0670	0·16	"	0·07	0·55	"	0·13	0·15	"	-0·01	0·14	"	0·01
	0664	0·20	"	0·11	0·48	"	0·06	0·19	"	0·03	0·25	"	0·12
	Mean	0·19	"	0·10	0·51	"	0·09	0·17	"	0·01	0·20	"	0·07
H	0590	0·20	"	0·11	0·43	"	0·01	0·21	"	0·05	0·20	"	0·07
	R7	0·19	"	0·10	0·57	"	0·15	0·14	"	-0·02	0·20	"	0·07
	R235	0·13	"	·004	0·58	"	0·16	0·21	"	0·05	0·12	"	-0·01
	0480	0·24	"	0·15	0·55	"	0·13	0·18	"	0·02	0·31	"	0·18
	Mean	0·19	"	0·10	0·53	"	0·11	0·19	"	0·03	0·21	"	0·08

Final and Initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets.

Group	Lamb No.	Muscle (rib)			Bone (rib)			Perirenal fat			Muscle (kidney)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	0·45	0·33	0·12	0·21	0·19	0·02	0·19	0·13	0·04	0·04	0·04	0·00
	B259	0·42	"	0·09	0·22	"	0·03	0·22	"	0·09	0·04	"	0·00
	B257m	0·37	"	0·04	0·23	"	0·04	0·19	"	0·06	0·04	"	0·00
	R82	0·61	"	0·28	0·22	"	0·03	0·26	"	0·13	0·04	"	0·00
	Mean	0·46	"	0·13	0·22	"	0·03	0·21	"	0·08	0·04	"	0·00
M	0481	0·45	"	0·12	0·26	"	0·07	0·16	"	0·03	0·04	"	0·00
	0482	0·44	"	0·11	0·21	"	0·02	0·10	"	-0·03	0·04	"	0·00
	0670	0·46	"	0·13	0·25	"	0·06	0·11	"	-0·02	0·05	"	0·01
	0664	0·44	"	0·11	0·23	"	0·04	0·31	"	0·18	0·04	"	0·00
	Mean	0·45	"	0·12	0·24	"	0·05	0·17	"	0·04	0·04	"	0·00
H	0590	0·46	"	0·13	0·25	"	0·06	0·16	"	0·03	0·06	"	0·02
	R7	0·50	"	0·17	0·17	"	-0·02	0·15	"	0·02	0·05	"	0·01
	R235	0·50	"	0·17	0·24	"	0·05	0·11	"	-0·02	0·05	"	0·01
	0480	0·51	"	0·18	0·32	"	0·13	0·19	"	0·06	0·05	"	0·01
	Mean	0·49	"	0·16	0·25	"	0·06	0·15	"	0·02	0·05	"	0·01

The gains in carcass measurements of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Area of M.l.d.(i)			Fat - thickness(ii)		
		Final	Initial	Gain	Final	Initial	Gain
L	B234	8·80	8·78	0·02	1·50	1·83	-10·33
	B259	9·13	"	0·35	1·75	"	-0·08
	B257	8·97	"	0·19	3·00	"	1·17
	R82	11·01	"	2·23	2·00	"	0·17
	Mean	9·48	"	0·70	2·06	"	0·23
M	0481	9·90	"	1·12	2·00	"	0·17
	0482	9·97	"	1·19	1·50	"	-0·33
	0670	10·60	"	1·82	1·50	"	-0·33
	0664	9·97	"	1·19	2·50	"	0·67
	Mean	10·11	"	1·33	1·88	"	0·05
H	0590	10·83	"	2·05	2·00	"	0·17
	R7	13·60	"	4·82	2·00	"	0·17
	R235	13·73	"	4·95	1·50	"	-0·33
	0480	12·53	"	3·75	2·50	"	0·67
	Mean	12·67	"	3·89	2·00	"	0·17

(i) M. longissimus dorsi at the 12th rib in sq. cm

(ii) Fat-thickness over M. longissimus dorsi at the 12th rib in mm

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	M. obliquus .... + M. transversus			M. semitendinosus			M. semimembranosus			M. gastrocnemius		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	148	116	32	80	49	31	239	154	85	110	88	22
	B259	148	"	32	79	"	30	212	"	58	102	"	14
	B257	125	"	9	62	"	13	218	"	64	97	"	9
	R82	158	"	42	84	"	35	240	"	86	120	"	32
	Mean	145	"	29	76	"	27	227	"	73	107	"	19
M	0481	149	"	33	64	"	15	187	"	33	99	"	11
	0482	138	"	22	79	"	30	216	"	62	105	"	17
	0670	159	"	43	85	"	36	203	"	49	103	"	15
	0664	146	"	30	74	"	25	225	"	71	97	"	9
	Mean	148	"	32	76	"	27	208	"	54	101	"	13
H	0590	125	"	9	71	"	22	214	"	60	113	"	25
	R7	159	"	43	78	"	29	235	"	81	135	"	47
	R235	170	"	54	86	"	37	265	"	111	140	"	52
	0480	169	"	53	94	"	45	255	"	101	132	"	44
	Mean	156	"	40	82	"	33	242	"	88	130	"	42

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	M. quadriceps			M. gluteus medius			M. extensor digitorum			M. psoas major		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	285	225	60	141	107	34	25	21	4	49	31	18
	B259	251	233	18	131	"	24	27	"	6	44	"	13
	B257	282	244	38	127	"	20	25	"	4	41	"	10
	R82	305	253	52	139	"	32	27	"	6	49	"	18
	Mean	281	239	42	135	"	28	26	"	5	46	"	15
M	0481	298	223	75	111	"	4	26	"	5	40	"	9
	0482	280	228	52	136	"	29	28	"	7	44	"	13
	0670	297	247	50	117	"	10	27	"	6	44	"	13
	0664	276	255	21	136	"	29	26	"	5	46	"	15
	Mean	288	238	50	125	"	18	27	"	6	44	"	13
H	0590	270	233	47	126	"	19	26	"	5	44	"	13
	R7	332	239	93	162	"	55	30	"	9	50	"	19
	R235	341	239	102	151	"	44	31	"	10	49	"	18
	0480	370	269	101	171	"	64	32	"	11	57	"	26
	Mean	328	242	86	153	"	46	30	"	9	50	"	19

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	M.l.d. (loin)(i)			M.l.d. (rib)(i)			Mm. petoralis			M. biceps		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	263	173	90	112	79	33	134	88	46	24	19	5
	B259	228	"	55	112	"	33	131	"	43	23	"	4
	B257	186	"	13	95	"	16	145	"	57	23	"	4
	B82	299	"	126	112	"	33	145	"	57	28	"	9
	Mean	244	"	71	108	"	29	139	"	51	25	"	6
M	0481	245	"	72	98	"	19	139	"	51	24	"	5
	0482	250	"	77	115	"	36	133	"	45	26	"	7
	0670	255	"	82	117	"	38	136	"	48	28	"	9
	0664	216	"	73	106	"	27	146	"	58	25	"	6
	Mean	249	"	76	109	"	30	139	"	51	26	"	7
H	0590	229	"	56	105	"	26	128	"	40	25	"	6
	R7	292	"	119	129	"	50	137	"	49	26	"	7
	R235	290	"	117	130	"	51	147	"	59	26	"	7
	0480	319	"	146	150	"	71	155	"	67	30	"	11
	Mean	283	"	110	129	"	50	142	"	54	27	"	8

(i) M. longissimus dorsi

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	M. bra chialis			M. extensor carpi....			M. infraspinatus			M. supraspinatus		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	17	13	4	25	23	2	80	74	6	90	80	10
	B259	21	"	8	31	"	8	84	"	10	100	"	20
	B257	17	"	4	29	"	6	87	"	13	90	"	10
	R82	18	"	5	31	"	8	98	"	24	101	"	21
	Mean	18	"	5	29	"	6	87	"	13	95	"	15
M	0481	16	"	3	28	"	5	88	"	14	91	"	11
	0482	17	"	4	30	"	7	90	"	16	95	"	15
	0670	20	"	7	31	"	8	98	"	24	112	"	32
	0664	16	"	3	31	"	8	85	"	11	93	"	13
	Mean	17	"	4	30	"	7	90	"	16	98	"	18
H	0590	18	"	5	30	"	7	92	"	18	106	"	26
	R7	17	"	4	31	"	8	105	"	31	105	"	25
	R235	17	"	4	35	"	12	98	"	24	107	"	27
	0480	20	"	7	35	"	12	108	"	34	110	"	30
	Mean	18	"	5	33	"	10	101	"	27	107	"	27

Final and initial weights (kg) and gains in weight in chemical components of fatty tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Dry matter			Ether extract			Crude protein			Gross energy (Mcal)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	0·88	0·65	0·23	0·74	0·56	0·18	0·11	0·07	0·04	7·64	5·70	1·94
	B259	1·17	"	0·52	1·07	"	0·51	0·08	"	0·01	10·48	"	4·78
	B257	1·35	"	0·70	1·25	"	0·69	0·08	"	0·01	12·21	"	6·51
	R82	1·38	"	0·73	1·25	"	0·69	0·12	"	0·05	12·34	"	6·64
	Mean	1·20	"	0·55	1·08	"	0·52	0·10	"	0·03	10·67	"	4·97
M	0481	1·09	"	0·44	0·96	"	0·40	0·12	"	0·05	9·72	"	4·02
	0482	0·93	"	0·28	0·85	"	0·29	0·09	"	0·02	8·31	"	2·61
	0670	0·83	"	0·18	0·72	"	0·16	0·10	"	0·03	7·27	"	1·57
	0664	1·29	"	0·64	1·18	"	0·62	0·12	"	0·05	11·64	"	5·94
	Mean	1·03	"	0·38	0·93	"	0·37	0·11	"	0·04	9·23	"	3·53
H	0590	0·93	"	0·28	0·79	"	0·23	0·11	"	0·04	8·20	"	2·50
	R7	1·03	"	0·38	0·96	"	0·40	0·09	"	0·02	9·41	"	3·71
	R235	0·70	"	0·05	0·59	"	0·03	0·10	"	0·03	6·05	"	0·35
	0480	1·33	"	0·68	1·15	"	0·59	0·15	"	0·08	11·74	"	6·04
	Mean	1·00	"	0·35	0·87	"	0·31	0·11	"	0·04	8·85	"	3·15

Final and initial weights (kg) and gains in weight in chemical components of muscle tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Dry matter			Ether extract			Crude protein			Gross energy (Mcal)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
L	B234	1·16	0·96	0·20	0·24	0·31	-0·07	0·76	0·58	0·18	7·21	6·39	0·82
	B259	1·27	"	0·31	0·33	"	0·02	0·77	"	0·19	8·17	"	1·78
	B257	1·19	"	0·23	0·41	"	0·10	0·67	"	0·09	8·12	"	1·73
	R82	1·48	"	0·52	0·43	"	0·12	0·78	"	0·20	9·70	"	3·31
	Mean	1·28	"	0·32	0·35	"	0·04	0·75	"	0·17	8·30	"	1·91
M	0481	1·16	"	0·20	0·38	"	0·07	0·75	"	0·17	7·76	"	1·37
	0482	1·06	"	0·10	0·26	"	-0·05	0·74	"	0·16	6·79	"	0·40
	0670	1·24	"	0·28	0·30	"	-0·01	0·79	"	0·21	7·87	"	1·48
	0664	1·15	"	0·19	0·34	"	0·03	0·78	"	0·20	7·60	"	1·21
	Mean	1·15	"	0·19	0·32	"	0·01	0·77	"	0·19	7·51	"	1·12
H	0590	1·22	"	0·26	0·24	"	-0·07	0·79	"	0·21	7·56	"	1·17
	R7	1·38	"	0·42	0·44	"	0·13	0·90	"	0·32	9·21	"	2·82
	R235	1·32	"	0·36	0·24	"	-0·07	0·90	"	0·32	8·22	"	1·83
	0480	1·33	"	0·37	0·14	"	-0·17	0·94	"	0·36	7·73	"	1·34
Mean		1·31	"	0·35	0·27	"	-0·04	-·88	"	0·30	8·18	"	1·79

The chemical composition of the fatty and muscle tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Fatty tissue			Muscle tissue		
		DM %	EE %	CP %	DM %	EE %	CP %
L	B234	72·0	60·4	8·9	29·6	6·5	19·2
	B259	87·8	72·5	6·0	31·3	8·1	18·6
	B257	79·4	73·4	5·5	32·3	11·3	18·2
	R82	78·2	70·9	6·9	31·8	9·5	17·0
	Mean	77·1	69·3	6·8	31·3	8·9	18·3
M	0481	71·1	62·6	8·6	29·2	9·7	18·6
	0482	73·3	65·6	7·8	26·8	6·7	18·6
	0670	73·7	63·1	9·2	28·6	7·3	18·1
	0664	79·0	72·1	6·9	28·8	9·2	18·7
	Mean	74·3	65·9	8·1	28·4	8·2	18·5
H	0590	71·7	61·2	9·1	31·1	6·6	19·6
	R7	77·3	70·7	6·8	29·8	8·6	19·2
	R235	70·5	58·8	10·7	28·2	4·9	18·9
	0480	74·7	64·0	8·8	28·3	3·0	19·5
	Mean	73·6	63·7	8·9	29·4	5·8	19·3

Percentage of DM in the muscle and fatty tissues of various parts of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Muscle tissue				Fatty tissue				M.l.d. (i)	Gut + Pluck
		Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
L	B234	28·02	32·46	28·06	29·78	75·97	68·86	66·87	76·12	25·88	34·22
	B259	30·11	31·95	29·78	33·15	82·52	78·28	75·00	79·45	25·30	38·13
	B257	31·55	34·30	30·59	32·85	82·49	75·15	76·36	83·73	26·02	34·06
	R82	28·85	31·92	33·59	32·82	76·79	77·94	76·67	81·30	26·22	35·56
	Mean	29·64	32·66	30·51	32·15	71·44	75·06	73·73	80·15	25·86	35·49
M	0481	27·81	31·55	30·97	26·46	66·98	68·82	70·78	77·69	28·67	37·68
	0482	24·57	28·64	27·83	25·95	72·42	72·57	67·54	80·47	25·13	33·63
	0670	25·76	30·51	27·53	30·76	75·65	70·54	72·94	75·54	26·39	30·76
	0664	26·30	29·87	27·09	31·81	78·80	78·86	79·34	78·89	25·71	42·26
	Mean	26·11	30·14	28·36	28·75	73·46	72·70	72·65	78·15	26·48	36·08
H	0590	27·80	31·99	31·69	32·81	75·79	70·76	69·51	70·55	25·87	31·45
	R7	28·88	29·61	28·73	31·80	77·47	72·47	76·35	82·90	26·50	32·95
	R235	26·35	28·69	29·39	28·34	71·97	65·22	69·62	75·22	25·45	32·15
	0480	27·14	29·61	28·00	28·47	75·24	73·21	72·82	77·43	25·77	33·92
	Mean	27·54	29·98	29·45	30·36	75·12	70·42	72·08	76·53	25·90	32·62

(i) M. longissimus dorsi (in rib area)

Percentage of EE in the muscle and fatty tissues of various parts of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Muscle tissue				Fatty tissue				(i) M.l.d.	Gut + Pluck
		Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
L	B234	4·42	7·73	6·31	7·59	61·55	58·05	54·75	67·34	3·87	21·18
	B259	7·17	8·43	8·16	8·54	77·81	70·64	68·20	73·46	3·18	25·73
	B257	11·21	12·30	10·09	11·73	77·73	66·83	69·66	79·33	3·08	22·16
	R82	5·88	9·21	11·55	11·51	68·52	70·85	69·62	74·50	2·88	22·61
	Mean	7·17	9·42	9·03	9·84	71·40	66·59	65·56	73·66	3·25	22·92
M	0481	7·91	11·56	13·03	6·15	56·82	59·46	62·81	71·30	5·72	24·71
	0482	4·29	7·70	8·78	5·95	63·26	63·06	60·04	76·14	1·78	20·49
	0670	6·25	11·08	6·22	5·79	66·34	56·24	63·94	66·04	4·70	17·16
	0664	6·08	10·02	8·24	12·33	72·07	70·88	73·47	71·84	2·69	30·88
	Mean	6·13	10·09	9·07	7·56	64·62	62·41	65·07	71·33	3·72	23·31
H	0590	4·51	8·60	5·69	7·67	65·43	59·37	60·89	59·19	3·12	17·69
	R7	12·07	8·04	7·84	6·59	69·91	65·01	69·62	78·31	2·77	18·92
	R235	5·42	7·61	2·92	3·80	60·68	50·98	58·89	64·66	1·76	18·12
	0480	4·01	4·14	1·09	2·75	62·75	63·59	60·69	68·91	2·57	19·67
	Mean	6·50	7·10	4·39	5·20	64·69	59·74	62·52	67·77	2·55	18·60

(i) M. longissimus dorsi (in rib area)

Percentage of CP in the muscle and fatty tissues of various parts of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Muscle tissue				Fatty tissue				M.l.d. (i)	Gut + Pluck
		Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
L	B234	19·68	20·07	18·21	18·67	9·73	6·86	10·44	8·47	20·75	9·48
	B259	19·81	19·01	17·61	17·97	4·53	7·14	6·60	5·80	20·65	9·92
	B257	18·27	18·33	17·83	18·45	3·72	7·43	6·15	4·55	21·40	9·39
	R82	16·00	17·00	17·85	17·26	7·86	6·14	6·74	6·76	21·47	10·63
	Mean		18·60	17·88	18·09	6·46	6·89	7·48	6·40	21·07	9·86
M	0481	18·74	17·96	18·70	19·08	10·10	9·55	8·08	6·58	21·85	10·19
	0482	18·49	19·30	17·85	18·57	9·67	9·25	8·12	4·19	19·28	10·95
	0670	18·81	17·98	17·29	18·10	7·94	12·28	8·40	8·02	23·51	11·59
	0664	19·91	18·15	17·36	19·18	7·10	6·61	5·84	8·22	21·64	9·10
	Mean	18·99	18·35	17·80	18·73	8·70	9·42	6·91	6·30	21·57	10·46
H	0590	20·42	18·88	19·52	19·48	9·16	9·12	8·14	9·92	20·50	11·16
	R7	18·39	17·25	22·32	18·77	7·39	8·10	6·64	5·06	29·53	11·85
	R235	19·28	19·32	17·42	19·59	10·37	12·77	10·01	9·74	21·89	11·69
	0480	19·38	16·38	20·08	22·26	9·62	8·83	9·00	7·79	21·57	11·36
	Mean	19·37	17·96	19·84	20·03	9·14	9·71	8·45	8·13	21·62	11·52

(i) M. longissimus dorsi (in rib area)

The caloric values* (Kcal/100 g fresh matter) of the muscle and fatty tissues of Blackface wether lambs fed different levels of daily intake of DCP in isocaloric diets

Group	Lamb No.	Muscle tissue				Fatty tissue				M.l.d.(i)	Gut + Pluck
		Gigot	Rib + Loin	Shoulder	Sec. cuts	Gigot	Rib + Loin	Shoulder	Sec. cuts		
L	B234	169·19	206·24	176·83	191·16	653·04	600·78	577·06	676·55	155·44	268·50
	B259	191·30	206·22	193·39	213·15	752·28	701·19	673·85	718·59	149·59	307·53
	B257	214·94	242·53	205·35	224·03	751·80	669·28	686·93	764·79	153·10	271·47
	R82	179·42	209·11	227·34	223·00	684·80	700·17	688·46	732·69	156·10	281·37
	Mean	188·76	213·94	200·76	212·83	710·46	667·86	656·61	723·16	152·91	282·20
M	0481	181·74	216·31	218·93	167·52	585·77	606·09	629·85	700·57	177·81	301·09
	0482	149·99	181·62	185·26	163·97	640·50	640·52	601·42	734·92	143·19	262·60
	0670	164·12	208·80	173·59	189·42	670·08	602·79	643·98	668·30	161·46	233·98
	0664	166·38	201·18	179·13	220·74	709·61	705·27	718·03	709·20	149·89	350·10
	Mean	165·54	202·91	189·26	185·46	651·46	638·68	648·83	703·18	158·10	286·93
H	0590	168·35	207·09	194·06	207·90	667·27	616·25	615·43	614·41	152·45	239·80
	R7	203·84	192·00	186·56	198·19	693·94	647·62	686·73	756·30	154·49	252·75
	R235	168·94	185·33	170·74	168·50	627·94	553·33	608·19	661·16	144·84	245·28
	0480	162·81	164·96	156·30	165·09	653·79	646·07	632·58	689·80	149·74	260·96
	Mean	174·75	187·38	176·83	184·94	660·73	615·86	635·76	680·34	150·38	249·71

* Calculated from the chemical composition (fat-free dry matter and ether extract) of these components.
The caloric value for 1 g fat-free dry matter = 5·42 Kcal
The caloric value for 1 g ether extract = 9·34 Kcal

(i) M. longissimus dorsi (in rib area)

A P P E N D I X VIII

Data pertaining to Experiment II

The chemical composition of the foodstuffs used in the energy level experiment (fresh basis)

%	Foodstuff			
	Soyabean meal	Bruised barley	Hay	Molassine* meal
Dry matter	86·85	85·63	85·49	78·48
Crude protein	47·16	9·92	8·81	6·79
Ether extract	0·67	1·60	0·92	0·16
Crude fibre	6·34	4·94	28·06	5·44
Total ash	5·77	2·31	7·18	17·52

Each figure is the mean value of these determinations

* Contains, approximately 75 per cent molasses and 25 per cent sphagnum moss.

The percentage digestibility for the diets used in the energy level experiment

Components	Diets											
	A				B				C			
	1	2	3	Mean	1	2	3	Mean	1	2	3	Mean
DM	74·61	73·25	73·78	73·71	76·18	76·25	76·58	76·34	72·31	76·81	73·68	74·27
CP	78·24	77·15	75·34	76·91	73·67	75·79	74·43	74·63	67·00	67·57	68·14	67·57
OM	78·10	75·95	77·19	77·08	78·96	79·11	79·47	79·18	74·93	79·03	75·69	76·55
ME	67·60	65·25	65·88	66·24	67·27	68·46	69·08	68·27	66·67	70·87	67·31	68·28

The analysis of variance of the percentage of digestible crude protein in the diets of experiment II

Source	d.f.	s.s.	m.s.	F
Treatments	2	142	71·0	40·57**
Replicates	2	1	0·5	0·29
Error	4	7	1·8	
Total	8	150		

** Significant at $p < 0·01$

L.S.D. between treatments means = 3·08 (p·05)

L.S.D. between treatments means = 5·11 (p·01)

The analysis of variance of the percentage of metabolizable energy in the diets of experiment II

Source	d.f.	s.s.	m.s.	F
Treatments	2	9	4·5	1·39 N.S.
Replicates	2	2	1·0	0·31
Error	4	13	3·3	
Total	8	24		

N.S. non-significant at $p < 0{\cdot}01$

Experiment II

Initial slaughter lambs slaughter data (kg)

Live wt. components	Lamb No.				
	517	519	P526	505	514
Live wt. (starved)	35·41	31·78	29·51	28·60	25·88
Pelt	3·06	3·40	3·06	2·95	3·18
Gut "fill"	5·08	2·73	4·90	5·05	3·39
S.E.B.	25·86	24·73	22·10	20·72	19·17
Components of S.E.B.:					
Warm carcass	16·54	16·28	13·62	12·90	11·77
Blood	1·24	1·40	1·37	1·29	1·20
Feet	0·67	0·69	0·67	0·66	0·58
Head	2·30	1·88	2·04	1·85	1·85
Pluck	1·69	1·41	1·37	1·33	1·17
Gut	2·33	1·65	2·26	2·13	1·93
Caul fat	1·09	1·41	0·75	0·56	0·66
Retail cuts:					
Gigot	2·72	2·69	2·27	2·21	1·90
Shoulder	2·89	2·88	2·40	2·34	2·03
Loin	0·93	0·99	0·67	0·60	0·83
Rib	1·05	1·14	0·84	0·80	0·76
Kidney plus perirenal fat	0·23	0·31	0·13	0·12	0·11
Brisket	0·34	0·40	0·28	0·28	0·22
Neck	0·32	0·19	0·26	0·23	0·24
Shank	0·39	0·37	0·38	0·38	0·27
Flank (gigot)	0·09	0·09	0·08	0·06	0·06
Flank (loin)	0·15	0·18	0·13	0·12	0·14
Flank (rib)	0·43	0·53	0·38	0·38	0·28
Major tissues (in ½ carcass):					
Fatty tissue	1·58	2·03	1·02	1·10	0·86
Muscle tissue	4·65	4·34	3·81	3·60	3·43
Bone tissue	1·56	1·58	1·41	1·32	1·30

Experiment II

Initial slaughter lambs slaughter data (kg)

Live wt. components	Lamb No.				
	517	519	P526	505	514
Major tissues in the retail cuts:					
Fat (gigot)	0·45	0·50	0·30	0·33	0·24
Muscle (")	1·79	1·69	1·49	1·40	1·28
Bone (")	0·48	0·49	0·47	0·47	0·37
Fat (shoulder)	0·54	0·60	0·41	0·45	0·27
Muscle (")	1·67	1·62	1·34	1·28	1·21
Bone (")	0·67	0·65	0·63	0·58	0·53
Fat (Loin)	0·18	0·31	0·11	0·11	0·15
Muscle (")	0·61	0·48	0·45	0·42	0·47
Bone (")	0·14	0·19	0·10	0·07	0·20
Fat (rib)	0·24	0·36	0·13	0·14	0·12
Muscle (")	0·54	0·51	0·49	0·46	0·43
Bone (")	0·26	0·25	0·21	0·19	0·20
Fat (kidney)	0·18	0·26	0·08	0·08	0·07
Muscle (")	0·05	0·05	0·05	0·05	0·04
Carcass measurements:					
Area of M.l.d. (sq.cm)(i)	9·45	9·30	9·50	9·05	9·05
Fat thickness (mm)(ii)	2·5	4·0	2·0	2·0	1·8

(i) Area of M. longissimus dorsi at the 12th rib.

(ii) Fat thickness over M. longissimus dorsi at the 12th rib.

Experiment II

Initial slaughter lambs slaughter data (g)

Individual muscles	Lamb No.				
	517	519	P526	505	514
M. obliquus internus abdominis + M. transversus abdominis	180	150	166	160	125
M. semitendinosus	77	81	61	56	57
M. semimembranosus	225	225	200	179	181
M. gastrocnemius	116	120	117	109	85
M. quadriceps femoris	348	325	280	275	235
M. gluteus medius	167	150	122	123	115
M. extensor digitorum longus	28	30	25	25	22
M. psoas major	47	45	45	38	38
M. longissimus dorsi (loin)	222	226	160	150	175
M. " " (rib)	114	115	97	86	85
Mm. pectoralis profundus et superficialis	122	128	118	99	110
M. biceps brachii	25	24	21	21	18
M. brachialis	16	16	16	13	12
M. extensor carpi radialis	34	31	28	28	25
M. infraspinatus	104	97	82	75	70
M. superspinatus	106	100	80	80	75

Percentage of DM in the fatty and muscle tissues of the initial slaughter group of Blackface wether lambs

Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
	Prime	Sec.	Prime	Sec.	Fat	Muscle	
517	78·59	81·56	28·65	31·57	92·22	26·00	35·38
519	83·33	82·21	29·40	32·30	94·62	27·63	46·92
P526	76·90	78·79	28·58	32·72	87·50	27·77	33·11
505	78·39	80·74	27·75	31·63	90·78	28·75	29·73
514	78·74	77·18	28·98	34·09	89·42	26·40	34·75
Mean	79·19	80·10	28·67	32·54	90·91	27·31	35·98

Percentage of EE in the fatty and muscle tissues of the initial slaughter group of Blackface wether lambs

Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
	Prime	Sec.	Prime	Sec.	Fat	Muscle	
517	69·60	70·73	7·54	10·67	90·07	4·06	20·89
519	75·01	75·54	4·15	11·65	92·45	3·20	30·14
P526	64·98	64·98	7·27	12·27	83·02	3·23	15·40
505	63·58	72·61	6·18	9·17	88·59	5·10	14·52
514	61·50	64·24	6·42	12·66	86·45	2·39	18·75
Mean	66·93	69·62	6·31	11·28	88·12	3·60	19·94

Percentage of CP in the fatty and muscle tissues of the initial slaughter group of Blackface wether lambs

Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
	Prime	Sec.	Prime	Sec.	Fat	Muscle	
517	6·23	6·81	17·77	17·86	2·12	19·74	10·54
519	5·87	5·42	19·79	18·37	1·78	21·27	10·70
P526	8·13	8·25	19·12	18·66	3·83	21·11	11·50
505	8·02	5·80	18·61	18·51	2·08	20·07	11·77
514	9·65	8·53	19·54	18·32	2·70	20·99	11·63
Mean	7·58	6·96	18·97	18·34	2·50	20·63	11·23

Experiment II

The caloric values (Kcal/100 g fresh matter) of the fatty and muscle tissues of the initial slaughter group

Lamb No.	Fatty tissue		Muscle tissue	
	Prime	Sec.	Prime	Sec.
517	693·18	713·34	181·01	208·95
519	739·85	736·09	171·33	216·73
P526	665·71	675·65	179·56	221·44
505	667·92	716·58	175·81	203·24
514	661·40	664·21	178·25	230·20
Mean	685·61	701·12	177·19	216·11

The caloric value for fat-free dry matter = 5·26 Kcal/g

The caloric value for ether extract = 9·28 Kcal/g

Experiment II

The chemical components of fatty and muscle tissues in half-carcass of the initial slaughter group

Lamb No.	Fatty tissue				Muscle tissue			
	DM (kg)	EE (kg)	CP (kg)	GE (Mcal)	DM (kg)	EE (kg)	CP (kg)	GE (Mcal)
517	1·26	1·11	0·10	11·07	1·36	0·38	0·83	8·68
519	1·69	1·53	0·12	14·98	1·30	0·25	0·84	7·82
P526	0·79	0·67	0·08	6·83	1·12	0·32	0·73	7·19
505	0·87	0·73	0·08	7·52	1·03	0·25	0·67	6·56
514	0·67	0·54	0·08	5·70	1·03	0·27	0·67	6·47
Mean	1·06	0·92	0·09	9·22	1·17	0·29	0·75	7·34

Experiment II

Dry matter weight of live weight components of the initial slaughter group
(kg)

Lamb No.	Head	Feet	Bone*	Blood	Pelt
517	1·01	0·37	1·84	0·24	1·82
519	0·83	0·38	1·86	0·27	2·03
P526	0·90	0·37	1·66	0·26	1·82
505	0·81	0·36	1·55	0·25	1·76
514	0·81	0·32	1·53	0·23	1·90
Mean	0·87	0·36	1·69	0·25	1·87

* In the whole carcass

Gross energy of live weight components of the initial slaughter group
(Mcal)

Lamb No.	Head	Feet	Bone*	Blood	Pelt
517	4·98	1·74	8·43	1·34	10·16
519	4·09	1·78	8·52	1·51	11·33
P526	4·44	1·74	7·60	1·45	10·16
505	3·99	1·69	7·10	1·40	9·82
514	3·99	1·50	7·01	1·28	10·60
Mean	4·30	1·69	7·73	1·40	10·41

* In the whole carcass

Live weight data (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Date / Lamb No.	1/12 1966	15/12	30/12	12/1 1967	26/1	9/2	23/2	2/3	23/3	6/4	20/4
A	516	30·87	29·96	30·87	32·23	32·23	33·60	34·96	35·41			
	504	29·51	28·60	28·15	30·42	30·42	32·69	33·60	32·23			
	527	28·60	28·15	30·87	30·42	30·87	32·69	33·60	34·50			
	524	25·88	25·88	26·33	27·24	28·15	30·42	30·87	31·33			
	Mean	28·72	28·15	29·08	30·08	30·42	32·35	33·26	33·37			
B	R124	31·78	32·69	34·50	34·05	35·41	36·32	37·23	38·14			
	510	30·42	28·15	33·60	32·69	33·60	35·41	38·14	37·23			
	513	28·15	27·69	30·42	31·78	31·33	33·14	35·41	34·96			
	521	24·97	26·33	28·15	28·60	30·42	32·23	31·78	33·14			
	Mean	28·83	28·72	31·67	31·78	32·69	34·28	35·64	35·87			
C	Y526	32·69	33·60	35·41	36·32	36·77	37·68	38·59	39·50			
	Y501	30·87	31·78	35·41	35·41	36·77	39·04	38·59	37·68			
	523	29·06	30·87	32·69	34·50	36·32	37·68	38·59	37·68			
	Y512	27·24	28·15	30·87	34·05	34·05	35·51	38·14	38·14			
	Mean	29·97	31·10	33·60	35·07	35·98	37·45	38·48	38·25			
D	528	31·33	30·87	32·69	33·14	34·05	35·41	37·68	38·14	39·04	38·59	40·86
	522	29·96	28·60	31·78	31·78	31·78	32·69	34·50	36·32	38·14	37·68	39·95
	525	29·96	28·60	29·96	31·78	31·33	33·14	34·50	34·96	35·41	36·32	36·32
	Y508	28·15	27·24	28·60	29·09	28·60	29·51	33·60	34·50	34·05	35·87	35·87
	Mean	29·85	28·83	30·76	31·45	31·44	32·69	35·07	35·98	36·66	37·12	38·25
E	506	31·33	33·14	33·60	33·14	34·96	37·68	38·14	38·59	40·86		
	502	30·42	32·23	32·69	32·23	33·60	36·32	37·68	37·23	39·50		
	515	29·51	29·06	31·78	30·87	32·23	34·05	36·77	36·32	40·41		
	Y509	26·33	26·33	27·69	29·06	31·33	32·23	32·23	33·60	36·32		
	Mean	29·40	30·19	31·44	31·33	33·03	35·07	36·21	36·44	39·27		

Final and initial weights (kg) and gains in weight of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Live weight			S.E.B.			Warm carcass		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	35·41	30·87	4·54	24·39	22·99	1·40	15·39	14·57	0·82
	504	32·23	29·51	2·72	23·62	21·97	1·65	15·20	13·82	1·38
	527	34·50	28·60	5·90	25·67	21·29	4·38	16·59	13·31	3·28
	524	31·33	25·88	5·45	22·07	19·25	2·82	13·78	11·81	1·97
	Mean	33·37	28·72	4·65	23·94	21·38	2·56	15·24	13·38	1·86
B	R124	38·14	31·78	6·36	27·94	23·68	4·26	18·76	15·08	3·68
	510	37·23	30·42	6·81	27·89	22·67	5·22	18·22	14·32	3·90
	513	34·96	28·15	6·81	26·41	20·95	5·46	16·81	13·07	3·74
	521	33·14	24·97	8·17	24·10	18·55	5·54	15·24	11·30	3·94
	Mean	35·87	28·83	7·04	26·58	21·46	5·12	17·26	13·44	3·82
C	Y526	39·50	32·69	6·81	30·08	24·36	5·72	19·92	15·58	4·34
	Y501	37·68	30·87	6·81	26·97	22·99	3·98	17·79	14·57	3·22
	523	37·68	29·06	8·62	26·89	21·63	5·26	17·44	13·57	3·87
	Y512	38·14	27·24	10·90	26·86	20·27	6·59	17·49	12·56	4·93
	Mean	38·25	29·97	8·28	27·70	22·32	5·38	18·16	14·07	4·09
E	506	40·86	31·33	9·53	29·24	23·34	5·90	18·87	14·83	4·04
	502	39·50	30·42	9·08	29·66	22·66	7·00	19·91	14·32	5·59
	515	40·41	29·51	10·90	29·14	21·97	7·17	19·39	13·82	5·57
	Y509	36·32	26·33	9·99	25·02	19·58	5·44	16·33	12·06	4·27
	Mean	39·27	29·40	9·87	28·26	21·89	6·37	18·62	13·76	4·86
D	528	40·86	31·33	9·53	28·40	23·34	5·06	19·02	14·83	4·19
	522	39·95	29·96	9·99	27·83	22·31	5·52	18·35	14·07	4·28
	525	36·32	29·96	6·36	25·70	22·31	3·39	17·26	14·07	3·19
	Y508	35·87	28·15	7·72	24·67	20·95	3·72	15·80	13·07	2·73
	Mean	38·25	29·85	8·40	26·65	22·23	4·42	17·61	14·01	3·60

Final and initial weights (kg) and gains in weight of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	~~Gut "fill"~~ pelt			~~Pelt~~ Gut "fill"			Blood		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	4·31	3·13	1·18	5·61	4·23	1·38	1·36	1·30	0·06
	504	4·43	"	1·30	3·58	"	-0·65	1·26	"	-0·04
	527	3·18	"	0·05	3·97	"	-0·26	1·38	"	0·08
	524	3·40	"	0·27	4·93	"	0·70	1·18	"	-0·12
	Mean	3·83	"	0·70	4·52	"	0·29	1·28	"	-0·02
B	R124	5·33	"	2·20	4·93	"	0·70	1·17	"	-0·13
	510	3·88	"	0·75	4·82	"	0·59	1·49	"	0·19
	513	3·75	"	0·62	4·16	"	-0·07	1·48	"	0·18
	521	4·77	"	1·64	3·31	"	-0·92	1·20	"	-0·10
	Mean	4·43	"	1·30	4·30	"	0·07	1·34	"	0·04
C	Y526	4·43	"	1·30	3·78	"	-0·45	1·42	"	0·12
	Y501	5·67	"	2·54	4·67	"	0·44	1·44	"	0·14
	523	4·99	"	1·86	5·21	"	0·98	1·40	"	0·10
	Y512	4·43	"	1·30	5·67	"	1·44	1·43	"	0·13
	Mean	4·88	"	1·75	4·83	"	0·60	1·42	"	0·12
E	506	4·54	"	1·41	6·18	"	1·95	1·43	"	0·13
	502	4·31	"	1·18	5·36	"	1·13	1·52	"	0·22
	515	4·77	"	1·64	5·38	"	1·15	1·42	"	0·12
	Y509	4·54	"	1·41	5·79	"	1·56	1·58	"	0·28
	Mean	4·54	"	1·41	5·68	"	1·45	1·49	"	0·19
D	528	4·77	"	1·64	6·61	"	2·38	1·45	"	0·15
	522	4·09	"	0·96	6·56	"	2·33	1·59	"	0·29
	525	4·54	"	1·41	4·98	"	0·75	1·22	"	-0·08
	Y508	3·74	"	0·61	5·15	"	0·92	1·64	"	0·34
	Mean	4·28	"	1·15	5·82	"	1·59	1·48	"	0·18

Final and initial weights (kg) and gains in weight of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Feet			Head			Pluck		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·92	0·65	0·27	2·31	1·98	0·33	1·41	1·43	-0·02
	504	0·79	"	0·14	2·05	"	0·07	1·24	1·35	-0·11
	527	0·82	"	0·17	2·02	"	0·04	1·49	1·31	0·18
	524	0·76	"	0·11	2·11	"	0·13	1·37	1·17	0·20
	Mean	0·82	"	0·17	2·12	"	0·14	1·38	1·31	0·07
B	R124	0·89	"	0·24	2·35	"	0·37	1·66	1·47	0·19
	510	0·85	"	0·20	2·20	"	0·22	1·49	1·40	0·09
	513	0·88	"	0·23	2·25	"	0·27	1·47	1·28	0·19
	521	0·85	"	0·20	2·01	"	0·03	1·47	1·12	0·35
	Mean	0·87	"	0·22	2·20	"	0·22	1·52	1·32	0·20
C	Y526	0·99	"	0·34	2·55	"	0·57	1·50	1·52	-0·02
	Y501	0·85	"	0·20	2·18	"	0·20	1·39	1·43	-0·04
	523	0·74	"	0·09	2·08	"	0·10	1·49	1·33	0·16
	Y512	0·81	"	0·16	2·03	"	0·05	1·56	1·24	0·32
	Mean	0·85	"	0·20	2·21	"	0·23	1·48	1·38	0·10
E	506	0·95	"	0·30	2·24	"	0·26	1·77	1·45	0·32
	502	0·86	"	0·21	2·11	"	0·13	1·58	1·40	0·18
	515	0·89	"	0·24	2·17	"	0·19	1·88	1·35	0·53
	Y509	0·83	"	0·18	2·06	"	0·08	1·40	1·19	0·21
	Mean	0·88	"	0·23	2·14	"	0·16	1·66	1·35	0·31
D	528	0·88	"	0·23	2·54	"	0·56	1·42	1·45	-0·03
	522	0·83	"	0·18	2·31	"	0·33	1·43	1·38	0·05
	525	0·83	"	0·18	2·49	"	0·51	1·35	1·38	-0·03
	Y508	0·85	"	0·20	2·36	"	0·38	1·43	1·28	0·15
	Mean	0·85	"	0·20	2·42	"	0·44	1·41	1·37	0·04

Final and initial weights (kg) and gains in weight of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Gut			Caul fat		
		Final	Initial	Gain	Final	Initial	Gain
A	516	2·11	2·06	0·05	0·87	0·89	-0·01
	504	1·95	"	-0·11	1·12	"	0·23
	527	2·07	"	0·01	1·29	"	0·40
	524	1·96	"	-0·10	0·90	"	0·01
	Mean	2·02	"	-0·04	1·07	"	0·18
B	R124	1·78	"	-0·28	1·32	"	0·43
	510	2·05	"	-0·01	1·57	"	0·68
	513	2·02	"	-0·04	1·49	"	0·60
	521	1·94	"	-0·12	1·38	"	0·49
	Mean	1·95	"	-0·11	1·44	"	0·55
C	Y526	1·99	"	-0·07	1·70	"	0·81
	Y501	2·20	"	0·14	1·11	"	0·22
	523	1·96	"	-0·10	1·77	"	0·88
	Y512	2·07	"	0·01	1·46	"	0·57
	Mean	2·05	"	-0·02	1·51	"	0·62
E	506	2·65	"	0·59	1·32	"	0·43
	502	2·20	"	0·14	1·48	"	0·59
	515	2·08	"	0·02	1·31	"	0·42
	Y509	2·08	"	0·02	0·74	"	-0·15
	Mean	2·25	"	0·19	1·21	"	0·32
D	528	1·78	"	-0·28	1·31	"	0·42
	522	2·24	"	0·18	1·08	"	0·19
	525	1·84	"	-0·22	0·71	"	-0·18
	Y508	1·99	"	-0·07	0·60	"	-0·29
	Mean	1·96	"	-0·10	0·92	"	0·03

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Total fat			Total muscle			Total bone		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·97	1·32	-0·35	4·86	4·06	0·80	1·99	1·45	0·54
	504	1·37	"	0·05	4·42	3·87	0·55	1·77	1·40	0·37
	527	1·71	"	0·39	4·83	3·75	1·08	1·69	1·37	0·32
	524	1·20	"	-0·12	3·93	3·37	0·56	1·83	1·28	0·55
	Mean	1·31	"	-0·01	4·51	3·76	0·75	1·82	1·38	0·45
B	R124	1·82	"	0·50	5·39	4·19	1·20	2·05	1·48	0·57
	510	2·36	"	1·04	4·78	4·00	0·78	1·82	1·43	0·39
	513	1·58	"	0·26	4·98	3·68	1·30	1·96	1·36	0·60
	521	1·56	"	0·24	4·27	3·24	1·03	1·59	1·25	0·34
	Mean	1·83	"	0·51	4·86	3·78	1·08	1·86	1·38	0·48
C	Y526	2·21	"	0·89	5·63	4·31	1·32	2·06	1·51	0·55
	Y501	2·14	"	0·82	4·61	4·06	0·55	1·94	1·46	0·48
	523	2·05	"	0·73	4·67	3·81	0·86	1·68	1·39	0·29
	Y512	1·41	"	0·09	5·46	3·56	1·90	1·99	1·33	0·66
	Mean	1·95	"	0·63	5·09	3·94	1·15	1·92	1·42	0·50
E	506	1·89	"	0·57	5·24	4·12	1·12	2·03	1·46	0·57
	502	2·45	"	1·13	5·45	4·00	1·45	1·88	1·43	0·45
	515	1·81	"	0·49	5·51	3·87	1·64	2·00	1·40	0·60
	Y509	1·36	"	0·04	4·83	3·43	1·40	1·76	1·30	0·46
	Mean	1·88	"	0·56	5·26	3·86	1·40	1·92	1·40	0·52
D	528	1·63	"	0·31	5·43	4·12	1·31	2·15	1·46	0·69
	522	1·37	"	0·05	5·31	3·93	1·38	2·22	1·42	0·80
	525	1·34	"	0·02	5·00	3·93	1·07	1·98	1·42	0·56
	Y508	0·79	"	-0·53	4·86	3·68	1·18	1·76	1·36	0·40
	Mean	1·28	"	-0·04	5·15	3·92	1·23	2·03	1·42	0·61

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Gigot			Shoulder			Loin		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	2·77	2·42	0·35	3·03	2·57	0·46	0·94	0·80	0·14
	504	2·55	2·30	0·25	2·89	2·44	0·45	0·93	"	0·13
	587	2·90	2·21	0·69	3·01	2·35	0·66	1·02	"	0·22
	524	2·26	1·97	0·29	2·75	2·09	0·67	0·89	"	0·09
	Mean	2·62	2·22	0·40	2·92	2·37	0·55	0·95	"	0·15
B	R124	2·91	2·50	0·41	3·46	2·66	0·80	1·35	"	0·55
	510	3·00	2·38	0·62	3·29	2·53	0·76	1·21	"	0·41
	513	2·79	2·17	0·62	3·11	2·31	0·80	1·28	"	0·48
	521	2·63	1·88	0·75	2·74	2·00	0·74	0·92	"	0·12
	Mean	2·83	2·23	0·60	3·15	2·38	0·77	1·19	"	0·39
C	Y526	3·28	2·58	0·70	3·67	2·75	0·92	1·33	"	0·53
	Y501	2·99	2·42	0·57	3·21	2·57	0·64	1·11	"	0·31
	523	2·70	2·25	0·45	3·13	2·40	0·73	1·13	"	0·33
	Y512	2·89	2·09	0·80	3·32	2·22	1·10	1·34	"	0·54
	Mean	2·97	2·34	0·63	3·33	2·49	0·84	1·23	"	0·43
E	506	2·97	2·46	0·51	3·60	2·62	0·98	1·21	"	0·41
	502	3·21	2·38	0·83	3·58	2·53	1·05	1·43	"	0·63
	515	3·12	2·30	0·82	3·60	2·44	1·16	1·16	"	0·36
	Y509	2·82	2·01	0·81	3·06	2·13	0·93	0·95	"	0·15
	Mean	3·03	2·29	0·74	3·46	2·43	1·03	1·19	"	0·39
D	528	3·15	2·46	0·69	3·56	2·62	0·94	1·12	"	0·32
	522	2·88	2·34	0·54	3·49	2·49	1·00	1·12	"	0·32
	525	2·68	2·34	0·34	3·42	2·49	0·93	0·98	"	0·18
	Y508	2·77	2·17	0·60	2·79	2·31	0·48	0·92	"	0·12
	Mean	2·87	2·33	0·54	3·32	2·48	0·84	1·04	"	0·24

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Rib			Kidney + perirenal fat			Brisket		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·97	0·91	0·06	0·16	0·18	-0·02	0·33	0·31	0·02
	504	1·01	"	0·10	0·23	"	0·05	0·35	"	0·04
	527	0·98	"	0·07	0·36	"	0·18	0·38	"	0·07
	524	0·91	"	0·00	0·19	"	0·01	0·32	"	0·01
	Mean	0·97	"	0·06	0·24	"	0·06	0·35	"	0·04
B	R124	1·34	"	0·43	0·23	"	0·05	0·49	"	0·18
	510	1·20	"	0·29	0·29	"	0·11	0·40	"	0·09
	513	1·13	"	0·22	0·25	"	0·07	0·44	"	0·13
	521	0·94	"	0·03	0·22	"	0·04	0·35	"	0·04
	Mean	1·15	"	0·24	0·25	"	0·07	0·42	"	0·11
C	Y526	1·38	"	0·47	0·28	"	0·10	0·45	"	0·14
	Y501	1·18	"	0·27	0·23	"	0·05	0·42	"	0·11
	523	1·16	"	0·25	0·31	"	0·13	0·32	"	0·01
	Y512	1·19	"	0·28	0·15	"	-0·03	0·38	"	0·07
	Mean	1·23	"	0·32	0·24	"	0·06	0·39	"	0·08
E	506	1·17	"	0·26	0·27	"	0·09	0·42	"	0·11
	502	1·19	"	0·29	0·43	"	0·25	0·44	"	0·13
	515	1·22	"	0·31	0·29	"	0·11	0·39	"	0·08
	Y509	0·97	"	0·06	0·22	"	0·04	0·35	"	0·04
	Mean	1·14	"	0·23	0·30	"	0·12	0·40	"	0·09
D	528	1·21	"	0·30	0·22	"	0·04	0·37	"	0·06
	522	1·21	"	0·30	0·23	"	0·05	0·36	"	0·05
	525	1·13	"	0·22	0·15	"	-0·03	0·32	"	0·01
	Y508	0·85	"	-0·06	0·11	"	-0·07	0·36	"	0·05
	Mean	1·10	"	0·19	0·18	"	0·00	0·35	"	0·04

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Neck			Shank			Flank (gigot)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·30	0·25	0·05	0·45	0·36	0·09	0·08	0·08	0·00
	504	0·30	"	0·05	0·38	"	0·02	0·08	"	0·00
	527	0·25	"	0·00	0·43	"	0·07	0·09	"	0·01
	524	0·20	"	0·04	0·41	"	0·05	0·06	"	-0·02
	Mean	0·29	"	0·04	0·42	"	0·06	0·08	"	0·00
B	R124	0·31	"	0·06	0·51	"	0·15	0·10	"	0·02
	510	0·32	"	0·07	0·46	"	0·10	0·10	"	0·02
	513	0·23	"	-0·02	0·43	"	0·07	0·05	"	-0·03
	521	0·22	"	-0·03	0·42	"	0·06	0·09	"	0·01
	Mean	0·27	"	0·02	0·46	"	0·10	0·09	"	0·01
C	Y526	0·31	"	0·06	0·52	"	0·16	0·11	"	0·03
	Y501	0·26	"	0·01	0·45	"	0·09	0·10	"	0·02
	523	0·33	"	0·08	0·39	"	0·03	0·09	"	0·01
	Y512	0·35	"	0·10	0·51	"	0·15	0·08	"	0·00
	Mean	0·31	"	0·06	0·47	"	0·11	0·10	"	0·02
E	506	0·37	"	0·12	0·43	"	0·07	0·08	"	0·00
	502	0·34	"	0·09	0·46	"	0·10	0·11	"	0·03
	515	0·29	"	0·04	0·42	"	0·06	0·09	"	0·01
	Y509	0·28	"	0·03	0·38	"	0·02	0·07	"	-0·01
	Mean	0·32	"	0·07	0·42	"	0·06	0·09	"	0·01
D	528	0·42	"	0·17	0·44	"	0·08	0·11	"	0·03
	522	0·45	"	0·20	0·41	"	0·05	0·08	"	0·00
	525	0·48	"	0·23	0·40	"	0·04	0·08	"	0·00
	Y508	0·22	"	-0·03	0·50	"	0·14	0·06	"	-0·02
	Mean	0·39	"	0·14	0·44	"	0·08	0·08	"	0·00

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Flank (loin)			Flank (rib)			Fat (gigot)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·19	0·14	0·05	0·42	0·40	0·02	0·26	0·36	-0·10
	504	0·16	"	0·02	0·41	"	0·01	0·31	"	-0·05
	527	0·23	"	0·09	0·43	"	0·03	0·45	"	0·09
	524	0·16	"	0·02	0·36	"	-0·04	0·31	"	-0·05
	Mean	0·19	"	0·05	0·41	"	0·01	0·33	"	-0·03
B	R124	0·27	"	0·13	0·59	"	0·19	0·49	"	0·13
	510	0·26	"	0·12	0·48	"	0·08	0·55	"	0·19
	513	0·21	"	0·07	0·45	"	0·05	0·33	"	-0·03
	521	0·17	"	0·01	0·40	"	0·00	0·40	"	0·04
	Mean	0·22	"	0·08	0·48	"	0·08	0·44	"	0·08
C	Y526	0·26	"	0·12	0·54	"	0·14	0·57	"	0·21
	Y501	0·20	"	0·06	0·49	"	0·09	0·57	"	0·21
	523	0·20	"	0·06	0·48	"	0·08	0·47	"	0·11
	Y512	0·30	"	0·16	0·48	"	0·08	0·36	"	0·00
	Mean	0·24	"	0·10	0·50	"	0·10	0·49	"	0·13
E	506	0·24	"	0·10	0·46	"	0·06	0·48	"	0·12
	502	0·24	"	0·10	0·48	"	0·08	0·57	"	0·21
	515	0·21	"	0·07	0·45	"	0·05	0·46	"	0·10
	Y509	0·16	"	0·02	0·36	"	-0·04	0·34	"	-0·02
	Mean	0·21	"	0·07	0·44	"	0·04	0·46	"	0·10
D	528	0·20	"	0·06	0·45	"	0·05	0·46	"	0·10
	522	0·10	"	0·05	0·47	"	0·07	0·32	"	-0·04
	525	0·19	"	0·05	0·37	"	-0·03	0·39	"	0·03
	Y508	0·14	"	0·00	0·32	"	-0·08	0·23	"	-0·13
	Mean	0·18	"	0·04	0·40	"	0·00	0·35	"	-0·01

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Muscle (gigot)			Bone (gigot)			Fat (shoulder)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	1·90	1·57	0·33	0·60	0·45	0·15	0·35	0·45	-0·10
	504	1·66	1·49	0·17	0·56	"	0·11	0·46	"	0·01
	527	1·84	1·44	0·40	0·59	"	0·14	0·49	"	0·04
	524	1·43	1·29	0·14	0·51	"	0·06	0·42	"	-0·03
	Mean	1·71	1·45	0·26	0·57	"	0·12	0·43	"	-0·02
B	R124	1·81	1·62	0·19	0·60	"	0·15	0·60	"	0·15
	510	1·86	1·54	0·32	0·58	"	0·13	0·79	"	0·34
	513	1·90	1·41	0·49	0·55	"	0·10	0·58	"	0·13
	521	1·65	1·23	0·42	0·57	"	0·12	0·51	"	0·06
	Mean	1·81	1·45	0·36	0·58	"	0·13	0·62	"	0·17
C	Y526	2·02	1·67	0·35	0·67	"	0·22	0·69	"	0·24
	Y501	1·77	1·57	0·20	0·65	"	0·20	0·73	"	0·28
	523	1·71	1·47	0·24	0·52	"	0·07	0·65	"	0·20
	Y512	1·93	1·36	0·57	0·59	"	0·14	0·45	"	0·00
	Mean	1·86	1·52	0·34	0·61	"	0·16	0·63	"	0·18
E	506	1·92	1·60	0·32	0·55	"	0·10	0·60	"	0·15
	502	2·10	1·54	0·56	0·52	"	0·07	0·74	"	0·29
	515	2·13	1·49	0·64	0·51	"	0·06	0·56	"	0·11
	Y509	1·95	1·31	0·64	0·51	"	0·06	0·48	"	0·03
	Mean	2·03	1·49	0·54	0·52	"	0·07	0·60	"	0·15
D	528	1·99	1·60	0·39	0·70	"	0·25	0·51	"	0·06
	522	1·92	1·52	0·40	0·63	"	0·18	0·49	"	0·04
	525	1·69	1·52	0·17	0·60	"	0·15	0·48	"	0·03
	Y508	1·92	1·41	0·51	0·61	"	0·16	0·31	"	-0·14
	Mean	1·88	1·51	0·37	0·64	"	0·19	0·45	"	0·00

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Muscle (shoulder)			Bone (shoulder)			Fat (loin)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	1·76	1·46	0·30	0·90	0·61	0·29	0·12	0·17	-0·05
	504	1·67	1·38	0·29	0·75	"	0·14	0·22	"	0·05
	527	1·80	1·33	0·47	0·70	"	0·09	0·25	"	0·08
	524	1·50	1·18	0·32	0·81	"	0·20	0·18	"	0·01
	Mean	1·68	1·34	0·34	0·79	"	0·18	0·19	"	0·02
B	R124	1·99	1·51	0·48	0·86	"	0·25	0·27	"	0·10
	510	1·74	1·43	0·31	0·75	"	0·14	0·38	"	0·21
	513	1·72	1·31	0·41	0·80	"	0·19	0·25	"	0·08
	521	1·57	1·13	0·44	0·64	"	0·03	0·24	"	0·07
	Mean	1·76	1·35	0·41	0·76	"	0·15	0·29	"	0·12
C	Y526	2·15	1·56	0·59	0·81	"	0·20	0·36	"	0·19
	Y501	1·70	1·46	0·24	0·77	"	0·16	0·32	"	0·15
	523	1·76	1·36	0·40	0·71	"	0·10	0·33	"	0·16
	Y512	2·05	1·26	0·79	0·81	"	0·20	0·28	"	0·11
	Mean	1·92	1·41	0·51	0·78	"	0·17	0·32	"	0·15
E	506	2·07	1·48	0·59	0·91	"	0·30	0·32	"	0·15
	502	2·04	1·43	0·61	0·78	"	0·17	0·43	"	0·26
	515	2·06	1·38	0·68	0·95	"	0·34	0·28	"	0·11
	Y509	1·74	1·21	0·53	0·80	"	0·19	0·19	"	0·02
	Mean	1·98	1·38	0·60	0·86	"	0·25	0·31	"	0·14
D	528	2·12	1·48	0·64	0·91	"	0·30	0·25	"	0·08
	522	2·00	1·41	0·59	0·99	"	0·38	0·17	"	0·00
	525	2·08	1·41	0·67	0·85	"	0·24	0·20	"	0·03
	Y508	1·79	1·31	0·48	0·67	"	0·06	0·08	"	-0·09
	Mean	2·00	1·40	0·60	0·86	"	0·25	0·18	"	0·01

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Muscle (loin)			Bone (loin)			Fat (rib)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·60	0·48	0·12	0·21	0·14	0·07	0·12	0·20	-0·08
	504	0·50	"	0·02	0·20	"	0·06	0·20	"	0·00
	527	0·58	"	0·10	0·19	"	0·05	0·21	"	0·01
	524	0·49	"	0·01	0·22	"	0·08	0·15	"	-0·05
	Mean	0·54	"	0·06	0·21	"	0·07	0·17	"	-0·03
B	R124	0·85	"	0·37	0·23	"	0·09	0·29	"	0·09
	510	0·61	"	0·13	0·22	"	0·08	0·40	"	0·20
	513	0·72	"	0·24	0·30	"	0·16	0·22	"	0·02
	521	0·52	"	0·04	0·16	"	0·02	0·24	"	0·04
	Mean	0·68	"	0·20	0·23	"	0·09	0·29	"	0·09
C	Y526	0·73	"	0·25	0·24	"	0·10	0·36	"	0·16
	Y501	0·57	"	0·09	0·21	"	0·07	0·33	"	0·13
	523	0·63	"	0·15	0·17	"	0·03	0·34	"	0·14
	Y512	0·81	"	0·33	0·25	"	0·11	0·21	"	0·01
	Mean	0·69	"	0·21	0·22	"	0·08	0·31	"	0·11
E	506	0·62	"	0·14	0·26	"	0·12	0·27	"	0·07
	502	0·69	"	0·21	0·30	"	0·16	0·38	"	0·18
	515	0·66	"	0·18	0·22	"	0·08	0·27	"	0·07
	Y509	0·57	"	0·09	0·18	"	0·04	0·18	"	-0·02
	Mean	0·64	"	0·16	0·24	"	0·10	0·28	"	0·08
D	528	0·66	"	0·18	0·20	"	0·06	0·24	"	0·04
	522	0·70	"	0·22	0·25	"	0·11	0·20	"	0·00
	525	0·59	"	0·11	0·20	"	0·06	0·18	"	-0·02
	Y508	0·59	"	0·11	0·24	"	0·10	0·08	"	-0·12
	Mean	0·64	"	0·16	0·22	"	0·08	0·18	"	-0·02

Final and initial weights (kg) and gains in weight of carcass components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Muscle (rib)			Bone (rib)			Fat (kidney)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	0·55	0·48	0·07	0·29	0·23	0·06	0·11	0·13	-0·02
	504	0·54	"	0·06	0·25	0·22	0·03	0·18	"	0·05
	527	0·56	"	0·08	0·21	0·21	0·00	0·31	"	0·18
	524	0·46	"	-0·02	0·30	0·19	0·11	0·14	"	0·01
	Mean	0·53	"	0·05	0·26	0·21	0·05	0·19	"	0·06
B	R124	0·69	"	0·21	0·36	0·23	0·13	0·18	"	0·05
	510	0·53	"	0·05	0·28	0·22	0·06	0·25	"	0·12
	513	0·59	"	0·11	0·31	0·21	0·09	0·20	"	0·07
	521	0·48	"	0·00	0·21	0·18	0·03	0·18	"	0·05
	Mean	0·57	"	0·09	0·29	0·21	0·08	0·20	"	0·07
C	Y526	0·69	"	0·21	0·33	0·24	0·09	0·23	"	0·10
	Y501	0·53	"	0·05	0·31	0·23	0·08	0·19	"	0·06
	523	0·54	"	0·06	0·28	0·21	0·07	0·26	"	0·13
	Y512	0·62	"	0·14	0·35	0·20	0·15	0·11	"	-0·02
	Mean	0·60	"	0·12	0·32	0·22	0·10	0·20	"	0·07
E	506	0·57	"	0·09	0·31	0·23	0·08	0·22	"	0·09
	502	0·57	"	0·09	0·28	0·22	0·06	0·38	"	0·25
	515	0·62	"	0·14	0·33	0·22	0·11	0·23	"	0·10
	Y509	0·52	"	0·04	0·26	0·19	0·07	0·17	"	0·04
	Mean	0·57	"	0·09	0·30	0·22	0·08	0·25	"	0·12
D	528	0·62	"	0·14	0·34	0·23	0·11	0·18	"	0·05
	522	0·64	"	0·16	0·36	0·22	0·14	0·19	"	0·06
	525	0·61	"	0·13	0·33	0·22	0·11	0·10	"	-0·03
	Y508	0·53	"	0·05	0·24	0·21	0·03	0·07	"	-0·06
	Mean	0·60	"	0·12	0·32	0·22	0·10	0·14	"	0·01

Final and initial weight (kg) and gain in weight of muscle tissue in the kidney of Blackface wether lambs fed different level of daily intake of metabolizable energy

Group	Lamb No.	Final	Initial	Gain
A	516	0·05	0·05	0·00
	504	0·05	"	0·00
	527	0·05	"	0·00
	524	0·05	"	0·00
	Mean	0·05	"	0·00
B	R124	0·05	"	0·00
	510	0·04	"	-0·01
	513	0·05	"	0·00
	521	0·04	"	-0·01
	Mean	0·05	"	0·00
C	Y526	0·05	"	0·00
	Y501	0·05	"	0·00
	523	0·04	"	-0·01
	Y512	0·05	"	0·00
	Mean	0·05	"	0·00
E	506	0·05	"	0·00
	502	0·05	"	0·00
	515	0·05	"	0·00
	Y509	0·05	"	0·00
	Mean	0·05	"	0·00
D	528	0·04	"	-0·01
	522	0·05	"	0·00
	525	0·04	"	-0·01
	Y508	0·04	"	-0·01
	Mean	0·04	"	-0·01

The gains in carcass measurements of Blackface wether lambs fed different level of daily intake of metabolizable energy

Group	Lamb No.	Area of M.l.d.(i)			Fat thickness(ii)		
		Final	Initial	Gain	Final	Initial	Gain
A	516	11·10	9·27	1·83	2·00	2·45	-0·45
	504	9·30	"	0·03	2·50	"	0·05
	527	11·80	"	2·53	3·50	"	1·05
	524	8·90	"	-0·37	2·00	"	-0·45
	Mean	10·28	"	1·01	2·50	"	0·05
B	R124	11·70	"	2·43	3·00	"	0·55
	510	11·20	"	1·93	4·50	"	2·05
	513	13·50	"	4·23	2·50	"	0·05
	521	10·95	"	1·68	2·50	"	0·05
	Mean	11·84	"	2·57	3·13	"	0·68
C	Y526	14·05	"	4·78	4·00	"	1·55
	Y501	10·00	"	0·73	5·00	"	2·55
	523	12·50	"	3·23	5·50	"	3·05
	Y512	13·45	"	4·18	2·75	"	0·30
	Mean	12·50	"	3·23	4·31	"	1·86
E	506	12·60	"	3·33	4·00	"	1·55
	502	14·10	"	4·83	7·00	"	4·55
	515	14·15	"	4·88	2·00	"	-0·45
	Y509	11·20	"	1·93	2·00	"	-0·45
	Mean	13·01	"	3·74	3·75	"	1·30
D	528	13·35	"	4·08	3·00	"	0·55
	522	13·00	"	3·73	3·00	"	0·55
	525	10·45	"	1·18	2·50	"	0·05
	Y508	10·85	"	1·58	1·50	"	-0·95
	Mean	11·91	"	2·64	2·50	"	0·05

(i) M. longissimus dorsi at the 12th rib in sq. cm

(ii) Fat thickness over M. longissimus dorsi at the 12th rib in mm

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M. obliquus .... + M. transversus			M. semitendinosus			M. semimembranosus		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	174	156	18	86	66	20	246	202	44
	504	154	"	-2	75	"	9	227	"	25
	527	158	"	2	88	"	22	255	"	53
	524	136	"	-20	75	"	9	209	"	7
	Mean	156	"	0	81	"	15	234	"	32
B	R124	209	"	53	100	"	34	255	"	53
	510	171	"	15	85	"	19	253	"	51
	513	176	"	20	97	"	31	303	"	101
	521	164	"	8	80	"	14	235	"	33
	Mean	180	"	24	91	"	25	262	"	60
C	Y526	217	"	61	89	"	23	270	"	68
	Y501	170	"	14	84	"	18	246	"	44
	523	172	"	16	85	"	19	241	"	39
	Y512	207	"	51	110	"	44	252	"	50
	Mean	192	"	36	92	"	26	252	"	50
E	506	165	"	9	93	"	27	250	"	48
	502	175	"	19	97	"	31	280	"	78
	515	176	"	20	109	"	43	282	"	80
	Y509	168	"	12	78	"	12	260	"	58
	Mean	171	"	15	94	"	28	268	"	66
D	528	196	"	40	96	"	30	255	"	53
	522	161	"	5	100	"	34	277	"	75
	525	169	"	13	73	"	7	224	"	22
	Y508	164	"	8	87	"	21	261	"	59
	Mean	173	"	17	89	"	23	254	"	52

Final and Initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M. gastrocnemius			M. quadriceps			M. gluteus medius		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	120	109	11	360	310	50	166	135	31
	504	109	"	0	324	290	34	132	"	-3
	527	122	"	13	340	280	60	164	"	29
	524	113	"	4	280	250	30	120	"	-15
	Mean	116	"	7	326	280	46	146	"	11
B	R124	117	"	8	359	320	39	159	"	24
	510	138	"	29	348	310	38	157	"	22
	513	143	"	34	351	280	71	175	"	40
	521	124	"	15	315	240	75	133	"	-2
	Mean	131	"	22	343	290	53	156	"	21
C	Y526	144	"	35	408	330	78	165	"	30
	Y501	143	"	34	348	310	38	145	"	10
	523	117	"	8	333	290	43	143	"	8
	Y512	140	"	31	360	270	90	175	"	40
	Mean	136	"	27	362	300	62	157	"	22
E	506	135	"	26	370	320	50	183	"	48
	502	139	"	30	402	310	92	198	"	63
	515	130	"	21	396	290	106	197	"	62
	Y509	130	"	21	357	260	97	173	"	38
	Mean	134	"	25	381	290	91	188	"	53
D	528	149	"	40	368	320	48	157	"	22
	522	122	"	13	358	300	58	160	"	25
	525	102	"	-7	335	300	35	145	"	10
	Y508	129	"	20	379	280	99	173	"	38
	Mean	126	"	17	360	300	60	159	"	24

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M. extensor digitorum			M. psoas major			M.l.d. (loin) (i)		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	33	26	7	60	43	17	235	187	48
	504	28	"	2	48	"	5	242	"	55
	527	32	"	6	50	"	7	281	"	94
	524	27	"	1	44	"	1	226	"	39
	Mean	30	"	4	51	"	8	246	"	59
B	R124	32	"	6	66	"	23	325	"	138
	510	30	"	4	47	"	4	312	"	125
	513	31	"	5	62	"	19	350	"	163
	521	29	"	3	45	"	2	262	"	75
	Mean	31	"	5	55	"	12	312	"	125
C	Y526	37	"	11	64	"	21	338	"	151
	Y501	33	"	7	48	"	5	280	"	93
	523	29	"	3	51	"	8	325	"	138
	Y512	34	"	8	70	"	27	380	"	193
	Mean	33	"	7	58	"	15	331	"	144
E	506	32	"	6	53	"	10	297	"	110
	502	33	"	7	65	"	22	335	"	148
	515	36	"	10	60	"	17	316	"	129
	Y509	32	"	6	49	"	6	273	"	86
	Mean	33	"	7	57	"	14	305	"	118
D	528	35	"	9	60	"	17	309	"	122
	522	34	"	8	52	"	9	355	"	168
	525	28	"	2	46	"	3	256	"	69
	Y508	33	"	7	52	"	9	270	"	83
	Mean	33	"	7	53	"	10	298	"	111

(i) M. longissimus dorsi

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M.l.d. (rib)(i)			Mm. pectoralis....			M. biceps		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	116	99	17	149	115	34	25	22	3
	504	116	"	17	149	"	32	23	"	1
	527	135	"	36	158	"	43	23	"	1
	524	106	"	7	130	"	15	22	"	0
	Mean	118	"	19	146	"	31	23	"	1
B	R124	127	"	28	181	"	66	28	"	6
	510	131	"	32	174	"	59	27	"	5
	513	157	"	58	178	"	63	27	"	5
	521	112	"	13	156	"	41	25	"	3
	Mean	132	"	33	172	"	57	27	"	5
C	Y526	144	"	45	186	"	71	39	"	17
	Y501	102	"	3	150	"	35	29	"	7
	523	135	"	36	147	"	32	29	"	7
	Y512	152	"	53	179	"	64	36	"	14
	Mean	133	"	34	166	"	51	33	"	11
E	506	135	"	36	167	"	52	25	"	3
	502	125	"	26	192	"	77	28	"	6
	515	153	"	54	192	"	77	30	"	8
	Y509	132	"	33	155	"	40	26	"	4
	Mean	136	"	37	177	"	62	27	"	5
D	528	157	"	58	185	"	70	35	"	13
	522	150	"	51	196	"	81	33	"	11
	525	128	"	29	177	"	62	30	"	8
	Y508	115	"	16	172	"	57	31	"	9
	Mean	138	"	39	183	"	68	32	"	10

(i) M. longissimus dorsi

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M. brachialis			M. extensor carpi...			M. infraspinatus		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	17	15	2	39	29	10	104	86	18
	504	16	"	1	32	"	3	96	"	10
	527	17	"	2	38	"	9	104	"	18
	524	15	"	0	30	"	1	95	"	9
	Mean	16	"	1	35	"	6	100	"	14
B	R124	21	"	6	38	"	9	126	"	40
	510	21	"	6	31	"	2	104	"	18
	513	22	"	7	37	"	8	102	"	16
	521	18	"	3	32	"	3	88	"	2
	Mean	21	"	6	35	"	6	105	"	19
C	Y526	26	"	11	45	"	16	119	"	33
	Y501	24	"	9	33	"	4	97	"	11
	523	22	"	7	32	"	3	103	"	17
	Y512	25	"	10	40	"	11	109	"	23
	Mean	24	"	9	38	"	9	107	"	21
E	506	20	"	5	35	"	6	115	"	29
	502	22	"	7	36	"	7	109	"	23
	515	20	"	5	39	"	10	110	"	24
	Y509	20	"	5	34	"	5	100	"	14
	Mean	21	"	6	36	"	7	109	"	23
D	528	21	"	6	40	"	11	109	"	23
	522	22	"	7	38	"	9	99	"	13
	525	23	"	8	40	"	11	112	"	26
	Y508	23	"	8	36	"	7	103	"	17
	Mean	22	"	7	39	"	10	106	"	20

Final and initial weights (g) and gains in weight of individual muscles (g) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	M. supraspinatus		
		Final	Initial	Gain
A	516	105	88	17
	504	101	"	13
	527	115	"	27
	524	100	"	12
	Mean	105	"	17
B	R124	120	"	32
	510	105	"	17
	513	105	"	17
	521	109	"	21
	Mean	110	"	22
C	Y526	130	"	42
	Y501	103	"	15
	523	112	"	24
	Y512	116	"	28
	Mean	115	"	27
E	506	119	"	31
	502	113	"	25
	515	117	"	29
	Y509	106	"	18
	Mean	114	"	26
D	528	119	"	31
	522	112	"	24
	525	121	"	33
	Y508	106	"	18
	Mean	115	"	27

Final and initial weights (kg) and gains in weight in chemical components of fatty tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Dry matter			Ether extract		
		Final	Initial	Gain	Final	Initial	Gain
A	516	0·75	1·06	-0·31	0·62	0·92	-0·30
	504	1·10	"	0·04	0·94	"	0·02
	527	1·44	"	0·38	1·28	"	0·36
	524	0·95	"	-0·11	0·79	"	-0·13
	Mean	1·06	"	0·00	0·91	"	-0·01
B	R124	1·46	"	0·40	1·27	"	0·35
	510	1·97	"	0·91	1·68	"	0·76
	513	1·26	"	0·20	1·09	"	0·17
	521	1·21	"	0·15	1·04	"	0·12
	Mean	1·48	"	0·42	1·27	"	0·35
C	Y526	1·81	"	0·75	1·57	"	0·65
	Y501	1·74	"	0·67	1·53	"	0·61
	523	1·69	"	0·63	1·52	"	0·60
	Y512	1·10	"	0·04	0·92	"	0·00
	Mean	1·59	"	0·53	1·39	"	0·47
E	506	1·51	"	0·45	1·34	"	0·42
	502	2·03	"	0·97	1·86	"	0·94
	515	1·39	"	0·33	1·23	"	0·31
	Y509	1·06	"	0·00	0·92	"	0·00
	Mean	1·50	"	0·44	1·34	"	0·42
D	528	1·24	"	0·18	1·10	"	0·18
	5522	1·06	"	0·00	0·95	"	0·03
	525	1·04	"	-0·02	0·92	"	0·00
	Y508	0·55	"	-0·51	0·46	"	-0·46
	Mean	0·97	"	-0·09	0·86	"	-0·06

Final and initial weights (kg) and gains in weight in chemical components of fatty tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Crude protein			Gross energy (Mcal)		
		Final	Initial	Gain	Final	Initial	Gain
A	516	0·09	0·09	0·00	6·45	9·22	-2·77
	504	0·12	"	0·03	9·58	"	0·36
	527	0·12	"	0·03	12·38	"	3·16
	524	0·09	0·09	0·00	8·23	"	-0·99
	Mean	0·11	"	0·02	9·16	"	-0·06
B	R124	0·14	"	0·05	12·77	"	3·55
	510	0·18	"	0·09	17·17	"	7·95
	513	0·14	"	0·05	11·04	"	1·82
	521	0·13	"	0·04	10·58	"	1·36
	Mean	0·15	"	0·06	12·89	"	3·67
C	Y526	0·17	"	0·08	15·86	"	6·64
	Y501	0·16	"	0·07	15·34	"	6·12
	523	0·15	"	0·06	15·02	"	5·80
	Y512	0·13	"	0·04	9·46	"	0·24
	Mean	0·15	"	0·06	13·92	"	4·70
E	506	0·16	"	0·07	13·30	"	4·08
	502	0·16	"	0·07	18·14	"	8·92
	515	0·15	"	0·06	12·24	"	3·02
	Y509	0·12	"	0·03	9·27	"	0·05
	Mean	0·15	"	0·06	13·24	"	4·02
D	528	0·14	"	0·05	10·92	"	1·70
	522	0·11	"	0·02	9·38	"	0·16
	525	0·10	"	0·01	9·13	"	-0·09
	Y508	0·08	"	-0·01	4·74	"	-4·48
	Mean	0·11	"	0·02	8·54	"	-0·68

Final and initial weights (kg) and gains in weight in chemical components of muscle tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Dry matter			Ether extract		
		Final	Initial	Gain	Final	Initial	Gain
A	516	1·45	1·17	0·28	0·39	0·29	0·10
	504	1·32	"	0·15	0·34	"	0·05
	527	1·48	"	0·31	0·46	"	0·17
	524	1·24	"	0·07	0·38	"	0·09
	Mean	1·37	"	0·20	0·39	"	0·10
B	R124	1·59	"	0·42	0·44	"	0·15
	510	1·59	"	0·42	0·50	"	0·21
	513	1·45	"	0·28	0·30	"	0·01
	521	1·27	"	0·10	0·26	"	-0·03
	Mean	1·48	"	0·31	0·38	"	0·09
C	Y526	1·65	"	0·48	0·34	"	0·05
	Y501	1·42	"	0·25	0·37	"	0·08
	523	1·56	"	0·39	0·49	"	0·20
	Y512	1·70	"	0·53	0·40	"	0·11
	Mean	1·58	"	0·41	0·40	"	0·11
E	506	1·65	"	0·48	0·56	"	0·27
	502	1·58	"	0·41	0·41	"	0·12
	515	1·66	"	0·49	0·52	"	0·24
	Y509	1·40	"	0·23	0·35	"	0·06
	Mean	1·57	"	0·40	0·46	"	0·17
D	528	1·55	"	0·38	0·40	"	0·11
	522	1·48	"	0·31	0·38	"	0·09
	525	1·44	"	0·27	0·45	"	0·16
	Y508	1·35	"	0·18	0·37	"	0·08
	Mean	1·46	"	0·29	0·40	"	0·11

Final and initial weights (kg) and gains in weight of chemical components of muscle tissue (kg) in half-carcass of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Crude protein			Gross energy (Mcal)		
		Final	Initial	Gain	Final	Initial	Gain
A	516	0·90	0·75	0·15	9·20	7·34	1·86
	504	0·86	"	0·11	8·31	"	0·97
	527	0·92	"	0·17	9·64	"	2·30
	524	0·70	"	-0·05	8·06	"	0·72
	Mean	0·85	"	0·10	8·80	"	1·46
B	R124	1·00	"	0·25	10·15	"	2·81
	510	0·90	"	0·15	10·35	"	3·01
	513	0·95	"	0·20	8·88	"	1·54
	521	0·81	"	0·06	7·74	"	0·40
	Mean	0·92	"	0·17	9·28	"	1·94
C	Y526	1·10	"	0·35	10·08	"	2·74
	Y501	0·87	"	0·12	8·94	"	1·60
	523	0·88	"	0·13	10·16	"	2·82
	Y512	1·03	"	0·28	10·55	"	3·21
	Mean	0·97	"	0·22	9·93	"	2·59
E	506	1·01	"	0·26	10·90	"	3·56
	502	1·08	"	0·33	9·96	"	2·62
	515	1·06	"	0·31	10·89	"	3·55
	Y509	0·98	"	0·23	8·74	"	1·40
	Mean	1·03	"	0·28	10·12	"	2·78
D	528	1·04	"	0·29	9·79	"	2·45
	522	1·02	"	0·27	9·29	"	1·95
	525	0·90	"	0·15	9·40	"	2·06
	Y508	0·91	"	0·16	8·62	"	1·28
	Mean	0·97	"	0·22	9·28	"	1·94

Final and initial weights (kg) and gains in weight in dry matter of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Head			Feet			Bone*		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	1·04	0·87	0·17	0·48	0·36	0·12	2·39	1·69	0·70
	504	0·92	"	0·05	0·42	"	0·06	2·12	"	0·43
	527	0·91	"	0·04	0·43	"	0·07	2·03	"	0·34
	524	0·95	"	0·08	0·40	"	0·04	2·20	"	0·51
	Mean	0·96	"	0·09	0·43	"	0·07	2·19	"	0·50
B	R124	1·02	"	0·15	0·45	"	0·09	2·41	"	0·72
	510	0·95	"	0·08	0·43	"	0·07	2·15	"	0·46
	513	0·98	"	0·11	0·44	"	0·08	2·31	"	0·62
	521	0·87	"	0·00	0·43	"	0·07	1·87	"	0·18
	Mean	0·96	"	0·09	0·44	"	0·08	2·19	"	0·50
C	Y526	1·12	"	0·25	0·52	"	0·16	2·51	"	0·82
	Y501	0·96	"	0·09	0·44	"	0·08	2·36	"	0·67
	523	0·91	"	0·04	0·39	"	0·03	2·04	"	0·35
	Y512	0·89	"	0·02	0·42	"	0·06	2·42	"	0·73
	Mean	0·97	"	0·10	0·44	"	0·08	2·33	"	0·64
E	506	0·98	"	0·11	0·51	"	0·15	2·48	"	0·79
	502	0·93	"	0·06	0·46	"	0·10	2·30	"	0·61
	515	0·95	"	0·08	0·48	"	0·12	2·44	"	0·75
	Y509	0·91	"	0·04	0·44	"	0·08	2·15	"	0·46
	Mean	0·94	"	0·07	0·47	"	0·11	2·34	"	0·65
D	528	1·10	"	0·23	0·47	"	0·11	2·62	"	0·93
	522	1·00	"	0·13	0·44	"	0·08	2·70	"	1·01
	525	1·08	"	0·21	0·44	"	0·08	2·41	"	0·72
	Y508	1·02	"	0·15	0·45	"	0·09	2·14	"	0·45
	Mean	1·05	"	0·18	0·45	"	0·09	2·47	"	0·78

* In the whole carcass

Final and initial weights (kg) and gains in weight in dry matter of live weight components (kg) of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Blood			Pelt		
		Final	Initial	Gain	Final	Initial	Gain
A	516	0·25	0·25	0·00	2·62	1·87	0·75
	504	0·24	"	-0·01	2·69	"	0·82
	527	0·27	"	0·02	1·93	"	0·06
	524	0·22	"	-0·03	2·06	"	0·19
	Mean	0·25	"	0·00	2·33	"	0·46
B	R124	0·22	"	-0·03	3·25	"	1·38
	510	0·28	"	0·03	2·36	"	0·49
	513	0·28	"	0·03	2·28	"	0·41
	521	0·22	"	-0·03	2·90	"	1·03
	Mean	0·25	"	0·00	2·70	"	0·83
C	Y526	0·29	"	0·04	2·75	"	0·88
	Y501	0·29	"	0·04	3·51	"	1·64
	523	0·28	"	0·03	3·09	"	1·22
	Y512	0·29	"	0·04	2·75	"	0·88
	Mean	0·29	"	0·04	3·03	"	1·16
E	506	0·30	"	0·05	2·95	"	1·08
	502	0·32	"	0·07	2·80	"	0·93
	515	0·30	"	0·05	3·10	"	1·23
	Y509	0·34	"	0·09	2·95	"	1·08
	Mean	0·32	"	0·07	2·95	"	1·08
D	528	0·29	"	0·04	3·19	"	1·32
	522	0·32	"	0·07	2·74	"	0·87
	525	0·24	"	-0·01	3·04	"	1·17
	Y508	0·33	"	0·08	2·50	"	0·63
	Mean	0·30	"	0·05	2·87	"	1·00

Gross energy and energy retained (Mcal) in live weight components of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Head			Feet			Bone *		
		Final	Initial	Gain	Final	Initial	Gain	Final	Initial	Gain
A	516	5·13	4·30	0·83	2·25	1·69	0·56	10·95	7·73	3·22
	504	4·54	"	0·24	1·96	"	0·27	9·71	"	1·98
	527	4·49	"	0·19	2·02	"	0·33	9·30	"	1·57
	524	4·68	"	0·38	1·88	"	0·19	10·08	"	2·35
	Mean	4·71	"	0·41	2·03	"	0·34	10·00	"	2·27
B	R124	5·03	"	0·73	2·11	"	0·42	11·04	"	3·31
	510	4·68	"	0·38	2·02	"	0·33	9·85	"	2·12
	513	4·83	"	0·53	2·06	"	0·37	10·58	"	2·85
	521	4·30	"	0·00	2·02	"	0·33	8·56	"	0·83
	Mean	4·71	"	0·41	2·05	"	0·36	10·01	"	2·28
C	Y526	5·52	"	1·22	2·44	"	0·75	11·50	"	3·77
	Y501	4·73	"	0·43	2·06	"	0·37	10·81	"	3·08
	523	4·49	"	0·19	1·83	"	0·14	9·34	"	1·61
	Y512	4·39	"	0·09	1·97	"	0·28	11·08	"	3·35
	Mean	4·79	"	0·49	2·08	"	0·39	10·68	"	2·95
E	506	4·83	"	0·53	2·39	"	0·70	11·36	"	3·63
	502	4·58	"	0·28	2·16	"	0·47	10·53	"	2·80
	515	4·68	"	0·38	2·25	"	0·56	11·18	"	3·45
	Y509	4·49	"	0·19	2·06	"	0·37	9·85	"	2·12
	Mean	4·65	"	0·35	2·22	"	0·53	10·73	"	3·00
D	528	5·42	"	1·12	2·20	"	0·51	12·00	"	4·27
	522	4·93	"	0·63	2·06	"	0·37	12·37	"	4·64
	525	5·32	"	1·02	2·06	"	0·37	11·04	"	3·31
	Y508	5·03	"	0·73	2·11	"	0·42	9·80	"	2·07
	Mean	5·18	"	0·88	2·11	"	0·42	11·30	"	3·57

Gross energy and energy retained (Mcal) in live weight components of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Blood			Pelt		
		Final	Initial	Gain	Final	Initial	Gain
A	516	1·40	1·40	0·00	14·62	10·41	4·21
	504	1·34	"	-0·06	15·01	"	4·60
	527	1·51	"	0·11	10·77	"	0·36
	524	1·23	"	-0·17	11·49	"	1·08
	Mean	1·37	"	-0·03	12·97	"	2·56
B	R124	1·23	"	-0·17	18·14	"	7·73
	510	1·56	"	0·16	13·17	"	2·76
	513	1·56	"	0·16	12·72	"	2·31
	521	1·23	"	-0·17	16·18	"	5·77
	Mean	1·39	"	-0·01	15·05	"	4·64
C	Y526	1·62	"	0·22	15·35	"	4·94
	Y501	1·62	"	0·22	19·59	"	9·18
	523	1·56	"	0·16	17·24	"	6·83
	Y512	1·62	"	0·22	15·35	"	4·94
	Mean	1·61	"	0·21	16·88	"	6·47
E	506	1·67	"	0·27	16·46	"	6·05
	502	1·79	"	0·39	15·62	"	5·21
	515	1·67	"	0·27	17·30	"	6·89
	Y509	1·90	"	0·50	16·46	"	6·05
	Mean	1·76	"	0·36	16·46	"	6·05
D	528	1·62	"	0·22	17·80	"	7·39
	522	1·79	"	0·39	15·29	"	4·88
	525	1·34	"	-0·06	16·96	"	6·55
	Y508	1·84	"	0·44	13·95	"	3·54
	Mean	1·65	"	0·25	16·00	"	5·59

Percentage of dry matter in live weight components of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Head	Feet	Bone	Blood	Pelt
Initial	44·05	55·08	58·99	19·33	59·60
A	45·06	52·60	59·91	18·67	60·70
B	43·38	50·40	58·87	18·73	60·89
C	43·97	52·04	61·03	20·13	61·99
E	43·94	53·39	61·10	21·24	64·99
D	43·35	52·88	60·91	19·83	66·91

Percentage of DM in carcass tissues of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
		Prime	Sec.	Prime	Sec.	Fat	Muscle	
A	516	77·98	76·73	29·22	31·92	89·32	26·12	40·32
	504	80·77	79·81	29·28	32·06	92·48	26·80	45·07
	527	83·94	84·17	29·64	34·31	92·44	29·47	45·18
	524	80·97	78·00	31·09	33·15	92·74	27·24	38·91
	Mean	80·92	79·68	29·81	32·86	91·75	27·41	42·37
B	R124	79·75	80·32	29·35	29·81	91·75	26·94	39·73
	510	83·42	84·06	32·30	36·67	94·34	31·68	47·61
	513	77·91	83·91	28·49	32·04	91·81	26·42	45·63
	521	77·35	79·15	29·16	31·45	88·48	26·15	42·77
	Mean	79·61	81·66	29·83	32·49	91·60	27·80	43·94
C	Y526	81·77	83·10	29·06	30·80	95·41	26·36	48·35
	Y501	81·11	82·25	30·24	33·25	91·99	27·42	44·00
	523	82·72	82·05	32·30	37·91	95·45	27·71	49·20
	Y512	80·22	74·87	30·20	34·56	91·52	27·02	38·05
	Mean	81·46	80·57	30·45	34·13	93·59	27·13	44·90
E	506	80·68	77·74	31·06	33·09	91·16	26·67	40·73
	502	82·33	83·59	28·63	30·71	91·11	25·79	41·82
	515	77·65	75·60	29·64	32·79	77·65	25·50	41·88
	Y509	77·10	78·25	28·69	30·00	90·45	26·30	30·41
	Mean	79·44	78·80	29·51	31·65	87·59	26·07	38·71
D	528	76·78	74·61	28·25	30·02	91·08	24·87	35·61
	522	78·48	75·68	27·19	30·28	91·40	24·52	33·99
	525	77·72	76·43	27·98	32·13	90·32	24·75	27·36
	Y508	69·75	69·49	27·29	30·08	86·69	24·36	21·15
	Mean	75·68	74·05	27·68	30·63	89·87	24·63	29·53

Percentage of EE in carcass tissues of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
		Prime	Sec.	Prime	Sec.	Fat	Muscle	
A	516	64·76	63·29	7·19	11·43	82·72	3·15	22·45
	504	67·41	70·43	7·26	9·35	88·23	2·69	27·39
	527	74·07	74·89	8·93	11·96	87·56	5·82	28·82
	524	66·02	66·29	9·19	11·81	88·71	2·00	22·50
	Mean	68·07	68·73	8·14	11·14	86·81	3·42	25·29
B	R124	69·27	70·67	8·13	8·85	87·74	3·11	23·31
	510	70·97	72·45	9·88	12·49	90·32	4·39	32·31
	513	67·37	71·80	5·59	8·64	86·95	1·84	28·60
	521	65·27	68·69	5·75	8·20	84·02	1·58	26·98
	Mean	68·22	70·92	7·34	9·55	87·26	2·73	27·80
C	Y526	71·61	69·76	5·26	8·97	91·80	1·54	31·09
	Y501	71·24	72·24	7·18	10·86	87·77	2·63	27·85
	523	74·57	73·90	9·45	15·10	92·29	3·99	32·50
	Y512	67·13	62·27	6·25	11·05	83·72	3·18	23·40
	Mean	71·14	69·54	7·04	11·50	88·90	2·84	28·71
E	506	72·75	68·22	10·09	12·74	87·05	3·82	24·50
	502	75·04	76·93	7·05	9·24	87·60	2·43	26·91
	515	68·35	66·55	9·06	12·52	84·35	2·69	27·48
	Y509	67·80	68·68	6·95	8·21	85·81	2·45	15·85
	Mean	70·99	70·10	8·29	10·68	86·20	2·85	23·69
D	528	68·53	65·29	6·88	9·44	88·82	2·55	23·63
	522	70·23	67·43	6·37	10·31	87·19	2·10	20·64
	525	68·86	67·78	8·09	12·42	85·92	2·98	11·33
	Y508	58·15	58·37	6·99	10·03	80·81	1·92	4·55
	Mean	66·44	64·97	7·08	10·55	85·69	2·39	15·04

Percentage of CP in carcass tissues of Blackface wether lambs for different levels of daily intake of metabolisable energy

Group	Lamb No.	Fatty tissue		Muscle tissue		Longissimus dorsi muscle		Gut + Pluck
		Prime	Sec.	Prime	Sec.	Fat	Muscle	
A	516	9·06	9·17	18·89	17·50	4·89	20·42	11·47
	504	9·49	8·17	19·66	18·72	3·97	20·59	10·35
	527	7·55	7·00	19·01	18·51	3·50	20·40	10·94
	524	7·55	9·11	18·38	17·89	3·66	19·77	11·54
	Mean	8·41	8·36	18·99	18·16	4·01	20·30	11·08
B	R124	7·83	7·31	18·45	18·40	3·94	20·58	11·88
	510	7·83	7·11	18·85	18·29	2·74	20·67	10·97
	513	9·43	8·15	18·85	19·17	3·59	20·42	11·15
	521	8·48	7·54	18·95	18·26	4·16	20·21	11·31
	Mean	8·39	7·52	18·78	18·53	3·61	20·47	11·33
C	Y526	7·75	8·56	19·66	19·34	3·29	21·82	11·24
	Y501	7·49	7·84	19·14	17·34	3·44	20·94	11·04
	523	7·35	7·95	18·86	18·49	2·73	20·82	10·55
	Y512	9·12	10·13	19·01	18·22	4·00	20·66	11·99
	Mean	7·93	8·62	19·17	18·35	3·37	21·06	11·21
E	506	7·45	9·19	19·33	19·56	3·58	21·13	11·45
	502	6·87	6·49	19·65	19·91	3·47	21·67	10·65
	515	8·71	8·83	19·36	19·12	3·93	21·42	11·54
	Y509	8·96	8·57	20·33	19·46	4·11	22·09	13·47
	Mean	8·00	8·27	19·67	19·51	3·77	21·58	11·78
D	528	8·08	8·80	18·99	19·42	2·45	20·92	9·52
	522	7·67	8·23	19·25	19·06	3·21	21·21	11·84
	525	7·46	8·46	18·08	18·12	2·97	20·34	12·20
	Y508	10·15	10·63	18·80	18·73	5·57	21·05	12·16
	Mean	8·34	9·03	18·78	18·83	3·55	20·88	11·43

The caloric values (Kcal/100g fresh matter) of the fatty and muscle tissues of Blackface wether lambs fed different levels of daily intake of metabolizable energy

Group	Lamb No.	Fatty tissue		Muscle tissue	
		Prime	Sec.	Prime	Sec.
A	516	670·51	658·02	182·60	213·85
	504	695·83	702·93	183·20	206·22
	527	739·29	743·79	191·80	228·55
	524	691·31	676·76	200·47	221·85
	Mean	699·23	695·38	189·52	217·62
B	R124	697·95	706·58	187·07	192·38
	510	724·09	733·41	209·62	243·10
	513	680·63	725·69	172·33	203·26
	521	669·25	692·46	176·50	198·40
	Mean	692·98	714·54	186·13	209·29
C	Y526	717·98	717·54	174·00	198·07
	Y501	713·03	723·04	187·93	218·50
	523	734·88	728·66	207·89	260·11
	Y512	691·82	644·15	183·98	226·20
	Mean	714·41	703·35	188·45	225·83
E	506	716·83	683·16	203·94	225·27
	502	734·72	748·94	178·93	198·68
	515	683·21	665·18	192·33	222·81
	Y509	678·10	687·69	178·85	190·84
	Mean	703·22	682·49	188·51	209·43
D	528	679·36	654·91	176·26	195·85
	522	695·13	669·15	168·62	200·72
	525	685·62	674·50	179·70	218·93
	Y508	600·65	600·16	171·65	198·54
	Mean	665·19	649·68	174·05	203·51

The caloric value for fat-free dry matter = 5·26 Kcal/g

The caloric value for ether extract = 9·28 Kcal/g