EFFECTS OF VARIATIONS IN DIETARY ENERGY LEVELS ON THE GROWTH AND CARCASS QUALITY OF THE NIGERIAN DWARF SHEEP

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EFFECTS OF VARIATIONS IN DIETARY ENERGY LEVELS ON THE GROWTH AND CARCASS QUALITY OF THE NIGERIAN DWARF SHEEP

BY

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SENIOR LECTURER

Dedicated to the memory of my late mother

MRS. CHRISTIANAH JOLADE ADEBAMBO

and to my Dad

MR. JOSIAH MARTINS ADENAIYA ADEBAMBO

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ABSTRACTS

. A total of 76 animal experiments, involving young Nigerian Dwarf Sheep, were conducted to investigate the growth response to effects of varying levels of dietary energy. The studies also embraced digestibility trials and carcass evaluation.

Results obtained appear to indicate that between the ages of 3 - 6 months, a daily intake of 107.1 kcal metabolizable energy was required for maintenance while from 6 - 9 months of age the requirement increased to 129.2 kcal per day. A growth requirement of 215 kcal ME/day/$W^{0.73}$kg and 1387 kcal ME/day$W^{0.73}$kg was obtained for animals between 3 - 6 months and 6 - 9 months respectively. An analysis of the pooled results seems to indicate that 134.04 kcal ME per day and 647kcal/ME/day/$W^{0.73}$kg was the requirement for maintenance and increase of 1 kg. live-weight respectively.

Studies on digestibility of feeds revealed that the effects of variations in the type of ration on digestibility was less marked than the effects due to age of the animals. Crude fibre digestibility coefficient for the basal diet was about 68.04% for the older animals while the corresponding values for the younger animals ranged between 54.4% and 56.0%. Values for the mixed diet and concentrate ration ranged from 68.3% to 77.45% and 71.3% to 79.5% respectively with the older animals while the corresponding

values for the younger animals were in the range of 58.01% to 60.59% and 63.8% to 65.02%.

Results of animal performance indicated that younger animals are capable of faster growth than older ones but the effect of low plane of nutrition as indicated by growth rates is more adversely felt by the younger animals. Thus the mean daily weight gains of the older animals were 79.6g, 83.8g, 82.2g, 55.7g for treatments A, B, C and D respectively while the corresponding values for the younger animals were 97.7g, 71.8g, 45.7g and 21.7g respectively.

The carcass evaluation showed that dressing percentages and percentage flesh increase with age. At six months and in all treatments, the range was between 34.3% to 43.8% while at 9 months it rose to 49.7% to 60.8%. Percentage of flesh in the carcass has been shown to range from 62.6% to 66.2% at birth with a possible increase of about 0.7% to 0.9% per kg live-weight gain.

The results of this study have shown that the younger animals are capable of faster growth and respond faster to high plane of nutrition but the effect of low plane of nutrition as indicated by growth rates of all animals on the lower energy level diets, is more adversely felt by the younger animals. It is to be noted that the early weaned lambs cannot survive on pasture alone.

The results also were discussed in terms of the economics of production.

CHAPTER 1

1.1 General Introduction.

Successful practical agriculture depends mainly on the effective understanding and control of the various processes involved in the phenomenon of growth in plants and animals. Growth studies in farm animals have been of special interest to farmers and breeders in their attempts to satisfy the ever-changing human tastes. Much attention has been paid to animal nutrition because an improvement in the level of animal nutrition makes for better animals which thus ultimately provide better nutrition for man.

In many agriculturally developed countries, much work has been done in the field of animal husbandry. Improved breeds of farm animals have been evolved to meet the needs of man. In many of these countries the level of animal protein in the human diet has been raised to a very reasonable standard.

In Nigeria, comparatively little has been done in the field of applied animal nutrition. More work has been carried out on the nutrition of pigs, concentrating mainly on the imported breeds. Poultry and cattle have also received attention, but it has been proved that the Nigerian breeds of these stocks cannot be used for much commercial production. Because of disease problems with the exotic breeds of cattle and the problem of adaptation to the tropical environment, attempts are being made to produce a breed of dairy cattle by crossing the high yielding exotic breeds with the best of the local breeds.

In recent years, much attention has been drawn to the relatively low levels of animal protein in the daily diets of the average Nigerian as compared with the developed countries of the world. The low level is probably due to the low productivity of Nigerian livestock and not to the numbers as, it would appear, there are large numbers of livestock in Nigeria especially in the Northern States where they are concentrated. The problem then is that of increasing the productivity and this can be achieved by the improvement of:-

a) animal nutrition through better pastures and feeding system.

b) animal environment by the drastic reduction and prevention of diseases.

c) Management practices.

1.2 World Protein Situation.

The most important problem facing nutritionists and other allied scientists is the provision of food for the ever increasing world population. This involves the provision of diets balanced in all respects, and in sufficient quantity at the appropriate stages and periods of the animal life. The most limiting constituent of a balanced diet is animal protein.

Many developed countries of the world have highly developed animal husbandry industries and hence the people enjoy high levels of animal protein while the developing countries, mostly in the tropical world, live mainly on cereals and tubers which supply high calories but lack the essential amino acids needed for growth and development. Protein deficiency in infancy and childhood has serious adverse effects on the normal development and ultimately on the later efficiency of the adult individual.

The disparity in protein consumption between the developed and the developing countries of the world is so great that one can easily classify the countries of the world into developing or developed on account of protein consumption levels.

Oyenuga (1971) has estimated that some developed countries produce protein sources that exceed requirements by some 22% whilst Nigeria's protein supply falls short of requirements by 75%. The animal protein position follows the same pattern. The developing countries are in short supply of protein from animal sources to the tune of 75% and this has very serious adverse effects on the efficiency of utilization of the 93% of the total protein available for consumption in Nigeria.

Table 1.1 shows comparative protein consumption figures (Oyenuga, 1969) of some developed and developing countries. There is a wide gap between the amount of protein made available in the developed and the developing countries as shown by the mean figures of 96.0 and 50.2 for Total Protein in four developed and four developing countries respectively. Of the total protein 66.7% and 16.8%

are from animal origin from the developed and developing countries respectively. This shows that the small quantity of protein consumed in the developing countries are also of low quality.

Fetuga (1972) points out that the Nigerian protein problem is a dual one - that of overcoming the general protein shortage and that of increasing the proportion of animal protein in the total. There is need to produce not only larger quantities of protein but also high quality proteins. It is therefore imperative to increase production of animal proteins from beef, pork, poultry, fish, mutton and goat meat and possibly from other non conventional sources such as game and snail.

To solve this ever present human problem, it is highly essential to have a well defined animal husbandry improvement programme in which management, health and nutritional status of the animals will be highly improved so as to increase both the number and quality of animals for improving protein quality consumption.

1.3 General Livestock Situation.

In most developing countries, the distribution of livestock is directly controlled by the climate and vegetation. In Nigeria, the vegetation thins down northwards. It varies from the thick mangrove and fresh water swamps (in the southern coast) through the low land rain forest, Derived Savanna (in the middle belt) to the southern and northern Guinea Savanna, Sudan and the sahel

Table 1.1 Daily Per Caput Net Food Supplies in Four Developed and Four Developing Countries 1966/67. (Oyenuga, 1969)

Developed Countries	Calories	Total Protein	Animal Protein	Proportion of Animal Protein to total protein	Proportion of calories supplied from protein
New Zealand	3,470	109.4	74.8	68.4	12.6
Denmark	3,290	91.9	61.7	67.1	11.2
U.S.A.	3,160	93.8	66.7	71.1	11.9
United Kingdom	3,220	88.9	53.3	60.0	11.0
Mean	3,285	96.0	64.1	66.7	11.7
Developing Countries					
India	1,810	45.4	5.4	11.9	10.0
Sri Lanka (Ceylon)	2,180	44.5	10.3	23.1	8.2
Tanzania	2,110	59.0	9.2	15.6	11.2
Nigeria	2,183	51.7	8.6	16.6	9.5
Mean	2,071	50.2	8.4	16.8	9.7

savanna of the extreme North. Distribution of livestock follows this natural pattern with most of the livestock being found in the savanna zones of the north while the coastal swamp and rain forest zones are areas of low livestock density.

Another factor is the prevalence of the tsetse fly, vector for trypanosomiasis. This limits the majority of livestock to the Northern savanna lands with low fly density. The Southern Forest zones are areas of very high density of tsetse fly and as such have low density of livestock, which are mostly the dwarf breeds with high tolerance to trypanosomiasis attack.

There is yet no accurate livestock population figure in Nigeria. Figures in use have been based on estimates as in the case for cattle in which given figures have ranged from 5.6 million (FAO, 1960) to 10.8 million (FAO, 1966) and extreme figure of 15 million by the Federal Ministry of Information (1964).

These various estimates have been based on information from tax returns, vaccination figures or in some cases formula estimates. Figures based on taxation and vaccination can highly underestimate the livestock population since it is based on the number of animals that have either been vaccinated or on which cattle tax known in Northern Nigeria as "jangali" has been paid. There is always the tendency for the cattle herdsmen to declare fewer animals than actually exists to avoid heavy taxation (St. Croix, 1945; Shaw and Colville, 1950; Stenning, 1959). For the same reason, cattle owners avoid vaccination for fear that it could reveal the real number of animals they possess and as such make them pay higher tax. Probably, the most reliable method of rough estimation is the Sample Surveys, provided the sample is correctly drawn or the number of farm households accurately known.

The Federal Department of Agriculture (1971) gave the following figures:-

Cattle	11,073,000
Sheep	8,125,000
Goat	26,013,000
Pigs	909,000
Poultry	86,118,000

Apart from the low figures, Oyenuga (1966) stated that proportion of livestock per 100 Nigerians is relatively low and deserves considerable expansion in order to meet the need of the rapidly increasing human population. The productivity per animal is generally low compared with their counterparts in the temperate world. Reports by Shaw and Colville (1950) indicate that Nigeria has indigenous breeds of cattle from which could be raised animals of suitable type and productivity, whether for economic production of beef or milk; but that the nutrition of the existing breeds must be put to a higher plane in order to achieve maximum productivity. This may also apply to other breeds of livestock.

1.4 Position of Sheep in Nigerian Agriculture.

Cattle and poultry supply most of the animal protein in Nigeria in form of beef, milk, eggs and poultry meat. Pigs provide less since fewer people consume pig meat for religious reasons. The greater attention paid by workers to cattle, poultry and pigs may therefore be due to their relatively greater importance, at present, to the Nigerian diet. Much work has thus been done in the fields of nutrition and the improvement of productivity of these farm animals.

The sheep industry, on the other hand, has been one of the most neglected aspects of Nigerian agriculture. This is probably due to the fact that the potential contribution of the species to the animal protein pool of the Nigerian diet has not yet been fully appreciated. The sheep industry makes major contributions to the economy of some countries and consumption per head of human population and exportation in these countries are quite high.

As could be seen in Table 1.2 the figures for Nigeria, which are FAO estimates in most cases, are quite low in comparison with world standards per caput; meat and meat-protein supplies are extremely low in Nigeria. Since the meat supply is low and sheep, as a source of meat, is not the most important in this country, it means that the supply of meat and meat protein from sheep is low. This could be due either to the comparatively low sheep population or the low harvest of meat from the available breeds of sheep.

Plate I - A Nigerian Dwarf sheep. Note the very hairy skin.

Plate II   A Nigerian Dwarf Sheep - Compair quantity with
Plate I

Within Nigeria, the position of sheep varies from state to state because of varied suitability of the vegetation to sheep farming. Production and per capita supply of sheep in the twelve states of Nigeria are presented in Table 1.3. It should be noted that the West African Dwarf sheep is the main breed in the southern states.

The comparatively low population of sheep and the low consumption throughout Nigeria are probably due to the greater importance placed on beef as a source of meat and this probably accounts also for the little amount of work done on sheep in Nigeria. Some attempts had earlier been made to study the performance of local breeds of sheep under local conditions and subsequently to examine and compare the performance of their crosses with selected exotic breeds such as the Merino and Black-headed Persian at Katsina Livestock Investigation and Breeding Centre in 1957 (Ferguson, 1964).

The other reports on the West African Dwarf sheep include the study by Jollans (1960) in the closed forest zone of Ashanti, Ghana, in which he investigated the growth rate and carcass quality, drawing attention to some production characteristics of the breed.

Hill (1960) gave a summary data from some experimental stations, where flocks of the Dwarf sheep were kept, between 1950 and 1959. This was as a result of the work of Okereke (1958) who

Table 1.2 Sheep population, mutton and lamb production, per capita meat and meat protein supply of some countries with organised sheep industry and some with peasant-type industry.

Countries with organised industries	Population "000"	Mutton and lamb production from slaughtered animals (1000 metric Tons)	Mutton and lamb production from indigenous animals (1000 metric Tons)	Per Caput meat supply (g/day)	Per Caput meat protein supply (g/day)
Australia	178,287	803	870	294	38.3
USSR	137,940	1,000	800	106	13.9
New Zealand	58,913	558	558	310	37.8
Argentina	43,800	170	180	335	47.7
United Kingdom	25,998	227	230	209	23.8
Peasang Type					
India	42,800	357	358	4	0.5
Nigeria	8,100	175	109	28	4.2

Source: F.A.O. Production Yearbook 1971

Table 1.3 . Production and per capita supply of sheep in the twelve states of Nigeria

States	Production (1000 Metric tons)	Per Capita kg/yr	Supply g/day
Benue-Plateau	1.866	0.413	1.132
East Central	1.928	0.237	0.132
Kano	4.578	0.703	1.926
Kwara	0.389	0.144	0.395
Lagos	-	0.022	0.060
Mid-West	0.123	0.043	0.118
North Central	2.571	0.556	1.523
North Eastern	4.726	0.538	1.474
North Western	2.069	0.320	0.877
Rivers	0.303	0.174	0.477
South Eastern	0.974	0.238	0.652
Western	2.018	0.189	0.518
Nigeria	30.48	0.485	1.329

Source: Olayide, Olatunbosun, Idusogie and Abiagom (1972)

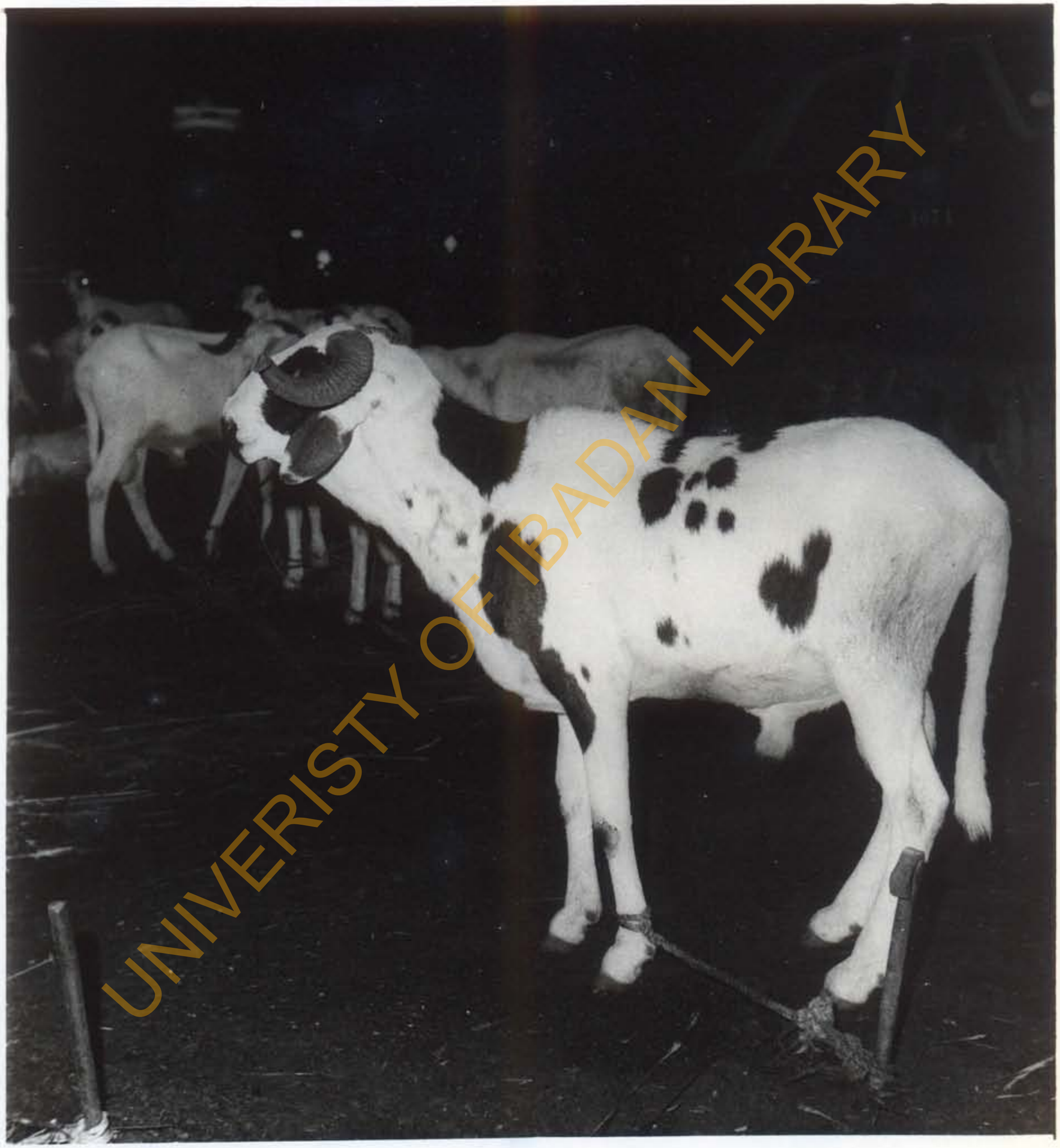

Plate III The Ouda Sheep from the North of Nigeria obtained some basic data on the carcass quality of the Dwarf sheep. Awoyemi (1962), in his unpublished work on the University of Ibadan Farm, also reported on the effect of season and plane of Nutrition on growth rate and carcass quality of the Nigerian Dwarf sheep.

1.5 Management

Apart from the few research stations such as Katsina, the University research and Teaching Farms and the livestock stations set up by the former Western and Eastern Regional governments at Agege, Oyo, Umuahia, Benin, Ado-Ekiti and Moor Plantation, there are no other organized sheep farms. In recent times, the sheep herds kept by the Western State Government at Upper Ogun near Oyo and at Ado-Ekiti have been folded up.

Management practices vary from area to area and this depends mostly on the living habits of the people. To the extreme North, the Oudawa tribe keep large flocks of the Ouda breed. This nomadic tribe, like the Fulani livestock owner, follow their animals to fresh feeding grounds with the change of season. Migrations in this trans-humane management system are determined by the availability of pasture.

The Y' ankassa to the south are kept in small flocks by town dwellers and nomads and live in close association with towns and villages where they may receive very limited supplementary feeding of guinea corn bran and dried groundnut tops in season (Ferguson, 1964).

The West African Dwarf sheep are kept in small numbers by families who take very little care of them. They are thus ubiquitous in villages and towns throughout the Nigerian rain forest zone. They exist and thrive to a considerable extent under local conditions by grazing, browsing and scarvenging. They seem to like road-side and fallow grasses, scrub bush and leaves of small trees. Occasionally, they may be given cassava and yam peels, groundnut tops and haulms, rice, maize and Guinea corn bran, orange and mango peelings and any other discarded scraps where these are available or they may be allowed on to the harvested plots but usually the animals spend most of the day browsing round the villages and are always on the look out for any waste food left anywhere. No special shelters are provided for the animals to spend the night, they however love warm and dry places and hence they may be found on dry mud floors in the kitchens, on the house porch, on fast draining sandy foot paths or on the tarmac of major roads. Under these conditions they keep fairly clear of heavy parasite burdens during the height of the rainy season and it is something of a paradox that in many cases where villagers have attempted to husband their sheep in a more orderly fashion, for example by the use of fenced paddocks and night enclosures, heavy losses from internal parasites have occurred (Hill, 1960).

On the University research farms where veterinary care is adequate, shelters have been provided for the sheep and they are given regular concentrate supplements in addition to established pastures and good water.

1.6 Marketing

Only the Ouda has a well organized slaughter trade. Large numbers are purchased by traders who either rail them or bring them down in heavy lorries most especially during the moslem festivals. The Y'ankassa has no well developed trade. They are offered for sale in local markets in small numbers and slaughtered locally occasionally.

The Dwarf sheep are usually not offered for sale unless there is an urgent and very serious need to raise funds for the family. The males are slaughtered only for special ceremonies and females only when traditions demand.

In recent times, however, the great demand for sheep and goats during both the Moslem and Christian festivals which have fallen at about the same time has caused all breeds of both species of livestock to flood the markets. Because of the high prices that have been paid for them the Northern tradesmen have rushed down both male and female stocks and in some cases animals too young for marketing.

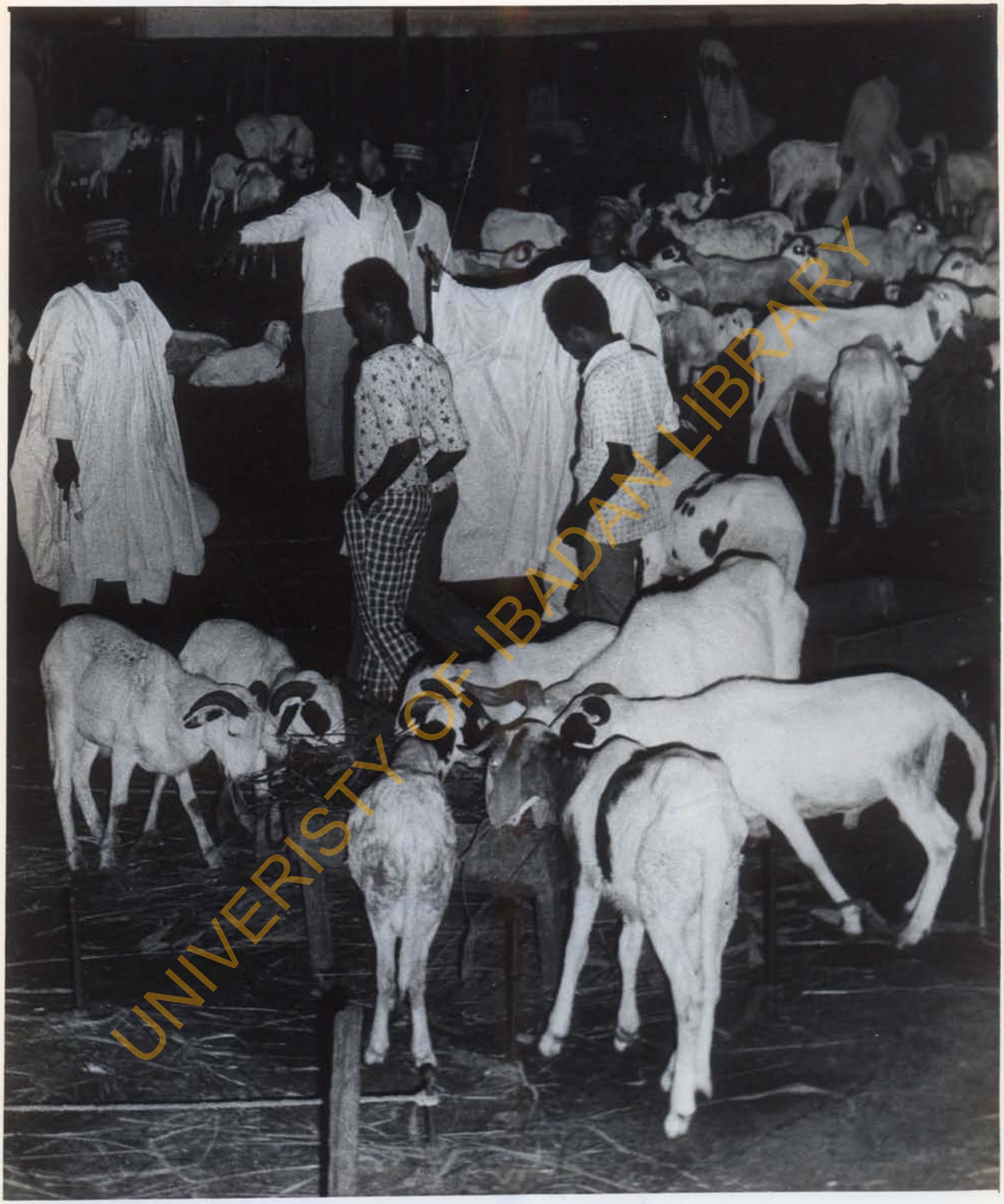

Plate IV   A Scene at a local Sheep market at Ibadan

Plate V Pricing Sheep at a local market - Assessment is by handling

1.7 Social and Cultural Importance of Sheep.

Like the cattle, numerical strength of the sheep flock is more important to the Northern herdsman than the quality and productivity of the animals. The wealth of a family was usually estimated in terms of the head of cattle, sheep and goats owned by such a family. The herdsman has a very strong attachment to his animals and he is unwilling to part with them except to pay bride price, or for other family commitments.

The West African Dwarf sheep is kept, more as a pet than as a commercial animal in the Southern States of Nigeria. This shows why they are rarely sold or slaughtered. They are however donated for slaughter during family ceremonies when they serve as the essential slaughter animal, in preference to goats. Cattle are usually too expensive for such ceremonies.

Absentees or late commers at family meetings,community gatherings or most especially at age-group cooperative farm work or building constructions called "Owe" were usually fined goats and rams. Officers of the group were dispatched to the homes of defaulting members to seize prescribed number of the animals. The animals would only be given back if tenable explanations were obtained within specified period of time.

The sheep has played very significant roles in the culture of Nigerians. It has served for a long time as the sacrificial animal. This is probably why it still comes in as the general all purpose slaughter animal at most ceremonies. A ram or ewe is offered at every special local party called "Sara" which is organised when a woman is either getting married or expecting a baby, when one is going on a long journey or for good luck in any undertaking.

When an elder dies many relations have to slaughter rams at the residence of the diseased and the son-in-laws have to present a ram each. In some areas, the ram is an essential part of the bride price.

There is also the religious significance of the ram which has its origin in the biblical story of Abraham and Isaac. Thus, the ram is an essential slaughter animal for every adult true moslem during their festivals. At this time only the ram is the truly acceptable slaughter animal. The Christians seem to have adopted this system also although the turkey, which has become too expensive, still comes in very much at Christmas.

1.8 Need for Work on Sheep Production.

Under the extensive system of management, the Nigerian Dwarf Sheep has thrived for a long time. They have been exposed to prolonged periods of under and malnutrition, disease infections and the unfavourable weather conditions. The resultant effect is permanent adaptation to low feed intake leading to dwarfism and general low productivity. The sheep owners who have invested very little in terms of labour and feeds always look up to whatever they get out of them as being profitable.

With increase in the level of education there has been a growing awareness of the need for balanced diet and hence there is a greater demand for animal protein. Added to this is the growing demand for other sources apart from beef. More people now opt for goat meat, mutton, poultry meat and eggs, milk, which is mainly imported, pork for the non muslims and game. It is in fashion now for mutton and goat meat to be sold, served with food more especially in the local canteens because people seem to have developed a taste for these in preference to beef. This, therefore, seems to initiate a good trade in sheep and goat, which, up to date, is dominated by the Northern breeds. Relatively, very few of the Dwarf breed are slaughtered.

This invariably means that the demand for these animals will increase and there will be a need to develop them to a good standard of productivity so as to meet this increasing demand.

Of the three Nigerian breeds of sheep, the Dwarf sheep is the smallest in body size and possibly in number. As in many other African countries relatively little work has been done to explore the potentialities of the sheep industry. Little has been done in determining the productivity of this breed when given improved conditions of management and feeding. Work by Hill (1960); Dettmers and Loosli (1974), point out that the breed could measure up to the reproductive performance of the temperate breeds if they are well cared for with good pasture, supplementary feed and superior management. The age of the ewes at first lambing (generation interval) was quite low. Hill (1960) reported an age of 11-14 months while Dettmers and Loosli (1974) reported 20 months but a closer look at the latter work revealed that 37% of the ewes were less than one year old and 66% were 15 months old at first lambing. The breed has also been described as being fairly prolific and lambing is all year round (Dettmers and Loosli, 1974) compared with the other Nigerian breeds, prolificacy measured in terms of average number of lambs produced per 100 ewes, the lambing percentage of the Dwarf sheep was 120 (Hill, 1960). The lambing percentage figure of 145 obtained by Dettmers and Loosli (1974) was higher than the Ouda with 134 but less than 174 for the Y'ankassa, the two most common and larger breeds to the North (Ferguson, 1964). Lambing percentage increased with lambings, being 121 for the first, 153 for the second and third and 183 thereafter (Dettmers and Loosli, 1974).

Compared with exotic breeds, the highest lambing percentage on record is 205 for East Friesian milk sheep, perhaps close to the Finn sheep. The Nigerian Dwarf sheep compares favourably with the Dutch Texel with 150 - 160% (Maymone, Haring and Linnenkohl, 1961) and 166 for the most prolific Sweedish Landrace (Johansson and Hansson, 1943).

Incidence of Twinning is also high in this breed. Hill (1960) reported 20% twins and no triplets; Ademosu, (1973) recorded 27% while Dettmers and Loosli (1974) reported that 55% of live lambs born were twins and 8% triplets being the highest reported for any Nigerian breed.

The rate of multiple births (twins and triplets combined) increased with lambings and was 37% for the first, 65% for the second and 81% thereafter (Dettmers and Loosli, 1974).

Ngere (1973) had reported a yearly lambing of 171 and twinning rate of 87% for 45 ewes which lambed out of 47 (96%) of Dwarf sheep (forest type) in Ghana.

The Dwarf sheep are thus superior to the temperate breeds in multiple birth rates. Johansson and Hansson (1943) reported 55% twins, 5% triplets and 0.4% quads and quins, a total of 60.4% for the Sweedish Landrace sheep. Among all breeds of sheep and types of environment, expectation is 176 pairs of twins and 10 sets of triplets in every 1000 births and one set of quadruplet lambs born in every 5,000 births (Reeve and Robertson, 1953) and the lamb crop is 119.6% (Ensminger, 1969).

Lambing intervals also point to the great potentialities of this breed. The lambing interval was 248 days compared to 236, 270, 273 - 284 for other Nigerian breeds, the Yankassa, Ouda and their crosses with Merino respectively (Ferguson, 1964). These intervals shortened with lambings, 277 days between first and second, reduced to 233 days between second, third and fourth and an average of 209 days between the 4th and 8th lambings.

Losses up to weaning reported were 25% (Hill, 1960), 20% (Dettmers and Loosli, 1974) and these figures for the Nigerian Dwarf sheep are better than 28% from birth to weaning all over the world reported by Ensminger (1969) who related that of the average 119.6% lamb crop mentioned earlier only 92% lambs were raised to one year and older. Their survival under the difficult management system is an indication that their performance will be much better under an improved system.

Writing on the importance of nutritional studies, Lamming (1960) stated that absence of hunger is essential for optimum performance in terms of growth, reproduction and lactation and therefore in terms of endocrine functions. Added to lack of hunger in importance is the great need for correct type of diet to be given at the appropriate time. This is the only way to have optimum growth in the shortest possible time.

The systems of feeding used on the research farms and government stations are meanwhile based on the recommendations for the exotic breeds in the temperate zones. Because of breed and climatic differences, these tropical breeds will be expected to have less requirements for maintenance and production.

A great deal of work must therefore be carried out to improve the present position of all breeds of sheep in the country and thus make the sheep industry an economically viable enterprise.

CHAPTER 2

Literature Review.

Work on intensive meat production from sheep in the temperate region was stimulated by the findings of Hammond (1932) and the classical experiments of P'alsson and Verges (1939, 1942, 1948, 1952). Prior to these, much of the nutrition studies with sheep have been concerned with determinations of digestibility and nutritive values of various feedingstuffs. Many workers have stopped at the live-weight or at most the carcass weight of the animal. P'alsson and Verges (1942) have remarked that this is insufficient as the animal and its carcass are not homogenous, some parts being inedible. The value of an animal for meat depends more on its anatomical composition than on any other factor.

Waters (1909) and Trowbridge, Moulton and Haig (1918-1923) approached the problem from the meat production side by studying the effect of different planes of nutrition on growth and carcass quality in cattle. Hammond (1932) studied intensively the growth and mutton qualities in the sheep, dealing with the problem of meat production in a different way. He studied the ultimate product, meat and worked backwards to elucidate the conditions or factors which affect its formation. He found that the value of an animal for meat could not be measured from its live-weight, nor even its carcass weight without consideration of several other factors because age, breed, sex, state of fatness have an effect not only on the proportions of dressed carcass to offals, but also on the relative development of the different joints and the different tissues, bones, muscle and fat in the different joints. He found these differences to be due to the fact that different parts of the body and different tissues of the carcass grow at different rates as the animal grows from birth to maturity. This differential growth rates was later confirmed by McMeekan (1940).

Commercial Lamb Rearing Methods.

The experiment of Palsson and Verges (1952) on the effect of plane of nutrition on growth and development of carcass quality of lambs was conducted in two parts. The first part concerns the effect of rearing lambs on two quantitatively widely different planes of nutrition on the growth and development of the different anatomical units and tissues with age. The second part is aimed at comparing the effects of four different planes of nutrition on carcass quality of lambs of the same carcass weight but of different ages. In this part special attention was paid to the effect of changing the plane of nutrition at a certain age from high to low and vice versa while others were left on high and low planes throughout. This was intended to bring out the four methods of rearing lambs, frequently followed by sheep farmers in commercial practice in the temperate region. They are:-

(i) The method of rearing lambs continuously on a high plane of nutrition from some time before birth to slaughter which is often used by sheep farmers catering for early fat lamb market if plenty of feeding stuffs and good grazing are available.

(ii) Good feeding of ewes during late pregnancy and the first few weeks after lambing followed by poorer feeding of the lambs later on is frequently met with, in cases where farmers who aim at the production of early fat lambs run short of pasture or feedingstuffs due to drought or other causes before the lambs are ready for the butcher.

(iii) The third type of growth produced by a low plane of nutrition in early life followed by a high plane later is commonly met with on hill sheep farms in years when the winter is severe and prolonged spells of cold prevent or retard growth of grass in spring.

(iv) The continuous underfeeding of lambs during the growing period, corresponds to the method of rearing lambs on poor hill pasture or on grossly overstocked land.

Palsson and Verges (1952) could not pin point which of the methods was the most economical from the food utilization point of view since they have been primarily concerned with the interplay of growth and nutritive environment and how the latter affects growth and development in general as well as the quality of the ultimate product, the carcass, at a suitable weight for marketing.

Dietary Protein Requirement.

Maynard and Loosli (1962) have produced sufficient evidence to show the importance of microorganisms in protein metabolism by ruminants. It was pointed out that bacteria and other micro-organisms play a large rôle in the breakdown of complex carbohydrates in the digestive tract, especially in the ruminants and as the bacteria multiply, they synthesize protein to construct their own bodies from amides, ammonium salts and even nitrates ingested in food. Zuntz (1891) pointed out the preference of amides, amino acids and ammonium salts to actual proteins by the rumen micro-organisms. Fingerling and coworkers (1937) produced clear evidence that calves can utilize urea to supply a part of the protein needs for growth.

McDonald (1954) found that when 94 per cent of the total nitrogen in a sheep ration was fed as zein, 40 per cent of it was used by rumen organisms to synthesize their own protein. Earlier, Loosli and associates (1949), using a nearly protein-free purified diet with lambs, showed specific evidence that microbial action in the rumen can synthesize from urea all of the 10 amino acids which are essential for rat growth. All these evidences seem to suggest that so far there is sufficient source of energy and other sources of nitrogen, microbes in the rumen can synthesize sufficient protein to build up their bodies and when they die the proteins are passed on to the host animals.

Andrews and Orskov (1970) criticized many of the published reports on the protein requirements of growing lambs on the ground that these reports were based on lambs whose initial weights exceeded 30 kg and that the diets containing different protein concentrations have been offered <u>ad libitum</u> and therefore any responses have been complicated by differences in the voluntary feed intake. They further stated that the A.R.C. (1965) reported that the protein requirements of lambs estimated from practical trials tended to be greater than those estimated by the factorial method and that this discrepancy was more marked for rapidly growing animals. Thus Andrews and Orskov (1970) conducted a trial to determine the protein requirements of lambs weaned at 4 and 5 months using a total of 97 lambs - 66 entire males and 33 females.

It was discovered that the total dry matter intake and the number of days on the experiment tended to decrease with increasing concentration of dietary protein and these trends became more marked as the feeding level increased.

Live-Weight and Protein Requirement.

Andrews and Orskov (1970) remarked that the rate of gain in body weight and growth response to increasing concentration of protein tend to decline. This, they explained, is due to an increasing tendency for lambs to deposit fat rather than lean tissue as they mature. Thus at the high feeding level, no consistent weight gain occurred as a result of increasing protein concentration. These statements are in complete agreement with the studies reported by Hinds, Mansfield and Lewis (1964); Hinds, Hatfield and Doane (1965) and Miller (1968). Ranhotra and Jordan (1966) found that although dietary crude protein concentration had no significant effect on live-weight gain from 6-15 weeks of age, it was apparent that 12-14% crude protein resulted in more rapid gains during the first 4 weeks than did lower protein concentrations. Andrew's and Orskov (1970) however are of the opinion that growth rates show a greater response to higher protein concentrations as feeding level increases. They therefore suggested, from their data, that over the 16-40 kg body weight range, optimum growth rate occurred at dietary crude protein concentration of about 17%; 15% and 11% on the high, medium and low feeding levels where the digestible energy intakes were of the order of 3.0 Mcal/day, 2.6 Mcal/day and 2.1 Mcal/day respectively. They added that more feeds tended to be left uneaten as the dietary protein concentration decreased despite the fact that the diets were given in restricted amounts. Similar results were obtained by Elliott and Topps (1963 (a) & (b)) on sheep fed pelleted diets.

Bush, Willman and Morrison (1965) had earlier made a comparison of the feed-lot performance of lambs fed rations with about 10.0%, 11.0% and 11.8% total protein and concluded that lambs fed rations with 11.8% total protein made more rapid gains but were not as fat as those fed the other rations at market weight.

Hinds, Mansfield and Lewis (1964), working on the protein requirements of early weaned lambs using protein levels of 13.0%; 16.2%; 19.1% and 22.1% in their first experiment and 15.4%; 18.4% and 21.5% crude protein in the second claimed that an increase in the level of protein in the diet from 13% to 16.2% resulted in a highly significant increase in gain and reduced the feed required per kg. gain. A further increase in the dietary protein increased gain but not significantly. Increasing the protein level from 15.4% to 18.5% in the second experiment resulted in a highly significant increase in weight gain and significantly decreased feed required per kg. gain. When data from both experiments were pooled and analysed, the protein requirement for maximum gain was given as 17.7%.

Maintenance Requirements and Feed Utilization.

Maintenance energy is defined as the sum of the basal expenditures of Energy and the Energy expended in voluntary and involuntary muscular movement (Blaxter, 1964). These energy expenditures vary appreciably from animal to animal within a species. Experiments in Scotland (Blaxter, 1962); in Holland (van Es, 1961) and in U.S.A. (Flatt and Coppock, 1963) with cattle and sheep show that basal metabolisms of animals of same size or weight vary about mean values with coefficient of variation of $\pm$ 0.01. These variations are proved to be true animal variations and not due to experimental error.

On the utilization of food for maintenance, Wallace (1948) reported average daily Gross Digestible Energy (GDE) requirements of 13 ewes as 1.35 lb. with a range of between 1.23-1.54 lb. for individual ewe in 1943 season while in 1944 he gave the average for 12 ewes as 1.40 lb. ranging from 1.27-1.52 lb. The average daily Protein Equivalent (PE) consumption in 1943 was 0.236 lb. (range 0.20 - 0.278) while in 1944 it was 0.235 lb. (range 0.212 - 0.264). This consumption however depended on the P.E. content of the ration fed. The above P.E. consumption was reported to be more than thrice the maintenance allowance indicated in the Ministry of Agriculture and Fisheries rationing scale (Wood and Woodman, 1939) which is 0.46 lb.for a sheep weighing 120 lb.

Brody (1945) drew attention to the lack of reliable data and agreement on the relation of maintenance energy to body weight. This, he said, was due to the considerable expense involved in maintaining adequately large numbers of farm animals in non productive condition for the long periods necessary to obtain accurate results. Most standards in practical use for feeding domestic animals propose certain allowance for each 100 or 1000 lb. of body weight. Thus for maintenance of dairy cattle, Forbes and Kris (1931) allowed 5.3 lb. Total Digestible Nutrient (TDN) per day per 1000 lb. live-weight; Hanson allowed 5.6 lb.; Armsby, 6.5 lb.; Kellner, 6.7 lb.; Morrison, 7.9 lb.; Eckles (1931), Morrison, (1923); and Gaines, (1938) all allowed approximately 8.0 lb. The Ministry of Agriculture and Fisheries Rationing Scale, (Wood and Woodman, 1939) proposed 4 lb. Starch Equivalent (SE) for cattle weighing 5 cwt. and an additional 0.5 lb. for each additional 1 cwt. up to 12 cwt.

For sheep kept under lowland conditions, the Ministry scale proposed 9 lb. S.E. per week for an animal of 100 lb. and an additional 0.5 lb. for each 10 lb. increase in live-weight. Brody

(1945) however believes that the energy cost of maintenance varies not with simple body weight but rather with the 0.73 power of the body weight. This, he claims, is probably equally applicable to all species of warm blooded animal from mice to elephants. Kleiber (1947) felt that $W^{3/4}$ provided a better fitting formula relating basal metabolism to body size than does $W^{0.734}$ proposed by Armstrong and Mitchell (1955). The National Research Council (NRC) of U.S.A. committee on Animal Nutrition adopted 0.75 or the factorial 3/4. Agricultural Research Council (ARC) adopted the exponent 0.73. Maintenance need is usually determined by feeding trials which involves the determination of food required to keep animals at constant body weight, as used by Devendra (1967) on pen-fed goats and Neville (1974) in non-lactating and lactating Hereford cows. The daily intake corrected for any fluctuations in live-weight becomes the maintenance requirement. Knot, Hodgson and Ellington (1953) proposed the figures:- kg. gained x 7.8 = TDN required for gain and kg. lost x 6.0 = TDN due for loss. Due to lack of knowledge of the type of tissues gained or lost which might be water which has no food equivalent these figures are taken as approximations. Devendra (1967) therefore suggested an extension in the experimental period and Garrett, Meyer and Lofgreen (1959) proposed inclusion of a slaughter test to minimise the uncertain feature. Coop (1962) used the equation: daily DOM intake = $aW^{3/4}$ + bg where, DOM is the digestible organic matter intake, "$aW^{3/4}$ is the maintenance requirement which is proportional to "W", "b" is the DOM per kg live-weight gain. Estimation of maintenance and growth requirements are made with adult animals (Coop, 1962; Devendra, 1967). Requirements of adult sheep cannot be the same as those of lambs since the young animals growth is principally due to increase in bone and muscle tissue while adult growth is accomplished by addition of fatty tissues (McMeekan, 1940) in pig, and Palsson and Verges (1951) in sheep. Garrett, et al (1959) found a positive linear correlation between TDN, Digestible energy or metabolizable energy per unit metabolic size and average daily gain in kg. and presented the equation as a +bg where "b" is thus the energy required per kg. live-weight gain, "g" the average daily gain in kg. and "a" the intercept on the ordinate axis is the energy requirement for maintenance. This relationship has been used (Swanson, 1971) to obtain the requirements for different ages.

Two main methods used for determining energy requirements for maintenance, growth (fattening), lactation and pregnancy are by energy balance techniques and feeding trials (Garret et al., 1959; Coop, 1962; Maynard and Loosli, 1969; Neville and McCullough, 1969; Moe, Tyrrell and Flat, 1970; Swanson, 1971, and Neville, 1974).

Thus maintenance requirements have been expressed in terms of feeding standards such as TDN, ME, DE and DOM which are common energy values. Kleiber (1947) also described the use of respiration chambers for energy balance studies in which measurement of gaseous exchange are used for calculation of heat production. Results of Beakley and Findley (1955); Garret et al. (1959); Blaxter (1967) and Sawyer, Hoover and Sniffen (1971) have shown that requirements obtained from the use of respiration chambers agree with values obtained by conventional methods.

Factors Affecting Feed Efficiency.

Blaxter (1964) described the efficiency of feed utilization as the weight of animal product obtained per unit weight of feed consumed; feed utilization as the number of lb. of feed required to produce 1 lb. weight of gain or milk and feed efficiency as the ratio of output to input.

At maintenance level, no weight gain occurred, therefore efficiency was zero, feed utilization was infinity, falling as feed intake increased. High efficiencies are common place in animals consuming highly nutritious feed, e.g., with baby pigs consuming sows milk, the efficiency of conversion is about 0.8 ob. gain/lb. milk solids (Lucas and Lodge, 1961).

Factors affecting efficiency are: voluntary intake of feed and nature and quality of feed. For all feed intakes and for all weight gains, the animal which has the lower maintenance level is more efficient. However, if two animals consume the same multiple of their feed needs for maintenance they are equally efficient as feed converters (Blaxter, 1964). Despite this equality of efficiency the animal with the higher maintenance cost will make the largest daily gain and therefore maintenance cost in terms of feed is the third determinant of efficiency.

For a young animal over a short period of time, weight gain is linearly related to feed intake but for older animals and long periods of measurement it is curvilinear because:-

(i) The last lb. of gain is more expensive to produce in terms of feed than the first.

(ii) The composition of weight gain changes with increased allowance of feed. Feed cost of laying fatty tissue of about 9.0 kcal/g is greater than that of laying down meaty tissue of 1.2 kcal/g. Ratios in terms of feed cost of making gains of meaty tissue and of fat is thus about 7 : 1.

If two animals gain weight at same rate, the one which deposits least fat is more efficient and hence the composition of gain is a 4th factor affecting efficiency. Efficiency of feed utilization declines with increasing age because fat % increase with age. For lambs, as carcass weight increases from 10 lb. - 80 lb., the percentage fat in the carcass increases from 13 - 44% and flesh decreases from 62 - 46% (Blaxter, 1964). Similar results were noted in cattle (Taylor, Watson and Young, 1962). Treatment of sheep with stilboestrol or hexoestrol usually increases efficiency of feed utilization because hormone administration results in carcass with more meat and bone and less fat (Aitken and Crichton, 1956).

Another factor (Blaxter, 1964) is the gain in weight of the digestive tract. During periods in which gut contents as percentage of weight are changing rapidly as at weaning in ruminants or when the character of diet is changed to one which increases fill, efficiency calculated in weight gain/unit weight of feed consumed can be spuriously high for this reason alone (Blaxter, 1964). In pigs, Coey and Robinson (1954) showed that by increasing the fibre content of diets the gut content at slaughter weight of 200 lb. increased to the extent that killing out percentage was reduced from 80 to 76%. Therefore, for two animals of equal weight at slaughter, the younger will be the more efficient converter, and therefore if animals are to be slaughtered at a fixed weight, the animal with the greatest mature weight and fastest growth is more efficient.

Metabolizable Energy (ME) has also been defined (Blaxter, 1964) as energy, ingested in food, which does not appear in faeces or urine. It is used in meeting maintenance requirement and the energy surplus after these needs have been met is then used for production. If gains in weight are expressed in terms of their calorific value, differences of efficiency due to changes in the composition of the gains tend to disappear (Blaxter, 1964). It is however clear that there is a definite relationship between live-weight and gross digestible energy (G.D.E.) consumption - the heavier the animal, the greater the maintenance requirement. Longlands, et al (1963) recommended 1.02 lb. Digestible Organic Matter (DOM) per day for a 100 lb. grazing sheep and 0.82 lb. DOM per day for a 100 lb. penned sheep as maintenance requirement.

Requirement for Growth.

Wallace (1948) gave an estimated 2.70 lb. (1943) and 3.27 (1944) of G.D.E. as being necessary to produce 1 lb. of live-weight increase. These are equivalent to 2.21 and 2.68 lb. S.E., the animals having a mean live-weight of approximately 120 lb. The average of 2.45 lb. S.E. is in very close agreement with the allowance of 2.5 lb. S.E. proposed by the Ministry of Agriculture and Fisheries for each pound of live-weight increase in animals weighing 120 lb. For a sheep of 100 lb. live-weight, Langlands *et al* proposed 4.2 lb. DOM and 3.7 lb. DOM respectively when grazed and when pen-fed in order to attain a gain of 1 lb.

Voluntary feed intake.

The primary problem in the study of the regulation of an animal's voluntary intake of food is to determine the changes that occur internally, causing it to eat or stop eating. During eating, changes occur within the body which directly or indirectly affect centres within the brain particularly the hypothalamus and which in turn control eating behaviour (Brobeck, 1955). Among the many factors that may act as signals to the integrating centres in the hypothalamus, Brobeck listed the metering of food through the mouth, distension of the digestive tract, changes in the concentration of metabolites in the blood consequent upon digestion, and a rise in heat production.

Campling (1966) working with cows, showed that the voluntary intake of hay was related to the amount of digesta in the reticulo-rumen during a meal. This agreed with the earlier work by Campling and Balch (1961). The effect on the intake of hay of the digesta in the reticulo-rumen is presumed to be due to distension (Kay, 1963). This work was not repeated with any other food. Campling (1962) however stated that the compensation in voluntary intake of hay by the cow when the amount of digesta in the reticulo-rumen was altered experimentally was never sufficient to equal the amount of dry matter contained in the digesta removed from the reticulo-rumen and on occasions when boluses of swallowed hay were caught and removed; the rate at which food was eaten was extremely slow toward the end of eating. Janowitz (1962) therefore suggested that the act of eating itself probably causes satiation as in the dog.

Contrary to results of Blaxter, Wainman and Wilson (1961 which suggested that sheep stopped eating roughage, whatever the kind, when their digestive tracts contained similar amount of dry matter, Campling and Balch (1961) postulated that the voluntary intake of oat straw was limited by the slow rate of disappearance of the material from the digestive tract due to slow digestion. Increased voluntary intake could be obtained by the daily intra ruminal infusion of urea (Campling, Freer and Balch, 1962) as this increased cellulolysis by the rumen microflora leading to increased digestibility of the straw and consequently time of retention of straw residue in the digestive tract is decreased.

Elliott and Topps (1963), investigating with Blackheaded Persian breed on voluntary intake of low protein diets of sheep, reported that the voluntary intake is closely related to the nitrogen content of the food although intake also apparently increased with digestibility of the food, this effect being entirely due to a small positive association between nitrogen content and digestibility. Blaxter, et al (1961) however found voluntary intake to be directly related to the digestibility of the fodder's energy. Results of Elliott and Topps (1963) and Blaxter et al (1961) are both in agreement with the concept of eating to a constant physical distention. Since Elliott and Topps worked with protein deficient feeds, the nitrogen content of the digesta may be the major factor limiting rate of fermentation in the rumen. It is known that certain groups of the rumen microflora require a minimum supply of certain amino acids in order to carry out digestion of feeds.

In Northern Rhodesia, Smith (1962) obtained 40-60% increase in the intake of mature Hyperrhenia forage by cattle when additional protein or urea was given. Additions of urea frequently but not invariably increase digestibility. With low protein foods, therefore, improved intake is not necessarily accompanied by increased digestibility. Elliott and Topps (1963) have suggested that the nitrogen content of low protein feeds, which is easily determined in the laboratory, may be a useful index for predicting voluntary intake.

Flatt and Coppock (1963) suggested that the maximal voluntary intake of feed by individuals given unlimited access to same feed varies within a species. Taylor and Young (1964) however showed that differences in appetite are genetically controlled.

It has also been proved that voluntary intake of feed varies with the physiological state of the animal. In cows and sheep, pregnancy depresses intake while lactation augments it. The fatter the animal the less it eats when feed is available ad lib (review by Balch and Campling, 1962).

Apart from the influence of the microflora, the mechanical activity of the digestive tract influence digestion and retention time (Freer, et al, 1962; Freer, et al, 1965; Peerce, et al, 1964).

Feed quality and voluntary intake.

It had long been known (Wright, 1929) that the relationship between voluntary intake of food by ruminants and bulk depended on the food's digestibility, the volume occupied by the dry matter in the digestive tract and on the rate of passage through the tract. More recently Crampton (1957) stated that the voluntary consumption of forage by ruminants was limited primarily by the rate of digestion of the cellulose and hemi-cellulose. There is a useful relationship between apparent digestibility and voluntary intake for herbages between 67 and 80% DM digestibility Conrad, Pratt and Hibbs (1964) reported that intake decreased with increasing digestibility with high roughage rations between 67 and 80% DM digestibility. Similar observation has also been reported earlier for over 70% DM digestibility (Hutton, 1962).

Effect of concentrates in decreasing voluntary intake in steers was reported by Weir, Meyer, Garnett, Lofgreen and Ihner (1959). Brent, Richardson, Tsien and Menzies (1961) claimed that digestible energy increased in an almost linear relationship with increasing concentrate in sheep ration with marked decreases in feed intake.

Depression of cellulose digestion by starch was noted by Head (1953) and others. This effect, Reid *et al* (1957) explained, is due to the lowering in rumen pH arising from an accumulation of lactic acid.

The higher the nutritive value of a diet offered to ruminants as judged by its apparent digestibility, the more of it is consumed each day. (Blaxter, 1950-1; Balch and Campling, 1962). Unlike pigs, rats, man and other species with simple digestive systems, ruminants do not regulate their feed intake according to their energy needs but in proportion to the distension which the feed exerts in their rumen. However, ruminants voluntarily consume less of grain diets and of silage than the apparent digestibilities of these diets suggest. Rather, they consume more of pelleted diets than it is expected of these groups of animals.

The amount of feed taken by ruminants measured in terms of dry matter, increases with increasing concentration of the ration as indicated by the Net Energy (NE) per kg. dry matter (Blaxter, Wainman and Wilson, 1961). The reverse is the case in other species. Bolton (1958, 1959) showed that the intake of digestible food nutrient by pullets and laying hens is the same whether high or low energy diets are given. Mayer (1955) expressed the fact that rats increase their feed intake when concentration of diet is reduced. This is due to the constant energy intake. Kennedy (1952-3) showed this trend also in lactating rats. Constancy of adult body weight in man presented with a variety of diets is said to show regulation of food intake of same general type.

Lehmann (1941) regarded the consumption of more of the high quality diet as an attempt to keep the amount of non digestible organic matter or "Ballast" constant. Criticising this, Crasemann (1955) states that satiety of nutrients and energy is more important as a factor of feed intake than ballast. Crasemann's contention was however based on experiments with pigs and rabbits rather than with ruminants. Crampton (1957) has affirmed the general truth that the quality of the food offered ruminants is an important factor governing voluntary consumption. Blaxter, Graham and Wainman (1956) have suggested that the mechanism concerned is purely one of digestive tract distension which is a function of the digestibility of the food and its rate of passage through the gut. According to Blaxter, Wainman and Wilson (1961) sheep eat to constant fill. This means that the amount of DM present in the gut at the end of a meal is constant. But when concentrates were added to the high quality ration, the consumption of DM as long fodder fell by slightly more than the amount of DM consumed as concentrate. Therefore, the substitution of one food for another is not in proportion to their DM content under all circumstances. Blaxter et al, 1956 suggested that voluntary intake of fodder by an animal can be used as an index of its nutritive worth over a wide range of fodder quality. The relationship is said to be best described by relating digested calories/24 hr/kg. $W^{0.734}$ to dry matter consumed/24 hr/kg. $W^{0.734}$ and the simple relationship is given as

$$E = 4.9\ (I-31)$$

where E = digested Energy in kcal/24 hr/kg. $W^{0.734}$

I = DM intake in gm/24 hr/kg $W^{0.734}$.

Thus Crampton, Lister and Lloyd (1957) found that voluntary intake of fodder is a better index of their nutritive value than either their chemical composition or TDN content. Animal to animal variation in voluntary intake is small and therefore possibility of breeding sheep for increased food intake is limited by a lack of real variation between individuals (Blaxter et al, 1956).

Physical and physiological factors regulating feed intake change in importance with increasing digestibility (Conrad, Pratt and Hibbs, 1964). At low digestibility they are:-

Body weight - reflecting roughage capacity

Undigested residue/unit body weight per day - reflecting rate of passage and dry matter digestibility.

At higher digestibilities, they claimed that intake appeared to be dependent on metabolic size, production and digestibility.

Effects of frequency of Feeding on Feed Intake.

In cows the increased intake may be large with continuous access than with limitation to 4-1/2 hr. daily. A difference of 21% was found with hay (Freer and Campling, 1962) and considerably greater differences with concentrates.

Dawson and Kopland (1949) recorded that with 2 meals a day, the intake of lucerne hay by dairy cows was 10% higher than with one meal. Campbell and Merilan (1961) claimed that the intakes of mixed diets by cows were higher with 7 or 4 than with 2 meals daily.

Blaxter, Wainman and Wilson (1961) however found that the voluntary intake of hay was not influenced by the number of times in a day that fresh hay was offered to sheep having continuous access to hay.

Balch and Campling (1962)suggest that the design of experiments on frequency of feeding should permit distinction between results arising from differences in intake and those due to the improved utilization of food which has been observed in growing sheep and cattle given more, but smaller, meals so that the total intake remained the same (Gordon and Tribe, 1952; Rakes, Lister and Reid, 1961; Hardison, Rakes, Engel and Graf, 1957).

Brobeck, (1955) stated that the average intake depends on how often the animal eats, how rapidly eating proceeds and how long it continues. In consequence the regulation of eating is based on the regulation of feeding behaviour, the behaviour peculiar to the beginning and ending of a typical period of eating. More recently Winge (1953) found significantly ($P < 0.05$) higher consumption in cattle offered feed 4 times than with 2 times.

It is commonly accepted that cattle graze 8 hr. ruminate for 8 hours and rest for 8 hours a day. Annison and Lewis (1959) expressed the view that under natural conditions, ruminants graze intermittently throughout the day and night and marked fluctuations in rumen conditions do not occur.

Tribe (1949) found sheep to graze an average of six times daily between the hours of 7 a.m. - 7 p.m.

Frequency of Feeding and Production.

Several workers have clearly shown that frequency of feeding will increase weight gains in non-lactating ruminants.

Gordon and Tribe (1952) found that a total of 196 lb. extra live-weight gain was made when sheep were fed ration in 8 equal parts than once.

Thomas and Mochrie (1956) obtained an average daily weight gain of 1.16, 1.22 and 1.85 lb. per animal when he fed dairy heifers 1, 2 and 4 times daily respectively. These results are similar to those of Hardison, Rakes, Engel and Graf (1957), who obtained a total body weight gains of 294 and 565 lb. for the 100 day feeding period from growing dairy heifers fed 2 and 10 times per day respectively. The differences were highly significant ($P < 0.01$). Mohrman, Neumann, Mitchell Jr. and Albert (1959) also found significantly greater feed consumption and gains in beef cattle when fed 6 times as compared to twice daily feeding.

Rakes, Lister and Raid (1961) observed that growing sheep (6 months old) fed 8 times a day significantly gained 65% more weight, ($P < 0.01$), excreted 20% less nitrogen in urine, ($P < 0.01$) and tended to produce less heat than when fed same quantity once. No effect was noted on body weight gain and urinary nitrogen excretion in adult sheep of 2.5 years of age.

Dawson and Kopland (1949) showed that when fed twice daily, dairy cows produced more milk and consumed more hay than feeding once.

Campbell and Merilan also remarked that feeding intervals have no effect on body weight gains in lactating dairy cows but significantly ($P < 0.01$) more milk is produced when fed 4 or 7 times daily than when fed twice. They however observed no marked difference between 4 and 7 times feeding.

Feeding Frequency and Feed Utilization.

Gordon and Tribe (1952) found a nitrogen balance in favour of those animals fed six times daily as compared to one feeding daily.

Moir and Somers (1957) found that both the DM digestibility and nitrogen retention were lower when fed the daily ration in a single feed than if the rations were fed in 2 or more portions during the day. They also observed lowered average ruminal bacteria and protozoa counts for once. They therefore concluded that a single feeding daily resulted in a poorer feed utilization than dual or multiple feeding.

Later Mohrman et al (1959) found highly significant increases ($P < 0.01$) both in nitrogen and energy digestibility when fed 4 times as compared to once daily feeding.

Birth Weight and Growth Rate.

The birth weight of an animal is influenced by the age, size and nutrition of the dam, gestation period, sex of the new born and size of the litter. Lambs that weigh more at birth in general record higher gains subsequently and the higher birth weight is correlated with higher rate of live weight increase (Datta, Sahani, Bhatnagar and Roy, 1963). These workers also gave factors affecting growth rate as climate, season and shelter in addition to nutritional effects. These, they claim, affect the growth rate of animals to a variable extent depending upon the species and also their relative adaptability to adverse conditions. For example, during the rains, damp sheds and surrounding pools of rain water bring flies, mosquitoes and other insects. Therefore the shed will be unhygienic and not conducive to health. The abundant flush pasture available during the rains could also be coupled with a high incidence of parasitism. Kean and Henning (1949) reported that the heaviest lamb at birth grew fastest and as such were fit for slaughter earlier. Bonsma (1939) found that 16% of weight differences at 12 weeks of age was accounted for by differences in birth weight.

Palsson and Verges (1952) reported that males were heavier than females at birth under both the high and low planes of nutrition. This is in agreement with the results of Nils Hansson

(1927), Donald and McLean (1935); Phillips and Dawson (1937); Bonsma (1939); and Underwood and Shier (1942) who all found that ram lambs were heavier at birth than ewe lambs; it however conflicts with Hammond (1932) who found ram lambs to be 6% lighter than the ewe lambs.

Palsson and Verges (1952) gave a comprehensive comparative report on the growth rate of male and female lambs from birth. They reported that although the females were significantly lighter than the males at birth, they grew at a faster rate at first so that they attained a greater live-weight at 2 weeks and remained slightly heavier up to 6 weeks. The rate of growth of the females however fell below that of the males during the 7th week. These workers did not report when the ewes reached puberty, neither did they know whether the internal secretion of the ovary at and after puberty had any inhibiting effect on Somatic growth in general in the ewe. It is known that sex hormones in the ram accelerate growth, at least of secondary sexual characters which results in increased body weight, i.e., thickness of bone, better development of forequarters (Hammond, 1932). It is also known that at maturity the ram or wether is much heavier than the ewe. This may be due to the longer span of growth in the male and by its higher rate of growth during the latter part of the growing period but only slightly or not at all by the higher birth weight of the male. The ewes appear to be earlier maturing than the rams. Palsson and Verges,(1952) also showed that castration has a retarding effect on the growth rate of the males but both sexes reached the maximum daily gain in the 10th and 11th week, the ewe lambs growing at a slower rate than the wethers. From the 12th to 17th week the difference in growth rate between the sexes increased considerably but after this period the growth rate declined but much more rapidly in the females. After the 22nd week of age the rate of growth rose again in the female up to the 36th week when they practically stopped growing. Between the 22nd and the 36th week the male however still increased their rate of gain in weight after which period it declined gradually to practically nothing at 41 weeks.

Nutritional Effects on Tissue and Skeletal Development.

Chirvinsky (1909), studying the effect of undernutrition on the development of the skeleton found that the thickness of bones was especially affected, those of undernourished animals remained more slender than those of the well fed animals. From the work of Hammond (1932) and McMeekan (1940) we know that the proportions of the animal at any stage of its development are the result of differential growth of its component parts and tissues.

Palsson and Verges (1952) also reported that sex differences in early developing parts of the body would not be masked to the same extent by poor nutrition as in later developing parts. This general theory is exactly in accordance with report by Hammond (1932) that the low-plane of nutrition prevented the wethers from exhibiting their extra capacity for greater muscular development in the late maturing loin-pelvis region, while it did not check extra development in the fore-quarters, characteristic of the male sex in sheep and most other animals. An extra thickening of the neck obtained in wethers on high plane of nutrition was not a special characteristic sex difference because, not only the trunk joints, but also their tissues, muscle and bone reach proportionately greater development than the neck. The apparent greater development of the neck in entire males compared with other parts of the body, commonly referred to by practical stockmen as well as in the literature on animal husbandry, and believed to be due to sex hormones, may be partly due to malnutrition, i.e., the males frequently do not receive enough nutrition while in active growth to allow the sex differences in the late developing joints to exhibit themselves fully while capable of doing so in the earlier developing joints like the neck.

Age and Growth Rate.

Lambs reach their maximum rate of growth during the third month, with a sudden rise in the daily gain due probably more to increase in stomach content than to actual growth because of increased consumption of dry bulky feed (Hammond 1932; Palson and Verges, 1952). Weekly fluctuations in the growth curves obtained were therefore assumed to be due to the variations in stomach content at the time of weighing.

For the West African Dwarf sheep, Awoyemi (1962) recorded the highest monthly weight gains between the 2nd and 4th months of age. He presumed that the animals gained optimum feed value from the ewes milk at this time. He also reported that a gradual decline in growth rate between the 4th and 6th month of age could be attributed to weaning and increased exposure to helminth parasites. The live weight of the young male Nigerian Dwarf sheep at 3 months of age is between 7.26 - 9.53 kg. (16 - 21 lb.) and at 6 months between 10.9 - 14.07 kg. (24 - 31 lb.) while adult rams weigh 22.7 - 25.42 kg. (55 - 56 lb.) and ewes 19.07 - 24.06 kg. (42 - 53 lb.) (Okereke, 1958); Dettmers and Loosli (1974) gave the live weight at 4 years of the same breed as about 30 kg. and growth rate as 85g per day up to 3 months of age, 31g. between 3 and 24 months and 5g per day from 2 to 6 or more years of age. They therefore recommend slaughter between 2 - 4 years. Hill (1960) reported live-weight at 9 - 12 months of age between 14 - 18 kg. and of 22 - 28 kg. at maturity 2 - 3 years.

Plane of Nutrition and Growth Rate.

Many workers especially with the exotic breeds of animals accept that the higher the plane of nutrition the faster the rate of growth and that growth rate could be regulated by a combination of high and low planes of diets (Palsson and Verges, 1939, 1952). This, however, contradicts the work on the West African Dwarf sheep (Awoyemi, 1962) in which the performance of low-plane groups were slightly superior and that of Adebambo (1970) in which the animals given the 50% energy level of the U.K. ARC (1965) performed better than those on the 100% energy level.

Animal production level falls with increase in temperature (Palsson and Verges, 1952); Adebambo (1970) attributed the general low production of the tropical breeds, especially the West African Dwarf sheep in Nigeria as being due to low consumption of feeds and hence stressed the need to work out the dietary requirements of the tropical breeds of animals.

Improvement by Cross-breeding.

Sidky (1947) reported a greater birth weight (30%) for crosses of the Egyptian native Ossimi ewes with Suffolk rams over the pure Ossimi and attributed this mainly to the sire. At 6 months the lambs from the crosses were 40% heavier. Ferguson (1964) working with the Northern Nigerian breeds proved that reproductive performance could be improved by crossbreeding of Uda ewes with Merino rams. Crosses were however inferior when Yankassa ewes were used; preferring Merino ewes x Yankassa rams which gave 2.6 - 16.6% superiority over the Yankassa. Although crosses with the exotic breeds of farm animal tend to perform better in terms of production of meat, milk and eggs it is doubtful if the natural adaptation to the environment and resistance or tolerance to certain diseases and pests are better in the crosses than in the native animals.

CARCASS ANALYSIS

Development of Muscle.

Palsson and Verges (1953) compared muscle in different joints with the heart muscle because it is an early developing muscular part and so less affected by nutrition than other muscles of the body. They claimed that high plane of nutrition increased the muscle in different joints at 41 weeks of age as compared with weights at birth as follows:- the head 0.7 times, the neck 1.7, thorax 2.2 and the loin 3.3. The arm and leg muscles 1.3

and 1.6 times respectively and the shoulder and thigh muscles 2.3 and 2.4 times respectively while the pelvis and tail occupy an intermediate position between the thigh and the loin, being 2.5 times heavier than their weights at birth, all weights expressed relative to heart muscle weights.

Considering the total muscle, muscle in the earliest developing parts, the head, arms, legs and neck makes up a relatively greater part of the total muscle at birth than later in life. At 9 and 41 weeks, muscles in the later developing parts - loin, pelvis, thigh, and shoulders account for a relatively greater part of the total muscle than at birth (Palsson and Verges, 1952). The thorax occupies an intermediate position. Though the thigh muscle is reported to be relatively later maturing than the muscles of the thorax, the latter as a joint is later maturing than the legs as a whole or even than the thighs. This is apparently due to the great accumulation of fat. With age, only relatively little fat is deposited either between the thigh or leg muscles or subcutaneously on the legs. Therefore the legs gain much less weight during fattening than the thorax.

Low plane of nutrition before birth affects mostly the muscles of the thigh, legs, thorax and head while those of the neck, pelvis, loin and shoulders are least affected. At 9 weeks the loin muscle was by far the most retarded, followed by the thigh, pelvis, thorax, shoulder and head while the earliest developing parts of the body, the arms, neck and legs are least affected. (Palsson and Verges, 1952). Consequently it could be said that the effect of plane of nutrition on muscle development exhibits a gradient from the early to the late developing parts of the body.

Carcass quality.

The consumer taste and demands change from time to time but the basic facts obtained from various studies indicate that the farmer can manipulate his management in terms of feeding to produce the type of animal demanded by the consumer for only by so doing can he find markets for his products.

In Nigeria, there are, at present, no standards for the grading of mutton carcass. This is largely due to the eating habits of the population, but at a time when importation of meat is being restricted, the productivity of the indigenous breeds in terms of conformation and carcass quality must be seriously looked into since more people have started to develop taste for good quality meat. Meanwhile a greater percentage of the Nigerian public is of the low income group and as such they care very little for the sophisticated idea of meat quality either in mutton or any other type. The present day Nigerian meat producer is concerned with quantity rather than quality. Modern tendencies will however probably increase the consumer's demand for high quality meat so that meat of good quality will not only fetch a higher price than poor quality meat but the latter may actually become undesirable.

Numerous factors contribute to quality in meat. These include the proportional development of the different joints and tissues of the carcass, various physical and chemical properties of the tissues and the chemical composition of the carcass as well as the size of the joints. The concept of meat quality varies from country to country and even from market to market in the same country.

Palsson and Verges (1952) mentioned the period 1920 - 1939, in Great Britain, when there was an ever increasing demand for small joints of young animals, with small bones and high proportion of lean to fat but fat enough to make it palatable and prevent the meat from drying in storage and cooking.

Hammond and Murray (1934) have shown how weight of carcass affects price per kg. of mutton and Hirzel (1939) presented the nature of the trend of change in demand in the Smithfield market from the large fat joints to the smaller, moderately fat one during the years 1921 - 1932. The prime quality article is usually more expensive to produce than the inferior grades and as such are bound to fetch more money. According to yield and quality (grades) used in the United States (Ensminger, 1969) a 50% yield is choice (with range of 47 - 53%, good is 47 (45 - 50), utility 44 (42 - 46) and cull 41 (38 - 44) for sheep carcasses. On this basis the West African Dwarf sheep was classified as barely utility (Dettmers and Loosli, 1974). The prime cuts are shoulder, rack, loin and leg. The carcass could also be described in terms of hind saddle (leg and loin) and fore-saddle (rack, shoulder and breast (Ensminger, 1969). Other systems are shoulder, leg, loin (chine), Ends and selbs as used by Awoyemi (1962).

Improvement of meat qualities in livestock is likely to occur more readily where farmers are producing for a market where the standard of living is high.

Hammond (1932) found that the value of an animal for meat could not be measured from its live-weight, nor even its carcass weight without consideration of several other factors because age, breed, sex, and state of fatness have an effect not only on the proportions of dressed carcass to offal but also on the relative development of the different tissues, bones, muscle and fat in the different joints. He therefore considered the prices given for carcasses of different weights and qualities dealing with mutton, beef and pork and reported that there is a greater difference in price due to the weight of the carcass than the quality as exemplified by breed differences and it would therefore follow that the first essential in grading meat carcass is to make weight classes and then sub-divide these according to quality.

Hammond and Murray (1934) stated that the quality of a carcass depends mainly on the proportion of fat, muscle and bone in the carcass and that these proportions change as the animal grows, changing at different rates in different breeds. They further reported that for every breed there is a carcass weight or weights at which that breed will be at the optimum quality (best proportion of muscle, fat and bones). They also claimed that there is a fall in prices of meat as weight increases above this optimum due to:-

(a) the increasing size of the joints, the modern trend being in favour of small joints

(b) the increase in the proportion of fat (beyond the optimum) in the carcasses of heavy weight for the breed in question.

Around the same time Hankins (1934) stated that the fatness of meat animals known as "finish" is a character of great importance. In animals intended for slaughter, fatness merits consideration with respect to both the growing of meat animals and requirements of consumers. Within a reasonable limit, increased finish is believed by many to be associated with increased desirability of meat from the consumer stand point.

Recently, Stanley et al (1963) have reported on the relationship between live and carcass measurements and attempted to predict yield of primal cuts.

Field et al. (1962) also studied various carcass traits in order to develop methods for prediction of lean, fat and bone in the carcass.

Relative to other measurements which may be taken on the live animal such as mechanical probing of back fat thickness it is of interest to note that percentage leg, and shoulder and loin eye area decreased with an increase in fatness but percentage loin and percentage rack and dressing percentage increased (Field et al, 1962).

Dressing Percentage (Carcass Yield).

Okereke (1958) reported the dressing percentage of the Nigerian Dwarf sheep as being rather low with an average of 38%, the highest figure (46%) being from a 30 month old ram. Adebambo (1970) however obtained dressing percentages which range from 43.48 - 49.17% from his experimental animals. The mean yield figure obtained by Dettmers and Loosli (1974) was 42.5%.

Okereke (1958) inferred that the proportions of different body parts did not appear to show considerable variations with increasing age of the animals. The carcass percentage however tend to increase while the pluck, the head and blood tend to decrease with the age of the animal but the skin and bone percentages change very little. Describing the carcass, Okereke (1958) further pointed out that the Dwarf sheep seems to dress out into a nice looking carcass with a good flesh colour and fine bone in the leg but the animal is very small, short and low in edible portions, the most striking features of the carcass being an almost complete absence of subcutaneous fat and a poor deposition of internal fat. This description agrees, in part, with the findings of Dettmers and Loosli (1974).

Hammond (1932) had earlier given the main factors responsible for the increase of carcass weight and dressing percentage with age as the laying down of fat; muscle and bone playing a secondary role. In the absence of much fat deposition, therefore, Okereke concluded that muscle and probably bone development would assume a major role in live-weight increases with age. He however explained that since the bones, then the muscles develop relatively early in life, it follows that when the animals are approaching full growth the rate of live-weight and thus carcass weight increase will be considerably reduced. From his experiments, he reported seemingly little increases in carcass percentage after the apparent period of maximum bone and muscle development. This is in contrast to the exotic breeds of sheep which exhibit substantial and distinct increases in the proportion of carcass and fillet with age and a definite and substantial drop in the percentages of bone, blood, pluck, head and skin with increase in age.

The comparative relative percentage increase in the development of carcass and fillet between the Nigerian Dwarf sheep and Suffolk sheep are 3% and 5% for the Dwarf sheep between the ages of 3 - 15 months and 6% and 20% for the Suffolk between 3 and 11 months. Bone however decreased by 5% in the Suffolk while it remained almost static in the Dwarf sheep (Okereke, 1958).

Okereke (1958) attributed the poor conformation of the Nigerian Dwarf sheep to several factors among which are the level of nutrition and management.

Hammond (1932) pointed out that the plane of nutrition exerts a main influence in the proportioning and composition of the carcass but the effect of high plane of nutrition may however be offset by some other factors.

Spedding (1956) in his experiments on worm infestation in sheep demonstrated a depression of as much as 15% of live-weight gain under a subclinical worm infestation. He suggested that the effect of the worms was a reduction in the growth rate which would produce differential effects on the carcass because of the differential development of the body parts of the growing animal.

Okereke (1958) postulated that worm infestation which is one of the greatest harzards of the sheep industry in Nigeria may have a considerable effect on the carcass weight due to its effect on the growth rate even when infestation is subclinical and that it is possible that this depression in nutritional level due to the indirect effect of a heavy worm burden may approach maintenance level. If this is the case with the Dwarf sheep, it may partially explain the lack of fat deposition since the available food will be used for maintenance of body processes rather than stored as fat.

In the Nigerian context, these shortcomings with respect to carcass quality and growth rate have little effect on the socio-economic value of the Dwarf sheep whose importance does not depend on carcass quality.

Okereke (1958) has rightly observed that:-

(i) the animals fit in so well into the peasant farming which characterises the main agricultural set up in Nigeria and other parts of West Africa where the method of rearing involves no cost.

(ii) The animal is a favourite slaughter animal for most native festivals especially the muslim festivals, burial, marriage and naming of new babies. This does not depend on quality of the carcass but just because it is a compulsory slaughter animal for most ceremonies and high prices are paid for the rams not for the meat content or quality but for the fact that they are male sheep.

The early workers, Palsson and Verges (1952); Hammond (1932); Wallace (1948), and others fed various rations to their experimental animals. Each made compositions on low and high diet basis but there was no specific definition of energy or protein content. All that Palsson and Verges did was to feed 1.5 lb. of Lucerne hay and straw to satisfy the animals' appetite to the low plane ones while the high plane level was fed 2.5 lb. Lucerne hay of medium quality and 3 lb. mixture of concentrates made up of bran, white fishmeal, crushed oats, crushed beans, linseed cake, flaked maize, split peas and locust bean meal.

Wallace (1948) gave his rations in terms of G.D.E./100 lb. of mixture and PE/100 lb. of mixture. There was therefore a complete lack of a specific reference standard. Each man worked out what he felt was low or high level of nutrition. We now have determinations of nutrient requirement for all species of domestic livestock (ARC, 1965; NRC) and it is now possible to give an exact definition of the level of feeding in terms of nutrients.

Most of the recommended nutrient requirements, for example the U.K., ARC recommendations have been worked out using the exotic breeds of animals that have been genetically up-graded and as such are fast growing and able to put up with a high intake of dry matter. These recommendations will therefore not be proper for the highly underdeveloped animals such as the Nigerian Dwarf sheep. This shows clearly in the work of Awoyemi (1962) and the preliminary work by Adebambo (1970) both of which point out that the 50% energy level ration based on the ARC, (1965) recommendation gave best results on the growth of these animals.

It is therefore necessary to work out a specific feeding standard that will give optimum growth and best carcass quality in the Nigerian Dwarf breed of sheep at their apparently low rate of growth and feed consumption. The availability of the recommended requirements for the temperate breeds is highly appreciated however, as this will serve as a basis for working out the required feeding standards for the tropical breeds.

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental Animals

All animals used were selected from the flock of the Nigerian Dwarf sheep on the University of Ibadan Teaching and Research Farm. The Nigerian Dwarf sheep is one of the three distinct breeds of sheep commonly found in Nigeria.

Nigerian Breeds of Sheep

Sheep have been given various classifications by earlier workers who have employed methods depending on the points that strike them most. Mason (1951) described two main groups of sheep in West Africa, namely, the WOOLED "MACINA" of the Sudan and the HAIRY African Long Legged type, which includes the Maure, or Arab, the Tuareg, the Fulani, including the Toronke of the Sudan and the Senegal, the Bali-Bali of Niger and the Ouda and Bornu of Northern Nigeria, Chad and the Cameroons, and lastly, under the Hairy type, the West African Dwarf or Fouta Djallon in the Southern, more heavily forested areas of West Africa (Hill, 1960).

Fitzinger, cited by Lydekker (1912), refers to three groups of sheep in West Africa; the lop-eared, the long legged and the maned sheep or *Ovis Catotis*, *Ovis longipes* and *Ovis jubata*. The last named was proposed by Peters (1876).

Lydekker (1912) recommends that these distinctive types are nothing more than highly specialized forms of _Ovis aries_ Linn. In accepting this view, Hill (1960) observed that the West African Dwarf sheep, a maned variety fits the description of _Ovis jubata_ given by the earlier writers.

There are three generally accepted and well recognized local breeds of sheep in Nigeria (Mason, 1951).

The Ouda occurs in the Sudan and Sahel Savanna vegetation zones to the extreme North of the country. The main breeding population is located on the Southern fringe of the Niger Republic and in the Northern Sokoto and Bornu provinces. Large flocks are kept by the Oudawa, a nomad sheep owning tribe in Bornu province, who may bring their flocks as far South as the Benue river around the 10°N. Parallel in the dry season.

The Y'ankassa is a short haired breed occuring over a wide area throughout most of Northern Nigeria but are generally confined to the Guinea and Southern part of the Sudan Savanna vegetation zones. They are kept in small flocks by town dwellers and nomads alike.

The West African Dwarf sheep was described by Mason (1951) as the Fouta Djallon, the Kjallonke or simply the Southern breed. This is a hairy breed of sheep which occurs in the whole area of West Africa south of latitude 14°N where it is confined almost entirely to the coastal areas. It is however found in the Cameroons, on the Jos plateau of Nigeria and also in Chad.

Since it occurs over such a wide geographical area, it has been given various local names. In Ghana it is called the Forest type; in the Chad it is Kirdi or Lakka; on the Jos plateau it is referred to as the Pagan sheep. Generally it is known as the Nigerian Dwarf sheep in Nigeria.

There is an array of coat colouration from all white, black or brown to spotted black, brown and white. The male has a heavy mane of long white hair (Ngere, 1973). Some of the long-legged varieties of West African sheep, for example, the Ouda and Y'ankassa in Northern Nigeria, have a heavy throat-fringe and in some cases what is virtually a mane (Fitzinger, cited by Lydekker, 1912) but for most part this characteristic growth of long, coarse hair in the throat and chest areas is confined to the Dwarf varieties (Hill, 1960). The rams have close to partial spiral horns, but in the ewes, horns are usually normally absent.

Disease Resistance

The Nigerian Dwarf sheep, like the West African Dwarf goat appears to thrive and breed successfully in areas of trypanosomiasis challenge. Results of a survey of the host animals of three widespread species of tsetse in Northern Nigeria showed that few blood meals were derived from sheep or goats despite their abundance in many of the fly collection areas (Jordan *et al*, 1962).

Size

The Nigerian Dwarf breed is characterized by its small size. Birth weights range between 1.4 kg and 2.8 kg depending on the environment and management practices. At the age of 1 year males attain a weight of 15.89 kg (35 lb) while females 14.98 kg (33 lb). Mature weights are 38.59 - 41.31 kg (85 - 91 lb) for rams and 32.69-34.05 kg (72 - 75 lb) for the ewes. Height at the withers reach between 40-60 cm (16 - 24 in) while a height of 65 cm is quite possible. The appearance of the Nigerian Dwarf sheep is that of a smart animal but has a timid disposition. This differentiates it from the stubborn West African Dwarf goat.

The University of Ibadan Flock of Sheep

The University of Ibadan, Teaching and Research Farm has a flock of Nigerian Dwarf sheep with up to 300 sheep; mostly breeding ewes and ewe lambs. This flock was established in 1950 from foundation stock donated to the Faculty of Agriculture by the then Lieutenant Governor of the Western Region of Nigeria, Sir Chandos Hoskin Abrahall and Lady Hoskins Abrahall. A few animals were also purchased locally. This flock has been multiplied and used continuously for obtaining basic data on the growth, reproduction and carcass quality of Nigerian Dwarf sheep. No breeding programme has been carried on to alter the potentialities, qualities or the general characteristics of the breed.

3.2 Experimental Site

All experiments on feeding trials were carried out in the sheep unit of the University of Ibadan, Teaching and Research Farm. Digestibility trials were conducted in metabolic cages kept in the section for running metabolic experiments on the same farm. The ecology of the Teaching and Research Farm has been adequately described by Olaloku (1972).

3.3 The Rations Fed.

(a) Grass

The basal ration fed in the experiments consisted mainly of freshly cut *Cynodon nlemfuensis* var *nlemfuensis*, otherwise known as 'Cynodon IB8'. It is a local hybrid developed at the University of Ibadan, Nigeria. It grows luxuriantly during the rainy season and is noted for its high dry matter yield and nutritious value. It is highly relished by all classes of livestock.

(b) Concentrate Mixtures

The concentrate mixtures in the first experiment were made up of maize, groundnut cake, dried brewer's grain and molasses. The ingredients used in the second experiment were guinea corn, groundnut cake, brewer's grain and cassava flour. Cassava flour which has been shown to be very low in protein and high in energy was substituted for molasses which is no more available as animal feedingstuff. The concentrate rations were in meal form and were mixed from locally purchased ingredients at the University of Ibadan, Teaching and Research Farm Feed Mill.

The maintenance requirements of the animals were met from the basal ration whilst for growth and fattening, different amounts of concentrate supplements calculated to supply metabolizable energy (ME) at 125%, 100%, 75% and 50% respectively and Available Protein (AP) at 100% of the U.K., A.R.C. (1965) feeding standard for fattening lamb were supplied. The levels of M.E. were designated A, B, C and D respectively. The TDN and DCP values of the ingredients as reported by Morrison (1956) and Oyenuga, (1968) were used in formulating the concentrate rations. ME and AP were converted to TDN and DCP respectively using the following formulae

(i) 1 kg TDN = 3559.4 kcal ME

converted from 1 lb TDN = 1616 kcal ME (Tyler, 1964)

(ii) DCP requirement (g/day) = AP requirement (g/day) + 16.8D where D = D.M intake in kg/day (ARC, 1965).

3.4 Measurement of Feed Intake

Using a spring balance, weighed amounts of fresh grass were fed to the experimental animals in two equal instalments in the morning and afternoon. The daily allowance of concentrate was weighed for each animal on an Avery Table balance. The refusals of both concentrate and grass were weighed back the following morning before supplying fresh rations. The amount consumed daily was therefore determined by difference.

3.5 Digestion Trials

Twelve wethers of the Nigerian Dwarf breed were used to assess the digestibility of the basal diet and concentrate supplement concurrently with the feeding trials. Total faeces collections were made over a 9-day period preceeded by a 14-day preliminary period.

2.72 kg. of fresh grass sample, from the same plot where grass was cut for zero grazing the experimental animals, was offered to each animal at 8.30 a.m. and 5.00 p.m. daily. Dry matter determination was carried out every alternate day on the samples of fresh grass as well as the residue. Dry matter determinations were also carried out on each weekly consignment of concentrate supplements and residue respectively were bulked separately and stored for chemical analysis.

Total collection of wet faeces voided by each of the stall fed wethers was effected by emptying the collection bag twice daily just before the morning and evening feeds were given. The faeces were weighed, mixed thoroughly with a pestle in a large alluminium bowl and 0.90 kg sample each of morning and evening collection taken, bulked and treated as follows:-

About 200 g subsample was taken for dry matter (DM) determination. 300 g of the remaining bulked sample was also taken and macerated with 300 ml of water and 10 ml of Toluene in a bowl using an egg beater till a homogenous cream was obtained. This was further subsampled by pouring part of the cream into a flat bottomed aluminium basin and dried at 90°C in a forced draught electric oven for 48 hours and later milked in a Christy-Noris hammer mill using a 2 mm sieve. After milling each sample was kept in a sealed polythene bag until ready for analysis.

3.6 Chemical Analysis of Feeds and Faeces.

All chemical analysis followed the conventional A.O.A.C. (1970) methods. Determinations were made in duplicate and their mean obtained. The results were expressed on dry-matter basis.

(a) Residual Moisture

2 g duplicate samples of milled material was dried to constant weight at 105°C in an electric oven for 24 hours at the end of which

samples were cooled in the descicator and weighed. The difference in weight expressed as a percentage of initial weight is the residual moisture percentage.

Dry matter percentage = 100 - moisture percentage.

(b) Total Ash

Dried material from (a) was ignited at 600°C in a muffle furnace until grey or nearly white. The weight of ash so obtained, after cooling in the descicator is expressed as a percentage of original weight taken.

(c) Organic Matter

This was taken as the difference between the weight of dry matter from (a) and the weight of total ash from (b).

(d) Crude Protein (Total Nitrogen)

This was determined by the macro-kjeldahl method using sodium sulphate - mercury catalyst mixture for the macro digestion followed by micro-distillation using Markham distillation apparatus. Boric acid was used as the receiving medium. The Crude Protein (CP) was calculated by multiplying the total nitrogen content by the factor 6.25.

(e) Ether Extract

This was obtained by extracting moisture-free milled samples with petroleum ether of boiling point 40°C - 60°C in a Soxhlet extraction chamber for eight hours.

(f) Crude Fibre

This was determined by the trichloro acetic acid method as described by Whitehouse, Zarrow and Shay (1945). The Trichloroacetic Acid digestion reagent is made up of a mixture of 500 ml glacial acetic acid, 450 ml water and 50 ml concentrated Nitric acid in which 20g trichloroacetic acid was dissolved.

(g) Nitrogen-free Extract

Estimation of NFE was by the difference between 100 and the sum of (a), (d), (e) and (f).

3.7 Growth Measurements

(a) Weighing

The animals were weighed at the beginning of the experiment, once a week throughout the experimental period, and before slaughter. Animals were weighed early in the morning, before food, by suspending them from a spring balance by means of two ropes made into loops. Readings were recorded to the nearest quarter of a pound. All weights were converted into metric using the formula

$$1 \text{ lb} = 454 \text{ g.}$$

(b) Linear Measurements

Linear measurements were made at the beginning of the experiment, once a week during the experiment and before slaughter. The body measurements considered were height at the withers, body length and heart girth.

(i) Height at the withers was taken at the highest point of the withers.

(ii) Body length was measured from the point of shoulder to the tuberosity of the Ischium.

(iii) Heart girth was measured at a point immediately behind the elbow.

The height and length were taken on both sides of the animal and the average taken. All body measurements were taken with the animals standing on a flat wooden platform to create a level base.

3.8 Carcass Evaluation

(a) Slaughter

Animals were starved for 12 hours and weighed in the morning just before slaughter. There was no Greener bullet-free humane killer at the time of slaughter and hence animals could not be stunned before they were bled directly by cutting the throat. Immediately after bleeding, the head was severed at its articulation with the atlas and the feet cut off at the proximal end of the cannon bones leaving the carpal and tarsal bones on the carcass. The carcass was then dressed, weighed warm and then stored in the cold room at -5^{o}C for 24 hours when the cold carcass weight was taken and

Plate VI Cold dressed carcasses awaiting analysis

Plate Vll   Half Carcasses

the dressing percentage calculated on cold carcass basis.

The dressed carcass was the dressed body of the animal excluding the head, feet, skin, pluck and gut offals.

(b) Joints

The following joints were considered:-

(i) The pluck consisted of the lungs, trachea, part of the oesophagus, heart, and other contents of the thoracic cavity and the liver.

(ii) The offal was the gut and its contents and other contents of the abdominal cavity except the kidneys which were left on the carcass.

(iii) The leg of mutton which was severed at the attachment of the femur to the acetabulum.

(iv) The loin (chine) was the lumbar region plus one pair of ribs.

(v) The Ends consisted of the six abdominal ribs.

(vi) The shoulders included the scapula, humerus, radius, ulna and carpals.

(vii) The sets was the chest and neck.

(viii) The skin excluded those of the head and feet.

All cuts were made on the half right side carcass and weights obtained were doubled. Complete disection of the other half carcass was made

Plate VIII Jeints as considered in the Carcass analysis

Plate VIII Joints as considered in the Carcass analysis

to determine the percentage of bone and flesh and thus the edible portion of the carcass.

(c) Linear Measurements

The following linear measurements were made on the carcass

1) The length of carcass which was an average of the lengths of the two half carcasses and was taken from the symphysis of the pubis to the junction of the first rib with the sternum.

2) The longissinum dorsi ("eye muscle") measurements were taken between the 12th and 13th ribs.

3) The width of leg was measured from the surface obtained by sawing across at the midpoint of the femur, taking the longer diameter to represent the depth while the shorter represented the width of leg.

3.9 Calculation of Results

(a) Feed intake was calculated by substracting the refusal from the amount of feed offered. Amount of nutrient in feed or faeces was calculated by multiplying the percentage of nutrient in feeds or faeces by the weight of feed consumed or faeces voided.

Thus the apparent digestibility coefficient of

$$X = 100 \frac{(\text{Amount of X in food eaten} - \text{Amount of X in Faeces})}{\text{Amount of X in food eaten}}$$

where X = dry matter (DM) or Organic Matter (OM) or Crude protein (CP) or Crude fibre (CF) or Ether Extract (EE) or Nitrogen-free Extract (NFE)

(b) The digestibility coefficients were calculated from the methods for mixed diets outlined by Crampton (1956) as follows:-

$$S = 100 \frac{(T - B)}{s} + B$$

where S = Digestibility of concentrate supplement

B = Digestibility of the basal diet -- grass

T = Digestibility of the mixed diet, i.e., concentrate supplement and grass basal diet

S = proportion of concentrate supplement in the mixed diet.

(c) Statistical Analyses

The calculations of the analysis of variance (ANOVA), Least significant difference (LSD), Correlation and Regression coefficients followed the methods of Snedecor and Cochran (1972).

CHAPTER 4

The effect of variations in dietary energy levels on the growth and carcass quality of the Nigerian Dwarf sheep at 6 months to 9 months of age.

4.1 Introduction

The sheep industry has been one of the most neglected aspects of Nigeria's livestock industry. This is probably due to the fact that the potential contribution of the specie to the Nigerian animal protein supplies has not yet been fully appreciated.

Preliminary observations (Adebambo, 1970) on meat production capacity of the Nigerian Dwarf sheep and the results of earlier work (Okereke, 1958; Awoyemi, 1962) indicate that the breed is capable of responding to better nutritional and management practices in much the same way as its exotic counterparts. Certain fundamental problems, however, remain to be solved before the relative significance and contribution of the breed to the country's livestock economy can be correctly assessed. These include investigations into:

(i) the general production characteristics of the breed

(ii) the best management practices that will give best results in terms of increased productivity

(iii) the breed's nutrient requirements and utilization for optimum growth.

Objective

This study is therefore designed to investigate among other things the influence of variations in dietary energy levels on growth rate and carcass quality of lambs at 6 - 9 months of age under an intensive system of management.

4.2 Materials and Method

(i) Animals: 24 rams, with an average age of 6 months and live weight ranging from 13.17 to 24.2 kg were selected from the flock of Nigerian Dwarf sheep on the University of Ibadan, Teaching and Research Farm. The identification of animals' ages, live-weight and ration treatments are shown in Table 4.1.

(ii) Rations: The basal ration consisted of freshly cut grass, mainly Giant star - Cynodon nlemfuensis var nlemfuensis.

The maintenance requirements of the animals were met from the basal ration whilst for growth and fattening, different amounts of concentrate supplements calculated to supply Metabolizable Energy (ME) at 125%, 100%, 75% and 50% respectively and Available Protein (AP) at 100% of the U.K., A.R.C. (1965) feeding standards for fattening lamb were supplied. The levels of ME were designated A,B,C and D respectively. Thus the formulation of the rations was based on the estimated energy requirements by fattening lambs of 20 kg live-weight and an expected daily gain of 300 g/day. This was equivalent to 4.2 Mcal ME/day and the supplementary requirement of 80 g AP/day.

Basing the calculation on metabolic body size $W^{0.73}$ kg, the daily requirements of ME and AP of each animal at the allocated feeding level was calculated. The requirements of ME and AP so

Table 4.1 Identification of Animals' Ages, Live-weight and Ration Treatment

Group	Animal No.	Age (months)	Weight (kg)	Ration Treatment
I	187	6.5	18.61	B
	192	6.5	18.16	D
	196	6.5	16.34	C
	203	6.0	14.98	A
II	204	6.0	14.98	A
	212	6.0	15.44	D
II	213	6.0	14.98	C
	216	6.0	18.16	B
	218	6.0	19.52	D
	222	6.0	17.71	B
III	223	6.0	17.03	A
	224	6.0	15.89	C
	226	6.0	15.89	D
	227	6.0	17.25	C
IV	231	6.0	19.98	A
	232	6.0	13.17	B
	246	6.0	13.62	A
	247	6.0	16.34	B
V	249	5.75	19.52	D
	252	5.75	19.98	C
	253	5.75	24.06	A
	254	5.75	15.89	C
VI	256	5.75	14.53	D
	271	5.50	13.39	B

Table 4.1 (Continued)

Ration A = 125% Energy Level

Ration B = 100% Energy Level

Ration C = 75% Energy Level

Ration D = 50% Energy Level

obtained were converted to TDN and DCP respectively.

The composition of the concentrate supplements together with the calculated TDN and DCP values which were obtained from the figures obtained by Oyenuga (1968) are shown in Table 4.2. The Table also shows the rates of concentrate feeding at the different levels of supplementation.

The chemical composition of the concentrate mixtures, as fed, as well as those of the basal diet are shown in Table 4.3.

(iii) Plan of Experiment

The 24 animals were divided into four groups designated A, B, C, and D representing 4 treatments respectively while the six animals in each group made up the six replicates of a Randomised complete block design shown in Table 4.4. Treatments A, B, C and D thus represent the 4 dietary energy levels, 125%, 100%, 75% and 50%, respectively. The experiment lasted for a period of 12 weeks.

(iv) Housing and Management

Throughout the experimental period, all animals were housed in individual stalls with concrete floor and wood shavings as bedding. They were brought out for measurements at the appropriate times (see chapter 3) and were allowed exercise for one hour a day in the open space attached to the experimental pens.

Table 4.2 Composition of Concentrate Supplement

	Ration A	Ration B	Ration C	Ration D
Maize (%)	93.25	88.00	84.50	65.50
Groundnut cake (%)	0.25	2.00	10.00	24.00
Brewers Grain (%)	0.50	5.00	2.75	8.00
Molasses (%)	6.00	5.00	2.75	2.50
Calculated TDN (%)	82.97	82.21	83.51	82.41
Calculated DCP (%)	7.84	8.90	12.80	17.80
Amount of food offered /day (kg)	1.47	1.18	0.88	0.59
Daily TDN Requirement (kg)	1.22	0.97	0.73	0.49
Daily TDN Supplied (kg)	1.22	0.97	0.73	0.49
Daily DCP Requirement (kg)	0.11	0.11	0.11	0.11
Daily DCP Supplied (kg)	0.12	0.11	0.11	0.11

Table 4.3 Mean Chemical Composition of Concentrate Supplement and Grass Basal Diet (Percentages on DM Basis)

	Grass	Ration A	Ration B	Ration C	Ration D
Dry matter	32.6	87.8	88.7	89.5	89.6
Organic Matter	17.1	82.5	85.3	85.8	85.5
Crude Protein	9.6	11.6	12.3	14.4	20.2
Crude Fibre	27.4	2.1	6.7	4.8	7.4
Ether Extract	1.1	2.3	3.4	5.3	6.2
Nitrogen-free Extract	46.4	78.6	74.2	71.8	62.0
Total Ash	15.5	5.4	3.4	3.7	4.2

Table 4.4 Position of Animal in the Experimental Design

	A		B		C		D	
	An.No.	Wt (Kg)	An.No.	Wt.(Kg)	An.No.	Wt.(Kg)	An.No.	Wt(Kg)
Block I	203	14.98	187	18.61	196	16.34	192	18.16
Block II	204	14.98	216	18.16	213	14.98	212	15.44
Block III	223	17.03	222	17.71	224	15.89	218	19.52
Block IV	231	19.98	232	13.17	227	17.25	226	15.89
Block V	246	13.62	247	16.34	252	19.98	249	19.52
Block VI	253	24.06	271	13.39	254	15.89	256	14.53
Total Wt.		104.65		97.38		100.33		103.06
Mean Wt.		17.44		16.23		16.72		17.18

(v) Feeding

The animals were given the supplementary rations daily in approximately two equal instalments in the morning at 8.00 a.m. and in the afternoon at 2.00 p.m. They were also given grass twice daily about one hour after the concentrate rations have been given. They had access to fresh clean water and mineral licks at all times.

(vi) Measurement of Feed Intake

The daily allowance of concentrate was weighed for each animal. Weighed amounts of fresh grass were fed to the animals in two instalments. The refusals of both concentrates and grass were weighed back the following morning before supplying fresh rations. The amount consumed daily was therefore determined by difference.

(vii) Parameters

The parameters considered for the growth studies include the weekly weight gains, body length, height at the withers, and heart girth. These measurements were taken before the start of the experiment, weekly during the experiment and before the animals were slaughtered at the end of the experiment.

The various joints and other parameters considered for the carcass analysis have also been well described in section 3.8.

(viii) Digestion Trials

Twelve wethers of Nigerian Dwarf breed were used to assess the digestibility of the grass and concentrate supplement concurrently with the feeding trials. Description of the method, collection of faeces and analysis of feeds and faeces together with the calculations of the results have been elucidated in sections 3.5, 3.6 and 3.9

RESULTS

4.3 Digestibility of Feeds

Table 4.5 shows the apparent digestibility coefficients of the feeds consumed by the animals.

Organic matter digestibility (OMD) was highest in treatment C, followed by treatment B and the least figure was obtained in D. Statistical analysis showed no significant difference due either to the animals or the rations.

Dry matter digestibility (DMD) varied slightly, with the mean for D higher than for A. Treatment C also has the highest mean and is followed by B. The differences between the means were not significant.

The means obtained for the Ether extract, Crude fibre and Nitrogen-free extract digestibilities respectively were not statistically significant.

Crude protein digestibility showed greater variation with a progressive increase from 69.55% in treatment A to 80.62% in D. The differences were highly significant ($P \angle 0.01$). Duncans multiple range test showed D to be significantly higher than A, B and C while C is significantly higher than A. There was no significant difference between A and B or B and C.

Table 4.6 shows the mean apparent digestibility coefficients of the nutrients in the grass basal diet while the mean apparent digestibility coefficients of the nutrients in the supplementary concentrates obtained by the method of Crampton (1956) is outlined in Table 4.7. Statistical analysis showed that variation in energy content of the diets had no significant effect on the apparent digestibility coefficients of Dry matter, Organic matter and Ether extract. Dry matter digestibility was highest in Treatment B (81.52%) and lowest in A (77.48%). Organic matter digestibility ranged from 77.56% in A to 84.62% in C. Ether extract digestibilities were 87.79%; 86.16% 87.78% and 84.68% for A, B, C and D respectively.

Crude fibre and Crude protein digestibilities showed greater variations and the differences were highly significant ($P \angle 0.01$). Crude protein digestibility in D was significantly superior to that in A, C and B which show no statistically significant differences among themselves. Crude fibre digestibility in treatment B was significantly lower than C, D and A while C was also significantly lower than A.

Table 4.5 Mean Apparent Digestibility Coefficient of Nutrients in the Mixed Diet (%)

Treatment	DM	OM	CP	EE	CF	NFE
A	72.185	78.32	69.55	85.81	72.38	82.55
B	76.99	81.32	71.80	87.34	68.33	84.16
C	77.50	81.71	73.24	87.45	70.93	83.62
D	75.35	77.29	80.62	86.15	71.47	83.23
Differences	NS	NS	**	NS	NS	NS

NS = Not statistically significant

** = Statistically significant ($P < 0.01$)

Table 4.6 Mean Apparent Digestibility Coefficient of Nutrients in the Basal Diet (Mean of 12 Animals

Nutrients	DM	OM	CP	EE	CF	NFE
%	73.58	78.87	61.68	86.78	68.04	78.04

Table 4.7 Mean Apparent Digestibility Coefficient of Nutrients in the Supplementary Concentrates (%)

Treatment	DM	OM	CP	EE	CF	NFE
A	77.48	77.56	86.44	87.79	79.46	89.24
B	81.52	82.68	85.66	86.16	71.28	92.89
C	80.50	84.62	86.41	87.78	75.34	91.22
D	77.63	78.11	94.36	84.68	78.61	92.22
Difference	NS	NS	**	NS	**	*

NS = Not statistically significant

** - Statistically significant (P∠0.01)

The differences between C and D and D and A were not statistically significant.

The highest mean of 92.9% for the NFE digestibility coefficient was obtained in treatment B. This is significantly higher ($P < 0.05$) than the least mean of 89.2% for treatment A which is also statistically significantly lower than the mean of 92.22 for treatment D. The differences between A and C, C and B and C and D were not significant.

4.4 Feed Intake

The daily intake of nutrients was obtained from the percentage of the nutrients in the rations and the dry matter intake of the rations.

(i) Dry Matter and Organic Matter Intake

Intake of dry matter and of organic matter are presented in Table 4.8.

Daily DM and OM consumption from the concentrate supplement decreased progressively from A, B, C to D with mean values of 768.9g, 677.2g and 459.1g respectively for the DM and 634.3g, 577.6g, 518.4g and 392.4g respectively for the OM. The differences were significant ($P < 0.05$).

Consumption of DM and OM of pasture grass were highest in treatment D with daily mean of 139.3g and 23.8g respectively. The least mean values of 137.5g DM and 23.4g OM were obtained from treatments B and C respectively. The variations were not significant.

Table 4.8 also shows that the animals in A consumed only 59.53% of the concentrate supplement offered while those in B, C and D consumed 64.71%, 77.12% and 86.82% respectively.

(ii) Digestible Nutrient Intake

The apparent digestible coefficients obtained for the chemical constituents of the grass basal diet and the concentrate supplement, and the intake of these constituents were used in calculating the digestible nutrient intake. The mean values are presented in Table 4.8 DDM Intake: Daily digestible dry matter intake from the concentrate supplement ranged from 356.4g in treatment D to 595.8g in A. The differences were statistically significant ($P<0.05$). DDM intake from the basal diet was highest in treatment D with a mean of 102.5g and lowest in C with 100.7g. The differences were not significant.

DOM, DNFE, and TDN Intake: Daily DOM, DNFE and TDN intake followed the same pattern as the daily DDM. Consumption of these fractions from the concentrate supplement decreased progressively from treatments A to D and the differences were statistically significant (P 0.05).

Differences in intake of DOM, DNFE and TDN from grass were however not significant and of the same trend as the DDM intake in which the highest intake was from treatment D and lowest from C.

Table 4.8 Mean Daily Intake of DM, OM and Digestible Nutrients (dry Matter Bases; g/head) and percentage consumption of concentrate offered

Treatment	DM	OM	DDM	DOM	DCF	DEE x 225	DCP	DNFE	TDN	% of feed consumed	Intake as % of A.R.C. std.
Concentrate Supplement											
A	768.9	634.3	595.8	497.3	12.8	15.7	77.0	539.6	645.2	59.53	74.41
B	677.2	577.6	552.1	465.4	32.2	20.0	71.6	467.0	590.8	64.71	64.71
C	604.1	518.4	486.3	413.4	21.7	28.3	75.3	395.5	520.8	77.12	57.84
D	459.1	392.4	356.4	301.1	26.8	24.0	87.3	262.9	401.0	86.82	43.41
	*	*	*	*	*	*	*	*	*		
Grass											
A	138.2	23.6	101.7	18.6	25.8	1.32	8.2	50.0	205.6		
B	137.5	23.5	101.5	18.5	25.6	1.31	8.1	49.8	204.6		
C	136.8	23.4	100.7	18.5	25.5	1.30	8.1	49.5	203.6		
D	139.3	23.8	102.5	18.8	26.0	1.33	8.2	50.5	207.3		
	NS	NS	NS	NS	NS	NS	NS	NS	NS		
Total											
A	907.1	657.9	697.5	515.9	38.6	17.1	85.2	589.6	850.8		
B	814.7	601.1	653.3	483.9	57.8	21.3	79.7	516.8	795.4		
C	740.9	541.8	587.0	431.9	47.2	29.6	83.4	445.0	724.4		
D	598.4	416.2	458.9	319.9	52.8	25.4	95.5	313.4	608.3		
	*	*	*	*	*	*	*	*	*		

NS = Not statistically significant
* = Statistically significant (P 0.05)

DCP Intake

DCP intake ranged from approximately 71.6 g/day in treatment B to 87.3 g/day in D with treatments A (77.0g) and C (75.3) respectively. The differences were statistically significant ($P < 0.05$). DCP intake g/day from the grass basal ration were 8.2, 8.1 , 8.1 and 8.2 for treatments A, B, C and D respectively. The variations were however not significant.

DCF Intake

Mean daily DCF intake from the concentrate supplement was highest (32.2 g/day) in treatment B while the lowest mean value of 12.8 g/day was recorded for treatment A. These differences were significant ($P < 0.05$) with the value for treatment A significantly less than for B, C and D and C also less than B and D. DCF intake from the basal diet showed no significant differences. Values obtained in g/day were 26.0, 25.8, 25.6 and 25.5 for treatments D, A, B and C respectively.

DEE Intake

Mean daily DEE intake from concentrate supplement differed significantly ($P < 0.05$) between the treatments with values of 15.7, 20.0, 28.3 and 24.0 g/day for treatments A, B, C and D respectively. DEE intake from grass, however differed very slightly with means of 1.32, 1.31, 1.30 and 1.33 g/day for treatments A. B, C and

D respectively and the differences were not significant.

(iii) Mean Intake of Nutrients day/$W^{0.73}$kg per Metabolic Weight

Expressing the nutrient intake per unit of metabolic size changed the trend of intake previously described (Table 4.9). DM, DDM, DOM and ME intake/day/$W^{0.73}$kg decreased progressively from treatments A to D. DCP intake was however lowest in Treatment A (7.9g) and highest in D (9.9g) while treatments B and C gave 8.5g and 8.2g respectively. Details of nutrient intake per day and nutrient intake/day/$W^{0.73}$kg are shown in Appendix Tables 2.3 - 2.6 and 2.7.

4.5 Growth Studies

Data for mean daily weight gains, and mean total gains in length, height at the withers and heart girth presented in Table 4.10 followed no uniform trend.

Treatment B had the best daily weight gains (82.8g) followed by 82.2g, 79.6g and 55.7g for treatments C, A and D respectively. These differences were highly significant ($P < 0.01$) with group D values significantly less than values for A, B and D respectively.

Total gains in height at the withers ranged from 6.8 cm in treatment A, 6.1 cm in B and 5.3 cm each in C and D respectively. These differences are not statistically significant.

Table 4.9 Mean Intake of Nutrients/day/$W^{0.73}$kg

Treatment	DM (g)	DDM (g)	DCP (g)	DOM (g)	ME (kcal)
A	90.08 ± 12.445	73.02	7.92 ± 0.458	52.14	281.55
B	81.40 ± 20.64	65.26	8.53 ± 0.79	49.50	267.28
C	72.49 ± 25.93	57.50	8.17 ± 0.789	44.76	223.85
D	61.80 ± 13.95	47.39	9.85 ± 0.886	35.18	190.51

Table 4.10 Mean Daily Weight Gains and Mean Total Gains in Withers Height, Body Length and Heart Girth

Treatments	Weight gains (g)	Height (cm)	Body Length (cm)	Heart Girth (cm)
A	79.64 ± 2.605	6.83 ± 0.657	5.92 ± 0.906	6.17 ± 0.964
B	83.81 ± 2.827	6.08 ± 0.784	5.83 ± 0.47	5.75 ± 0.719
C	82.21 ± 2.026	5.30 ± 0.047	7.70 ± 0.044	7.50 ± 0.775
D	55.71 ± 2.916	5.30 ± 0.868	4.90 ± 0.498	6.30 ± 0.769

The gains in body length were not consistent with the levels of energy feeding. The greatest increase in length was made by treatment C (7.7 cm) and the lowest by D (4.9). Treatments A and B gained a mean length of 5.9 cm and 5.8 cm respectively. Differences were not significant.

The levels of feeding appear to have no significant influence on the heart girth increases. Treatment C. animals made the best gains in heart girth with 7.5 cm. This is followed by 6.3 cm, 6.2 cm and 5.8 cm for treatments D, A and B respectively. Details of these values are presented in Appendix Table 1.9.

4.6 Relationship Between Nutrient Intake/$W^{0.73}$kg and Daily Weight Gains (g)

A positive linear relationship was found between (Y) the daily Metabolizable energy intake (kcal/$W^{0.73}$kg) and (X) daily weight gains (g). The regression equation (Table 4.11 was Y = 129.182 + 1.387x. The correlation coefficient (r) = 0.669 was significant ($P < 0.01$). The relationship is illustrated in Fig. 4.1. The intercept on the intake axis gives the maintenance requirements of 129.182 kcal for the animals at this stage of their development and the cost of live-weight gain is 138.0 kcal per kg live-weight increase.

The regression equation relating (Y) daily DOM intake (g/day/$W^{0.73}$kg) to (X) the daily weight gains was Y = 13.952 + 0.414x (r = 0.768 ± 0.009). The correlation coefficient (r) of 0.768 was

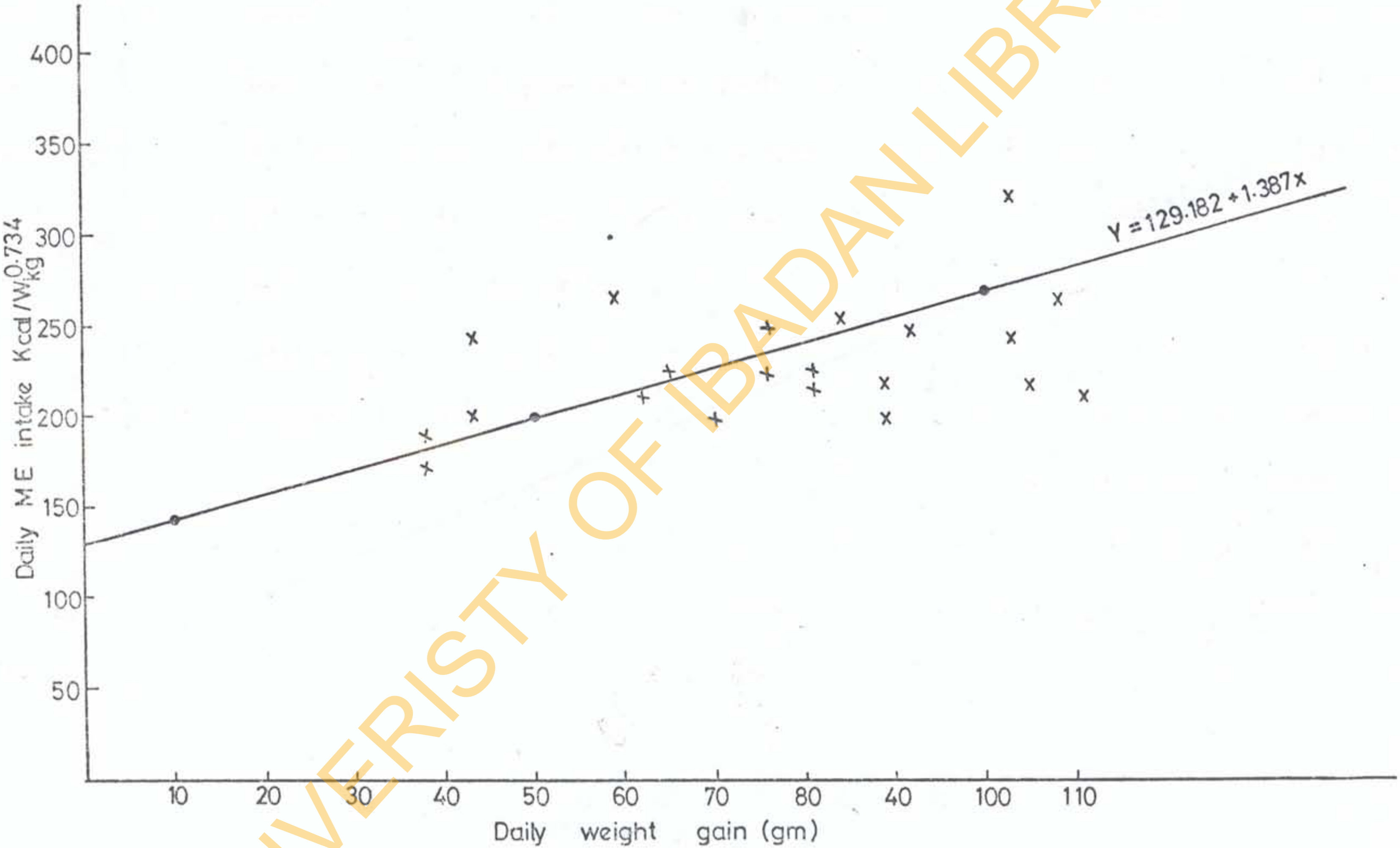

FIG.41 REGRESSION OF M E INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 6-9 MONTHS OF AGE

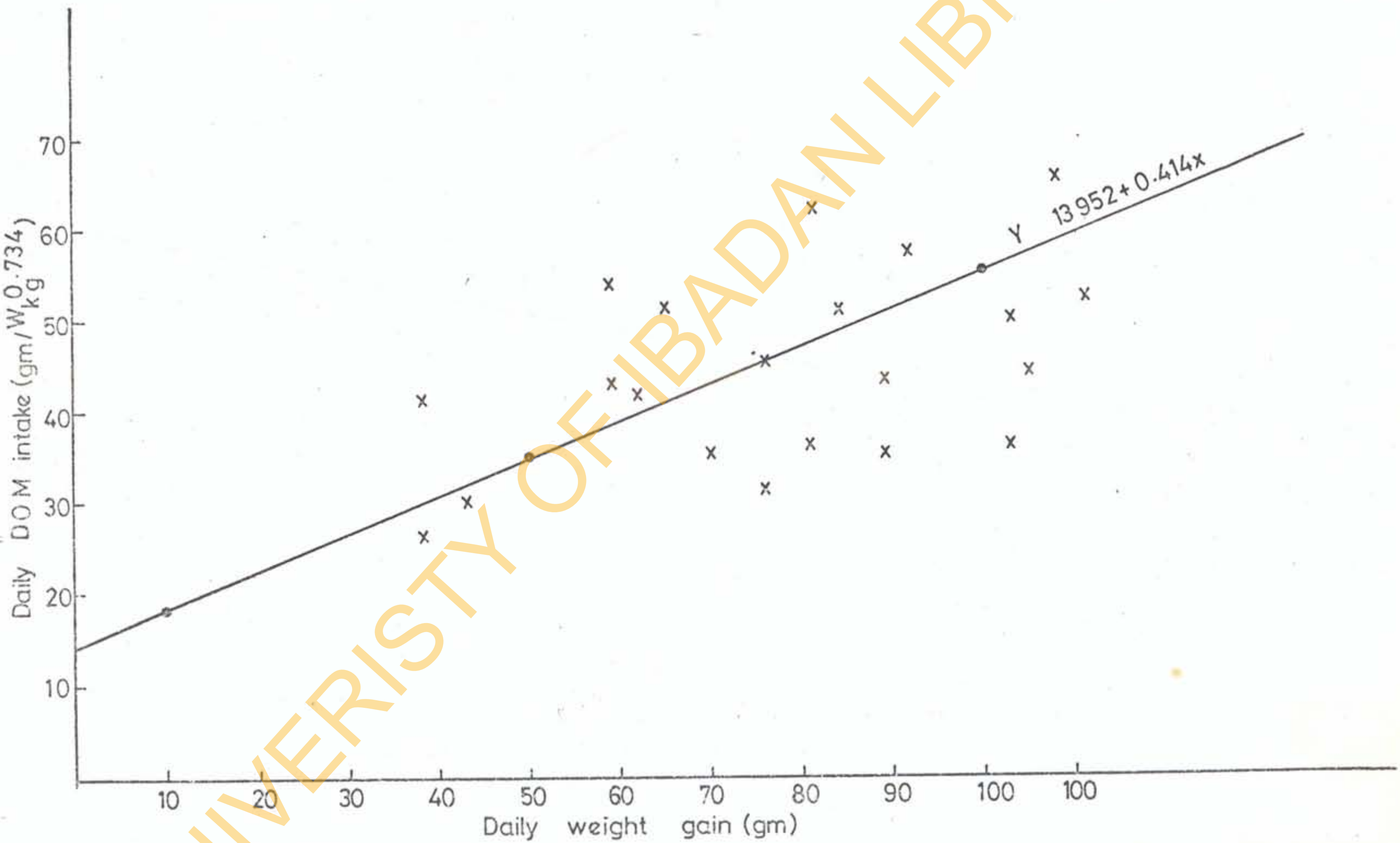

FIG. 4.2 REGRESSION OF DAILY DOM INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMAL 6-9 MONTHS OF AGE

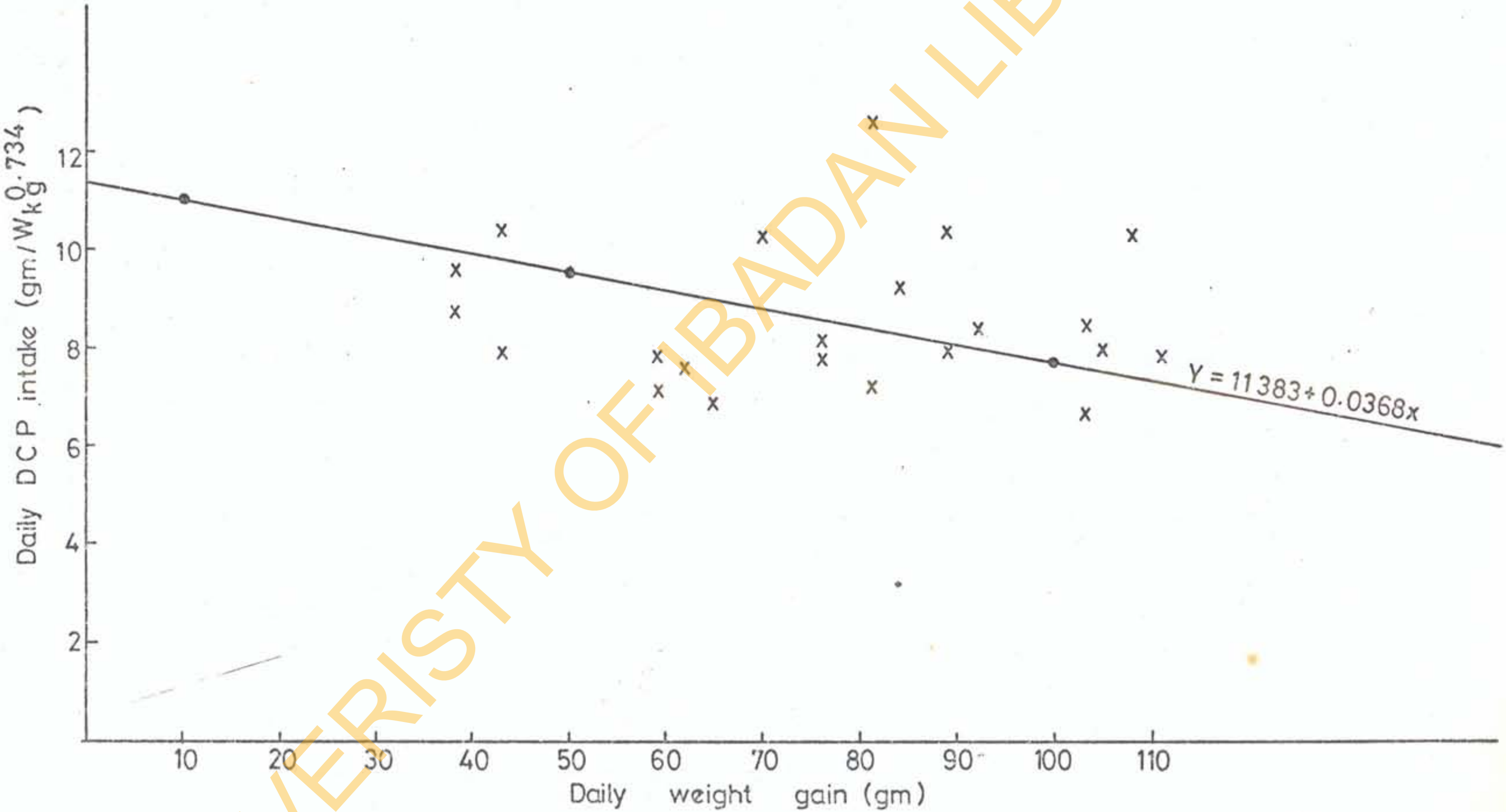

FIG.4.3 REGRESSION OF DCP INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 6-9 MONTHS OF AGE

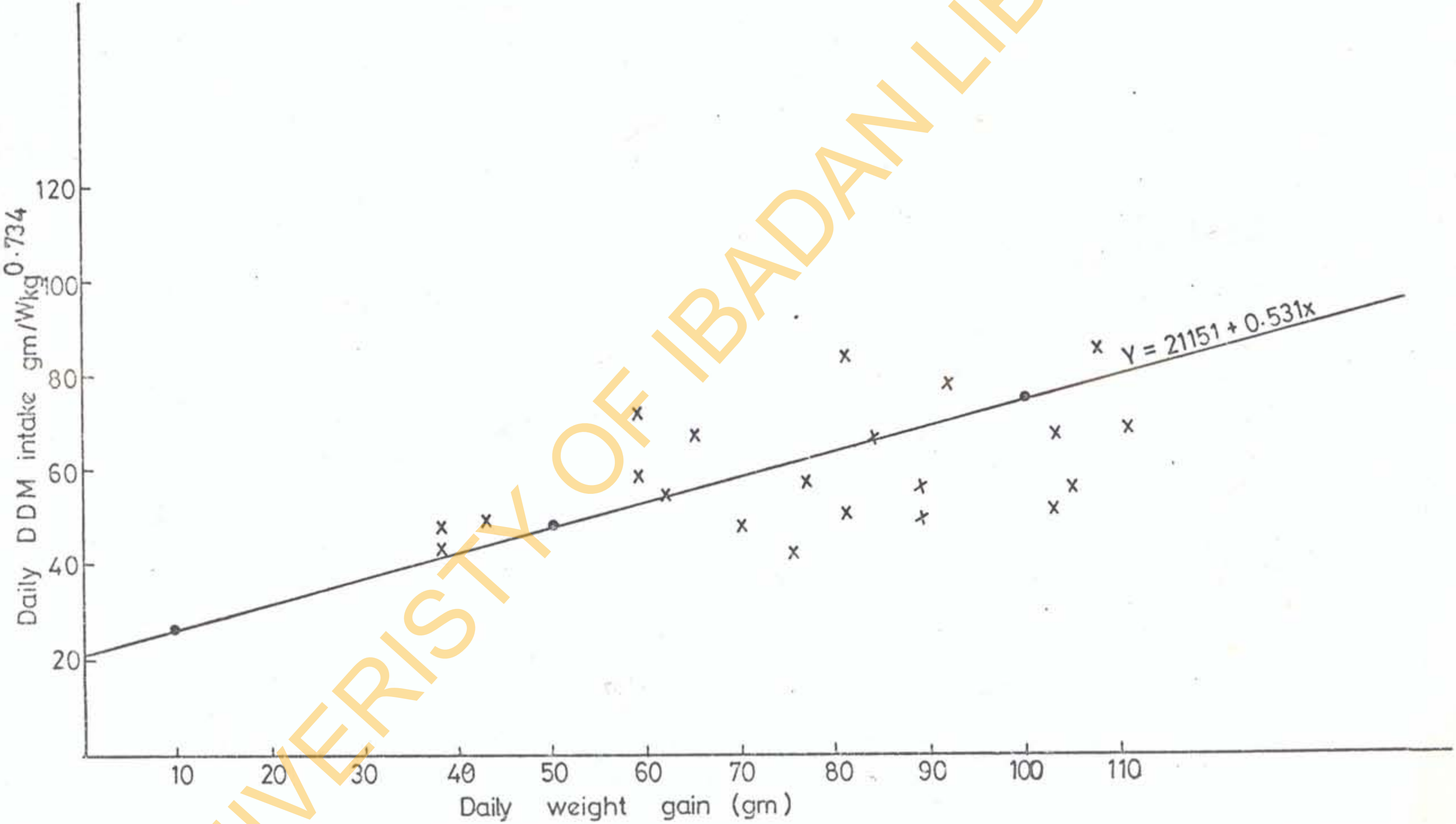

FIG. 4.4 REGRESSION OF D D M INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 6-9 MONTS OF AGE

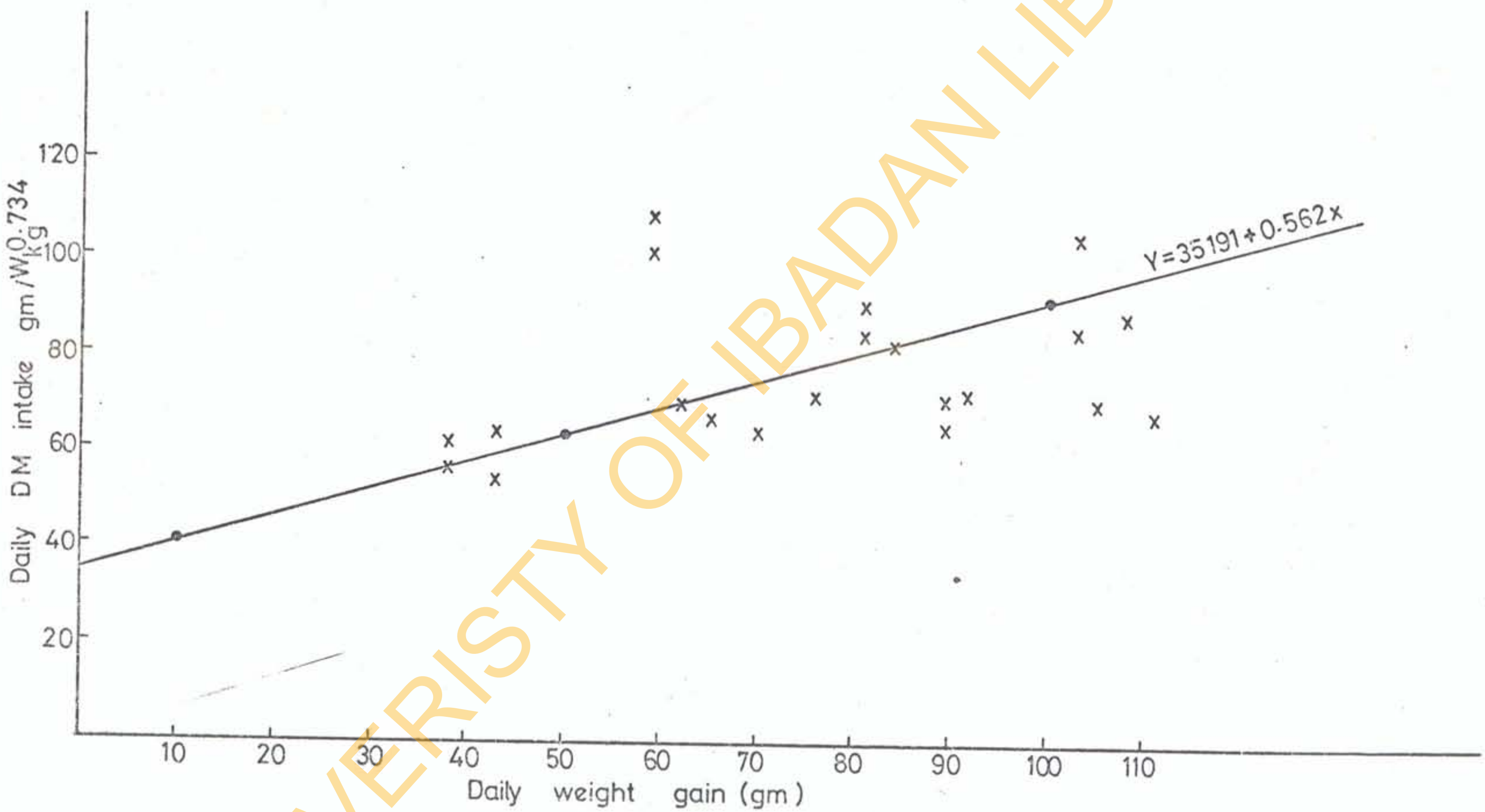

FIG.4.5 REGRESSION OF DM INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 6–9 MONTHS OF AGE

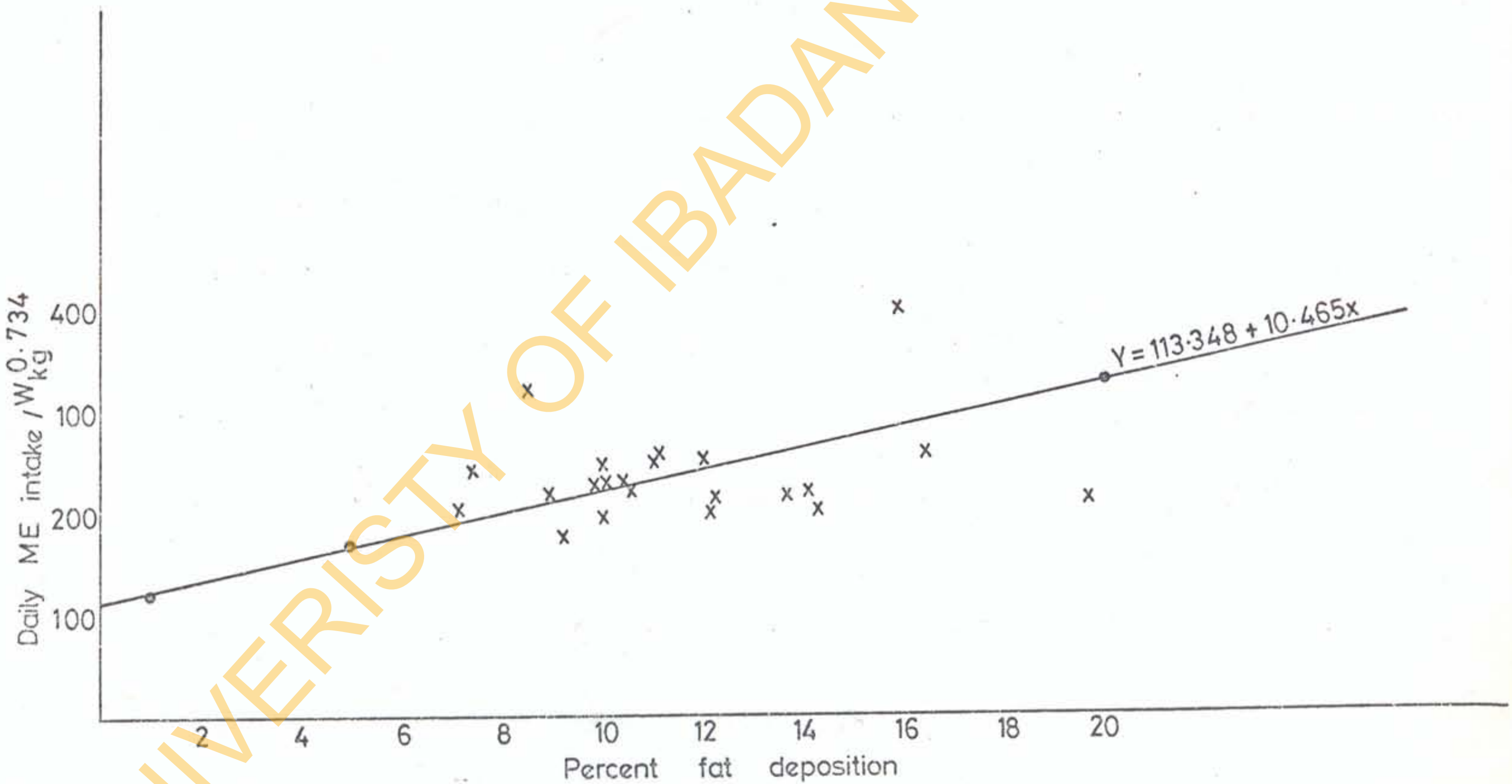

FIG.4.6 REGRESSION OF ME INTAKE / $W_{kg}^{0.734}$ ON FAT DEPOSITION

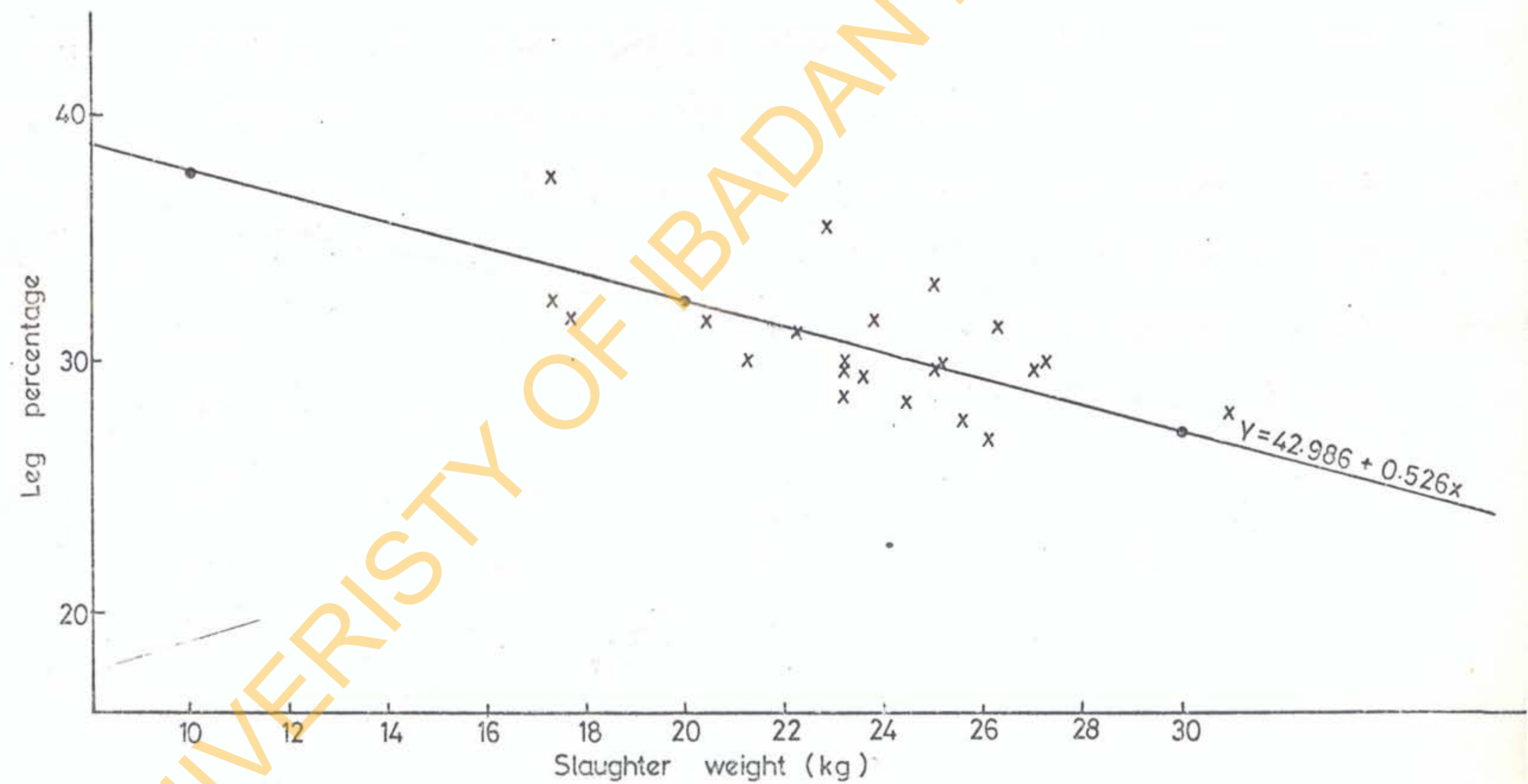

FIG. 4 7 RELATIONSHIP BETWEEN PERCENTAGE LEG JOINT (Y) AND THE SLAUGHTER WEIGHT (X)

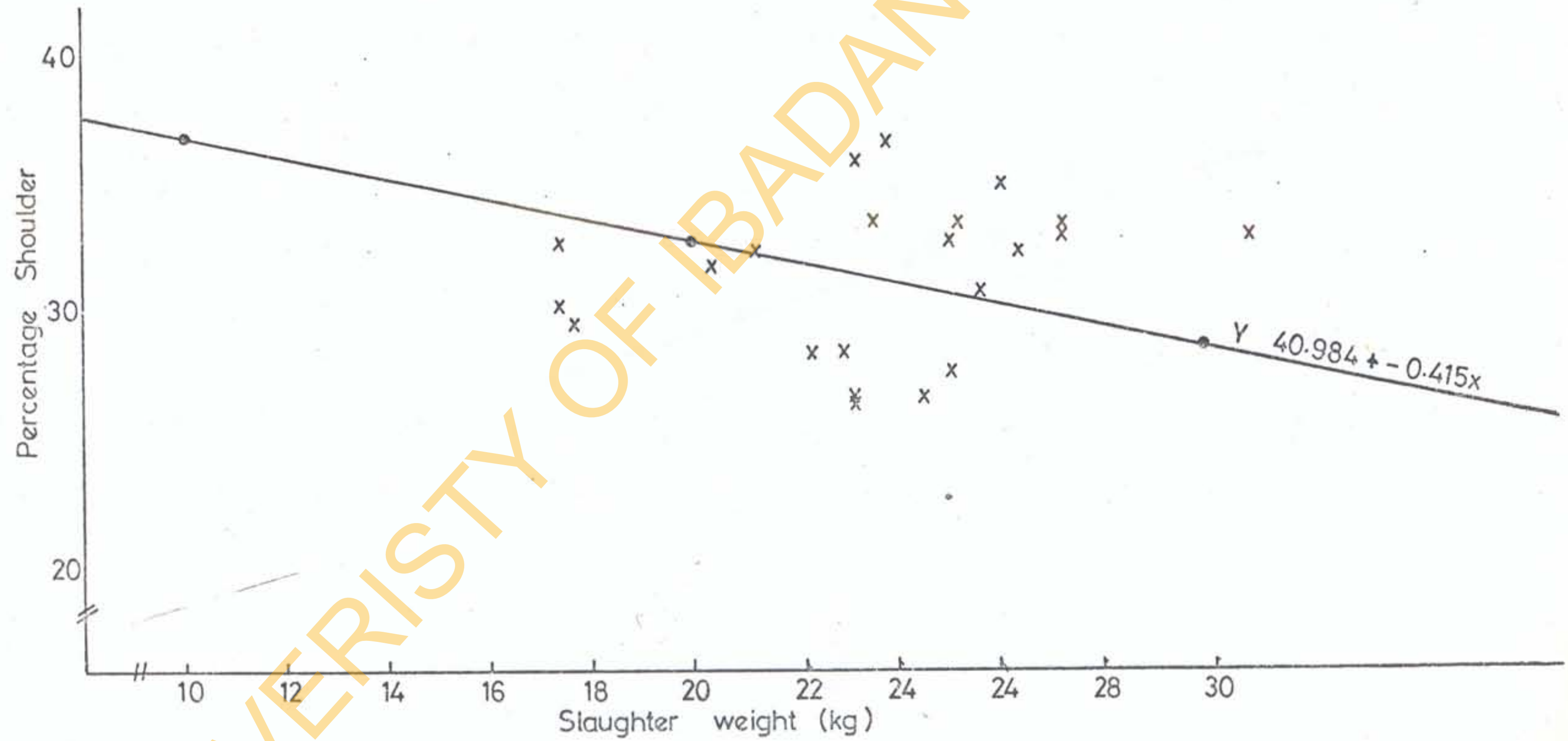

FIG. 4.8 RELATIONSHIP BETWEEN THE PERCENTAGE SHOULDER JOINT (Y) AND THE SLAUGHER WEIGHT (X) IN Kg.

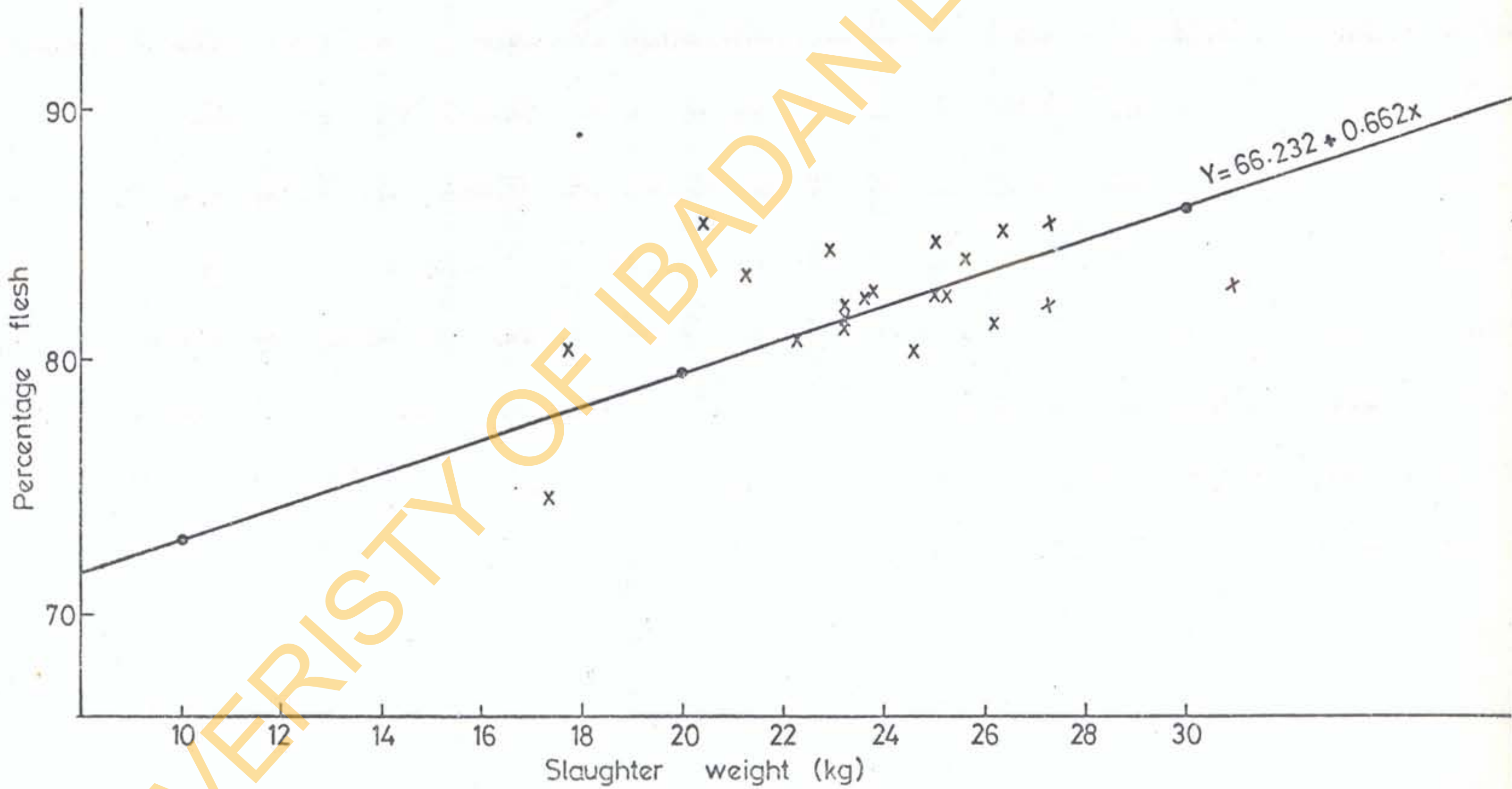

FIG.4.9 RELATIONSHIP BETWEEN THE PERCENTAGE FLESH (Y) AND THE SLAUGHTER WEIGHT (X)

significant ($P < 0.01$). The constant factor, 13.952 is the DOM required for maintenance. The DOM required for an increase of 1 kg live-weight is thus 414 g/day/$W^{0.73}$kg (Fig. 4.2).

DCP intake (g/day/$W^{0.73}$kg) was negatively correlated with the daily weight gains (g/day). The correlation coefficient (r) was -0.582 and Standard Error (SE) was $\pm$0.001 (Table 4.11). The intercept on the intake axis which indicates the maintenance requirement was 11.383 g/day/$W^{0.73}$kg. while there seems to be reduction of 582 g/day/kg live-weight gain from the maintenance requirement.

Daily DDM and DM intake (g/day/$W^{0.73}$kg) were positively correlated with the daily weight gains with regression equations:-

DDM = Y = 21.151 + 0.531x (r = 0.758; SE = $\pm$ 0.018)

DM = Y = 35.191 + 0.562x (r = 0.693; SE = $\pm$ 0.035)

Both correlation coefficients were significant ($P < 0.01$) and the relationships are illustrated in Fig. 4.4 and Fig. 4.5.

The intercepts on the Y axis indicate the DDM and DM requirements at zero weight gain and this is 21.151 g/day and 35.191 g/day of DDM and DM respectively while the cost of 1 kg liveweight gain is 531 g/day and 562 g/day DDM and DM respectively. The regression equation Y = 113.348 + 10.465x (Table 4.11) with correlation coefficient 0.676 $\pm$ 1.256 obtained from the relationship of (Y) ME intake

Table 4.11 Regression Equations for Animals 6 - 9 months of Age

Y	X	Regression Equation	Correlation Coefficient (r)	Std. Error of Regression Se_b	Difference
Daily ME intake/kg $W^{0.734}$	Daily weight gains	Y = 129.182 + 1.387x	+ 0.669	±0.358	**
Daily DOM intake/kg $W^{0.734}$	Daily weight gains	Y = 13.952 ± 0.414x	+ 0.768	± 0.00892	**
Daily DCP intake/kg $W^{0.734}$	Daily weight gains	Y = 11.383 - 0.0368x	- 0.582	± 0.00053	**
Daily DDM intake/kg $W^{0.734}$	Daily weight gains	Y = 21.151 + 0.531x	+ 0.758	± 0.018	**
Daily DM intake/kg $W^{0.734}$	Daily weight gains	Y = 35.191 + 0.562x	+ 0.693	± 0.0351	**
Daily ME intake/kg $W^{0.734}$	Fat deposition	Y = 113.348 + 10.465x	+ 0.676	± 1.256	**

** = Significant at 1% level.

(kcal/day/$W^{0.73}$kg) and (X) fat deposition showed that an animal maintained on 113.348 kcal ME/day/$W^{0.73}$kg will deposit no fat while fattening could be increased by 1 kg if 10.465 Mcal ME/day is fed above the zero fat level. The linear regression obtained is shown in Fig. 4.6.

4.7 Carcass Evaluation

(i) Slaughter Weight

The slaughter weights of the animals are presented in Table 4.12. Best mean slaughter weight was for treatment C (24.15 kg) while treatments A, B and D had means of 24.03 kg, 23.65 kg and 22.47 kg respectively.

(ii) Cold Carcass Weight and Dressing out Percentage

The dressing out percentage was calculated from the cold carcass weight and the slaughter weight. The means for cold carcass weight and dressing out percentage are shown in table 4.13. The data presented in this table show that treatment A had the best mean cold carcass weight (13.19 kg) and dressed out best (52.82%). Treatment D had the least mean cold carcass weight (11.78 kg), the least mean slaughter weight (22.47 kg) but the second best carcass yield (52.42%). Treatment C, with the second best mean cold carcass weight (12.25 kg) the best mean slaughter weight (24.15 kg) had the second lowest carcass yield of 50.71%. Treatment B which had the least dressing out percentage

Table 4.12 Animals Body Weight at Slaughter (kg)

	A	B	C	D
	20.43	26.11	25.20	24.97
	24.52	27.24	22.25	23.84
	25.65	26.33	23.25	23.15
	24.97	21.34	22.93	Dead
	17.71	23.61	27.24	23.15
	30.87	17.25	Dead	17.25
Mean	24.03	23.65	24.15	22.47

(49.92%) was second to the last in mean cold carcass weight and mean slaughter weight (11.8 kg and 23.65 kg respectively).

(iii) Carcass Joints

The mean percentage of joints expressed as percentage of cold carcass weight is presented in Table 4.13. An examination of the data shows that the greater part of the carcass went to the shoulder and leg joints. Treatment D had the highest percentages of sets and shoulders (12.9% and 32.7% respectively) while treatment C has the highest percentages of ends, loin and leg which are 12.9%, 13.4% and 31.2% respectively. The lowest shoulder ends and leg percentages of 29.7%, 11.1% and 30.0% respectively were in treatment A which also had the second lowest percentages for sets and loin with 11.0% and 13.1% respectively. The differences in all cases were not statistically significant.

(iv) Fat, Flesh and Bone

The fat considered is the abdominal fat around the gastro-intestinal tract and the fat in the carcass around the kidney. The data in Table 4.13 shows that the mean fat percentage ranged from 9.6% in treatment B to 13.5% in treatment A. Treatments C and D were in between with 12.8% and 10.6% respectively. Analysis of variance shows that the differences were not statistically significant.

Table 4.13 Mean Percentage of Joints, Fat, Flesh and Bone Expressed as Percentage of Cold Carcass Weight

	Treatment A	Treatment B	Treatment C	Treatment D	
Slaughter wt (kg)	24.03	23.65	24.15	22.47	NS
Cold carcass weight (kg)	13.19 ± 1.253	11.81 ± 0.683	12.25 ± 0.326	11.78 ± 0.632	
Dressing percentage	52.82 ± 0.940	49.70 ± 0.666	50.79 ± 0.769	52.45 ± 0.278	
Sets (%)	11.01 ± 0.921	10.61 ± 0.492	11.24 ± 0.727	12.88 ± 1.484	NS
Shounders (%)	29.69 ± 0.939	32.56 ± 0.591	19.88 ± 1.319	32.66 ± 1.656	NS
Ends (%)	11.13 ± 0.698	11.64 ± 1.349	12.85 ± 0.626	12.71 ± 0.487	NS
Loin (%)	13.12 ± 0.403	13.38 ± 0.896	13.44 ± 0.838	12.40 ± 0.573	NS
Leg (%)	29.99 ± 0.877	30.76 ± 1.350	31.24 ± 0.942	30.40 ± 0.658	NS
Fat (%)	13.50 ± 0.874	9.58 ± 0.525	12.75 ± 1.744	10.60 ± 1.113	**
Flesh (%)	82.11 ± 0.825	81.61 ± 1.355	82.09 ± 0.409	80.66 ± 1.459	NS
Bone (%)	17.11 ± 0.791	18.40 ± 1.393	17.73 ± 0.589	19.34 ± 1.403	

NS = Not Significant

** = Significant at 1% level.

Dissecting the carcass enables one to visualize the actual edible portion of the carcass. From the results presented in Table 4.13, treatment A showed the highest percentage of edible meat (82.2%) and thus the lowest bone percentage (17.1%). Treatment D with the lowest meat percentage of 80.7% thus had the highest bone ratio of 19.3%.

(v) <u>Relationships Between Leg, Shoulder and Flesh Percentages and the Slaughter Weight</u>

Both leg and shoulder percentages were negatively correlated with the slaughter weights of the animals (Fig.4.7 and Fig. 4.8). The regression equations were:-

$$\text{Leg} = Y = 42.986 - 0.526x \quad (r = -0.699 \pm 0.069)$$

$$\text{Shoulder} = Y = 40.984 - 0.415x \quad (r = -0.452 + 0.078)$$

The correlation coefficients of $r = 0.699$ was significant ($P < 0.01$) while $r = 0.452$ was not significant.

At birth, percentage of leg and shoulder would thus be about 42.99% and 40.98% respectively, with a decrease of 0.526% and 0.415% respectively for every kg increase in live-weight.

There was a positive linear relationship between flesh percentage (Y) and slaughter weight (X). The regression equation obtained was

$$Y = 66.232 + 0.662x$$

The correlation coefficient (r) which was significant ($P < 0.01$) was 0.818 with a standard error of ± 0.569. Hypothetically, at birth, percentage of flesh would be about 66.23% and this would increase by 0.662%/kg increase in live-weight. The relationship is pictured out in Fig. 4.9.

(vi) Other Parts

Table 4.14 shows the mean percentage of the pluck and the offals which was made up of the skin, gut, feet and head. They were all expressed as percentages of the slaughter weights of the animals.

The levels of feeding had no significant effect on the percentages of pluck as evidenced by the little differences in the figures 5.86%, 5.48%, 5.41% and 5.38% for treatments C, B, A and D respectively.

The highest mean for the percentage skin was obtained in treatment C (13.72%) as compared with 11.88%, 11.49% and 11.30% for treatments D, A and B respectively.

Treatment C had the highest mean percentage of 22.72% for the full gut but had the second highest (8.82%) for the empty gut. Treatment B which had the best percentage of 8.85% for the empty gut was second best for full gut with 20.65%. In both the full and empty gut, treatment D had the lowest percentages. The differences for the full gut were statistically significant (P 0.05) but differences exhibited by the empty gut were not significant.

Variations of dietary energy levels had no significant effect on both the head and feet percentages with means of 2.9%, 2.8%, 2.7% and 2.7% for treatments D, C, A and B respectively for feet while mean percentages of head were 7.6%, 7.4%, 6.7% and 6.6% for treatments D, B, A and C respectively.

4.8 Economic Considerations

Table 4.15 shows the summarized data for the average daily gains in weight, feed/gain ratio, average gains /100g TDN and cost/kg live-weight gain. Treatment C had the least feed/gain ratio, (6.48); the highest gains/100g. TDN consumed (15.98) and the least cost/kg live-weight gains (₦1.20). Other means for the feed/gain ratios, 8.08, 8.24, and 9.65 for treatments D, B and A respectively were significantly higher (P 0.05) than 6.48 obtained for treatment C.

Gains/100g TDN values for B, D and A were 14.18g, 13.89g and 12.34g respectively while the cost/kg live-weight gain were ₦1.26, ₦1.31 and ₦1.63 for treatments D, B and A respectively.

Table 4.14 Mean percentage of Pluck, Offals, Skin, Head and Feet Expressed as Percentage of Live-weight at Slaughter

Treatments	Skin	Pluck	Full Gut	Empty Gut	Feet	Head
A	11.49±0.433	5.41±0.093	20.02	8.59±0.346	2.72±0.335	6.72±0.141
B	11.30±0.879	5.48±0.241	20.65	8.85±0.340	2.60±0.162	7.42±0.142
C	13.72±0.510	5.86±0.265	22.72	8.82±0.437	2.82±0.369	6.64±0.316
D	11.88±0.528	5.38±0.161	19.17	8.54±0.345	2.90±0.369	7.21±0.038
	NS	NS	*	NS	NS	NS

NS = Not significant

* = Significant at 5% level.

Table 4.15 Average Daily Weight Gains, Feed Consumption, Efficiency of Feed Utilization and Production Cost Data

Characteristics	A	B	C D	D
Av. Daily wt. gains (g)	79.64	83.81	83.21	55.71
Av. Daily DM consumption (concentrates)	768.92	677.23	604.08	459.10
Av. Cost of daily feed consumed (₦)	0.13	0.11	0.10	0.07
Feed/Gain ratio	9.65	8.08	6.48	8.24
Wt. Gains g/100g TDN consumed	12.34	14.18	15.98	13.89
Cost/kg of live-weight gain (₦)	1.63	1.31	1.20	1.26

DISCUSSIONS

The results obtained from this experiment provided data on comparative growth of the various parts of the Nigerian Dwarf sheep in response to the varying levels of intakes of nutrients at the various levels of energy provided.

The digestibilities of the basal diet and of the supplementary concentrates illustrated that the figures obtained when both diets were considered together were quite high in all the treatments. This could be due to the fact that the grass at the time of the experiment had a mean crude fibre percentage of 27.4% and the crude fibre contents of the supplementary concentrates were also low. The highest figure was 6.67% crude fibre from ration B. Since the crude fibre fractions were low, the digestibilities of the rations and hence of the dry matter, organic matter, ether extract and nitrogen-free extract fractions will be high.

Considering the digestibility of the concentrate supplement, the highest mean crude protein digestibility coefficient was from treatment D which had the highest percentage crude protein composition. The crude protein percentages in the concentrate supplements ranged between 11.5% in A and 20.15% in D and quite comparable to the protein levels of 10.0% to 11.8% fed by Nush, Willman and Morrison (1955); 12.0% - 14.0% by Ranhotra and Jordan (1966) and 11.0% to 17.0% by Andrews and Orskov, (1970). It can therefore be said that all the concentrate supplement were adequate in protein. The formulation was based on the standard recommendation of the ARC (1965) of Britain.

The digestibility of crude fibre in ration A was highest. It must be noted however that this ration had a very low crude fibre fraction (2.1%) as compared to 6.7%, 4.8% and 7.4% for rations B, C and D respectively. It will therefore be relevant to link the high crude fibre digestibility coefficient obtained in D to the high crude protein content in that ration. This is in accord with results of Elliott and Topps (1963) who reported a positive association between nitrogen content of feeds and their digestibility. Other workers (Campling, Freer and Balch, 1961; 1962; Campling and Balch, 1962; Blaxter and Wilson, 1963), have also obtained higher digestibility figures by improving the protein content of rations or total nitrogen by the addition of urea. It could therefore be claimed that the high crude protein levels of the rations had an added advantage in increasing the digestibility of other constituents especially the crude fibre.

The results of this experiment confirms the earlier observations of Adebambo (1970)that the level of dry matter intake recommended in the U.K., ARC (1965) may be too high for the Nigerian Dwarf sheep. Recommended figures were obtained using the exotic breeds of sheep of the temperate zones. The dry matter intake in g/day/$W^{0.73}$kg ranged between 61.8g to 90.1g. This is comparable to the range of 54.8 - 90.2 g/day/$W^{0.73}$kg obtained for the Nigerian Dwarf goat by Akinsoyinu, (1974).

The dry matter intake of the animals in this experiment is however higher than the values of 2.11 - 2.22 kg per 100 kg live-weight proposed for ruminants in the tropics by Marshall, Bredon and Juko (1961). When the means for total dry matter intake of the animals on this experiment were converted on this basis, group A had a mean of 3.78 kg/100 kg live-weight while groups B, C and D consumed 3.45 kg, 3.07 kg and 2.66 kg/100 kg live-weight respectively.

Although the dry matter intake of the group D animals was lowest, they actually consumed 86.8% of their daily supply of concentrate supplement (Tables 4.2, 4.8), while the group A animals with a high dry matter intake (768.9g) consumed only 59.53% of their daily supplies. The daily concentrate ration given the animals on the high energy level treatments was higher than those with the lower ones (Table 4.2).

The experimental animals were slow in adapting to their new concentrate supplements and to enforce this quantity, the basal diet offered had to be drastically reduced from 0.908 kg to 0.454 kg.

The mean daily intake of digestible organic matter, digestible nitrogen-free extracts and total digestible nutrients (Table 4.8) followed the pattern of the feed intake. This is to be expected since all the rations were quite digestible and hence the constituents were also highly digestible. It is also to be noted that there were only little variations in the dry matter content of the rations (Table 4.3).

Although the total digestible nutrient intake of the animals on treatment D was lowest, they consumed 82.33% of the expected requirement at 50% energy level (Table 4.3), while treatments C, B and A consumed a mean of 71.29%, 60.66% and 52.97% respectively.

The generally low intake of concentrate supplement and the fact that the animals on the higher energy level rations were expected to consume more to make up for their requirements of energy probably accounted for this reversal in percentage consumption of Total digestible nutrient.

The expected live-weight gains of the animals from recommendations of the U.K., ARC (1965) on which the calculations of the rations were based was to be about 300 g/day. The animals in the experiment had a mean daily gain much less than these expected values. Values obtained ranged from 55.7 g/day in treatment D to 83.8 g/day in B. It would therefore appear that the weight gains of treatments A, B and C were not compatible with the energy levels.

The lower weight gains from the higher energy level ration A are in agreement with those of Awoyemi (1962) and Adebambo (1970) but contrasts with those of Palsson and Verges (1952) who obtained mean daily weight gains of up to 566 g for animals on the highest plane of nutrition between the age of 24 - 36 weeks and only 162 g/day for those on a lowest plane of nutrition.

The low weight gains could be due to the low feed intake, the genetic constitution of the animals and the efficiency of feed utilization of the Nigerian Dwarf sheep. The low feed intake could be attributed to the small size of the animals but might be a genetic defect which needs to be corrected in the breed. It will therefore be necessary to investigate ways by which feed consumption of this breed could be improved.

Attempts have been made to show the relationships between some of the nutrient intakes and the daily weight gains (Fig.4.1 - Fig. 4.5). This is intended to help in working out possible estimates of requirements for maintenance and production.

An estimate of 35.2g Dry matter per day/$W^{0.73}$kg was obtained for maintenance by a regression of dry matter intake on changes in live weight. This is about 49% of the lower limit of dry matter recommendation by Marshall _et al_ (1961) who suggested an intake of 2.11 - 2.22 kg DM/100 kg live-weight which would be equivalent to 71.82 - 75.56 g/day/$W^{0.73}$kg. Since the digestibility of dry matter obtained in this experiment is quite high, the estimated 21.5g

DDM/day/$W^{0.73}$kg would be assumed to be low. The dry matter and digestible dry matter cost of live-weight increase obtained in this experiment (562 and 531 g/day/kg live-weight gain respectively) appear to be a fair estimate of requirement above the maintenance level.

The digestible organic matter requirement for maintenance obtained in this experiment is 13.95g DOM/day/$W^{0.73}$kg while 414g DOM/day/kg live-weight increase is the cost of production. This maintenance requirement is about 56.7% of the value of 24.61g DOM/day/$W^{0.73}$kg proposed by Langlands, et al, (1963) but the value for production of 1 kg live-weight obtained is about thrice the value of 143g DOM/day/kg live weight increase, (3.7 lb DOM for a sheep of 100 lb wt.) proposed by Langlands et al, (1963), for pen-fed sheep.

There is lack of reliable data and agreement on the relation of maintenance energy to body weight due to the considerable expense involved in maintaining adequately large number of farm animals in non-productive condition for the long periods necessary to obtain accurate results (Brody, 1945). Thus there is a lot of disparity in the recommended values of energy for maintenance.

The regression of ME intake kcal/$W^{0.73}$kg on the live-weight gains (Fig. 4.1) gave an estimate of 129.182 kcal/day/$W^{0.73}$kg for maintenance which is higher than 112 kcal/day/$W^{0.73}$kg for sheep as recommended by the ARC, (1965) and NRC, (1968). The value of 65 kcal/day/$W^{0.73}$kg given as the fasting energy metabolism of a 20kg sheep which if multiplied by 1.36 (Blaxter, 1962) gives a requirement of 88.4 kcal ME/day/$W^{0.73}$kg for maintenance is lower than the value obtained in this experiment.

The average live-weight of the animals in this experiment is 23.6 kg. Thus for a 20 kg animal the maintenance requirement is 124.34 kcal ME/day/$W^{0.73}$kg. This is comparable to the estimate of 88 - 124 kcal ME/day/$W^{0.73}$kg recommended by Rattrary et al, (1974).

The energy cost of live-weight gain obtained in this experiment was 1387 kcal ME/day/$W^{0.73}$kg for an increase of 1 kg live-weight under an intensive management system. An animal of 20 kg live-weight therefore needs 13,591 kcal ME/day for an increase of 1 kg live-weight. This value is about double the value of 6333.6 kcal recommended by the ARC, (1965) and NRC, (1968).

The maintenance requirements in terms of dry matter, digestible dry matter and digestible organic matter obtained in this experiment appear to be generally low. This might be due to the small size of the Nigerian Dwarf sheep as compared with the exotic breeds.

The high production cost obtained in terms of these nutrients probably points out to the low efficiency of utilization of feeds by the breed. It is generally accepted that the Nigerian Dwarf sheep has a very slow rate of weight gains (Dettmers and Loosli, 1974) and hence they will be inefficient utilizers of feeds.

Fig. 4.3 shows that there was a negative correlation between the digestible crude protein intake and the mean daily weight gains of the animals from the regression equation the maintenance requirement is 11.38 g/day for a 20 kg animal. The ARC (1965) and NRC, (1968) recommended a range equivalent to 7.8g to 18.0g for a 20 kg sheep depending on the energy concentration of the diet. The figures obtained is also comparable to the 14.0 g/day suggested by Wood and Woodman (1939).

The negative correlation obtained in this experiment is an effect of dilution of digestible crude protein in the rations as the energy levels increase. The rations were formulated in such a way as to offer each animal, daily, the same amount of crude protein which is the standard recommendation of the ARC (1965). The animals on the higher energy level ration were however offered more concentrate rations per day (Table 4.2). It means therefore that the digestible crude protein dilution in their daily ration was greater from the percentage consumption of the daily rations (Table 4.8), it would be obvious that the animals on the higher energy level rations consumed less digestible crude protein per day. Their rate of growth was however faster as compared with the group D animals. It appears therefore that the animals that were placed on a higher energy level ration consumed less digestible crude protein but had a higher daily weight gain.

This might be due to the greater importance of energy in the rations of ruminants as evidenced by the works of Zuntz, (1891); Fingerling, et al (1937); McDonald, (1954) and Maynard and Loosli, (1962) who have all shown that if there is sufficient source of energy in the ruminant diet, the rumen micro-organisms can synthesize their body proteins from various sources of nitrogen and when they die these proteins are passed on to the host animal.

A consideration of the slaughter weights of the animals on this experiment reveals that many of them had attained a live-weight range of 24.97 kg - 27.24 kg recommended by Hill, (1960) as the best slaughter weight for the Nigerian Dwarf sheep. After this weight, he observed that the animals would lay down more fat than lean meat. He however pointed out that this weight range could be attained between 14 - 16 months of age under semi-intensive conditions.

Adebambo, (1970) obtained animals of this live-weight range in 12 months. Both studies were carried out with grazing animals. Hill's work was actually based on a collection of data from the general management on the University of Ibadan, Teaching and Research Farm.

The ages of animals in this experiment at slaughter were about 9 months. The animals were zero-grazed and as such would be expected to have converted energy for grazing into energy for production. The reduction in the age at which the animals attained this slaughter weight agrees with the concept that better performance and faster turn over can be obtained for fattening lamb by the intensive management system.

Okereke (1958) gave the weight of the adult rams as between 22.7 kg and 27.24 kg. He however gave no age at maturity. With the intensive system of management, it will be quite possible to rear rams to a higher mature weight. No work has however been conducted on the correct weight and age at maturity of the Nigerian Dwarf sheep.

Okereke (1958) also observed that the live-weights did not appear to increase regularly with age. This agrees with the results obtained in this experiment. A consideration of the weight at slaughter (Table 4.12) and the age of the animals as could be assessed from Table 4.1, shows that some younger animals had higher initial and slaughter weights than some older animals.

This lack of progressive live-weight gains with increase in age, for which corrections were made by initially balancing the ages and live-weights of animals in the groups to reduce variations, is probably due to genetic differences in individual animals and the variations in feed intake or the rate of conversion of feeds to flesh. It might also have originated from differences in birth weights which is a result of the effect of the dam and her nutrition during pregnancy.

Much importance is attached to the appearance of the live animal in the trade in sheep in this country. Apart from the weight of the animals which is usually assessed, consideration is usually given to the height, girth and vigour of the animal.

The weight of the carcass is however given more prominence than the carcass quality. A heavier carcass is more likely to bring in a higher price than a good quality but smaller carcass. This agrees with the observation of Hammond (1932) that there is a greater difference in price due to the weight of the carcass than to the quality as exemplified by breed differences.

The situation in this country is much worse because quantity is the important yardstick for the consumers with considerably less emphasis being paid to meat quality.

The animals on Treatment C had the best mean slaughter weight but were only second best in mean cold carcass weight. They had a mean dressing percentage of 50.71% which was second to the last and lower than that for treatment D. The animals on Treatment B which had lower mean slaughter weight had the heaviest carcasses and thus dressed out best. This is because they had more of flesh and bones than other parts such as pluck and offals.

The animals on Treatment C probably had more of their weights taken up by other parts not normally included in the carcass such as the offal especially the contents of the alimentary tract. High figures were recorded for the percentage skin, full gut, and feet for the animals in this group (Table 4.14).

A consideration of dressing percentage alone without reference to the actual slaughter weight tends to give a wrong impression of the production of the animal. This is exemplified by Treatment D figures for dressing out percentage (52.42%) which was higher than that for Treatment C (50.71%). Treatment C, however, had a higher mean carcass weight and slaughter weights than D. This is similar to the observations of Hammond (1932), who therefore suggested that the first essential in grading meat carcass is to make weight classes and then subdivide these weight classes according to quality.

It therefore follows that comparison of dressing percentages will mean more for animals of the same weight class.

Okereke (1958), gave an average dressing percentage of 38% for the Nigerian Dwarf sheep. Awoyemi (1962), reported percentages of 44.18 and 44.30 for the animals on Low and High planes of nutrition respectively.

Adebambo (1970), also obtained figures of 45.9% and 46.71% for animals on the 100% and 50% energy level rations. Dettmers and Loosli (1974), obtained a carcass yield ranging from 42 - 43% from the same flock of sheep on the University of Ibadan, Teaching and Research Farm.

All these figures are lower than figures obtained in this experiment (Table 4.13). The figures are however not comparable as this will give a wrong impression since there are differences in diets, ages, and weights of the various animals and the management systems used by each worker.

According to yield and quality (grades) used in the United States of America (Ensminger, 1969) a 50% yield (47 - 53%) is Choice, Good is 47% (45 - 50%), Utility is 44% (42-46%) and Cull is 41% (38 - 44%) for sheep carcasses. The animals in this experiment would be classified as Choice when based on yield alone.

The meat trade in Nigeria is dominated by the local markets where selling by the standard joints is not considered. Emphasis is however placed on the amount of bones and flesh present in the cuts. The more sophisticated markets such as the supermarkets however sell in terms of the standard joints: shoulders, sets, loin, best ends and leg.

The animals on treatment D had the highest mean figures for sets, shoulders and ends. These animals had the smallest slaughter weights and carcass weights. The three joints have a great amount of bones. Treatment C had the highest mean percentage of the loin and leg and the highest mean slaughter weight. These two joints had more flesh than bones. It would appear that the mean percentages in all the joints of animals in Treatment A were fairly well distributed. Statistical analysis showed that levels of nutrition had no significant effect on the distribution of joints.

The shoulder and leg always account for the greater percentage of the carcass. Both joints have accounted for between 59% and 63% of carcasses in this experiment. The importance of the flesh percentage of the carcass cannot be over emphasized. It is therefore desirable that one is able to predict the percentages of these three important fractions of the carcass from the live-weight of the animals. This may help in assessing the price to be expected from the slaughtered animals.

The relationship between the leg and shoulder percentages (Y) and slaughter weights (X) of the animals shows negative correlation Fig. 4.7 and 4.8). Leg percentage at birth is about 42.99.% and decrease by 0.5% for every kg increase in live-weight. Similarly, shoulder percentages at birth is about 40.98% decreasing by 0.42% for every kg increase in live-weight. Thus the two equations are:-

$$\text{Leg \%} = Y = 42.986 - 0.526x \quad (r = 0.699 \pm 0.069)$$

$$\text{Shoulder \%} = Y = 40.984 - 0.415x \quad (r\ 0.452 \pm 0.078)$$

It may therefore be possible to estimate the weights of these major joints at any live-weight.

The leg percentage would be preferable however, since the correlation coefficient for the regression of shoulder percentage on live-weight is not statistically significant.

The percentage flesh is positively correlated with the live-weight. The regression equation:-

$Y = 66.232 + 0.662x$ shows that the expectation of flesh percentage at birth is about 66.2% increasing by 0.66% for every kg. live-weight increase. It is therefore easy to estimate the percentage flesh to be expected from any live-weight of the Nigerian Dwarf sheep. Estimates of cost of production at any stage can therefore be compared with the price expectation estimated from the above relationship.

It is however possible that at higher weights this relationship may be affected by fat deposition. The tendency for animals to lay down more fat than lean meat may affect this linear relationship.

The other parts considered in Table 4.14 are of great importance in the Nigerian context. Only the horn and in some cases the hair is useless in any slaughtered animal. The gut is washed clean of its content and the head and feet are all processed and highly relished by the people. Hence they need serious consideration.

These other parts, the pluck, feet, gut offals and head mature early in the life of the animal and attain maximum size early also. The skin could however be affected in two ways by the later nutritional regimes of the animal. The weight of the skin may vary either as a result of differential laying down of subcutaneous fat or the differential growth of hair. Plates 1 and 2 show two animals which have different amount of hair cover. Amount of hair cover varies in the breed from the very hairy type - Plate 1 to the slightly hairy type - Plate 2. Subcutaneous fat is not very important in this breed of sheep.

Since the parts considered attain a fixed size, smaller animals tend to have greater percentages of these parts; while larger animals have lower percentages. This is exemplified by the smaller animals of treatment D which had the highest percentages of feet and head.

This is consistent with the findings of Palsson and Verges (1952) who obtained higher figures for head, feet, skin, wool and alimentary tract, all expressed as percentages of live-weight, from the smaller animals on low plane of nutrition as compared with lower figures from the larger animals on the high plane of nutrition. This shows that above a certain age, the proportions of these parts vary inversely as the age and growth rate of the animals.

Horned animals can however introduce another variation due to differential development of horns which start to grow later in life and can continue to grow throughout life. This is not clearly brought out in this experiment because all male animals of the breed are horned. The percentage of head and the slaughter weight are thus in inverse relationship.

The only desirable fraction of any carcass is the flesh. Although the bones are essential parts of the animal, they are not consumable and as such higher meat: bone ratio is always locked for in a good quality carcass.

Marbled fat is, to some extent, desirable as it increases the palatability of the meat. The removable fat, those around the gastro-intestinal tract and in the carcass around the kidney or pelvic fat are not very desirable.

Hammond and Murray (1934) stated that the quality of a carcass depends mainly on the proportion of fat, muscle and bone in the carcass and these proportions change as the animal grows and change at different rates in different breeds.

Treatment A had the highest percentage of flesh while treatment D had the lowest. This is consistent with the earlier observations that the smaller animals have lower meat: bone ratio. The highest bone percentage was for Treatment D.

Treatment A had a very high fat percentage. This is a high energy level ration, (125% energy level). This probably explains why fat deposition was high. Fat deposition is a result of excess energy not utilized for production. As regards the production of lean meat, the treatment B ration would appear to be best.

. Animal production involves the raising of animals at the fastest rate of growth so as to have the fastest turn over in the shortest possible time. This involves the feeding of the best ration that will give optimum growth.

To achieve this, one has to be guided by the economics of feeding and the efficiency of utilization of the feeds.

The cost of adding 1 kg live-weight obtained varied from ₦1.20 to ₦1.63. This cost appears to be too high since this will mean selling the dressed carcass at a much higher price. The Nigerian market is however presently dominated by live animals and prices are not paid for the weight of the animals. During the religious festivals a 20-30 kg animal will easily sell for between ₦30.00 and ₦40.00. It is therefore economical to produce animals at this rate and intensively to meet these specific periods. The high cost obtained in this experiment had been due more to the slow rate of growth of the animals than to the feed intake. This might be another pointer to the inefficiency of feed conversion which is probably a genet fault which needs to be investigated and corrected in the breed. The feed/gain ratio obtained for the average 6-9 months appears too high (6.48 - 9.65). This will probably be lower at younger ages since it is generally accepted that the last kg of gain is more expensive to produce in terms of feed than the first. This shows that the older an animal is, the more expensive, in terms of feeds and hence in terms of cash, to obtain weight gains.

An examination of Table 4.15 points to the fact that Treatment C has the best feed/gain ratio, and gain/100g TDN consumed but the lowest cost/kg live-weight gains. This is a clear indication that it is highly more economical to feed ration C which is a 75% energy level ration to the Nigerian Dwarf sheep between the ages of 6 to 9 months.

The higher energy level rations, especially ration A (125% energy level) are wasteful. Ration A had the highest feed/gain ratio, the lowest gain/100g TDN consumed and the highest cost/kg live-weight gain.

This result is however contrary to results of many workers with the exotic breeds of sheep who have always reported a greater and faster returns for a higher quality ration but is in agreement with the results of Awoyemi (1962) who got a better performance of the Nigerian Dwarf sheep from the group on a low plane of nutrition.

This also seems to confirm the early investigations by Adebambo (1970) in which a better performance was obtained from the animals on the 50% energy level when compared with those fed the 100% energy level ration.

CHAPTER 5

Studies on the Effects of Variations in Dietary Energy Levels on the Growth and Carcass Quality of the Nigerian Dwarf Sheep from the Age of 3 Months to 6 Months.

5.1 Introduction

Lambs are usually weaned between 12-16 weeks. On the University of Ibadan, Teaching and Research Farm, the practice is to leave the lambs with the ewes till they are naturally weaned. This is probably not the best method of rearing lambs as this may affect the normal breeding cycle of the ewes in that they may not return to cycle in time.

It is also known that the milk yield of the ewe declines rapidly after the 2nd to 3rd week peak, and by the 12th week may become inadequate to support the growth of the lamb. It is therefore advisable to wean the lambs at this stage, and put them on a system of feeding that would ensure proper growth and development for mutton production. For the Nigerian Dwarf lamb, there are as yet no studies to indicate the appropriate dietary requirements at this stage of development.

This experiment was therefore conducted to assess the influence of variations in dietary energy levels on growth rate and carcass quality of lambs at 3-6 months of age, and the extent to which variations in the frequency of feeding influences feed intake in the Nigerian Dwarf sheep.

5.2 Materials and Method

(i) Animals:

The experiment was carried out in two phases. In the first phase, 18 rams, with an average age of about 3 months and live-weights ranging from 5.0 - 11.2 kg were selected from the flock of West African Dwarf sheep on the University of Ibadan, Teaching and Research Farm. For phase two, 10 rams with an average age of about 3 months and live-weights ranging from 6.5 - 10.6 kg were selected from the same flock. The combined identification of animals' ages, live-weight and ration treatments are shown in Table 5.1.

5.2 (ii) The Rations:

The maintenance requirements of the animals were to be met from the basal ration of freshly cut Giant Star gras - *Cynodon nlemfuensis* var *nlemfuensis* whilst production was met from different amounts of concentrate supplements calculated to supply Metabolizable Energy (ME) at 125%, 100%, 75% and 50% respectively and Available Protein (AP) at 100% of the U.K., ARC (1965) feeding standard for fattening lamb. The control group had no supplementation. The levels of ME were designated A, B,C,D and E respectively. The formulation of the rations was based on the estimated energy requirements by fattening lambs of 10 kg live-weight and an expected daily weight gain of 200g. Basing the calculation on metabolic body size of $W^{0.73}$kg, the daily requirements of ME and AP of each animal at the allocated feeding level was calculated. The requirements were converted to TDN and DCP respectively.

The composition of the concentrate supplement showing the calculated TDN and DCP values which were obtained using figures reported by Morrison (1956) and Oyenuga (1968) are shown in Table 5.2. The Table also shows the rate of concentrate feeding at the different levels of supplementation.

The chemical composition of the concentrate mixture, as fed, as well as the basal diet are shown in Table 5.3.

5.2 (iii) Experimental Design

In the first phase 18 animals were divided into 3 groups designated C, D and E, representing 3 treatments while the six animals in each group made up the six replicates of a randomised complete block design shown in Table 5.4. Treatments C, D and E thus constitute the 3 dietary energy levels 75%, 50% and 0% respectively, being tested. The 6 animals in each group were also divided into two. Three animals were fed twice daily while the remaining three had their concentrate mixtures thrice daily.

For the second phase only 10 animals were available and these were divided into two groups designated A and B, representing the two remaining treatments which are the 125% and 100% energy

Table 5.1 Identification of Animals' Ages, Live-weight and Ration Treatment

Animal No.	Age (Months)	Weight (kg)	Ration Treatment
860	3.5	11.15	C
862	3.5	9.50	D
865	3.5	7.75	C
866	3.5	7.50	D
876	3.5	7.85	E
882	3.5	9.50	E
884	3.5	5.60	D
897	3.25	9.60	D
916	3.25	7.75	C
919	3.25	7.50	C
921	3.25	5.00	C
922	3.0	9.00	E
924	3.0	6.25	D
925	3.0	6.00	E
926	3.0	6.00	D
929	3.0	5.75	E
939	3.0	7.75	C
942	3.0	5.5	E
982	3.25	7.00	B
984	3.25	10.60	A
991	3.25	6.50	A
993	3.25	9.30	B
998	3.0	8.50	B
1004	3.0	7.00	B
1005	3.0	7.00	A
1013	3.0	7.25	A
1015	3.0	7.50	A
1016	3.0	7.50	B

A= 125% Energy level

B= 100% Energy level

C= 75% Energy level

D= 50% Energy level

E= 0% Energy level.

Table 5.2 Composition of Concentrate Supplements

	A 125%	B 100%	C 75%	D 50%
Guinea corn (%)	69.0	60.0	40.0	10.0
Groundnut cake (%)	10.5	19.5	25.5	55.0
Brewer's grain (%)	10.0	10.0	5.0	2.5
Mineral mixture (%)	0.5	0.5	0.5	0.5
Calculated TDN (%)	76.17	77.14	74.143	76.411
Calculated DCP (%)	12.80	16.18	20.121	31.638
Rate of feeding (g/day)	439	347	270.6	175.0
Estimated TDN requirement (kg/day)	0.3343	0.2674	0.2006	0.1337
Estimated DCP requirement (kg/day)	0.0562	0.0562	0.0562	0.0562
Estimated supply of TDN (kg/day)	0.3344	0.2677	0.2006	0.1337
Estimated supply of DCP (kg/day)	0.0562	0.0562	0.0540	0.0554

Table 5.4 Position of animals in the Experimental Design

	Phase I		Phase II		
	C	D	E	A	B
	Animal Numbers				
Feeding Thrice daily	919	862	876	984	982
	860	866	922	991	993
	865	924	929	1005	998
Feeding Twice daily	916	884	882	1013	1004
	921	897	925	1015	1016
	939	926	942		

A = 125% Energy level supplementation

B = 100% " " "

C = 75% " " "

D = 50% " " "

E = No supplementation.

levels of supplementation respectively. Each phase of the experiment lasted 12 weeks.

5.2 (iv) Housing and Management

Throughout the experimental period, all animals were housed in individual stalls with concentrate floor and wood shavings as bedding. They were brought out for measurements at the appropriate times and were allowed exercise for one hour a day in the open space attached to the experimental pens.

5.2 (v) Feeding

The animals fed thrice daily were given a third of their daily concentrate rations at 8 a.m., 12 noon and 3 p.m. respectively. Basal ration of grass were offered twice in all cases at 9 a.m. and 1 p.m. daily. All animals had access to clean cold water and mineral licks at all times.

5.2 (vi) Measurement of Feed Intake

The daily allowance of concentrate was weighed for each animal. The refusals of both concentrate and grass were weighed back the following morning before fresh supplies. The amount consumed was therefore determined by difference.

5.2 (vii) Parameters.

The parameters used for growth measurements and carcass analysis were the same as in the first experiment and have been well explained (See Sections 3.7 and 3.8).

5.2 (viii) Digestibility Trials

Digestibility trials were carried out following the same pattern as in the first experiment. Method of collection and analysis of faeces and calculation of the apparent digestibility coefficients were also the same as enunciated in sections 3.5, 3.6 and 4.2 (viii).

The digestibility trials were carried out in two phases. The first phase involving the 75% and 50% energy level rations was run concurrently with the feeding trials on same rations while the second phase using the 125% and 100% energy level rations was run at the same time as the feeding trials on these rations was conducted.

RESULTS

5.3 Digestibility of Feeds

Table 5.5 shows the mean apparent digestibility coefficient of nutrients in the mixed diet. The dry matter digestibility, organic matter digestibility, ether extract digestibility, crude fibre digestibility, and nitrogen-free extract digestibility decreased from treatment A to D. The differences were not statistically significant.

The means for the crude protein digestibility were 60.83%, 60.85%, 58.28% and 58.56% for treatments A, B, C and D respectively. The variations were not also significant.

Table 5.6 shows the mean apparent digestibility coefficients of the nutrients in the basal diet for phases 1 and 2, treatments C and D and A and B. Each figure is a mean of 12 animals. For all the nutrients except the Nitrogen-free extract, the means were higher for A and B than for C and D. The differences were however not statistically significant.

The apparent digestibility coefficients for the nutrients in the concentrate supplements (Table 5.7) was calculated from the figures for the mixed diet and the basal diet by the method of Crampton (1956). Organic matter digestibility decreased from A to D with means of 67.95%, 66.17%, 64.05% and 63.73% for A, B, C and D respectively. The Nitrogen-free extract digestibility followed this same trend with means of 76.28%, 75.41%, 71.60% and 70.12% for treatments A. B, C and D respectively. Statistical analysis showed no significant differences for both the organic matter digestibility and Nitrogen-free extract digestibility.

The Ether extract and crude fibre digestibilities showed that the means for treatment C were higher than those for treatment B.

Table 5.5 Mean Apparent Digestibility Coefficient of Nutrients in the Mixed Diet (%)

Treatment	DM	OM	CP	EE	CF	NFE
A	60.61	62.61	60.83	51.37	60.59	66.02
B	60.37	60.94	60.85	47.20	59.92	64.07
C	58.35	59.01	58.28	45.16	58.76	62.43
D	56.65	56.78	58.56	40.81	58.02	61.34
	NS	NS	NS	NS	NS	NS

NS = Not significant.

Table 5.6 Mean Apparent Digestibility Coefficient of Nutrients in Basal Diet (%)

Treatment	DM	OM	EE	CF	CP	NFE
*A and B	55.17 ± 0.318	56.92 ± 0.418	28.26 ± 1.386	56.01 ± 0.617	55.13 ± 0.845	55.30 ± 0.723
*C, D and E	54.52 ± 0.539	55.68 ± 0.747	35.10 ± 2.071	54.40 ± 1.376	53.11 ± 1.651	56.16 ± 0.669
	NS	NS	NS	NS	NS	NS

* = Mean of 12 animals

NS = Not significant

Table 5.7 Mean Apparent Digestibility Coefficient of Nutrients in the Concentrate Supplements (%)

	DM	OM	EE	CF	CP	NFE
A	65.76 ± 0.628	67.95 ± 0.408	64.30 ± 1.085	65.02 ± 0.595	67.26 ± 0.982	76.28 ± 1.175
B	67.01 ± 0.373	66.17 ± 0.587	62.27 ± 0.306	64.77 ± 0.381	66.84 ± 0.408	75.41 ± 0.504
C	63.00 ± 0.529	64.05 ± 0.968	62.38 ± 3.317	66.64 ± 0.764	64.54 ± 1.115	71.60 ± 1.467
D	62.11 ± 1.806	63.73 ± 1.165	57.10 ± 1.743	63.80 ± 0.914	78.81 ± 1.252	70.12 ± 1.152
	NS	NS	NS	NS	NS	NS

NS = Not significant

Ether extract digestibility coefficients were in the order 64.30%, 62.38%, 62.27% and 57.10% for groups A, C, B and D respectively. The mean crude fibre digestibilities were also 65.02%, 66.64%, 64.77% and 63.80% for treatments A, C, B and D respectively.

The highest mean of 78.81% for Crude protein digestibility was obtained in treatment D while treatments A, B and C had means of 67.26%, 66.84% and 64.54% respectively.

Dry matter digestibility ranged from 62.11% in D to 67.01% in B. Mean for A and C were 65.76% and 63.00% respectively. The differences for the Dry matter and Crude protein digestibilities were not statistically significant.

5.4 Feed Intake

The mean daily dry matter intake from grass and concentrate mixtures and mean total daily dry matter intake are presented in Table 5.8. The table also shows the dry matter intake/$W^{0.73}$kg. Dry matter intake from the basal ration decreased progressively from A to D. Statistical analysis showed that the differences were highly significant ($P < 0.01$) with the intake from both groups A and B significantly higher than means from C and D.

Dry matter intake from the concentrate supplement followed the same trend. Daily means were 261.2g, 241.9g, 237.1g and 155.1g for treatments A, B, C and D respectively. The variations were statistically significant and means for groups A, B and C are all significantly higher than D. Mean for A was also significantly higher than B and C. The differences between B and C were however not significant.

The mean total dry matter intake is the mean of the addition of daily intake from both basal diet and concentrate supplement. The highest mean of 402.3g was obtained for group A while 378.3g, 354.3g and 259.4g were the means for groups B, C and D respectively. The differences were highly significant ($P < 0.01$) with each group significantly different from the other.

5.5 Variation in Frequency of Feeding

Table 5.9 presents the mean daily dry matter intake of the animals of phase 1 fed twice and thrice daily respectively. Those fed thrice had a higher mean intake of 327.7g DM/day while those fed twice consumed a mean of 286.0g DM/day. Statistical analysis show no significant difference due to the variation in frequency of feeding.

5.6 Digestible Nutrient Intake

The digestible nutrient intake was obtained from the daily dry matter intake for each ration multiplied by the percentage composition of the nutrient and the apparent digestibility coefficient

Table 5.8 <u>Mean Daily Dry Matter Intake (g)</u>

	Grass	Concentrate supplement	Total	Intake g/day/$W^{0.73}$kg
A	141.07 ± 1.985	261.23 ± 9.541	402.31 ± 11.278	50.28
B	136.35 ± 3.107	241.91 ± 10.256	378.26 ± 10.878	54.94
C	117.20 ± 4.136	237.10 ± 15.853	354.30 ± 19.627	57.24
D	104.29 ± 5.533	155.11 ± 9.810	259.40 ± 17.828	50.62
	**	**	**	*

** = Statistically significant ($P < 0.01$)

* = Statistically significant ($P < 0.05$)

Table 5.9 Effect of Variation in Number of Times Feed is Offered on Feed Intake. Mean Daily DM Intake (gm)

	Feeding thrice	Feeding twice	
	404.79	372.96	
	379.51	348.08	
	366.85	253.60	
	287.32	240.60	
	271.36	295.11	
	256.37	205.61	
Mean	327.7±23.61	285.99±49.26	NS

NS = Not significant.

Table 5.10 Mean daily intake of Digestible Nutrients and DM from both Basal Diet and Concentrate Mixtures

	DDM (gm)	DOM (gm)	DEE x 2.25 (gm)	DCF (gm)	DCP (gm)	DNFE (gm)	TDN (gm)	ME (kcal)	DM (gm)
A	253.22 ± 8.59	212.68 ± 6.20	7.35 ± 0.18	37.93 ± 0.80	29.26 ± 0.92	179.54 ± 5.63	254.08 ± 7.52	904.36 ± 26.87	402.31
B	237.33 ± 7.22	193.66 ± 5.78	18.08 ± 0.66	38.25 ± 0.79	29.77 ± 1.03	153.43 ± 5.08	239.52 ± 7.50	852.57 ± 26.61	378.26
C	215.44 ± 11.98	180.83 ± 10.24	19.79 ± 1.28	38.44 ± 2.56	42.17 ± 2.67	119.00 ± 6.85	219.39 ± 12.97	780.91 ± 46.177	354.30
D	153.39 ± 7.27	129.67 ± 6.27	13.51 ± 0.81	28.92 ± 1.29	40.76 ± 2.39	78.95 ± 3.72	160.14 ± 7.92	570.01 ± 28.086	259.40
	**	**	**	**	**	**	**	**	**

** = Statistically significant at 1% level.

Table 5.11 Mean Daily Intake of Digestible Nutrients and DM from Concentrate Supplement and Basal Diet

	DDM (gm)	DOM (gm)	DEE x 2.25 (gm)	DCF (gm)	DCP (gm)	DNFE (gm)	TDN (gm)	ME (kcal)	DM (gm)
Concentrate Supplement									
A	171.79 ± 6.25	146.97 ± 5.36	4.84 ± 0.18	12.33 ± 0.45	23.61 ± 0.88	142.11 ± 5.19	182.89 ± 6.67	650.99	261.23
B	162.11 ± 6.69	130.15 ± 5.50	15.65 ± 0.67	13.50 ± 0.56	24.31 ± 1.05	117.26 ± 4.94	170.72 ± 7.22	607.67	241.91
C	149.88 ± 9.535	127.18 ± 8.506	18.73 ± 1.260	15.84 ± 1.055	38.03 ± 2.542	87.06 ± 6.631	159.67 ± 10.673	568.34	237.10
D	96.34 ± 6.088	81.93 ± 5.186	12.57 ± 2.467	10.30 ± 1.836	37.07 ± 2.354	48.54 ± 3.057	108.47 ± 6.860	386.10	155.11
	**	**	**	**	**	**	**	**	*
Basal Diet									
A	77.83 ± 1.08	65.71 ± 0.91	2.51 ± 0.03	25.60 ± 0.38	5.64 ± 0.08	37.43 ± 0.45	71.18 ± 0.99	253.36	141.07
B	75.22 ± 1.75	63.51 ± 1.48	2.43 ± 0.06	24.75 ± 0.57	5.45 ± 0.13	36.17 ± 0.83	68.80 ± 1.60	244.89	136.35
C	63.90 ± 2.248	53.65 ± 1.91	1.07 ± 0.004	20.93 ± 0.07	4.14 ± 0.13	31.94 ± 1.13	58.08 ± 2.057	206.73	117.20
D	56.88 ± 3.023	47.74 ± 2.54	0.96 ± 0.004	18.62 ± 0.98	3.68 ± 0.21	28.42 ± 1.50	51.67 ± 2.752	183.92	104.29
	*	**	**	**	**	**	**	**	*

** = Statistically significant (P 0.01)
* = Statistically significant (P 0.01).

Table 5.12 Mean Daily Intake of Digestible Nutrients, DM and Mean Digestible Nutrient Intake/Unit Metabolic Size

	A	B	C	D	
Dry matter intake (g/day)	402.31	378.26	354.30	259.30	**
Dry matter intake (g/day/$W^{0.734}$kg)	50.28	54.94	57.24	50.62	NS
Digestible dry matter intake (g/day)	253.22	237.33	215.44	153.39	**
Digestible dry matter intake (g/day/$W^{0.734}$kg)	32.67	34.47	34.80	29.93	*
Digestible organic matter intake (g/day)	212.68	193.66	180.83	129.67	**
Digestible organic matter intake (g/day/$W^{0.734}$kg)	27.42	28.13	29.20	25.30	*
Digestible crude protein intake (g/day)	29.26	29.77	42.17	40.76	**
Digestible crude protein intake (g/day/$W^{0.734}$kg)	3.77	4.32	6.79	7.92	**
Metabolizable energy intake (kcal/day)	904.36	852.57	790.91	570.01	**
Metabolizable energy intake (kcal/day/$W^{0.734}$kg)	116.62	123.81	126.24	111.11	*

NS = Not significant
* = Significant at 5% level
** = Significant at 1% level.

of the nutrient. These are presented in Tables 5.10 and 5.11 for the mixed diet, concentrate supplement and basal diet respectively. Figures for digestible ether extract were multiplied by the factor 2.25. Table 5.12 shows the mean daily intake of digestible nutrients and dry matter and mean daily digestible nutrient intake per unit metabolic size.

Dry matter intake per day expressed per unit metabolic size shows a trend which differs from the daily intake. The highest mean was 57.24g DM/day/$W^{0.73}$kg was obtained in treatment C followed by B, D and A with 54.94, 50.62 and 50.28 g/day/$W^{0.73}$kg respectively in that order. Daily intake decreased progressively from treatment A to D. The differences were not significant.

The mean daily consumption of digestible dry matter, digestible organic matter, digestible nitrogen-free extract, total digestible nutrient and metabolizable nutrient from the concentrate supplement and basal diet, (Table 5.11) and the total (Table 5.10) all decreased progressively from treatment A to D. Digestible ether extract, crude fibre and crude protein consumption did not follow any particular trend. The differences in all cases are highly significant ($P < 0.01$).

Comparison of daily nutrient intake and intake per unit metabolic size (Table 5.12) showed a variation in the trends. When the digestible dry matter intake which decreased from A to D was

Table 5.13 Regression Equations for Animals 3-6 months of Age

	X	Regression Equation	Correlation Coefficient	Std. Error of Coefficient Seb	Difference
Daily DOM intake/kg $W^{0.734}$kg	Daily Weight Gains	Y = 24.61 + 0.0508x	+0.683	±0.00917	**
Daily DCP intake/kg $W^{0.734}$kg	Daily Weight Gains	Y = 9.0195-0.0559x	-0.942	±0.0003	**
Daily DDM intake/kg $W^{0.734}$kg	Daily Weight Gains	Y = 29.0234+0.0686x	+0.701	±0.0131	**
Daily ME intake/kg $W^{0.734}$kg	Daily Weight Gains	Y = 107.097+0.215x	+0.696	±0.173	**
Daily DM intake/kg $W^{0.734}$kg	Daily Weight Gains	Y = 48.104+0.0987x	+0.702	+0.0350	**
Shoulder percentage	Slaughter Weight	Y = 36.780-0.382x	-0.755	±0.302	**
Leg percentage	Slaughter Weight	Y = 39.611-0.480x	-0.713	±0.330	**
Flesh percentage	Slaughter Weight	Y = 62.569+0.888x	+0.872	±1.599	**

** = Statistically significant at 1% level.

expressed as intake per metabolic size intake/$W^{0.73}$kg the highest intake was 34.8g DDM/day/$W^{0.73}$kg from treatment C, followed by 34.47, 32.67 and 29.93g DDM/day/$W^{0.73}$kg for treatments B, A and D respectively.

Digestible organic matter and metabolizable energy intake per unit metabolic size also followed this trend. Mean digestible crude protein intake which was highest in treatment C with 42.2 g/day followed by treatments D, B and A with 40.8 g/day and 29.3 g/day respectively increased progressively from treatment A to D when expressed as intake per unit metabolic size with means of 3.8, 4.3, 6.8 and 7.9g DCP/day/$W^{0.73}$kg for treatments A, B, C' and D respectively.

5.7 Estimates of requirements for maintenance and production

There was a highly significant ($P < 0.01$) positive correlation between dry matter intake (g/day/$W^{0.73}$kg) and live-weight gains (g/day), with correlation coefficient (r) of 0.702 ± 0.035 (Table 5.13). The dry matter value at the point of zero live-weight gain gives the maintenance requirement and is 48.104g DM/day/$W^{0.73}$kg) (Fig.5.1). The cost of 1 kg live weight gain is thus 98.7g DM/day.

The regression equation showing the relationship between digestible dry matter intake (Y) and live-weight gain (X) =

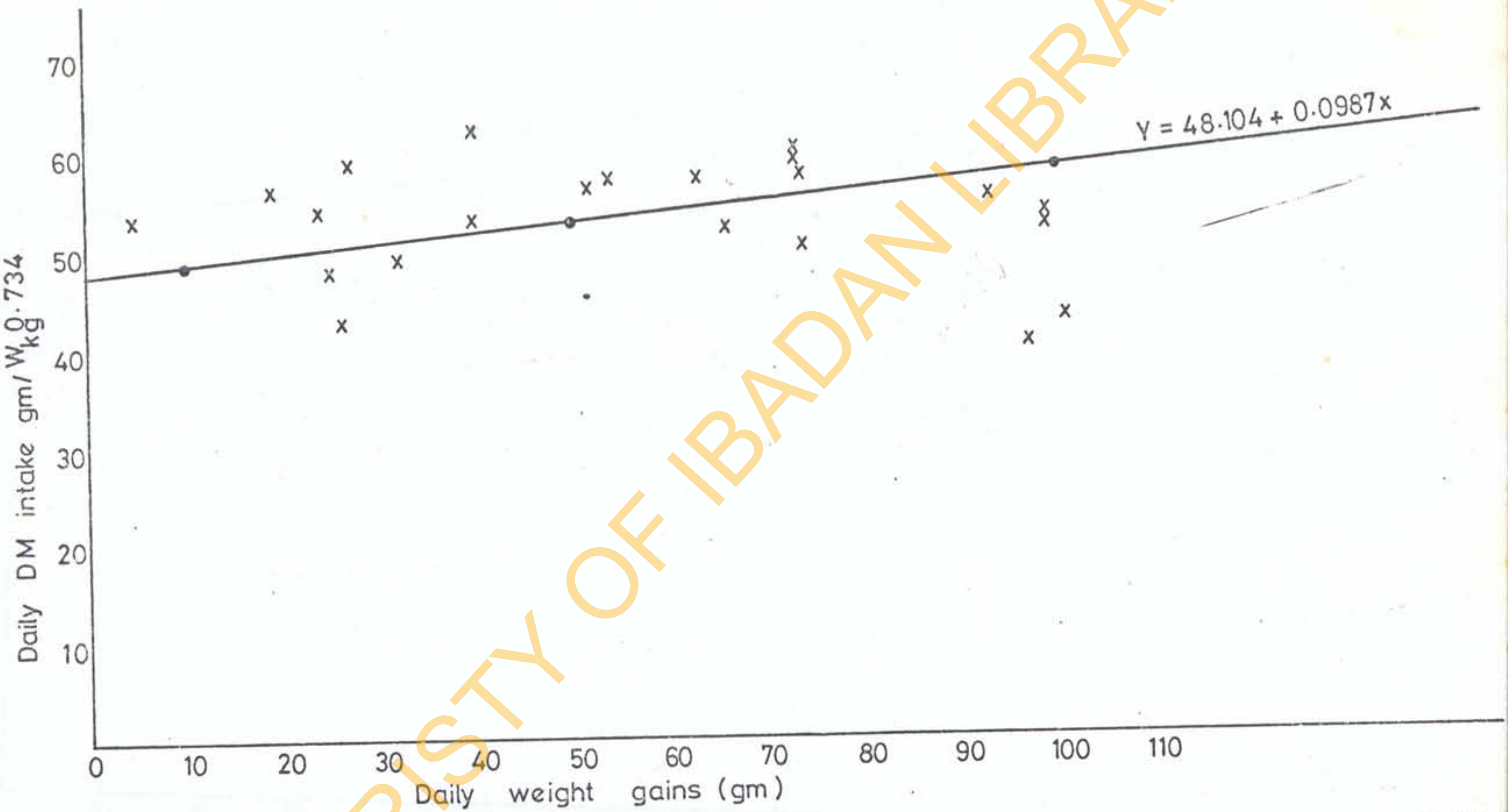

FIG. 5.1 REGRESSION OF DAILY DM INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 3-6 MONTHS OF A

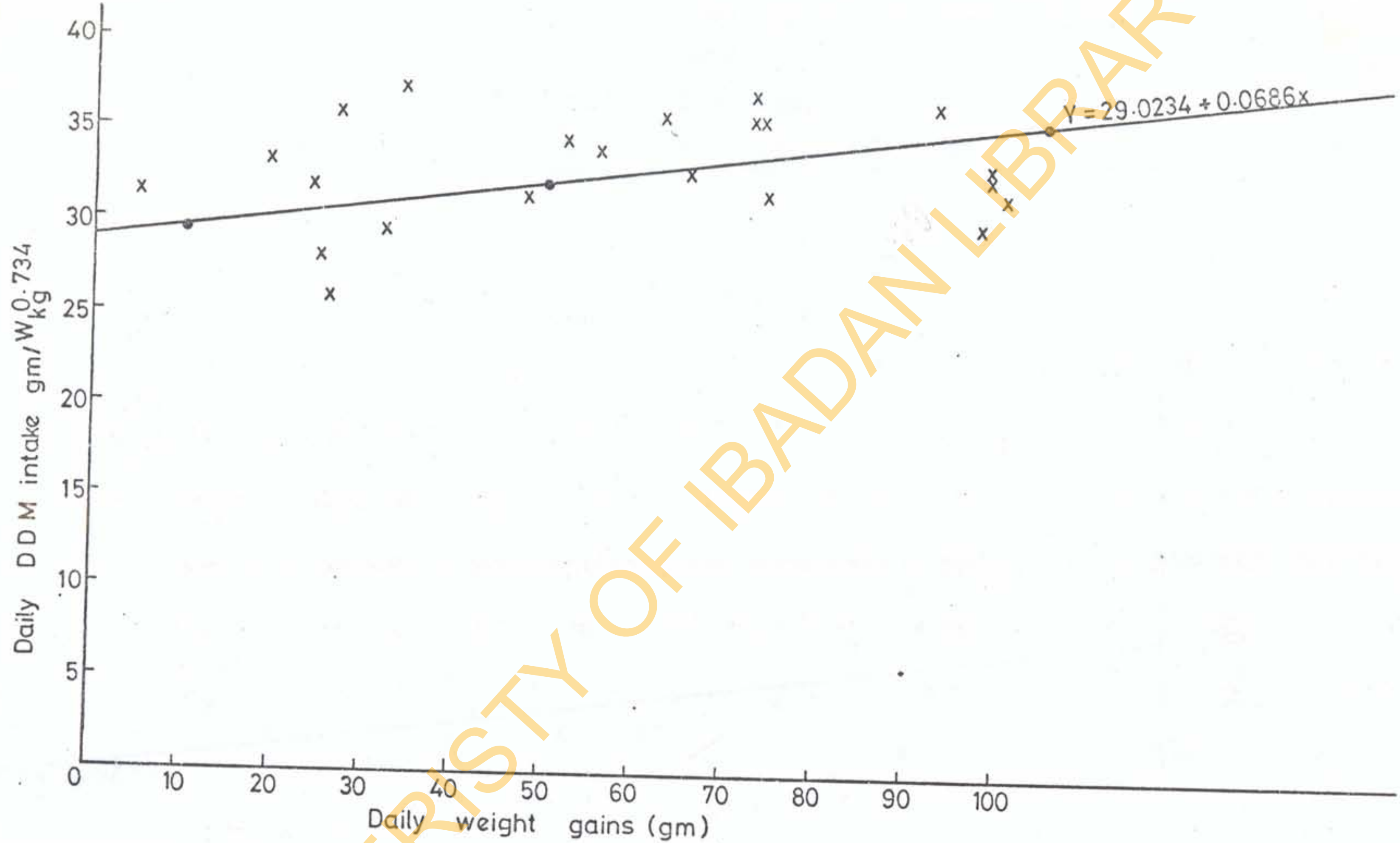

FIG.5.2 REGRESSION OF DAILY DDM INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 3–6 MONTHS OF AGE

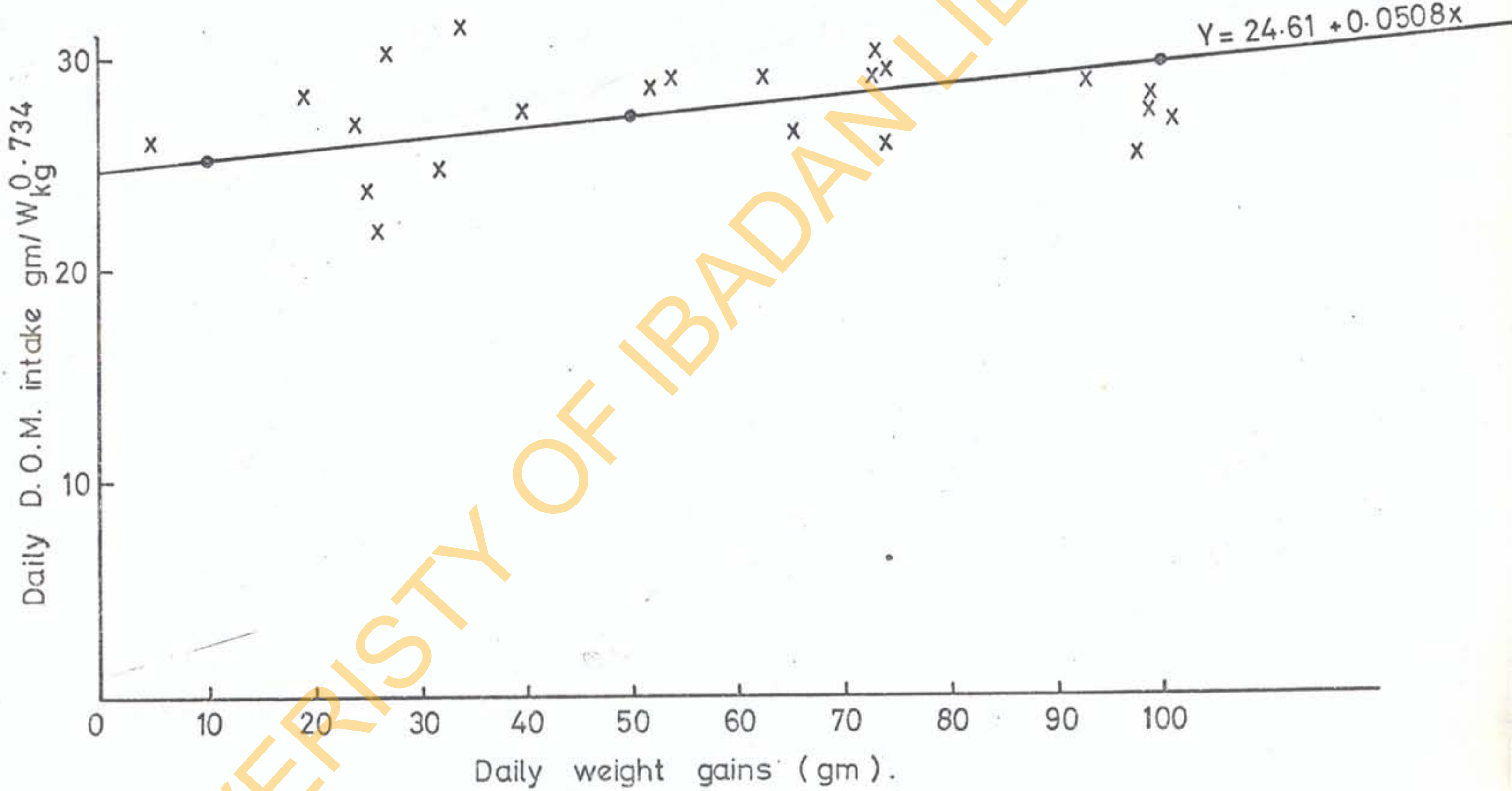

FIG.5.3 REGRESSION OF D.O.M. INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 3-6 MONTHS OF AGE.

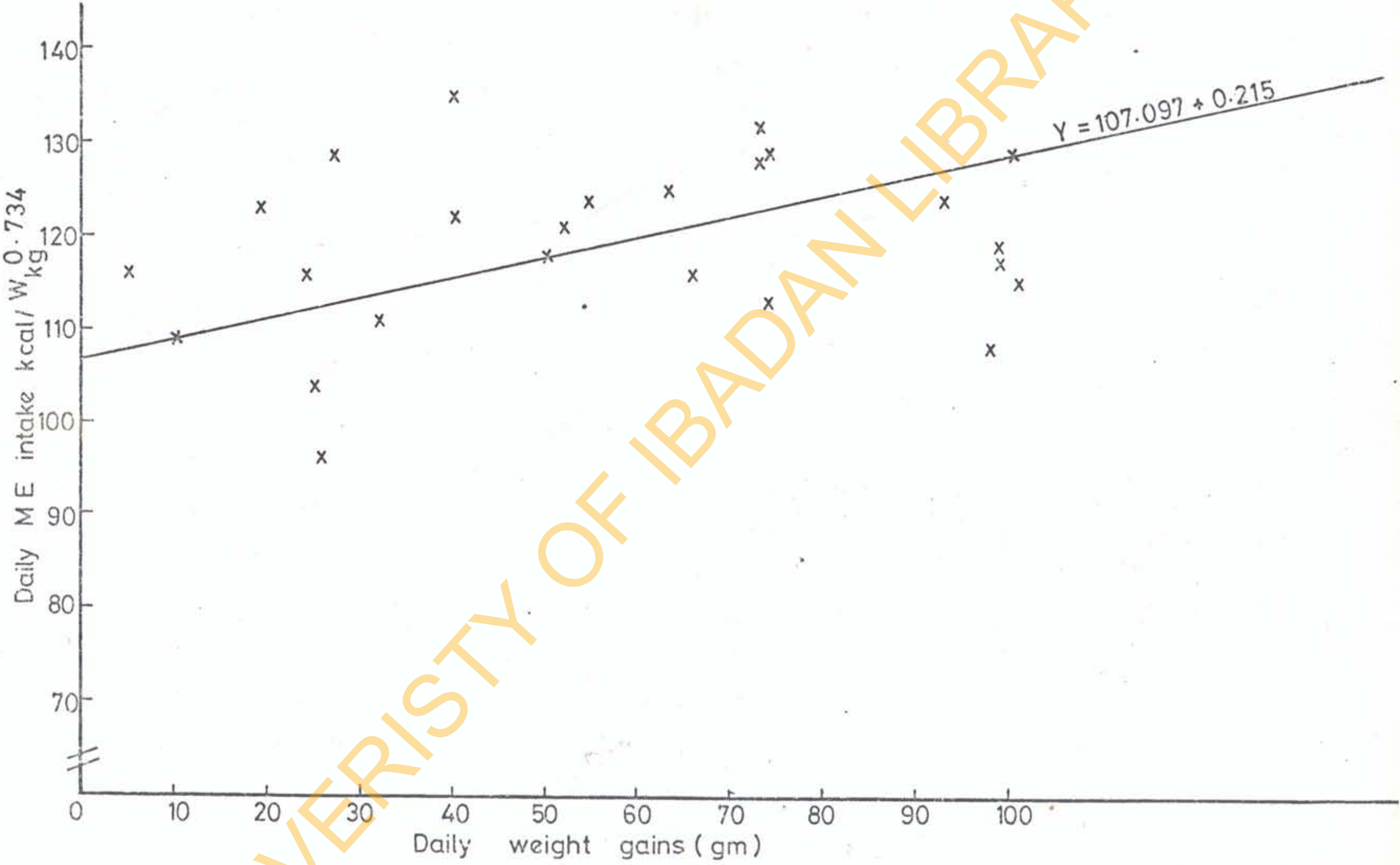

FIG. 5.4 REGRESSION OF DAILY M.E. INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 3-6 MONTHS OF AGE.

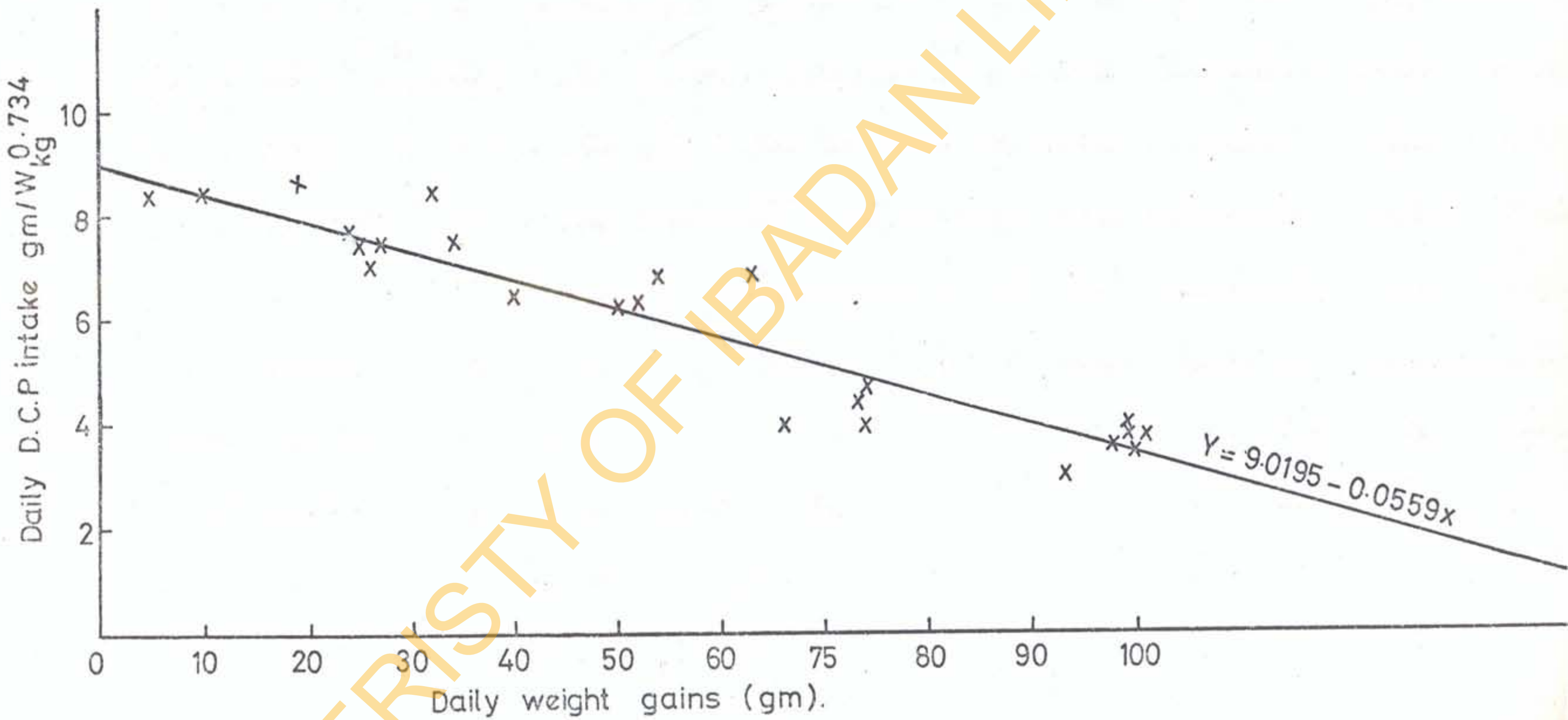

FIG.5.5 REGRESSION OF DAILY D.C.P INTAKE PER $W_{kg}^{0.734}$ ON DAILY WEIGHT GAINS FOR ANIMALS 3–6 MONTHS OF AGE.

Y = 29.0234 + 0.0686x. The correlation coefficient (r) value of 0.701±0.013 is significant ($P < 0.01$).

Therefore the maintenance requirement is 29.02g DDM/day/$W^{0.73}$kg and 68.6g DDM/day will be needed for 1 kg live-weight gain.

The regression of daily digestible organic matter intake (g/day/$W^{0.73}$kg) on daily weight gains (g/day) is illustrated in * Fig.5.3 and the regression equation Y = 24.61 +0.0508x is shown in Table 5.13. There was a significant correlation (P 0.01) with r = 0.683 ± 0.0092. The intercept of the line of fit on the Y axis (Fig 5.3) shows the estimated DOM intake when the animals hypothetically had a zero live-weight gain and this is 24.61g DOM/day/$W^{0.73}$kg which is the maintenance estimate in terms of digestible organic matter. The index of the digestible organic matter cost of 1 kg live-weight increase is 50.8g DOM/day

Digestible crude protein intake (g/day/$W^{0.73}$kg) was negatively correlated with the daily live-weight gains. The regression equation is Y = 9.0195 - 0.0559x (Fig.5.5). The correlation coefficient r = -0.942 ± 0.003 and it is significant ($P < 0.01$). The relationship is illustrated in Fig. 5.5. The figure shows that the maintenance requirement is 9.02g DCP/day/$W^{0.73}$kg and this is supposed to decrease by 55.9g/day for 1 kg increase in live-weight.

5.8 Growth Measurements

Table 5.14 indicates the mean daily weight gains and mean total increase in height at the withers, body length and heart girth.

The best mean daily weight gains of 97.74g. was from group A and there is a progressive decrease from this to 71.79 g/day; 45.71 g/day, 21.67 g/day for treatments B, C and D respectively. The differences were highly significant statistically ($P < 0.01$).

The pattern of increase in height at the withers, body length and heart girth is also similar to the above trend. Increase in height was 6.3 cm, 5.2 cm, 3.6 cm and 2.2 cm throughout the 12 weeks for groups A, B, C and D respectively. The differences are highly significant ($P < 0.01$). Groups A and B are significantly higher than groups C and D.

Length increases were 4.8 cm, 4.6 cm, 3.8 cm and 2.9 cm for groups A, B, C and D respectively. Variations in length increases were highly significant ($P < 0.01$), A and B being significantly higher than C and D and also C significantly higher than D.

The range of heart girth increases was from 2.3 cm in D to 5.7 cm in A with B and C gaining a mean of 4.7 cm and 3.9 cm respectively. Variations in energy levels have a highly significant ($P < 0.01$) effect on heart girth increase.

Table 5.14 Mean Daily Weight Gains (g) and Mean Total Gains in Height at the Withers, Body Length and Heart Girth

	Weight Gains (g)	Height (cm)	Body Length (cm)	Heart Girth (cm)
A	97.74 ± 0.0394	6.3 ± 0.482	4.8 ± 0.0304	5.7 ± 0.347
B	71.79 ± 0.455	5.0 ± 0.774	4.6 ± 0.0295	4.7 ± 0.347
C	45.71 ± 1.587	3.60 ± 0.235	3.75 ± 0.0233	3.92 ± 0.0208
D	21.67 ± 3.463	2.15 ± 0.0187	2.92 ± 0.0355	2.25 ± 0.0196
	**	**	**	**

Table 5.15 Mean percentage of joints, fat, flesh and bone expressed as percentage of cold carcass weight

	Treatment A	Treatment B	Treatment C	Treatment D	
Slaughter weight (kg)	15.98	13.89	11.66	9.23	
Cold carcass weight (kg)	7.01	5.678	4.222	3.178	NS
Dressing percentage	43.766 ± 0.478	41.362 ± 0.739	35.917 ± 2.006	34.33 ± 1.789	**
Sets	10.692 ± 0.334	12.568 ± 0.134	12.003 ± 0.416	11.643 ± 0.339	NS
Shoulders	32.322 ± 0.374	30.976 ± 0.436	31.505 ± 0.408	33.157 ± 0.750	NS
Ends	9.59 ± 0.031	10.94 ± 0.454	10.048 ± 0.339	9.998 ± 0.402	NS
Loin	14.36 ± 0.425	13.628 ± 0.225	12.23 ± 0.615	11.385 ± 0.556	*
Leg	33.658 ± 0.619	32.088 ± 0.213	34.705 ± 0.418	33.728 ± 1.265	NS
Fat	1.319 ± 0.078	0.842 ± 0.065	--	--	
Flesh	77.248 ± 0.563	74.338 ± 0.441	73.36 ± 0.745	70.472 ± 1.190	*
Bone	22.752 ± 0.563	25.662 ± 0.491	26.64 ± 0.745	29.528 ± 1.263	**

Table 5.15 (Contd.)

NS = Not significant

* = Significant at 5% level

** = Significant at 1% level.

5.9 Carcass Analysis

Table 5.15 shows the mean slaughter weight, cold carcass weight, dressing percentage and percentage joints, fat, flesh and bone expressed as percentage of cold carcass weight. Mean slaughter weights ranged from 9.23 kg in treatment D to 15.98 kg in treatment A.

Mean cold carcass was highest in treatment A with 7.01 kg. Treatments B, C and D had mean cold carcass weights of 5.68 kg, 4.22 kg, and 3.18 kg respectively.

The dressing out percentages follow the same trend as the mean slaughter weight and the cold carcass weight. The highest mean of 43.77% was obtained in treatment A while B, C and D had means of 41.36%, 35.92% and 34.33%. The differences were highly significant ($P<0.01$) with A and B significantly higher than C and D. There are no significant differences either between A and B or C and D.

Shoulder percentage ranged from 30.98% in B through 31.51% in C to 32.32% and 33.16% in A and D respectively. The differences were statistically non-significant.

The leg percentages are 32.09%, 33.66%, 33.73% and 34.71% for groups B, A, D and C respectively. The mean leg percentages were higher than the mean shoulder percentages in all the groups. The differences in the mean leg percentages show no statistical significance.

The percentage loin which decreased progressively from A to B, C and D (14.36%, 13.63%, 12.23% and 11.39% respectively) exhibited a variation which was statistically significant ($P < 0.05$).

Mean percentage sets was highest in treatment B with 12.57% and lowest in treatment A with 10.69%. Treatments C and D had means of 12.0% and 11.64% respectively.

The trend of the Ends was similar to the Sets. Treatments B, C, D and A had mean Ends percentages of 10.94%, 10.05%, 10.0% and 9.59% respectively. The differences between the mean percentages of the Sets as well as the Ends were not statistically significant.

The percentage flesh was least in group D increased progressively to A. The mean values were 77.25%, 74.34%, 73.36% and 70.47% for treatments A, B, C and D respectively. The differences were statistically significant ($P < 0.05$). A was statistically higher than B, C and D while B and C were significantly higher than D. There were no significant differences between B and C. Since the bone percentage is 100 - flesh %. The reverse of the flesh percentage is the case with bone percentage which increased progressively from A to D. The mean values were 22.75%, 25.66%, 26.64% and 29.53% for groups A, B, C and D respectively. The variations were highly significant ($P < 0.01$).

Fat percentages were very low. Only groups A and B had three animals each which have deposited fat. The mean values are 1.32% and 0.84% for groups A and B respectively.

5.10 Other Parts

The other parts of the animals considered are the skin, pluck, gut offals, feet and head. The weights are expressed as percentages of slaughter weights of the animals.

The mean percentages for the skin, pluck, and head follow the same pattern. Least figures were obtained from group A and there is a progressive increase to B, C and D.

Skin percentages were 10.55%, 11.06%, 11.33% and 12.10% for groups A, B, C and D respectively.

Groups A, B, C and D had mean pluck percentages of 4.48%, 5.02%, 5.38% and 5.62% respectively while the corresponding head percentages were 8.52%, 8.98%, 9.20% and 9.62%.

The feet showed lower means for A and B, (3.31% and 3.81% respectively) than for C and D, (4.48% and 4.21% respectively) but in this case D mean percentage was lower than C. The highest mean percentage of the gut offals was obtained from treatment C with 11.26% and the lowest was from B having 10.75%. Treatments A and D had mean values of 10.9% and 10.99% respectively. The differences in the values obtained for each of the parts considered (skin, pluck, gut offals, feet and head) were statistically non-significant.

5.11 Estimates of Shoulder, Leg and Flesh percentages

Table 5.16 shows the regression equations of shoulder, leg and flesh percentages (Y) on the live-weight at slaughter (X).

There is a negative correlation between the shoulder percentage and the slaughter weight. Regression equation is Y = 36.78 - 0.382x with a correlation coefficient (r) of -0.755±0.302 which is highly significant ($P < 0.01$) (Fig.5.6).

Leg percentage (Y) is also negatively correlated with the slaughter weight (X) with a regression equation of Y = 39.611 - 0.48x and a correlation coefficient of -0.713±0.33 highly statistically significant ($P < 0.01$) (Fig.5.7).

Flesh percentage (Y) has a positive correlation with slaughter weight (X). The equation obtained was

$$Y = 62.569 + 0.888x; \; r = 0.872 \pm 1.599.$$

The correlation coefficient is significant ($P < 0.01$) and the relationship is illustrated in Fig. 5.8).

5.12 Economic Consideration

Table 5.17 shows the average daily weight gains, feed consumption, efficiency of feed utilization and production cost data. From the average daily feed intake and the current price

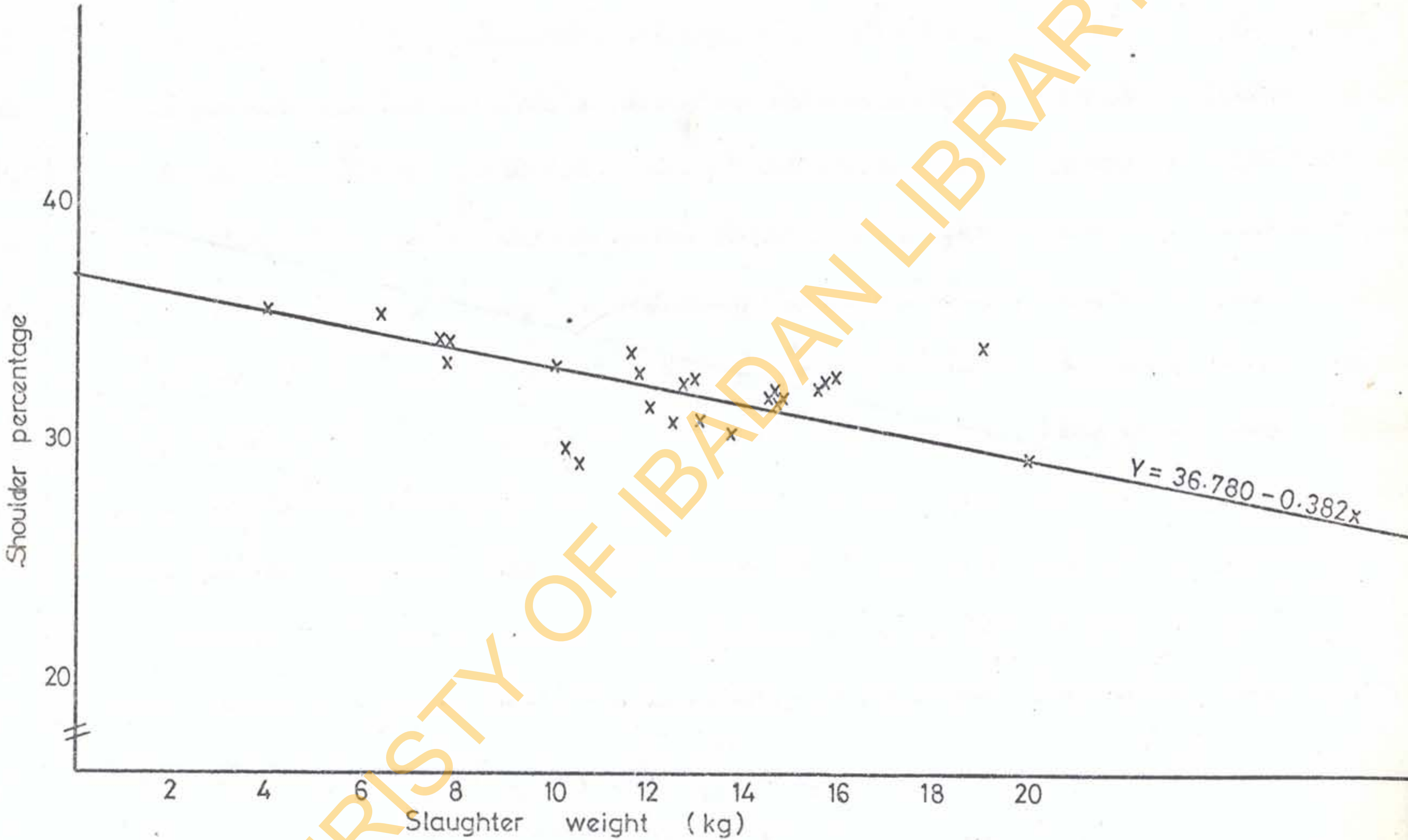

FIG.5.6 RELATIONSHIP BETWEEN SHOULDER PERCENTAGE AND THE SLAUGHTER WEIGHT.

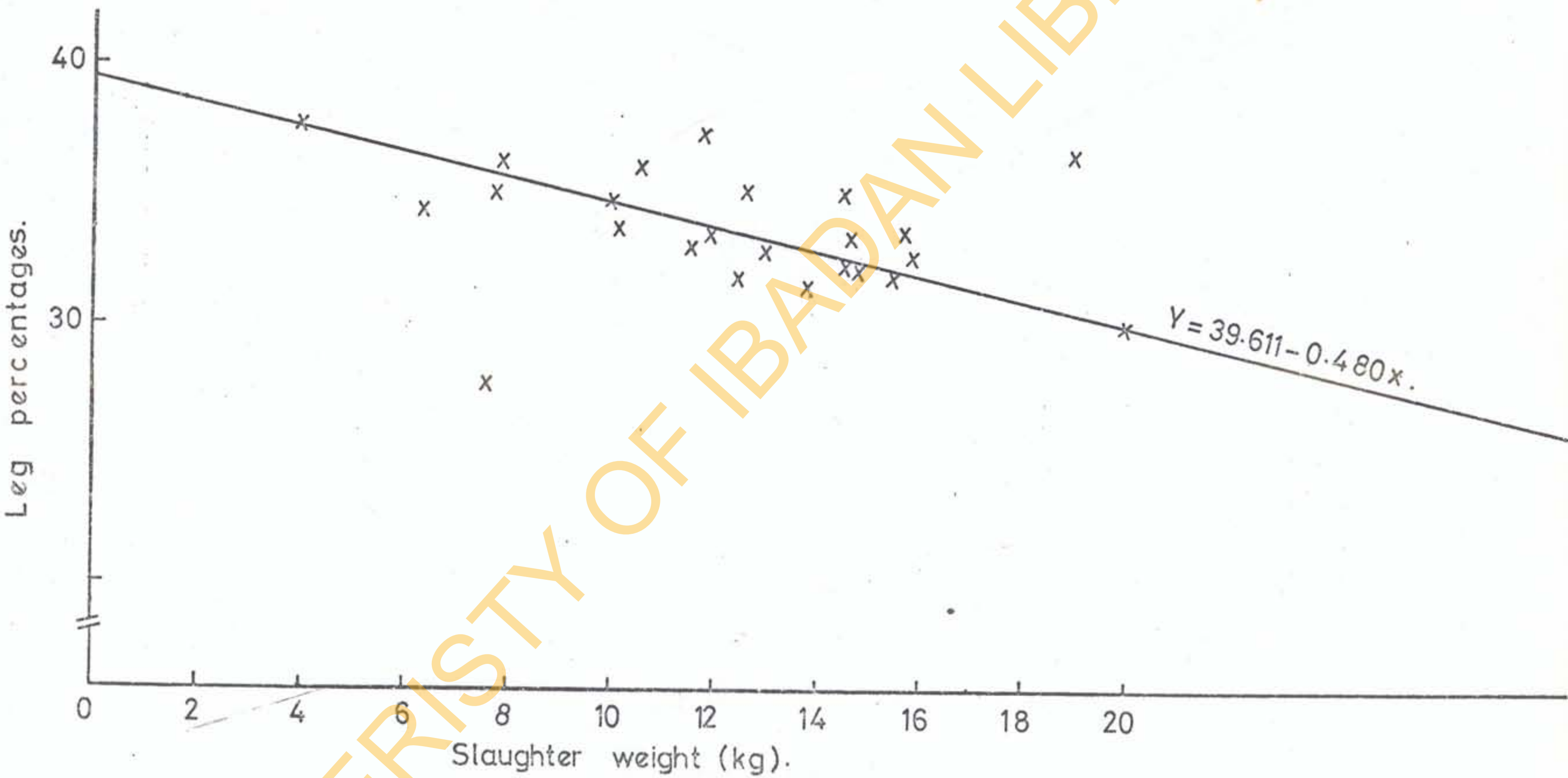

FIG. 5.7 RELATIONSHIP BETWEEN THE LEG PERCENTAGES AND THE SLAUGHTER WEIGHTS IN kg.

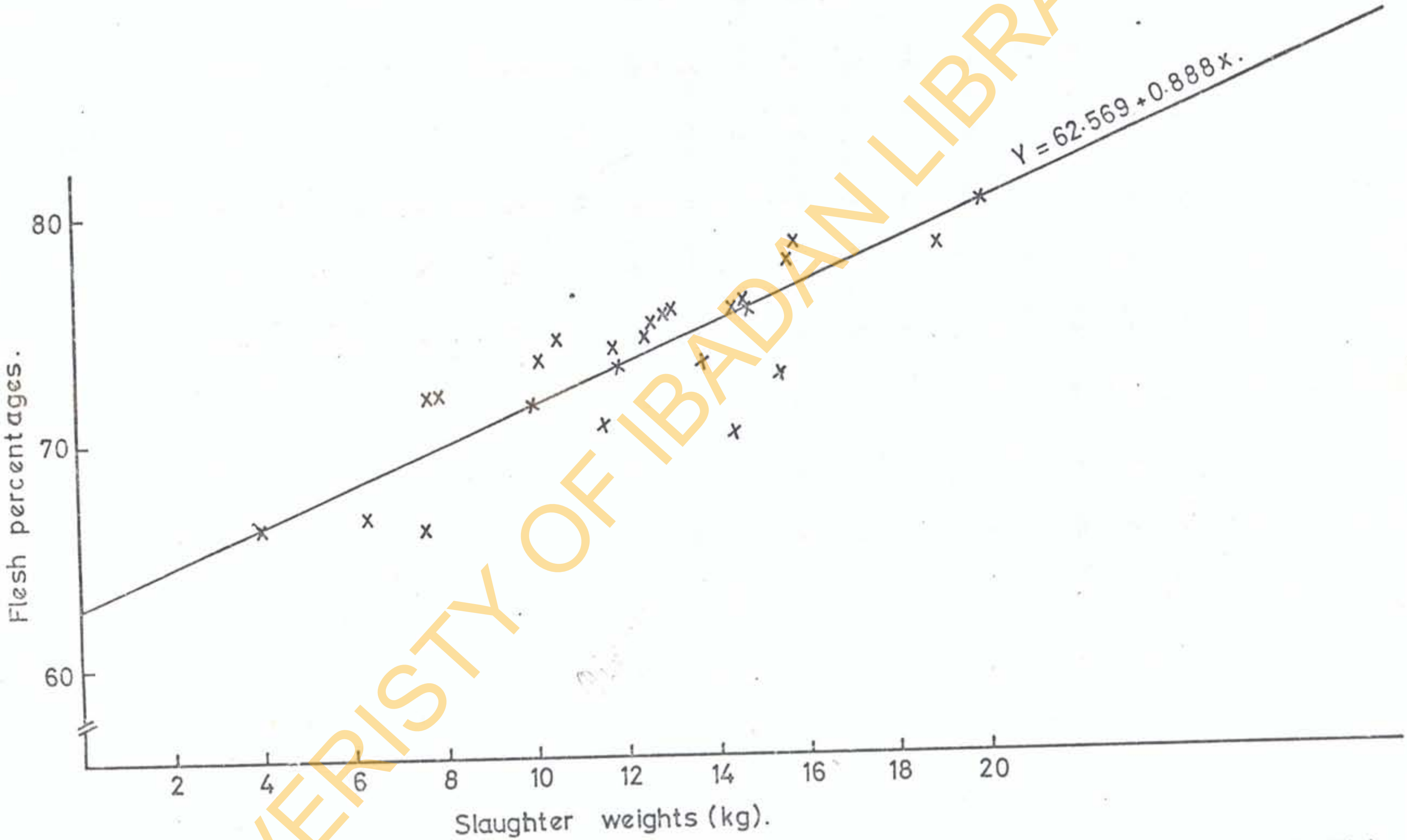

FIG. 5.8 RELATIONSHIP BETWEEN THE FLESH PERCENTAGES AND THE SLAUGHTER WEIGHT IN kg.

of ingredients at the time of the experiment, the average cost of daily feed consumed was calculated and this is highest for group A with ₦0.05 per day. There is a progressive decrease in value to B, C and D with ₦0.048, ₦0.03 and ₦0.02 respectively.

The feed/gain ratio increased from 2.62 in A to 3.37, 5.19 and 7.16 for B, C and D respectively.

Weight gains in g/100g TDN consumed was highest in A with 39.26g and decreased to 29.97g, 20.84g and 13.53g for B, C and D respectively.

The cost of production of 1 kg live-weight increased from A through B, C, D and were ₦0.54, ₦0.71 and ₦0.78 for groups A, B, C and D respectively.

Table 5.16 Mean Percentage of Pluck, Offals, Skin, Head and Feet expressed as Percentage of Live-weight at Slaughter

	Slaughter wt. (kg)	Skin	Pluck	Gut Offals	Feet	Head
A	15.98	10.55 ± 0.293	4.48 ± 0.438	10.90 ± 0.026	3.31 ± 0.369	8.518 ± 0.191
B	13.89	11.056 ± 0.141	5.02 ± 0.204	10.75 ± 0.176	3.81 ± 0.393	8.978 ± 0.379
C	11.66	11.33 ± 1.329	5.38 ± 0.713	11.26 ± 0.344	4.48 ± 0.641	9.20 ± 1.283
D	9.23	12.10 ± 0.653	5.62 ± 0.333	10.99 ± 0.474	4.21 ± 0.647	9.62 ± 0.744
		NS	NS	NS	NS	NS

NS = Not significant.

Table 5.17 Average Daily Weight Gains, Feed Consumption, Efficiency of Feed Utilization and Production Cost Data

Characteristics	A	B	C	D
Average Daily Gains (g)	99.74	71.79	45.71	21.67
Average Daily DM Feed Consumption (g)	261.2	241.9	237.1	155.1
Average Cost of Daily Feed Consumed (₦)	0.05	0.048	0.03	0.02
Feed/Gain Ratio	2.61	2.37	5.19	7.16
Weight Gains/100g TDN Consumed	39.3	29.97	20.84	13.53
Cost/kg of Live-weight Gain (₦)	0.54	0.67	0.71	0.78

DISCUSSION

The results obtained in this experiment illustrate some of the factors which influence the intake of nutrients in the early weaned lambs and the significance of the quantity of nutrient intake to the growth rate of the lambs at this very critical period of their growth.

The results have also helped in indicating various parameters for the measurement of requirements for maintenance and growth of lambs of the Nigerian Dwarf sheep.

In all the groups there were no statistical differences in the apparent digestibility coefficients of the nutrients in both the mixed diet and the concentrate supplements. This shows that the variation in the chemical composition of the basal diet and the concentrate supplement had no significant effect on the digestibilities of the rations.

It is to be noted that the digestibility trials for groups A and B, and C and D were carried out at different times of year and hence the observed differences in the chemical composition of the grass offered (Table 5.3). Trials C and D were just before the rains and grass had to be cut along the stream. Thus the dry matter and crude fibre percentages of the grass offered were slightly higher than percentages obtained for the grass fed to groups A and B, a phase which was on by the time the rains had started.

The digestibility of the basal diet could therefore be said to be slightly affected by the season and probably it also affected the chemical composition of the fodder given.

This is in agreement with the work by Greenhalgh, Corbett and McDonald (1960), who found differences in the digestibility of fodder in spring and summer. Minson and Raymond, (1958) had earlier also observed a decline in digestibility with time in spring. These general observation agrees with reports by many other earlier workers (Jarl and Helleday, 1951; Homb, in Scandinavia (1953) and Reid, Kennedy, Turk, Slack, Trimberger and Murphy, 1959). In the summer months Greenhalgh, et. al obtained a steady decline in digestibility to the tune of 0.25 units per day. The differences in digestibility referred to in this experiment could similarly be ascribed to the seasonal effects on the fodders. Increase in age of fodders is accompanied by a corresponding increase in dry matter and crude fibre and hence a decrease in digestibility.

The higher digestibility coefficients obtained for the dry matter, organic matter and nitrogen-free extracts in groups A and B could be attributed to the fact that the crude fibre percentage of these rations were lower than those for rations C and D (Table 5.3). Crude fibre percentages were 7.26, 8.62, 10.02 and 10.40 forrations A, B, C and D respectively.

One could have expected the very high percentage of crude protein in rations C and D, 24.86% and 30.33% respectively as compared with 13.44% and 15.04% for A and B respectively to be an advantage in the digestibility of these as expressed by Elliott and Topps (1963) who found a small positive association between the nitrogen content of feeds and their digestibility. The increased digestibility obtained as a result of daily intra-ruminal infusion of urea (Campling et al, 1962) is also due to the same increase in Nitrogen which directly increases the crude protein content.

It is however noteworthy that the crude protein content of all the concentrate mixtures were high enough to enhance easy digestibility of the nutrients. The crude protein content of rations A and B are quite comparable to rations of 11% to 17% (Andrews and Orskov, 1970), 12-14% by Ranhotra and Jordan (1966) and 10.0% to 11% used by Bush, Willman and Morrison (1955). It can therefore be inferred that the rations were quite adequate in crude protein.

It is quite possible that an excessive increase in percentage crude protein affected the digestibility of the rations C and D. This is indirectly inferred from the results of Hinds, Mansfield and Lewis (1964) who obtained a significant increase in performance of their experimental animals with increased crude protein from 13% to 16.2%

Further increase in dietary protein increased performance but not significantly.

Throughout the experimental period, the animals used in this experiment were given equal amount of the grass basal diet (0.5 kg/day). Intake was however low at the beginning and this increased steadily till towards the end of the experiment when daily intake was more or less stable.

Intake by groups A and B animals increased much more than those of groups C and D. It is probable that the intake has been affected by the digestibility of the rations. The basal rations for A and B were more digestible than the ones for C and D. This will also affect the rate of passage through the alimentary tract. This agrees with the reports by Campling and Balch (1961); Campling (1966) who postulated that the voluntary intake of oat straw was limited by the slow rate of disappearance of the material from the digestive tract. This observation seems contrary to the results of Blaxter, Wainman and Wilson (1961) who suggested that sheep stopped eating roughage, whatever the kind, when their digestive tracts contained regulated amount of dry matter.

The nitrogen-free extract digestibility of rations A and B were higher than C and D. One may infer therefore that the energy of these rations was more digestible and this might also explain why intake from these rations was higher than from rations C and D. This is supported by the results of Blaxter, Wainman and Wilson (1961) who reported that voluntary intake is directly related to the digestibility of energy but is in contrast to reports by Elliott and Topps (1963) who claim that voluntary intake is closely related to the nitrogen content of the food although they agree that intake also apparently increased with digestibility of the food. Since Elliott and Topps (1963) worked with protein defficient feeds, the Nitrogen content of the digesta may be the major limiting factor. This had earlier been postulated by Smith (1962), who obtained 40 - 60% increase in the intake of mature Hyperrhenia forage by cattle when additional protein or urea was given.

The higher the nutritive value of a diet offered to ruminants as judged by its apparent digestibility the more of it is consumed each day (Blaxter, 1950-1; Balch and Campling, 1962). This shows that the ruminants do not regulate their feed intake according to their energy needs but in proportion to the distention which the feed exerts in their reticulo-rumen.

It is also observed in this trial that the animals on the high energy level concentrate mixtures had a significantly higher ($P < 0.01$) intake of dry matter than their counterparts on the low energy level rations. This agrees with reports by Blaxter, Wainman and Wilson (1961) that the amount of feed taken by ruminants measured in terms of dry matter increases with increasing concentration of the ration in terms of Net energy per kg dry matter.

The higher consumption of the higher quality and more digestible rations A and B might also be due to an attempt to keep the amount of non-digestible organic matter or "ballast" constant. This agrees with suggestion by Lehmann (1941) in favour of the constancy of ballast but he was criticized by Crasemann (1955) who stated that satiety of nutrients and energy is more important as a factor of feed intake than ballast. Crasemann's contention might be wrong however since it was based on work with pigs and rabbits rather than with ruminants.

Crampton (1957) affirmed the general truth that the quality of the food offered ruminants is an important factor governing voluntary consumption. Blaxter, Graham and Wainman (1956) had suggested that the mechanism concerned is purely one of digestive tract distension which again is a function of digestibility of the food.

Conrad, Pratt and Hibbs (1964) postulated that physical and physiological factors regulating feed intake, change in importance with increasing digestibility. At low digestibility they are: body weight, reflecting roughage capacity; undigested residue per unit body weight per day, reflecting rate of passage and dry matter digestibility. At higher digestibilities, they claimed that intake appeared to be dependent on metabolic size, production and digestibility. Results of this experiment seem to support this view in that the differences between the mean dry matter intake when expressed per unit metabolic size was not significant (cf. DM intake/g/day, highly significant - $P < 0.01$).

Since the rations were highly digestible (Tables 5.5 - 5.7) the intake of digestible nutrient in g/day was dependent on the dry matter intake in g/day. Intake of digestible dry matter, digestible organic matter and metabolizable energy followed the same trend as the dry matter intake and the differences in the mean values were highly significant ($P < 0.01$). When these values were expressed in g/day/$W^{0.73}$kg the differences were only significant ($P < 0.05$). This still shows that intake of nutrients at high digestibility is dependent on metabolic body size.

The mean dry matter intake in g/day/$W^{0.73}$kg (Table 5.12) is lower than figures obtained for the exotic breeds in literature (Palsson and Verges, 1952; Elliott and Topps (1963b) and other workers). Since the tropical animals need less nutrients for maintenance it is to be expected that intake of dry matter by tropical animals will be lower than the intake for the temperate breeds of animals under temperate conditions.

Digestible crude protein intake seems to decrease as the energy level of the ration increases. This is due to the fact that all animals were expected to consume equal amount of digestible crude protein per day. The daily ration offered each animal contains the standard amount of digestible crude protein recommended by the U.K., ARC (1965). To vary the energy level, the amount of feeds offered had to vary as shown in Table 5.2, the animals were offered 439g, 347g, 270.6g and 175g feed in groups A, B, C and D respectively. Since these various amounts of feeds contain same amount of digestible crude protein, it means that the dilution of this nutrient in the feeds increases with increasing levels of energy. This also accounts for the decreased amount consumed by animals on the higher energy level rations.

Maintenance requirements have been expressed in terms of feeding standards such as Total digestible nutrients, metabolizable energy, digestible energy and digestible organic matter. Attempts have been made to show the relationships between some of these standards and the daily weight gains of the animals (Fig. 5.1 - Fig.5.5).

An estimate of 48.104 g DM/day/$W^{0.73}$kg was obtained for maintenance by a regression of dry matter intake on changes in live-weight. This value and the value of 29.023 g DDM/day/$W^{0.73}$kg appear to be very low compared with estimates in the literature. However, the estimate of 107.1 kcal ME/day/$W^{0.73}$kg obtained for maintenance from a regression of metabolizable energy intake per unit metabolic size on changes in live-weight is comparable to 100 kcal ME/day/$W^{0.73}$kg for non lactating cows (Moe, Tyrrell and Flat, 1970) using energy balance trials, slightly lower than 112 kcal ME/day/$W^{0.73}$kg for sheep recommended by ARC, 1965 and NRC (1968).

Recently, Akinsoyinu (1974) recommended an estimated value of 99.8 kcal ME/day/$W^{0.73}$kg for the Nigerian Dwarf goat. The fasting energy metabolism of a 20 kg sheep is 65 kcal/day/$W^{0.73}$kg, (Brody, 1945) and if this value is multiplied by 1.36 (Blaxter, 1962) a requirement of 88.4 kcal/day/$W^{0.73}$kg is obtained for maintenance. These values are not very much lower than the 107.09 kcal/day/$W^{0.73}$kg obtained in this studies. Results of Rattrary, Garrett, Hainman and East (1974) suggest that the maintenance requirement for cattle and sheep ranged from 88 - 124 kcal ME/day/$W^{0.73}$kg. From the low standard error of the mean values obtained in this trial it is reasonable to suggest that 107 kcal ME/day/$W^{0.73}$kg is required by 20 kg Nigerian Dwarf sheep for maintenance.

The energy cost of live-weight gain obtained in this studies is 215 kcal ME/day/$W^{0.73}$kg per kg. This means that a sheep of 20 kg live-weight would require 1938.01 kcal/ME/day above maintenance level in order to put on 1 kg live-weight. The energy estimate from the formula of Garrett, Meyer and Lofgreen (1959) which is the basis of ARC (1965) and NRC (1968) recommendations for a 20 kg sheep is 6333.6 kcal ME/day/kg live-weight gain. The value recommended by Akinsoyinu (1974) is 5142.6 kcal ME. The value obtained in the present studies is 30.6% of ARC (1965) value and 37.69% of Akinsoyinu's (1974) recommendations. Both studies were carried out with adult animals. Younger and fast growing animals as used in the present studies would need less energy to put up 1 kg live-weight gain. The low daily feed intake of the animals in this studies as compared to figures of intake of the two earlier workers probably also accounts for the low value obtained.

Estimate obtained in these studies for the digestible organic matter requirement for maintenance is 24.61 g/day/$W^{0.74}$kg. This value is quite comparable to 22.66 g/day/$W^{0.73}$kg (0.82 lb DOM/day for a 100 lb penned sheep) recommended by Langlands _et al_, 1963. It is however lower than 28.19 g/DOM/day/$W^{0.73}$kg (1.02 lb DOM/day for a 100 lb grazing sheep) put forward by Langlands et al, (1963). These seem to point out that the maintenance requirement of the Nigerian Dwarf sheep between 3 - 6 months of age is slightly higher than that of the exotic breed used by Langlands _et al_, (1963)

Opinions are divided as to the effect of frequency of feeding on feed intake. This study has however shown that increasing the frequencies of feeding two to three times increases intake but not significantly.

This result agrees with the results of Freer and Campling (1962); Dawson and Kopland (1949); Campbelland Merilan (1961) who all observed increased feed intake in cows when frequency of feeding was increased. It is however contradictory to the results of Blaxter, Wainman and Wilson (1961) who found that intake of hay was not influenced by increased frequency of feeding.

Following the work by Brobeck, (1955) who stated that the average intake depends on how often the animals eat, it could be suggested that an increase in the frequency of feeding from 2 times daily to 3 times a day will be a means of increasing the voluntary feed intake of the Nigerian Dwarf sheep.

It is possible however that the effect of increasing frequency of feeding may not show much in a breed of animals that normally consume high amount of feeds such as the exotic breeds. The Nigerian Dwarf breed has been shown to be defficient in feed consumption and therefore increasing the frequency of feeding may be a way of increasing their feed intake.

Results of this study show that growth of the animals, as depicted by measurements of daily weight gains, height at the withers, body length and heart girth, is affected by variations in energy levels of the diets. The high energy level rations appear to have offered better performance. This seems to agree with results of many workers with the exotic breeds of sheep (Palsson and Verges, 1939, 1952). It is however contradictory to the results of Awoyemi, (1962) and Adebambo, (1970) both of which support a lower energy level diet. It is quite probable however that, for younger, fast growing animals as used in this work, higher energy level rations may favour faster weight gains. Awoyemi (1962) and Adebambo (1970) used older animals.

The mean daily weight gains of 97.74g, 71.79g, 45.71g for groups A, B and C respectively are higher than 31g obtained for the same breed between 3 and 24 months of age (Dettmers and Loosli, 1974). Since the rate of weight gains decrease with increasing age, it is probable that higher figures could have been obtained by Dettmers and Loosli (1974) if they only considered the weight gains of animals between the age of 3 and 6 months. This increased value is however not likely to be as high as the group B value of 71.79 g/day. It is quite clear that the animals in this study performed better than the animals considered by these earlier workers. Improvement might be due to both the system of management and the diet fed. While the system in this study was intensive the results of Dettmers and Loosli (1974) were obtained from data collected from the animals under a semi-intensive general management system on the University of Ibadan, Teaching and Research Farm.

The effect of the rations is borne out by the weight gains of the animals which decrease as the levels of energy decreased. The group D animals on the 50% energy level ration gained a mean of 21.67 g/day while none of the group E animals on zero supplementation survived.

The initial live weights of the animals was lower than the suggested range for their age but by the end of the experiment the mean live-weight of 15.98 kg, 13.89 kg, 11.66 kg and 9.23 kg for groups A, B, C and D were well in the range of 10.9 - 14.07 kg. (24 - 31 lb), given for the breed by Okereke (1958).

The better animal performance in groups A and B in this study would probably be due to the increased feed intake due to the increased frequency of feeding in agreement with Gordon and Tribe (1952), Thomas and Mochrie (1956), Hardison et al,(1957), Mohrman et al (1959), Rakes et al (1961) and Dawson and Kopland (1949) or to the intensive method of management adopted and the high level of energy in the rations.

Considering the carcass grades according to yield as given by Ensminger (1969) the animals in this trial will be regarded as culls. Using the same standard, Dettmers and Loosli (1974) graded the adult Nigerian Dwarf sheep as "barely utility". It is however to be noted that the animals in this trial had not reached the accepted slaughter age and weight. Dressing percentage (yield %) increases with increasing size and age of the animal provided the animal is still growing. One can thus regard the yield of 41.4% and 43.8% for groups A and B respectively as being quite good at 6 months of age. These values are higher than 38% obtained for the breed by Okereke (1958), they are comparable to values of 42.5% (Dettmers and Loosli, 1974) and 43.48% - 49.17% (Adebambo, 1970) although animals used in all these cases are quite older and bigger than animals slaughtered in this trial.

The concept of meat quality varies from country to country and even from market to market in the same country. There is no set standards for meat quality in Nigeria. Sheep is usually obtained live and the price paid depends on physical and visual assessment of the animal. It is only in the Super markets and Government stations that mutton is sold by weight. In the local markets the price to be paid depends on the amount of flesh in the required part of the animal. This is by visual assessment. It is therefore essential to have a high percentage of flesh in the carcass.

The leg and shoulder account for the greater part of the carcass. In the present experiment both joints account for between 65% and 67% of the carcass. These are relatively later maturing parts and are expected to increase in size up to maturity.

Since these are the fleshy parts, the price that can be obtained for a carcass could be said to depend on the percentage of these two parts. From the regression of shoulder and leg percentages on the live-weight of the animals, it may be possible to obtain an estimate of the weights of these joints at various live weights of the dwarf sheep. Percentage leg and shoulder are both negatively correlated with live-weight. Figures obtained show that shoulder percentage at birth is about 36.8% and decreases by 0.382% for every kg. increase in live weight (Fig.5.6). The leg percentage at birth is estimated to be about 39.6% decreasing by 0.48% for every kg increase in live-weight (Fig.5.7).

Another important factor contributing to quality in meat is the proportional development of fat, muscle and bone in the carcass. For the Nigerian Dwarf sheep, fat is not very important since the animals lay down little or no subcutaneous fat and very little abdominal and pelvic fat especially at the age considered. The percentage flesh is therefore the most important factor. This is significantly ($P<0.05$) affected by the level of nutrition. The higher the energy level in the feed the higher the percentage flesh. Since market prices in Nigeria appear to depend on a visual assessment of the flesh percentage this could also be used as an index for estimating price obtainable from a sheep of known live weight. Flesh percentage has been shown to be highly possitively correlated to the live weight with a correlation coefficient of 0.872±1.599. Thus at birth the flesh percent is estimated as 62.57% increasing by 0.89% for every kg increase in live weight (Fig.5.8).

In Nigeria, the pluck, offals, skin, head and feet are consumed along with the other parts of the animals. The hair is normally removed with hot water or by burning before jointing. The moslems however remove the skin which they dry and later use for prayers. Considerations therefore, has to be given to these parts. Variations in energy levels have no significant effect on the percentages of these parts (Table 5.14). The table also shows the mean slaughter weights of the animals. Since all these parts are relatively early maturing (with the exception of the skin which increased with the size of the animals) there is little increase in the size and weights due to age. Therefore level of nutrition has little effect on the weight of these parts. The trend observed in the percentages in which there is a progressive decrease with increasing level of energy is due to the higher slaughter weights of the animals on the higher planes of nutrition. Since these animals are bigger, it appears as if the percentages of these parts expressed as percentages of the slaughter weights is smaller than those on the lower energy levels.

Considering the profitability of feeding the various energy levels for growth, Table 5.16 clearly shows that the average cost of daily feed consumed decreases with a decrease in energy levels because a high energy level ration is more expensive to compound due to the high cost of grains. When the efficiency of feed utilization, and cost/kg of live weight gain are considered, it appears that high energy level rations are best used for the Nigerian Dwarf sheep between weaning and 6 months of age since those on the high energy level rations have the lowest feed/gain ratio, the highest weight gains in g/100g TDN consumed and the least cost/kg live weight gain.

CHAPTER SIX

Studies on the Effect of Age of Animals on the Production Performance of the Nigerian Dwarf Sheep fed Rations of varying Energy Levels.

6.1 Introduction

The young lamb, like the adult ruminant has a stomach of four parts at birth, although only the abomasum or fourth stomach, with a capacity about twice that of the other compartments, is functional. The reticulorumen, although non-functional, has an inherent capacity of about 2 litres at birth. (Warner, Flatt and Loosli, 1956). In the adult ruminant however, only 8% of the total capacity is in the abomasum whereas the volume of the rumen represents 80% of the total.

It therefore follows that digestion in the lamb which is essentially enzymatic at birth, as in the monogastrics, changes to the fully ruminant type as the rumen develops.

The age at which the transition to the ruminant method of digestion occurs is largely dependent on the diet a calf receives. The longer the period that a calf has acces to plentiful supply of milk the less will be its urge to supplement its diets with other foods and hence the slower the rumen development.

Opinions are divided as to the age at which lambs change to the ruminant system of digestion. Many workers have suggested that digestion in the lamb at 3 weeks is comparable to that of the adult ruminant. (Bryant, Small, Bonma and Robinson 1958;

Lengemann and Allen, 1959; Maller and Walker, 1961). Rumination has been observed in lambs of 2 weeks of age, (Schalk and Amadon, 1928; Swanson and Harris, 1958), since the young lamb will normally start to eat solid food when it is between 2 and 3 weeks of age (Walker and Walker, 1961). It is however generally accepted that maximum development of the rumen is attained at maturity and hence maximum ruminant activities are attained at this stage.

It therefore follows that, at least, till the matured stage is attained, digestion could be affected by the age of the animal. The age of the animal could also affect the feed intake and the efficiency of feed utilization which could be measured from the productivity of the animal.

The rate of growth and development of the animal depends on the amount of nutrient available to supply the needs of the body for maintenance and production. This also depends on the digestibility capacity of the animal, which, before maturity may depend on the age of the animal and the stage of development of the digestive tract.

It is definite that the performance of the lamb depends on and is influenced by its age and stage of development.

This chapter is therefore intended to show to what extent the production performance of the Nigerian Dwarf sheep has been affected by the age of the animals when fed rations of varying energy levels.

6.2 Results

6.2.1 Source of data

The data collected on animals in experiments I and II reported in Chapters 4 and 5 respectively were used in this exercise.

The parameters considered include:

i) The digestibility coefficients of the nutrients in both the basal diet and concentrate supplements

ii) Daily feed and nutrient intake

iii) Growth studies in which the weight gain per day and growth curves for ages 3 - 6 months, 6 - 9 months and hence 3 - 9 months were plotted

iv) Metabolized energy requirements for maintenance and growth obtained by the regression of the pooled M.E. intake/day/ $W^{0.734}$kg on the daily weight gains of all the animals

v) Carcass analysis studies involving the dressing out percentages, the percentage leg, shoulder, flesh and fat in the carcasses.

6.2.2 Digestibility Studies

Comparison of the mean values of the apparent digestibility coefficients of the nutrients in the diets fed to animals in

Chapter 4 (6 - 9 months of age and Tables 4.5; 4.6 and 4.7 with values for Chapter 5 (3 - 6 months of age; Tables 5.5; 5.6 and 5.7) shows that the coefficients obtained for all diets and all nutrients in Chapter 4 were higher than the corresponding values obtained in Chapter 5. The Tables show that the effects due to variations in the type of ration, as shown by the lack of statistical significance for most of the nutrients in the tables, except for C.P; C.F. and NFE in Table 4.7, is less marked than the effects on digestibility due to age. Crude fibre digestibility coefficient obtained for the basal diet was about 68.04% for the older animals while the corresponding values for the younger animals ranged between 53.11% and 55.13%. Values for the mixed diet and concentrate supplement in Chapter 4 (Tables 4.5 and 4.7) ranged between 68.33% to 87.45% and 71.28% to 79.46% respectively while the corresponding values for the younger animals of Chapter 5 were in the range of 58.02% to 60.59% and 63.80% to 65.02% for the mixed diet and concentrate supplements respectively. The pattern for the other nutrients is similar to this.

6.2.3 Feed and Nutrient Intake

Dry matter intake (g/head) from the grass basal diet, by animals in Chapter 5 (Table 5.8) on the high energy level rations A and B (125% and 100% energy level respectively) is comparable with the virtually regular DM intake by animals in all the treatments in Chapter 4 (Table 4.8). The older animals (Chapter 4) consumed mean dry values of 138.17g, 137.49g, 136.81g and 139.34g for treatments A, B, C and D respectively while the younger animals of Chapter 5 had a mean Dry intake of 141.07g and 136.35g for treatments A and B respectively and lower means of 117.20g and 104.29g for treatments C and D respectively.

Considerable disparity in intake of DM from the concentrate supplements exist between the younger animals and the older ones. Table 4.8 and Table 5.8 respectively). Mean daily intakes/head in Chapter 5 were 33.97%, 35.72%, 39.25% and 33.79% of the corresponding values in Chapter 4 for treatments A, B, C, and D respectively.

The total DM intake in g/head/day from both basal and concentrate rations for the younger animals used in experiment II was 44.35%, 46.43%, 47.82% and 43.33% of the corresponding values in Treatments A, B, C and D respectively of the animals in experiment I. Expressing the values in both experiments as DM intake per unit metabolic size (Tables 4.9 and 5.10) brought them closer and the percentages increased to 55.82%, 67.49%, 78.96% and 81.91% for treatments A, B, C and D respectively.

Intake of digestible nutrients followed the same trend as expressed above for the DM intake.

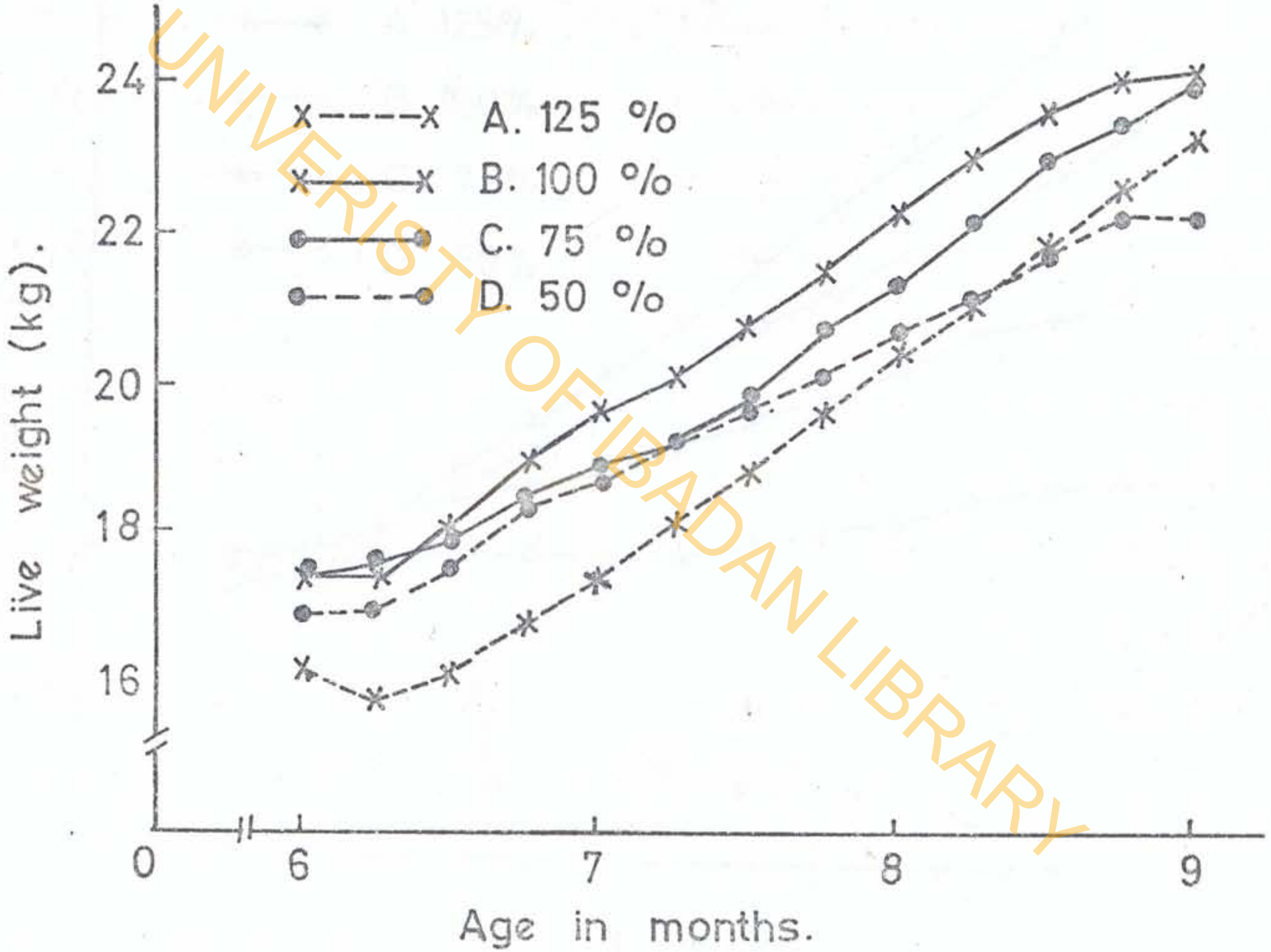

FIG. 6.1 GROWTH CURVE FOR ANIMALS 6 - 9 MONTHS.

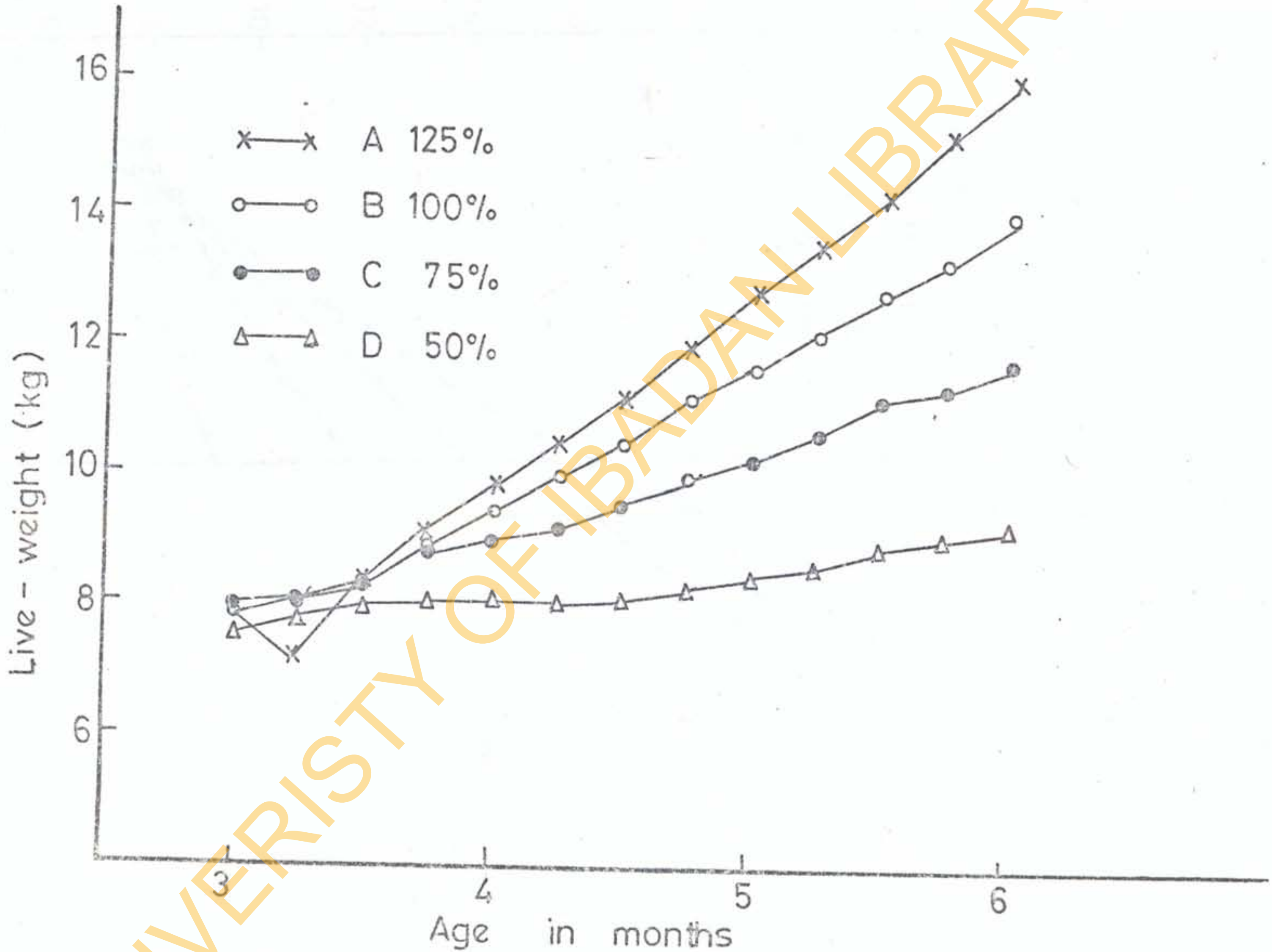

FIG. 6.2 GROWTH CURVE FOR ANIMALS 3-6 MONTHS

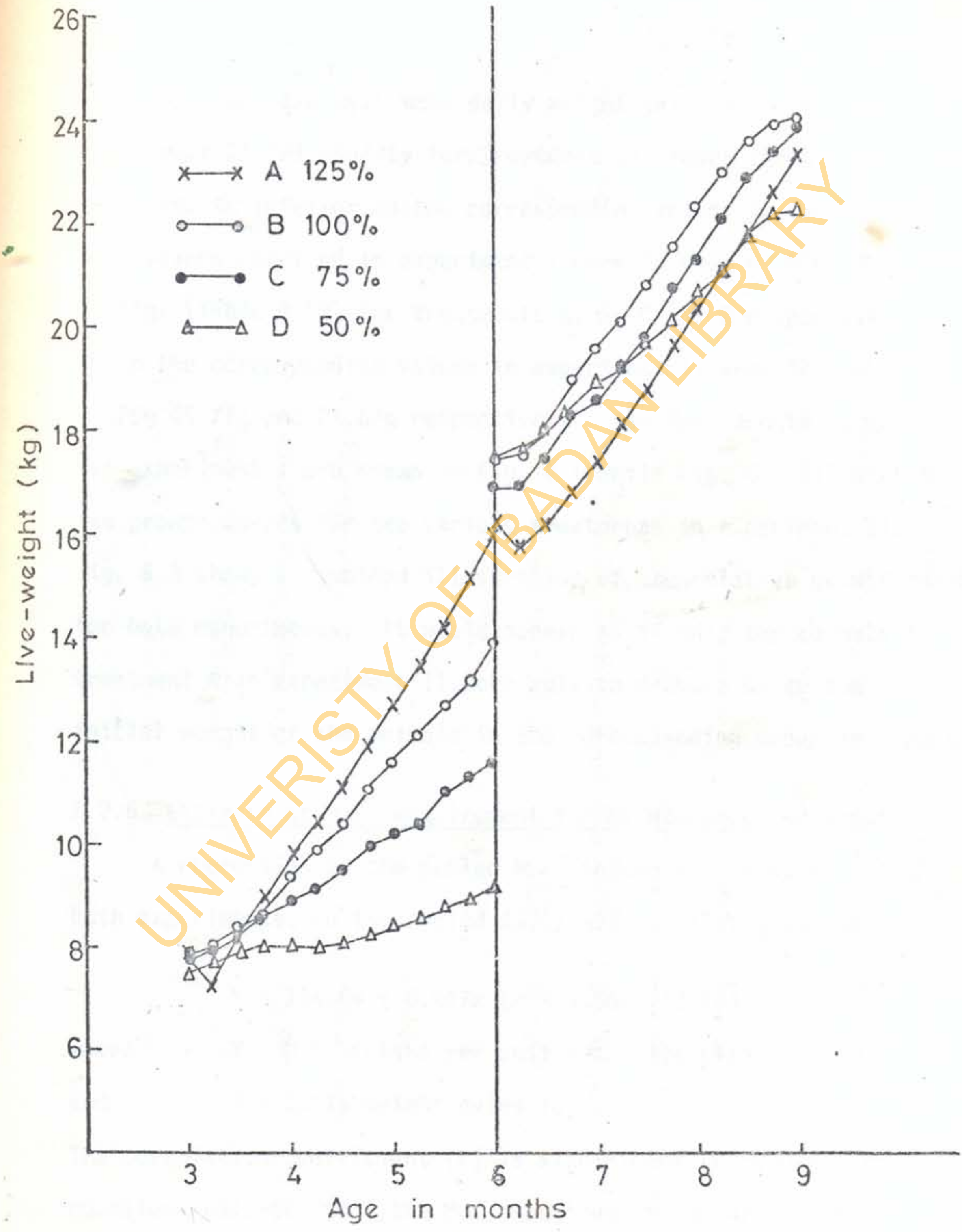

FIG. 6.3 COMBINED GROWTH CURVE 3-9 MONTHS

6.2.4 Growth Studies

Although the best mean daily weight gains was obtained in experiment II (97.74g/day for Treatment A), lower energy levels gave results inferior to the corresponding values in experiment I. Thus values obtained in experiment I were 79.64g, 83.81g, 82.21g and 55.71g. (Table 4.10) for treatments A, B, C and D respectively while the corresponding values in experiment II were 97.74g, 71.79g 45.71g and 21.67g respectively. The four growth curves for experiment I are shown in Fig. 6.1 while Fig. 6.2 illustrates the growth curves for the various treatments in experiment II. Fig. 6.3 shows a combined illustration of the relative growth curves for both experiments. It would appear as if only the animals of treatment A in experiment II were able to measure up to the initial weight of the animals in the corresponding group in experiment I

6.2.5 Estimate of M.E. Requirement for Maintenance and Growth

A regression of the pooled M.E. intake (kcal/day/$W^{0.734}$kg) for both experiments, on the pooled daily weight gains gave the equation:

$$Y = 134.04 + 0.647x \ (r = 0.504 \pm 0.154$$

where Y = M.E. intake per unit metabolic size

and X = Daily weight gains (g)

The correlation coefficient (r) is significant (P 0.05). The equation indicates that the M.E. requirement for maintenance

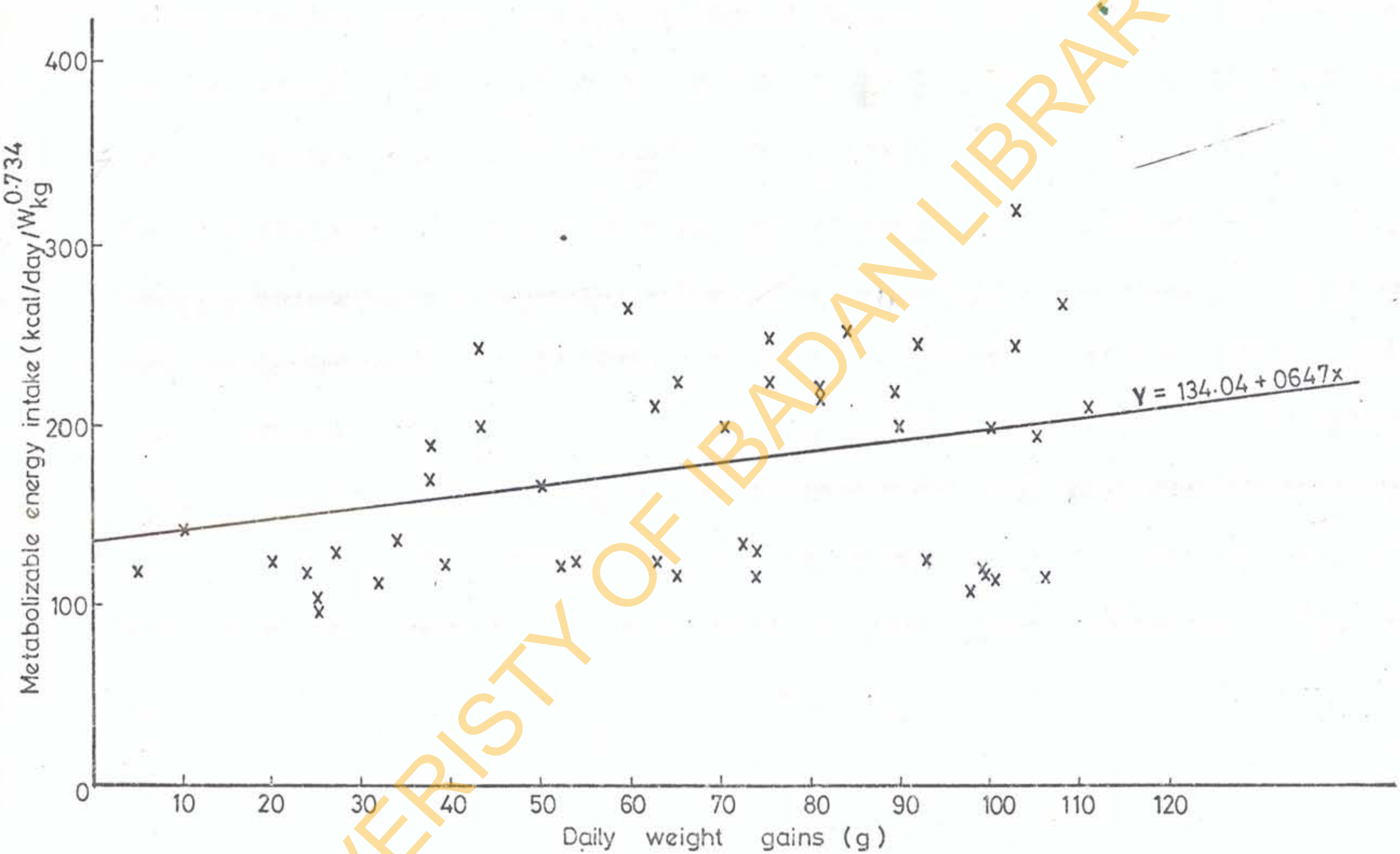

FIG.6.4 RELATIONSHIP BETWEEN (Y) M E INTAKE (kcal/day/$W_{kg}^{0.734}$ AND (X) DAILY WEIGHT GAINS

is 134.04 kcal/day/$W^{0.734}$kg while the energy cost for 1 kg. live-weight gain is 647 kcal ME/day/$W^{0.734}$kg. This is equivalent to 6339.95 kcal/day for an animal of 20kg live-weight. The relationship is illustrated in Fig. 6.4.

6.2.6 Studies of Carcass Evaluation

Results obtained in both experiments (Table 4.13 and Table 5.13) show that the mean values of dressing percentage for the animals in experiment II which was 43.77%, 41.36%, 35.92% and 34.33% for treatments A. B, C and D respectively were lower than values for corresponding treatments obtained in experiment I (52.82%; 49.70%; 60.77% and 52.45% for treatments A, B, C and D respectively).

The percentage flesh in the carcass was also lower in experiment II than in I. The range of flesh percentage was 70.47 to 77.25 for experiment II while it ranged from 80.66% to 82.89% in experiment I . Fig. 6.5 and Fig. 6.6 present an illustration of the carcass composition at 9 and 6 months respectively, (at the end of experiment I and II respectively), in which the percentage Fat, Bone and Flesh are clearly indicated for each treatment. The histograms show that fat deposition is more in the older animals than the younger ones, percentage of bone in the carcass was higher in the younger animals than in the older ones while flesh percentage is superior in the older than the younger animals.

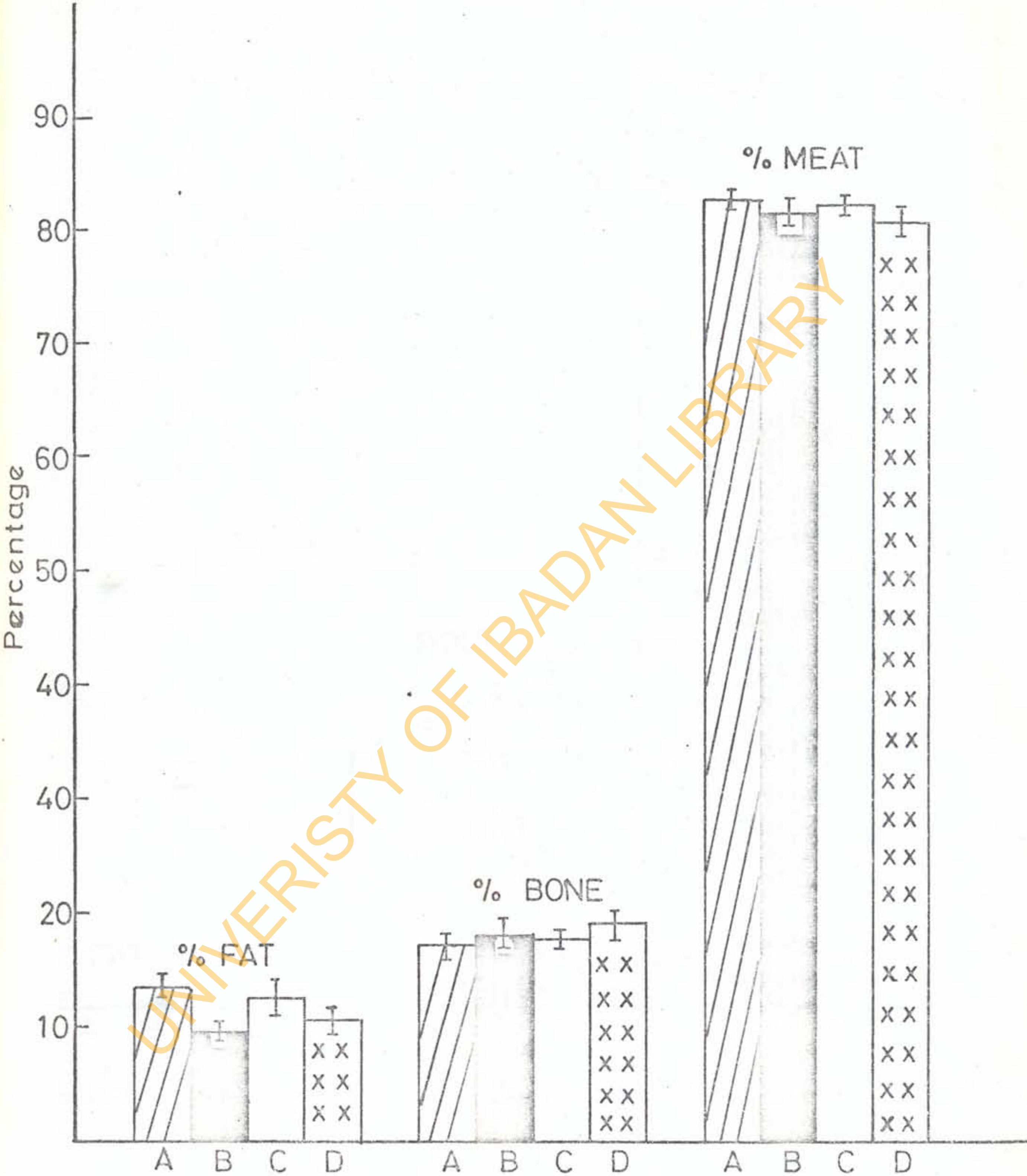

FIG.6.5 HISTOGRAM OF CARCASS COMPOSITION AT 9 MONTHS

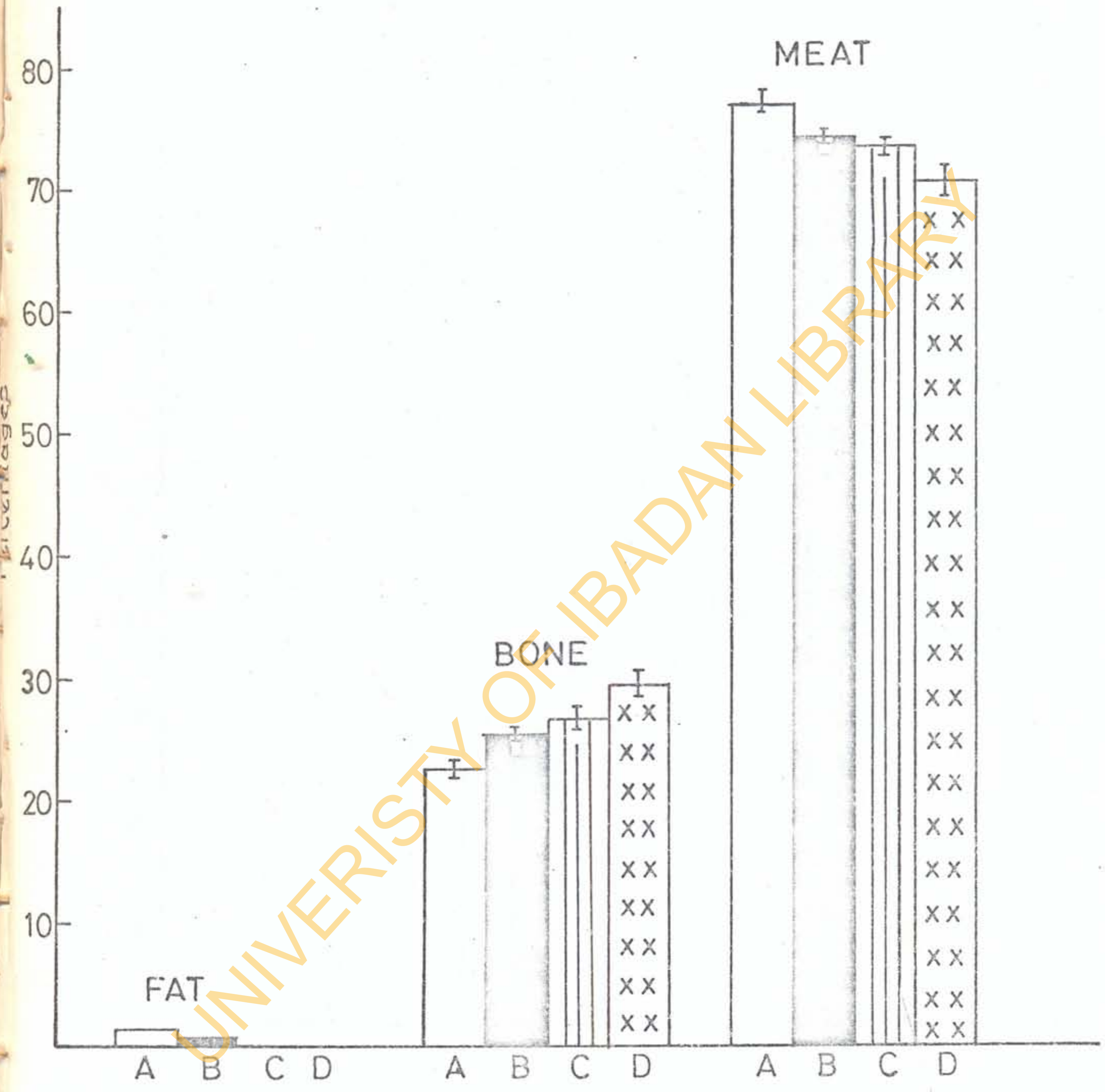

FIG.6.6 HISTOGRAM OF CARCASS COMPOSITION AT 6 MONTHS

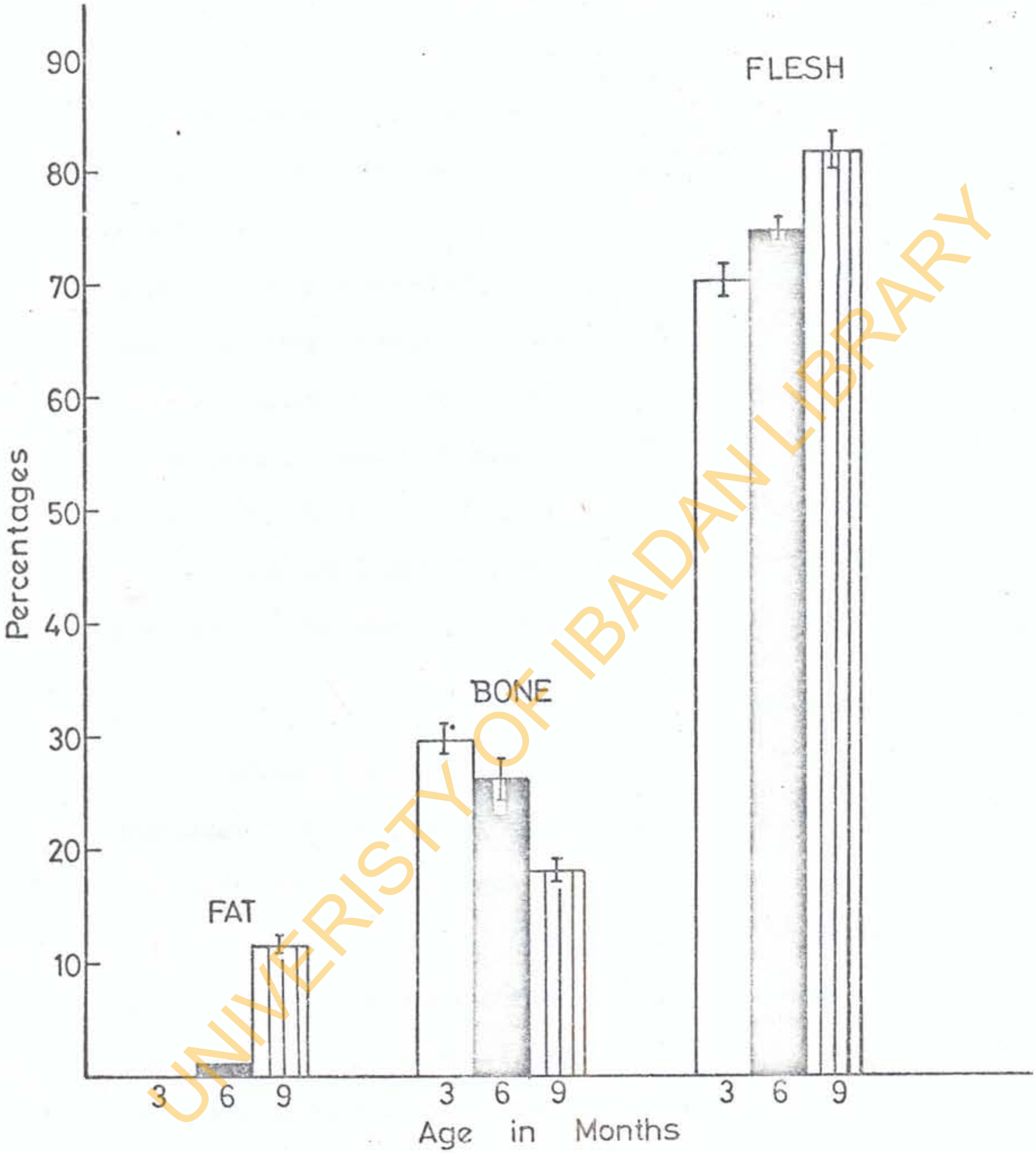

FIG. 6·7 VARIATION IN FAT FLESH AND BONE RATIONS WITH AGE (3–9 Months)

The two major joints, shoulder and leg attained higher percentages in experiment II than in I. Shoulder percentages were 29.69, 32.56, 29.88 and 32.66 for treatments A, B, C and D respectively of experiment I while the corresponding values for same treatments in experiment II were 32,32, 30.98, 31.51 and 33.16 respectively. The leg was 29.99%; 30.76%, 31.24% and 30.40% of the cold carcass in treatments A, B, C and D of experiment I while it was 33.66%, 32.09%, 34.71% and 33.73% of the cold carcass in corresponding treatments in experiment II. Similar trends are observed for the percentages of head, feet and gut offals.

6.2.7 Efficiency of Feed Utilization and Production Cost

A comparison of data presented in Table 4.15 and Table 5.16 indicates that the younger animals used in Chapter 5 were more efficient and cost much less in terms of feed. The average daily feed cost per animal ranged from ₦0.02 in Group D to ₦0.05 in Group A in Chapter 5 while the corresponding range obtained for the older animals was ₦0.07 to ₦0.13 in groups D and A respectively. In both experiments the higher energy level rations cost more to feed.

The Feed/weight gain ratios obtained for the young animals were much less than figures obtained for the older ones. Values were 9.65, 8.08, 6.48, 8.24 for groups A, B, C and D respectively in experiment I while the corresponding values in experiment II were 2.62, 3.37, 5.19 and 7.158. It is to be noted that while the values obtained in experiment II were inversely proportional to the energy levels of the rations, group C had the lowest value in experiment I.

The higher efficiency of the younger animals could be shown more vividly by a consideration of the weight gains in g/100g. TDN consumed. Figures of 39.26g, 29.97g, 20.84g and 13.53g were obtained in experiment II in groups A, B, C and D respectively while the respective values for these corresponding treatments in experiment I were 12.34g, 14.18g, 15.98g and 13.89g. Animals of the high energy level performed best in experiment II but animals of treament C (75% energy level) performed best in experiment I.

Another important factor is the financial cost of live-weight gain. Cost/kg live-weight gain increased with decreasing energy levels of the rations in experiment II from about ₦0.54; ₦0.67, ₦0.71 to ₦0.78 in Groups A, B, C and D respectively. In experiment I, group C presented the least cost (₦1.20/kg live wt. gain) and this is followed by groups D, B and A in that order with ₦1.26, ₦1.31 and ₦1.63 per kg. live weight gain.

DISCUSSIONS

The apparent digestibility coefficients of nutrients in both the basal diet and concentrate supplements were lower in experiment II than in experiment I. Since there is very little difference in the crude fibre content of the rations offered in experiment I and II and the levels of protein could not be regarded as low enough to impair the digestibility of the diets which were prepared in the same way in both experiments, the only possible cause of the difference would be the difference in the conditions of the alimentary tracts of the two sets of animals.

There is lack of specific evidence as to the age at which sheep attain maturity in respects to the alimentary tract development. There have been a good deal of conflicting reports on the maturity of ruminant digestive tract based on various methods of approach.

A study of blood glucose and volatile fatty acids concentrations suggests that values comparable with the adult are not reached till 13 weeks of age in the case of blood glucose but as early as 3 weeks with blood volatile fatty acids (Kronfeld, 1957). Reid (1953) however reported that blood glucose levels are similar to those of the adult sheep by 6-9 weeks of age while Jarrett and Portter (1952) and McArthy and Kesler (1956) found that the fall in blood sugar levels continue up to 13 weeks.

Results of Bryant Small, Bonma and Robinson (1958), Lengemann and Allen (1955, 1959), who used bacterial and protozoal counts as basis, indicated that the contents of the rumen of calves are comparable with those of adults as early as 3 weeks in some aspects while they are not similar until 6 months in other aspects. It is therefore possible that the rumen of the experimental animals had not yet been fully developed by the 6th month.

This result is contradictory to the reports by Walker and Walker (1961) who claimed that the rumen microorganisms of 3 weeks old lamb are able to digest as wide a variety of carbohydrates and protein as the adult ruminant. They however claim that maturity is not reached before the 4th month of age, this may be because there will be a difference in the quantity of the nutrients the young animals can digest. The differences in the digestibility values obtained in these experiments could therefore be due to the differences in age, the animals in experiment I being older than those in experiment II were capable of higher digestibility than the younger ones.

Many of the earlier workers have directly or indirectly agreed on the regulatory effect the digestibility capacity of an animal has on the voluntary intake of feeds. (Brobeck, 1955, Campling, 1966, Balch, 1961, Kay 1963, Campling et al 1961, 1962; Elliot and Topps, 1963; Wright, 1929; Campton, 1957; Hutton, 1962 and Conrad et al 1964). This is due to the effect of digestibility on the rate of passage of the digesta through the reticulorumen and the fact that the animals would stop eating when the digestive tract is fully distended. Increase in nitrogen content of feeds increases voluntary intake because digestibility is increased. It is therefore clear that the animals of experiment I are presumably likely to consume more of the feeds than the younger animals of experiment II. This also probably accounts for the higher intake of dry matter and hence digestible nutrients per unit metabolic size by the older animals that digested the feeds better.

Results of this study have shown that the younger animals are capable of faster growth than the older animals but that the effect of low plane of nutrition as indicated by growth rates of animals on the lower energy level diets, is more adversely felt by the younger animals. This is in agreement with reports in literature that young animals are capable of faster growth than older animals (Hammond, 1932; Palsson and Verges, 1952, Awoyemi, 1962 Adebambo, 1970). However, because of the lower resistance of the younger animals and the fact that their feed intake is low young animals need feeds of high quality. It is to be noted that the early weaned lambs were not able to survive on roughage alone. Older animals used by Adebambo (1970) performed better on roughages alone. While the general growth rate of the animals used is quite comparable and even higher than those reported for some of the tropical breeds of sheep, it is generally lower than growth figures of the temperate breeds of sheep.

Dry matter intake of some of the animals in experiment I was higher than figures proposed by Marshall, Bredon and Juko (1961) for ruminants in the tropics.

The animals used in experiment I had an initial weight lower than the expected live weight for their age. It is however seen that the growth rate of those on the 125% energy level ration were able to measure up to the initial weights of the older animals at 6 months of age (Fig. 1, Fig. 6.2 and Fig. 6.3).

Metabolizable energy requirement for maintenance was estimated as 129.19 kcal M.E./day/$W^{0.73}$kg in experiment I (Chapter 4) while an estimate of 107.1 kcal M.E./day/$W^{0.73}$kg was obtained in Chapter 5. This shows that the younger animals have less maintenance cost in terms of energy than the older ones. Similarly the metabolizable energy cost of live-weight gain is higher with the older animals (1387 kcal ME/day/kg live-weight gain) than with the younger animals (215 kcal ME/day/kg live-weight gain). This shows that the younger animals are nore efficient utilizers of energy than the older ones and efficiency declines with increasing age. This agrees with the general principles reported in the literature. Maintenance requirement of young animals is usually less than that for older animals and since younger animals normally consume less feeds and are faster growing, they are bound to be more efficient as in the case with the animals used for this study.

The metabolizable energy requirement for maintenance obtained from the regression of the pooled metabolizable energy intake from Chapter 4 and 5 on the love weight gains is 134.04 kcal ME/day/$W^{0.73}$kg. This value is higher than the 112 kcal ME/day/$W^{0.73}$kg recommended for sheep by the A.R.C. (1965) and NRC (1968). It is also above the range of 88 - 124 kcal ME/day/$W^{0.73}$kg suggested by Rattrary, Garrett, Hinman and East (1974) as the maintenance requirement for cattle and sheep. This result also shows that the maintenance cost of the Nigerian Dwarf sheep is higher than that for the Nigerian Dwarf goat since the value obtained by Akinsoyinu (1974) for the Nigerian Dwarf goat is 99.0 kcal/ME/day/$W^{0.73}$kg while Brody (1945) gave a requirement equivalent to 88.4 kcal ME/day/$W^{0.73}$kg for sheep. Moe, Tyrrell and Flat (1970) also recommended 100 kcal ME/day/$W^{0.73}$kg for non lactating cows. It therefore appears that the Nigerian Dwarf sheep is highly inefficient in terms of metabolizable energy utilization when compared with other breeds of sheep and with the other ruminants. This follows from the results of Blaxter (1964) that for all feed intakes and for all weight gains, the animal which has the lower maintenance level is more efficient.

The metabolizable energy cost of live-weight gain obtained in this study for animals 3 - 9 months old (Fig. 6.4) is 647 kcal ME/day/$W^{0.73}$kg/kg live-weight gain. For an animal of 20kg the requirement is 6339.95 kcal ME/day/kg live-weight gain. This is quite comparable to the 6333.6 kcal ME/day/kg live-weight gain recommended by the ARC (1965) for a 20 kg sheep.

The dressing percentage of animal carcasses increases with increasing age and size of the animal. This is explained as being due to the fact that the offals and pluck not included in the carcass are relatively early maturing while the flesh which makes up a greater percentage of the carcass increases with increasing size of the animal. The results of this study have fallen in line with this generally accepted fact.

Dressing percentages of the older animals are higher than those of the younger animals. Fig. 6.5 and 6.6 also indicate that the flesh percentage at 9 months is higher while the bone which reaches maximum size early in the life of the animal has a lower percentage in the older than the younger animals.

Fat deposition has been shown to be directly proportional to the age of the animals and the level of nutrition as indicated in Fig. 6.5 and Fig. 6.6. These findings on the carcass quality agree with results of Hammond (1932); Hammond and Murray (1934); Hirzel (1939) and Palsson and Verges (1952) who all infer that smaller or younger animals have a higher percentage of lean to fat in their carcasses. This also agrees with the findings of Blaxter (1964) who claims that efficiency of feed utilization declines with increasing age because fat percentages increase with age and that for lambs, as carcass weight increases from 10 lb to 80 lb, the percentage fat in the carcass increases from 13 - 14% and flesh decreases from 62.46%. Negative correlations have also been obtained in this study between the percentage flesh and the weight gains or age of the animals. Similar results were noted in cattle by Taylor, Watson and Young (1962) while the increase in efficiency of feed utilization obtained by Aitken and Crichton (1956) who treated sheep with stilboestrol or hexoestrol was due to the effect of hormone administration in producing carcasses with more meat and bone and less fat.

The two major joints, the leg and shoulder have been shown to be negatively correlated with the increase in live-weight gain (Fig. 4.7, 4.8, 5.6 and 5.7). Therefore, the percentages of these joints are inversely proportional to the age of the animals. This is because the rate of increase of these joints is slow as compared with the overall increase in the size and weight of the carcass. Other early maturing parts such as the head, feet and gut offals also exhibit lower percentages as the animals grow older. This is in accord with observations of Palsson and Verges (1952).

Feeds have been shown to be more efficiently utilized by the younger animals than the older ones. Feed consumption is shown to increase with increasing age of the animals, rates of gain especially at the higher energy levels decrease with age while the cost of live-weight gain increase with age. This seems to support the results of Blaxter (1964) that the last pound of gain is more expensive to produce in terms of feed than the first, as the animal grows older. It has also been observed that the composition of weight gains changes with increased allowance of feed. Feed cost of laying fatty tissue (about 9.1 kcal/g) is greater than that of laying down meaty tissue being about 1.2 kcal/g. The ratio in terms of feed cost of making gains of meat and fat is thus about 7:1 (Blaxter, 1964).

Since fat deposition has been proved to increase with age and deposition of fat is an inefficient way of utilizing feed, it means that there will be a decrease in the efficiency of feed utilization as the animals increase in age.

The cost of production of a kilogram live-weight gain is also in favour of the younger animals. This increases with the age of the animals due to the fact that the gain/feed ratio is much higher with the younger animals than the older ones.

It therefore appears that for two animals of equal weight at slaughter, the younger will be the more efficient converter and therefore if animals are to be slaughtered at a fixed weight, as suggested for the Nigerian Dwarf sheep by Hill (1961), the animal with the greatest mature weight and fastest growth is more efficient (Coey and Robinson, 1954; Blaxter, 1964). Attempts should therefore be made to reduce the age at which animals reach a good slaughter weight by feeding appropriate level of nutrition at the right age.

Since the 125% energy level ration gave the best result for animals of 3 - 6 months of age and the 75% energy level ration was best for animals between ages of 6 - 9 months, it is therefore suggested that animals should be weaned at 3 months, placed on a high energy diet (125%) from 3 months to 6 months at which time they could be changed over to the 75% energy level ration till they are ready for slaughter. This would probably be about the 9th month of age.

CHAPTER 7

General Summary of Conclusions

Results of this study have shown the pattern of growth and changes in carcass quality of the Nigerian Dwarf sheep between the ages of 3 - 9 months in relation to variations in energy levels of the rations.

A common feature of the results has been the greater variation due to the age of the animals as indicated by the less variation in animal responses to varied energy levels of rations within the age groups 3 - 6 months and 6 - 9 months than between these age groups.

Variations in the apparent digestibility coefficients obtained in experiments I and II were not significant, however, a comparison of the values obtained in both experiments show that digestibility values were higher in experiment I than in experiment II.

This difference has been attributed to the difference in the development of the digestive tract between the two sets of animals. No work has been done, however, to show the age at maturity of the Nigerian Dwarf sheep in respect to the rumen development.

Difference in feed intake as represented by the dry matter intake also varied more between the age groups. Differences of means values in each experiment could be due to restricted and varied amount of feed offered in each treatment in order to vary the levels of energy offered. The great difference between the values obtained in the two experiments could also be due to the effect of age. The younger animals were probably incapable of higher consumption because of the smaller capacity of their reticulorumen and the slower digestibility rates which will also slow down the rate of passage of the digesta through the tract.

It could be observed that the variation in energy levels had less effect on the performance of the animals of 6 - 9 months of age while low levels of energy had serious adverse effects on the animals of 3 - 6 months of age. None of the animals on zero supplementation survived. This is in agreement with various work in literature where better quality feed is generally recommended at the early ages of animals.

The estimated 134.04 kcal ME/day/$W^{0.73}$kg for maintenance of the Nigerian Dwarf sheep, obtained from the pooled metabolizable energy intake and growth rates is slightly higher than figures obtainable in literature but estimated metabolizable energy cost of liveweight gain of 647 kcal ME/day/$W^{0.73}$kg for 1 kg live-weight gain is approximately equivalent to the values recommended by the ARC (1965). This recommendation is equivalent to 6339.95 kcal ME/day/ $W^{0.73}$kg for a sheep of 20 kg live-weight as compared to 6336.6 kcal

ME/day/$W^{0.73}$kg recommended for the same live-weight by the ARC (1965).

In agreement with general observations, the shoulder and leg percentages were negatively correlated with live-weight gain and thus with age while the flesh percentage and fat deposition increased with increased live-weight and age. High levels of dietary energy also tended to lead to greater fat deposition.

A little increase in feed consumption was obtained by increasing the frequency of feeding from twice to thrice. The differences were however not significant. There are conflicting opinions on the effects of increased frequency of feeding on the quantity of feed consumed but it appears that more workers who have used a wider range of frequency of feeding for their studies have come to conclusions in favour of increased frequency of feeding.

From the regressions of shoulder, leg and flesh percentages on the live-weight gain of the animals it has been possible to give estimates of the expected percentages of these fractions of the carcass at all live-weights of the animal from the age of 3 - 9 months. Since the leg and shoulder joints claim a considerable percentage of the carcass and the flesh percentage is of utmost importance in profitable animal husbandry, it is thus hoped that these recommendations can help in assessing the expected price of an animal at any live-weight.

Production data and consideration of efficiency of feed utilization proved thatyoung Nigerian Dwarf sheep which consumed less feeds than the older ones, and are faster growing are more efficient feed converters than the older ones. This is in accord with the general reports in literature that younger and faster growing animals have a higher efficiency of feed utilization than older animals.

Consideration of all factors employed in this study has shown that animals from the age of 3 to 6 months require a high energy level ration. It is highly economic to feed the 125% energy level at this age since the cost per kilogram live-weight gain was least. At a higher age (6 - 9 months) the best performance was obtained from the 75% energy level ration. It however appears as if the cost of feeding at this higher age is high. This becomes much reduced when the total cost from 3 - 9 months is considered.

It is generally observed that keeping animals intensively makes for good fat lamb production. By zero-grazing, a lot of energy that could have been used up in the field is converted to production energy. Thus it is shown that it is quite possible to rear the Nigerian Dwarf sheep intensively from weaning at about 3 months to a good slaughter weight at about 9 months of age.

It is therefore suggested that animals be placed on the supplementary ration which contains 125% energy level of the ARC

(1965) recommendation from the age of 3 - 6 months and then change to the 75% energy level ration till slaughter at about 9 months.

Since age has been shown to influence the performance of the animals, a lot of work needs be done in ascertaining the age at maturity of the Nigerian Dwarf sheep in relation to the digestive tract development.

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Appendix 1.1

Digestibility (Apparent) Coefficient of Nutrients in Concentrate Supplement and Grass (%)

Animal No.	D.M.	O.M.	C.P.	E.E.	C.F.	N.F.E.
A 96	80.85	84.47	71.61	87.67	66.63	84.92
A 107	73.80	79.00	71.96	81.58	69.00	83.68
A 116	76.61	80.80	71.84	86.76	69.35	83.89
B 84	74.98	76.54	72.33	89.68	72.23	81.72
B 109	73.17	80.58	67.20	84.55	72.86	82.30
B 122	72.40	77.85	69.13	83.21	72.06	83.64
C 88	77.49	81.82	74.23	86.88	70.73	83.27
C 91	79.45	83.20	73.74	86.28	72.04	83.71
C 113	75.55	80.10	72.74	89.18	70.03	83.88
D 89	79.16	83.28	80.44	85.71	74.14	83.07
D 95	70.53	69.66	80.11	86.48	67.31	83.51
D 108	76.35	78.92	81.32	86.26	72.96	83.11

Appendix 1.2

Apparent Digestibility Coefficient of Nutrients in Grass (%)

Animal No.	D.M.	O.M.	C.P.	E.E.	C.F.	N.F.E.
A 96	78.95	83.88	62.10	88.62	63.12	79.55
A 107	68.80	80.81	62.76	86.24	67.69	78.75
A 116	74.64	77.06	62.85	89.50	68.28	76.75
B 84	74.87	76.36	61.30	89.83	68.23	77.08
B 109	67.48	82.49	51.54	82.12	68.12	77.12
B 122	70.25	76.37	55.99	81.53	68.31	79.76
C 88	75.79	78.74	64.38	86.12	65.54	78.55
C 91	77.11	81.44	66.36	85.95	70.02	78.75
C 113	73.59	79.11	64.12	89.61	68.37	78.36
D 89	78.01	83.67	61.14	87.97	70.78	77.34
D 95	69.30	68.33	60.18	86.91	60.15	77.31
D 108	74.17	78.20	61.41	86.98	77.86	77.09

Appendix 1.3

Apparent Digestibility Coefficient of Nutrients from Concentrate Supplement

Animal No.	D.M.	O.M.	C.P.	E.E.	C.F.	N.F.E.
A 96	83.70	85.36	85.88	86.24	71.90	92.98
A 107	81.30	76.38	85.76	89.59	70.97	91.08
A 116	79.57	86.41	85.33	82.65	70.98	94.60
B 84	75.15	76.81	88.80	89.45	78.23	88.68
B 109	81.70	75.80	81.69	88.20	79.97	89.57
B 122	75.60	80.07	88.84	85.73	80.19	89.46
C 88	80.04	86.44	89.01	88.02	78.52	90.35
C 91	82.96	85.84	84.56	86.78	75.07	91.15
C 113	78.49	81.59	85.67	88.53	72.52	92.16
D 89	80.89	82.69	93.39	82.32	79.18	91.67
D 95	72.38	71.63	93.51	85.83	78.05	92.86
D 108	79.62	80.00	96.19	85.88	78.61	92.14

Appendix 1.4 Intake of DDM and Digestible Nutrients - Grass

	DDM	DOM	DEEx2.25	DCF	DCP	DNFE	TDN
	102.017	18.704	2.955	25.647	8.129	49.816	86.547
	101.657	18.638	2.975	25.824	8.185	50.158	87.142
	101.770	18.475	2.922	25.360	8.038	49.256	85.576
	101.537	18.616	2.930	25.435	8.062	49.403	85.830
	101.705	18.646	2.979	25.481	8.195	50.217	86.872
	102.569	18.805	2.958	25.672	8.137	49.863	86.630
MEAN	101.878	18.647	2.953	25.632	8.124	49.785	86.494
	± 0.118	±0.0606	±0.0116	±0.0682	±0.00914	±0.0784	±0.189
	101.225	18.558	2.978	25.848	8.193	50.205	87.224
	101.921	18.686	2.967	25.759	8.164	50.028	86.916
	100.089	18.350	2.942	25.532	8.093	49.591	86.158
	100.386	18.405	2.964	25.727	8.154	49.969	86.814
	102.041	18.708	2.969	25.727	8.168	50.052	86.916
	101.321	18.576	2.994	25.988	8.237	50.477	87.696
MEAN	101.164	18.547	2.968	25.759	8.223	50.032	86.982
	± 0.285	±0.0624	±0.0829	±0.107	±0.0123	±0.172	±0.216

	100.338	18.396	2.929	25.423	8.058	49.379	85.789
	101.250	18.563	2.956	25.654	8.131	49.828	86.569
	100.050	18.343	2.921	25.350	8.035	49.237	85.543
	100.841	18.488	2.944	25.550	8.098	49.626	86.218
	100.841	18.488	2.944	25.550	8.098	49.626	86.218
MEAN	100.664	18.456	2.938	25.505	8.084	49.539	86.066
	± 0.189	±0.1349	±0.0109	±0.0787	±0.0044	±0.364	±0.199

	102.018	18.704	2.978	25.848	8.193	50.206	87.225
	102.185	18.734	2.983	25.891	8.206	50.288	87.368
	102.253	18.765	2.988	25.933	8.240	50.370	87.511
	103.576	18.989	3.023	26.243	8.318	50.973	88.557
	102.556	18.802	2.994	25.985	8.236	50.470	87.685
MEAN	102.518	18.799	2.993	25.977	8.236	50.455	87.658
	± 0.496	±0.02449	±0.0044	±0.00626	±0.076	±0.150	±0.226

Appendix 1.5 Intake of DDM and Digestible Nutrients - Conc. Mixture

	DDM	DOM	DEEx2.25	DCF	DCP	DNFE	TDN
	442.598	365.480	41.355	29.569	65.741	428.494	565.159
	468.725	387.055	49.380	35.308	78.499	511.645	674.832
	630.398	520.559	65.127	46.567	103.532	674.805	890.031
	620.870	512.590	40.997	29.313	65.171	424.780	560.261
	732.308	604.712	39.555	28.282	62.880	409.845	540.562
	679.652	561.231	33.773	24.248	53.688	349.932	461.541
MEAN	595.756	491.955	45.032	32.198	71.586	466.586	615.402
	±43.201	±35.655	±3.144	±0.931	±5.581	±12.376	±48.713
	507.005	438.591	21.182	9.532	57.229	400.836	488.779
	605.390	523.701	27.843	10.095	60.608	424.499	523.045
	798.446	690.707	37.446	13.577	81.512	570.917	703.452
	502.608	434.788	36.880	13.372	80.280	562.288	692.820
	484.938	419.502	43.500	15.772	94.690	663.212	817.174
	414.048	358.178	40.372	14.638	87.881	615.524	758.415
MEAN	552.073	477.578	35.389	12.831	77.033	539.544	664.797
	±50.469	±43.650	±4.116	±2.942	±6.554	±42.629	±17.779

	488.169	440.322	63.838	21.791	75.615	396.884	558.128
	521.833	470.687	68.240	23.293	80.829	424.253	596.615
	457.120	412.317	59.778	20.405	70.805	371.641	522.629
	433.263	390.798	56.658	19.340	67.110	352.245	495.353
	531.006	478.961	69.440	23.703	82.250	431.711	607.104
MEAN	486.278	438.617	63.591	21.706	75.322	395.348	555.968
	±16.650	±15.013	±2.176	±0.746	±2.578	±13.353	±19.029
	404.181	347.639	61.306	30.369	98.994	298.122	488.791
	392.207	337.339	59.490	29.469	96.061	289.289	474.309
	386.655	332.564	58.648	29.052	94.701	285.194	467.595
	319.371	274.693	48.442	23.997	78.222	235.566	386.227
	279.606	240.491	42.410	21.009	68.482	206.236	338.137
MEAN	356.404	306.545	54.059	26.779	87.291	262.880	431.009
	±21.672	±18.654	±3.289	±1.627	±5.295	±15.997	±26.220

Appendix 1.6 Total Intake of DDM and Digestible Nutrients

	DDM	DOM	DEx2.25	DCF	DCP	DNFE	TDN	ME	$ME/W^{0.234}_{kg.}$
	544.615	384.184	44.310	55.216	73.870	479.310	651.706	2319.73	214.37
	570.382	405.693	52.355	61.132	86.684	561.803	761.974	2712.22	243.03
	732.168	539.034	68.049	71.927	111.570	724.061	975.607	3472.64	319.76
	722.407	531.306	43.927	54.748	73.233	474.183	646.091	2299.74	246.22
	834.013	623.358	42.534	53.763	71.075	460.062	627.434	2233.33	222.00
	872.221	580.036	36.731	49.820	61.825	399.795	548.171	1951.20	243.90
MEAN	712.634	510.602	47.984	57.768	79.710	516.536	701.831	2498.15	281.55
	608.230	457.149	24.160	35.380	65.422	451.041	576.003	2050.27	224.17
	707.311	542.387	30.810	35.854	68.772	474.527	609.961	2171.14	209.97
	898.535	706.057	40.338	39.109	89.605	620.508	789.610	2810.59	263.16
	602.994	453.193	39.844	39.099	88.434	612.257	779.634	2775.08	265.05
	586.979	438.210	46.469	41.499	102.858	713.284	904.090	3218.08	394.86
	515.369	376.759	43.336	40.626	96.118	666.001	846.111	3011.71	246.46
MEAN	653.236	495.626	37.498	38.595	85.202	589.603	750.902	2672.81	267.28
	588.507	458.718	66.767	47.214	83.673	446.263	643.917	2292.00	217.46
	623.083	489.250	71.196	48.947	88.960	474.081	683.184	2431.77	252.52
	557.170	430.660	62.699	45.755	78.840	420.878	608.172	2164.77	217.78
	534.104	409.286	59.602	44.890	75.208	401.871	581.751	2070.08	210.37
	631.847	497.449	72.384	49.253	90.348	481.337	693.322	2467.86	221.13
MEAN	586.942	457.073	66.530	47.212	83.406	444.886	643.033	2285.30	223.85
	506.199	366.343	64.284	56.217	107.187	348.328	576.016	2050.31	195.83
	494.392	356.073	62.473	55.360	104.267	339.577	561.677	1999.27	197.36
	488.908	351.329	61.636	54.985	102.941	335.564	555.106	1975.88	199.38
	422.947	293.682	51.465	50.240	86.540	286.539	474.784	1689.98	170.53
	382.162	259.293	45.404	46.994	76.718	256.706	425.822	1515.70	189.46
MEAN	458.922	325.344	57.052	52.759	95.531	313.343	518.681	1846.23	190.51

Appendix 1.7 Weekly Weight Measurement (kg)

187	18.61	17.93	18.16	19.07	20.20	20.88	21.79	22.25	22.70	23.15	23.85	24.74	25.42
216	18.16	17.71	17.71	18.16	18.16	19.30.	20.43	21.56	22.24	23.61	24.52	25.42	26.79
222	17.71	16.57	17.25	18.84	19.75	20.67	21.11	22.25	22.93	23.38	24.52	25.88	26.33
232	13.17	12.71	13.62	13.85	14.53	14.98	15.44	16.34	17.48	18.39	19.30	20.20	20.88
247	16.34	15.89	16.34	17.48	17.71	18.16	18.64	19.52	20.43	20.88	21.79	22.70	23.15
271	13.39	13.17	13.62	13.62	14.30	14.76	15.21	15.89	16.34	16.57	16.80	16.80	17.03
MEAN	16.23	15.66	16.12	16.84	17.44	18.13	18.77	19.64	20.25	21.00	21.80	22.62	23.27
203	14.98	14.98	15.44	16.80	17.25	18.16	18.39	18.84	19.07	19.75	20.20	20.66	20.43
204	14.98	15.66	15.89	16.57	16.80	17.25	18.39	19.07	20.20	21.34	22.47	23.38	24.30
223	17.03	17.03	18.06	19.07	20.20	20.88	21.79	22.47	23.15	24.29	25.42	25.61	26.11
231	19.93	19.30	19.52	20.88	21.34	21.57	22.02	23.15	23.61	24.29	24.74	24.97	24.97
246	13.62	13.62	14.07	14.75	15.20	15.63	15.89	16.34	17.25	17.48	17.71	17.93	18.16
253	24.06	24.06	24.97	25.65	26.55	27.24	28.14	29.05	30.42	30.64	30.87	31.33	30.42
MEAN	17.43	17.44	18.01	18.95	19.56	20.12	20.77	21.49	22.28	22.97	23.57	23.98	23.07
196	16.34	17.03	17.71	18.61	19.07	19.52	20.20	21.34	22.02	23.15	24.28	24.97	25.20
213	14.98	15.21	15.44	16.34	16.80	17.50	18.16	19.07	19.98	20.43	21.34	21.79	22.02
224	15.89	16.34	17.25	18.16	18.16	19.07	19.75	20.20	20.66	21.34	22.25	22.47	23.38
227	17.25	17.25	17.71	17171	18.16	18.61	19.07	19.75	20.66	21.34	21.79	22.47	22.70
252	19.98	18.61	19.30	20.43	20.66	21.11	22.02	22.93	23.38	24.06	24.74	25.42	26.33
254	----------	----------	----------	----------	----------	D	E	A	D	----------	----------	----------	----------
MEAN	16.89	16.89	17.48	18.25	18.57	19.16	19.84	20.66	21.34	22.06	22.88	23.42	23.93
192	18.16	18.16	19.07	19.52	19.97	20.20	20.88	21.79	22.25	22.70	23.61	24.29	24.57
212	15.44	15.44	15.89	16.80	17.25	17.49	19.93	18.16	18.84	19.52	21.11	22.25	22.93
218	19.52	19.30	19.98	20.43	21.33	21.57	22.24	22.70	23.15	23.61	24.06	24.52	23.15
226	----------	----------	----------	----------	----------	D	E	A	D	----------	----------	----------	----------
249	19.52	19.07	19.52	19.75	20.43	20.88	21.11	21.34	22.24	22.70	22.70	22.47	22.70
286	14.53	15.44	15.21	15.66	15.44	15.89	16.34	16.51	16.80	17.03	17.25	17.48	17.71
MEAN	17.43	17.48	17.93	18.43	18.88	19.21	19.70	20.11	20.66	21.11	21.75	22.70	22.21

Appendix 1.8 Weekly Height Measurement (cm)

	1	2	3	4	5	6	7	8	9	10	11	12
187	52	52	53	54.5	55	56	56	56	58	59	59	59.5
216	52	52	53	53.5	54	55	55	55	56	56.5	57.5	57.5
222	53	54	55	55.5	56	57	58	58	58	58	58.5	59
232	47	48	50	50.5	52	53	53	53	53	54.5	55	55.5
247	49.5	50	50	50.5	50.5	51	51	51	51.5	52	52	53
471	46.5	48	49.5	52	52	52	53	53	52	53	54	53
203	51	52	52.5	53	53	54	55	55	56	56	56	56.5
204	48	49	49.5	49.5	50	51	52.5	51	52	51	51	51.5
223	48.5	49	50.5	52	52	53	53	53.5	55	56	57	57
231	48	48	49	49	50	52	53	54	55	55	55	56
246	46	48	50	51.5	51	52	53	54	55	55	55.5	55.5
253	51	52	53	54	55	56	56	56	57.5	57.5	57.5	58
196	51	52	53	53.5	54	55	54	55	56	57	57	57
213	48	48	49	50	50	52	52	51	52	53	54	54.5
224	47	47	47	48	48	49	50	49.5	49	49	50	52
227	53	54	55.5	55	55	55	56	57	56.5	56	57	58
252	48	48.5	49	49	50	50	51.5	51	52	53.5	53.5	52
254	47	47	48	48	48	50	51					
192	49	50	50	51	52	53	54	53	53.5	53.5	54.5	54.5
212	49	50	50	51	52	53	54	53	53.5	53.5	54.5	54.5
218	50	51	51	52	53	54	53	54	54.5	54.5	55	55
226	49	52	53	51	54	54						
249	52	53	54	54	53	54	54	54.5	53.5	53.5	54	54
256	48	48	49	49	50.5	52	52	52.5	53	53	53	54

Appendix 1.9 Weekly Heart Girth Measurement (cm)

	1	2	3	4	5	6	7	8	9	10	11	12
187	63	63	63	64	64	65	65	66	67	67	67.5	67.5
216	60	61	62	61	61	62	63.	64	65.5	66	66	66
222	60	61	62	62	64	65	65	66	67	67	67	67.5
232	55	56	57	57	58	57	57	57	58	59	60	61
247	58	59	60	61	62	62	64	64.5	64	65	66.5	66
271	58	58	57	57	57	57	57	57	57.5	59	59.5	59.5
203	57	59	59	59	59	60	60	61	62	63	63	63
204	55	57	59	59	58	59	60.5	61.5	63	63	62	63
223	60	61	61	61	62	64	63	64	66	68	68	69
231	62	62	63	64	65	64	65	64	65	65	66	66
246	56	57	57	57	58	58	57	58	60	60	59.5	61
253	68	69	69	69	70.	72	72	72	72	74	74	73
196	58	59	59	62	64	64	63	63.5	64.5	66.5	67	67
213	56	58	59.5	62	63	63	63	63.5	64	65.5	65	65
224	59	61	61	61	61	62	62	62	62	63	646	64
227	62	62	62	63	64	64	63	64.5	65	66.5	67	68
252	59	59	61	63	64	65	63	64.5	66	67	68	68.5
254	56	57	57	58	59	58						
192	58	59	60	61	62	62	62	63	64	65	65	66
212	57	58	59	60	61	61	61.5	62.5	64	64	64	65
218	59	61	62	63	63	63.5	64	64	64	64	64.5	65
226	59	61	61	62	64	61						
249	60	61	62	63	64	64	64	63.5	63	64	63.5	65
256	57	57	57	57	58	58	59	59	60.5	60	60	61

Appendix 1.10 Weekly Length Measurement (cm)

	1	2	3	4	5	6	7	8	9	10	11	12
187	55	56	56	57	59	59	59	60	60	60	60.5	60.5
216	54	55	56	58	58	58	58	59	59	60	60.5	60.5
222	57	58	59	60	61	62	62	62.5	62.5	62.5	63	63
232	50	52	54	55.5	57	58	58	58	58	57	59.5	60
247	56	57	57	57	57	57	57	58	58.4	58.5	59	59
271	54.5	55	55	55	56	56	57	57	58	58.5	58.5	58.5
203	51	52	53.5	53.5	54	55	55.5	56.6	56.5	56.5	56.5	57
204	55	55.5	56	56.5	57	57	57.5	57.5	59	59.5	60	60
223	54	55	56	56.5	56.5	57	57	58	59	59.5	59.5	61.5
231	54	55	55.5	55.5	56	57	58	59	60	60	60.5	61
246	52	53	54.5	54.5	55	55	55	55.5	55.5	56	56	56
253	59	60	61	62	62	62.5	63	64	64	64	65	65
196	52.5	52.5	53	53.5	54	55	56	57	58	59	60.5	61.5
213	51	52.5	53	54.5	55	55	55	56	56	57.5	57.5	59
224	50.5	51	52	53.5	54	54	55	55.5	55.5	56.5	57.5	57.5
227	53	53	54	54.5	55	55	56	56.5	56.5	57	58	59
252	54	55	56	56.5	57	58	59	69	61	51	61.5	62
254	52	56	56	56.5	60	60.	58					
192	53	53	53.5	53.5	54	54	55	56	57	57	57.5	58
212	55	55	55.5	56.5	57	58	58.5	58.5	59	59.5	60	61
218	55	56	56	56.5	57	57	57	57	57	57	58	58
226	52.5	57	54.5	54.5	54	54						
249	53	54	55	55	55	55.5	56	56.5	56.5	57.5	59	59
256	52	53	53	53.5	54	54	54	55	55.5	55.5	56.5	56.5

Appendix 1.11 Carcass Analysis (a) Analysis at Slaughter (kg)

ANIMAL NO.	SLAUGHTER WT.	DRESSED CARCASS (WT)	HEAD	OFFAL	EMPTY OFFAL	PLUCK	FEET	SKIN
A 187	26.105	13.053	2.043	6.129	2.270	1.362	0.681	2.724
A 216	27.240	14.307	1.930	5.562	2.043	1.476	0.681	3.859
A 22	26.332	13.393	1.930	5.675	2.270	1.135	0.568	1.930
A 232	21.338	10.442	1.703	4.654	2.157	1.305	0.568	2.611
A 247	23.608	12.035	1.816	4.767	2.270	1.816	0.568	2.951
A 271	17.252	9.421	1.135	2.838	1.476	1.022	0.568	1.930
B 203	20.430	10.095	1.589	3.632	1.703	1.135	0.681	2.724
B 204	24.516	12.372	1.816	5.675	1.986	1.986	0.681	2.611
B 223	25.651	14.188	1.816	4.881	2.015	1.362	0.681	3.178
B 231	24.970	14.188	1.249	4.994	1.930	1.249	0.681	2.724
B 246	17.706	9.704	1.135	3.859	2.043	0.908	0.454	1.816
B 253	30.872	16.117	2.043	5.675	2.469	1.816	0.681	3.519
C 196	25.197	13.393	1.816	5.675	2.497	1.703	0.681	3.348
C 213	22.246	12.088	1.135	4.881	2.043	1.362	0.568	2.611
C 224	23.154	12.258	1.816	4.256	2.157	1.305	0.681	3.405
C 227	22.927	11.577	1.362	5.902	1.589	1.135	0.681	3.178
C 252	27.240	13.620	1.930	6.810	2.384	1.589	0.795	4.086
C 254	D E A D							
D 192	24.970	13.620	2.043	4.994	2.043	1.362	0.681	2.951
D 212	23.835	12.145	1.703	4.767	2.384	1.362	0.681	2.611
D 218	23.154	12.939	1.816	3.859	1.816	1.135	1.681	3.178
D 226	D E A D							
D 249	23.154	12.599	1.930	4.460	2.043	1.135	0.624	2.384
D 256	17.252	9.307	1.135	3.292	1.362	1.022	0.568	2.157

Appendix 1.12 Cold Carcass Analysis. Weight of Joints

ANIMAL NO.	COLD CARCASS (WHOLE)	CARCASS LEFT	CARCASS RIGHT	CARCASS LENGTH (cm)	LEG	LOIN	ENDS	SHOULDER	SETS	BONE	MEAT	FAT
A 187	12.712	6.356	6.356	48	1.703	0.795	0.795	2.213	0.681	1.192	5.164	1.362
A 216	13.847	6.867	6.980	50	2.043	0.908	0.681	2.270	0.795	1.022	5.902	1.022
A 222	13.393	6.583	6.810	52.5	2.100	0.908	0.739	2.157	0.568	1.135	5.562	1.135
A 232	10.215	5.108	5.108	48	1.532	0.681	0.624	1.646	0.624	0.851	4.029	1.135
A 247	11.577	5.902	5.675	48.5	1.703	0.738	0.681	1.930	0.624	0.908	4.767	1.135
A 271	9.080	4.540	4.540	49.5	1.703	0.681	0.568	1.362	0.454	0.795	3.378	0.908
B 203	10.783	5.335	5.335	45.5	1.703	0.681	0.681	1.703	0.681	0.795	4.540	1.135
B 204	12.031	5.902	6.129	51.0	1.703	0.908	0.681	1.589	0.908	1.135	4.494	1.476
B 223	14.074	6.924	7.151	50.5	1.930	0.908	0.681	2.157	0.738	1.135	5.448	1.930
B 231	14.074	7.037	0.037	52.5	2.327	0.968	0.568	1.930	0.568	1.078	5.954	2.327
B 246	9.307	4.540	4.767	50.5	1.476	0.568	0.568	1.362	0.454	1.908	3.859	1.476
B 253	15.890	7.945	7.945	55	2.213	0.965	1.022	2.611	0.795	1.362	5.959	1.930
C 196	12.939	6.470	6.470	50	1.930	0.681	0.795	1.157	0.795	1.135	5.335	1.135
C 213	11.691	5.789	5.902	51	1.816	0.908	0.795	1.646	0.511	1.135	4.540	1.305
C 224	12.088	5.902	6.186	49	1.816	0.908	0.681	1.589	0.795	1.362	4.824	1.703
C 227	11.464	5.789	6.526	51	1.986	0.759	0.851	1.589	0.568	0.908	4.313	2.213
C 252	13.280	6.810	6.526	51	1.986	0.795	0.795	2.213	0.795	1.135	5.108	1.334
C 254		D E A D										
D 192	13.053	6.470	6.583	49.5	1.930	0.851	0.795	2.128	0.738	1.135	5.335	1.589
D 212	11.804	5.902	5.902	50	1.873	0.653	0.681	2.157	0.681	1.022	4.767	1.703
D 218	12.712	6.356	6.356	49	1.816	0.795	2.270	0.908	1.135	5.221	5.221	0.908
D 226		D E A D										
D 249	12.258	6.072	6.186	49	1.816	0.681	0.908	1.589	1.135	1.135	5.051	1.135
D 256	9.080	4.540	4.540	48	1.476	0.568	0.568	1.476	0.397	1.162	3.378	0.908

Appendix 1.13 Parts as Percentage of Whole Animal

ANIMAL NO.	PARTS AS PERCENTAGE OF SLAUGHTER WT.						LIVE-WEIGHT AT SLAUGHTER (kg)
	SKIN	PLUCK	OFFAL	EMPTY OFFAL	FEET	HEAD	
A 187	10.43	5.22	23.48	8.70	2.61	7.83	26.11
A 216	14.17	5.42	20.42	7.50	2.50	7.08	27.24
A 222	7.31	4.31	21.55	8.62	2.16	7.33	26.33
A 232	12.23	6.12	21.81	10.11	2.66	7.98	21.34
A 247	12.5	5.88	20.19	9.62	2.40	7.69	23.61
A 271	11.18	5.92	16.45	8.55	3.29	6.58	17.25
	±0.879	±0.241	±0.885	±0.340	±0.162	±0.142	±1.909
MEAN	11.30	5.48	20.65	8.85	2.60	7.42	23.65
B 203	13.33	5.56	17.78	8.33	3.33	7.78	20.43
B 204	10.65	5.56	23.15	8.10	2.78	7.41	24.52
B 223	12.39	5.31	19.03	7.85	2.66	7.08	25.56
B 231	10.91	5.00	20.00	7.73	2.73	5.00	24.97
B 246	10.26	5.13	21.80	11.54	2.56	6.41	17.71
B 253	11.40	5.88	18.38	8.00	2.21	6.62	30.87
	±0.4332	±0.093	±0.990	±0.546	±0.355	±0.141	±1.688
MEAN	11.49	5.41	20.02	8.59	2.71	6.72	24.01
C 196	13.29	6.76	22.52	9.91	2.70	7.21	25.20
C 213	11.73	6.12	21.94	9.18	2.55	5.10	22.25
C 224	14.71	5.64	18.38	9.31	2.94	7.84	23.15
C 227	13.86	4.95	25.74	6.93	2.97	5.94	22.93
C 252	15.00	5.83	25.00	8.75	2.92	7.08	27.24
C 254			DEAD				
	±0.510	±0.265	±0.572	±0.437	±0.435	±0.316	±0.842
MEAN	13.72	5.86	22.72	8.82	2.82	6.64	24.15
D 192	11.92	5.45	20.00	8.18	2.73	8.18	24.97
D 212	10.95	5.71	20.00	10.00	2.86	7.14	23.84
D 218	13.73	4.90	16.67	7.84	2.94	7.84	23.15
D 226			DEAD				
D 249	10.29	4.90	19.61	8.82	2.70	8.33	23.15
D 256	12.50	5.92	19.08	7.89	3.29	6.58	17.25
	±0.528	±0.161	±0.572	±0.345	±0.369	±0.038	±1.210
MEAN	11.88	5.38	19.07	8.54	2.90	7.21	22.47

Appendix 1.14 Joints as Percentage of Cold Carcass

Animal No.	Cold Carcass Weight (kg)	Dressing Percentage	Joints as Percentage of Cold Carcass							
			Leg	Loin	Sets	Ends	Shoulders	Meat	Bone	Fat
A 187	12.71	48.7	26.78	12.50	10.72	12.50	34.82	81.25	18.75	10.71
A 216	13.85	50.83	29.50	13.12	11.48	9.84	32.78	85.25	14.75	7.38
A 222	13.39	49.14	31.36	13.56	8.48	11.02	32.20	83.05	16.95	8.48
A 232	10.22	47.87	30.00	13.34	12.22	12.22	32.22	83.33	16.67	11.11
A 247	11.58	49.04	29.42	12.74	10.78	11.76	33.34	82.35	17.65	9.80
A 271	9.08	52.63	37.50	15.00	10.00	12.50	30.00	74.40	25.60	10.00
	±0.683	±0.666	±1.350	±0.306	±0.492	±1.349	±0.591	±1.355	±1.393	±0.5247
MEAN	11.81	49.70	30.76	13.38	10.61	11.64	32.56	81.61	18.40	9.58
B 203	10.78	52.78	31.58	12.64	12.64	12.64	31.58	85.26	14.74	10.53
B204	12.03	49.07	28.30	15.10	15.10	11.32	26.42	80.19	19.81	12.26
B 223	14.07	54.87	27.42	12.90	10.48	9.68	30.62	83.87	16.13	13.71
B 231	14.07	56.36	33.06	13.72	8.06	8.06	27.42	84.68	15.32	16.53
B 246	9.31	52.36	31.70	12.20	9.76	12.20	29.26	80.49	19.51	15.85
B 253	18.89	51.47	27.86	12.14	10.00	12.86	32.86	82.86	17.14	12.14
	±1.253	±0.940	±0.877	±0.403	±0.921	±0.698	±0.939	±0.825	±0.791	±0.874
MEAN	13.19	52.82	29.99	13.12	11.01	11.13	29.69	82.89	17.11	13.50
C 196	12.94	51.35	29.82	10.52	12.28	12.28	33.34	82.46	17.54	8.77
C 213	11.69	52.55	31.06	15.54	8.74	13.60	28.16	80.58	19.42	11.17
C 224	12.09	52.21	30.04	05.02	13.14	11.26	26.30	81.22	18.78	14.08
C 227	11.24	49.01	35.36	14.14	10.10	15.16	28.28	84.16	15.84	19.70
C 252	13.28	48.75	29.92	11.96	11.96	11.96	33.34	82.01	17.09	10.04
C 254										
	±0.326	±0.769	±0.942	±0.838	±0.727	±0.626	±1.319	±0.409	±0.589	±1.744
MEAN	12.25	50.77	31.24	13.44	11.24	12.85	29.88	82.09	17.73	12.75
D 192	13.05	52.27	29.56	13.04	11.30	12.18	32.60	82.61	17.39	12.17
D 212	11.80	49.52	31.74	11.06	11.54	11.54	36.54	82.69	17.31	14142
D 218	12.71	54.90	28.58	14.28	14.28	12.50	35.72	82.14	17.86	7.14
D 226										
D 249	12.26	52.94	29.62	11.12	18.52	14.82	25.92	81.48	18.52	9.26
D 256	9.08	52.63	32.50	12.50	8.76	12.50	32.50	74.40	25.50	10.00
	±0.632	±0.798	±0.658	±0.543	±1.484	±0.487	±1.656	±1.459	±1.403	±1.113
MEAN	11.78	52.45	30.40	12.40	12.88	12.71	32.66	80.66	19.34	10.60

Appendix Table 2.1

Apparent Digestibility Coefficient of Nutrients in Basal Diet (%)

	DM	OM	EE	CF	CP	NFE
Treatment A	54.25	56.36	32.65	57.43	50.87	56.75
	52.74	54.81	33.46	55.67	53.75	57.29
	55.64	57.23	32.41	56.74	54.33	52.93
	56.75	58.14	38.26	54.25	56.78	51.88
	53.34	55.43	41.27	55.56	49.99	54.18
	54.83	57.67	42.68	53.83	55.67	53.37
Mean	54.59 ±0.578	56.61 ±0.418	36.79 ±1.697	55.58 ±0.517	53.57 ±0.946	54.40 ±0.808
Treatment B	54.51	55.34	34.21	56.36	57.61	55.71
	56.24	58.16	32.42	53,18	56.34	55.09
	53.60	55.53	37.78	55.74	59.10	57.13
	57.22	58.34	38.26	56.91	58.36	53.89
	56.83	58.16	40.16	59.23	54.71	58.11
	56.12	57.76	37.56	57.15	53.95	57.23
Mean	55.75 ±0.580	57.22 ±0.417	36.73 ±1.075	56.43 ±0.717	56.68 ±0.743	56.19 ±0.638
Treatment C	53.40	54.39	36.37	58.24	56.23	55.68
	57.93	59.40	31.03	53.55	59.10	52.51
	57.34	58.77	38.17	52.51	53.11	58.45
	55.28	56.37	24.56	50.47	50.33	57.04
	54.83	55.89	38.34	50.21	50.67	56.06
	54.58	55.87	40.47	59.20	57.69	57,74
	55.56 ±0.646	56.78 ±0.714	34.82 ±2.221	54.03 ±1.437	54.52 ±1.378	56.25 ±0.783
Treatment D	51.99	52.94	31.63	57.94	50.40	53.63
	54.10	55.16	33.50	55.88	53.77	55.88
	53.91	52.41	31.20	53.25	53.95	55.07
	52.83	56.13	37.41	51.12	44.07	56.98
	54.20	55.10	33.83	50.54	50.69	58.06
	53.87	55.69	44.72	59.80	57.33	56.80
*Mean	54.52 ±0.539	55.68 ±0.747	35.10 ±2.071	54.40 ±1.376	53.11 ±1.651	56.16 ±0.669

* Mean for C and D

Table 2.2 Apparent Digestibility Coefficient of Nutrients in Concentrate Supplement (%)

	DM	OM	EE	CF	CP	NFE
Treatment A	65.14	69.34	61.21	66.38	70.46	75.61
	65.83	67.56	60.94	65.46	69.35	77.46
	69.11	68.66	63.38	63.36	66.76	78.13
	65.00	70.12	65.46	67.40	68.51	76.58
	66.11	65.33	68.58	64.18	63.41	74.69
	63.34	66.71	66.21	63.33	65.06	75.48
	65.76 ±0.628	67.95 ±0.408	64.30 ±1.085	65.02 ±0.595	67.26 ±0.982	76.28 ±1.175
Treatment B	67.36	68.10	60.87	63.71	68.13	74.23
	66.85	64.36	59.43	64.94	66.45	78.08
	65.53	65.75	68.41	66.45	71.04	74.57
	68.71	67.89	64.72	63.83	67.65	75.62
	65.71	64.67	60.28	65.23	64.31	73.55
	67.88	66.25	59.91	64.46	62.48	76.38
	67.0. ±0.373	66.17 ±0.587	62.27 ±0.306	64.77 ±0.381	66.84 ±0.408	75.41 ±0.504
Treatment C	65.05	66.10	61.73	64.91	67.22	73.87
	61.56	62.25	57.67	68.86	66.57	74.33
	61.50	65.57	52.92	69.15	60.74	72.45
	62.40	66.98	79.15	66.12	63.85	72.69
	63.68	63.36	62.07	67.30	61.39	72.46
	63.81	60.03	60.74	64.47	67.47	63.81
	63.00 ±0.527	64.05 ±0.968	62.38 ±3.317	66.64 ±0.764	64.54 ±1.115	71.60 ±1.467
Treatment D	56.79	60.42	64.03	66.54	74.52	65.92
	61.54	65.36	57.74	65.20	76.09	68.95
	56.71	63.05	61.24	60.61	80.83	75.15
	63.23	64.05	52.45	61.48	83.99	70.66
	69.00	64.54	53.11	63.30	79.49	70.46
	65.39	65.21	54.00	65.68	77.93	69.60
	62.11 ±1.806	63.73 ±1.165	57.10 ±1.743	63.80 ±0.914	78.81 ±1.252	70.12 ±1.152

Table 2.3 Mean Daily Intake of Digestible Nutrients from Basal Diet (gm)

	DDM	DOM	DDEx2.25	DCF	DCP	DNFE	TDN
Treatment A	78.76	66.49	2.54	25.91	5.71	37.87	72.03
	81.96	69.19	2.64	26.96	5.94	39.41	74.95
	77.10	65.10	2.49	25.36	5.59	37.08	70.52
	76.49	64.58	2.47	25.16	5.55	36.78	69.96
	74.84	63.19	2.41	24.62	5.43	35.99	68.45
	77.83	65.71	2.51	25.60	5.64	37.43	71.18
	±1.05	±0.91	±0.03	±0.38	±0.08	±0.45	±0.99
Treatment B	74.59	62.98	2.41	24.54	5.41	35.87	68.23
	74.76	63.12	2.41	24.59	5.42	35.95	68.37
	81.24	68.59	2.62	26.73	5.89	39.07	74.31
	76.38	64.49	2.46	25.13	5.54	36.73	69.86
	69.14	58.38	2.23	22.75	5.01	33.25	63.24
	75.22	63.51	2.43	24.75	5.45	36.17	68.80
	±1.75	±1.48	±0.06	±0.57	±0.13	±0.83	±1.60
Treatment C	72.46	60.84	1.22	23.72	4.69	36.22	65.85
	66.76	56.06	1.12	21.86	4.32	33.37	60.67
	63.94	53.68	1.07	20.97	4.14	31.96	58.14
	60.20	50.55	1.01	19.71	3.90	30.09	54.71
	65.44	54.95	1.10	21.43	4.24	32.71	59.48
	54.58	45.83	0.92	17.87	3.53	27.28	49.60
	63.90	53.65	1.07	20.93	4.14	31.94	58.08
	±2.248	±1.91	±0.004	±0.07	±0.13	±1.13	±2.0573
Treatment D	64.22	53.92	1.08	21.03	4.16	32.10	58.37
	62.82	52.75	1.06	20.57	4.07	31.40	57.10
	49.59	41.50	0.83	16.18	3.20	24.70	44.91
	61.60	51.73	1.04	20.17	3.99	30.79	55.99
	58.79	49.36	0.99	19.25	3.81	29.38	53.43
	44.28	37.18	0.74	14.50	2.87	22.13	40.24
	56.88	47.74	0.96	18.62	3.68	28.42	51.67
	±0.023	±2.54	±0.004	±0.98	±0.21	±1.50	±2.752

Table 2.4 Mean Daily Intake of Digestible Nutrients from Concentrate Supplements (gm)

	DDM	DOM	DEEx2.25	DCP	DCP	DNFE	TDN
Treatment A	172.94	147.96	4.87	12.41	23.77	143.06	184.11
	192.13	164.37	5.41	13.79	26.41	158.94	204.55
	180.40	154.34	5.08	12.95	24.80	149.24	192.07
	160.78	137.56	4.52	11.54	22.10	133.01	171.17
	152.69	130.64	4.30	10.96	20.99	126.32	162.57
	171.79	146.97	4.84	12.33	23.61	142.11	182.89
	±6.25	± 5.36	±0.18	±0.45	±0.88	± 5.19	± 6.67
Treatment B	133.19	106.93	12.86	11.09	19.98	96.34	140.27
	160.99	129.25	16.54	13.41	24.15	116.45	169.55
	174.05	139.74	16.81	14.49	26.10	125.90	183.30
	167.10	134.16	16.13	13.91	25.06	120.87	175.97
	175.20	140.66	16.92	14.59	26.28	126.72	184.51
	162.11	130.15	15.65	13.50	24.31	117.26	170.72
	± 6.69	± 5.50	±0.67	±0.56	±1.05	± 4.94	± 7.22
Treatment C	171.29	145.84	21.48	18.16	43.61	99.84	183.09
	161.95	137.89	20.31	17.17	41.23	94.39	173.10
	161.08	137.15	20.20	17.08	41.01	93.89	172.10
	149.73	127.49	18.78	15.88	38.12	87.27	160.05
	155.50	132.39	19.50	16.49	39.59	90.63	166.21
	99.70	82.33	12.13	10.25	24.62	56.36	103.36
	149.88	127.18	18.73	18.84	38.03	87.06	159.67
	± 9.535	± 8.506	± 1.260	±1.055	±2.542	±6.631	±10.673
Treatment D	105.30	89.55	13.73	11.26	40.52	53.05	118.56
	77.87	66.23	10.16	8.33	29.97	39.23	87.69
	112.23	95.45	14.64	12.00	43.19	56.54	126.37
	113.11	96.20	14.75	12.09	43.53	56.99	127.36
	92.26	78.46	12.03	9.86	35.50	46.48	103.87
	77.26	65.70	10.08	8.26	29.73	38.92	86.99
	96.34	81.93	12.57	10.30	37.07	48.54	108.47
	±6.088	±5.186	±2.469	±1.836	±2.354	±3.057	±6.860

Table 2.5 Mean Total Daily Intake of Digestible Nutrients (gm)

	DDM	DOM	DEEx2.25	DCF	DCP	DNFE	TDN	ME(kcal)
	251.70	214.45	7.41	38.32	29.48	180.93	256.14	911.72
	274.09	233.56	8.05	40.75	32.35	198.35	279.50	994.85
	275.50	219.44	7.57	38.31	30.39	186.32	262.59	934.66
Treatment A	237.27	202.14	6.99	36.70	27.65	169.79	241.13	858.28
	227.53	193.83	6.71	35.58	26.42	162.31	231.02	822.31
	253.22 ± 8.59	212.68 ± 6.20	7.35 ±0.18	37.93 ±0.80	29.26 ±0.92	179.54 ± 5.63	254.08 ± 7.52	904.36 ±26.87
	207.78	169.91	15.27	35.63	25.39	132.21	208.50	742.15
	235.75	192.37	17.95	38.00	29.57	152.40	237.92	846.87
	255.29	208.33	19.43	41.22	31.99	164.97	257.61	916.96
Treatment B	243.48	198.65	18.59	39.04	30.60	157.60	245.83	875.01
	244.34	199.04	19.15	37.34	31.29	159.97	247.75	881.84
	237.33 ± 7.22	193.66 ±5.78	18.08 ±0 66	38.25 ±0.79	29.77 ±1.03	153.43 ±55.08	239.52 ± 7.50	852.57 ±26.61
	243.75	206.68	22.70	41.88	48.30	136.06	248.94	886.09
	228.71	193.95	21.33	49.03	45.55	127.76	243.67	867.34
	235.02	190.83	21.27	38.05	45.15	125.85	230.32	819.82
Treatment C	209.93	178.04	19.59	35.59	42.02	117.36	214.76	764.43
	220.94	187.34	20.60	37.92	43.83	123.34	225.69	803.34
	154.28	128.16	13.05	28.12	28.15	83.64	152.96	544.46
	215.44 ±11.976	180.83 ±10.237	19.79 ±1.281	38.44 ±2.557	42.17 ±2.665	119.00 ±6.852	219.39 ±12.968	780.91 ±46.177
	169.52	143.47	14.81	32.29	44.68	85.15	176.93	629.78
	140.69	118.98	11.22	28.90	34.04	70.63	144.79	515.38
	161.82	136.95	15.47	28.18	46.39	81.24	171.28	609.67
Treatment D	174.71	147.93	15.73.	32.26	47.52	87.78	183.29	652.42
	151.05	127.82	13.02	29.11	39.31	75.86	157.30	559.90
	122.54	102.88	10.82	22.76	32.60	61.05	127.23	452.87
	153.37 ± 7.272	129.67 ± 6.272	13.51 ±0.807	28.92 ±1.288	40.76 ±2.390	76.95 ±3.723	160.14 ± 7.918	570.01 ±28.086

Table 2.6 Mean Daily Dry Matter Intake (gm)

		Grass	Concentrate Supplement	Total
Treatment A		142.75	262.99	405.74
		148.55	292.17	440.72
		139.65	274.33	414.08
		138.65	244.50	383.15
		135.66	232.20	367.86
	Mean	141.07 ±1.985	261.23 ±9.541	402.31 ±11.278
Treatment B		135.20	198.76	333.96
		135.50	240.25	175.75
		147.25	259.74	406.99
		138.45	249.37	387.82
		125.33	261.45	386.78
	Mean	136.35 ±3.107	241.91 ±10.256	378.26 ±10.878
Treatment C	919	132.90	271.89	404.79
	860	122.45	257.06	379.51
	916	117.28	255.68	372.96
	921	110.41	237.67	348.09
	865	120.03	246.82	366.85
	939	100.11	153.49	253.60
	Mean	117.20 ±4.136	237.10 ±15.853	354.30 ±19.629
Treatment D	862	117.79	169.53	287.32
	884	115.22	125.38	240.60
	866	90.66	180.70	271.36
	897	112.99	182.12	295.11
	924	107.83	148.54	256.37
	926	81.22	124.39	205.61
	Mean	104.29 ±5.533	155.11 ±9.810	259.40 ±17.828

Table 2.7 Mean Daily Intake of Digestible Nutrients per kg Metabolic Size

Treatment	DM $gm/kgW^{0.734}$	ME $kcal/kgW^{0.734}$	DDM $gm/kgW^{0.734}$	DCP $gm/kgW^{0.734}$	DOM $gm/kgW^{0.734}$
	52.18	117.26	32.37	3.79	27.58
	50.86	114.80	31.63	3.73	26.95
A	54.85	123.80	36.49	4.03	29.06
	53.13	119.02	32.90	3.83	28.03
	40.40	108.20	29.94	3.48	25.50
Mean	50.284	116.616	32.666	3.772	27.424
	52.30	116.22	32.54	3.98	26.61
	50.30	113.37	31.56	3.96	25.75
B	56.90	128.19	35.69	4.47	29.12
	58.70	132.44	36.85	4.63	30.07
	56.51	128.83	35.70	4.57	29.08
Mean	54.942	123.81	34.468	4.322	28.126
	56.53	123.76	34.04	6.75	28.87
	53.34	121.90	32.14	6.40	27.26
C	56.75	124.74	35.76	6.87	29.04
	61.50	135.08	37.10	7.43	31.46
	58.86	128.88	35.45	7.03	30.06
	56.43	121.15	34.33	6.26	28.52
Mean	57.235	126.085	34.803	6.79	29.202
	47.55	104.23	28.06	7.40	23.75
	54.30	116.31	31.75	7.68	26.85
	49.36	110.89	29.43	8.44	24.91
D	43.39	95.93	25.69	6.99	21.75
	56.49	123.38	33.29	8.66	28.17
	52.64	115.94	31.39	8.35	26.34
Mean	50.622	111.113	29.932	7.92	25.295
	NS	*	*	**	*

Table 2.8 Carcass Analysis: Weights at Slaughter (kg)

	Slaughter Weight	Hot Carcass Weight	Cold Carcass Weight	Head	Offal	Pluck	Skin	Feet	Flesh	Bone	Sets	Shoulders	Blood	Loin	Ends	Leg	Fat
	14.65	6.83	6.23	1.26	1.61	0.67	1.47	0.51	2.36	0.75	0.64	1.96	0.62	0.96	0.58	2.09	-
	18.95	9.37	8.57	1.75	2.0	0.72	1.85	0.54	3.36	0.92	0.83	2.90	0.77	1.09	0.81	3.11	0.158
	15.70	7.63	7.03	1.27	1.71	0.71	1.59	0.52	2.73	0.78	0.80	2.26	0.69	0.94	0.67	1.36	0.056
Treatment	14.75	6.86	6.31	1.26	1.64	0.69	1.66	0.53	2.39	0.77	0.74	2.00	0.61	0.90	0.63	1.29	-
A	15.85	7.51	6.91	1.28	1.74	0.69	1.62	0.53	2.71	0.74	0.72	2.24	0.67	1.02	0.67	2.26	0.091
	12.50	5.47	4.97	1.25	1.33	0.71	1.44	0.53	1.85	0.63	0.63	1.51	0.45	0.71	0.54	1.58	-
	15.20	7.45	6.70	1.17	1.72	0.68	1.65	0.53	2.44	0.91	0.80	2.13	0.60	0.90	0.74	2.13	0.089
Treatment	14.60	6.91	6.21	1.26	1.60	0.67	1.57	0.53	2.35	0.75	0.79	1.98	0.65	0.88	0.61	2.02	0.029
B	13.10	5.66	5.29	1.25	1.38	0.69	1.47	0.51	2.00	0.65	0.67	1.62	0.58	0.71	0.54	1.74	-
	13.75	5.90	5.62	1.27	1.45	0.72	1.53	0.53	2.06	0.75	0.71	1.69	0.54	0.73	0.72	1.77	.041
	12.00	4.50	4.18	1.00	1.5	0.50	1.00	0.50	1.5	0.55	0.22	0.65	0.5	0.32	0.24	0.70	
	14.50	5.50	5.37	1.00	1.5	0.50	1.5	0.50	1.9	0.81	0.33	0.85	0.5	0.28	0.26	0.95	
Treatment	13.00	5.25	5.05	1.00	1.3	0.50	1.25	0.50	1.9	0.62	0.31	0.82	0.5	0.31	0.26	0.83	NO
C	10.60	4.00	3.76	0.75	1.09	0.57	1.0	0.31	1.4	0.48	0.26	0.54	0.25	0.21	0.19	0.68	FAT
	7.75	3.00	2.51	1.50	0.99	0.50	1.75	0.75	0.90	0.35	0.15	0.41	0.5	0.15	0.11	0.44	
	12.10	5.50	4.45	1.00	1.50	0.5	1.25	0.50	1.65	0.55	0.25	0.72	0.5	0.27	0.23	0.79	
	11.60	4.5	4.37	1.0	1.20	0.5	1.5	0.50	1.6	0.67	0.24	0.73	0.25	0.20	0.22	0.72	
	7.60	3.0	2.51	0.5	0.95	0.5	1.0	0.20	0.86	0.44	0.16	0.43	0.25	0.13	0.13	0.35	
Treatment	10.20	3.5	3.29	1.0	1.03	0.5	1.0	0.31	1.20	0.43	0.19	0.48	0.25	0.23	0.19	0.55	NO
D	11.75	4.5	4.16	1.0	0.96	0.5	1.0	0.25	1.50	0.53	0.23	0.68	0.25	0.25	0.19	0.78	FAT
	7.85	3.5	2.56	0.75	1.00	0.5	1.0	0.5	0.90	0.35	0.14	0.44	0.50	0.14	0.13	0.46	
	6.40	2.25	2.15	1.0	0.83	0.5	1.05	0.5	0.70	0.35	0.14	0.38	0.75	0.12	0.91	0.37	

Table 2.9 Parts as Percentages of Whole Animal

		Parts as Percentages of Slaughter Weight				
		Skin	Pluck	Offal	Feet	Head
Treatment A		11.40	4.60	11.00	3.51	8.63
		9.75	3.80	10.55	2.84	9.23
		10.10	4.50	10.90	3.28	8.06
		11.25	4.65	11.10	3.58	8.57
		10.25	4.48	10.95	3.35	8.10
	Mean	10.55 ±0.293	4.41 ±0.438	10.90 ±0.026	3.31 ±0.369	8.52 ±0.191
Treatment B		11.54	5.65	10.65	4.25	10.00
		10.65	4.40	11.10	3.43	7.55
		10.75	4.60	10.95	3.62	8.60
		11.25	5.25	10.50	3.92	9.54
		11.10	5.20	10.55	3.82	9.20
	Mean	11.056 ±0.141	5.02 ±0.204	10.75 ±0.176	3.81 ±0.3[illegible]3	8.98 ±0.393
Treatment C		8.70	4.35	13.04	4.35	8.70
		11.11	3.70	11.11	3.70	7.41
		10.20	4.08	10.61	4.08	8.16
		10.12	5.75	10.99	3.11	7.59
		18.42	5.26	10.47	7.89	15.79
		9.43	8.87	11.32	3.77	7.55
	Mean	11.33 ±1.329	5.38 ±0.713	11.26 ±0.344	4.48 ±0.641	9.20 ±1.283
Treatment D		13.64	4.55	10.91	4.55	9.09
		13.42	6.71	12.71	2.68	6.71
		10.46	5.23	10.49	3.20	10.46
		9.52	4.76	9.14	2.38	9.52
		12.12	6.06	12.12	6.06	9.09
		13.46	6.41	10.59	6.41	12.82
	Mean	12.10 ±0.653	5.62 ±0.333	10;99 ±0.474	4.21 ±0.647	9.62 ±0.744

Table 2.10 Carcass Analysis:- Parts as percentages of whole animal

	Live-Wt at Slaughter (kg)	Cold Carcass (kg)	Dressing out Percent-age	Joints as Percentages of Cold Carcass							
				Leg	Shoulder	Loin	Sets	Ends	Flesh	Bone	Fat
Treatment A	14.65	6.23	42.51	33.48	31.51	15.44	10.25	9.32	75.81	24.19	
	18.95	8.57	45.21	36.26	33.85	12.76	9.68	9.45	78.45	21.55	1.844
	15.70	7.03	44.76	33.56	32.15	13.41	11.35	9.53	77.75	22.25	0.797
	14.75	6.31	42.75	32.34	31.64	14.33	11.73	9.96	75.68	24.32	
	15.85	6.91	43.60	32.65	32.46	14.74	10.45	9.70	78.55	21.45	1.317
Mean	15.98	7.01	43.766	33.658	32.32	14.36	10.692	9.59	77.248	22.752	1.319
			±0.478	±0.619	±0.374	±0.425	±0.334	±0.031	±0.563	±0.563	±0.0781
Treatment B	12.50	4.97	39.75	31.84	30.47	14.24	12.68	10.77	74.51	25.49	
	15.50	6.70	43.22	31.86	31.75	13.36	11.97	11.06	72.84	27.16	1.328
	14.60	6.21	42.56	32.45	31.84	14.16	12.75	9.80	75.56	24.44	0.467
	13.10	5.29	40.37	32.81	30.68	13.47	12.75	10.29	75.45	24.55	
	13.75	5.62	40.91	31.48	30.14	12.91	12.69	12.78	73.33	26.67	0.730
Mean	13.24	5.68	41.36	32.09	30.976	13.628	12.568	10.94	74.338	25.662	0.842
			±0.739	±0.213	±0.436	±0.225	±0.134	±0.454	±0.491	±0.491	±0.065
Treatment C	12.00	4.184	36.38	33.65	31.05	15.34	10.66	11.33	73.10	26.90	
	14.50	5.37	39.80	35.19	31.58	10.53	12.13	9.77	70.2	29.80	
	13.00	5.05	41.25	32.87	32.50	12.17	12.43	10.34	75.43	24.57	
	10.60	3.76	38.09	36.13	28.70	11.39	13.74	10.07	74.43	25.57	
	7.75	2.51	26.37	35.09	32.95	11.62	12.01	8.54	72.00	28.00	
	12.66	4.45	33.61	35.30	32.25	12.33	11.05	10.24	75.00	25.00	
Mean	11.66	4.222	35.92	34.705	31.505	12.23	12.003	10.048	73.36	26.64	
	±0.626	±0.380	±2.006	±0.448	±0.408	±0.615	±0.416	±0.339	±0.745	±0.745	
Treatment D	11.60	4.37	39.76	32.98	33.47	9.21	10.86	9.83	70.59	29.41	
	7.60	2.51	33.62	27.66	34.09	10.70	12.77	10.66	66.10	33.90	
	10.20	3.29	34.41	33.71	29.41	13.68	11.75	11.64	73.53	26.47	
	11.75	4.16	39.63	37.39	32.64	12.16	10.97	9.34	73.94	26.06	
	7.85	2.56	31.03	36.21	34.14	11.17	10.82	10.00	72.00	28.00	
	6.40	2.15	27.53	34.33	35.19	11.39	12.69	8.52	66.67	33.33	
Mean	9.23	3.178	34.33	33.728	33.157	11.385	11.643	9.998	70.472	29.528	
	±0.55	±0.361	±1.789	±1.265	±0.750	±0.556	±0.339	±0.402	±1.190	±1.190	