GENETIC AND ENVIRONMENTAL EFFECTS ON THE GROWTH RATE OF YANKASA LAMBS

BY

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A Thesis

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

W. Akin. Hassan

Date: 6th January 1988

CERTIFICATION

This thesis entitled 'Genetic and Environmental effects on the growth rate of Yankasa lambs' by W. Akin. Hassan, meets the regulations governing the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

Lambs of Yankasa sheep were evaluated for effects of genetic and environmental factors on their body weights at birth, 3,6,9 and 12 months of age. The lambs were born between 1981 and 1985 in an on-going accelerated lambing programme at National Animal Production Research Institute (NAPRl), Nigeria,

Type of birth significantly affected weights from birth to 12 months of age. Lambs born as singles were consistently heavier at all stages with the difference being most pronounced at weaning. Ram lambs were 0.22kg and 4.88kg heavier than ewe lambs at birth and 12 months of age, respectively. The effect of parity of ewe on lamb growth was significant at birth, 3 and 6 months of age. Lambs born during the rainy season had higher mean weights at birth and weaning. The order was however reversed at 6 months with lambs born during the dry season being heavier, though the difference was not significant. Effect of season was therefore significant at birth, 3 and 12 months of age only. Lambs born in 1981 had the heaviest mean weights from birth to 6 months of age. The superiority of the lambs sired by the fourth sire-group was maintained from weaning to one year.

Additive adjustment of lamb weights for the identified environmental factors was prefered to multiplicative adjustments because of larger reduction of error variances associated with these factors.

Estimates of repeatability for weights were 0.14, 0.06, 0.19, 0.28 and 0.17 at birth, 3, 6, 9 and 12 months respectively. Corresponding estimates for heritability were 0,22, 1.14, 1.06, 0.94 and C.51. Genetic and phenotypic correlations between birth weight and weaning weight, weaning weight and 6-month weight, and weaning weight and 9-month weight were found to be 0.10 and 0.17, 0.27 and 0.43, and 0.17 and 0.39, respectively.

It was concluded that under this environment, it would be necessary to adjust body weights of growing lambs for the effects of type of birth, sex of lambs, parity of ewe, season and year of lambing.

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1. INTRODUCTION

Sheep in Nigeria are kept primarily for meat production. They contribute about 11% (48,00 metric tons) to the total meat supply (Adu and Ngere, 1979). Buvanendran et al. (1981) noted that there was no particular preference for lamb or mutton and so the market values of animals are determined by the size. Thus, traits of importance in commercial sheep production are reproduction and milk production in the ewe and growth rate in the lamb. In other words, the number of lambs weaned per ewe per year and how fast the lambs grow to mature market weights greatly determine the returns from commercial sheep. production.

To increase meat yield and economic returns from the indigenous sheep breeds will require genetic improvement through proper selection and breeding programmes. The performance of animals for any production purpose has been known to be greatly influenced by different environmental (internal and external) factors. Therefore selection if genetically superior animals as parents can only be successful if the influence of such factors can be disetangled and the performance records of animals adjusted so that the adjusted data would more closely reflect the true genetic worth of the animals. Such procedures form the basis of various breeding programmes adopted in most developed countries for the improvement of various economic traits of farm animals. These have been facilitated by the availability of data on large numbers of animals; a situation that could hardly be met in the less developed/developing nations in general and Nigeria in particular due chiefl to mostly extensive system of management.

Nonetheless, very few studies have been carried out in Nigeria to identify some genetic and environmental factors influencing weights of lambs at various stages of growth and probably correct for them in the final evaluation of the animals (Nwagbogu, 1969; Ademosun, 1973; Adu, 1978; Ngere et al., 1979; Buvanendran et al., 1981; Taiwo et al., 1982; Adeleye, 1984).

Of the Nigerian breeds of sheep, Yankasa is perhaps the most widely distributed and most numerous in the northern part of the country as it occurs throughout the Sahel, Sudan and Guinea Savanna zones. Despite its wide distribution only one of the cited studies (Buvanendran et al., 1981) gave estimates of correction factors for some effects in the breed. This calls for more study towards the genetic improvement of the sheep breed, hence the need for this work. The main objectives of this study therefore were:

(a) to quantify the effect of environmental and genetic factors influencing weights of Yankasa lambs at various stages of growth.

(b) to compare the effect of two types of correction

(c) to determine the relationship between pre- and post-weaning growth traits.

(d) to estimate genetic parameters for lamb weights at different ages.

2. REVIEW OF LITERATURE

2.1 SHEEP PRODUCTION IN THE TROPICS

Sheep are maintained in the tropics mainly for production of meat, their other functions being to supply skins, milk and fiber (Williamson and Payne, 1968). In addition, they are used as investments, as insurance against the failure of crops, for purposes of ownership, for slaughter during festive occasions, for recreation, for transport, as a source of manure or fertilizer and also as experimental animals. Sheep also supply horns, hooves, blood for serum, blood and bone meal all of which have commercial value (Devendra, 1976b).

According to 1976 FAO Production Yearbook (FAO, 1976), the less developed countries, most of which are located in the tropics and sub-tropics possess approximately 400 million sheep or about 39% of the total world population; the highest population (160 million or 15.4%) is found in Africa. Sheep in the less developed countries contributed about 46% of the world mutton and lamb production, 47% of the world's sheep milk and 40% of the total world sheep hide and skin production.

However, despite high concentration of sheep in the less developed countries, particularly in Africa, the present level of productivity is generally low. This low productivity will persist until improvements are made in husbandry, management, organized breedings and disease control (Devendra, 1981). This review, therefore, attempts to examined briefly the various aspects of sheep production in the tropics with particular reference to Nigeria, and to relate the contributions of past research work in breed performance evaluation with a view to improving the nation's sheep industry.

2.1.1 SYSTEMS OF PRODUCTION

Any discussion on the productive performance of sheep breeds in the tropics, particularly in Nigeria, cannot be complete and meaningful without a description of the system under which the animals are kept and managed. Devendra (1976a) classified the systems of sheep production in the tropics and subtropics into four categories and noted that the type of husbandry which is appropriate depends on the type of animal available as well as on the natural environment (climate, vegetation, disease) and economic and social factors. The systems are:

a) Intensive System: In this system, the animals are fed in confinement with limited access to land; cultivated grasses and/or by-products are fed. It is by definition a system with a high labour and capital input. The continuous housing, however provides maximum protection from the adversities of difficult environments. The system is very convenient for the control of feeding and mating. A variation of intensive production based on a stall-feeding approach is feedlot fattening especially in environment where agro-industrial by-products are plentiful (Salah et al., 1970; Aud and Brinckman, 1981).

b) Extensive System: This is by far the most common production system. Sheep graze over large areas, usually on low rainfall marginal lands unsuitable for alternative forms of agriculture. For instance, the Fulani being semi-nomads graze from North to South of the country in response to rainfall pattern and availability of pasture (Adu and Ngere, 1979). A very low level of mostly unpaid

family labour represents the main labour input. The system is characterized by the fact that more animals tend to be raised than in the intensive system. Also little or no concentrate, salt or mineral licks are provided. Extensive husbandry systems provide least protection from the natural environment.

c) Semi-intensive System: According to Devendra and Burns (1970) the system covers all degrees of compromise between range management and zero grazing, but usually involves controlled grazing of fenced improved pastures with supplementary concentrate feeding. In the southern part of Nigeria, sheep are left to roam, especially during the day, browsing roadside herbage and consuming kitchen wastes like yam and plantain peels. During the cropping season, the animals are tethered either on fallow fields or in the compound. In the evening or early morning, they may be given supplementary feeds in the form of chopped cassava roots, plantain, grain and some herbage. The compound system practised by the Hausas in the northern part of Nigeria is also semi-intensive. Those people keep the animals in their compound during the wet season and feed them on freshly-cut grass. During the dry season, animals are allowed to roam and fend for themselves. Some of the farmers feed their animals on crop residues such as groundnut haulms, husks, grain offals and cottonseed. An insignificant proportion of Nigeria's sheep population (Adu and Ngere, 1979) is managed semi-intensively on government and research farms.

d) Integration with cropping systems: This involves basically the integration of animals with plantation crops (Devendra, 1978). It has been practised in some countries and the nature and extent of the integration depend on the type of crops being grown and the relative importance of sheep. For example, in Sri Lanka, Malaysia, Indonesia and the Phillipines, sheep undergraze coconut, oil palm or rubber plantations. The system results in increased fertility of the land via the return of dung and urine, control of waste herbage, reduced fertilizer wastage, easier management of the crop and possibilities of increases in crop yields and greater economic returns. Though this husbandry system is not yet popular in Nigeria's sheep industry, it could be fully exploited especially in the forest and guinea savanna zones of the country where there are well established government-owned and private plantations.

2.1.2 Constraints to increased productivity

The present level of productivity of tropical breeds of sheep is generally low, due to a combination of factors such as under-feeding, disease, poor husbandry and poor quality of genetic resources (Devendra, 1981). As a broad generalization (Gatenby, 1982) the major factors limiting the productivity of sheep in Africa appear to be poor nutrition in the semi-arid areas and disease in the more humid areas. Drinking water may appear to be more critical than nutrition in some dry areas, and water and food are obviously closely related.

Oyenuga (1963) attributed the low productivity of Nigeria's indigenous livestock population to the inadequate and unbalanced nutrition, disease and lack of attention to sound management that exist under the traditional system of husbandry. On the other hand, records of the performance of indigenous livestock breeds managed under the organized systems of production practised on some of the government stations and university experimental farms have consistently shown better performances. Such results to some extent indicate the promising prospects of increased production that may derive from the application of improved systems of production to the indigenous livestock population (Adu, 1975; Adu and Ngere, 1979).

A brief discussion of the major production constraints and their direct and indirect influences on sheep performance in the tropics in general and in Nigeria in particular is hereby given:

a) Nutrition and husbandry practices: Of the various environmental factors which limit production from tropical and sub-tropical sheep, nutrition is by far the most important (Devendra, 1981). Even when there appears to be an adequate quantity of vegetation available (Gatenby, 1982), nutrient content in terms of metabolizable energy, digestible protein, and minerals may be poor. In semi-arid areas the main problem occurs in the dry season and strategies to ameliorate the problem can be divided into those which attempt to improve nutrition in the dry season and those which attempt to improve nutrition throughout the year. These reports truly describe sheep production in

Nigeria where about 50% of the total sheep population are managed by the Fulani pastoralists. The Fulanis, being semi-nomads, are ever in a cyclic movement in search of food and water for their animals, resulting in a corresponding cyclic gain and loss in body weights for the animals. Oyenuga (1963) attributed the poor conformation of Nigerian animals, their leggedness and the low qualities and toughness of their meat to bad and poor feeding which in no doubt has persistently been the principal factor limiting their productivity. He recommended the intensification of the programme for settled animal husbandry through farm settlements and co-operative farms for livestock owners as the general solution to the improvement of livestock production in our country.

According to 1966 FAO Production Yearbook (FAO, 1966), the traditional system of husbandry in which the majority of the sheep in Nigeria depend on the overgrazed ranges for their subsistence is not efficient enough to meet the present needs nor the increasing demand for mutton which was estimated to rise by 70% by the year 1979/80. Ademosun (1973) noted that as long as our sheep and goats in Nigeria continue to live on waste products from kitchen and traditional waste products such as bran from maize or peels from cassava and yams and cattle roam about the country side grazing on coarse bush savanna land without our planning for adequately feeding them, so long will their level of productivity be low.

b) Disease: One of the main constraints on sheep production in the tropics and the sub-tropics is the high

incidence of diseases. Economic loss due to disease and parasites is probably high, and in densely populated areas where the veterinary and diagnostic services are weak the losses could be considerable. It is perhaps worth stressing that in adults the most severe effects of disease and parasites are manifested in production losses, including reduced growth rate and problems of fertility (Devendra, 1981; Gatenby, 1982).

In Nigeria, Ferguson (1964) studied the performance potentials of Uda and Yankasa and their crosses with Merino and Black Headed Persian at the Katsina Livestock Investigation and Breeding Centre (LIBC) and found that the successful elimination and control of helminths resulted in better live weight gain, Kuil (1970) also reported that gastro intestinal helminthiasis was the most serious disease problem among Uda and Yankasa sheep. Ikede (1974) reported that occurrence of mycotic diseases on the West African Dwarf sheep which have resulted from some other conditions such as chronic parasitism, bacterial infections and malnutrition and concluded that improved sanitation in the farm can help reduce incidence of these diseases. Veen (1974) reported that settled herds are more affected by parasitic diseases than the true nomadic herds. The finding of Kuil (1970) was confirmed by Olubajo (1976), and Adu and Ngere (1979) who reported that the high incidence of helminthios and pneumo - gastroenteritis ("Kata") accounted for a high percentage of mortality especially under intensive system of management.

c) Quality of genetic resources: Oyenuga (1958) described all the Nigerian domestic livestock, in comm n with others in West Africa, as slow in their rate of growth, late-maturing, restricted in productive capabilities and economically less desirable as converters of feed into animal products than the corresponding European breeds. Along the same line, Williamson and Payne (1968) reported that breeds of tropical sheep, judged by the standards of the temperate zone, respond poorly to good feeding and on their normal grazing grow comparatively slowly and never become fat. The lambs respond to good feeding more by an increase in vitally than size and as adults or near adults most of the feed above that required for maintenance is used in the production of body fat which does little to improve the quality of the meat, and in the living animal may be a misleading indication of it. Devendra (1981) however attributed generally poor performance of sheep in the tropics and the sub-tropics to inadequate knowledge of the value and productive capacity of indigenous breeds and limited purposeful selection and breeding.

2.1.3 Prospects for improvement.

The brief elucidation of the major production constraints on improved performance of sheep in the tropics as a whole does not only diagnose the problem at hand but also serves a pointer to possible manipulations of the prevailing circumstances in order to achieve, very economically, the much-needed increased production from the species. Oyenuga (1963) pointed out that to raise the efficiency of Nigerian farm animals, it would be necessary

to develop available feed resources and to evolve breeds of livestock capable of utilizing them to advantage. It is generally accepted that this should involve improvements in husbandry practices and breeding schemes. Therefore a meaningful search for increased productivity of sheep in the tropics should resolve around these two areas. Some of the efforts made in this country and elsewhere towards the realization of this much desired goal are reviewed.

a) Improved systems of husbandry: It is becoming more and more obvious that animals must be kept in the kind of environment that allows them to show their genetic merit (Lasley, 1978). In considering future prospects for sheep industry, it is therefore, essential first to improve the environment to avoid diseases and pests, and to provide correct and adequate nutrition through the supply of feeds. In order to increase the production from sheep in the less developed countries (Devendra, 1981), every effort must be made to ensure that animals are well fed quantitatively and qualitatively through application of current concepts of applied nutrition. Furthermore, vigorous research on animal diseases with the primary aim of reducing production loss represents another potential means of increasing productivity from sheep breeds in the tropics.

In Nigeria, Adu and Ngere (1979) pointed out that improvements in the traditional management systems by introduction of supplementary feeds during critical animal's productive life could lead to increases in prolificacy and weight gains in our indigenous sheep breeds.

b) Breeding Schemes: The small size of most sheep in Africa has sometimes been attributed to inbreeding. However, due to communal grazing, deliberate policy to swap animals (swapping breeding animals takes place in Nigeria), transfer of animals between relatives and friends, and financial transactions involving sheep, the amount of inbreeding in tropical sheep flocks is probably mininized. Harsh environment and poor nutrition are therefore probably more important causes.

Conservation of the indigenous breeds: The local breeds constitute an irreplaceable stock of adapted germ plasm and should be conserved for both present and future use (Mason and Buvanendran, 1982). It is most important that the utility of the local breeds should be demonstrated by comparing them with temperate breeds (in overall production efficiency not merely in short-term milk yield or growth rate) so that they are not decimated by premature programmes of cross-breeding and replacement. Adu and Ngere (1979) suggested that the introduction of a system where ram lambs are purchased from farmers, performance-tested at government controlled stations, and the superior rams sold to the farmers at subsidized rates could lead to genetic improvement in Nigerian breeds of sheep.

Cross breeding: This is a mating system often used by the producers of market animals to combine the desirable traits of two or more breeds in their crossbred offspring. This has been used to advantage in sheep industry of some developed countries. In the tropics however there have been few

successful systematic crossing programmes. This is not because heterosis has been shown to be absent. In fact, there have been few experiments designed to detect it and little data on which it could be studied. Also, sheep in the dry tropics are kept extensively on the range and under these conditions it is not possible to cross with an unadapted breed, however productive it may be in its home environment. In the wet tropics, sheep are kept on a subsistence basis by small holders and in small numbers. These could not easily support the sophistication of even the smallest crossing scheme (Mason and Buvanendran, 1982).

Nevertheless, Gatenby (1982) reported that attempts to improve the productivity of sheep earlier in this century in Africa concentrated on the importation of exotic breeds and indigenous sheep were "improved" by cross breeding. He noted that this approach was unsatisfactory except in a few areas such as the highlands of Kenya. One of the main reasons for failure was the poor quality food available for sheep. Disease also caused problems as importation of animals into the tsetse belt resulted in high mortality.

2.2 Nigerian Breeds of sheep and their performance characteristics

The indigenous sheep breeds are found in different ecological zones of the country in accordance with the climatic and vegetational characteristics. Hill (1964) reported that Nigerian hair sheep include the Northern long-legged, large breeds - Yankasa and Uda and the dwarf

in the southern area of the country. Adu and Ngere (1979) described four main breeds of sheep indigenous to Nigeria and noted that the breeds differ considerably in size, coat-colour and other characteristics though they are all hairy. The breeds are:

a) Balami: The breed is named after the tribe 'Bornu' that owns it in large numbers. It is most predominant in the North Eastern part of Nigeria and the heaviest breed of sheep in Nigeria. The Balami is predominantly white with a pronounced convex head. It has a dewlap - like fold of skin with white mane. The ear is large and droopy and the tail is long. Horns are prominent in rams and are usually absent in ewes.

b) Uda: The breed is also called 'Fulani' after the tribe that has the largest concentration of this breed. It occurs throughout the Sahel-Sudan vegetation zone of Nigeria. Uda is a large and long-legged breed with a convex facial profile. It has a characteristic coat - colour pattern which is entirely brown or black from the forehead to the lumber-abdominal girth line and white posteriorly. The ears are long, large and pendulous. The rams have large, wide and spiral horns which are usually absent in the ewes. The breed appears to thrive in hot, dry environments and suffers from poor survival outside the ecologic zone. It is particularly adapted to extensive grazing and is renowned for its trecking abilities.

c) Yankasa: Also called 'Hausa' after the tribe that owns it in large numbers. The Yankasa is perhaps the most widely distributed and most numerous breed of sheep in the northern

part of Nigeria because it occurs throughout the Sahel, Sudan and Guinea Savanna zones. A strain of the Yankasa called the "Biu local" occurs mainly in Bornu State. In size it is intermediate between the Uda and the Southernly West African Dwarf sheep. The body colour of Yankasa is typically white with black patches around the eyes, ear, muzzle and sometimes the feet. The rams have curved horns and heavy hairy white mane, some of the ewes have tassels on the neck.

d) West African Dwarf (WAD) sheep: The breed has been described as Fouta Djallon, Djallonke (Mason, 1951). Within Nigeria the breed is variously called southern forest sheep (Orji et al., 1977) or Nigeria dwarf sheep (Adu, 1972). The breed is the most widely distributed in the hot and humid coast area south of latitude 14°N. Within this wide geographical range variations in type are found. Different names have been used to describe the varieties found in particular localities. For example, the "Pagan" sheep on the Jos Plateau, "Umuahia" sheep in the Eastern states. The West African Dwarf is a small (almost half the size of the Northern breeds), compact hardy breed with a wide range of coat colours which may be all white, black or brown or spotted black or brown on a white coat. The breed is characterized by a smart appearance with a timid disposition. West African Dwarf is tolerant to trypanosomiasis and is said not to respond to extensive (range) management. Mature rams have close spiral horns and a heavy mane of hair.

Reproductive performance: Sheep in Nigeria can breed throughout the year (Hill, 1960) although some months favour lambing more than others (Molokwu and Umunna, 1980, Buvanendran et al., 1981). Ferguson (1964) also reported that Nigerian sheep have excellent reproductive performance.

Ngere et al. (1983) reported that due to small size, West African Dwarf sheep should be bred at the age of one year and above. Chiboka (1979) however found that WAD and WAD x Permer ewes could be successfully bred at 8 months of age. Findings of other workers on the reproductive parameters of Nigerian sheep are summarized in Table 2.2(a).

Birth Weight and Growth Performance; Birth weight in the indigenous sheep is known to be affected by breed, season of birth, sex of lamb and age of the ewe. The bigger northern breeds generally have heavier birth weights than the southern dwarf breed. Birth weights recorded for the indigenous sheep at different locations are shown in Table 2.2(b). In all these observations, singles were heavier than twins at birth.

Because sheep are used mainly for meat production in Nigeria, rapid growth rate is of considerable importance for efficient meat production. Lamb birth weight is, of course, one of the most important factors influencing growth as a high birth weight confers an initial advantage which, other things being equal will be maintained at least until weaning (Adu et al., 1978). Reported growth rates in the

indigenous sheep (Adu and Ngere, 1979) show wide variation, but there seems to be significant differences between the breeds. Dettmer et al. (1976) found that Nigerian Dwarf sheep were early maturing but they were small and almost finished their growth by two years of age. Pre-weaning growth rate in the indigenous sheep is slow with the result that the animals are weaned at comparatively lighter weights (Nwagbogu, 1969; Adu, 1978).

Meat Production: There is not much information on the carcass characteristics of the indigenous sheep. Hill (1960) reported absence of subcutaneous and internal fat deposition in the Dwarf sheep. However, Ferguson (1964) found that Uda and Yankasa carcasses contained much fat. Adeleye and Oguntona (1975) found small amounts of subcutaneous and internal body fat in the Dwarf sheep and noted that sex effect on the body composition was not apparent before maturity. Adu and Ngere (1979) gave values obtained by workers for yield and carcass traits of the indigenous sheep. One might conclude from these values that the indigenous sheep have good potentials for meat production that can be exploited through better management.

Milk Yield and Composition: There is a dearth of information on this performance trait for the indigenous sheep. Tosun (1972) found that the low milk yield of the Dwarf sheep was not sufficient to rear her lambs. Adu (1975) reported that milk yield in the Dwarf sheep was comparatively lower than those recorded for temperate breeds of sheep during

a 10 or 14 week lactation, but the shape of the lactation curve was similar to that reported elsewhere. In Yankasa and cross-bred ewes, Ehoche et al. (1983) reported a significant effect (P/0.05) of age of ewe on cumulative milk yield at 8 and 12 weeks of lactation with the 4 year-old ewes producing more milk than 3 year-olds and the crossbreds significantly (P/0.05) produced more milk at all stages of lactation than the Yankasa ewes. Breed of the ewe had a significant (P/0.05) effect on the fat content of the milk but age of the ewe did not influence the fat and protein contents.

Lamb mortality and Diseases: Lamb mortality is influenced by birth weight and type of birth (Nwagbogu, 1969; Adu et al., 1978). lamb sex and season of lambing (Nwagbogu, 1969; Adu, 1978, Taiwo, 1979). It usually reduces after 4 months of age (Adu, 1978). Adegbola and Obioha (1978) found that cold, skin disease, diarrhoea, cough and foot-rot were the major problems to increased production of Nigerian Dwarf sheep in the Southern Nigeria, For the indigenous sheep, Dettmers et al. (1976) and Molokwu and Umunna (1980) reported 12-29% pre-weaning mortality. 3-11% adult mortality was reported by Nuru (1985).

2.2.1 Selection Programmes in Sheep in the Tropics

Genetic improvement of sheep in developed countries in the early days concentrated on growth and meat conformation, or on wool weight and quality. It has been realized however, that reproductive rate is the most

important factor whether wool or meat is the main product and that selection on high wool or body weight without adjustment for litter size at birth could lead to selection against twins and so a lowering against twins of reproductive rate (Turner, 1961). This realization has led to selection programmes aimed at increasing the reproductive rate of pure breeds (Turner, 1977) and to crossing programmes with prolific breeds such as the Finn (Donald et al., 1968). In Africa as in the rest of tropics where sheep are exploited for meat, milk, skins and pelts, the main characteristics important for production are reproductive rate, body weight and early high growth rate.

In formulating selection schemes, certain flock characteristics inherent in the production systems in the tropics should be recognised. In general, flock sizes are large in breeds kept extensively, but recording in these flocks is often unpracticable. On the other hand, the flock sizes of breeds kept semi-intensively are too small for effective selection procedures. Some of the most prolific breeds of sheep (Mason, 1980a) are kept under these systems. For example (D'Man of Morocco, Priangan of Java, Barbados Black-belly of tropical America). Breeding programme should therefore give consideration to selection in institutional flocks or group breeding schemes.

a) Selection for reproductive rate: Reproductive rate can be increased either by raising the number of offspring at parturition or by decreasing the period between parturitions. In tropical countries, where breeding seasons are long, and nutritional levels frequently low, the second may be the more practical course, as ewe might find difficulty in rearing more than one lamb. There is considerable interest around the world in increasing the frequency of parturition and there have been some success. There is little information so far, however, on the effect of more frequent parturition on total lifetime productivity. With the year round reproduction which occurs in Africa , there is scope for research on the heritability of the parturition interval and the effect of decreased parturition interval on lamb survival and growth (Turner, 1982).

Where multiple births are considered, selection for this is more likely to increase reproductive rate than selection against barrenness. Traits associated with reproduction are usually considered to be lowly heritable (Young and Turner, 1965), but in spite of this, response to selection has been obtained (Turner, 1978). Failure to lamb at the first lambing in some sheep breeds may not indicate poor performance; selection should be based on more than one record, On the other hand, ewes which produce more than one lamb at their first lambing are likely to be good performers.

The simplest method of selection for reproductive rate is to select rams from among the multiple - born lambs on the basis of other criteria such as growth rate or wool. In the case of ewe lambs, all lambs born in multiple births are chosen and the balance required is made up from single lambs. When full lambing and pedigree records are available, lambs are selected on the basis of a dam's index which combines data of all her lambing records.

b) Selection for growth rate: Where sheep are kept primarily for meat production, selection will be on the number and weight of offspring weaned per female per year. The genetic correlation between prolificacy and growth rate is positive and therefore selection for both traits can be done simultaneously without any danger of antagonism. Where selection is for weaning weight as in advanced sheep-raising countries where weaned lamb is the end product of meat breeds of sheep, the growth rate should be adjusted for the effects of age at weaning, type of birth and age of dam. However, when trait selected is weight at a later age as is the case in the tropics where animals are rarely slaughtered at weaning, adjustments are unnecessary as these traits are not much influenced by the above factors (Mason and Buvanendran, 1982).

2.2.2 Selection Techniques in the Tropics

Techniques for genetic improvement include selecting between breeds (or strains), selecting within breeds and crossing. Crossing includes grading up, developing new breeds and exploiting heterosis.

2.2.3 Selection between breeds: Many international meetings over the last few years have stressed the need to look more closely at indigenous (also called local or native) breeds, because of their adaptation to their environments, instead of assuming that importation of a so-called "improved" breed is a short cut to increased production. An important characteristics of tropical sheep is their adaptation to the environment. The harsh, arid tropical environment exerts a profound influence on the productivity of sheep. Nutritional deficiencies and climatic extremes impose a restriction on production during much of the year. Thus, the most important economic characteristic required in tropical sheep kept under current management systems is adaptability to the environment. Tropical breeds have acquired this characteristic through a long period of natural selection and therefore sheep improvement programmes in the tropics should rely largely on genetic improvement of adapted breeds. Selection between breeds will therefore mean comparing indigenous breeds as well as comparing an indigenous with and exotic or its cross, as in the past, Selection between breeds must be based on performance data collected from groups run in the same environment. Comparisons in the past have usually been on experiment stations; there is a great need for them to be made in the environment where the animals will run. Comparisons should be made in order to give realistic estimates of lifetime production of not only measures of products such as body, fleece or milk weights but also reproduction, mortality and morbidity rates.

2.2.4 Within breed selection: Selection is usually done within a flock, that is, among animals of the same age which have been run together. Due to the traditional husbandry systems often practised in tropical and sub-tropical areas the wisest policy for improvement would be to carry out selective breeding in seedstock flocks. These flocks could in turn serve as a reservoir of stocks for upgrading the local population. But the environment for the seed stocks must be carefully considered if the results are to be applied in practices. Flock owners may refuse to accept rams produced at a government experiment station unless they have reasonable confidence that the rams offered to them will contribute to their flocks. In the seedstock flocks emphasis should be given to prolificacy of ewes such as regular lambing and, possibly frequency of twining. Most tropical breeds appear to have reasonably good lambing rates already. Emphasis on twining should depend upon the level of environment; twin lambs may be a disadvantage where feed supplies are poor, but in general twin production is profitable.

2.2.5 Crossing: Crossing may be between indigenous breeds or between indigenous and exotic breeds. Very often in the past it has been assumed that exotic breeds from temperate areas, with high production in their homeland will automatically raise productivity when crossed with local breeds in tropical areas and very

often the introductions have failed (Turner, 1982). One would expect that meat production of tropical sheep could be improved by some sort of systematic crossing system, as with beef cattle, based on the local breed and on an improved mutton breed, No such programmes have developed. There have been sporadic crossbreeding trials but none left permanent results. Even in subtropical countries such as Iran and Afghanistan, Yalcin (1979) concluded that the results of experimental crossbreeding had not been sufficiently encouraging for it to be extended to the much poorer environmental conditions in the field. In addition to the prevailing unfavourable nutritional and management conditions, there is the difficulty of natural mating between thin-tailed foreign rams and fat-tailed native ewes. In the tropics attempts have been somehow discouraging. Wool and meat-wool breeds have been imported off and on into Java since 1864 but no trace of these early imports remains (Mason, 1981). Ferguson (1964) reported that crossing of Yankasa and Uda breeds of Nigeria with Merino imported from South Africa and East Africa did not improve lambing interval in the two breeds. He however noted that Merino x Yankasa crosses exceeded the Yankasa by 2.6 to 16.6% in growth rate with the superiority increasing as the animal grew older, while the Merino x Uda crosses were superior at earlier ages. No significant differences were observed in the dressing percentages of the two local breeds and their

crosses with Merinos. Lambing per ewe per year and lambing interval and percent singles were improved by cross breeding of Uda ewes with Merino rams; crosses were inferior when Yankasa ewes were used. Adu et al. (1978) studied the reproductive performance of the indigenous Uda and Yankasa sheep and their crosses with Suffolk. They reported that fertility, livability and overall production efficiency were generally higher in the crossbreds than for the indigenous breeds. Ademosun (1985) however, noted that crossbreeding particularly with exotic breeds has not been beneficial and suggested that we perhaps should be more inward looking by first improving our local breeds by selection for desirable characters within breeds and if crossbreeding was to be done at all it should be between adapted local breeds such as Yankasa and West Africa Dwarf sheep.

Grading up: Involves replacement of one breed by another with continual back-crossing, while development of a new breed means crossing of two (or more) breeds, then at some stage mating inter-se with selection. Most of the sheep crossbreeding in the tropics has been in the form of grading-up or the formation of new breeds.

Exploitation of heterosis: This is a technique widely used in Europe and North America particularly with cattle. It is useful if a cross between two (or more) breeds has higher production than the superior parents. This is sometimes the case, and the technique is used in Australia for lamb

production. Merino ewes are crossed with Border Leicester or Dorset rams. The crossbred ewe progeny is then mated to the sire of a meat breed such as Dorset or Suffolk. The crossbred ewe has a higher lambing percentage than either parent, and the terminal sire transmits fast growth rate to the lamb. Use of such a system means there must be a continual supply of the parent breeds. Too little work has been done on the crossing of two adapted breeds to exploit either hybrid vigour or complementarity. There are some indications that in the dry subtropics the local coarse wool breed can be improved by crossing with a similar breed from elsewhere. Thus in Libya the Barbary has been improved in size, weight and fleece weight, by crossing with the White Karaman from Turkey. In Egypt hybrid vigour is exhibited when the Ausimi and Rahmani are crossed. In Iran the Shal breed has been improved by crossing with the Israeli Awassi. Heterosis was exhibited in lambing rate, litter size, milk yield and growth rate (Yalcin, 1979). Nonetheless, estimates of heterosis for sheep and goats vary widely, and more data are required before such schemes could be recommended for small ruminants under African conditions.

Mason and Buvanendran (1982) noted that persistence of crossbreds in the absence of any special breeding programmes indicates their thriftness and suggests that more systematic effort should be put into mutual improvement of tropical breeds - and especially hair breeds - with the eventual aim of forming new breeds based on crossbred formulation. In

this connection the prolific tropical breeds have a special role to play since in order to improve b meat production increase in the number of lambs may be more important than increase in growth rate. In conclusion it may be suggested that there are three ways of improving meat breed of sheep in the tropics, depending on the severity of the environment and the standard of management: (a) In the hot wet tropics selection will be for the local hair breed of sheep or crossing with another tropical hair sheep particularly a prolific one to produce a new breed. (b) In the hot dry tropics selection will be for the local coarse wool breed from a similar environment. (c) In the wet dry tropics or subtropics mating the local sheep to crossbred rams (European x Local) or to a new breed with this genetic composition should be used.

2.2.6 Factors Influencing response to selection: The change produced in population mean through selection is termed response to selection (R). It is the difference of mean phenotypic value between the offspring of the selected parents and the whole of paternal generation before selection. The amount of genetic progress (ΔG) made in one generation of selection for a quantitative trait such as weaning weight, depends on heritability (h^2) of the trait and the selection differential (S_d) for the trait, and is given by $\Delta G = h^2 x S_d$. The amount of expected genetic gain made over a period of time (ΔG_t) through selection depends on the size of the

selection differential, the degree of heritability of the trait and the length of generation interval (I_g) and is given by $\Delta G_t = S_d \times h^2/I_g$.

Estimates of heritability of body weight of sheep reported for both temperate and tropical breeds, using various methods range from - 0.22 to 0.89; -0.59 to 0.93; 0.19 to 0.57; 0.10 to 0.33; and 0.10 to 0.88 for birth, weaning -, 6 month-, 9 month-, and yearling weights respectively (Tables 2.2(c) to (g)). Large variations among reported heritabilities may in part be due to the methods of analysis of the data or the environmental conditions under which growth was being measured, and are not necessarily due to differences in the amount of additive genetic variance in the different populations.

Body weights later than at weaning can be selected on a single measurement for both sexes as heritability estimates for such traits are moderately high. However, selection for traits that are lowly heritable, such as preweaning rate of gain, should be based on more than one record and the repeatability of such records should be considered. Estimates of the repeatability would in this case, represent the degree to which the trait of the lamb is a constant characteristic of the ewes. Values reported for repeatability of birth - and weaning weights in the literature are given in Tables 2.2(h) and (i). A large proportion of the same genes seem to be responsbile for rapid gains in all phases of growth period in sheep (Olson et al., 1976). This

indicates genetic correlation, and so selection for heavier body weight for any stage in life should improve this trait at other stages. Genetic and phenotypic correlations are normally included in selection indexes for selection for body weights in sheep. Tables 2.2(j) to (n) show phenotypic and genetic correlations between various body weights in sheep.

The selection differential (S_d) refers to the superiority, or inferiority of those selected for parents as compared to the average of the population from which the breeding animals were selected. It depends on the accuracy of selection (measurement rather than age appraisal), the proportion of animals saved, and the variability of the character concerned. When flocks are small, the proportion of animals saved will be high, and the selection differential lowered, particularly for rams; progress through selection will thus be very slow. Further, if rams are always chosen from within the flock, inbreeding levels become high. Ways of overcoming this problem include establishment of central sire-breeding nucleus of larger size either by government or private ownership, establishment of co-operative breeding schemes, and the use of ram circles and ram exchange. High selection differential may not be feasible in tropical areas because of low reproductive rate, long lambing interval, high lamb mortality, long generation interval resulting from late age at maturity or first lambing, all of which tend to lower genetic progress made in any given generation.

Estimates of lambing intervals in some breeds of West African sheep range from 248 to 307 days (Dettmers et al. 1976; Molokwu and Umunna, 1980; Fall et al., 1982).

2.2.7 Selection Schemes in the Tropics

Genetic improvement programmes similar to those used in developed countries are suitable in the tropics if the herds are large and facilities for performance recording are available. However, in most cases, either herd sizes are too small or where they are large, recording may be impossible, e.g. nomadic herds. Therefore alternative schemes that may be used included :

Institutional herds: Institutional herds have an important role in the tropics since these may be the only herds where genetic improvement of indigenous breeds can be carried out. Institutional facilities are also necessary in selection programmes for exotic breeds which are required in pure or crossbreeding programmes. Many tropical countries have government owned herds with the objective of producing superior stock for distribution. For effective breeding programmes, it is important that such herds should maintain a fairly reasonable population size in order to permit adequate selection intensity without appreciable increase in inbreeding. For institutional and other flocks that have at least 100 breeding females, Mason and Buvanendran (1982) described a scheme for improvement of prolificacy and growth rate. They pointed out that in flocks of this size, it is necessary to have a short lambing season to avoid

the need for adjustment factors which cannot be properly estimated if lambing is year round. According to them, a minimum of eight ramsshould be used if the flock is to remain closed. To minimize the generation interval, rams should be chosen as soon as they reach puberty nd replaced every mating season. Assuming that the number of breeding females is about 100 and a percentage of lambs weaned to ewes joined of 100 (a figure likely to be achieved with about 20 percent twinning), the number of lambs of each sex available at weaning is about 50. The first selection of lambs should be on weaning weight. Though selection of all ram lambs from twinsis desirable a few singles may also be chosen to put some selection pressure on growth rate. Thus, at weaning, all twin and about 4-6 single ram lambs are retained and at 15-16 months of age, when the final selection of 8 rams is made, 6 would be twins and 2 singles. Selection of ewe lambs is less intense because of the need to maintain flock size. Thus, all twin-born ewe lambs are retained and the balance made up from singles based on 15-16 month weight.

b) Nulceus breeding scheme: Another possible breeding scheme that would probably best suit the tropical situation because of the limited scope for recording is the Nucleus breeding scheme. In most instances, the only data available may be those obtained from questioning of farmers. The scheme has become popular in New Zealand and Australia for both sheep and cattle (Turner, 1982). It is based on the

principle that in each herd or flock, there is a small number of genetically very superior animals, which if brought together will form a nucleus whose average merit is far greater than that in any of the contributing herds (Nicoll, 1976). Therefore, the main advantage of the nucleus herd is that it starts off at a higher genetic level than that of the base herds. Once the nucleus herd is assembled, an efficient system of recording and selection is implemented.

The nucleus flock should aim at having above 500 breeding ewes. Such a size is necessary not only to make sizeable selection gains but also to meet the requirements of farmers outside the nucleus scheme. Selection of animals for the nucleus should be based on observation and interviews in the absence of objective data. Thus, ewes selected should at the time of selection be rearing twin lambs and have a history of twinning in one or more earlier lambings. Ram lambs should be selected from among multi-born lambs on size and constitution. Where the choice of base flocks is wide, it is preferable to select rams from flocks that do not contribute ewes, in order to minimize inbreeding. In the central nucleus selection on measured performance would be practised, so that response to selection would be predicted. Males from the nucleus would be distributed to small flocks. Whatever rate of genetic progress was achieved in the nucleus would also be achieved in the flocks which consistently drew

their males from it. This progress could be 1-2% per year for the suggested selection criteria. This may seem small, but remember that it is cumulative, so that after 10 years, production would be 10-20% higher. Since indigenous breeds have become adapted to various harsh environments throughout Africa, it would be logical to choose among the breeds within each region, then establish a sire breeding nucleus for each.

c) Ram circles and ram exchange: Ram circles as operated in Scandinavia and Ireland, require backing from extensive record-keeping and data analysis in all flocks involved. In the absence of such infra-structure, they are not adaptable to African condition at present. Ram exchange is however more feasible. If several small flocks are normally herded together so that their general environment can be regarded as the same, then the females' reproductive performance can be recorded provided they are identified. Males can be selected from the combined flock on a combination of their own weight (age adjusted) and their dam's reproductive performance. This would help to increase the selection differential, and if rams were rotated among similar flocks, inbreeding would be lowered.

2.3 BODY WEIGHTS AND THEIR IMPORTANCE IN SELECTION PROGRAMME

Body weight of sheep is a factor which contributes to the quality and quantity of meat to be produced and affects the market price of an animal (Haider and Shah, 1974). It is the most important character affecting the selction of lambs, especially among breeds of sheep which give a small

crop of wool of poor quality (Karam, 1959).

2.3.1 Birth Weight: Taneja (1971) noted that birth weight is the first measure of the prospective value of the animals weight since it is significantly correlated with subsequent body weight (Harrington et al., 1958). Birth weight has no economic value per se but it is one of the important factors influencing growth because a high birth weight confers an initial advantage which other things being equal will be maintained at least until weaning (Adu et al., 1978). It would also permit early selection and culling if large positive genetic and phenotypic relationship exists between birth weight and weaning weight. Such correlation would be of special value in purebred flocks by allowing early selection of lambs to be kept for replacement (Haider and Shah, 1974). Sometimes birth weight is used as an early criterion for selectioninceases of castration or whenever lambs are sold before weaning. Although birth weight is genetically correlated with other growth traits and is very important from the stand point of its relation with lamb death losses and certain productive characters (Shelton, 1964, Thrift et al., 1967) direct selection for this trait would create lambing problems due to increased size of lamb at birth. Thus, where it is desirable to select for increased growth rate in flock, it is suggested that selection be directed to one of the traits other than birth weight. Both the heritability and repeatability of birth weight in sheep are estimated to be 30-35% (Lasley, 1978).

2.3.2 *Weaning Weight:* The live weight of a lamb at weaning is a characteristic of economic importance since it is a convenient measure of the inherent rate of gain of the lamb up to the stage at which weaning occurs, and a partial measure of the milking ability of the dam. It is also a component of the total weight of lamb weaned by an ewe, a characteristic which Ray (1956) has suggested as a useful measure of the lamb production of a ewe (Chang and Roe, 1961). Selection programmes designed for sheep improvement lay much emphasis on weaning weight (Karam, 1959), as it is highly correlated with market weight (Ragab *et al.*, 1953) and also with yearling weight (Terrill and Stoehr, 1942). Selection of at least some animals for breeding at the time of weaning has the advantage of allowing the disposal of cull animals with an associated reduction in the generation interval (Fogarty, 1972). The efficiency of selection at this time is however often reduced by an inability to identify genetic value because of overriding environmental effects and an inadequate knowledge of the relationships among the traits being considered (Bassett *et al.*, 1967). The heritability of weaning weight in lambs is estimated to be 30-35%. Thus, selection for this trait will result in some improvement, although it may be slower than for post weaning gains or some other traits. Weaning weight in sheep is about 20-25 percent repeatable, which indicates that culling ewes from the herd on the basis of their first year's production is practical. The culling of poorly producing ewes will increase the average

weaning weight of the entire herd thereafter if environmental conditions remain unchanged (Lasley, 1978).

2.3.3 Six-month weight: There is very little work reported in the literature on six-month body weight of lambs. Nonetheless Chopra and Acharya (1971) noted that it might be desirable to retain a few more ram lambs entire up to six months so that more selection on six-month weight could be practised. Such selection would allow additional genetic improvement in market weight and mature body weight. Ragab et al. (1953) reported heritability estimate of 0.29 for marketing (six months) weight in Ossimi sheep. It was not possible to compare this estimate with those of other workers since age of marketing varies in different flocks as well as in the different localities. Post-weaning rate of gain in the feedlot in sheep is 40-45 percent heritable so mass selection to improve this trait should be effective (Lasley, 1978).

2.3.4 Yearling weight: This is a better measure of hereditary growth rate since it is less affected by the maternal environment (Karam, 1959). Selection at yearling age should permit a greater opportunity for the genetic value to be expressed in measurable or identifiable scores. But economic consideration of keeping a large number of ewe lambs makes this practice impracticable for the commercial operator. However, if it can be shown that genetic value is more easily identified at yearling age, then it is possible that part of the economic disadvantage is partially balanced by more efficient selection (Bassett

et al., 1967). Yearling body weight is also highly heritable, averaging between 40 and 45 percent, It is also highly repeatable, so selection for this trait would probably be effective and desirable (Lasley, 1978).

2.4 FACTORS AFFECTING WEIGHTS AT BIRTH 3,6,9 and 12 MONTHS OF AGE

Studies have been carried out both in the temperate and tropical climates to evaluate factors influencing the pre-and post-weaning growth performance of sheep and correct for them accurately in the final evaluation of the animals (Hazel and Terrill, 1945; Sidwell and Grandstaff, 1949; Blackwell and Henderson, 1955; DeBaca et al., 1956; Harrington et al., 1958; Karam, 1959; Shelton and Campbell, 1962; Turner et al., 1962; Vesely and Peters, 1964; Bowman and Broadbent 1966; Dass and Acharya, 1970; Acharya and Malik, 1971; Baker et al., 1974; Makarechian et al., 1977; Jury et al., 1979; Galal and Awgichew, 1981; Ruvanendran et al., 1981; Gupta et al., 1983; Abouiheif and Alsobayel, 1983). From available literature most of the studies have been conducted in temperate regions with temperate breeds. There is need, therefore for conducting more studies in tropical environment using indigenous breeds.

Certain non-genetic sources of variation in lambs body weight usually can be identified and eliminated at least partially, thus increasing the fraction of the differences among the animals which is genetic. Such elimination of the environmental effects would improve the efficiency of selection. Type of birth (litter size),

sex of lamb, age of dam at lambing, parity, month or season of lambing and year of lambing have been identified as some of the important factors contributing to variation in body weights of lambs during various periods of life (Donald and Mclean, 1935; Phillips and Dawson, 1937; Blunn, 1944; Kennedy and Bettenay, 1950; More O'Ferrall and Vial, 1963; Smith and Lidvall, 1964; Juma and Faraj, 1966, Trail and Sacker, 1966; Bassett et al., 1967; Ozcan, 1970; Haider and Shah, 1974; Johar and Norton, 1977; Ngere et al., 1979; Khalifa and Duayfi, 1979; Buvanendran et al., 1981; Adu et al., 1985; Poonia et al., 1984; Charyulu and Munirathnam, 1984; Tiesnamurti et al., 1985).

2.4.1 Effect of type of birth (litter size)

Reports from 1935 to date indicate that the average weights of single-born lambs and twin-born lambs differ significantly at all ages particuarly from birth to one year even when raised under similar environmental conditions, with the former being heavier than the latter (Donald and MLLean, 1935; Ali, 1952; Blackwell and Henderson, 1955; Karam, 1959; Ray and Smith, 1966; Tomov, 1967; Vesely et al., 1970; Ademosun, 1973; Adu, 1978; Ngere et al., 1979; Taiwo et al., 1982; Adu and Buvanendran, 1982; Nivsarker et al. 1984).

a) Birth weight: The birth weight which is the first trait that can be easily measured on the newborn lamb, has been shown to be significantly influenced by type of birth, though the effect becomes less important as the lamb grows older (Bonsma, 1939; Kennedy and Bettenay, 1950; Vesely

and Peters, 1964; Juma and Faraj, 1966; Adu, 1973; Buvanendran et al., 1981; Taiwo et al., 1982). Other various workers including Phillips et al. (1940); Asker et al. (1952); Ray and Smith (1966); Johar and Norton (1977) and Tiesnamurti et al. (1985) reported similar results using various breeds of sheep. Reported differences from literature range from 0.18 to 1.15kg (Table 2.4 (a)). The authors noted that the variations in weights of single and multiple-born lambs at birth might be due partly to the stress the twin-lambs suffered from a diminished nutritional supply in utero.

b) Weaning weight: Many investigators have shown that the growth rates (Average liveweight Daily Gain) of single-born and twin-born lambs from birth to weaning differ significantly (Shelton and Campbell, 1962; Smith and Lidvall, 1964; Ademosun, 1973; Adu, 1978; Ngere et al., 1979; Tiesnamurti et al., 1985) with the single-born lambs growing at significantly faster rates than twin-born lambs. Consequently the body weights of the lambs at weaning have been shown to be affected significantly by type of birth by many workers (Hazel and Terrill, 1945a; Kasam, 1959; Galal et al., 1965; Aktas, 1971; Fogarty, 1972; Shin et al., 1975; Buvanendran et al., 1981; Slana et al., 1983; Nivsarker et al., 1984) (Table 2.4 (b)). Rate of growth of a lamb during early part of its life is largely determined by the ewes milk yield which in turn depends upon her nutritional status during later part of gestation and during lactation. Bonsma (1939); DeBaca et al., (1956) and Iwan et al., (1971) asserted that differences in growth rates

between single and twin-lambs were due to the ability of the former to retain their initial weight advantage throughout their rapid linear-rate stage of growth. Consequent on this, they established that about 1/7th of the variation in liveweight at six weeks of age and 1/8th at 12 weeks were associated with differences in birth weight.

c) Six month weight: Some workers have shown that single-born lambs have significantly faster post weaning rates of gain than twin-born lambs. As a result, liveweights of the latter have been reported to be significantly lower than those of the former (Phillips and Dawson, 1940; Asker et al., 1952; Chang and Rae, 1970; Galal and Awgichew, 1981). Buvanendran et al., (1981) attributed the significant difference in live weights of single and twin lambs to the inability of the twins to recover from the nutritional stress they suffered in-utero and during the suckling period.

d) Yearling weight: Not much has been reported on the effect of type of birth on this trait. However, some workers including Phillips and Dawson (1937); Karam (1959); Galal and Awgichew (1981); Fourie and Heydenrych (1982) showed that single lambs were significantly heavier at one year than twin lambs.

2.4.2 Effect of sex of lamb

Various investigators have shown that sex is an important source of variation in the body weight of lambs with the male being heavier than the female (Phillips and Dawson, 1937; Hazel and Terrill, 1945; Starke et al., 1958;

Morsy and Karam, 1967; Pilla, 1968; Rottensten and Ampy, 1971; Malik and Acharya, 1972; Kornal et al., 1976; Khalifa and Duayfi, 1979; Kaul and Tomar, 1982; Gupta et al., 1983 and Tiesnam'urti et al., 1985).

a) Birth weight: Results of studies by many workers have demonstrated the significance of sex of lamb as a source of variation in the birth weight of the lamb. The ram lambs have been found to be significantly heavier than ewe lambs at lambing (Blackwell and Henderson, 1955; Singh and Prasad, 1962; Haider and Shah, 1974; Johar and Horton, 1977; Bohra et al., 1979; Galal and Awgichew , 1981; Fourie and Heydenrych, 1982; Vinayak et al., 1982; Nivsarker et al., 1984). Reported values for the differences due to sex of lamb in birth weight vary from 0.02 to 0.94kg (Table 2.4 (c)). Using Magra and Polwarth lambs respectively, Malik et al. (1970) and Figueiro (1980) however reported non-significant differences between sexes at lambing. El-Kimairy et al. (1979) attributed the variation in birth weight of lambs caused by sex to genetic differences with the male foetus probably beginning to liberate androgenic substances earlier and hence growing and developing faster than the female.

b) Weaning weight: Several results have shown that the growth rate (ADG) of male lamb from birth to weaning is significantly greater than that of the female counterpart (Shelton and Campbell, 1962; Smith and Lidvall, 1964; Dass and Acharya, 1970; Khalifa and Duayfi, 1979, Galal and

Awgichew, 1981; Poonia et al., 1984). Finci (1957); Jacubec (1958); Juma et al. (1969) Raman et al. (1981) and Buvanendran et al. (1981) also reported appreciable contribution of sex to pre-weaning rate of gain, though the differences were not statistically significant. Results of studies of all the foregoing authors and those of others like Blackwell and Henderson (1955); Karam (1959); Hill (1960); Nwagbogu (1969); Adu et al. (1978); Poonia et al. (1984) and Charyulu and Munirathram (1984) showed that male lambs are significantly heavier than female lambs at weaning. Table 2.4(d) gives some values reported in literature.

c) Six-month weight: The influence of sex of lamb on body weight has been shown in some studies to persist post-weaning with the male lambs still maintaining the initial advantages (Asker et al., 1952; Arora and Acharya, 1972; Galal and Awgichew, 1981; Buvanendran et al., 1981; Charyulu and Munirathram, 1984).

d) Yearling weight: Some studies carried out both in the temperate and tropical countries have demonstrated the significant effect of sex on lamb's yearling weight. Rams have been shown to weigh significantly more than ewes at one year of age (Karam, 1959; Malik et al., 1970; Arora and Acharya, 1972; Galal and Awgichew, 1981; Fourie and Heydenrych, 1982; Gupta et al., 1983).

Malik et al. (1970) noted that the sex difference in weaning and post-weaning live weights of lambs might be due to higher initial benefit of birth weight; It is

however postulated that the differential effect of the gonadal hormones (androgen and oestrogen) on growth of lambs might be primary cause of sex differences (Owen, 1976). Through the influence of sex hormones females have slower growth rate and reach small mature size. This is said to be due to the effect of oestrogens which restrict the growth of long bones in females compared to males while the male hormones (androgens) have been shown to be anabolic steroids in promoting growth.

2.4.3 Effect of Age/Parity of dam

The influence of age/parity of dam on birth weight and lambs growth performance to one year has long been recognised (Donald and McLean, 1935; Kennedy and Bettenay, 1950; Blackwell and Henderson, 1955; Maymone and Dattilo, 1962; Sidwell et al., 1964; Pilla, 1968; Vesely et al., 1970; Wright et al., 1975; Yalcin, 1979; Tecza and Szewcyk, 1981; Nilausen 1982; Tiesnamurti et al., 1985).

a) Birth weight: Lambs from mature ewes have been found to be significantly heavier at birth than those from maiden or young ewes (Bogart et al., 1957; Vesely and Peters 1964; Dass and Acharya, 1970, Chang and Ray, 1970; Ozean 1970; Prud'hon et al., 1970; Haider and Shah, 1974; Adu, 1978; Magid et al., 1981; Osselaer et al., 1983; Slana et al., 1983). Table 2.4(e) gives some reported values for difference between birth weights of lambs born to young and mature ewes. A few authors also underlined the effect of the parous state of the ewe on the birth weight of the lamb. This has to do with the number of lamb crop the ewe

has previously had. First lambing ewes have been found to produce significantly lighter lambs than subsequent lambings (Bonsma, 1939; Belic and Ognajanovic, 1955; Dalton, 1962; Juma and Faraj, 1966; Ojeda, 1974). In addition, Dalton (1962) noted the effect of parity X sex interaction on birth weight of lamb.

b) Weaning weight: Both significant and non-significant effects of age/parity of dam on pre-weaning rate of gain have been observed by some workers (Dalton, 1962; Dass and Acharya, 1970; Magid et al., 1981). A host of other workers reported significant effect of age/parity of dam on live weight of the lamb at weaning. Lambs born to older ewes have been found to be appreciably heavier at weaning than those born to younger or maiden ewes (Sidwell and Gradstaff, 1949; Karam; 1959; Dalton, 1962; Smith and Lidvall, 1964; Vesely et al., 1970; Marais and Pretorius, 1977; Fourie and Heydenrych, 1982). Table 2.4(f) gives some values (differences) reported in the literature. Some workers however found the differences in the two groups of lambs to be non-significant statistically (Asker et al., 1952; Blackwell and Henderson, 1955; Ray and Smith, 1966; Magid et al., 1981).

c) Six-month weight: Effect of age/parity of dam on post weaning rate of gain and live weight of lambs has been found to be negligible. This is consistent with the view that maternal influence has a much larger effect on lamb performance up to weaning than post weaning. Six-month

weight of lambs was found to increase with the age/parity of dam but the differences were considerably less and mostly non-significant (Asker et al., 1952; Chang and Rae, 1970; Buvanendran et al., 1981).

d) Yearling weight: Very few studies have been carried out on the effect of age/parity of dam on this trait. Lambs from mature ewes have been found to be significantly heavier than lambs from two-year old ewes at 12 months of age (Karam, 1959; Fourie and Heydenrych, 1982). The latter noted that age of dam had a diminishing influence on body weight traits as the lambs grew older.

2.4.4 Effect of month or season of lambing

Though it is rather difficult to describe quantitatively the various seasons and the change from one to the other, it is a well known fact that month or season of lambing significantly influences birth weight and growth rate of lambs. The usual procedure is to classify season of birth by month of the year. Sometimes the months are grouped together in an attempt to associate them with the major rainfall periods, rainfall being the major seasonal variable in the tropics. Thus, birth seasons have been formed by grouping the together wet and dry months (Nwagbogu, 1969; Buvanendran et al., 1981; Adeleye, 1984).

a) Birth weight: Reports by some workers have indicated significant effect of month or season of lambing on birth weight, with lambs born in dry month/season being lighter than those born during the wet month/season (Donsma, 1939; ; Asker et al., 1952; Trail and Sacker, 1966; Nwagbogu, 1969;

Malik and Acharya, 1972; Buvanendran et al., 1981; Taiwo et al., 1982; Adeleye, 1984). Significant effects of month x sex (Kurbanov, 1958; Kornal et al., 1976) and season X type of birth (Marais and Pretorius, 1977) interactions on birth weight were also reported.

b) Weaning weight: Studies tend to show the influence of month or season of lambing on rate of gain to weaning and the body weight of the lamb at weaning. Lambs born in the rainy season are known to have a significantly faster rate of gain from birth to weaning than those born in the dry season (Karam, 1959; Smith and Lidvall, 1964; Kaushik and Singh, 1968; Malik et al., 1978; Adeleye, 1984; Poonia et al., 1984). The faster rate of gain of lambs born at the end of dry season in the tropics and at the end of winter in the temperate climates will consequently result in their heavier weights at weaning as confirmed by many other workers (Saraswat et al., 1968; Gould and Whiteman, 1971; Malik and Acharya, 1972; Marais and Pretorius, 1977; Malik et al., 1978; Stritzke and Whiteman, 1982; Peacock, 1982; Gupta et al., 1983). This is due primarily to the fact that their dams would have plenty of good pasture in the wet season and produce more milk to feed the lamb.

c) Six-month weight: Karam (1959) and Kaushik and Singh (1968) established the superiority of lambs born in the wet season over those born in the dry season in growth rate up to 12 months of age. Consequent on this the live weight of lambs at six months have been reported to be significantly

affected by month or season of lambing (Saraswat et al., 1968; Arora and Acharya, 1972; Singh et al., 1982; Charyulu and Munirathram, 1984). However, Buvanendran et al. (1981) reported a non-significant small magnitude of seasonal effect on this trait.

d) Yearling weight: The effect of the month or season of lambing on this trait of lambs appears to be rather inconsistent but seems related to the stage in wet or dry weather cycle in which the animal reaches the age. Nevertheless some studies have confirmed the significant effect of period of lambing on this trait with lambs born in the wet season outweighing those born in the dry season more so in the males than in the females (Karam, 1959; Kaushik and Singh, 1968; Malik and Acharya, 1972, Malik et al., 1978).

2.4.5 Effect of Year of Lambing

The variations between years of lambing in live body weights of growing lambs on range conditions have been extensively reported in the literature. The general conclusion was that the year of lambing effects were due to differences in the amount and distribution of rainfall between years (Blunn, 1944; Asker et al., 1952, Karam, 1959; Juma and Faray, 1966; Dass and Acharya, 1970; Raman et al., 1979: Buvanendran et al., 1981). The variation in the annual rainfall would generally be reflected in the lamb's growth presumably through the amount and quality of forage available to the dams and their lambs. Karam (1959) attributed yearly fluctuations

in lambs body weight to variations in disease conditions as well as differences in the genetic and age composition of the flock.

a) Birth weight: Many workers in various studies have demonstrated that birth weight of lamb was significantly affected by differences in year of lambing (Knothe and Stalinski, 1960; Smith and Lidvall, 1964; Pillo, 1968; Haider and Shah 1974; Mahajan and Singh , 1978; Bohra et al., 1979; Buvanendran et al., 1981; Singh et al., 1982; Poonia, et al., 1984). Johar and Norton (1977) and Raman et al. (1979) however reported that difference due to year of lambing were not significant for birth weight.

b) Weaning weight: The influence of year of lambing on average liveweight daily gain from birth to weaning has been found to be significant (Smith and Lidvall, 1964; Dass and Acharya, 1970; Bohra et al., 1979; Poonia et al., 1984). These workers along with many others (Blunn, 1944; Sidwell and Grandstaff, 1949; Asker et al., 1952; Blackwell and Henderson, 1955; Kassab and Karam, 1961; Vesely and Peters, 1964; Shin et al., 1975; Nivsarker et al., 1984) amply reported the significant effect of difference in years of lambing on the lamb's weaning weight. Bassett et al. (1967) however reported non-significance of yearly differences as a source of variation in body weight of lamb at weaning.

c) Six-month weight: Reports of studies on post-weaning rate of gain and live weights of lambs as they are affected by differences due to year of lambing are very few. However, some workers (Asker et al., 1952; Buvanendran et al.,1981; Galal and Awgichew, 1981; Singh et al., 1982) reported the significant influence of year of lambing on six-month weight.

d) Yearling weight: Though the effect of differences in years of lambing on this trait has not been extensively studied, a few workers reported that year of lambing significantly influenced live weight of lamb at one year of age (Kassab and Karam, 1961; Dass and Acharya, 1970; Galal and Awgichew, 1981).

Table 2.2. (a); Reproductive Performance of Nigerian Indigenous Sheep

Trait	Breed	Location	Value	Author(s)
Age at first lambing (Months)	Balami	Marguba	18.6	Buvanendran & Adu, 1987
	WAD	Ibadan	15	Dettmers & Loosli, 1974
	"	"	12.5-13.2	Adu, 1975
	"	"	20.5	Dettmers et al., 1976
	"	"	10.3-23.07 (16.68)	Orji et al.,1976
	"	Ile-Ife	13	Chiboka, 1979
	"	Ibadan	11-14	Hill, 1960
	"	"	15	Ngere et al., 1979
	"	"	22.4 (10.9-37)	Olaloku et al., 1973
	Yankasa	Samaru	15.5	Molokwu & Umunna, 1980
Lambing rate (%)	Balami	Marguba	142.5	Adu and Ngere, 1979
	"	Katsina	128.6	"
	"	Shika	114.3	"
	Uda	Kwotorkoshi	131	"
	"	Katsina	107.9	"
	"	Shika	128.9	Adu, 1978
	WAD	Ibadan	90-120	Hill, 1960
	"	Ile-Ife	118.5	Ademosun, 1973
	"	Ibadan	126	Dettmers et al., (1976)
	"	"	121	Ngere et al., 1983

Table 2.2 (a): Contd.

Trait	Breed	Location	Value	Author (s)
	Yankasa	Katsina	110.1	Adu, 1978
	"	Samaru	139-148	Molokwu & Umunna, 1980
	"	Shika	112.6	Adu, 1978
Twining rate (%)	Uda	Shika	17.0	Ferguson, 1964
	"	"	24.1	Adu et al., 1978
	WAD	Ukwele	52.15	Eastern Region Agric. Dept. 1956
	"	Ibadan	20	Hill, 1960
	"	Shika	63	Ferguson, 1964
	"	West & Mid-West	15.82	Nwagbogu, 1969
	"	Ile-Ife	37	Ademosun, 1973
	"	Ibadan	35-71	Dettmers & Loosli, 1974
	"	"	38	Orji et al., 1976
	Yankasa	Shika	23	Ferguson, 1964
	"	Samaru	23	Molokwu & Umunna, 1980
	"	Shika	17.8	Adu et al., 1978
Lambing interval (days)	Balami	Marguba	238-308	Buvanendran & Adu, 1987
	Uda	Shika	270	Ferguson, 1964
	WAD	"	248	" "
	"	Ibadan	209-277	Dettmers & Loosli, 1974
	"	"	248	Dettmers et al., 1976

Table 2.2(a):contd.

Trait	Breed	Location	Value	Author (s)
	WAD	Ibadan	151-571	Orji et al., 1976
	Yankasa	Shika	236	Ferguson, 1964
	"	Samaru	291	Molokwu & Umunna, 1980
Weaning rate (%)	Balami	Marguba	90.4	Adu and Ngere, 1979
	"	Katsina	87.2	" "
	"	Shika	81.6	" "
	Uda	Kwotorkoshi	79.3	" "
	"	Katsina	68.6	" "
	"	Shika	71.8	Adu, 1978
	WAD	Ibadan	70.0	Dettmers et al., 1976
	Yankasa	Katsina	70.2	Adu and Ngere, 1979
	"	Shika	78.5	Adu, 1978
Mortality rate (up to weaning) %	Balami	Marguba	6.3	Adu and Ngere, 1979
	"	Katsina	9.1	" "
	"	Shika	12.3	" "
	"	"	15.0	Taiwo & Buvanendran, 1985.
	Nigerian Dwarf	Ibadan	12.0	Taiwo et al., 1982
	Uda	Kwotorkoshi	11.2	Adu, 1978
	"	Katsina	16.1	"
	"	Shika	14.0	"
	"	"	15.0	Taiwo & Buvanendran, 1985.
	WAD	Ibadan	20.0	Dettmers et al., 1976
	"	"	25.0	" "

Table 2.2. (a): Contd.

Trait	Breed	Location	Value	Author
	WAD	Ibadan	20.0	Ngere et al., 1979
	Yankasa	Katsina	14.4	Adu and Ngere, 1979
	"	Shika	12.0	Adu, 1978
	"	Samaru	12.0	Molokwu & Umunna, 1980
	"	Shika	15.0	Taiwo & Buvanendran, 1985

Table 2.2 (b): Birthweight of the Indigenous Sheep

Breed	Location	Single	Twin	Author (s)
Balami	Marguba	3.5	3.1	Adu and Ngere, 1979
"	Shika	3.3	3.0	"
Nigerian Dwarf	Ibadan	2.58	2.12	Taiwo et al., 1982
Uda	Katsina	3.3	3.0	Adu and Ngere, 1979
"	Shika	3.8	3.4	Adu, 1978
"	"	3.54 (Mixed)		Buvanendran et. al., 1981
WAD	Ibadan	1.7	1.5	Ngere et al., 1979
"	"	1.80 (Mixed)		Adu, 1978
"	Ife-Ife	2.5	2.1	Ademosun, 1973
"	Jos	1.18 (Mixed)		Vet. Res. Lab. Rep., 1950
"	Ukwele	1.18 (Mixed)		East. Reg. Agr. Dept. 1956
"	West and Mid-West	1.62 (Mixed)		Nwagbogu, 1969
Ya				
Yankasa	Katsina	3.6	3.0	Adu and Ngere, 1979
"	Shika	3.2	2.9	Adu, 1978
"	"	2.86 (Mixed)		Buvanendran et. al., 1981

Table 2.2(c): Estimates of Heritability of Birth Weight of lamb from Literature

Breed	Location	Estimate	Method	Author(s)
Awassi	Jordan	0.89±0.05	Intra-class correlation	Khalifa & Dmayfi, 1979
"	India	0.14±0.10	Half-sib analysis	Alrawi et. al., 1982
Bannur	"	0.29±0.20	Not stated	Dikshit, 1982
Barki	Egypt	0.16	Dam-Offspring correlation	Fahmy, 1967
"	"	0.22±0.09	PHS[1] Correlation	Fahmy, et. al. 1968
"	"	0.18±0.10	"	Galal, 1968
"	"	0.25±0.10	"	Guirgis et al., 1982
Bihar & Bikaneri		0.07±0.34	"	Singh & Prasad, 1962
Bikaneri		0.44±0.20	"	Bass & Acharya, 1970
"		0.10±0.03	"	Chopra & Acharya, 1971
Corriedale		0.15	"	Nelson and Venkatachalan, 1949
"		0.70	DD[2] regression	"
Corridale, Hampshire Shropshire & Dorset Horn		0.34	Dam-offspring regression	Blackwell & Handerson, 1955
Corriedale (Canadian)	Alberta	0.36	Not stated	McNaughton, 1957
Corriedale		-0.22	Intra-sire DD regression	Butcher et al., 1959

[1] PHS = Paternal half-sibs

[2] DD = Daughter - Dam

Table 2.2, (c): Contd.

Corriedale, Hampshire Shropshire & Southdown		0.14±0.10	Intra-sire regression	Butcher et. al., 1964
Southdown		0.14±0.09	Intra-sire multiple regression	"
		0.10	PHS correlation	"
Corriedale	Alphine	0.21	Hierarchical anova	Shin et al., 1976
Daglic		0.19	Intrasire dam-daughter correlation	Yalcin, 1969
"		0.08	PHS correlation	
Hampshire		0.13	Intra-sire DD regression	Butcher et al., 1959
"	Lincoln	0.21±0.08	PHS correlation	Dzakuma et al., 1978
"	"	0.33±0.24 (singles) 0.63±0.28 (twins)	Not stated	Morrison et al., 1984
Karakuls (purebred		0.64	Intra-sire regression	Yac et al., 1953
		0.18	PHS correlation	"
Kivirocik		0.21	Intra-sire dam-progeny correlation	Ozcan, 1970
		0.31	Dam-progeny regression	" "
		0.15	PHE correlation	" "
Mancha	Spain	0.16 (single male)	Sire components	Ojeda, 1974
		0.34 (Twin male	" "	" "
		0.05 (Single female)	" "	" "

Table 2.2 (c): Contd.

Marwari		0.20	Square of path coefficients	Taneja, 1971
Merino		0.61	Not stated	Nelson & Venkatachalam, 1949
Merino		0.01	Not stated	Ceranic, 1971
Merino (Arles)		0.24	"	Berny et al., 1974
Merino (Stavropol)	South India	0.46±0.23	"	Raman et al.,1981
Merino (Dohne)		0.21±0.14	Half-sib analysis	Fourie & Heydenrych, 1982
Merino (Soviet)		0.54±0.23	Not stated	Kaul & Tomar, 1982
Merino (Stavropol)		0.46±0.20	"	"
Merino (Soviet)		0.33±0.12	"	Singh et al., 1984
Najdi (Black)	S. Arabia	0.12±0.07	"	Abouiheif & Alsobayel, 1983
Nali	Haryana	0.15±0.13	Sire components of variance & covariance	Acharya & Malik, 1971
"		0.18	PHS correlation	Singh et al., 1973
Navajo		0.22	Intra-sire correlation	Butcher et al., 1964
Nellore		0.22+0.08	Not stated	Reddy et al., 1983
Norwegian	Norway	0.12±0.05	PHS correlation	Gjedrem, 1967
Ossimi		0.34±0.13	Intra-sire regression	Ragab et al., 1953

Table 2.2 (c): Contd.

Rahmani	Alexandria	0.16±0.12	PHS Correlation	Karam, 1959
Rambouillet	Alberta	0.27	Not stated	McNaughton, 1956
"		0.25	OP[3] regression	Osman & Bradford, 196
"		0.34	OD[4] regression	"
"	Raleigh	0.30±0.10	Components of variance & co variance	Vesely et al., 1970
"	Pakistan	0.69±0.19	PHS correlation	Jabar & Ahmed, 1973
		0.11±0.06	Intra-sire regression	"
Romnelet	Raleigh	0.28±0.10	Components of variance &covariance	Vesely et al., 1970
		0.01±0.83	Not stated	Radomska & Klewiec, 1975
Shropshire and Southdown		0.08±0.40	"	Esminger et al., 1943
Sopravissona		0.16+0.26 (Single male)	Half sib correlation	Pilla, 1968
		0.14+0.31 (Single female)	"	"
		0.35±0.33 (Twin female	"	"
Southdown		0.33	OD regression	Blackwell & Henderson, 1955
"		0.72	Intra-sire DD regression	Nelson & Venkatachalam, 1949
"		0.08	"	Butcher et al., 1959

[3] O = Offspring-Parent

[4] OD = Offspring-Dam

Table 2.2. (c): Contd.

Texel	Egypt	0.10	Not stated	Morsy & Karam, 1967
Welsh Mountain	Bangor	0.21±0.07	Offspring-parent regression	Dalton, 1962
Whiteface-Targhee		0.19	PHS correlation	Osman & Bradford, 1965

Table 2.2. (d): Estimates of Heritability of Weaning weight of lamb from literature

Breed	Location	Estimate	Method	Author(s)
Awassi	Jordan	0.9±0.11	Intra-class correlation	Khalifa & Duayfi, 1979
		0.73±0.21	PHS correlation	Alrawi et al., 1982
Bannur		0.57±0.32	Not stated	Dikshit, 1982
Barki	Egypt	0.45±0.11	PHS correlation	Fahmy et al., 1968
		0.27±0.11	"	Guirgis et al., 1982
Bikaneri		0.68±0.26	"	Dass & Acharya, 1970
Border Leicester		0.46 (uncorrected)	"	Gregory et al, 1977
Chios		0.73±0.17	Not stated	Mavrogenis et al., 1980
Corriedale		0.45	"	Hazel & Terrill, 1946
"	Alpine	0.26	Hierarchical Anova	Shin et. al., 1975
Corriedale (Canadian)		0.45	Not stated	McNaughton, 1956

Table 2.2. (d): Contd.

Corriedale (Columbia)		0.07±0.16	Sire-Offspring regression	Botkin et al. 1969
Daglic		0.04	PHS correlation	Yalcin, 1969
		0.08	Intra sire (DD) correlation	"
Dorset	Oklahoma	0.10±0.07	PHS correlation	Thrift et al., 1973
"	Kensington	0.27 (uncorrected)	"	Gregory et al., 1977
"	"	0.11 (corrected by ADG[5])	"	"
"	"	0.15 (corrected Pooled(regression)	"	"
"	"	0.18 (corrected by least squares)	PHS correlation	"
"	"	0.04 (uncorrected)	Dam Offspring regression	"
"	"	0.06 (corrected by ADG)	"	"
"	"	0.09 (corrected by pooled regression)	"	"
"	"	0.10(corrected by least squares)	"	"
"	Lincoln	0.09±0.06	PHS correlation	Dzakuma et al., 1978
"	"	0.06±0.07	OS[6] regression	"
"	"	0.05±0.11	OD regression	"

[5] ADG = Average Daily Gain

[6] OS = Offspring-Sire

Table 2.2 (d): Contd.

Dorset	Lincoln	0.12±0.07	OP regression	Dzakuma et al., 1978
Mancha		0.09	Intra-sire DD correlation	Ariturk et al., 1979
Merino	Lubiana	0.54	Half-sib analysis	Radomska et al., 1972
"	Trangie	0.00 (ewes)	Dam-Offspring	Taneja, 1958
"		0.15 (rams)	regression	
"		0.35 (rams)	Daughter offspring regression	Young et al., 1965
"		0.32 (ewes)	"	"
"		0.10 (both sexes)	PHS correlation	"
Merino (stavropol)	India	0.58±0.29	Not stated	Raman et al., 1981
Merino (Soviet)	"	0.58±0.21	"	Kaul & Tomar, 1982
		0.19±0.12	"	"
		0.93±0.21	"	Singh et al., 1984
Nali	Haryana	0.29±0.10	PHS correlation	Acharya & Malik, 1971
"		0.13±0.06	"	Thrift et al., 1971
Nellore		0.67±0.18	"	Reddy et al., 1983
Norwegian	Norway	0.18±0.06	"	Gjedrem, 1967
Ossimi		0.10±0.07	Intra-sire daughter dam (DD) regression	Ragab et al., 1953
Perendale	Newzealand	0.20±0.01	PHS correlation	Elliot et al., 1979
Rahmani		-0.59	OP regression	Kady, 1952
"	Alexandria	018±0.02	Half-sib correlation	Karam, 1959

Table 2.2. (d): Contd:

Range Columbia		0.21	Not stated	Hazel & Terrill, 1946
Romney Marsh		0.35±0.05	OD regression	Chang and Rae, 1961
"		0.18±0.10	Not stated	Radomska & Klewiec, 1975
Romnelet		0.28±0.09	Intra-sire OD regression	Vesely & Slen, 1961
"	Raleigh	0.06±0.05	Components of variance & Covariance	Vesely et al, 1970
Romney		0.30	PHS correlation	Chang & Rae, 1970
"		0.23	DD regression	" "
Shropshire, Corriedale, & Dorsethorn Hampshire		0.07	Not stated	Blackwell & Henderson, 1955
Shropshire, Southdown & Corriedale, Hampshire		0.00	PHS correlation	Butcher et. al., 1964
		0.00	Intra-sire multiple regression	" "
		0.00	Intra-sire regression	" "
Southdown		0.29	Intra-sire DD regression	Nelson & Vankatachal. n, 1949
Targhee		-0.01	Not stated	Hazel & Terrill, 1946
Texel	Egypt	0.07	"	Morsy & Karam, 1967
Welsh Mountain		0.51±0.07	PHS correlation	Gjedrem, 1967

Table 2.2. (e): Estimates of Heritability of 6-month weight of lamb from Literature

Breed	Location	Estimate	Method	Author(s)
Awassi		0.48+0.17	PHS correlation	Alrawi et al., 1982
Bikaneri		0.57±0.34	Not stated	Gupta et al., 1983
Dohne		0.53±0.19	PHS analysis	Fourie & Heydenrych, 1982
Hampshire	Lincoln	0.28±0.10	PHS correlation	Dzakuma et al., 1978
"	"	0.19±0.11	OS regression	"
"	"	0.34±0.09	OD regression	"
"	"	0.33+0.08	OP regression	"
Merina (Soviet)		0.44±0.17	Not stated	Singh et al., 1984
Nali		0.51±0.26	"	Acharya & Malik, 1971
Nellore		0.57+0.16	PHS correlation	Reddy et al., 1983
Ossimi		0.29+0.20	Intra-sire DD regression	Ragab et al., 1953

Table 2.2 (f): Estimates of Heritability of 9-month weight of lamb from Literature

Breed	Location	Estimate	Method	Author(s)
Nali	Haryana	0.33+0.26	Not stated	Acharya & Malik, 1971
Nellore		0.10±0.09	PHS correlation	Reddy et al., 1983

Table 2.2 (g): Estimates of Heritability of Yearling weight of lamb from Literature

Breed	Location	Estimate	Method	Author
Awassi		0.53±0.18	Not stated	Alrawi et al., 1982
Barki	Egypt	0.41±0.11	PHS correlation	Fahmy et al., 1968
"		0.28±0.11	"	Guirgis et al., 1982
Bikaneri		0.38±0.23	"	Dass & Acharya, 1970
"		0.48±0.07	"	Chopra & Acharya, 1971
Ethiopian Adal		0.34±0.13	Not stated	Gupta et al., 1983
				Galal & Awgichew, 1981
Hampshire	Lincoln	0.11±0.11	PHS correlation	Dzakuma et al., 1978
"	"	0.44±0.12	OS regression	"
"	"	0.58±0.17	OD regression	"
"	"	0.64±0.12	OP regression	"
Merino	Australia	0.36±0.23	OP regression	Morley, 1955
"	Grootfontain	0.42±0.54	Not stated	Bosman, 1958
Nali	Haryana	0.15±0.24	"	Acharya & Malik, 1971
Nellore		0.10±0.04	PHS correlation	Reddy et al., 1983
Perendale	Newzealand	0.24	"	Elliot et al., 1979
"	"	0.44	DD regression	"
Polish mountain		0.17	PHS correlation	Tecza et al. 1974
Rahmani		0.19±0.16	PHS correlation	Karam, 1959
Rambouillet		0.40	Not stated	Terrill & Hazel, 1943
"	Montana	0.85±0.26 (unadjusted)	"	Bassett et al., 1967
	"	0.82±0.26 (adjusted)	"	"

Table 2.2. (g): Contd.

Romnelet		0.37±0.11	DD regression	Vesely & Slen, 1961
Romney		0.51	PHS correlation	Ch'ang & Rae, 1970
"		0.46	DD regression	"
Romney Marsh		0.11±0.09	Not stated	Radomska & Klewiec, 1975
Targhee	Columbia	0.21(rams) 0.40(ewes)	Not stated	Kyle & Terrill, 1953

Table 2.2. (h): Estimates of Repeatability of Birth weight of lamb from Literature

Breed	Location	Estimate	Author
Awassi	Iraq	0.13	Juma & Faraj, 1966
"		0.13	Kazzal, 1978
Konya Merino		0.23	Yalcin et al., 1979
Norwegian		0.29 ± 0.03	Gjedrem, 1967
Romney	Newzealand	0.27	Barnicoal et al., 1957
Welsh Mountain	Bangor	0.23	Dalton, 1962
Yankasa Uda & crosses with exotic breed	Shika	0.25 ± 0.13	Buvanendran et al., 1981

Table 2.2. (i): Estimates of Repeatability of Weaning Weight of lamb from Literature

Breed	Location	Estimate	Author
Awassi		0.26	Kazzal, 1978
Konya Merino		0.20	Yalcin et al., 1979
Navajo		0.22	Sidwell & Grandstaff, 1949
Norwegian	Norway	0.21±0.03	Gjedrem, 1967
Welsh Mountain	Bangor	0.43	Dalton, 1962
Yankasa	Shika	0.21±0.19	Buvanendran et al., 1981

Table 2.2(j): Coefficients of Phenotypic correlation of Birth weight with Weaning, 6-month, 9-month and Yearling weights of lamb from literature.

Birth weight	Breed	Estimate	Author (s)
Weaning weight	Bannur	0.37±0.03	Urala, 1978
	Barki	0.30	Kassab & Karam, 1961
	"	0.12	Galal, 1967
	"	0.28	"
	"	0.47	Fahmy et al., 1968
	Bibrik	0.18	Haider & Shah, 1974
	Bikaneri (Magra)	0.25±0.02	Chopra & Acharya, 1971
	Canadian Corriedale	0.52	McNaughton, 1957
	Corriedale	0.35	Butcher et al., 1964
	Dala & Steigar	0.29	Gjedren, 1967
	English Leicester	0.68	Donald & McLean, 1935
	Hampshire	0.40	Butcher et al., 1964
	Hampshire (Magra)	0.25±0.02	Chopra & Acharya, 1971
	Harnai	0.20	Haider & Shah, 1974
	Mandya	0.95	Purushotam, 1978
	Merino (S.Africa)	0.41	Bonsma, 1939
	Nellore	0.98	Purushotam, 1978
	Ossimi	0.59	Ragab et al., 1953
	Rahmani	0.21±0.05	Karam, 1959
	Rambouillet	0.40	McNaughton, 1957
	"	0.29	Vesely et al, 1970

Table 2.2. (j): Contd.

Weaning weight	Romnelet	0.38	Vesely et al., 1970
	Shrosphire	0.37	Butcher et al., 1964
	Sijonicca	0.51	Milosavljevic, 1971
	Southdown	0.40	Donald & McLean, 1935
	"	0.16	Butcher et al., 1964
	Stavropol Merino	0.48±0.05	Raman et. al. 1981
	Texel	0.19	Morsy & Karam, 1967
	Uda	0.55	Buvanendran et al., 1981
	Welsh Mountain	0.10	Dalton, 1962
	Yankasa	0.47	Buvanendran et al.,1981
6-month weight	Bannur	0.21±0.04	Urala, 1978
	Bikaneri (Magra)	0.28±0.03	Chopra & Acharya, 1971
	Hampshire	0.22	Dzakuma et al., 1978
	Nigerian Dwarf	0.41	Taiwo et al., 1982
	Ossimi	0.48	Ragab et al., 1953
	Uda	0.18	Buvanendran et al.,1981
	Yankasa	0.43	"

Table 2.2. (j): Contd.

9-month weight	Bannur	0.43±0.03	Urala, 1978
Yearling weight	Bannur	0.[illegible]±0.04	Urala, 1978
	Barki	0.29	Kassab & Karam, 1961
	"	0.32	Fahmy et al., 1968
	Bikaneri (Magra)	0.28±0.03	Chopra & Acharya, 1971
	Canadian Corriedale	0.36	McNaughton, 1957
	Hampshire	0.23	Dza kuma et al., 1978
	Rahmani	0.21±0.06	Karam, 1959
	Rambouillet	0.36	McNaughton, 1957
	Texel	0.16	Morsy & Karam, 1967

Table 2.2 (k): Coefficients of Phenotypic correletion of Weaning weight with 6-month, 9-month and Yearling weights of lamb from literature

Weaning weight	Breed	Estimate	Author (s)
6-month weight	Bikaneri	0.62±0.02	Chopra & Acharya, 1971
	Hampshire	0.61	Izakuma et al., 1978
	Nigerian Dwarf	0.55	Taiwo et al., 1982
	Ossimi	0.86	Ragab et al., 1953
	Uda	0.72	Buvanendran et al., 1981
	Yankasa	0.71	"
9-month weight	Nigerian Dwarf	0.32	Taiwo et. al., 1982
Yearling weight	Barki	0.23	Kassab & Karam, 1961
	"	0.68	Fahmy et al., 1968
	Bikaneri	0.45±0.03	Chopra & Acharya, 1971
	Canadian Corriedale	0.61	McNaughton, 1957
	Hampshire	0.50	Dzakuma et al., 1978
	Mutton Merino	0.43 + 0.07	Gartner & Ungern-Sternberg, 1938
	Nigerian Dwarf	0.02	Taiwo et al., 1982
	Perendale	0.44	Elliot et al., 1979
	Rahmani	0.32 + 0.05	Karam, 1959
	Rambouillet	0.76	Terrill et al., 1950
	"	0.46	McNaughton, 1957
	Romney Marsh	0.61	Radomska & Klewiec 1975
	Texel	0.33	Morsy & Karam, 1967

Table 2.2 (1): **Coefficients** of Phenotypic correlation **of 6-month and Yearling weights** of lamb from Literature

6-month weight	Breed	Estimate	Author(s)
Yearling weight	Bikaneri (Magra)	0.70 ±0.02	Chopra & Acharya, 1971
	Hampshire	0.77	Dzakuma et al., 1978
	Merino	0.78 (rams)	Morley, 1951
	"	0.71 (ewes)	"

Table 2.2 (m); Coefficients of Genetic correlation of Birth Weight with Weaning, 6-month, 9-month and Yearling weights of lamb from Literature

Birth weight	Breed	Estimate	Author(s)
Weaning weight	Bannur	0.14±0.40	Urala, 1978
	Barki	0.47	Fahmy et. al, 1969
	Bikaneri (Magra)	0.12±0.07	Chopra & Acharya, 1971
	Canadian Corriedale	0.54	McNaughton, 1957
	Dala & Steigar	0.42	Gjedrem, 1967
	Ossimi	1.04	Ragab et. al.1953
	Perendale	0.13±0.14	Elliot et al., 1979
	Rambouillet	0.24	McNaughton, 1957
	"	0.33±0.30	Vesely et. al.,1970
	Rambouillet, Columbia & Corriedale	0.59±0.38	Thrift et al., 1973
	Romnelet	0.00	Vesely et al., 1970
	Stavropol Merino	0.26±0.18	Raman et. al 1981
6-month weight	Bannur	0.67+0.21	Urala, 1978
Yearling weight	Bannur	0.37±0.43	Urala, 1978
	Bikaneri (Magra)	-0.07±0.30	Chopra & Acharya, 1971
	Ossimi	0.82	Ragab et. al., 1973
	Soviet Merino	0.51±0.23	Singh et al., 1984
9-month weight	Bannur	-0.20±0.18	Urala, 1978
Yearling weight	Bannur	0.37±0.43	Urala, 1978
	Barki	0.32	Fahmy et al., 1969
	Bikaneri (Magra)	-0.11±0.22	Chopra & Acharya, 1971

Table 2.2(n): Coefficients of Genetic correlation of Weaning weights of 6-month, 9-month and Yearling weights of lamb from Literature

Weaning weight	Breed	Estimate	Author (s)
6-month weight	Bannur	0.82±0.12	Urala, 1978
	Bikaneri (Magra)	0.90±0.03	Chopra & Acharya, 1971
	Ossimi	0.96	Ragab et al., 1953
	Soviet Merino	0.72±0.17	Singh et al., 1984
9-month weight	Bannur	-0.16±0.17	Urala, 1978
Yearling weigh	Bannur	0.71 +0.24	Urala, 1978
	Barki	0.68	Radomska & Klewiec, 1975
	Bikaner (Magra)	0.73±0.03	Chopra & Acharya, 1971
	Perendale	0.66+0.10	Elliot et al, 1979
	Romney Marsh	0.86	Radomska & Klewiec, 1975

Table 2.4 (a): Effect of Type of birth on Birth weight of lamb from literature

Breed	Location	Birthweight kg		Difference	Author(s)
		Single	Twin	kg	
Awassi	Lebanon	4.45	3.48	0.80	Rottensten & Ampy, 1971
Balami	Marguba	3.50	3.10	0.40	Adu and Ngere, 1979
"	Shika	3.30	3.00	0.30	" " "
Black Nadji	S. Arabia			6.90%	Abouiheif & Alsobayel, 1983
Blackhead Persian	S. Africa	2.72	2.54	0.18	Tangayika Dept. Vet. Ser., 1960
Corriedale	Alphine			0.87	Shin et al., 1975
"	India	3.37	2.64	0.73	Kornal et al, 1976
Edilbaev	Russia	5.30	4,15	1.15	Ermekov & Kairgaliev, 1971
Hampshire				0.72	Smith & Lidvall, 1964
Ile-de-France		3.89	3.48	0.41	Aktas, 1971
Kivircik				0.82	Vesely et. al., 1970
Merino	South Africa	3.94	3.20	0.93	Bonsma, 1939
Nigerian Dwarf	Ibadan	2.58	2.12	0.46	Taiwo et al., 1982
Rahmani	Alexandria			0.40	Karam, 1959
Rambouillet, Pommelet				0.89	Vesely et al., 1970
Sopravissona		4.23 male	3.40male	0.83	Pilla, 1968
		4.04 female	3.20 female	0.84	" "
Suffolk	Sao Paulo	3.94	3.20	0.70	Santiage & Neto, 1954
Uda	Katsina	3.30	3.00	0.30	Adu and Ngere, 1979
"	Shika	3.80	3.40	0.60	" " "
"	"	3.80	3.40	0.60	" " "
WAD	Ibadan	1.70	1.50	0.20	Ademosun, 1973
"	Ile-Ife	2.50	2.10	0.40	" "
Yankasa	Katsina	3.60	2.90	0.30	Ngere et al., 1979
Yankasa, Uda & Crossbreds with Wesleydale	Shika	3.30	2.82	0.48	Buvanendran et. al., 1981

Table 2.4 (b): Effect of Type birth on Weaning weight of lamb from Literature

Breed/Location	Age (days)	Weaning weight (kg)		Difference (kg)	Author(s)
		Single	Twin		
Corriedale (Alpine)				2.07	Shin et al, 1975
Hampshire	120			3.70	Smith & Lidvall, 1964
Ile-de-France		23.24	21.94	1.30	Aktas, 1971
Merino (S. Africa)	120	20.38	16.11	4.27	Nel, 1971
Navajo	139			5.09	Sidwell & Grandstaff, 1949
Rambouillet	124			4.20	Hazel & Terrill, 1945 (a)
Rambouillet & Romnelet (Raleigh)				7.87	Vesely et. al., 1970
Yankasa, Uda & Crossbreds with Wesleydale (Shika)	90	15.50	13.42	2.08	Buvanendran et al., 1981

Table 2.4 (c): Effect of Sex on Birth Weight of lamb from Literature

Breed/Location	Ram lamb (kg)	Ewe lamb (kg)	Difference (kg)(%)	Author (s)
Awassi	4.15	3.95	0.20	Rottensten & Ampy, 1971
Bihar, Bikaneri & their crosses	2.44	2.27	0.17	Singh & Prasad, 1962
Black Najdi (S. Arabia)			3.9	Abouiheif & Alsobayel, 1983
Blackhead Persian (S. Africa)	2.72	2.54	0.18	Tangayika Dept. Vet. Serv. 1960
Corriedale			0.34	Shin et al., 1976
"	3.11	2.89	0.22	Kornal et al., 1976
Edilbaev (Russia)	4.85	4.60	0.25	Ermekov & Kairgaliev, 1971
Galway, Scottish Blackface, Greyface & Suffolk x halfbred			0.32	More O'ferrall & Vial, 1963
Hampshire			0.19	Smith & Lidvall, 1964
Ile-de-prana (Konya Eregli)	3.85	3.52	0.33	Aktas, 1971
Kivircik			0.46	Ozcan, 1970
Merino (Australia)	4.13	3.93	0.20	Kennedy & Bettenay, 1950
Merino, Blackhead Persian & Cross breds			5.10	Starke et al., 1958
Merino Polas (Romania)	3.72	3.54	0.18	Teodoereanu, 1962
Merino stavropol	3.62	3.44	0.18	Kaman et al., 1979
Nigerian Dwarf & cross breds (Ibadan)	2.42	2.28	0.14	Taiwo et al., 1982
Rambouillet (Oklahoma)	4.30	3.36	0.94	Gould & Whiteman, 1971
Shropshire			0.02	Ali, 1952
Suffolk (Brazil)	3.71	3.45	0.26	Santiago & Neto, 1954
Texel	4.10	3.90	0.20	Morsy & Karam, 1967
Yankasa, Uda & crossbreds (Shika)	3.11	3.01	0.10	Buvanendran et el., 1981

Table 2.4 (d): Effect of Sex on Weaning weights of lamb from Literature

~~Breed~~/Location	Age (days)	Weaning weight (kg) Male	Female	Difference (kg)	Author(s)
Bibrif (Pakistan)				1.50	Haider & Shah, 1974
Corriedale				1.32	Shin et al., 1975
Galway, Scottish Blackface, Greyface & Suffolkx halfbrea				1.5-5.4	More O'ferrall & Vial, 1963
Hampshire	120			2.80	Smith & Lidvall, 1964
Harnai (Pakistan)				1.10	Haider & Shah, 1974
Ile-de-France (Konya-Eregli)		23.08	22.13	0.95	Aktas, 1971
Merino		36.40	27.47	8.93	Ceranic & Trajic 1971
Merino (S. Africa)		20.37	19.15	1.22	Nel, 1971
Merino (Stavropol)	90			0.71	Raman et al., 1981
Navajo	139			2.00	Sidwell & Grandstaff, 1949
Rambouillet	124			3.80	Hazel & Terril, 1945
Ramanov		31.40	29.30	2.10	Jadricev & Stepanova, 1965
Texel		21.80	19.4	2.40	Morsy & Karam, 1967

Table 2.4 (c): Effect of Age of dam on Birth weight of lamb from Literature (Lambs from young and mature ewes compared)

Breed of ewe	Location	Difference (kg 1%)	Authors
Awassi	Jordan	12	Khalifa and Duayfi, 1979
Mancha		0.38	Sanchez and Minoz, 1972
"	Valdepenas	0.40	Ojeda, 1974
Shropshire	Canterbury	0.30	Ali, 1952
Galway, Scottish Blackface, Greyface		0.55-0.73	More O'ferrall and Vial, 1963
Not stated		0.20	Tomov, 1967
Uda, Yankasa & Crosses with Weleydale	Nigeria	10	Buvanendran et. al., 1981

Table 2.4 (f): Effect of Age of dam on Weaning weight of lamb from Literature (Lamb from young and mature ewes compared)

Breed/Location	Age (days)	Difference	Author(s)
Awassi (Jordan)	60	12	Khalifa & Duayfi, 1979
Galway, Scottish Blackface, Greyface		3.20	More O'ferrall & Vial, 1963
Suffolk crossbreds		3.20	
Rambouillet		2.32 (8)	Shelton & Campbell, 1962
"	124	2.77	Hazel & Terrill, 1945(b)
Shropshire		2.59	Ali, 1952
Uda, Yankasa & crossbreds (Shika)	90	10	Buvanendran et al., 1981
Wiltshire crossbreds		5.0	Donald, 1962

3. MATERIALS AND METHODS

3.1 DESCRIPTION OF THE ENVIRONMENT

The study was carried out at the National Animal Production Research Institute (NAPRI), Shika-Zaria, Nigeria.

Shika lies between latitude 11 and 12°N and between longitude 7 and 8°E at altitude of 640m. The area falls within the Northern Guinea Savanna Zone. The average annual precipitation is 1100mm, which spreads from late April or May to October, with a peak between June and September (wet season). The wet season is usually followed by 'Harmattan', a period of dry cool weather, which lasts from mid-October to January (post-rains). This is followed by dry, hot weather from February to May (pre-rains). Thus, the dry periods are long and pronounced, often causing serious shortage of water and feed supply for the animals.

The mean annual rainfall in millimetres recorded over a period of five years (1981-1985) on the research station is as shown in Fib. 3.1. The overall mean for the period was 936mm per year. The highest annual rainfall of 1228.46mm was recorded in 1985, while the lowest one, 616.68mm, was recorded in 1983. This 1983 happens to be a year when there was a serious drought.

Daily temperature ranges from 14°C to 30°C during the harmattan season, and from 21°C to 36°C during the hot season, while relative humidity varies from approximately 21% during the harmattan to 37% during the hot season. The

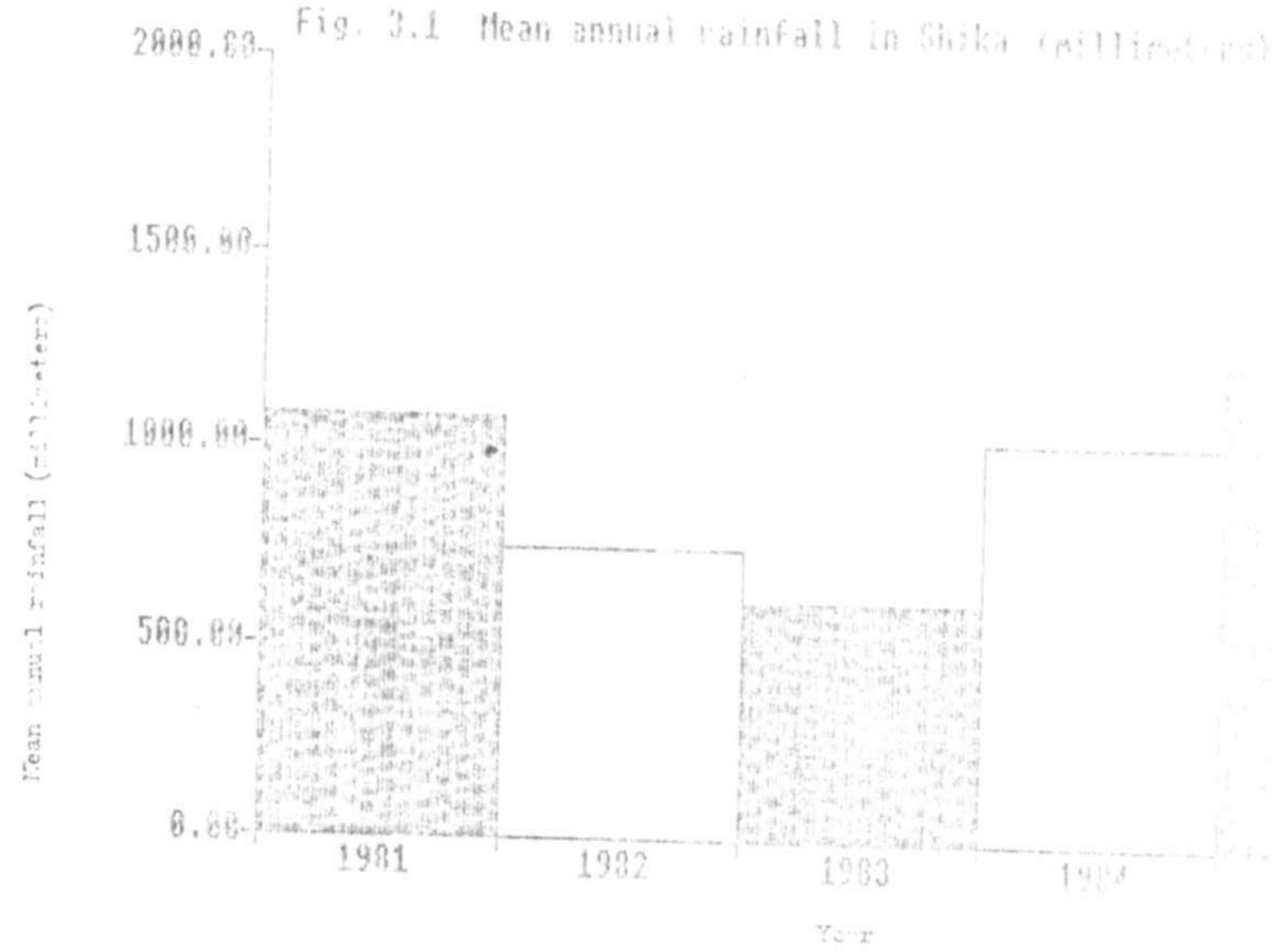
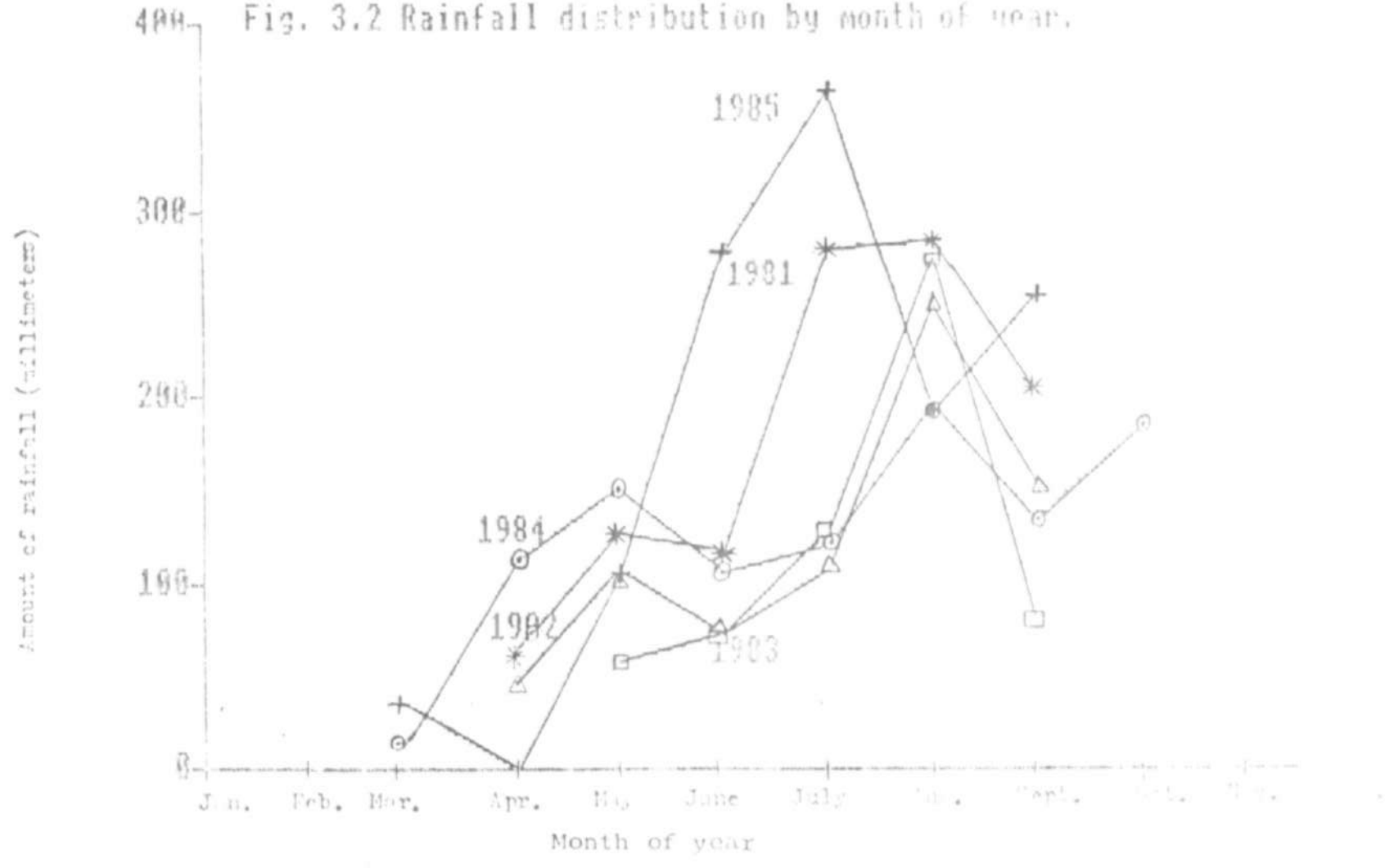


Fig. 3.1 Mean annual rainfall in Shaka (millimetres)

Fig. 3.2 Rainfall distribution by month of year.



Source: N.A.P.R.I. Rainfall data

average temperature and humidity during the wet season are 24.8^{C} and 77%, respectively.

3.2 THE DATA

3.2.1 Source

The data consisted of birth weight and monthly live weight records of 357 lambs up to twelfth month. All animals were born in the Institute between 1981 and 1985 in an on-going accelerated programme involving lambings twice-yearly at January-March and July-September.

3.2.2 Preparation for analysis

Age of lamb at every weighing, dam's age at lambing and lambing interval were computed. Data analysed for the lambs at different ages are summarized in table 3.2. The discrepancy in the number of records at different ages is due to lack of complete records on all animals, as many are culled or died or transfered to nutritional or other experiments. The available data refer to information on animals kept under the normal management system.

3.3 THE FLOCK

Established in 1981, the foundation stock of this flock composed of 2 to 3 year old Yankasa sheep purchased in small batches from different markets within Kaduna State Nigeria, in order to have representative sample. The animals were bought based on visual appraisal alone as neither performance records nor pedigree information was available.

Table 3.2: Records of lambs at different ages for Models I & II

Age	Number of records	
	Model I	Model II
Birth	357	356
3 months	297	305
6 months	167	149
9 months	144	128
12 months	92	63

3.3.1 Breeding and Selection Schemes

Breeding of the ewes was by artificial insemination or natural mating. In the early years of the programme, the few acquired rams were used for three or more consecutive matings but in 1983, yearly selection of breeding animals began. Ram lambs were chosen so that about 60% are from twin born lambs and the balance from singles, selection being on weaning weights adjusted for non-genetic effects. All twin born ewe lambs were chosen and about 50% of singles were selected based on their adjusted weaning weights. Adult ewes were culled based on lambing performance in at least three successive lambings. A set of rams was used for mating only once with a joining ratio of not more than 1 ram to 15 ewes.

3.3.2 Management of the flock

The animals were taken out for grazing on improved pastures twice daily from 0700 to 1000h and 1500 to 1800h. They were housed at night. In the dry season when forage was scarce, animals were fed hay ad libitum in between grazing periods. A concentrate supplement consisting of 25% cottonseed cake and 75% maize was fed throughout at the rate of 0.3kg/head/day. Water and mineral salt licks were provided ad libitum. Lambs were left with their dams until weaning at 3 months of age. They received the same treatment as the dams after weaning. Animals were routinely dewormed and sprayed against ectoparasites.

3.4 METHODS

3.4.1 Statistical procedures

The statistical analyses were done in stages. The first analysis was carried out to establish the correlation between age of ewe at lambing and its parity. A high correlation would justify the inclusion of only one of the two effects in the models. The correlation proved to be quite high ($r = 0.93$; $P < 0.001$). So, parity of the ewe was included as only about one third ($n = 150$) of the total cases had observations for age of ewe. The next stage was to calculate the age adjustment factors for body weights. This was necessary due to differences in dates of weighings. Using SPSS subprogram 'condescriptive' average ages of lambs at monthly weighings were calculated. Body weights of lambs (birth weight excluded) were adjusted to a constant age by multiplying average daily live weight gain (ADG) during the period under consideration by the average ages of lambs so calculated (Table 3.4 (a)).

In the third stage of the analysis two basic models were used. In model I, a linear model was assumed on which type of birth of lamb (litter size), sex of lamb, parity of ewe, season of lambing and year of lambing, were taken to have a fixed effect on each growth trait of the lamb. In model II type of birth, sex of lamb, parity of ewe and sire groups (different ram groups) were included. The effects of each subset of constraints and the variance attributed to them were estimated from a least squares analysis according

Table 3.4 (a): Formulae for age-adjusted body weights of lambs at different ages

Trait	Formula
3 - month weight	$(W_3 \times 80)/A_3$
6 - month weight	$(W_6 \times 170)/A_6$
9 - month weight	$(W_9 \times 265)/A_9$
Yearling weight	$(W_{12} \times 355)/A_{12}$

W_3, W_6, W_9 and W_{12} represent body weight of lambs (kg) at 3, 6, 9 and 12 months of age.

80, 170, 265 and 355 represent average age of lamb (days) at 3, 6, 9 and 12 months.

A_3, A_6, A_9 and A_{12} represent age of any given lamb (days) at 3, 6, 9 and 12 months.

to the procedures of Harvey (1960). This was accomplished by constructing a 16 x 16 system of equations (1 mean, 2 type, 2 sex, 5 parity, 2 season and 4 year) and a 15 x 15 system of normal equations (1 mean, 2 type, 2 sex, 5 parity and 5 sire groups) in models I and II respectively. These were accordingly reduced to full ranks of 11 x 11 and 11 x 11 systems by substracting from each subset the equation which appeared first in the subset. This procedure automatically imposes the restriction that the sum of the effects equals zero, The reduced system was subsequently solved on a high speed computer, Cyber 72 (3) at the Ahmadu Bello University Computer Centre.

The two models used were asf follows:

Model I

$$Y_{ijklf} = \mu + T_i + S_j + P_k + M_l + Y_f + E_{ijklf}$$

where Y_{ijklf} = body weight of lamb at a given age

μ = mean that would exist if all classes had equal numbers

T_i = effect of i^{th} type of birth; i = 1, 2

S_j = effect of j^{th} sex of lamb; j = 1, 2

P_k = effect of k^{th} parity of ewe; k = 1, 5

M_l = effect of l^{th} season of lambing; l = 1, 2

Y_f = effect of f^{th} year of lambing; f = 1, 4

E_{ijklf} = a random effect peculiar to each lamb (normally, independently and identically distributed with mean zero and variance σ^2_e).

Model II

$$Y_{ijkl} = \mu + T_i + S_j + P_k + G_l + E_{ijkl}$$

where Y_{ijkl} = body weight of lamb at a given age

μ = mean that would exist if all classes had equal numbers.

T_i = effect of i^{th} type of birth; i = 1, 2

S_j = effect of j^{th} sex of lamb; j = 1, 2

P_k = effect of k^{th} parity of ewe; k = 1, 5

G_l = effect of l^{th} sire group; 1 , 5

Eijkl = a random effect peculiar to each lamb (normally, independently and identically distributed with mean zero and variance σ^2_e).

As the model I was intended to be applied to compare the effect of additive and multiplicative correction factors, the data were then adjusted additively by adding to each observation an appropriate linear function of opposite sign of the estimate. And for multiplicative correction each observation was multiplied by an appropriate constant, obtained as the ratio of the overall mean to each subclass least square mean. In model II, data adjusted using additive correction factors were used in estimating variance and covariance components for estimates of heritability, repeatability and genetic and phenotypic correlations.

(i) Repeatability: This parameter estimates the relationship between repeated measurements on the same individual. Lambs birth weight when considered as a trait of the ewe is repeated each time the ewe lambs and thus estimates of repeatability of this trait are possible. The statistical model used was $Y_{km} = \mu + \alpha_{k+} e_{km}$, where Y_{km} is the m^{th} measurement on the k^{th} individual. The SPSS subprogram 'oneway' was used in estimating the repeatability of a trait by the method of intraclass correlation among records of the same ewe. By proper data manipulation, the subprogram gives the required components of the formula for estimating the repeatability, that is, the components of variance between and within the dams, the numbers of measurements per dam, the number of dams and the total number of measurements. The mean squares were computed as indicated in tables 3.4 (b) and (c). All effects were assumed random, normal and independent with their means being zero. Finally, these mean squares were equated to their expected values and the resulting equations solved for the required variance components. Variance components are estimated as follows:

$$\delta^2_E = MS_E; \quad \delta^2_W = \frac{MS_W - MS_E}{K_1}$$

$$\text{Repeatability (R)} = \frac{\delta^2_W}{\delta^2_W + \delta^2_E}$$

Standard error or (R) was calculated according to Swiger et al. (1964). This is an approximate method for standard error. Normality of repeatability and unequal numbers per group are assumed.

Table 3.4(b): Analysis of variance for estimating repeatability

Source	d.f.	SS	MS	EMS
Between dams	N-1	SS_W	M_W	$\delta^2_E + K_1 \delta^2_W$
Between measurements, within dams	M-N	SS_E	MS_E	δ^2_E

where

N = number of dams

M = total number of measurements

K_1 = harmonic mean of number of measurements per individual = $\frac{1}{N-1}\left(M - \frac{\sum m^2_k}{M}\right)$

m_k = number of measurements taken on the k^{th} dam

Table 3.4(c): Computational formula for estimating repeatability

Source	d.f.			
Correction term (CT)	1	$\frac{Y^2..}{M}$		
Between dams	N-1	$\sum_k \frac{Y^2_{k.}}{m_k} - C.T.$	$\frac{SS_W}{(N-1)}$	$= MS_W$
Within dams between measurements	M-N	$\sum\sum_{km} Y^2_{k_m} - \sum_k \frac{Y^2_{k.}}{m_k}$	SS_E	$= MS_E$

$$S.E.\ (R) = \sqrt{\frac{2(M-1)\ (1-R)^2\ (1+(K-1)\ R)^2}{K_1^2\ (M-N)\quad (N-1)}}$$

(ii) Heritability: The SPSS subprogram 'oneway' was used in estimating the heritability of traits studied by the method of paternal half-sib correlation. The model used was

$$Y_{ij} = \mu + S_i + E_{ij}, \text{ where}$$

Y_{ij} is the j^{th} observation for each trait on the i^{th} sire, and

μ is the common mean

S_i is the additive effect of the i^{th} sire, and

E_{ij} is the uncontrolled environmental and genetic deviation attributable to individuals within sires.

Under random mating the sire variance (σ^2_s) is expected to contain one-fourth of the genic variance plus a small amount of the epistatic variance. The expected value of the error variance ($\sigma^2 e$) is three-fourth of the genic variance plus the environmental variance. The heritability estimate would then be $4\ \sigma^2_s / (\sigma^2 s + \sigma^2 e)$. However as the present data comprise both full and half-sibs in each sire group, the relationship within progeny groups which should normally be greater than one-fourth was calculated using the following formula suggested by Osborne (1975):

$$\hat{r}_g = \frac{n(d+1) - 2}{4(dn-1)}$$

where $\hat{r}_g$ is the within progeny group relationship, d is the number of dams mated to each sire, n is the number of offspring per dam. Tables 3.4 (d) shows the within-progeny group relationship for the body weight traits.

Heritability was therefore estimated as

$\hat{r}_g^{-1} \times \sigma^2 s / (\sigma^2 s + \sigma^2 e)$. The mean squares were computed as indicated in tables 3.4 (e) and (f). Standard error of heritability, S.E. (h^2), was calculated according to Swiger et al. (1964). This is an approximate method for standard error. Normality of the intraclass correlation, t, is assumed.

S.E. (h^2) =

$$\hat{r}_g \sqrt{\frac{2(n.-1)\,(1-t)^2\,(1+(k-1)\,t)^2}{h^2\,(n.-s)\,(s-1)}}$$

(iii) Genetic and Phenotypic correlations: With the aid of SPSS subprogramm 'Anova', analysis of variance of cross-products using the paternal half-sib model described earlier on was employed in order to obtain components of covariance between breeding values of the growth traits. The covariance and variance components were used to estimate both genetic and phenotypic correlations. The components of variance for $\sigma^2 s(x)$, $\sigma^2 s(y)$, $\sigma^2 w(x)$ and $\sigma^2 w(y)$ were obtained as done for heritability, and the components of covariance were derived from the analysis of covariance using the mean cross products as shown in tables 3.4 (g) and (h). Genetic correlation, r_G was estimated as

Table 3.4(d): Within progeny group relationship for body weight of lambs

Trait	Mixed			Singles		
	d	n	$\hat{r}_g$	d	n	$\hat{r}_g$
Birth weight	11.77	2.30	0.2633	9.04	1.97	0.2644
Weaning weight	10.28	2.30	0.2643	7.76	1.72	0.2645
6-month weight	5.41	1.63	0.2701	4.70	1.23	0.2620
9-month weight	4.86	1.58	0.2717	4.29	1.20	0.2647
Yearling weight	3.71	1.26	0.2674	3.35	1.12	0.2607

Table 3.4 (e): Analysis of variance for estimating heritability

Source	d.f.	SS	MS	EMS
Between sires	S-1	SS_s	MS_s	$\sigma^2_W + K\sigma^2_s$
Progeny within sires	n.-s	SS_W	MS_W	σ^2_W

where

S = number of sires

k = harmonic mean of number of progeny per individual sire

$= 1/s-1 \quad (n.- \frac{\sum ni^2}{n.})$

n. = total number of progeny

n_i = number of progeny within the i^{th} sire

Table 3.4(f): Computational formula for estimating heritability.

Source	d.f.	SS	MS
Correction Term (C.T.	1	$\frac{Y^2..}{n.}$	
Between sires	S-1	$\sum_i \frac{Y_{i.}^2}{ni} - C.T.$	$SS_s/(S-1) = MS_s$
Progeny within sire	n.-s	$\sum_i \sum_k Y^2_{ik} - \sum_i \frac{Y^2_i}{ni}$	$SS_W/n.-s = MS_E$

$\sigma^2_w = MS_E$

$\sigma^2_s = MS_{S/E} MS_{E/K}$

$$r_G = \frac{\delta_{s(x)s(y)}}{\sqrt{\delta^2_{s(x)} \quad \delta^2_{s(y)}}}$$

The standard error of the correlation was estimated using the formula given by Robertson (1959). Thus, S.E. (r_G) =

$$\frac{1 - r_G^2}{\sqrt{2}} \sqrt{\frac{S.E.\ (h_1^2)\ S.E.\ (h_2^2)}{h^2_1 \quad h^2_2}}$$

Phenotypic correlation, r_p, was calculated according to the Becker (1968); Thus,

$$r_p = \frac{\delta_{w(x)\ w(y)} + \delta_{s(x)\ s(y)}}{\sqrt{\delta^2_{w(x)} + \delta^2_{s(x)} \quad (\delta^2_{w(y)} + \delta^2_{s(y)}}}$$

Where $\delta_{w(x)\ w(y)}$ = within sire component of covariance for traits x and y.

$\delta_{s(x)\ s(y)}$ = between sire component of covariance for traits x and y.

$\delta^2_{w(x)}, \delta^2_{w(y)}$ = the within sire components of variance for triats x and y, respectively.

$\delta^2_{s(x)}, \delta^2_{s(y)}$ = the sire components of variance for traits x and y, respectively.

Table 3.4(g): Analysis of covariance for estimating genetic and phenotypic correlations.

Source	d.f.	Mean Cross Products (MCP)	Expected mean cross products (EMCP)
Between sires	S-1	MCP_s	$Cov_w + KCov_s$
Progeny within sires	n.-s	MCP_w	Cov_w

Table 3.4(h): Computational formula for estimating genetic and phenotypic correlations

Source	Sum of Cross Products (SCP)	Mean Cross Products (MCP)
Correction Term (C.T.)	$\frac{X.. \; Y..}{n..}$	
Between sires	$\sum_i \frac{Xi. \; Yi}{ni.} - C.T.$	$SCP_{s/S-1} = MCP_s$
Progeny within sire	$\sum\sum_{ik} X_{ik} \; Y_{ik} - \sum\sum_{i \; k} \frac{Xi. \; Yi.}{ni}$	$SCP_{w/n.-s} = MCP_w$

Cov_W ==MMC MCP_W

$Cov_S = MCP_s - MCP_w/k$

**• 4. RESULTS

4-.1 MiilN ANALYSIS - GENETIC AND ENVIRONMENT J, EFFECTS ON LAMB WEIGHTS.

The analyses of variance given in tables 4.1(a) and (b) show the importrnt sources of variation in weights of lamb at five strges of growth. The interactions (first-order) between the main effects were mostly non-significant (Appendices 1 (a) and (b)) and were theref excluded from the main analysis. The means and standard deviations for birth weight and age-adjusted body weights are given in tables 4..2(a) to (f). The number of observations within each subclass indicates that the data are unbalanced, hence the need to use least-squares procedures to estimate the fixed effects. The esti:::' ted least-squares constants for body weight at the different stages arc for the reduced models in which all the non-significant interactions were eliminated, and there constants are shown in Appendices 2 (a) and (b).

The least-SGueres means for body weights at birth, 3, 6, 9 and 12 months of age in table 4.3(a) show that lambs gained 8.39kg from birth to 3 months (or 0.103 k.-;/ head/day), 4.4?kg from 3 to 6 months (or 0.050kg/hc: d/day), 5.00kg from 6 to 9 months (or 0.053kg/head/day) and 4.14kg from 9 to 12 months (0.046kg/head/day). Thus, the moat rapid growth occured during the first 3 months of life.

Except for sire group effect in model II, the absolute magnitudes of the least-squares constants (Appendices 2 (a) and (b) for the various effects air body weights in both models I and II follow the same general pattern.

The relative sizes of the constants in relation to the means were however different. The least-squares effects expressed as deviations from the overall mean and also the corresponding standard errors provide a means of appraising the significance of the differences between subclasses. These differences are discussed under each appropriate class of effects.

4.1.1 Effect of Type of birth (litter size)

Type of birth had very highly significant effect ($P<0.001$) on lamb weight up to 9 months of age and highly significant ($P<0.01$) up to 12 months of age (Table 4.1 (a)). Lambs born as singles were heavier than twin-born lambs by 0.54kg (19.4%) at birth, 3.24kg (25.83%) at 3 months, 3.24kg (19.08kg) at 6 months, 2.96kg (13.55%) at 9 months and 3.18kg (12.19%) at 12 months of age (Table 4.3 (a)).

4.1.2 Effect of Sex of lamb

Sex of lamb also had a very highly significant effect ($P<0.001$) on lamb weight at birth, 3 months, 9 months and 12 months and highly significant effect ($P<0.01$) at 6 months of age (Table 4.1 (a)) with male lambs being heavier than the female lambs. Thus, male lambs were heavier than female lambs by 0.22kg (8.40%) at birth, 1.54kg (13.20%) at 3 month, 1.58kg (10.00%) at 6 months, 3.20kg (14.57%) at 9 months and 4.88kg (18.11%) at 12 months of age (Table 4.3 (a)).

4.1.3 Effect of Parity/Age of ewe

The effect of parity on lamb weight was very highly significant (P<0.001) at birth and 3 months and significant at (P<0.05) at 6 months of age. (Table 4.1(a)). Lambs from the fourth parity had the highest mean birth weight (2.71kg), while those from the first parity had the lowest mean birth weight (2.51kg). This represented a decrease of 0.20kg or 7.40%. At 3 months, lambs from the fifth parity had the highest mean weaning weight (12.42kg), while those from the first parity had the lowest mean weaning weight (8.98kg), resulting in a decrease of 3.44kg or 27.70%. The decrease in weights of lambs from the fourth and first parities at 6 months of age was 2.03kg or 12.16% (Table 4.3(a)). Although the differences between the first and fourth parities at 9 and 12 months of age were not significant, lambs from the fourth parity were equally heavier than those from the first parity at these ages.

4.1.4 Effect of Month/Season of lambing

The season of lambing had a very highly significant effect (P<0.001) on lamb weights at birth, 3 and significant effect (P<0.05) at 12 months of age (Table 4.1(a)). Lambs born between May-October (rainy season) were heavier at birth (2.64kg) than those born between November-April (dry season). The difference in birth weight between the two seasons was 0.26kg (9.8%). Also at 3 months of age lambs born during the rainy period were 1.80kg (15.25%) heavier than those born during the dry season (11.80kg)

compared with(10,00kg) (Table 4.3(a)). Though the difference was not statistically significant, lambs born during the dry season were heavier at 6 months of age than those born during the wet season. (15.56kg compared with 15.16kg).. Despite the slow post-weaning growth rate of lambs in both seasons, lambs born during the rainy season were ultimately heavier at 12 months of age. The 2.14kg (9.9%) difference was significant (P$<$0.05).

4.1.5 Effect of Year of lambing

Year of lambing had a highly significant effect (P$<$0.01) on lamb weight at birth and a very highly significant effect (P$<$0.001) on lamb weight from 3 months to 12 months of age (Table 4.1 (a)). The differences in weight of lambs between the extreme years were 0.38kg (14.2%) at birth (1981 compared with 1984), 3.79kg (30.4%) at 3 months (1981 compared with 1984), 3.54kg (20.6%) at 6 months (1981 compared with 1983), 5.00kg (22.6%) at 9 months (1982 compared with 1983) and 6.24kg (23.2%) at 12 months (1982 compared with 1983) (Table 4.3 (a)).

4.1.6 Effect of Sire group

The effect of sire group on lamb weight was very highly significant (P$<$0.001) from birth to 9 months of age and highly significant (P$<$0.01) at 12 months of age. (Table 4.1(b)). The differences in weight between the extreme groups were 0.38kg (14.2%) at birth (group 2 compared with group 3), 3.82kg (32.5%) at 3 months

(group 4 compared with group 3), 4.04kg (25.9%) at 6 months (group 4 compared with group 5), 5.17kg (23.9%) at 9 months (group 4 compared with group 5) and 6.13kg (23.4%) at 12 months (group 4 compared with group 2) (Table 4.3 (b)).

4.2 ESTIMATES OF CORRECTION FACTORS AND GENETIC PARAMETERS FOR BODY WEIGHTS

4.2.1 Additive versus multiplicative correction factors for body weights of lambs

Tables 4.4(a) - (e) show the least-squares means, standard deviation and coefficients of variations for lamb weights at different ages. A critical look at the data given in the tables revealed that neither the standard deviations nor the coefficients of variations were homogenous for the subclass within each group of effects. It therefore became difficult to decide whether additive or multiplicative correction factors should be used. However, except in the case of type of birth effect, the standard deviations for the subclasses within each group did not seem to increase with the means, which probably suggested that additive correction may have an advantage over multiplicative adjustments. Estimates of additive and multiplicative correction factors were obtained and the means and variances that resulted from their use as correction factors in the data are shown in Appendices 3 (a) - (e). The overall means, standard deviations and coefficients of variation are given in table 4.5.

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4.2.2 Genetic analysis of body weight

(a) Repeatability of lamb weight

The repeatability estimates of weights of lambs from birth to 12 months of age considered as characteristics of the ewe are shown in tables 4.6(a) and (b). Using uncorrected and corrected data separately, estimates of repeatability were calculated for single-born lambs only and mixtures of single-and twin born lambs. The estimates were of low magnitude. However, values obtained from corrected data were generally higher at all stages of growth than those from uncorrected data. Except for birth weight, values obtained for mixed lambs were lower than those for single-born lambs using the corrected data. Negative estimates were obtained for body weight at 3 months (single) and 12 months (mixed) with the uncorrected data.

(b) Heritability estimates

The heritability estimates of body weights from birth to 12 months of age calculated using both uncorrected and corrected data are given in tables 4.7(a) [illegible]. For the uncorrected data, all the values obtained for mixed lambs were lower than those obtained for single lambs at all ages from birth to 12 months. The trend in the estimates from corrected data was however inconsistent. For both sets of data, the heritability estimates obtained for birth and 12-month weights were of medium values while the values for 3-, 6- and 9-month weights were of high magnitude.

(c) Genetic and Phenotypic correlations

The coefficient of genetic and phenotypic correlations between body weights of lambs estimated from both uncorrected and corrected records are shown in tables 4.8(a) to (d). Estimates of genetic correlations between uncorrected lamb weights as shown in table 4.8(a) were generally low but positive (0.12 - 0.26). Estimates for the corrected lamb weights were also generally low (Table 4.8(b)), and a negative correlation was obtained for lamb weights at 6 and 12 months of age. Phenotypic correlations between uncorrected and corrected lamb weights were also low and positive (Tables 4.8(c) and (d))for adjacent weights but were however mostly higher than values for non-adjacent weights.

Table 4.1(a): Analysis of variance of lamb weights (kg) (Model I)

Source of variation	d.f.	Mean squares of weights at different ages				
		Birth	3 mont	6 month	9 month	12 month
Type	1	19.73***	580.08***	322.99***	205.50***	145.80**
Sex	1	3.97***	172.58***	95.80**	322.50***	486.03***
Parity	4	2.95***	45.54***	33.98* (3)[a]	14.20 (3)[a]	25.85 (3)[a]
Season	1	5.18***	203.82***	5.04	12.15	82.81*
Year	3	1.38**	90.34***	58.76***	154.12***	141.08***
Residual		0.31 (346)[a]	6.26 (287)[a]	9.33 (157)[a]	11.17 (134)[a]	16.88 (82)[a]

* = P<0.02
** = P<0.01
*** = P<0.001
a = degrees of freedom.

Table 4.1(b): Analysis of variance lamb weights (kg) (Model II)

Source of variation	d.f.	Means squares of weights at different ages				
		Birth	3 month	6 month	9 month	12 month
Type	1	20.33***	621.51***	309.55***	169.29***	79.08*
Sex	1	3.06***	148.71***	256.97***	362.01***	285.31***
Parity	4	2.67***	55.71***	14.01*	3.77NS	7.37 NS (3)[a]
Sire group	4	1.64***	180.78***	61.71***	75.00***	73.88** (3)[a]
Residual		0.26 (345)[a]	4.74 (294)[a]	5.52 (138)[a]	7.56 (117)[a]	13.26 (54)[a]

* = P/0.05

** = P/0.01

*** = P/0.001

a = degrees of freedom

Table 4.2 (a): Means and standard deviations for birth weight and age-adjusted body weights by type of birth of lamb

Type of birth	Birth			3-month			6-month			9-month			12-month		
	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D	No.	Mean	S.D.	No.	Mean	S.D
Single	257	2.63	0.65	216	11.67	3.17	123	16.20	3.36	110	21.00	4.27	70	24.97	5.67
Twin	100	2.20	0.51	82	8.85	2.53	44	13.01	3.16	34	18.32	3.75	22	23.01	4.15

Table 4.2 (b): Means and standard deviations for birth weight and age-adjusted body weights by sex of lamb.

Sex of lamb	Birth			3-month			6-month			9-month			12-month		
	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
Male	185	2.61	0.67	142	11.57	3.31	69	16.28	3.36	54	22.50	4.25	48	26.89	4.51
Female	172	2.40	0.59	156	10.28	3.09	98	14.71	3.61	90	19.09	3.80	44	21.90	5.10

Table 4.2 (c): Means and standard deviations for birth weight and age-adjusted body weights by parity of ewe

Parity of ewe	Birth			3-month			6-month			9-month			12-month		
	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D
1	102	2.34	0.67	82	11.05	3.35	57	15.06	3.69	49	21.07	4.04	31	24.21	5.10
2	88	2.57	0.62	75	10.87	2.75	52	15.24	3.37	44	19.60	3.90	25	22.96	5.42
3	89	2.50	0.56	79	10.56	3.29	40	15.39	3.52	34	19.80	4.04	23	25.35	5.30
4	93	2.67	0.68	45	11.00	3.96	18	16.56	4.04	17	21.44	6.00	13	26.66	5.77
5	25	2.61	0.67	17	11.53	2.79									

Table 4.2 (d): Means and standard deviations for birth weight and age-adjusted body weights by season of birth.

Season of lambing	Birth			3-month			6-month			9-month			12-month		
	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D	No.	Mean	S.D.	No.	Mean	S.D.
Nov-April	171	2.34	0.58	142	9.66	3.09	78	15.65	3.28	63	20.05	4.09	46	23.37	6.16
May-Oct	186	2.67	0.65	156	12.02	3.00	89	15.11	3.83	81	20.61	4.45	46	25.63	4.25

Table 4.2(e): Means and standard **deviations for birth** weight and age-adjusted body weights by year of birth

Year of Lambing	Birth			3-month			6-month			9-month			12-month		
	No	Mean	S.D	No	Mean	S.D	No	Mean	S.D.	No	Mean	S.D.	No	Mean	S.D.
1981	21	2.48	0.78	15	12.13	2.80	15	16.94	2.07	16	21.82	3.50	14	25.26	4.37
1982	59	2.67	0.62	47	12.46	3.00	38	15.95	4.33	32	22.72	3.96	13	26.86	3.88
1983	98	2.44	0.64	88	11.22	3.09	68	14.24	3.20	56	17.94	3.12	34	21.64	5.53
1984	179	2.50	0.63	148	10.08	3.25	46	16.00	3.75	40	21.30	4.67	31	26.31	4.97

Table 4.2(f): Means and standard deviations for birth weight and age-adjusted body weights by sire-group

Sire group	Birth			3-month			6-month			9-month			12-month		
	No	Mean	S.D.	No	Mean	S.D.	No	Mean	S.D.	No	Mean	S.D.	No	Mean	
1	46	2.32	0.59	38	11.35	2.75	34	14.96	3.28	25	18.30	3.00	20	18.77	4.71
2	51	2.55	0.67	49	11.07	3.37	33	13.43	3.00	30	17.67	3.29	18	26.31	3.27
3	97	2.31	0.55	85	8.39	2.50	29	15.37	3.48	22	20.78	3.79	13	28.21	3.84
4	81	2.71	0.65	63	12.63	2.72	22	16.02	4.24	20	21.99	5.21	17	25.36	5.18
5	81	2.42	0.49	70	9.36	2.56	31	11.42	2.17	31	16.24	2.24			

Table 4.3(a): Least-squares means (LSM) for lamb weights (kg) at birth, 3, 6, 9 and 12 months of age (Model I)

Variable	Birth		3 month		6 mont		9 month		12 month	
	2.52		10.90		15.36		20.36		24.50	
Overall mean	No	LSM	No	LSM	No	LSM	No	LSM	No	LSM
Type of birth										
Single	257	2.78	216	12.52	123	16.98	110	21.84	70	26.09
Twin	100	2.24	82	9.28	44	13.74	34	18.88	22	22.91
Sex of lamb										
Male	185	2.62	142	11.67	69	16.15	54	21.96	48	26.94
Female	172	2.40	156	10.13	98	14.57	90	18.76	44	22.06
Parity of ewe										
1	102	2.09	82	8.98	57	14.66	49	19.14	31	22.61
2	88	2.51	75	10.25	52	15.25	44	20.33	25	24.91
3	89	2.58	79	11.14	40	15.82	34	20.68	23	25.33
4	53	2.71	45	11.71	18	16.69	17	21.39	13	25.14
5	25	2.66	17	12.42						
Season of lambing										
Nov-April	171	2.38	142	10.00	78	15.56	63	20.03	46	23.43
May-Oct	186	2.64	156	11.80	89	15.16	81	20.09	46	25.57
Year of lambing										
1981	21	2.68	15	12.46	15	17.18	16	21.68	14	26.35
1982	59	2.66	47	11.78	38	16.00	32	22.44	13	26.87
1983	98	2.39	88	10.69	68	13.64	56	17.36	34	20.63
1984	179	2.30	148	8.67	46	14.62	40	19.96	31	24.15

Table 4.3(b): Least-square means (LSM) for lamb weights (kg) at birth 3, 6, 9 and 12 months of age (Model II)

Variable	Birth		3 month		6 month		9 month		12 month	
Overall	2.47		10.23		14.12		18.66		24.05	
	No	LSM	No	LSM	No	LSM	No	LSM	No	LSM
Type of birth										
Single	237	2.74	201	11.81	94	15.72	84	19.98	46	25.44
Twin	119	2.20	104	8.65	55	12.52	44	17.34	17	22.66
Sex of lamb										
Male	184	2.56	156	10.94	58	15.50	47	20.50	36	26.71
Female	172	2.38	151	9.52	91	12.74	81	16.82	27	21.39
Parity of ewe										
1	50	2.05	41	8.29	18	12.52	12	17.99	9	22.73
2	83	2.47	76	9.68	41	13.96	36	18.33	19	24.49
3	97	2.57	89	10.81	46	14.70	40	19.06	22	24.45
4	74	2.66	59	10.83	23	14.88	22	19.14	13	24.53
5	52	2.60	40	11.53	21	14.53	18	18.77		
Sire group										
1	46	2.37	38	11.44	34	14.78	25	18.38	20	20.02
2	51	2.68	49	11.57	33	13.71	30	17.49	13	24.64
3	97	2.30	85	7.93	29	14.69	22	19.39	13	25.39
4	81	2.58	63	11.75	22	15.58	20	21.63	17	16.15
5	81	2.41	70	8.96	31	11.54	31	16.46		

Table 4.4(a). Least-square means, standard deviations and coefficients of variation for lamb weights by type of birth

Type of birth	Birth			3 month			6 month			9 month			12 month		
	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV
Single	2.78	0.54	19.56	12.52	2.47	19.74	16.98	3.05	17.99	21.84	3.62	16.57	26.09	4.52	17.33
Twin	2.24	0.34	15.18	9.28	1.52	16.41	13.74	1.83	13.30	18.88	2.01	10.66	22.91	2.53	11.06

Table 4.4(b): Least-square means, standard deviations and coefficients of variation for weights by sex of lamb.

Sex of Lamb	Birth			3 month			6 month			9 month			12 month		
	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV
Male	2.62	0.40	15.33	11.67	1.76	15.05	16.15	2.04	12.65	21.96	2.19	0.96	26.94	3.14	11.67
Female	2.40	0.39	16.12	10.13	1.34	18.17	14.57	2.44	16.71	18.76	2.82	15.06	22.06	3.01	13.64

LSM = Least-square mean (kg); S.D. = Standard Deviation (kg); C.V. = Coefficient of variation (%)

Table 4.4(c): Least-square means, standard deviations and coefficients of variation for lamb weights by parity of ewe

Parity of ewe	Birth			3 month			6 month			9 month			12 month		
	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV
1	2.09	0.71	33.83	8.98	3.30	36.70	14.66	5.42	36.96	19.14	4.40	22.96	22.61	5.19	22.95
2	2.51	0.61	24.26	10.25	2.78	27.09	15.26	3.23	21.19	20.33	3.50	17.19	24.91	4.45	17.88
3	2.58	0.55	21.23	11.54	2.54	22.85	15.82	2.89	18.26	20.68	3.17	15.32	25.33	3.83	15.13
4	2.71	0.53	19.58	11.71	2.42	20.69	16.69	2.91	17.44	21.30	3.21	15.09	25.14	4.28	17.04
5	2.66	0.50	18.82	12.42	2.21	17.82									

Table 4.4(d): Least-square means, standard deviations and coefficients of variation for lamb weights by season of lambing

Season of lambing	Birth			3month			6 month			9 month			12 month		
	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV
Nov-April	2.38	0.42	17.63	10.00	1.38	18.82	15.56	2.35	15.10	20.03	2.51	12.53	23.43	3.28	14.00
May-Oct	2.64	0.44	16.59	11.80	1.97	16.72	15.16	2.51	16.56	20.69	2.84	13.75	25.57	3.28	12.83

LSM = Least-square mean (kg) ; S.D. = Standard deviation (kg) ; C.V. = Coefficient of variation (%)

Table 4.4(e) : Least-square means standard deviations and coefficients of variation for lamb weights by year of lambing

Year of lambing	Birth			3 month			6 month			9 month			12 month		
	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV	LSM	SD	CV
1981	2.68	0.46	17.10	12.46	2.05	16.45	17.18	2.64	15.36	21.68	2.99	13.81	26.35	3.98	15.09
1982	2.66	0.54	20.29	11.78	2.46	20.87	16.00	3.13	19.54	22.44	3.43	15.30	26.87	3.60	13.41
1983	2.39	0.58	24.48	10.69	2.78	26.05	13.64	3.36	24.64	17.36	3.71	21.38	20.63	4.54	22.00
1984	2.30	0.88	38.44	8.67	4.17	48.14	14.62	3.98	27.23	19.96	4.36	21.86	24.15	5.83	24.13

LSM = Least-square mean (kg); SD = Standard deviation (kg); C.V. = Coefficient of variation (%)

Table 4.5 : Additive versus multiplicative adjustments for birth 3, 6, 9 and 12 - months lamb weights

	Birth			3 month			6 month			9 - month			12 - month		
LSE[1]	LSE[1]	Adj[2] Adj	Mult[3] Adj	LSE	Adj Adj	Mult Adj	LSE	Adj Adj	Mult Adj	LSE	Adj Adj	Mult Adj	LSE	Adj Adj	Mult Adj
Mean (kg)	2.51	2.54	2.56	10.90	11.57	11.73	15.36	15.36	15.21	20.36	20.85	20.39	24.50	24.73	25.53
S.D. (kg)	0.64	0.55	0.56	3.26	2.59	2.69	3.59	3.01	3.37	4.29	3.24	4.52	5.39	3.90	6.54
C.V. (%)	25.50	21.65	21.88	29.91	22.38	22.93	23.37	19.60	22.16	21.07	15.54	22.1	22.00	15.77	25.62

1 = Least-square Estimate
2 = Means after additive adjustment
3 = Meanas, after multiplicative adjustment

Table 4.6(a) : Estimates of repeatability of uncorrected lamb weights (kg)

Age	Type	Degrees of freedom: Dam	Error	Repeatability
Birth	Single	75	127	0.04 ± 0.08
	Mixed	94	235	0.08 ± 0.06
3-month	Single	64	95	-0.04 ± 0.09
	Mixed	85	186	0.02 ± 0.06
6 - month	Single	22	26	0.30 ± 0.18
	Mixed	44	65	0.13 ± 0.12
9-month	Single	21	28	0.20 ± 0.18
	Mixed	38	51	0.18 ± 0.13
12-month	Single	7	8	0.04 ± 0.36
	Mixed	10	12	-0.09 ± 0.28

Table 4.6(b): Estimates of repeatability of corrected lamb weights (kg)

Age	Type	Degrees of freedom: Dam	Error	Repeatability
Birth	Single	75	127	0.10 ± 0.08
	Mixed	94	235	0.14 ± 0.06
3-month	Single	64	95	0.09 ± 0.10
	Mixed	85	186	0.06 ± 0.06
6-month	Single	22	26	0.25 ± 0.18
	Mixed	44	65	0.19 ± 0.12
9-month	Single	21	28	0.33 ± 0.17
	Mixed	38	51	0.28 ± 0.13
12-month	Single	7	8	0.27 ± 0.34
	Mixed	10	12	0.17 ± 0.28

Table 4.7(a) : Estimates of heritability of uncorrected lamb weights (kg)

Age	Type	Degrees of freedom: Sire	Degrees of freedom: Error	Heritability
Birth	Single	21	177	0.43 ± 0.23
	Mixed	21	281	0.29 ± 0.16
3-month	Single	20	142	0.98 ± 0.34
	Mixed	20	227	0.82 ± 0.28
6-month	Single	16	63	0.79 ± 0.45
	Mixed	21	110	0.72 ± 0.33
9-month	Single	16	56	0.96 ± 0.49
	Mixed	21	95	0.71 ± 0.35
12-month	Single	10	27	0.64 ± 0.62
	Mixed	13	40	0.26 ± 0.50

Table 4.7(b) : Estimates of heritability of corrected lamb weights (kg)

Age	Type	Degrees of freedom: Sire	Degrees of freedom: Error	Heritability
Birth	Single	21	177	0.21 ± 0.19
	Mixed	21	281	0.22 ± 0.14
3-month	Single	20	142	1.09 ± 0.35
	Mixed	20	227	1.14 ± 0.31
6-month	Single	16	63	1.11 ± 0.48
	Mixed	21	110	1.06 ± 0.36
9-month	Single	16	56	1.01 ± 0.49
	Mixed	21	95	0.94 ± 0.37
12-month	Single	10	27	0.45 ± 0.66
	Mixed	13	40	0.51 ± 0.53

Table 4.8(a) : Coefficient of genetic correlation between uncorrected lamb weights (kg) at different ages.

Age	3-month	6-month	9-month	12-month
Birth	0.12 ± 0.30	0.22 ± 0.17	0.17 ± 0.19	0.23 ± 0.70
3-month		0.26 ± 0.26	0.14 ± 0.28	0.23 ± 0.54
6-month			0.14 ± 0.33	0.13 ± 0.65
9-month				0.14 ± 0.67

Table 4.8(b) : Coefficients of genetic correlation between corrected lamb weights (kg) at different ages.

Age	3-month	6-month	9-month	12-month
Birth	0.10 ± 0.29	0.26 ± 0.30	0.19 ± 0.34	0.33 ± 0.51
3-month		0.27 ± 0.20	0.17 ± 0.22	0.08 ± 0.37
6-month			0.14 ± 0.25	-0.04 ± 0.42
9-month				0.18 ± 0.44

Table 4.8(c) : Coefficients of phenotypic correlation between uncorrected lamb weights (kg) at different ages.

Age	3-month	6-month	9-month	12-month
Birth	0.14	0.13	0.11	0.09
3-month		0.34	0.30	0.24
6-month			0.26	0.31
9-month				0.20

Table 4.8(d): Coefficients of phenotypic correlation between corrected lamb weights at different ages.

Age	3-month	6-month	9-month	12-month
Birth	0.17	0.18	0.14	0.12
3-month		0.43	0.39	0.27
6-month			0.33	0.47
9-month				0.33

5. DISCUSSION

5.1 COEFFICIENTS OF DETERMINATION

The first least-squares model (model I) accounted for about 28%, 43%, 31%, 43% and 48% of the total variation in body weight of lamb at birth, 3, 6, 9 and 12 months of age, respectively. Corresponding figures for the second model (model II) were 31%, 53%, 59%, 56% and 65%. These coefficients were very highly significant ($P<0.001$) at all stages for the two models. The variation accounted for by the variables considered in the models became relatively more important as the lambs grew older. This was probably due to the increasing influence of sex of lamb and year of lambing for model I and sex of lamb and sire-group for model II. The effects of parity of the dam and season of lambing became relatively less important as the lamb grew older, whereas, the importance of type of birth remained relatively constant from birth through weaning to yearling age. When selecting replacement lambs in the present flock the environmental factors to be considered and the amount of emphasis to be put on them, would be determined greatly by the stage of growth of the lambs when the selection is carried out.

5.2 EFFECT OF TYPE OF BIRTH

Significant differences in weight between single and twin lambs with the latter being lighter than the former were in close agreement with earlier reports (Hazel and Terrill, 1945a, Santiago and Neto, 1954; Smith and Lidvall 1964; Rottensten and Ampy, 1971; Buvanendran et al., 1981).

The body weight difference of 0.54kg (19.4%) in favour of single lambs at birth (Table 4.4(a))agrees closely with values reported by Santiago and Noto (1954), Pilla (1968), Ermekov and Kairgaliev (1971), Rottenston and Ampy (1971), Kornal et al. (1976) and Taiwo et al. (1982). These authors and many others attributed differences in birth weight of single and twin lambs to the stress the twin lambs suffered from a diminished nutritional supply in-utero.

The weight difference of 3.24kg (25.88%) in favour of single lambs at 3 months of age, falls within the range of 1.30 to 7.87kg generally reported in literature (Hazel and Terrill, 1954a, Sidwell and Grandstaff, 1949; Smith and Lidvall, 1964; Vesely et al., 1970; Aktas, 1971; Nel, 1971 and Shin et al., 1975). The variations in body weight of single and twin lambs at weaning were due to differences in birth weights (Bonsma, 1939; DeBaca, 1956 and Iwan et al., 1971).

Differences in post-weaning body weights of single and twin lambs (up to 12 months) observed in this study agree with earlier reports by Phillips and Dawson (1940), Chang and Roe (1970) and Buvanendran et al. (1981) who attributed these to significantly faster post-weaning rate of gain of single lambs and the inability of the twins to recover from the nutritional stress they suffered in-utero and during the suckling period.

5.3 EFFECT OF SEX OF LAMB

The highly significant heavier body weights of ram lambs compared to ewe lambs from birth to 12 months of age conform with earlier reports (Sidwell and Grandstaff, 1949; Asker et al., 1952; Jadricev and Stepanova, 1965; Ceranic and Trajic, 1971).

The weight difference of 0,22kg (6.40%) in favour of males at birth (Table 4.4(a)) falls within the range of 0.02 to 0.94kg reported in the literature (Table 2.4.2 (a)) and closely agrees with values reported by Santiago and Neto (1954), Singh and Prasad (1962), Aktas (1971) and Kornal et al. (1976). The variation in birth weights of lambs caused by sex could be attributed to genetic differences with the male foetus probably beginning to secrete androgenic substances earlier and hence growing and developing faster than the female (El-Kimairy et al., 1979).

The weight difference of 1.54kg (13.20%) in favour of ram lambs at 3 months of age falls within the range of 0.71 to 8.93kg reported in the literature (Hazel and Terrill, 1945b; Sidwell and Grandstaff, 1949; More O'Ferrall and Vial, 1963; Smith and Lidvall, 1964; Jadricev and Stepanova, 1965; Morsy and Karam, 1967; Aktas, 1971, Cerenic and Trajic, 1971; Nel, 1971; Haider and Shah, 1974; Chin et al., 1975; Raman et al., 1981).

Very highly significant (P/<.001) differences in post-weaning body weights of lambs owning to sex as observed in the present study, for instance, 1.58kg (9.78%) at 6 months, 3.20kg (14.57%) at 9 months and 4.88kg (18.11%) at 12 months, all in favour of the ram lambs, confirm previous results (Asker et al., 1952; Arora and Acharya, 1972; Galal and Awgichew, 1981; Buvanendran et al., 1981; Gupta et al., 1983 and Charyulu and Munirathram, 1984). Malik et al. (1970) attributed heavier weights of ram lambs to higher initial benefit of birth weight, while Owen (1976) noted that through the influence of sex hormones females have slower growth rate and reach smaller mature size than the males.

5.4 EFFECT OF AGE/PARITY OF EWE

The observation that first lambing ewes produced significantly lighter lambs at birth than at subsequent lambings confirms earlier reports by Bonsma (1939), Belic and Ognajanovic (1955), Dalton (1962), Juma and Faraj (1966) and Ojeda (1974).

The lowest weaning weight obtained for lambs from first lambing is also not surprising as previous studies by Sidwell and Grandstaff (1949), Karam (1959), Dalton (1962), Smith and Lidvall (1964), Vesely et al. (1970), Marais and Pretorius (1977) and Fourie and Heydenrych (1982) showed the same trend. This according to them, is due mainly to the milk yield of the ewe which has been shown to increase with parity.

The significance of the effect of parity on the 6-month weight of lamb however seems to be at variance with reports by Asker et al. (1952), Chang and Rae (1970) and Buvanendran et al. (1981) who reported mostly non-significant parity or age of dam effect at that age. They contended that maternal influence has a much larger effect on lamb performance up to weaning than post-weaning. The significance of parity effect on the body weights of lambs upto 6 months of age as observed in this study could be due to disparity in the ages of the ewes at various parous states.

Lambs from the fourth parity had the heaviest weights at all stages from birth except at 12 months of age. This is quite expected as there exists a good correlation between parity and age of the ewes. In other words, ewes at the fourth parous state were quite older and fully mature (Appendix 4). They were therefore capable of supporting heavier lambs at least up to weaning. The post-weaning differences in weight due to parity could be attributed to initial weight advantages at the earlier stages which of course, is supported by better management practices in the flock.

5.5 EFFECTS OF MONTH/ SEASON OF LAMBING

Lambs born in the rainy season were heavier at birth, 3, 9 and 12 months of age than dry season born lambs with the differences being significant ($P \leq 0.05$) only at birth, 3 and 12 months of age. The significant ($P \leq 0.05$) effect of season on birth weight is well supported by earlier work

(Bonsma, 1939; Trail and Sacker, 1966; Malik and Acharya 1972; Buvanendran et al., 1981; Taiwo et al., 1982; Adeleye, 1984). The difference could be due to these factors. The availability of highly nutritive forages caused by the onset of rains offers better grazing materials for the gestating ewes. Secondly, the fall in the ambient temperature increases feed intake as well as efficiency of utilization of net energy. All ewes in their last trimester of pregnancy within this period would probably be in a better position physiologically to lamb heavier lambs.

The fact that dams have plenty of good pasture in the wet season and produce more milk to feed the lamb in the wet season explains the significantly ($P<0.05$) heavier weaning weights of lambs born in the wet season. This result agrees with reports of Saraswat et al. (1968), Gould and Whiteman (1971), Marais and Fretorius (1977), Peacock (1982) and Gupta et al. (1983).

Lack of significant effect of season of lambing on six month weights of lambs confirms early report by Buvanendran et al. (1981). It however runs contrary to reports of Saraswat et al. (1968). Acharya (1972), Singh et al. (1982) and Charyulu and Munirathram (1984) who observed significant effect of month or season of lambing on the trait.

Season of lambing had significant influence on body weight of the lambs at 12 months of age. This

closely agrees with the results of Karam (1959), Kaushik and Singh (1968), Malik and Acharya (1972), Malik et al. (1978). The effect of season of lambing on this trait seems to be related to the stage in wet or dry weather cycle in which the animal reaches the age.

5.6 EFFECT OF YEAR OF LAMBING

The highly significant differences between years of lambing in the weights of lambs from birth to 12 months of age conform to what would be expected in a situation where there are differences in the amount and distribution of rainfall between years (Blunn, 1944; Juma and Faraj, 1966; Raman et al., 1979, Buvaneniran et al., 1981). The variation in the annual rainfall was generally reflected in lamb growth, presumbly through the amount and quality of forage available to the dams and their lambs. Incidentally, in the present study the heaviest lambs were born in the wettest year (1981) and they maintained the weight advantage from birth till six months up to one year of age. Lambs born in the following year (1982), though hitherto of smaller weights, superceded the 1981 born lambs and recorded the average heaviest body weights at 9 and 12 months. The total amount of rainfall for the year 1982 was about 5/7th of that of previous year (Fig. 3.1). Lambs born in the year with the least total annual rainfall (1983) had heavier body weight from birth to weaning than those born in the second wettest year (1984) but the reverse was the case at the post-weaning

stage up to one year. A further look at the body weights of the lambs at the various growth stages between the four years under consideration reveals that the distribution of rainfall within a given year and how it relates to the period of lambing are of greater importance than the total annual rainfall per se.. In the present study, lambings occurred twice per year, that is, between January to March and July to September. The second lambing period coincided with the peak of the rain (Fig. 3.2). This partly explains the outstanding pre-weaning growth performances of the 1981-born lambs as they were born in the second lambing period when the ewes were on good quality and abundant herbage. Lambs born in the first lambing period would, more often than not, suffer some set-back at the pre-weaning stage due partly to the hagard conformation of the gestating ewe caused by lack of adequate feeding. Their weaning might coincide with the onset of rain which might result in their better post-weaning performance. The supremacy of rainfall distribution and its relation to period of lambing over the total annual rainfall in this study is well supported by the observed significance of year x season interaction at 3 and 9 months of age (Appendix 1a).

5.7 ADJUSTMENT OF BODY WEIGHT FOR ENVIRONMENTAL EFFECTS

The results have shown that weights of lambs are influenced by certain environmental effects that may obscure genetic differences. Thus, to better estimate

genetic differences between these lambs, and progeny groups from dams or sires, environmental effects on trait need to be eliminated by adjustment. Correction of records for the effects also increases accuracy of selection. The results also indicate that the magnitude of some of the environmental effects studied changed as the lambs grew older and heavier (Appendix 2a). This implies that if the same correction factors are used for lambs differing in age, error could be introduced.

Both the additive and multiplicative correction factors have the same effect on the weights of lambs up to weaning as they increase the means and lower the standard deviation (Table 4.6). From 6 to 12 months of age, the effects of the two types of adjustment become different and rather inconsistent. It could be concluded that in the present flock, for weights of lambs at the early stages of growth (up to weaning) either of the two methods can be employed to correct for the environmental effects so considered. The additive correction is however more favoured because of larger reduction of the standard deviation. The inconsistency of the correction factors on weights of lambs at later stages of growth (post-weaning) could be due to the fact that some non-significant environmental effects were corrected for. Also, the number of lambs involved was too small for estimating good adjustment factors.

Estimates of adjustment factors obtained are unfortunately of limited application due to scantiness of the data (Buvanendran et al., 1981). They cannot be used in other breeding farms where environmental conditions may be different. However, on the basis of this study, it would appear that type of birth, sex of lamb, age or parity of ewe, season and year of lambing have such important influence of lambs weights that adjustment for them is necessary to establish genetic differences among lambs in sheep farms in Nigeria.

5.8 GENETIC ANALYSIS OF BODY WEIGHT

(a) Repeatability of lamb weights

The estimated repeatability of 0.14 for birth weight closely agrees with 0.13 reported by Juma and Faraj (1966) for Awassi sheep in Iraq but lower than values (0.23 - 0.29) recorded by Bernicoat et al. (1957), Dalton (1962), Gjedrem (1967) and Buvanendran et al. (1981). The estimated value of 0.06 obtained for 3-month weight is very much lower than values (0.21 - 0.43) reported by Sidwell and Grandstaff (1949), Dalton (1962), Gjedrem (1967) and Buvanendran et al. (1981). The repeatability of 0.19 obtained for 6-month weight is higher than 0.09 reported for the same trait using the same breed (Buvanendran et al., 1981). It is also higher than the estimates for birth and 3-month weights got in this study. So far no values from literature to which repeatabilities of 9 and 12 month weights could be related have been seen. Gjedrem (1967)

noted that traits such as weights of lambs at different ages occur only once in an animals lifetime and are repeatable only when considered as characteristics of the ewe. An ewe influences the early weights of a lamb by the genes she transmits to the lamb and the maternal environment she provides until weaning. Thus, repeatability as here estimated represents an upper limit of heritability of maternal influences on lamb weights, not of the heritability of early weights considered as the characteristics of the lamb, such as the estimates obtained from the paternal half-sib correlations. Lower estimates of repeatability for birth and 3-month weights compared with 6-month weight as observed in the present study runs contrary to earlier report (Buvanendran et al., 1981) which attributed higher repeatabilities of birth and 3-month weights to their closer links with the ewe.

Lower magnitudes of repeatabilities obtained in this study and the large standard errors associated with them are due probably to the method of computation (intra-class correlation) as correlation between adjacent records has been shown to be higher than that of non-adjacent, or randomly chosen records (Dalton, 1952) and the limited volume of the data.

(b) Heritability of lamb weights

The heritability estimate of 0.22 obtained for birth weight closely agrees with estimates reported by Yao et al. (1953), Karam (1959), Osman and Bradford (1965),

Fahmy et al. (1968), Galal (1968), Singh et al. (1973), Dzakuma et al. (1978), Fourie and Heydenrych (1982). The workers used the same paternal half-sib correlation method. Estimates of 1.14, 1.06 and 0.94 reported for lamb weights at 3, 6 and 9 months of age respectively fell outside the ranges reported for the same traits in the literature (Tables 2.2.3 (b) to (d). However the estimate of 0.51 for yearling weight compared favourably with result by Chopra and Acharya (1971) and Chang and Rae (1970). So far no other estimates of the heritability of body weights for Yankasa sheep are available for comparison with the present results.

The low estimate of heritability of birth weight may be due to large maternal effects operating through the size of the ewe during the paternal development and growth of lamb (Acharya and Malik, 1971). The tendency of the estimates to increase with age from birth to yearling is well supported by Hazel and Terrill (1945b), Bichard and Yaldin (1964) and Chopra and Acharya (1971) who showed that with advancing age the maternal influences in terms of milk yield of the dam start declining and the body weight at later ages reflect more of genetic differences.

Most of the estimates of heritability obtained from uncorrected records are of lower magnitudes than those obtained from corrected data. This confirms earlier finding (Tallis, 1960; Gregory et al., 1977) that environmental factors tend to bias heritability estimates downwards. Bowman (1976) noted that large variations among

reported heritability estimates may in part be due to type of analyses used or the conditions under which growth was being measured, and are not necessarily due to differences in the amount of additive genetic variation present in the different populations. High magnitude of most of the estimates is attributable mainly to the limited volume of the data. This would be corrected by periodic review, and since the accelerated lambing programme is continuing, the volume of the data would grow over years.

(c) Genetic and Phenotypic correlations

Genetic correlation coefficient of 0.10 obtained between birth and weaning weights closely agrees with some earlier estimates (Chopra and Acharya, 1971; Elliot et al., 1979; Urala, 1978). The range of estimates is however, much wider and ranges from 0.24 (McNaughton, 1957) to 1.04 (Ragab et al., 1953). Correlation between birth and 6-month weights (0.26) is lower than most reported values (Ragab et al., 1953; Urala, 1978 and Singh et al., 1984). Chopra and Acharya (1971) however got a negative value between the two weights. The only available estimate to which the coefficient of 0.19 got between birth and 9-month weights can be compared is negative (Urala 1978). The 0.33 obtained between birth and yearling weights closely agrees with earlier estimates by Fahmy et al. (1969) and Urala (1978). Coefficients of genetic correlation obtained between weaning and post-weaning weights of lambs in the present studies, except 9-month

weight, are lower than reported values (Table 2.2.3 (j)). Urala (1978) reported a negative coefficient between weaning and 9-month weight.

Phenotypic correlation of 0.17 between birth and weaning weights agrees closely with values reported by Karam (1959), Butcher et al. (1964), Morsy and Karam (1967), Haider and Shah (1974) and Taiwo et al. (1982). It however falls towards the lower end of range of estimates in the literature which ranges from 0.10 (Dalton, 1962) to 0.98 (Purushotam, 1978). The estimate of 0.18 for between weaning and 6-month weights is similar to that reported by Buvanendran et al. (1981) for Uda sheep and very close to those of Dzakuma et al. (1978) and Urala (1978) for Hampshire and Bannur respectively. The phenotypic correlation of 0.14 between birth and 9-month weight is lower than earlier estimates (0.43) by Urala (1978) and 0.12 for birth and yearling weights does not fall within the range of estimates in the literature. The literature values range from 0.16 (Morsy and Karam, 1967), to 0.37 (McNaughton, 1957.

Estimate of 0.43 for weaning and 6-month weights is lower than earlier estimate for the same breed by Buvanendran et al. (1981) and 0.55-0.86 for other breeds (Table 2.2.3 (i)), while the estimate of 0.39 for weaning and 9-month weights is higher than 0.32 reported for Nigerian Dwarf by Taiwo et al. (1982). Correlation of 0.27 between weaning and yearling weights falls within the range of 0.02

(Taiwo et al., 1982) to 0.76 Terrill et al., 1950) reported in the literature. The estimate between 6-month and yearling weights (0.47) is lower than reported estimates by Morley (1951), Chopra and Acharya (1971) and Dzakuma et al. (1978).

The presence of relatively high genetic and phenotypic correlations between weaning and 6- and 9-month weights indicates that some proportion of genetic gain from selection on weaning weight may be carried on to weights at 6 and 9 months of age. Therefore in the selection of lambs for 6- or 9-month weight, some preliminary culling may be based on weaning weight.

6. CONCLUSIONS

The following conclusions can be drawn from the present study:

a. The significant influence of environmental factors such as type of birth, sex of lamb, parity of ewe, season and year of lambing on weights of lambs at different stages of growth up to one year requires adjustment of lamb weights for these factors before their growth rate can be unbiasedly compared.

b. The environmental factors to be adjusted for and the amount of emphasis to be put on them would depend on the stage of growth of the lambs when comparison is being made.

c. Additive adjustment of lamb weights for identifiable environmental factors is more favoured because of larger reduction of error variance associated with these factors for a particular trait.

d. As heavier weaning weights were obtained from lambs born in the rainy season, it is advisable to plan the matings of the ewes so that lambing would occur at the beginning of rains if heavy lambs are to be weaned.

e. When selecting ewes on the basis of lamb weaning weight, it is necessary to correct for each parity since primiparous lambs show the largest different from other groups.

f. The lack of previous reports on heritability estimates for growth traits of indigenous sheep makes comparison of the estimates obtained somehow difficult. This calls for more efforts in this direction.

g. Positive genetic and phenotypic relationships exist among weaning, 6-month and 9-month weights, indicating that selection for any of these would make changes in all.

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Appendix 1(a): Analysis of variance of main effects and interactions (Model I)

Source of variation	d.f.	Mean squares of weights at different ages				
		Birth	3 month	6 month	9 month	12 month
Type (of birth)	1	19.73***	580.08***	322.98***	215.50***	145.80**
Sex	1	3.99***	172.58***	95.80***	328.51***	486.03***
Parity	4	2.95***	45.53***	33.98**	14.20	25.85
				(3)[a]	(3)[a]	(3)[a]
Season	1	5.18***	203.82***	5.04	12.15	92.61*
Year	3	1.38**	90.34***	58.76***	154.22***	141.08***
Interactions						
Type x Sex	1	0.40	20.80*	13.94	23.78	0.96
Type x Parity	4	0.16	11.36	2.25	9.56	6.91
				(3)[a]	(3)[a]	(3)[a]
Type x Season	1	0.08	0.66	8.78	13.02	1.63
Type x Year	3	0.03	11.32	3.52	4.00	3.91
Sex x Parity	4	0.18	12.18	5.78	7.59	38.36
				(3)[a]	(3)[a]	(3)[a]
Sex x Season	1	0.04	2.96	5.54	12.12	0.80
Sex x Year	3	0.07	12.58	23.06*	11.29	28.58
Parity x Season	4	0.14	5.96	12.31	12.27	3.66
				(3)[a]	(3)[a]	(3)[a]
Parity x Year	6	0.26	9.26	8.74	5.10	25.13
Season x Year	3	0.19	15.75*	16.72	30.72*	30.41
Residual		0.32	5.16	7.93	10.48	14.01
		(316)[a]	(257)[a]	(150)[a]	(107)[a]	(55)[a]

* = P<0.05 ** = P<0.01 *** = P<0.001 a = degrees of freedom.

Appendix 1(b):: Analysis of variance of main effects and interactions (Model II)

Source of variation	d.f.	Mean squares of weights at different ages				
		Birth	3 month	6 month	9 month	12 month
Type (of birth)	1	20.37***	621.51***	309.55***	169.29***	79.08*
Sex	1	3.06**	148.71***	256.97***	362.01***	285.31***
Parity	4	2.67***	55.71***	14.01*	3.76	7.36
Sire group	4	1.64***	180.78***	61.71***	73.30***	73.99** (3)[a]
Interactions						
Type x Sex	1	0.21	26.25*	0.10	0.02	10.29
Type x Parity	4	0.35	8.23*	2.70	5.10	5.42 (3)[a]
Type x Sire group	4	0.34	7.66	6.63	7.23	14.00 (3)[a]
Sex-Sire group	4	0.22	3.62	0.92	11.07	14.12 (2)[a]
Parity x Sire group	13	0.41	8.25*	9.84* (11)[a]	9.18 (10)[a]	12.56 (7)[a]
Residual		0.25 (315)[a]	4.42 (264)[a]	4.73 (110)[a]	6.59 (90)[a]	12.95 (35)[a]

* = P/0.05 ** = P/0.01 *** = P/0.001 a = degrees of freedom

Appendix 2(a): Least-square constants (LSC) for lamb weights (kg) at birth 3, 6, 9 and 12 months of age (Model I)

	Birth		3month		6 month		9 month		12 month	
Mean variables	2.51		10.90		15.36		20.36		24.50	
	No	LSC	No	LSC	No	LSC	No	LSC	No	LSC
Type of birth										
Single	257	$+0.27^{a}$	216	$+1.62^{a}$	123	$+1.62^{a}$	110	$+1.48^{a}$	70	$+1.59^{a}$
Twin	100	-0.27^{b}	82	-1.62^{b}	44	-1.62^{b}	34	-1.48^{b}	22	-1.59^{b}
Sex of lamb										
Male	185	$+0.11^{a}$	142	$+0.77^{a}$	69	$+0.79^{a}$	54	$+1.60^{a}$	48	$+2.44^{a}$
Female	172	-0.11^{b}	156	-0.77^{b}	98	-0.79^{b}	90	-1.60^{b}	44	-2.44^{b}
Parity of ewe										
1	102	-0.42^{a}	82	-1.92^{a}	57	-0.70^{a}	49	-1.22	31	-1.89
2	88	$+0.00^{bc}$	75	-0.65^{ac}	52	-0.10^{ab}	44	-0.03	25	+0.41
3	89	$+0.07^{bcd}$	79	$+0.25^{bce}$	40	$+0.46^{abc}$	34	+0.32	23	+0.83
4	53	$+0.20^{bcde}$	45	$+0.81^{bdef}$	18	$+1.33^{abc}$	17	+0.94	13	+0.64
5	25	$+0.15^{bcde}$	17	$+1.52^{bdef}$						
Season of lambing										
Nov-April	171	-0.31^{a}	142	-0.90^{a}	78	+0.20	63	-0.33	46	-1.07^{a}
May-Oct.	186	$+0.13^{b}$	156	$+0.90^{b}$	89	-0.20	81	+0.33	46	$+1.07^{b}$
Year of lambing										
1981	21	$+0.17^{a}$	15	$+1.56^{a}$	15	$+1.82^{a}$	16	$+1.32^{a}$	14	$+1.85^{a}$
1982	59	$+0.15^{bc}$	47	$+0.88^{bc}$	38	$+0.64^{bc}$	32	$+2.08^{ac}$	13	$+2.37^{ac}$
1983	98	-0.12^{bde}	88	-0.21^{bde}	68	-1.72^{bde}	56	-3.00^{bde}	34	-3.87^{bde}
1984	179	-0.21^{bde}	148	-2.23^{bdf}	46	-0.74^{bde}	40	-0.40^{bde}	31	-0.35^{bde}

*Values within each sub-class with different superscript differ significantly ($P<0.05$)
No letter indicates sub-class group did not show a significant difference in the analysis of variance.

Appendix 2(b): Least-squares constants (LSC) for lamb weights (kg) at birth, 3,6,9 and 12 months of age (Model II)

	Birth		3 month		6 month		9 month		12 month	
Mean	2.47		10.23		14.12		18.63		24.05	
variables	No	LSC*	No	LSC	No	LSC	No	LSC	No	LSC
Type of birth										
Single	237	+0.27	201	+1.58	94	+1.60	84	+1.32	46	+1.39
Twin	119	-0.27	104	-1.58	55	-1.60	44	-1.32	17	-1.39
Sex of lamb										
Male	184	+0.09	154	+0.71	58	+1.38	47	+1.84	36	+2.66
Female	172	-0.09	151	-0.71	91	-1.38	81	-1.84	27	-2.66
Parity of ewe										
1	50	-0.42	41	-1.94	18	-1.60	12	-0.67	9	-1.32
2	33	-0.00	76	-0.55	41	-0.16	36	-0.33	15	+0.44
3	97	+0.10	89	+0.58	46	+0.58	40	+0.40	22	+0.40
4	74	+0.19	59	+0.60	23	+0.76	22	+0.48	13	+0.48
5	52	+0.13	40	+1.30	21	+0.41	18	+0.11		
Sire group										
1	46	-0.10	38	+1.21	34	+0.66	25	-0.28	20	-4.93
2	51	+0.21	49	+1.34	33	-0.41	30	-1.17	13	+0.50
3	97	-0.17	85	-2.30	29	+0.57	22	+0.73	13	+1.34
4	81	-0.11	63	+1.52	22	+1.76	20	+2.97	17	+2.10
5	81	-0.06	70	-1.27	31	-2.58	31	-2.24		

Appendix 3(a): Effect of additive versus multiplicative adjustment factors on birth weight of lambs.

		Additive factors			Multiplicative factors		
	LSM (kg)	Adjusted Mean (kg)	S.D. (kg)	C.V. (%)	Adjusted Mean (kg)	S.D. (kg)	C.V. (%)
Type of birth							
Single	2.78	2.54	0.54	21.26	2.57	0.57	22.18
Twin	2.24	2.54	0.58	22.83	2.55	0.53	20.78
Sex of lamb							
Male	2.62	2.54	0.55	21.65	2.55	0.54	21.18
Female	2.40	2.54	0.54	21.26	2.57	0.57	22.18
Parity of ewe							
1	2.09	2.54	0.59	23.23	2.58	0.64	24.81
2	2.51	2.54	0.55	21.65	2.56	0.55	21.48
3	2.58	2.54	0.48	18.90	2.56	0.49	19.14
4	2.71	2.54	0.56	22.05	2.55	0.52	20.39
5	2.66	2.54	0.57	22.44	2.55	0.52	20.39
Season of lambing							
Nov-April	2.38	2.54	0.51	20.08	2.56	0.55	21.48
May-Oct.	2.64	2.54	0.58	22.83	2.56	0.56	21.88
Year of lambing							
1981	2.68	2.54	0.78	30.71	2.60	0.81	31.15
1982	2.66	2.54	0.58	22.83	2.58	0.57	22.09
1983	2.39	2.54	0.53	20.87	2.56	0.56	21.88
1984	2.30	2.54	0.51	20.08	2.56	0.52	20.31

Appendix 3(b): Effect of additive versus multiplicative adjustment factors on 3-month weight of lambs

		Additive factors			Multiplicative factors		
		Adjusted			Adjusted		
	LSM (kg)	Mean (kg)	S.D. (kg)	C.V. (%)	Mean (kg)	S.D. (kg)	C.V. (%)
Type of birth							
Single	12.52	11.55	2.70	23.38	11.78	2.64	22.41
Twin	9.28	11.63	2.31	19.86	11.61	2.81	24.20
Sex of lamb							
Male	11.67	11.59	2.63	22.69	11.76	2.64	22.45
Female	10.13	11.55	2.56	22.16	11.71	2.74	23.40
Parity of ewe							
1	8.98	11.65	2.92	25.06	11.89	3.05	25.65
2	10.25	11.39	2.25	19.75	11.71	2.45	20.92
3	11.14	11.48	2.46	21.45	11.63	2.59	22.27
4	11.71	11.73	3.00	25.58	11.59	2.90	25.02
5	12.42	11.96	1.86	15.55	11.91	1.72	14.44
Season of lambing							
Nov-April	10.00	10.72	2.33	21.74	11.65	2.80	24.03
May-Oct.	11.80	12.34	2.58	20.91	11.80	2.59	21.95
Year of lambing							
1981	12.45	11.59	2.86	24.68	11.94	2.72	22.78
1982	11.78	11.96	3.22	26.92	11.92	3.26	27.35
1983	10.69	11.62	2.25	19.36	11.62	2.47	21.26
1984	8.57	11.41	2.54	22.26	11.72	2.63	22.44

Appendix 3 (e) : Effect of additive versus multiplicative adjustment factors on 6-month weight of lambs

		Additive factors			Multiplicative factors		
	LSM (kg)	Mean (kg)	S.D. (kg)	C.V. (%)	Mean (kg)	S.D. (kg)	C.V. (%)
Type of birth							
Single	16.98	15.31	3.11	20.31	15.20	3.27	21.51
Twin	13.74	15.47	2.73	17.65	15.24	3.69	24.21
Sex of lamb							
Male	16.15	15.34	2.99	19.49	17.10	3.14	18.36
Female	14.57	15.36	3.04	19.79	13.88	2.87	20.68
Parity of ewe							
1	14.66	14.70	3.42	23.26	14.53	3.06	12.06
2	15.26	15.69	3.01	19.18	15.44	3.50	22.67
3	15.82	15.70	2.56	16.30	15.62	3.58	27.92
4	16.69	15.70	2.32	14.78	15.75	3.42	21,71
Season of lambing							
Nov-April	15.56	15.38	2.75	17.88	15.54	3.20	20.59
May-Oct.	15.16	15.33	3.23	21.07	14.91	3.51	23.54
Year of lambing							
1981	17.18	14.83	2.47	16.66	14.55	2.39	16.43
1982	16.00	15.04	4.20	27.92	14.77	3.44	23.29
1983	13.64	15.46	2.26	14.81	15.20	3.18	20.92
1984	14.62	15.63	2.99	19.13	15.79	3.85	24.38

Appendix 3(d): Effect of additive versus multiplicative factors on 9-month weight of lambs

		Additive factors			Multiplicative factors		
		Adjusted			Adjusted		
	LSM (kg)	Mean (kg)	S.D. (kg)	C.V. (%)	Mean (kg)	S.D. (kg)	C.V. (%)
Type of birth							
Single	21.34	20.85	3.34	16.02	20.40	4.47	21.91
Twin	18.88	20.85	2.91	13.96	20.38	4.78	23.45
Sex of lamb							
Male	21.96	20.85	3.67	17.60	24.47	3.89	15.88
Female	18.76	20.85	2.96	14.20	17.93	2.75	15.34
Parity of ewe							
1	19.14	20.85	3.66	17.55	20.27	3.87	19.09
2	20.33	20.85	3.05	14.63	19.99	4.47	22.36
3	20.68	20.85	2.38	11.41	20.83	4.69	22.42
4	21.30	20.85	4.09	19.62	20.92	6.14	29.35
Season of lambing							
Nov-April	20.03	20.85	3.24	15.54	20.84	4.43	21.26
May-Oct.	20.69	20.85	3.33	15.97	20.04	4.60	22.95
Year of lambing							
1981	21.68	20.85	3.46	16.59	20.38	4.38	21.49
1982	22.44	20.85	3.84	18.42	19.83	3.85	19.42
1983	17.36	20.85	2.65	12.71	19.95	4.21	21.10
1984	19.96	20.85	3.48	16.69	21.48	5.40	25.14

Appendix 3(e): Effect of additive versus multiplicative adjustment factors on 12-month weight of lambs

		Additive factors			Multiplicative factors		
		Adjusted			Adjusted		
	LSM (kg)	Mean (kg)	S.D. (kg)	C.V. (%)	Mean (kg)	S.D. (kg)	C.V. (%)
Type of birth							
Single	26.09	24.72	4.13	16.71	25.62	6.68	26.07
Twin	22.91	24.73	3.16	12.78	25.27	6.18	24.46
Sex of lamb							
Male	26.94	24.72	3.98	16.10	30.40	4.53	14.90
Female	22.06	24.73	3.85	15.57	20.22	3.56	17.61
Parity of ewe							
1	22.61	24.73	4.24	17.14	24.62	5.16	20.96
2	24.91	24.73	3.58	14.48	24.86	7.24	29.12
3	25.33	24.72	3.91	15.82	27.00	7.13	26.41
4	25.14	24.72	4.10	16.58	26.43	7.17	27.13
Season of lambing							
Nov-April	23.43	24.73	4.08	16.50	25.60	6.95	27.15
May-Oct.	25.57	24.73	3.76	15.20	25.40	6.17	24.23
Year of lambing							
1981	26.35	24.73	4.63	18.72	23.19	5.18	22.34
1982	26.87	24.73	4.23	17.10	24.95	5.46	21.88
1983	20.63	24.73	3.55	14.36	25.12	7.46	29.70
1984	24.15	24.72	3.98	16.10	27.29	6.22	22.79

Appendix 4 : Mean ewe age at lambing

Parity	No	Age (Months)
1	21	15.00
2	35	22.94
3	41	29.35
4	31	34.45
5	22	41.85