LACTATION CURVE AND RELATIONSHIP BETWEEN MILK YIELD AND PREWEANING GROWTH RATE IN LAMBS OF YANKASA SHEEP

BY

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CERTIFICATION

This Thesis "Lactation curve and relationship between milk yield and preweaning growth rate of lambs in Yankasa sheep" by R.A. Afolayan meets the guidelines stipulated for the award of the degree of Master of Science (M.Sc) of Ahmadu Bello University and it is certified for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my brothers, Messrs M.F. Olowa, J.K. Afolayan and S.O. Afolayan for their immense contributions towards my academic career and to my beloved mum, Mrs. C.A. Olowa for her love and affection.

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ABSTRACT

Lactation records on 168 Yankasa ewes, with either complete or in complete lactation records, under semi intensive management system in sheep project of NAPRI were used in this study. The ewes were hand milked at weekly intervals after thorough disinfection of the udder. The daily milk yield was estimated from the weekly milk yield curve. Least squares analysis showed that milk yield was significantly ($P< 0.001$) affected by birth type, parity and month of birth.

Base class adjustment of data to twin birth, 4th parity and July lambing dam was done prior to regressions to obtain the lactation curve using Wood,s model:

$$Y_n = {}^{270}n^{0.697}e^{-0.298n}$$

($R^2 = 0.71$; $P<0.001$)

Peak yield was observed in the 2nd to 3rd week of lactation and the total 90-d milk yield of 13.45kg with an average daily yield of 149.40g.

Correlation analysis was carried out beween lamb weight gain and dam milk yield using the weight records from lambs weighed at weekly intervals corresponding to milking dates of their dams. The result obtained indicated a high and positive relationship in the early lactation which decreased in intensity as the lactation advanced.

The effect of type of birth, parity, season of lambing and lactation length (of below and equal to 84 days) on the components of lactation curve(a, b, c and s) were also analysed

by least-squares procedures. The goodness of fit of the function did not differ between the lower lactation of below 84 days and complete lactation length of 84 days; lower lactation of below 84 days however in addition to a lower persistency also showed a low general level of production.

Genetic and phenotypic correlation estimates were obtained for both lactation parameters and weight records of lamb using 143 dams sired by 16 rams and 134 lambs sired by 10 rams respectively.

Heritability estimates by half-sib analysis were 0.3 and 0.7 for birthweight(BWT) and 90-day weaning weight(WWT) while the genetic and phenotypic correlations between these traits were 0.7 and 0.3 respectively. For the lactation parameters, estimates of 1.4, 0.3, 0.2 and 0.5 were obtained for a, b, c and total lactation(T) respectively. Phenotypic correlations between a and b, a and c, a and T, b and c, b and T, a and T were 0.2, 0.2, 0.5, 0.6, -0.1 and -0.06 while the corresponding genetic correlations were -0.4, 0.3, 0.8, 0.0, -0.2, and -0.1 respectively.

From this study, Yankasa sheep seem to be a poor milk producer,however concerted effort need to be made to intensively select them for milk production traits to ascertain their potentiality. For more or better precision, a larger data set has to be generated over many years. Moreover, milk production from dam is related to the growth of lamb most especiall in the early stage of growth.

CHAPTER ONE

1.0. INTRODUCTION

The survey of the national sheep distribution in Nigeria showed that the majority are kept under traditional system of management in household throughout the various ecological zones. Presently, the indigenous sheep population stands at about 22.3 million (FDLPCS, 1991) among which are 4 major breeds, namely; West African Dwarf (WAD), Yankasa, Balami and Uda. Within the indigenous sheep breeds, the Yankasa is the most numerous and is widely distributed throughout the Guinea and Sudan Savanna Vegetational Zones. It is estimated to constitute 60% of the total national herd. Being a medium-sized breed in addition to its hardiness, it seems to be very popular among sheep farmers most especially in Northern Nigeria.

Sheep like other livestock such as cattle and goats are reared basically for meat while unlike others they are rarely milked for human consumption. Other sheep products of economic importance include skin for the leather industry, manure for soil improvement and bone, hooves, horns and blood used in the preparation of feed. Sheep milk, even though rarely consumed by man has tremendous influence on the growth rate of the lamb. Preweaning survival of the lambs is also significantly affected by the milk producing ability of the ewe.

To increase the productivity of the indigenous sheep breed, efforts have to be made to establish their current potentials for economic traits. Thus, genetic improvement through proper

selection and breeding programmes could then be evolved. The traits of importance in sheep enterprises are reproduction and milk production in the ewe and growth rate/viability in the lamb. The potential of local breeds of animals for improvement is enormous, but a painstaking process of upgrading through selection and good management is required.

The performance of animals for any production purpose has been known to be greatly influenced by different environmental (internal and external) factors. Thus, selection of genetically superior animals as parents for subsequent generations could only be facilitated if the influence of such hampering factors on the actual breeding value could be removed through data adjustment. By so doing, the adjusted data would reflect more closely the true genetic capability of such animals. Some studies have shown significant effects of sex, age and weight of dam, type and season of birth and birth weight on preweaning growth in different sheep breeds including Yankasa Sheep (Maroof, et al., 1986; Osinowo, et al., 1991). Moreover, the milk yield of tropical sheep breeds have also been reported to be affected by these factors.

Correlation studies among economic traits provide a useful tool for indirect selection. Certain traits are usually difficult for direct selection either for or against and such traits might be closely related to others that require simple selection procedure. Moreover, the relationship between ewe milk production and preweaning growth rate of lamb determines the extent to which lamb growth performance could be attributed to milk production from dam

most especially at the early age of lamb.

Heritability estimate, could serve as a basis for meaningful selection of animals with potentials in economic and reproductive traits. Large variability within a particular flock could warrant quick improvement if selection differentials are large and heritability of the character under investigation is high. Substantial genetic esimates have been obtained for the growth and reproductive traits in tropical sheep breeds including Yankasa sheep. However, little or nothing has been done on the genetic merit of tropical sheep breeds, most especially Yankasa sheep, in terms of the milk production.

This study was therefore designed to: (1) Study the lactation curve of Yankasa sheep, (2) Estimates the phenotypic correlations between preweaning growth weights and milk yield and (3) Estimate genetic parameters for body weights and lactation curve parameters.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Sheep Production in the Tropics

The tropical sheep breed are predominantly reared for meat and rarely are they be milked for human consumption. Their skins are also excellent material in the leather industry for making valuable products such as shoes, bags, belt and even wears. Over two decades ago the complimentary role of sheep milk to dairy production was also realised. Williamson and Payne (1968) observed that sheep were also being kept for milk and fiber production in the tropics. Sheep can also serve as a source of; manure, ready cash incase of crop failure, research animals, recreation, transportation, slaughter animals at festivals and prestige.

In the developing countries, mostly to be found in the tropics and sub-tropics there are over 600 million sheep or about 53% of the total world population (FAO, 1988). According to the FAO year book for 1988, Africa has over 190 million or 32.2% on the average while sheep in the developing countries produce about 48% of the world mutton and lamb production, 58% of the world's sheep milk and 47% of the total world sheep hide and skin production came from the same region. Invariably, more than half of the total sheep and sheep milk are produced in the developing contries. One would then expect that research into various aspect of improvement in both production and economic traits to have been perfected. On the contrary this is not so because conserted effort has not been made to actually assess the potential of the indigenous sheep breed for

milk production.

The dairy potential of Awassi sheep in Israel has been documented (Finci, 1957; Folman et al., 1966a,b; Epstein, 1977). In view of the large population of sheep in Nigeria most espe- cially Yankasa breed, the complementary role of sheep to rural dairy production in Nigeria should not be over-looked (Ehoche, 1990). This review focused on milk production from sheep and the various factors (Environmental and Genetics) militating against improved productivity. The relationship of this economic trait to lamb growth was also be assessed.

2.2. Indigenous Sheep Breeds and their Growth/Reproductive Performance

There are four main indigenous sheep breeds in Nigeria. As described by Adu and Ngere (1979), the Nigerian sheep breeds are:

2.2.1. Balami

The breed are predominantly found in the North Eastern part of Nigeria and the heaviest of all the indigenous breeds. The Balami are fast growing and usually attain a weaning weight of 18 kg in 12 weeks. The yearling weights for both ewes and rams ranges from 35-40 kg and 45-60 kg, respectively. This breed has a range of 114-142%, 81-90% and 6-12% for the lambing, weaning and mortality rate depending on the location (Adu, 1978a) while the birth weight and average daily gain ranges between 3.1-3.5kg and 93.4-120.3g regardless of the type of birth and stage of growth. Buvanendran

and Adu (1987) observed that Balami ewe lambed at 18.6 months of age while Buvanendra and Adu (1987) and Forgorty (1972) reported 308 days lambing interval for this breed.

2.2.2. Uda

The breed could be found throughout the Sahelo-Sudan Vegetation Zone of Nigeria. This is yet another large and long - legged breed. Mature weights range from 34 - 40 kg for ewes and 45 -55 kg for rams. The birth weight and average daily gain ranges between 3.0 - 3.8 kg and 68.4 - 156.1 g depending on the location and regardless of the time of birth and stage of growth (Adu 1978a). Lambing, weaning and mortality percentages for uda sheep ranges between 108 - 131, 68-79 and 11-16 respectively depending on locations. Kuteyi et al. (1979) reported 290, 24, 13 and 19 for age at first oestrus (days), live weight at first oestrus (kg) and oestrus period duration in hours and oestrus cycle length (days) for this breed concurrently. Buvanendran and Adu (1978) reported 270 days lambing interval for Uda sheep. Fogorty (1972) and Adu et al. (1978b) reported a twinning rates of 17.0 and 24.1% respectively for Uda breed.

2.2.3. Yankasa

The Yankasa sheep is perhaps the most numerous breed and is widely distributed throughout the Sahel, Sudan and Ginuea Savanna Vegetation Zones. It is a medium sized breed (intermediate between

Uda and the West African Dwarf Sheep) and very hardy, an attribute which makes it a popular breed among sheep keepers in the North. It is an hairy sheep with a predominantly white coat and black patches around the eyes, muzzle and hooves. It has an estimated population size of 13.62 million or 60% of the total sheep population in Nigeria. The major product and by-product obtained from the breed are meat and skin respectively. The mature weights are 25-40 kg for ewes and 35-50kg for rams. The birth weight and average daily gain for Yankasa breed ranges between 2.9 - 3.6 kg and 72.8-116.2 g depending on the location and regardless of the birth type and stage of growth (Adu, 1978a). The same author gave the ranges for the lambing, weaning and mortality rate as 110-113%, 70-79% and 12-14%, respectively while Osinowo and Abubakar(1988) reported an average litter size of 1.31, weaning rate of 79%, lambing rate of 98%, average birth weight of 2.5kg and weanig weight of 10.2kg. The age at first oestrus (days), liveweight at first oestrus (kg), oestrus period duration (hrs) and oestrus cycle length (days) on the average are 214.5, 21.8,15 and 18.5 (Kuteyi et al., 1978). Molokwu and Umunna(1980) noted that Yankasa ewe lambed for the first time at approximately 15.5 months of age and that the lambing rate ranges between 139-148%. The lambing interval for these breeds ranges from 236-291 days (Fogorty, 1972; Molokwu and Umunna 1980). The twinning rate as documented by Fogorty (1972), Molokwu and Umunna (1980) and Adu et al. (1978) were 23 and 17.8 percent, respectively.

2.2.4. West African Dwarf (WAD) Sheep

In Nigeria the breed is variously called Southern forest sheep (Orji et al., 1976) or Nigeria Dwarf Sheep (Adu, 1972). It is widely distributed throughout the hot and Humid coast area south of latitude 140 N. Within this wide geographical range, variation in type are found. The West African Dwarf sheep is a small (almost half the size of the northern breeds), and compact body and hardy breed. Mature weights are 20 - 25 kg for ewes and 25 - 30 kg for rams. The birth weights of WAD ranges between 1.5-2.5 kg while the average daily liveweight gain ranges from 29.8 - 100g depending on location and regardless of birth type and stage of growth (Ngere et al., 1979; Ademosun, 1973; Adu, 1975). The ranges of lambing, weaning and mortality rate reported for WAD sheep as a result of locational changes are 119-126, 70 and 20-25 percent respectively (Ngere et al., 1979; Dettmers et al., 1976, Ademosun, 1973). The average age(month) and weight(kg) at first oestrus, oestrus duration(days), oestrus cycle length(days), gestation period(days) and age at first lambing (months) are 15, 15, 33, 18.5, 147 and 20.5 (Ngere et al., 1979; Adu, 1972; Dettmers et al., 1976). Fogorty (1972) reported 148 day lambing interval while twinning rate which ranges from 37 to 63 % was recorded at various locations (Fogorty, 1972; Ademosun, 1973, Orji et al.,1976).

2.3. Milk Production in different Sheep Breeds

Milk production in sheep serves as an estimator of the relative production efficiency of sheep. For example, economic

sheep production in most of the mediterranean countries is largely based on the sheep milk sold commercially for the production of cheese and associated milk products (Guirgis et al., 1982). Awassi sheep in Israel and Dorset sheep in Newzealand have been recognised as breeds with dairy potentials (Folman et al.,1966; Geenty, 1980).

According to Maroof et al (1986) survival and growth rate in lambs which are two key areas to productivity in sheep depend largely on the milk production from the ewes. In Egypt and many other subtropical countries, effort is being geared towards improving lamb production from non-dairy local breed. The potential for milk production seems of special importance particularly with the impracticability of artificial rearing of the lambs in these regions. Thus every attempt to increase the supply of milk and at the same time achieve satisfactory rearing of lambs, is of great importance.

Tropical sheep breeds differ in their milk production pattern with reference to total yield, peak yield and persistency of milk production.

a. Total Milk Yield

The total milk yield of different sheep breeds as reported by many authors is determined by the lactation length period. Maroof et al. (1986) obtained an average preweaning and lactation yields of 62.2 kg and 77.3 kg in Hamdani sheep over a period 92.6 and 152.1 days, respectively. In Karadi sheep the average milk yields

reported were 59.21 kg during 112 days (Mohammed, 1982) and 91.62 kg during 105 days (Kutaibani, 1981) while in the Awassi sheep it varies between 105.9 kg in 142 days (Eliya and Juma, 1970) and 115.7 kg in 135 days (Karam et al., 1971). Better yields have also been obtained in some other breeds like East Friesian, Sardinian, Tsigai, Valachian or Lancoune sheep and even the Awassi in Turkey and Palestine. Lactation yield in these breeds average 306.3 (Saliov and Tanev, 1967), 196.1 (Bonelli, 1969), 141.3 in 207 days (Baia et al., 1966), 134.7 in 200 days (Horak, 1965), 121.5 (Leroy, 1968), 184.6 in 189 days (Sonmez and Wassmuth, 1964) and 314.0kg in 201.3 days (Finci, 1957), respectively.

b. Peak Yield and Persistency

The peak milk yield as described by various authors ranges between 1st to 3rd or at most 5th week of production (Peart et al., 1975; Aboul-Nagal et al., 1981; Ehoche et al., 1990). Aboul-Nagal et al. (1981) observed peak yield differences in three different types of sub-tropical non-dairy sheep. While the milk of the Barki ewes declined steadily after peak at 2nd week and sharply from the 6th week, peak lactation of Rahamani and Ossimi ewes extended till the 3rd week of lactation.

Karam, et al.(1971) and Maroof, et al.(1986) reported a marked differences in periods of peak yield attainment in twin and single lambed ewes. The twin lambed ewes reached peak yield at the third week compared with single lambed ewes which attained peak at the fourth week postpartum. Milk yield usually decrease linearly as

from 28 to 98 days. Regardless of breed type, Snowder and Glimp(1990) indicated in his findings a 33% and 28% decline in milk yield from 28 to 56 days in ewes with singles and twins, respectively. Lactation curves usually decreases more rapidly as from 10th week of production. This period conincides with two factors; the lambs' decreasing dependence on milk due to increased grazing and forage intake of lambs and period of dryness due to pregnancy. Peart (1967) concluded that the total milk yield and shape of lactation curves may be considerably influenced by the appetite of lambs for milk.

2.4. Factors affecting Milk Production in Sheep

Many factors have been reported to affect the amount of milk produced by ewes and obtained by the lambs. Some relate to the ewe performance itself i.e. breed of ewe, plane of nutrition and age and weight of ewe. Others relate to the lambs suckled, i.e. number of lambs suckled, lamb's genotype and performance.

2.4.1. Breed of Sheep

The varied genetic composition of different breeds of sheep might be the cause of the observed variation in them. Although there are individual differences, such variation are less pronounced within breed than between breeds. Karam et al., (1971) observed in Awassi sheep subjected to a 12h milking interval an average milk yield of 115.65 kg in 134.87 days compared to 116.05 kg in 90 days for Merino ewes with the same milking interval in

Hungary. The milk yield of crosses between Yankasa and Suffolk or Wenselydale breed is significantly ($P<0.01$) higher than the pure breed Yankasa as reported by (Ehoche et al., 1990). Doney et al.(1981) found that the milk yield of East Friesland and Scottish Blackface (FFX) ewes was significantly ($P< 0.05$) greater than that of pure bred black face (BF) ewes when suckling single or twin lambs.

It has also been shown that breed differences in lambs can influence maternal milk yield (Moore, 1966; Langlands, 1972; Peart, et al., 1975). Doney et al. (1981) reported that the Suffolk cross lambs born to East Friesland x Blackface ewes induced a higher milk output than pure blackface lambs, irrespective of the breed of ewe suckled. Thus, comparisons of milk output between ewes of different breeds may be confounded by associated genetic differences in the lambs that suckled them.

2.4.2. Type of Birth and Suckling Intensity

Lactation in sheep can be influenced by the type of birth and by the suckling intensity which is a function of the number of lambs reared. Many workers observed that the milk yields from ewes that produced twins were higher than those ewes with single lambs (Doney and Munro 1962; Karam et al., 1971; Peart, 1967). However, other workers found that the milk yield was affected by the number of lambs suckled but not by the number of lambs born (Alexandra & Davies, 1959; Doney and Munro, 1962; Peart, 1967; and Corbelt, 1968). Thus the increase in milk yield observed in the group

rearing twins was obviously due to increased stimulation of the udder. There was no appreciable differences in milk yield of ewes bearing twins but rearing singles to that of ewe rearing natural singles (Doney & Munro, 1962).

Snowder and Glimp (1991) working with four different breeds of sheep observed that within the Rambouillet, Columbia and Polypay breeds, the total estimated milk yield of ewes with twins was 44% to 47% significantly ($P< 0.05$) higher than that of ewes with singles, whereas in the Suffolk breed, suckling twins significantly ($P< 0.05$) increased total milk yield by 64% over that of ewes with singles. Ehoche and Buvanendran (1983) also observed a 20% over production in milk from does with twin kids compared to single kidded does. Thus the number of nursing lambs or kids has a major influence on milk yield. Ewes suckling twins produced significantly ($P<0.05$) more milk than those suckling single lambs at each stage of lactation. However twin lambs induced a larger differential in dam milk production in late lactation than in earlier lactation.

The suckling period could also constitute a variation in milk yield. The average milk production during the suckling period of 90 days was 100.42 kg in Awassi ewes whereas in a 120- day suckling period an average of 101.5 kg was obtained (Eliya and Juma, 1973).

2.4.3. Milking Interval

Regardless of the age of dam, milk production in sheep increases with a decrease in the interval of milking. A decrease

in milking interval from 12 to 4 hr led to 40 and 60% increase in milk production of both Merino and Awassi sheep (Karam et al., 1971). The same author observed a significant correlation between yield based on 12 and 4 hr intervals for both breeds at all ages. Morag (1969) however reported that the secretion rates of milk increased following milking intervals of 4 - 12hr and decreased after intervals greater than 12 hr.

2.4.4. Age and Weight of Dam

The reports on the effect of age of ewe on milk yield are not consistent. Eliya and Juma (1970) and Corbelt (1968) asserted that milk production increases with advancing age of ewes up to 4 years. Their findings was similar to that reported on the Awassi ewes in Turkey (cited by Karam et al. 1971). However, Owen (1957) and Torres-Hernandez and Hohenboken (1980) found little non significant ($P > 0.05$) difference in milk yield between 3 and 4 year old ewes. Milk yields and lactation period increased after first lactation to reach maximum at 5 years of age (Maroof et al., 1986). Milk yield was also reported by Bonelli (1969) to increase to the 3rd lactation and to remain nearly steady with no statistically significant variation till the 7th lactation. In Awassi sheep in Irag, age had been established to have no significant effect on milk production (Karam et al., 1971) after the first lactation, whose yield was lower than that of subsequent lactations. Kutaibani (1981) had similarly found no significant effect of age on milk yield after first lactation.

Al-saigh and Al-Khauzai (1991) reported a positive and highly significant correlation (0.49) between lactation milk yield and ewe weight at mating and weight at different periods of lactation for Arabi sheep.

2.4.5. Lactation Length

There are breed differences in lactation length. Consequently, breeds of sheep with prolonged lactation tend to produce more milk than those with short lactation. Maroof et al. (1986) observed in Hamdani sheep of Iraq an average lactation yield of 62.2 kg in 92.6 days and 77.3 kg in 152.1 days, respectvely. In Karadi sheep the average varied between 59.21 kg during 112 days (Mohammed, 1982) and 91.62 kg during 105 days (Kutaibani, 1981). While in Awassi it varied between 105.9 kg in 142 days (Eliya and Juma, 1970) and 115.7 kg in 135 days (Karam et al., 1971). As reported by Karam et al. (1971), the duration of lactation had a highly significant ($P< 0.01$) effect on total milk yield. The correlation coefficient obtained was 0.49. Also, the work on three indigenous breeds of sheep in Turkey, showed low and positive correlations between length of lactation and milk production (Sonmez and Wassmuth, 1964).

2.4.6. Stage of Lactation and milk yield

The milk yield at each stage of lactation which is a function of ewes persistency is another determinant of total milk yield in different sheep breeds. Various investigators agreed that the

maximum daily milk production in ewes is attained during the first month of lactation, especially between 15 and 20 days postpartum (Peart, 1968a, b; Corbelt, 1968; Ehoche et al., 1990) Roda et al., (1990) noted an increasing trend in milk production of Corriedale and Polworth ewes up to the 3rd week after which it declined steadily. For the Polworth ewes the values were 0.48, 1.25, 1.32, 1.13, 1.05, 0.91, 0.74, 0.54, while that of Corriedale ewes were 0.98, 1.38, 1.49, 1.11, 1.01, 0.86, 0.72 and 0.42 kg at 7th, 14th, 21st, 28th, 35th, 42nd, 56th and 63rd day of lactation, respectively.

2.4.7. Nutrition

Within genetical limits nutrition during lactation is the primary factor influencing milk production of ewes, though maximum production is dependent on adequate nutrition in both late pregnancy and early lactation. Reduced nutrient intake in early lactation could lead to a decrease in quantity of milk produced by lactating ewes. Peart (1968) had shown that substantial decrease in ewe live-weight and milk production occur when nutrient intake is restricted. Indeed, lactation period is the period of highest nutrient requirement in the ewe's annual production cycle. Slight restrictions of nutrient intake in lactating ewes in some instances may result in the loss of body weight and body reserves of the ewe which eventually lead to reduce milk production (Peart, 1992).

Nutrition at pre- or immediately post-parturition and type of birth had effects on persistency and period of maximum milk

production in sheep. Peart (1968) observed early attainment of maximum milk yield (2 weeks) which persisted more in better fed ewes pre- and post-partum than poorly fed ewes (3 weeks). The same author noted similar trend with ewes nursing twin and single lamb respectively.

2.4.8. Season or Month of lambing

The season or month of lambing is another factor that significantly affects the milk production of the ewe. Scardella and Pilla (1989) noted that month of lambing together with other environmental factors constituted about 80% of the variation in the milk yield of Comisana sheep. Martini et al. (1990) reported that for ewes lambing in January - June and July - December, milk yield averaged 149.8 kg and 147.3 kg, respectively.

2.5. Genetic and Phenotypic correlations between Milk and Growth Traits

In sheep, preweaning weight gain of the offspring is influenced by milk production of the dam (Burris and Baugus, 1955; Barnicoat et al., 1956). Correlation studies between milk yield of dam and weight gain are required to determine the level of dependency of lambs on their dams most especially in early age. Al-saigh and Al-Khauzai (1991) obtained a correlation coefficient of 0.53 between the dam lactation milk yield and average daily gain of Arabi lambs. Torres-Hernandez and Hohenboken (1980) similarly observed a large and significant phenotypic correlation between

weight gain of lambs and milk yield of their dams mostly at the start of lactation and these tended to decrease in magnitude as lactation progressed. For the entire lactation, values of 0.64 ($P<0.01$) and 0.55 ($P<0.01$) were obtained for single and twin lambs, respectively. Similar results had earlier been reported by some authors (Coombe et al., 1960; Munro, 1962, Slen et al., Folman et al., 1966a, b; Peart, 1967, 1968; Butterworth et al., 1968; Acharya and Bawa 1971; Peart et al., 1975). However, these findings were in contrast to those of Ehoche et al., (1990) who obtained large and significant correlation coefficients between lamb weight gain and milk yield of dam in all stages of lactation for both Yankasa sheep alone and its crosses with Suffoik/Wenselydale breed.

Eliya and Juma (1970), Karam et al.(1971) and Maroof et al.(1986) also obtained highly significant correlation between weaning weight and milk yield ranging from 0.63 - 0.78 while Sada (1980) and Kutaibani (1981) had similar report on liveweight of ewe and milk yield in different sheep breeds. However, Folman et al (1966a; 1966b) had mild and insignificant correlation coefficient between body weight and milk yield of ewes.

2.6. Regression of Lamb weight gain on dam milk yield

The regression studies involved economics of production. They tended to either evaluate or justify the need to further improve the performance of an animal for a particular trait. In the study carried out by Torres Hernandez and Hohenboken (1980), the regression coefficient of lamb weight gains on milk production of dam tended to decrease as lactation progressed. In an entire lactation, lamb weight gain increased with 0.11 kg for single lambs and 0.07 kg for twins for each additional litre of milk produced by the ewe. Consequently, for each additional kilogram of weight gain in single and twin lambs, 9.1 (the reciprocal of b=0.11) and 14.3 (the reciprocal of b=0.07) additional litres of milk respectively, were required. For a more precise prediction of lamb weight gain on milk production of dam, Scales (1968) suggested the inclusion of either fat, protein or both components in the regression equation. However, Torres-Hernandez and Hohenboken (1980), Slen et al. (1963) and Moore (1966) found little improvement in the relationship between milk intake and growth rate when milk production was expressed in terms of components rather than whole milk.

2.7. Regression of milk Production of dam on weight gain of lamb

The regression of milk production of dam on weight gain of their lamb is meant for prediction of milk production from weight gain. To regress milk production on weight gain is really counter to the expected biological cause and effect relationship. However, such findings could aid in estimating milk production, which is

costly and difficult to measure from lamb weight gain, but much easier to measure using this relationship. It is worth mentioning therefore that such estimate could only be applicable locally within a population or herd, management systems and a particular environment.

For week 1 postpartum, the regression coefficients indicated that single lambs and twin sets gaining 1 kg more than average had dams whose milk production were 5.06 and 4.98 litrers above average, respectively (Torres-Hernandez and Hohenboken, 1980). However, the regressions could only explain 65% and 69% of the total variation in the week 1 milk production. The authors further stressed that the magnitude and significance of the regression coefficients tended to decrease as lactation progressed, but only in the last week were they negative (though not significant). For the entire lactation, regression coefficients obtained were 3.74 liters/kg and 4.27 liters/kg, with R^2 values of 0.41 and 0.30, respectively.

The estimation of ewe milk production with information on lamb growth has been investigated by Doney and Munro (1962). Other investigators have also attempted using different approaches. Owen (1957) included lamb birth weight as independent variables influencing milk production, while, Robinson et al. (1969) estimated daily milk consumption of the lamb as a function of lamb body weight and lamb body weight change.

2.8. Lamb Birth weight and body weights to 3 Months of Age

Different studies have shown that birth weight and preweaning growth performance of sheep are greatly influenced by many factors. In order to enhance the efficiency of selection, there is need to identify and eliminate the effects due to these environmental factors (Buvanendran et al., 1981; Hassan, 1987; Fayomi, 1988). The most important among those factors include: sex of lamb, type of birth (Litter size), age of dam at lambing or parity, month or season of lambing, breed of lamb, year of lambing and milk yield of dam (Haide and Shah, 1974; Ngere et al., 1983; Buvanendran et al., 1981; Adu, et al., 1985; Negi, et al., 1987; Torres-Hernandez and Hohenboken, 1980; Snowder and Glimp, 1990)

2.8.1. Effect of Sex lamb

The effect of sex of lamb on birth weight and subsequent preweaning and weaning weights at 3 months of age have been shown to be very important by several workers (Hassan, 1987; Fayomi, 1988; Iyeghe, 1991; Maroof et al., 1986).

Maroof et al,(1986) working with Hamdani sheep, Hassan (1987) and Iyeghe (1991) on Yankasa and Fayomi (1989) on Balami and Uda sheep breeds have shown that the ram lambs are significantly ($P< 0.05$) heavier than the ewe lambs at lambing. These authors have also shown that the growth rate of male lambs from birth to weaning was significantly greater than that of their female counterparts. These differences in rate of growth were however partly attributed to the initial birth weight advantage of 0.44 and 0.30 kg in favour

of males in both Yankasa and Balami breeds. Kornal et al. (1979) attributed the variation in birth weight of lambs caused by sex to the genetic differences with the male foetus secreting androgens which stimulate protein anabolism, increased nitrogen and mineral retention for growth and development. Peter (1990) reported the same for East Friesian sheep while Tizikara and Chiboka (1980) gave a contrary report that sex of lamb had a significant ($P< 0.05$) effect on all other weights except the birth weight.

2.8.2. Effect of Type of Birth (Litter Size)

The mean weights of single and twin-born lambs at birth and at subsequent growth phases have been reported to differ significantly ($P< 0.05$) with single born lambs being heavier than their twin-born counter-parts (Notter et al., 1975) The advantage in weights of single birth over and above twin or multiple birth could be attributed to the initial advantage in the uterus and partly due to the extra nourishment single lambs receive from the dam (Garicia et al., 1980; Josh and Delta, 1985; Iyeghe 1991). Peter (1980) observed that the birth weight of twins, triplets and quadruplets were 13.2, 21.3 and 26.0% respectively lower than those of single-born lambs. The pre-weaning average daily gain and weaning weight of single and twin-born lambs were also reported to differ significantly (Ngere et al., 1979; Tuah and Baah, 1985; Adu et al., 1985; Osinowo et al., 1991b), with the single-born lambs being superior in rate of growth than twin born lambs. Tizikara and Chiboka (1990) working on pure West African Dwarf and its crosses

with other breeds observed significant (P< 0.05) effects of type of birth on birth weight and subsequent weights. Single born lambs were significantly heavier than twins in all the breed types.

2.8.3. Effect of Age/Parity of Dam

The information on performance of lamb in terms of birth weight, pre-weaning average daily gain and weaning weight as influenced by age/parity of dam were contradictory. While some workers believed that the lambs born to older ewes were significantly (P< 0.05) heavier at weaning than those born to primparous or younger ewes (Vesely et al., 1970; Fourie and Heydenrych, 1982; Osinowo et al., 1991b) others were of the view that the differences were not statistically significant (Magid et al., 1981; Maroof et al., 1986). The effects of dam weight on lamb birth weight and weaning weight were also reported. Maroof et al. (1986) observed a highly significant (P< 0.01) effect of dam weight on birth weight in Hamdani sheep with a value of 0.033 + 0.01 kg as the regression of birth weight on weight of dam. Similar report has been given by Juma and Faray (1986). However, the effect of weight of dam on weaning weight was not significant (b = -0.133 + 0.122kg) (Maroof et al., 1986). This was contrary to the significant positive relationship reported by Haider and Shad (1974). Work on Corriedale and Polworth sheep studied by Ehoche et al. (1990) showed lambs born to ewe above 2yrs as being heavier than those from younger ewes for both birth and weaning weight

2.8.4. Effect of Month or Season of Lambing

The effects of month or season on birthweight, pre-weaning weight gain and weaning weight have also been widely reported. Lambs born in the wet months/season are generally accepted as being heavier than those born during the dry months/season (Buvanendran et al., 1981; Taiwo et al., 1983; Osinowo et al., 1991).

Fayomi (1989) classified seasons into four and observed that lambs born between May-June (early wet) season were heavier than those born in the other seasons of August-October (late wet), November-January (early dry) and February-April (late dry) in that order. The trend was similar at 3-month of age. This might be due to the fact that the dams lambing in the wet season have access to better pasture resulting in the production of more milk for their lambs than those lambing in the dry season.

2.8.5. Effect of breed of lamb

Breed differences in birth weight, preweaning growth rate and probably weaning weight are due to the difference in the genetic make up or composition (Combellas et al.,1980; Arora et al., 1986). Negi et al. (1987) however observed that the significance of breed type of lamb on rate of growth reduces with age.

There are a contradictory reports on the breed of lamb effect on weights. Fayomi (1989) reported that Balami lambs are heavier than Uda lambs by 0.01 kg at birth and 0.94 kg at 3 months,

respectively. Geenty (1979) compared growth of Dorset, Corriedale and Romney twin lambs from birth until weaning at 12 months of age. The Dorset lambs were 6% heavier at weaning than Corriedales and Romneys, respectively. Combellas et al.(1980) and Arora et al. (1986) also observed a significant ($P< 0.05$) effect of breed type on weaning weight. The differences however, represented both the effects of differences among the breeds in milk production and differences among lamb breeds in growth potential. Negi et al. (1987) on the other hand indicated no sigificant ($P> 0.05$) differences due to breed type on body weight at weaning.

2.8.6. Effect of Year of Lambing

The differences between years in the amount and distribution of rainfall which determine the feed availability could be the source of variation in lamb's live body weights between years.

Several findings have indicated the significant effect of year of lambing on birth weight of lambs (Combellas et al., 1980; Abouiheif and Alsobayel, 1983; Negi et al., 1987). However, Raman et al. (1979) observed no significant effect due to year of lambing. Combellas et al.(1980) and Negi et al.(1987) have also reported a significnt ($P< 0.05$) difference of the influence of year of lambing on average daily gain from birth up to weaning. Basset et al. (1967) however, noted no significant effect of year as source of variation in body weight of lambs at weaning. Cho et al. (1989) analysed the effect of year of birth on weights at birth and weaning for Corriedale and Polworth sheep and observed a

highly significant ($P < 0.01$) relationship.

2.9. Milk Production Improvement Methods in Sheep

Milk production character of sheep could be improved genetically through selection. For selection for several characters selection indices can be constructed based on the heritability and genetic variation of the characters, the genetic correlation between them and their relative economic values.

In Africa, as in the rest of the tropics, sheep are usually exploited for meat, milk, skins and pelts. Other main characters of importance for productivity include reproductive rate, body weight, growth rate and milk production. In formulating selection schemes, certain flock characteristics peculiar in the production systems in the tropics need to be recognised. Generally, while flock sizes are large in breeds managed extensively and are associated with poor recording, those kept semi intensively had fewer flock size for effective selection procedure. Consequently, breeding programme should give adequate consideration to selection in a flock be it institutional flock or group breeding schemes.

Prominent among the various improvement techniques in the tropics, as in the temperate areas, are:- selection within breeds and crossing (including upgrading), development of new breeds and exploitation of heterosis. All these methods have their merits and demerits.

2.9.1. Selection within Breed

This refers to selection among animals of the same breeds of either same or different ages that were run in the same environment for a particular trait e.g milk production traits. By so doing both sire and dam line need to be selected for the trait under consideration. For sex limited trait, such as milk production, sire breeding value or potential are got through progeny testing. In this case, the daughters to the same or different dams sire by the same or different sires in milk production are studied in the same or different generations. Seed stock will be developed in both male and female lines in the institutional or government farm through selective breeding. These flocks could in turn serve as a reservior of stocks for upgrading the local population of the same and/or different breeds. Leroy (1968) reported that milk production of the lacaunne ewes in the region of Roquefort rose from 86.4 kg in 1963 to 102.5 kg in 1966. For practical application however, the environment has to be carefully considered for seed stock formation.

The resolutions within various international meetings of breeds and/or geneticist of recent revealed that a more closely look at the indigenous or the local breeds could be highly beneficial in a selection programme. The assumption was that this category of stock are adapted to their local environment hence working on them would afford the pain-staking importation of the so called "improved" breed which can not probably survive under the tropical environment. The harsh, arid tropical environment

exerts a profound influence on the productivity of sheep. There is restriction to production impose by nutritional deficiences and climatic stresses during much of the year. Tropical breeds in ages through natural selection have acquired this characteristic hence genetic improvement of any sort should rely on adapted breeds.

2.9.2. Crossing

This may involve crossing between indigenous breeds or between indigenous and exotic breeds. Earlier assumption has been that exotic breeds from temperate region with high productivity crossed with local breeds in the tropic will automatically improve production. However, this might be said to be far from being the truth. The problem might be connected to the much poorer environmental condition (i.e. unfavourable nutritional and management conditions). Moreover, there might be natural difficulty in mating between the two categories of breeds has seen between thin-tailed foreign rams and fat - tailed native ewes. However, Ehoche et al. (1990) had shown that crossing Yankasa ewe with Suffolk x Wenselydale sires improved milk production substantially. On the average, the daily milk production of the former (348.1 g) was significantly lower than that of the latter (505.7 g). Doney et al. (1981) found similar results with Blackface ewes and their crosses with East Friesland ewes. The latter had a higher peak and a more sustained level of production than the former.

In general, Ademosun (198') noted that cross-breeding most

especially with exotic breeds has not been beneficial and thus suggested that we perhaps should be more in ward looking by improving our local breeds through selection for desirable characters within them and if cross breeding was to be explore at all it should be between adapted local breeds.

Grading up is another aspect of crossing involving the replacement of one breed by another with continual back-crossing while development of a new breed involved crossing of two (or more) breeds, then at a desired stage there would be an inter-se mating within the selected animals. The cross breeding programme commonly practised here in the tropics are usually in the form of either grading-up or formation of a new breed.

The system of heterosis as a method is extensively utilized in Europe and North America most especially on cattle. It is benefical when a cross between two (or more) breeds in a particular trait has higher production than the superior parents. This is sometimes the case, and the technique (heterosis) is widely used in Australia for lamb production. For the utilization of such a system there must be a continual supply of the parent breeds. In the tropics, little or nothing has been done on the crossing of two adapted breeds to exploit the good in either hybrid vigour or develop a new breed through heterosis. In Iran the Shal breed had been improved by crossing with the Isreal Awassi. Heterosis was exhibited in lambing rate, litter size, milk yield and growth rate (Yalcin, 1979).

2.10. Heritability of Traits

The heritability of a trait in a breed concept is the fraction of the observed phenotypic variance which results from differences in heredity-among the genes and gene combination for such trait. In this sence the heriditary variance is considered as the sum of the additive genetic, the dominance, and the epistatic variances. The narrower definition which is more useful in most aspect of animal improvement however, defines heritability as the fraction of the observed phenotypic variance which is additively genetic or which is associated with differences in average breeding values.

Heritability expresses the reliability of phenotypic value as a guide to breeding value. This is the reason why Falconer (1989) defined heritability as the ratio of additive genetic variance to phenotypic variance which equally means that it is the regression of breeding value on phenotypic value. $h^2 = V_A/V_P = b_{AP}$. V_A is the additive genetic variance and V_P is the phenotypic variance while b_{AP} is the regression of breeding value on phenotypic value.

In theory, the value of heritability ranges from 0 to 1, but these extreme values are rarely encountered in practice. The reason being that heritability is descriptive of a trait in a particular population and of the environmental circumstance to which the individuals are subjected within such population.

$$h^2 = \frac{\sigma^2_g}{\sigma^2_g + \sigma^2_d + \sigma^2_i + \sigma^2_e}$$

σ^2 represents the non-genetic variance. Since the value of the

heritability depends on the magnitude of all the components of variance, its value can be varied by changes in the additively genetic variance of the numerator or by changes in any one or all of the components of variance in the donominator. It should be noted however that the additively genetic variance is closely associated with the gene frequency of the genes influencing the trait in question.

The heritability estimates for birth weight, weaning weight and average daily gain range from 0.12 - 0.34, 0.41-0.52 and 0.33-0.56, respectivley (El-karim and Owen, 1988; Boujenane and Kerfal 1990; Osinowo et al., 1991). Bonelli (1969) estimated the heritability of 180-day milk yield of the first lactation of Sardinian ewes at 0.41 while Boylan and Sakul (1990) obtained an average value of 0.30 as heritability for milk production of sheep in the temperate region. For some temperate cattles,heritability estimates for milk production range from 0.12 - 0.59 (Abubakar et al.,1987; Camoens et al.,1976; Macdonald et al.,1976; Maijala and Hanna,1970). While Sonmez et al. (1991) reported a range of between 0-0.51 and 0-0.12 as heritability estimates for both lactation yield and length within breed type for 3 different breeds of sheep.

2.11. Estimation of heritability

Numerous procedures for computing heritability are used in research studies. The underlying basis for determining heritability depends on evaluating how much more alike individuals with similar genotypes are then unrelated or less closely related

individuals. Different kinds of relatives are used to estimate either the additive genetic variance from covariance, or the heritability from the regression or correlation coefficient. The parent-offspring and the paternal half-sib relatiohships are the most widely used to determine heritability in farm animals. The full-sib correlation which is the only relatiohship for which an environment component of covariance is well known is the least reliable of all. In all, it should be noted that due to statistical sampling and variation, rather large bodies of information are required to provide meaningful estimates.

2.11.1. Parent - Offspring

The regression of offspring on parent is most commonly used in heritability estimation. The more precise statistical procedure involve obtaining measurements of the traits in question on both the parents and their offspring. Cianci, Martini and Taccini (1989) reported an estimate of 0.39 for milk yield heritability of Messese sheep in Pistoia province through analysis of data on 95 dam-daughter pairs. These measurements are usually corrected for environmental effects that are likely to influence the measurement. The sum of products for the paired observations for parent and for offspring is obtained which is divided by the degrees of freedom to give an estimate of the covariance between parent and offspring. Since the offspring receive a sample half of the genes of the parent, the covariance between parent and offspring is expected to include one-half of the additive genetic

variance for such trait. The variance of the parents' measurement is obtained and the regression of offspring on parent represents one - half of heritability

$$b_{op} = \frac{\sigma_{op}}{\sigma^2_p} = \frac{d^2_g/2}{\sigma^2_p}$$

The regression must be multiplied by 2 to compute heritability.

2.11.2. Paternal Half-sibs

Half-sibs on the average have only one-quarter of their gene in common rater than one-half as with parent and offspring. Usually paternal half-sibs are used since there are few maternal half-sibs in a set, and their similarity may even be influenced by maternal effects. The heritability is determined through an analysis of variance. The intra-class correlation between paternal half-sibs can be computed as a ratio of the components of variance. Since half-sibs have only one - fourth of their gene in common, the heritability is computed by multiplying the paternal half-sibs correlation by four. Osinowo et al. (1991a) reported an half-sib heritability estimates of 0.27, 0.45 and 0.45 for birthweight, weaning weight and average daily gain for Yankasa sheep.

2.13. Repeatability of traits

Repeatability is a concept closely allied to heritability and is useful for traits which are expressed several times during an animal's life time. Since neither the genes nor gene combination

influencing the successive expressions of a trait change, repeatability could be as large as heritability in the broad sence.

Repeatability can be defined as the ratio of the variance due to the animal effects to the total phenotypic variance.

$$r = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_E} = \frac{\sigma^2_A}{\sigma^2_P}$$

It can also be computed as the regression of future performance on past performance. In addition to being computed as a regression it may be derived from an analysis of variance as an intra-class correlation among records or observations of traits on the same animal or individual. Boylan and Sakul (1990) obtained an average estimate of 0.53 for milk yield in 10 breeds of sheep in the USA while for Massese sheep in the Pistoia province the value ranges between 0.47-0.61 (Cianci, Martini and Tallini, 1989) for pairs of lactations. Pagnacco et al. (1989) however had repeatability for milk yield and litter size as low as 0.27 and 0.10, respectively. For the indigenous strains of African goats and sheep, Wilson, Murayi and Rocha (1989) reported a range of 0.03-0.19 respectively, for litter size.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Description of environment

This study was conducted at the National Animal Production Research Institute (NAPRI), Shika. This region lies 640m (2100ft) above sea level and falls within latitude 11013/N and longitude 7033/E. The climate is sub-humid and it is located in the Northern Guinea Savannah Zone. It receives a mean precipitation of 1107mm per annum, streching over 120-170 days from late April to early september. Seasonal distribution of rainfall is approximately 0.1% in the late dry (January - March), 25.8% in early wet (April - June), 69.6% in late wet (June - September) and 4.5% in the early dry (October - December) season, respectively. Mean annual temperature at Samaru, 10km from Shika is 24.4°C with a range of about 8°C (during harmattan) to 37°C (during the hottest season) depending on year. The mean relative humidity during dry and wet seasons are 21 and 72% respectively. Good quality forage is more abundant in the late wet and early dry seasons while forages are generally scarce and very low in quality during late dry and early wet seasons.

3.2 Population and Management

A total of one hundred and sixty eight Yankasa ewes of varying parities were used in this experiment. These sheep were part of the experimental flock kept for the Nucleus

Breeding Project. The sheep were under semi-intensive system of feeding and management. They were allowed to graze on improved pastures for 6-8 hours daily, and were given 0.3-0.5 kg/day of a 15-20% crude protein concentrate supplement consisting of cotton seed cake, maize grain (ground) or maize offals, bone meal and salt throughout the year. The concentrate supplement offered depends on season (feed availability) and the physiological status, whether pregnant, nursing or dry. Animals were housed in cross ventilated pens and have free access to water and mineral salt licks. Routine health management system involves regular deworming and deticking. The ewes were routinely bred to ram through controlled natural matings following heat detection using apron fitted rams in a twice yearly accelerated lambing programme. Mating ratio is 1 ram to 10 ewes.

3.3 Procedure

The breeding and pedigree records for the ewes were obtained from the herd books. Following parturition, ewes with their lambs were separated into a nursing pen. The birth weights of the lambs were recorded. Daily milk yield of the ewes were determined at weekly intervals from about one week after lambing till the 14th week of lactation. For each collection day, lambs were separated from their dams over-night and milked 24 hours later to obtain the day's total milk yield. The dams were milked dry by hand milking after thorough disinfection of the udder. The milk collected

for each ewe was weighed and then fed to the lambs. The lambs were also weighed on weekly basis on days corresponding to the milking dates. All lambs were allowed free access to both grazing and concentrate supplement feed given to their dams except on milking days.

3.4 Data correction

Before any analysis for a specific information required as regards the traits under consideration, proper data editing as specified below were carried out:

For the weight traits in the lambs, twin born lambs that were raised as singles as a result of the death of others were assumed to be single. In the genetic analyses for both weight and lactation traits, all the records that were incomplete due to loss of lamb and dryness of dam were deleted.

In determining the least square means of milk yield of the ewes, the total ewes(168) used at the on-set of the experiment were used on one hand while those with the complete 84 days(143) lactation were also used on the other hand(Tables 1 and 2). The basis for the comparison was to determine the average flock unit milk yield when the estimation is based on either ewes with complete 84 days lactation or those without regard to lactation length. A total of 24 ewes were excluded due to incomplete lactation records of 84 days caused by sudden dryness.

The total 168 ewes were involved in the estimation of the lactation curve parameters(Tables 3 and 4). This was to

determine the effect of lactation length on the shape of the curve at different phases.

For the least-square means estimation of the lamb weight at different stages of growth only 136 out of the total 186 lambs were used. These were lambs with complete weight records to 90 days(Tables 5 and 6). A total of 50 lambs weight records were excluded due to death.

In the correlation analysis analysis between preweaning gains of lamb and milk yield of dam, only ewes with the complete lactation(143) records were used with their lambs(Tables 7, 8 and 9)

For the genetic analysis, heritability and correlation esimates for weight of lambs were based on 136 lambs with weight gain to 90-days while corrected curve parameter values obtained from ewes with complete lactation records(143) were used(Tables 10 and 11).

3.5 Statistical Analysis

The least-square procedures (SYSTAT, 1989) were used in determining the effects of type of birth, parity and month of birth on milk yield with age of lamb(A) as a covariate. The statistical model used was:

$$Y_{ijk} = U + T_i + P_j + M_k + bA + E_{ijk}$$

Where: Y_{ijk} was the milk yield of dam with i^{th} type of birth, j^{th} parity and k^{th} month of birth. E_{ijk} is the error due to uncontrollled, random environmental and genetic deviation attributed to the ijk^{th} dam. The partial regression

coefficient is represented by b. Base class adjustment of milk yield data to that of a twin birth, 4th parity dam lambing in July was done using the least square constants.

The lactation curve was derived by regression using the gamma function of Wood (1969):

$$Y_n = {}^{a}n^{b}e^{cn}$$

Where: Coefficients a, b and c define the curve of milk production Y_n at week n and e stands for the base of natural logarithm. The parameters Ln A(a), b and c were estimated for lactation by fitting multiple regressions of Ln Y on Ln n and n. The estimation of peak yield, total yield and mean daily yield was by the use of Wood's equation.

The effect of sex and type of birth of lamb, parity of dam and season of lambing on weight at birth and at 6, 24, 48, 72 and 84 days post-partum were studied using the model below:

$$W_{ijkl} = U + S_i + T_j + P_k + A_l + E_{ijkl}$$

Where W_{ijkl} was weight at birth or at 12,30,54,78 and 90 days post-partum, S was the fixed effect of i^{th} lamb sex, T was the fixed effect of j^{th} type of birth, P was the fixed effect of the k^{th} parity of dam and A was the fixed effect of the l^{th} season of birth. E was error due to the random effect term associated with each record. Least square procedures for unbalanced data (Harvey, 1990) were used for the analysis due to unequal subclass numbers.

Consequent upon data adjustment for the effects due to

environmental factors, phenotypic correlations were computed between preweaning weight gains and milk yield using the Pearson correlation module while test of significance at 5% was carried out using Bonferroni probabilities in accordance with the procedures of Wilkinson (1988) using SYSTAT.

The effects of type of birth of lamb, parity of dam, season of lambing and lactation length class on each of the components of the lactation curve (a, b, c and s) were examined by least-squares analysis (Harvey, 1960). The constants a, b and c are parameters which determine the shape of the curve. While a is the general level of production, b was the parameter of pre-peak curvature, c was the parameter of post-peak curvature and s was the measure of persistency obtained as -b/a. The curve parameters were estimated through multiple regression for each ewe's milk production throughout the lactation period. The type of birth classification was either single or twin birth. Parity was classified into five classes of 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and $>4^{th}$ parity. The seasons considered were early wet (April-June) and late wet (July-September). Lactation length were classified into two, of below and equal to 84 days The statistical model used was as follows;

$$Yijklm = U + T_i + P_j + S_k + L_l + E_{ijklm}$$

Where Y_{ijklm} was the observation of the m^{th} animal with i^{th} type of birth of the j^{th} parity in the k^{th} season of lambing and l^{th} lactation length class. U was the overall mean, T_i

was the effect due to type of birth (i=1,2), P_j was the effect due to parity of dam(j=1,....,5), S_k was the effect due to season of lambing(k=1,2) and L_l was the effect due to lactation length class(l=1,2).

After data adjustment for significant environmental effects, genetic parameters for birth (BWT), weights at 30, 60 and 84 days and lactation curve parameters (a, b, c and s) were estimated by paternal half sib analysis using the mixed model least-squares and maximum likelihood computer program(Harvey, 1990). Heritability estimates of the traits were estimated by one way variance component analysis(unbalanced design) using correlation.

The model used was as given below:

$$P_{ij} = U + b_i + w_{ij}$$

Where

U = mean common to all records

b_i = an effect in common to members of the i^{th} genetic group

W_{ij} = is a random effect associated with the j^{th} member of the ith group

The assumptions are:

The b's and w's were identical and independently distributed with means equal to zero and b's and w's are uncorrelated.

Variance components were:

Sire variance ($\sigma^2 s$) estimates genetic variance and

environmental variance(σ^2w) which estimates remainder of genetic plus all environmental variance.

These are estimated as follows:

$$\sigma^2b = \frac{GRPSS - CT - (B-1)\ \sigma^2w}{n. - 1/n.\Sigma ni^2}$$

where

GRPSS = Genetic group sum of squares

CT = Correlation term

$$\sigma^2w = \frac{\text{Total SS - GRPSS}}{n. - B}$$

B = Number of animals within sire group

n. = Overall total number of animals

n_i = Number of animals within the i-th sires

$$h^2s = \frac{1/a_{ii}\ \sigma^2b}{\sigma^2b + \sigma^2w}$$

since it is by half-sib correlation,

$a_{ii} = 1/4$

a_{ii} = Genetic level of relationship between animals

Therefore, $h^2s = \frac{4\sigma^2b}{\sigma^2b+\sigma^2w}$

Genetic and phenotypic correlations were also computed by variance and covariance (cov) component analysis, using Harvey's Least-squares and Maximum Likelihood computer program (Harvey, 1990). Covariance for estimating correlations between traits i and j were obtained from the variances (var) through the relationships:

$$\sigma_{ij} = 1/2 \ (\ \sigma^2(i+j) \ - \ \sigma^2(i) \ - \ \sigma^2(j) \ )$$

$$\text{Genetic correlation } (r_{ij}) = \frac{\sigma S_i S_j}{\sqrt{(\sigma^2 S_i)(\sigma^2 S_j)}}$$

$$\text{Phenotypic correlation } (r_p) = \frac{\sigma S_i S_j + \sigma E_i E_j}{\sqrt{(\sigma^2 S_i + \sigma^2 E_i)(\sigma^2 S_j + \sigma^2 E_j)}}$$

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. RESULTS

4.1.1. Milk yield

The result of the least-squares analysis for milk yield are shown in Tables 1 and 2. All factors under consideration except parity very highly significantly ($P<0.001$) influenced the 84-day milk yield. The overall least squares mean for the 84-day lactation was 12.3 ± 0.3 kg. Dams with twin lambs produced more milk than those with single lambs. There was an increase in milk production as the parity progressed upto the 4th parity before a decline. However, this observed trend was not significant ($P>0.05$). Ewes that lambed within July to September (season 2) had very highly significantly better yield ($P<0.001$) compared to those within April to June (season 1). Ewes with lower lactation length expectedly yielded lower milk per day compared with those that lactated to 84 days (Table 2).

Table 1. Least-squares analysis of variance for milk yield of Yankasa ewes

Source	84-day Lactation only		<84-day Lactation inclusive	
	DF	MS	DF	MS
Type of birth	1	67.642***	1	80.648***
Parity	4	3.63^{NS}	4	3.140^{NS}
Season of birth	1	251.801***	1	254.510***
Lactation length			1	764.095***
Error	136	7.426	160	7.425

NS - Non-Significant
*** - P<0.001

Table 2. Least-square means for effects of birth type, Parity, Season and lactation length on dam milk yield

Classification	84-day lactation only		<84-day lactation inclusive	
	No.	Milk Yield(kg)	No.	Milk Yield(kg)
Overall Mean	143	12.63±0.36	168	9.68±0.43
Type of birth				
Single	126	11.49^{a}±0.28	150	8.47^{a}±0.33
Twin	17	13.78^{b}±0.69	18	10.89^{b}±0.72
Parity				
1	48	12.39±0.47	59	9.42±0.49
2	30	12.42±0.60	35	9.62±0.62
3	18	12.92±0.69	21	9.72±0.69
4	24	13.15±0.63	27	10.21±0.66
>4	23	12.27±0.62	26	9.44±0.64
Season of birth				
1(April-June)	50	11.11^{a}±0.44	58	8.27^{a}±0.48
2(July-Sept.)	93	14.15^{b}±0.45	110	11.09^{b}±0.49
Lactation length				
84-day	143	12.70^{b}±0.64		
>84-day	25	6.66^{a}±0.64		

4.1.2. Lactation curve

The daily milk yield increased to reach a peak in the second to third week of lactation and then declined gradually to the end of lactation (Fig. 1). The pattern was similar for both adjusted and unadjusted data. The Wood's gamma function was fitted after regression for the lactation curve and the parameters of the equation were:

$Y_n = 248.887n^{0.915}e^{-0.355n}$ ($R^2 = 0.67$; $P<0.001$)

$Y_n = 270.697n^{0.697}e^{-0.298n}$ ($R^2 = 0.71$; $P<0.001$)

for unadjusted and adjusted data, respectively. The adjustment increased the goodness of fit. The total yield estimates using the Wood's gamma function for both unadjusted and adjusted lactation curves were 11.62 and 13.44 kg, respectively with corresponding average daily yields of 129.08 and 149.39 g in 84 days lactation. The peak yield of 250g/day was attained between the 2nd and 3rd weeks of lactation for the adjusted data.

Figure 2 gives a comparison of lactation patterns between dams with twin lambs and those with singles. Dams with twins had better general production level with higher persistency compared with those with singles. Dams with single lambs, however, had higher rate of rise and decline from peak production.

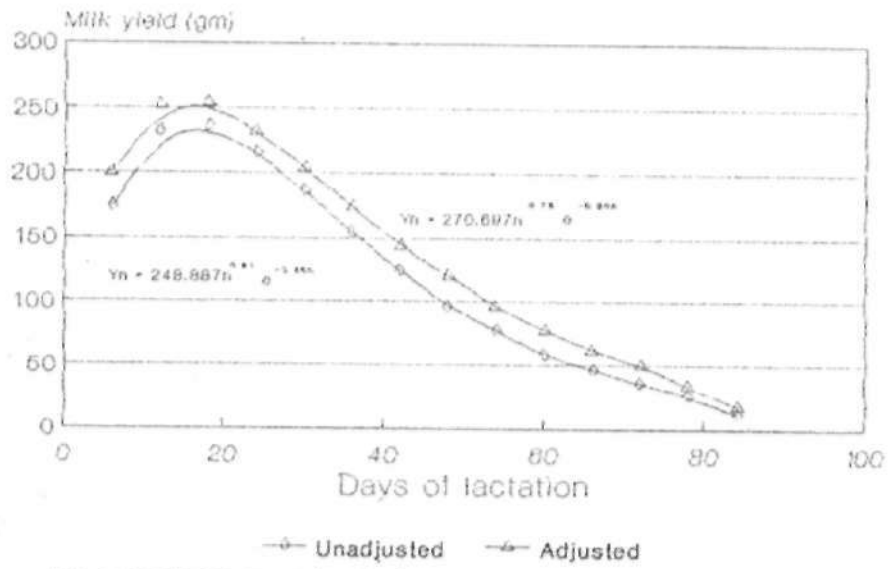


Fig. 1. Lactation curve for Yankasa ewes: Adjusted Vs. Unadjusted

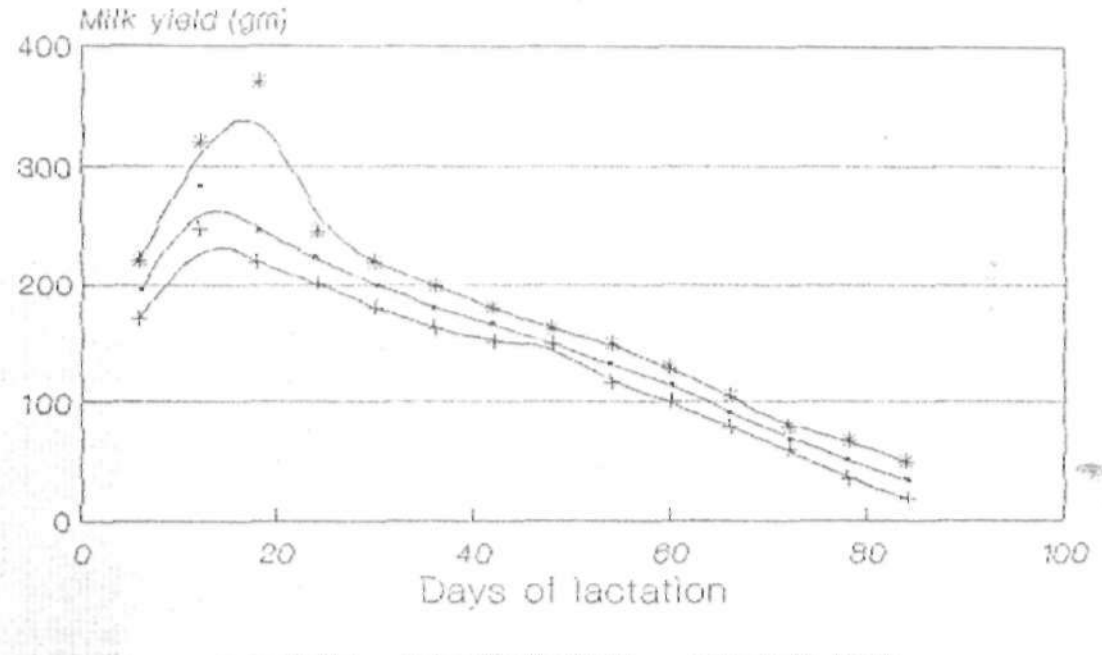


Fig. 2. Lactation curve for Yankasa ewes: Type of birth effect.

The production level was significantly ($P< 0.05$) higher in season 2 while the rate of rise and decline from peak was non-significantly better in season 1 (Fig. 3). The persistency in production was however significantly higher in season 2 compared to season 1.

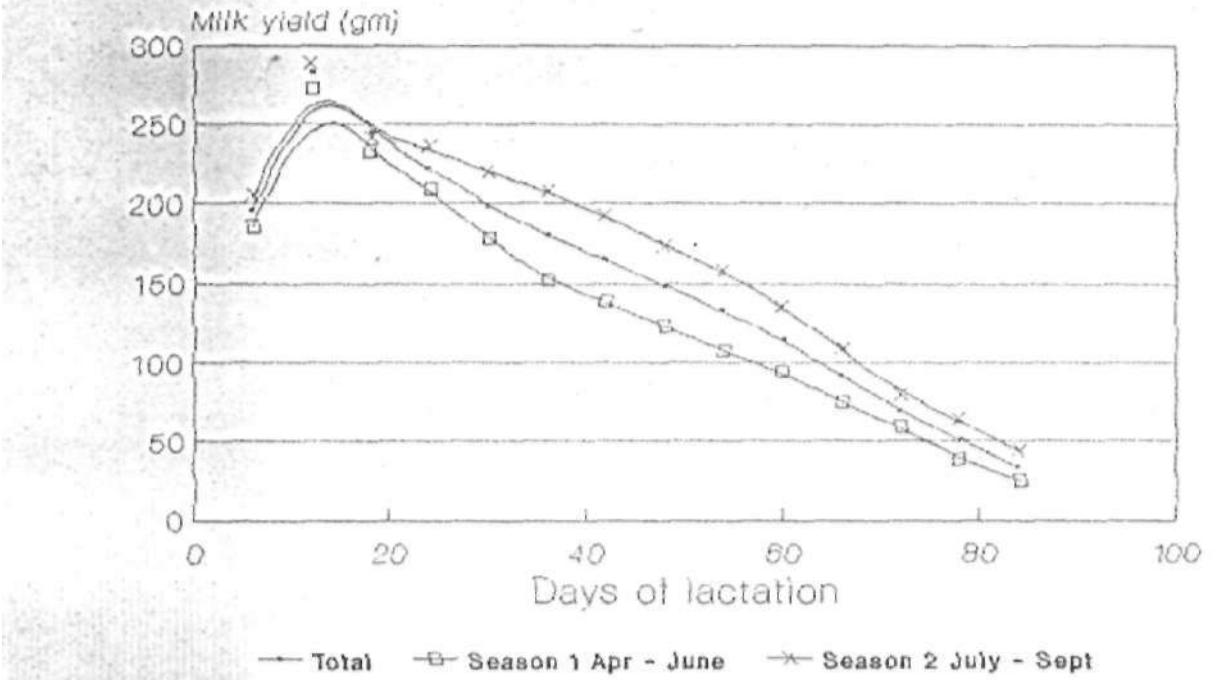


Fig. 3. Lactation curve for Yankasa ewes: *Season of birth effect*

4.1.3. Lactation curve Parameters

Tables 3 and 4 provide the result of the analysis of variance and the least-squares means for the curve parameters a, b, c and s. As earlier stated while A(a) stands for the general level of production, b is the rate of rise to peak and c and s are the rate of decline from peak and persistency in peak production, respectively. The type of birth effect was not significant for a and s while for b and c a significant ($P< 0.05$) effect were observed. Likewise, the parity of dam effect was not significant for any of the traits examined while the effect due to season of lambing was significant in all the traits. Lactation length class had significant effect on all the curve parameters.

From Tables 3 and 4, it could be seen that dams with single lambs had significantly higher rates of rise and decline compared to the dam with twin lambs. However, the general level of production seemed better in dams with twins but the difference compared to dams with singles was not significant. Moreover, ewes that lambed within July to September (season 2) as compared to those within April to June (season 1) had higher general level of production, lower rate of rise and decline from peak and higher persistency. The correlation coefficient (R) between actual yield and the lactation curve parameters was significantly ($P< 0.05$) higher in season 1 than season 2. The general level of production and persistency of ewes with complete lactation of 84 days

was significantly ($P< 0.01$) higher compared with those with lower lactation days. However, the reverse was the case for the rate of rise to and decline from the peak production. The function used gives as good a fit to lower lactation length (<84-day lactation; $R^2=0.81$) as for complete lactation (84-day lactation; $R^2=0.83$)

Table 3. Least-square analysis of variance for the functions of the lactation curve

Source of variance	DF	a	b	c	s
Type of birth	1	0.246	0.144[a]	0.063[a]	2.048
Parity	4	0.022	0.075	0.010	0.691
Season of lambing	1	1.076[x]	0.185[y]	0.049[x]	2.746[x]
Lactation length class	1	1.274[x]	6.603[y]	1.059[y]	49.258[y]
Error	158	0.184	0.087	0.010	0.834

P< 0.05 = x, P< 0.01 = y

Table 4. Least square means for the functions of the lactation curves(a, b and c), persistency(s) and the correlation coefficient(R) in Yankasa ewes

Classification	No.	a±S.E.	b±S.E.	c±S.E.	s±S.E.	R±S.E.
Overall mean	168	5.51±0.06	0.38±0.06	0.27±0.02	-1.37±0.19	0.78±0.02
Type of birth:						
Single	150	5.44±0.07	0.43^{y}±0.05	0.31^{y}±0.02	-1.57±0.16	0.79±0.01
Twin	18	5.58±0.13	0.32^{x}±0.09	0.24^{x}±0.03	-1.18±0.27	0.76±0.02
Parity:						
1	59	5.53±0.09	0.34±0.06	0.26±0.02	-1.27±0.02	0.78±0.02
2	35	5.53±0.12	0.33±0.08	0.26±0.03	-1.23±0.25	0.79±0.02
3	21	5.53±0.53	0.48±0.08	0.31±0.03	-1.69±0.26	0.78±0.02
4	27	5.54±0.12	0.35±0.08	0.25±0.03	-1.26±0.26	0.78±0.02
>4	26	5.47±0.15	0.38±0.10	0.28±0.03	-1.39±0.31	0.77±0.02
Lambing season:						
1	58	5.55^{x}±0.08	0.49^{y}±0.06	0.32^{y}±0.02	-1.82^{x}±0.17	0.84^{y}±0.02
2	110	5.76^{y}±0.08	0.31^{x}±0.10	0.25^{x}±0.04	-1.15^{y}±0.31	0.75^{y}±0.03
Lact. length:						
84-day	143	5.65^{y}±0.09	0.06^{x}±0.06	0.15^{x}±0.02	-0.52^{y}±0.20	0.78^{y}±0.02
<84-day	25	5.38^{x}±0.11	0.69^{y}±0.08	0.40^{y}±0.03	-2.22^{x}±0.23	0.77^{x}±0.02

Within each variable,means with the same superscript are not significantly different ($P< 0.05$; $P< 0.01$)

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4.1.4. Weight of lamb

The least-squares analysis of variance and least-squares means for the weight traits are presented in both Tables 5 and 6. Birth weight and the subsequent weights were very significant ($P<0.001$) affected only by the season of birth. The overall means for the birth and 90-day weights were 2.74 ± 0.06 and 10.00 ± 0.18, respectively.

Table 5. Least squares analysis of variance for weight of lambs at various stages of growth

Source	DF	Weight mean squares					
		BWT	12-day	30-day	54-day	78-day	90-day
Type of Birth	1	0.067	0.102	0.165	2.119	1.120	1.497
Parity	4	0.061	0.007	0.677	1.096	1.795	2.117
Season of birth	1	0.097	1.494**	13.857***	21.677	22.482	12.265***
Error	127	0.174	0.186	0.486	1.040	1.565	1.633

** - P<0.01
*** - P<0.00

Table 6. Least square means for weight of lamb at different stages of growth

Classification	No.	BWT	12-DAY	30-DAY	54-DAY	78-DAY	90-DAY
Overall mean	136	2.74±0.06	3.18±0.06	4.64±0.01	6.65±0.14	8.82+0.17	10.00±0.18
Type of birth:							
Single	120	2.78±0.05	3.23±0.05	4.70±0.08	6.86±0.11	8.97±0.14	10.18±0.14
Twin	16	2.70±0.11	3.13±0.11	4.59±0.18	6.44±0.27	8.67±0.33	9.83±0.33
Parity:							
1	46	2.18±0.08	3.19±0.08	4.66±0.13	6.49±0.27	8.65±0.23	9.80±0.23
2	30	2.77±0.09	3.19±0.01	4.71±0.16	6.57±0.23	8.75±0.28	9.98±0.29
3	15	2.70±0.11	3.16±0.12	4.42±0.19	6.74±0.28	8.93±0.34	10.10±0.35
4	22	2.72±0.10	3.21±0.10	4.92±0.17	6.98±0.25	9.24±0.30	10.45±0.31
>4	23	2.71±0.10	3.17±0.10	4.52±0.17	6.47±0.23	8.54±0.29	9.69±0.29
Season of birth:							
1	49	2.71±0.07	3.06^{a}+0.07	4.52^{a}±0.16	6.19^{a}±0.1	8.35^{a}±0.20	9.66^{a}±0.21
2	87	2.77±0.07	3.31^{b}±0.08	5.01^{b}±0.12	7.11^{b}±0.18	9.29^{b}±0.22	10.35^{b}±0.22

Within each variable,means with the same superscript are not significantly different ($P< 0.01$; $P< 0.001$)

4.1.5. Phenotypic Correlations

The phenotypic correlations (r_p) between weight gains of lambs at various stages of growth ranges between 0.48-0.95 (Table 7). These values were generally positive and very highly significant (P<0.001). The lower correlations between weight gains were observed at the earlier stages of growth and these increased as the stage progressed.

The estimates of the correlations (r_p) for milk yield at different stages of lactation were represented in Table 8. The value obtained were very significantly (P<0.001) positive and it ranges between 0.49-0.94. The highest correlation occured between stages 2 and 5 and the lowest between 1 and 4.

Weight gains of lambs to 30, 54, 78 and 90 days post-partum were correlated to the dam milk yield at various stages of lactation. The highest and highly significant(P<0.01) relationship of 0.31 was obtained between the 3rd stage of lactation and weight gain to 54 days of growth (Table 9).

Table 7. Phenotypic correlations between weight gains of lamb at different stages of growth(P< 0.001)

	1	2	3	4
WTG1	1.00			
WTG2	0.58	1.00		
WTG3	0.53	0.86	1.00	
WTG4	0.48	0.80	0.95	1.00

WTG1- Weight gain of lamb to 30-day
WTG2- Weight gain of lamb to 54-day
WTG3- Weight gain of lamb to 78-day
WTG4- Weight gain of lamb to 90-day

Table 8. Phenotypic correlation between dam milk production at different stages(P< 0.001) of lactation

	1	2	3	4	5
1	1.00				
2	0.78	1.00			
3	0.61	0.81	1.00		
4	0.49	0.67	0.78	1.00	
5	0.91	0.94	0.86	0.72	1.00

1 - Milk production between 6th and 24th day postpartum
2 - Milk production between 25th and 48th day postpartum
3 - Milk production between 49th and 72th day postpartum
4 - Milk production between 73th and 84th day postpartum
5 - Milk production between 6th and 84th day postpartum

Table 9. Phenotypic correlations between weight gains of lamb and milk yield of dam at different stages of lactation

Stages of lactation	Weight gains			
	1	2	3	4
6--24 days	0.16	0.1[illegible]	0.17	0.16
25--48 days	0.17	0.1[illegible]	0.16	0.12
49--72 days	0.25	0.31**	0.28*	0.23
73--84 days	0.07	0.06	0.07	0.05
6--84 days	0.20	0.2[illegible]	0.21	0.18

1 - Lamb weight gain to 30 days
2 - Lamb weight gain to 54 days
3 - Lamb weight gain to 78 days
4 - Lamb weight gain to 90 days
* P< 0.05; ** P< 0.01

4.1.6. Heritability Estimates

a) Weight of lamb

The paternal half-sib heritability estimates (h^2) for birth weight (BW) and body weights of lamb at 30, 60, and 90 days are presented in Table 10. Positive estimates were obtained for all the traits. The BW and 30-day weight had a similar h^2 of 0.30 which, however, was lower than those obtained for either 60-or 90 day weight. Standard errors were large and almost the same as the heritability estimates for many of the traits considered.

b) Lactation Parameters

The heritability estimates using the paternal half-sib relationships for the lactation parameters (a, b, c and T) are shown in Table 11. There were generally positive and highly significant ($P< 0.01$) estimates obtained for all the traits. Very high estimate was obtained for the general level of production (a) while others were within the range of 0.3-0.5.

Table 10. Estimates of heritability, genetic, phenotypic and environmental correlations between birth (BWT), 30, 60 and 84-day weights of Yankasa lambs

Traits	Variance or covariance components					
	Among	Within	$h^2 \pm S.E$	$r_g \pm S.E$	r_p	r_e
BWT	0.0103	0.1267	0.30±0.35			
Weights						
30 days	0.0497	0.6054	0.30±0.35			
60 days	0.1175	1.0829	0.40±0.37			
90 days	0.2826	1.2687	0.73±0.43			
BWT and: 30-day weight	0.0324	0.0847		1.43±0.68	0.39	-0.06
BWT and: 60-day weight	0.0419	0.0776		1.20±0.59	0.30	-0.18
BWT and: 90-day weight	0.0390	0.0972		0.72±0.50	0.30	-0.10
30 and 60 days weight	0.0958	0.6125		1.25±0.30	0.80	0.56
30 and 90 days weight	0.1348	0.5063		1.14±0.30	0.64	0.23
60 and 90 days weight	0.1500	0.9963		0.82±0.19	0.84	0.99

Table 11. Estimate of heritability, genetic, phenotypic and evironmental correlations between lactation parameters and 84 days lactation_in Yankasa ewes

Traits	Variance or covariance components: Among	within	$h^2 \pm S.E.$	$r_g \pm S.E.$	r_p	r_e
a	0.0537	0.0980	1.42±0.4			
b	0.0038	0.0473	0.30±0.2			
c	0.0003	0.0043	0.28±0.2			
T*	1.1898	8.3989	0.50±0.32			
a and b	-0.0061	-0.0116		-0.43±0.48	0.20	-0.14
a and c	-0.0016	0.0051		0.39±0.42	0.26	-0.02
a and T	0.2042	0.3447		0.81±0.21	0.46	0.49
b and c	0.0080	0.0087		0.72±0.37	0.62	0.58
b and T	0.0325	-0.1051		-0.29±0.38	-0.10	-0.49
c and T	0.0273	-0.0399		-0.11±0.47	-0.06	-0.96

T* - Total lactation yield at 84 days

4.1.7. Genetic covariances

a) Weight of lamb

Estimated values of genetic covariance for weights of lambs are presented in Table 10. Positive covariances were estimated for all the combinations and such include BWT amd 90-day weight, 30 and 60-day weight, 30 and 90-day weight and 60 and 84-day weight.

b) Lactation Parameters

The genetic covariances estimated for the lactation parameters are shown in Table 11. Mostly negative estimates were obtained. Positive covariances were estimated for combinations like general level of production (a) and total 84-day lactation (T), rate of rise to peak (b) and rate of decline from peak (c). Negative estimates were recorded between a and b, b and T and c and T.

4.1.8. Genetic Correlations

a) Weight of lamb

Estimated genetic correlation (r_g) between weight traits under consideration are given on Table 10. High and positive estimates were obtained for all the traits. Positive and high genetic correlation were obtained between BWT and 90, 60- and 90-day weights, while very high r_g estimates with some outside the parameter space were obtained for all other combinations for the productive traits.

b) **Lactation Parameters**

The genetic correlations between lactation parameters are presented in Table 11. Both positive and negative estimates were obtained. Positive and high estimates were recorded between a and T, and b and c. Negative but moderate correlations obtained were between a and b while the estimates for b and T, and c and T were both negative and low.

4.1.9. Phenotypic Covariances

a) **Weight of lamb**

Table 10 shows estimates of phenotypic covariances between the productive traits. From the table, positive but weak covariances were observed between BWT and 30-day weight, BWT and 60-day weight while positive and moderate covariances were between BWT and 90-day weight, 30 and 60-day weight, 30 and 90-day and positive and high covariance was obtained between 60 and 90-day weight.

b) **Lactation Parameters**

Estimated values of phenotypic covariances are presented in Table 11. A range of positive to negative estimates were obtained from the traits investigated. Positive but weak covariance were recorded between a and c and b and c, while that between a and T was moderate and positive. Negative and weak covariances were observed for combinations like a and b, b and T and c and T.

4.1.10. Phenotypic Correlations

a) Weight of lamb

The estimates of the phenotypic correlations (r_p) for the weight traits in this study are shown in Table 10. All of the phenotypic correlations were positive and ranged from moderate to high in magnitude. Moderate estimates were obtained for r_p between BW and 30-day weight, BWT and 60-day weight and BWT and 90-day weight. However, the high and positive estimates were recorded between 30- and 60-day weight, 30- and 90-day weight and 60- and 90-day weight, respectively.

b) Lactation Parameters

The phenotypic correlations (r_p) obtained for the lactation functions are given in Table 10. Ranges of positive to negative estimates were observed. For the positive estimates, low r_p was obtained between a and b while a and c, a and T and b and c respetively, had a moderate r_p. A negative but weak phenotypic correlation was recorded between b and T, while between c and T it was still negative and low.

4.2. DISCUSSION

4.2.1. Milk Yield

The total pre-weaning milk yield of 12.6 kg (Table 2) over 84-day lactation period for Yankasa ewes in this study is quite low compared to other tropical breeds like Hamdani (Maroof et al., 1986); Karadi (Mohammed, 1982; Kutaibani,

1981) and Awassi (Eliya and Juma, 1970; Karam et al., 1971). This was partly due to differences in methods of milk extraction or estimation. While some authors used oxytocin injections prior to milking, others estimated milk yield using lamb weight differences before and after suckling. Moreover the lactation lengths for all these breeds were greater than that used in this study.

Ehoche and Buvenendran (1983) had a similar report of dam with twin kids producing more milk than those with single kids while Torres-Hernandez and Hohenboken (1979) and Doney, Peart and Smith (1981) had the same experience with crossbred sheep. However, Linzell and Peaker (1971) attributed no physiological relevance to the increased milk production from dams with twins but rather to the increased frequency of suckling.

The milk yield increased up to the 4th parity before a decline. This observations followed the same trend with Corbelt's (1968) result of increases in milk yield with advancing age since parity is a function of age. The result also agrees with that of Maroof et al. (1986) who observed no significance due to age on milk production in Hamdani Sheep. The observed variation in milk production between season of birth can safely be attributed to changes in feed availability. July to September corresponds to the period of peak rain during which forage is abundant. Moreover, there is less heat load due to lower temperature and higher cloud

cover during this season.

4.2.2. Lactation Curve

The pattern of lactation observed for the Yankasa ewes in Figure 1 was similar to that of Red Sokoto does. However, there appeared to be a sharp drop after the second week for latter species (Ehoche and Buvanendran, 1983). Wood's gamma function used for the fitting of the lactation curve had been adopted earlier as effectively describing the lactation pattern in dairy cattle (Wood, 1969). Moreover, the biasedness brought about by the various environmental factors (i.e. litter size, parity and month or season of birth) on milk yield was controlled through data adjustment. This intervention enhanced the goodness of fit for the adjusted data curve (Fig. 1).

The peak yield observed within the 2nd and 3rd weeks of lactation was in agreement with the findings of many authors (Peart et al., 1975; Aboul-Nagal et al., 1981; Ehoche et al., 1990). Aboul-Nagal et al. (1981) noticed that while the milk of Barki ewes declined steadily after peaking at the 2nd week, peak lactation of Rahamani and Ossimi ewes extended till the 3rd week of lactation.

As seen in Figure 2, ewes with twins produced more milk than singles at every stage of lactation. Ewes nursing twins have been reported to generally produce more milk than those with singles (Doney and Munro 1962; Pear, 1967; Karam et al., 1971; Hernandez and Hohenboken, 1980). The earlier

attainment of peak lactation by ewes with twins in this study quite agree with the findings of Maroof et al.(1986). The decline in milk yield for ewes with singles which was 56% compared to 44% for ewes with twins was in line with the earlier findings of Snowder and Glimp(1991). The rapid rate of decline observed as from the 10th week can safely be attributed to the decreased dependance of lambs on milk and increased grazing and forage intake.

Seasonality differences of the lactation curves observed on figure 2 is due to changes in forage availability. Season 2 (July-September) coincides with the period of abundant pasture as a result of adequate amount and distribution of rainfall. In addition, heat stress which can depress lactation is minimal due to low temperature and high cloud cover.

4.2.3. Curve Parameters

From Tables 4, the higher general production level (a) observed in dams with twin lambs compared with those with single lambs support earlier findings (Karam et al., 1971; Hernandez and Hohenboken, 1979). However, the non-significant difference obtained between these two dam groups may be explained by the results of others (Doney and Munro, 1962; Peart; 1967; Corbelt 1968). These workers asserted that rather than number born it is the number of lambs suckled by the dam that determines the milk yield.

The observed higher rate of rise (b) and decline (c) from peak production (Table 4.) for singles agree with the findings of Snowder and Glimp (1990). Persistency observed in this study agrees with that of Peart (1968) who found that ewes nursing twins persisted more in production than those nursing singles.

Though all the milk production traits under consideration increased with advancing parity, the observed values were not significantly ($P > 0.05$) different from each other (Table 4.). This might partly be attributed to the small sample size for different parity classes. However, this result supported the findings of Karam et al. (1971) who found that age had no significant effect on milk production, but obtained a lower 1st lactation yield compared to subsequent lactations. Kutaibani (1981) had similarly found no significant effect of age on milk yield. These reports on age could be expected, since parity is a function of age.

The significant seasonal effect on lactation curve functions (a, b, c and s) observed in this study was similarly reported by other authors (Martini et al., 1980; Scardella and Pilla, 1989). Scardella and Pilla (1989) reported that the month of lambing, which is a function of season of lambing, constituted among other environmental factors about 80% of variation in the milk yield of Comisana sheep. Season 2 (July-September) in this study coincides with the period of abundant good quality pasture. This might have

accounted for the significantly (P<0.01) higher lactation curve functions observed in this season compared to season 1 (April- June).

The effect of lactation length on milk yield is important in the tropics. This is because lactation yields are highly correlated with lengths of lactation. The function used in this study gives as good a fit to shorter lactations (R=0.77) as for lactations of longer duration (R=0.78) as shown in Table 4. However, compared to lactations of longer duration, components of the function such as a, b and c differ in the former. In essence, short lactations show a fast rate of rise to peak yield (b) but have a much quicker rate of decline from the peak (c). Moreover, the general level of production (a) is also low in shorter lactations. It would therefore imply that ewes with short lactation lengths also suffer from a low level of production so that the net effect on yield is a reduction due to a combination of these factors. Moreover, there might be a more pronounced inhibitition to the myoepithelial cells that supply oxytocin that causes activation of the alveoli and small milk duct in a neurohormonal reflex of shorter lactation. This findings was also observed on Friesian-Bunaji crossbreed cattle by Abubakar and Buvenendran (1981).

4.2.4. Weight of lamb

The overall average birth weight obtained in this study was slightly higher than those reported by Adu and

Buvanendran (1982), Hassan(1987) and Osinowo et al. (1993) However, it was lower than that observed by Adu et al. (1979) for the same breed. The 90-day weight closely agrees with that reported by Hassan (1987) and Osinowo et al. (1993), all of which were higher than the earlier estimate of 9.14 by Adu and Buvanendran (1982).

4.2.5. Phenotypic Correlations between weight gain of lamb and milk yield of dam

The phenotypic correlation (r_p) between weight gain and milk yield obtained in this study clearly showed a particular trend (Table 9). Early weight and late weight gains of lambs could not be strictly attributed to the milk yield of their dams. The growth performance of the lamb in the early age depends on the confounded effects of both the dam's uterine condition and post-partum milk availability. Likewise, the weight gain later in life (after about 10 weeks of age) is mainly accounted for by the quality and quantity of the available forage. This time coincides with the period when the lambs decreasingly depend on milk while increasingly dependent on grazing and forage intake. This could be why low and non significant correlation (r_p) were observed between lamb weight gain and dam milk yield at both stages of growth. The moderate and significant ($P< 0.05$) correlations obtained in weight gain to 54 and 78-day post-partum and milk yield at the 3rd stage clearly shows the dependency of the lamb on milk at this stage. Moreover, more milk was obtained

over same period of time, at the 3rd stage of lactation.

4.2.6. Heritability estimates

(a) Weight of lamb

The heritability estimates (h^2s) obtained for BWT (Table 10) in this study is intermediate between those reported for Sudan Desert sheep (0.12) by El-Karim and Owen (1988) and for D'man sheep (0.34) by Boujenane and Kerfal (1990). The high value of 0.7 obtained as the h^2s estimate for the 90-day weight closely agree with the h^2 estimate for the 90-day weaning weight for the same breed (Osinowo et al., 1993).

The moderate to high estimates observed for the growth traits clearly showed that the variations due to the additive gene action is probably large. The high standard errors obtained may be attributed to the sample sizes, which are considered to be too small and may not be representative of the whole population.

(b) Lactation Parameters

The paternal half-sib estimates of heritability (h^2s) for the curve parameters (a ,b, c) and total lactation yield (T) obtained in this study range from moderate to very high values (Table 11). The range of 0.3-0.5 h^2s estimates obtained for both b, c and T closely agrees with Cianci et al. (1989) estimate for heritability of milk yield in Massese sheep through daughter-dam regression. The very high estimates obtained for the general level of production (a) was rather unusual as

they exceed most that were reported from literature (0.2-0.4) for the milk yield traits (Dalton, 1982).

In general, estimates do not conform to the normal expectations probably due to the following reasons. Heritability being a ratio rather than an absolute value could vary greatly depending on the methodology used for computing the parameters. Moreover, h^2 from variance component may be subjected to large sampling errors and can be over-estimated due to inclusion of non-additive genetic effects (Warwick and Legates, 1970). In addition, milk production is a sex-limited trait and as such the potential of dam as a result of x-chromosomes derived from its sire may be a factor.

The number of animals used (sample size) is also important since the more animals the more reliable the estimates . Indeed, sample size contributed to the outrageous estimates obtained in this study. The sample size of about 140 ewes was considered too small and did not represent the whole population. This could also account for the high standard errors obtained.

4.2.7. Correlations

(a) Weight of lamb

The genetic correlation shows the extent to which two traits are influenced by the same genes. The high and positive genetic correlation observed between BWT and other weights in this study shows that only one single gene

(Pleiotropy) influence these traits. This thus supports the earlier assertion that the genetic cause of a correlation is chiefly pleiotropy. Invaribly, selection for higher BWT will ensure selection for higher subsequent weights.

The observed high phenotypic correlation estimate in later weights in this study clearly pointed to the fact that the genetic effect on weight in lamb decreases with age. More of the environmental effect (i.e. feed) determines the value of the subsequent weights apart from BWT.

(b) Lactation Parameters

The genetic correlations (r_g) between lactation parameters do not follow a particular pattern. These conflicting results especially in sign do not give any direction as to the nature of genetic correlations between a and b , a and c, a and T, b and c and b and T. From the result obtained however, it could be said that the additive action of the gene responsible for these parameters (curve traits) has a greater influence at the early lactation. Invariably, the potential of ewes in late lactation is more prone to the environment compared to the early lactation. This is clearly evidenced from the result of the phenotypic correlations between these traits. The phenotypic correlation between the early curve functions ranges from low to moderate while those between the middle and total lactation even attained negative value.

It should however, be noted that since the genetic correlation is also a function of the covariance and

respective variances of two traits, it is subject to the same sources of bias with regard to variance component estimation.

Summary and conclusion

Yankasa ewes could be said to be poor milkers based on the result of this study. Sheep milk production from the indigenous breed is barely enough to support the growth of the lambs. However, few individual animals among those used in the present study produced approximately 1 litre per head per day. In this regard, it is possible to develop indigenous stock with dairy potential if a delibrate attempt is made to intensively select them for milk production. Moreover, such an effort need to be done repeatedly in a number of generations for a more reliable result. In the same vein, a reasonable genetic parameter estimates could only be obtained from a large data set generated over a long period of time.

From the result, it could be deduced that ewes with short lactation lengths also had a low level at all stages of production and the net effect on yield is a reduction which invariably affect the lamb production. Therefore, a systematic production procedure that involve routine selection against this detrimental effect be evolved in sheep flock.

The moderate heritability estimate for BWT and the higher and positive genetic correlation between BWT and subsequent weights indicate that selection for the former invariably lead to the selection for the latter. Moreover, the nature and magnitude of the estimate obtained for heritability and correlation for lactation parameters in this study could be

attributed to the small sample size. In addition, the data used for these estimates is from one production cycle. For the growth traits (BWT and weaning weight), the stock used have been selected for an upward of over 8 years. However, for the milk production traits, small data set generated in a single production cycle has been used. For future work therfore, considerable larger population size should be used and preferably such study should involved a data set collected over many generations for a more reliable result.

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