GENETIC AND PHENOTYPIC PARAMETERS OF REPRODUCTIVE TRAITS IN YANKASA SHEEP

BY

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DECLARATION

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

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CERTIFICATION

This thesis entitled '*Genetic and phenotypic parameters of reproductive traits in Yankasa sheep*' by M.N Bemji, meets the regulation governing the degree of Master of Science in Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

A study was conducted to determine genetic and phenotypic parameters of reproductive traits from 2773 lambings of a semi-intensively managed breeding flock of Yankasa sheep at the National Animal Production Research Institute (NAPRI), Shika, situated within the subhumid zone of Nigeria.

Edited records of 2204, 2490, 1225, 1461, 1196, 1204 and 247 lambings were used to analyse for environmental effects on litter size (LS), birth weight (BWT), litter birth weight (LBWT), 90-day weaning weight (WWT), gestation length (GL), lambing interval (LI) and age at first lambing (AFL), respectively.

Least-squares means (±SE) were 1.22±0.01 (LS), 2.48+0.01 kg (BWT), 3.57±0.03 kg (LBWT), 10.58±0.11 kg (90-day WWT), 151.37+0.01 days (GL), 249.81+2.72 days (LI), and 575.00±9.55 days (AFL). Litter size was significantly ($P<0.001$) affected by parity, season and year of birth. Multiparous ewes and ewes lambing in the dry season were superior in litter size to primiparous ewes and ewes lambing in the rainy season. Ram lambs were consistently heavier than ewe lambs ($P<0.001$) by 0.12 and 0.78 kg respectively at birth and at weaning. A similar trend was observed with single and twin bom lambs, the difference ($P<0.001$) being 0.39 and 2.32 kg in favour of single born lambs at birth and at weaning respectively. Lambs from multiparous ewes had higher body weights than lambs from primiparous ewes, likewise rainy season born lambs than dry season bom lambs. Gestation length was significantly affected by parity ($P<0.05$) and year of birth ($P<0.001$), but not by litter size, sex and season of birth ($P>0.05$). Younger ewes had shorter GL than older ewes, being 150.94 vs 151.70 days for primiparous and sixth parity ewes. Parity, litter size and sex of lamb insignificantly ($P>0.05$) affected LI, while the effects of season ($P<0.01$) and year of birth ($P<0.001$) were highly significant. Ewes lambing in the rainy season had shorter LI than ewes lambing in the dry season (249.64 vs 249.99 days). AFL was significantly affected by type of birth ($P<0.05$), season and year of birth of ewe ($P<0.01$). AFL was attained earlier in single than twin bom ewes.

Additive environmental adjustment factors for effects of parity of dam, type of birth, sex of lamb and season of birth for LS, BWT, and 90-day WWT were derived.

Heritability estimates for LS from daughter-dam regression was 0.07. Using paternal half-sib analysis. BWT, LBWT, 90-day WWT, GL as dam trait. GL as foetal trait, LI and AFL were estimated at 0.41±0.08, 0.12±0.07, 0.59±0.12, 0.15±0.12, 0.21+0.08, 0.73+0.26 and 0.99±0.38 respectively. With the exception of low heritability estimate for litter size, most values were moderate to high suggesting moderate to high genetic responses to selection for these traits. Estimates for LI and AFL were, however, considered inflated and attributed to dominance and epistatic effects. There were high genetic and phenotypic correlations (0.69±0.16 vs 0.36) between BWT and 90-day WWT indicating a high positive correlated response to selection for these traits. Genetic correlations between LS and BWT, LS and 90-day WWT, LS and GL, and LBWT and GL were -0.08±0.35, -0.25+0.33, -0.11±0.32 and 0.07+0.27 respectively. Corresponding phenotypic correlations were -0.14, -0.34, 0.02 and 0.09. Generally, genetic and phenotypic correlations for most traits were moderate to low, and /or negative.

DEDICATION

This thesis is dedicated to my uncle ***Mr. Forsuh George Mumah***, whose untiring efforts and concern about my education have contributed substantially to the success of this study.

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CHAPTER ONE

INTRODUCTION

Sheep are the second most numerous and third most important livestock species in Nigeria in terms of animal protein, value and biomass (17.8%). They are kept all over Nigeria with an estimated population of 22.09 million, 13% of which are pastoral, found throughout the North-central regions with major concentrations around the larger Northern towns (Nig. Livestock Resources, 1992). There are four main breeds of sheep native to Nigeria: the Balami, Uda, Yankasa and West African Dwarf (WAD). Balami and Uda are kept in the semi-arid regions, WAD in the south and Yankasa throughout the country. Sheep are pre-eminently bred for ceremonial slaughter in Nigeria. They are required for many Islamic festivals, but are also commonly slaughtered in the South for a variety of occasions including traditional religious sacrifices and christian festivals, burials, marriages and naming ceremonies. They supply not only meat and milk but also skin, bone, blood, horn and wool for textile industries.

Management systems include: free range, tethering, nomadic and semi-intensive. With the exception of some semi-intensive management system, most adopt management practices that owe little to controlled breeding and selection for performance. There is therefore need to give priority to the development of technology capable of having a significant impact on the efficiency of sheep raising under improved production systems. Majority of improved breeds in the world today resulted from the combination of various traits such as: body type and conformation, growth rate, prolificacy, milking and mothering abilities, litter traits, lamb survival and fleece characteristics (Lasley, 1978; Dalton, 1981; Croston and Pollot, 1985). Genetic and phenotypic variations of reproductive performance of these traits in sheep have been the subject of many discussions for several reasons. Land and Robinson (1985) stated that reproduction is seen as a principal limit to the overall productivity of sheep as well as goat and cattle.

Yankasa sheep breed has been studied in Nigeria with more emphasis on nutrition and health management. However, very few investigations have been made, and in most cases, with much fewer records on genetic and environmental factors influencing weights of lamb at various stages (Hassan, 1987). Records of reproductive performance (Adu et al., 1979), oestrus synchronization, artificial insemination and early rebreeding (Osinowo, 1982), estimates of genetic and phenotypic parameters for birth weight weaning weight and preweaning gain (Osinowo et al., 1987; 1990; 1992a) have been reported.

There is therefore a need for broader investigation of possibilities of utilising genetic and phenotypic variations of economically important reproductive traits in breed improvement.

Objectives of study

The objectives of this study are:

- To examine environmental effects (parity, type of birth, sex of lamb, season and year of birth) on litter size, birth weight, litter birth weight, weaning weight, gestation length, lambing interval and age at first lambing.
- To derive additive adjustment factors for environmental effects on litter size, birth weight and weaning weight.
- To estimate heritabilities, genetic, phenotypic and environmental correlations of reproductive traits.

CHAPTER TWO

LITERATURE REVIEW

2.1 *Introduction*

Much work has been undertaken on genetic and phenotypic parameters of reproductive traits in sheep with emphasis on exotic breeds. Comparatively, there are far less specific studies carried out on indigenous breeds of Nigeria even though most conclusions drawn have been assumed to apply for most breeds. Most disscussions have so far been directed at reducing cost of market lambs obtainable by crossing specialized maternal populations with specialized paternal populations. Boylan (1978) suggested the following approaches in developing superior maternal populations:

- Selection among existing breeds;
- Systematic crossing of selected breeds;
- Combining several selected breeds to form composite breeds and
- Further selecting within existing breeds or composite breeds.

All these will depend on evaluation of reproductive traits of economic importance upon which selection will be based. Most findings have generally agreed on fertility, litter traits, post weaning gain, milk productivity, type and conformation, carcass quality and fleece traits.

2.2 *Litter size*

Litter size or number of lambs born per parturition is an important component in sheep productivity contributing much more to the difference in the weight of lambs weaned per ewe than growth rate of individual lambs (Bradford, 1985). In sheep, it is assumed that the genetic variation in litter size is due solely to ovulation rate (Hammond, 1914; Bradford, 1985; Sandford, 1986; Morris, 1990 and Nawaz and Meyer, 1991). Consequently, selection for ovulation rate is predicted to increase litter size more effectively than direct

selection for litter size. The correlation between ovulation rates and litter size was found to be nearly linear at ovulation rates up to four (Hanrahan, 1982) while there are still some variations among breeds. Bradford (1985), Laymaster and Bennet (1990) further viewed litter size as the product of ovulation rate and embryo survival. It was suggested that improvement in embryo survival can contribute to achieving the goal of increased uniformity in litter size (Bradford, 1985). Studies involving factors regulating ovulation rate and litter size in ewe lambs include nutrition (Scaramuzzi and Radford, 1983), breed type (Lysandrides, 1981; Hoeke and Visscher, 1987; Duman et al., 1988; Boujenane et al., 1991), dams' age (Gates, 1990), ewes' birth year (Gates, 1990; Abad et al., 1991; Boujenane et al., 1991), parity (Bradford, 1985; Hoeke and Visscher, 1987; Muka-Mugerwa et al., 1991), breeding season (Hoeke and Visscher, 1987; Gates, 1990; Ambruster et al., 1991; Boujenane et al., 1991), lambing date (Gates, 1990) and ewes' body weight (Nawaz and Meyer, 1991) which have significant but small effect especially on litter size conceiving to twin ovulations in Copworth, Polypay and crossbred ewes. It has been generally concluded that prolificacy will be lower in first lambing ewes regardless of age at first lambing. In the temperate region (Northern Spain), ewes lambing in April to May had higher litter size than ewes lambing in August to September and December to January (Abad et al., 1991), while West African Dwarf ewes in the tropics (Cote d'Ivoire) had increased litter size when born during the dry season than in the rainy season. In another study, Lasley (1978) observed more lambs per litter in open faced ewes than those with wool covered faces. Studies on nutrition (Scaramuzzi and Radford, 1983) indicate that ewes can respond to short-term changes in protein and energy availability with an increased number of twin ovulations and hence increase in litter size. Tables 1 and 2 represent range or mean litter sizes, heritability and repeatability estimates from literature, respectively.

Table 1. *Range or mean litter size in some sheep breeds from literature*

Breed	Location	Litter size	Rereference
Barbados Blackbelly	Caribbean	1.97±0.04	Duman et al. (1988)
Black Head Persian	"	1.64±0.04	"
Virgin Island White	"	1.29±0.04	"
Crossbreds	"	1.63±0.05	"
Coopworth, Polypay	USA	1.83	Nawaz & Meyer (1991)
Crossbred (C X P)	"	1.96	"
BooroolaXS Australia	Australia	2.3	Kleeman et al. (1988)
Merino	"	2.3	"
Rambouillet	Mexico	1.06±0.28	Urrutia et al. (1992)
Ile-de-France, FL	Netherlands	2.01-2.21	Hoeke & Visscher (1987)
Reciprocal crosses	"	3.02-3.26	"
Romanov	Cyprus	1.4	Lysandrides (1981)
Finnish Landrace	"	1.3	
Chios	"	1.27	"
Menz ewes	Ethiopia	1.07 (1-2)	Muka-Mugerwa et al. (1991)
Ethiopian highland sheep	"	1.25	Mukasa-Mugerwa & Tekele (1988)
Salz ewes		1-3	Abacia et al. (1991)
Crossbreds of Sardi, D'man, D X Sardi	Morocco	3.0	Boujenane et al. (1991)
Sudan Desert sheep	Sudan	1.15-1.29	El- Karim & Owen (1987)
Nigerian Dwarf	Nigeria	1.4 (1-3)	Orji et al. (1976)
Yankasa	Nigeria	1.17±0.43	Osinowo et al. (1988)

Table 2. *Estimates of heritability and repeatability of litter size*

Breed	Location	Heritability	Repeatabilty	Reference
Canadian, Suffolk Outaouis, Rideaux &FL	Canada	0.18±0.05		Shrestha & Heaney (1990)
D'man	USA		0.27	Bradford et al. (1989)
D'man	Morocco	0.09±0.6[a]	0.11[a]	Boujenane et al. (1990)
FL, Rambouillet X Dorset	USA	26%		Mohammed-Yusuff et al. (1992)
FL(S X Targhee)	"	11%		"
German Mutton Merino	Germany	0.15±0.05	0.323±0.014	Konic & Schieck (1987)
"	"	0.17		Schmalwasser et al. (1989)
African small ruminants	Addis Ababa		0.03-0.19	Wilson et al. (1989)
Karakuls		0.04		Sukhar'kov (1990)
Langhe	Italy		0.097	Pagnacco et al. (1989)
Merino Long Wool	Germany	0.16		Schmalwasser et al. (1989)
Morada Nova	Franca, Sao Paulo		0.23	Costa et al. (1990)
North Kazkh Merinos	USSR	0.326		Nortbaev & Ayazov (1988)
Pelibuez & Barbados Blackbelly	Mexico	0.496±.19		Carillo and Mococha (1990)
Rambouillet	USA	0.34	0.19	Bunge et al. (1990)
Rasa Aragonesa	Spain	0.02±0.14-0.41-0.06	0.08-0.19	Gabina et al. (1989)
Sardi	USA		0.18	Bradford et al. (1989)
Sardi, D'man, SXD	Morocco		0.22	Boujenane et al. (1991)
Rwanda & Mozambique			0.03-0.19	Wilson et al. (1989)
Synthetic breeds	Canada	0.17[a]	0.24	Fahmy (1990)
from (Australian-		0.14[a]		"
Dorset, Border		0.22[b]		"
Leicester & Suff.)		0.04[c]		"
Scotish Blackface	UK	0.12	0.22±0.02	Atkins (1986)

[a]*paternal half-sib method,* [b]*full-sibs,* [c]*regression on dam*

2.3 ***Birth weight***

Hamada (1976), working with Rahmany breeds in Switzerland related birth weight with postnatal performance and concluded that heavier lambs at birth were generally found

to be superior in vigor and tended to be heavier in weight postnatally. High mortality rates of 44.80% and 13% have been reported in Bannur lambs (Narayanaswamy and Yadav, 1980) and Menz ewe lambs (Muka-Mugerwa et al., 1991) respectively, weighing ≤1.3kg at birth. Average birth weight was found to increase significantly for lambs raised in uninsulated buildings in Norway (Boek et al., 1991) and with the introduction of increasing levels of exotic genes up to 75% (Olsson and Beyene, 1990). In the tropical and Mediterranean areas, exposure to heat in the second half of pregnancy resulted in decreased birth weight (Cosu et al., 1991). Most results on factors affecting birth weight in sheep indicate that male lambs are significantly heavier than females at birth and at all ages (Solis, 1979; Kantharaju et al., 1981; Fernandez and Deshmukh, 1988; Niakare and Jagtap, 1988; Ganai and Pandey, 1990; Mukhamedgliev et al., 1990). Contrary to this observation, non-significant sex differences were reported in Polworth lambs (Figuero, 1980) for birth weight. Breed type (Flavey and Prakob, 1979; Ramachandraiah, 1990), parity (Ganai and Pandey, 1990; Kulkarni and Deshpande, 1991), birth type, single vs twins (Figuero, 1980; Ganai and Pandey, 1990) and season of birth (Kantharaju et al., 1981; Urrutia et al., 1992; Kulkarni and Deshpande, 1991) significantly influenced birth weight. Studies in India on Deccani, Deccani X Dorset and Deccani X Merino showed that females born in summer were significantly heavier than those born in winter, spring or monsoon seasons (Kulkarni and Deshpande, 1991) which conflicts with heaviest lambs obtained in Sri Lanka during winter in Bannur sheep (Kantharaju et al., 1981) and during spring in Rambouillet ewes in Mexico (Urrutia et al., 1992). Single lambs have been noted for heavier weights than twins (Figuero, 1980; Review by Lysandrides, 1981) as well as lambs produced from ewes with wool covered faces (Figuero, 1980). Tables 3 and 4 summarise ranges or mean values for birth weight, and heritability and repeatability estimates, respectively.

Table 3. *Range or mean birth weight in some sheep breeds from literature*

Breed	Location	Birth weight(kg)	Reference
Arles Merino	Yugoslavia	3.67	Petrovic (1988)
Awassi X White Karaman	Turkey	3.94	Karca et al. (1991)
Bannur lambs	India	≤2.5	Narayanaswamy & Yadav (1980)
"	Sri Lanka	1.95 (M)	Kantharaju et al. (1981)
"	"	1.84 (F)	"
Chios lambs	Cyprus	4.6 (M)s	Rev. by Lysandrides (1981)
"	"	4.3 (F)s	"
"	"	3.8 (M)m	"
"	"	3.5 (F)m	"
Corriedale	Pinar del Rio	2.76	Santa-Maria et al. (1981)
Deccani	India	3.32 (M)	Kulkani & Deshpande (1991)
"	"	2.84 (F)	"
Deccani & Dorset	"	3.34 (M)	"
"	"	3.18(F)	"
Deccani & Merino	"	3.4 (M)	"
"	"	3.06 (F)	"
Merino Chokla X D	"	2.65	Ramachandraiah et al. (1990)
Corriedale X Deccani	"	2.30	"
Deccani	"	2.09	"
Bangladesh-Bermese	N. Thailand	3.6	Flavey & Prakob (1979)
Thai lambs	"	2.76	"
German Merino X Thai crossbred	"	3.77	"
Dorset lambs		3.86	Solis (1979)
Ile-de- France X Corriedale	France	5.59 (M)	Surreaux et al. (1980)
		5.03 (F)	"
Kazkh Finewool	Netherlands	5.51 (M)	Mukhamedgaliev et al. (1990)
"	"	5.22 (F)	"
Linkoln Longwool	"	5.54 (M)	"
"	"	5.41 (F)	"
Romney	"	5.02 (M)	"
"	"	5.52 (F)	"
Merino Lauchaf Pirot	Yugoslavia	4.06	Petrovic (1988)
Polworth lambs	Brazil	3.42 (M)[s]	Figuere (1980)
"	"	3.27 (F)[s]	"
"	"	3.39 (M)[t]	"
"	"	2.09 (F)[t]	"
Rambouillet	Mexico	4.33±0.79	Urrutia et al. (1989)
R, R X Australian Merino	Australia	2.98-3.7	Ganai & Pandey (1990)
White Brazilian Wooless	Brazil	2.95-3.29	Freitas et al. (1980)
Djalonke X Sahelian	Ghana	2.44	Kabuga & Akowuah (1991)
Balami	Shika,Nig.	3.3[s]	Adu & Ngere (1979)
"	"	3.0	"
Yankasa	"	2.32±0.02[t]	Osinowo et al. (1990)
Nigerian Dwarf	Ibadan, Nig.	2.58[s]	Taiwo et al. (1982)
"	"	2.12[t]	"
Uda	Shika, Nig.	3.8[s]	Adu (1978)
"	"	3.4[t]	"
"	"	3.54 (mixed)	Buvanendran et al. (1981)
Yankasa	Katsina, Nig.	3.6[s]	Adu & Ngere (1979)
"	"	3.0[t]	"
"	Shika, Nig.	3.2s	Adu (1978)
"	"	2.9[t]	"
"	"	2.86 (mixed)	Buvanendran et al. (1981)

M - *male*, F - *female*, m - *multiple*, [s]*single*, [t]*twin*.

Table 4. *Estimates of heritability and repeatability of birth weight*

Breed	Location	heritability	Rep.	Reference
Columbias	USA		0.36	Burfening & Kress (1992)
Churru	Spain	0.29		Corriedo & San Primitovo (1988)
D'man	Morocco	0.15±0.07[a]	0.12b	Boujenane et al. (1990)
African-Long-Fat tailed	Rwanda	0.29±0.12	0.22[c]	Murayi & Wilson (1991)
Finnish L.,				
R X D	USA	0.25		Mohammed-Yusuff et al. (1990)
FL, (S X T)	"	0.28		"
Karakul		0.06		Sukhar'kov (1990)
Merino X Nilgiri	India	0.10±0.07		Mani & Rodricks (1987)
"	"	0.05±0.111		Mani& Rodricks (1990)
Nali	"	0.26±0.14		Poonia et al. (1988)
Patanwadi	"	0.693±0.224		Qureshi & shukla (1990)
Rambouillet	USA		0.29	Burfening & Kress (1992)
Shugor & Watish	Sudan	0.12		El-Karim & Owen (1988)
Sumatran	Indonesia		0.38	Iniguez et al. (1991)
Dorper	Kenya	0.15±0.07[a]		Inyangala et al. (1992)
Yankasa	Shika, Nig.	0.27±0.065[a]		Osinowo et al. (1990)
Yankasa, Uda, & crosses with exotic breeds	"		0.25±0.13	Buvanendran et al. (1981)

[a]*heritability estimated by paternal half-sib* [b]*repeatability by intraclass correlation.* [c]*repeatability of birth weight as dam trait*

2.4 *Weaning weight*

Weaning weight of lamb is a trait of medium heritability and economically very important in sheep productivity (Dalton, 1981). Hassan et al. (1991) working with Yankasa sheep observed lower estimates of weaning and postweaning weights than reported values and attributed it to large maternal and environmental influences on the weight of lambs. Weaning weight was however found in this study to be more strongly correlated phenotypically with 9-month and yearling weight, the magnitude of coefficient

obtained indicating that some proportion of genetic gain from selection on weaning weight might be carried onto weight at 6 and 9 months. Several reports have shown that age at which lambs are weaned varies under different conditions but 90 days is often used for selection purposes (Lasley, 1978). Weaning weights of individual animals also vary, reflecting birth type, single vs twins (Ganai and Pandey, 1990), sex of lamb (Solis, 1979; Kantharaju et al., 1981; Ganai and Pandey, 1990; Karca et al., 1991; Buvanendran et al., 1992), season of birth (Kantharaju et al., 1981; Buvanendran et al., 1992), age at weaning (Guillen and Rondon, 1987; Buvanendran et al., 1992) year (Kantharaju et al., 1980; Buvanendran et al., 1992), parity (Ganai and Pandey, 1990), age of dam (Bunge et al., 1990; Buvanendran et al., 1992) and ram lamb age (Bunge et al., 1990). The latter further observed that Rambouillet ewes mated to single born ram lambs bore lambs with lower weaning weights than lambs obtained from ewes mated to ram lambs born in a litter of two or more. Olsson and Beyene (1990) noted that total weaning weight of lambs per ewe increased with increasing levels of exotic genes up to 50%. Some observed values obtained in several breeds at 90 days include: 21.5 kg and 28.8 kg in Arles Merino and Merino Lanchaf Pirot lambs from ewes mated 6-7 months and 18-19 months of age, respectively (Petrovic, 1988), 22.84±3.09 kg in Ile-de-France X Corriedale - lambs (Surreaux et al., 1980), 14.2-16.1 kg at 100 days of age in Brazilian Wooless lambs (Freitas et al., 1980), 28.4, 31.1 and 26.1 kg for males and 15.5, 18.1 and 24.3 kg for ewe lambs at 4 months of age in Kazakh Finewool, Lincoln Longwool and Romney breeds, respectively (Mukhamedgaliev et al., 1990), 31.7 in Awassi X White Karaman lambs (Karca et al., 1991), 21.77 vs 22.13-22.19 kg in Rambouillet and its crosses with German Merino (Ganai and Pandey, 1990), 16.83±3.44 kg in Rambouillet in Mexico (Urrutia et al., 1992) 10.42 kg for males and 9.42 kg for females in Bannur lambs (Kantharaju et al., 1981) 28.84±3.09 kg in Dorset X Tabasco (Solis, 1979), 9.63±0.11kg in Yankasa (Osinowo et al., 1992b) and 13.8±0.7 kg in Yankasa ram lambs at 13.9±0.1 weeks of age (Osinowo et al., 1991). Guillen and Rodon (1987) reported that late weaned lambs are

significantly heavier at 70 days (10.61 kg) than early weaned lambs (8.65 kg) in West African Dwarf ewes. Older ewes produced lambs of higher weaning weights than younger ewes (Petrovic, 1988) and males are significantly heavier in most cases than ewe lambs. Table 5 represents estimates of heritability and repeatability from literature.

Table 5. *Estimate of heritability and repeatibility of weaning weight in sheep*

Breed	Location	Heritability	Rep.	Reference
Australian Poll Dorset	Austr.	0.21-0.31		Atkins et al. (1991)
Awassi	Pakistan	0.34±0.08[a]		Babar et al. (1989)
"	"	0.43±0.14[b]		"
Columbias	USA		0.18	Burfening & Kress (1992)
Corriedale	Korea	0.44±0.14		Cho et al. (1988)
D'man	Moroco	0.08±0.05[b]	0.15[c]	Boujenane et al. (1990)
Dorper	Zimbabwe	0.19	0.27	Buvanendran et al. (1992)
East Friesian crossbred	Bulgaria	0.54		Kareheva & Baulov (1989)
(FL(R X D)	USA	8%		Mohammed-Yusuff et al. (1992)
(FL(Suffolk X Targhee	"	28%		"
Hampshire	Iraq	0.22±0.05[b]		Waleed et al. (1986)
Xbred sheep of Ethiop.	Sweden	0.35±0.162		Olsson & Beyene (1990)
Merino X Nilgiri	India	0.28±0.13		Mani & Rodricks (1987)
Merino	Australia	0.18±0.05		Davis (1987)
Nali	India	0.19±0.15		Poonia et al. (1988)
Patanwadi	"	0.345±0.162		Qureshi & Shukla (1990)
Polworth	Korea	0.41±0.20		Cho et al. (1988)
Rambouillet	USA	0.07	0.36	Bunge et al. (1990)
Romanov	Spain	0.58		Maria (1992)
Rambouillet	USA		0.24	Burffening & Kress (1992)
Shugor & Watish	Sudan	0.41		El-Karim & Owen (1988)
Sumatran	Indonesia		0.36	Iniguez et al. (1991)
Targhees	USA		0.17	Burfening & Kress (1992)
T & S, pure & crossbred	USA	0.07		Long et al. (1989)
Dorper	Kenya	0.18±0.08[b]		Inyangala et al. (1992)
Yankasa	Nigeria	0.453±0.075		Osinowo et al. (1990)
"	"	0.21±0.19		Buvanendran et al. (1981)

[a]*Intrasire regression,* [b]*paternal half-sib analysis,* [c]*Intraclass correlation (litter weight)*

2.5 *Gestation period*

Trimnell et al. (1988) observed that an accurate knowledge of gestation length in sheep is an aid to flock management as it permits the prediction of expected lambing dates, as well as being the main determining factor of the available time for rebreeding in a twice-yearly lambing programme. Pregnacy duration in several breeds is known to be influenced by breed type (Roda and Otto, 1989), sex of lamb (Swamy, 1978; Trimnell et al., 1988), with males having longer gestation lengths than females; age of dam (Swamy, 1978; El-Karim and Owen, 1987; Trimnell et al., 1988; Sahani and Chand, 1990; Bocherov, 1979). Ewes aged 1.5 years and below had significantly shorter gestation lengths than older ewes. Likewise, twin-bearing ewes tended to carry their lambs for a shorter time than single-bearing ewes (El-Karim and Owen, 1987). Lambing season had significant effects (Swamy, 1978; Toteda et al., 1988; Trimnell et al., 1988). The latter observed longer gestation period during the dry season than during the wet season in Yankasa ewes studied in Nigeria. Year of observation (Trimnell et al., 1988), sire effect (Swamy, 1978) and pelt type (Salavatov, 1991) significantly affected gestation lengths. Lambs of caucasian pelt type had longest gestation periods in all three colour groups of Karakul ewe lambs (Salavatov, 1991). However, conflicting results had been obtained in which no consistent effect of breed (Santa-Maria et al., 1981; Sahani and Chand, 1990), sex of lamb (El-Karim and Owen, 1987; Toteda et al., 1988) and age of dam (Mrowinski and Cynka, 1978) were observed. Early maturing meat breeds of sheep (South Down or Hampshire) and highly prolific fertile breeds (Finnsheep or Romanov) have short gestation periods (Hafez, 1980) averaging 144-145 days. Slow maturing fine wool breeds (Merino or Rambouillet) have long periods of 150 to 151 days while crossbred types (Columbia, Targhee) have intermediate periods of 148 to 149 days. Heritability estimate of 0.18 ± 0.05 had been obtained (Shrestha and Heaney, 1990) in Finnish Landrace, Canadian and

Suffolk ewes, Outasuais and Rideaux. Range or mean gestation lengths are indicated in Table 6.

Table 6. *Range or mean gestation lengths from literature*

Breed	Location	Gestation L. (days)	Reference
Alamura	Apulia	150.9	Toteda et al. (1988)
Apulian Merino	"	149.7	"
Bannur sheep	India	148.08	Swamy (1978)
Camiso	Apulia	152.7	Toteda et al. (1988)
Corriedale	Brazil	148.2	Roda & Otto (1989)
"	Pinar de Rio	146(139-153)	Santa-Maria et al. (1981)
Karakul & its crosses with carpet wool sheep	India	149.7±0.52-152.7±0.8	Sahani & Chand (1990)
Leece	Apulia	152.9	Toteda et al. (1999)
Malpura & Sonadi		150.7	Rev. by Trimnell et al. (1988)
Mancha	Spain	151±2.1	Perez et al. (1980)
Merino		150.87	Rev. by Trimnell et al. (1988)
Polworth	Brazil	1503.3	Roda & Otto (1989)
Sardinia	Apulia	151.9	Toteda et al. (1988)
Sur Karakul	India	148-151.1	Salavatov (1991)
Shugor &Watish Varieties of Desert Sudanese		150±0.05	El-Karim & Owen (1987)
Yankasa	Nigeria	151.44±0.13	Trimnell et al. (1988)

2.6 *Lambing interval*

Interval between lambings, calculated from the day of lambing to the day prior to the date of the next lambing which allows for a rebreeding period from lambing to next conception (Osinowo, 1982) is an important predictor of lifetime reproductive performance in sheep. Reports show that tropical breeds of sheep are year-round breeders (Osinowo, 1982) in contrast to their temperate counterparts characterized by the presence of an anoestrus season. Hafez (1980) noted that it is possible to increase lambing frequency from once a year to 3 times in 2 years (8 months lambing interval) or to twice a year lambing (6 months lambing interval). This is observed in tropical ewes (Osinowo, 1982) provided the period between lambings and next conception can be restricted to 33 days. In an experiment to investigate the resumption of ovarian activity in lactating ewes,

it was observed that interval from lambing to first postpartum oestrus averaged 35 days in Dorset, Suffolk and Peliquez ewes (Martinez, 1979), 35.7 vs 45.4 days in lactating Salz ewes with a litter size of 2 or more lambs (Abacia et al., 1991) and 43.3-71.1 days in West African Dwarf ewes (Guillen and Rodon, 1987). Under favourable conditions, service or rebreeding period averaged 30-90 days in Yankasa sheep (Osinowo, 1982), 46.6-76.6 days in WAD ewes (Guillen and Rodon, 1987), 42±3 days postpartum in Chios ewes under accelerated breeding system (Mavrogenis and Chimonides, 1992). In the latter case, shorter intervals were obtained than in annual breeding systems. Conversely, Jenkins and Ford (1991) reported lambing intervals of 6 months in Landrace X (Dorset and Rambouillet) in accelerated lambing system which was far better than with lambing interval obtained in annual lambing system. Lambing interval is significantly influenced by age of ewe (Kabuga and Akowuah, 1991) mating season (Urrutia et al., 1992), year of lambing (Kabuga and Akowuah, 1991) and breed types (Hoeke and Visscher, 1987; Suleiman and Wilson, 1989). Crossbred ewes had shorter lambing intervals than pure breeds (Hoeke and Visscher, 1987), as observed in Ile-de-France, Finnish Landrace and their reciprocal crosses. Relationship between litter size and lambing interval in this trial suggests that larger litters are associated with longer intervals between lambing. This was similarly noted in older ewes >4 years (Hernandez et al., 1990). Ewes aged 2 years (Rambouillet (R) X Suffolk (S), S X R and Chios) had significantly shorter intervals. Range or mean values of lambing intervals as well as heritability and repeatability estimates are shown in Tables 7 and 8 respectively.

Table 7. *Range or mean lambing interval (LI) from literature*

Breed	Location	LI (days)	Reference
White Brazilian Wooless	Brazil	218	Teixeira (1980)
Chios ewes	Cyprus	294[a]	Mavrogenis & Chimonides (1992)
"	"	141[b]	"
Ile-de-France, FL & Reciprocal crosses	Netherlands	8-≥12 (mnths)	Urrutia et al. (1992)
Rambouillet (R)	Mexico	8 (mnths)	"
Rambouillet	"	211±23.29	Hernandez et al. (1990)
R X Suffolk	"	210±27.35	"
Suffolk (S)	"	213±20.04	"
S X R	"	217±20.11	"
Ethiopian highland ewes	Ethiopia	239	Mukasa-Mugerwa & Tekelye (1988)
Shugor ewes	Sudan	449	Suleiman & Wilson (1989)
Dubasi ewes	"	425	"
Watish	"	403	"
Djallonke, Sahelian, & crossbreds	Ghana	279	Kabuga & Akuwuah (1991)
West African Dwarf		194-225.4	Guillen & Rodon (1987)
Nigerian Dwarf	Nigeria	234 (151-571)	Orji et al. (1976)
WAD	Nigeria	248-307	Rev. by Osinowo (1982)
Yankasa	Shika, Nig.	236	Ferguson (1964)
"	Samaru, Nig.	291	Mołokwu & Umunna (1980)

[a]*mean lambing interval from annual breeding system,* [b]*value obtained from accelerated system*

Table 8. *Estimates of heritability and repeatability of lambing interval*

Breed	Location	Heritability	Rep.	Reference
Bergschaf	Germany	0.15		Mendel et al. (1987)
Karakul			20%	Schoeman et al. (1991)
Morada Nova	Franca, Sao Paulo		0.51	Costa et al. (1990)
Rasa Agonesa	Spain	0.4	0.10-0.16	Gabina (1988)
Sumatran	Indonesia		0.06	Iniguez et al. 1991)
Morlam & Dorset	USA	0.06		Iniguez et al. 1991)

2.7 ***Age at first lambing***

Age at first lambing, calculated from day of birth to the day prior to the date of the first lambing was found to be an important parameter to be included in selection programmes because lifetime reproductive performance is significantly influenced by this sub-index (Schoeman et al., 1991). Reports have shown that age at first lambing is affected by plane of nutrition (Croston and Pollot, 1985; Muka-Mugerwa et al., 1991). Muka-Mugerwa et al. (1991) observed that supplementary feeding increased postweaning gains and reduced age at first lambing by 2-5 months in Menz ewe lambs. Month of birth was found to have significant effects (Abad et al., 1991; Schoeman et al., 1991) on age at first lambing. Repeatability estimate of 36% was observed, with spring-born Karakul ewe lambs lambing at a younger age than summer or winter-born ewes (Schoeman et al., 1991). In another trial, Abad et al. (1991) in Northern Spain, working with 70 ewes born in April-May, 11 ewes born in August-September and 107 ewes in December-January had 7.1, 9.1 and 4.7% respectively lambing first at 12 months of age; 37.2, 27.3 and 45.8%, respectively lambing at 16 months of age; and 100, 81.9 and 89.7, respectively lambing at 24 months of age. All ewes had lambed at 24 months of age. Other results indicate that Chios ewes lambed first at one year of age in accelerated breeding systems (Mavrogenis and Chimonides, 1992). Ile-de-France, Finnish Landrace and their reciprocal crossbreds in natural breeding systems had similar results (Hoeke and Vissecher, 1988). Orji et al. (1976) observed an average of 424.9 (310-692) days in West African Dwarf sheep in Nigeria. Bradford (1985) concluded that prolificacy will be lower in first lambing ewes regardless of the age at first lambing. Other observations with Nigerian indigenous breeds are shown in Table 9 as well as heritability and repeatability estimates from literature in Table 10.

Table 9. *Range or mean age at first lambing from literature*

Breed	Location	Mean or range(mnths)	Reference
Balami	Nigeria	18.10 (sedentary)	Nig. Livest. Res. (1992)
"	"	11.05 (transhumant)	"
"	Marguba	18.6	Buvanendran & Adu (1987)
Uda	Nigeria	12.71 (sedentary)	Nig. Livest. Res. (1992)
"	"	12.46 (transhumant)	"
WAD	Ibadan	15	Rev. by Hassan (1987)
"	"	12.5-13.2	"
"	"	10.3-23.07	"
"	Ile-Ife	13	"
"	Ibadan	11-14	"
Yankasa	Nigeria	12.67(sedentary)	Nig. Livest. Res. (1992)
"	"	11.96(transhumant)	"
"	Samaru	15.5	Molokwu & Umunna (1980)

Table 10. *Estimates of heritability and repeatability of age at first lambing*

Breed	Location	Heritability	Rep.	Reference
Karakul			36%	Schoeman et al. (1990)
Merino	Yugoslavia	0.06±0.08[a]		Peric et al. (1986)
"	"	0.28±0.22[b]		"
Morlam & Dorset	USA	0.31		Iniguez et al. (1986)
Rasa Aragonesa	Spain	0.12±0.12-0.14±0.07		Gabina (1989)
Tsigai	Yugoslavia	0.12±0.5		Vidovic et al. (1990)

[a]*mixed*, [b]*twins*

Table 11. *Coefficients of genetic correlations (r_g) of reproductive traits*

Correlated traits	Breed	Location	r_g	Reference
Birth wt & Weaning wt	Merino X Nilgiri	India	>0.5	Mani & Rodricks (1990)
	Shugor & Watish	Sudan	>0.85	El-Karim & Owen (1988)
Gestation & prolificacy	Canadian & Suffolk, Outaouais & Rideau and Finnish Landrace	Canada	0.09+0.09	Shrestha &Heaney (1990)
1st & 2nd litter size	Karakul		0.14	Sukhar'kov (1990)
3rd & 4th litter size	Karakul		0.15	Sukhar'kov (1990)
Litter size & lambing date	DLS (Australian, Dorset, Border Leicester & Suffolk	Canada	-0.38[a]	Fahmy (1990)
"	"	"	-0.25[b]	"

[a] *sire components*, [b] *full-sibs*

Table 12. *Coefficients of phenotypic (r_p) correlations of reproductive traits*

Correlated traits	Breed	Location	r_p	Reference
Birth wt & Weaning wt	Canadian			
	Corriedale	Canada	0.52	Rev. by Hassan (1987)
	Corriedale		0.35	"
	Merino	S. Africa	0.41	"
	Rambouillet		0.40	"
	Bannur	India	0.37±0.03	"
	Uda	Nigeria	0.55	Buvanendran et al. (1981)
	Yankasa	"	0.47	"
	"	"	0.215	Osinowo et al. (1990)
Gestation & Prolificacy	Canadian & Suffolk, Outaouais & Rideau & Finnish Landrace	Canada	0.06	Shrestha & Heaney (1990)

CHAPTER THREE

MATERIALS AND METHODS

3.1 *Description of environment*

This study was conducted at the National Animal Production Research Institute (NAPRI), Shika. The region lies 640 m (2100 ft) above sea level and falls within latitude $11^{o}13'$N and longitude $7^{o}33'$E. The climate is sub-humid and located in the Northern Guinea Savanna zone. It receives a mean precipitation of 1107 mm per annum, stretching over 120-170 days from late April or May to October. Seasonal distribution of rainfall is approximately 0.1% in the late dry season (Jan.- March), 25.8% in the early wet season (April-June), 69.6% in late wet season (June-Sept.) and 4.5% in early dry season (Oct.-Dec.) as reviewed by Osinowo et al. (1993b). Mean annual temperature at Samaru, 10 km from Shika is 24.4^{o}C. 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 of low quality during late dry and early wet seasons.

3.2 *Acquisition of breeding stock*

Yankasa sheep breed was initially developed as a 'nomadic' breed in the Southern Sudan and Northern Guinea Savannah zones, but is now becoming 'semi-nomadic' and completely sedentary as pressure on grazing land intensifies. It was first introduced alongside Uda into Shika in 1971 and established in 1981 (Adu et al., 1985). The foundation stock of the breeding flock comprised 2-3 year old Yankasa sheep purchased in small batches from different markets within Kaduna State, Nigeria. The acquisition was

based on visual appraisal as small ruminant management systems in Nigeria are characterized by lack of performance and pedigree records. In 1987, the flock was enlarged from 100 to 300 ewes through additional purchases from livestock markets in some Northern regions of Nigeria as before (Osinowo et al., 1992a).

3.3 *Management practices*

The Yankasa flock was maintained on grazing pastures of mixed species of grasses. Animals were allowed to graze for 6-8 hours daily. Supplementary concentrates of about 15% CP consisting of cottonseed cake or groundnut cake, maize grain (ground), bone meal and salt were offered in the morning before the animals are turned out to graze. An allowance of 200-500g/herd/day was given throughout the year depending on season (feed availability) and physiological status of the animal. Animals were housed in cross-ventilated pens and had free access to water and mineral salt licks. The animals were routinely dewormed and deticked.

3.4 *Breeding practices*

The flock has been maintained as a closed flock since 1983, except for the introduction of additional 200 ewes in 1987 and five breeding rams in 1993. Yankasa sheep at this station were routinely bred to lamb twice a year as an accelerated lambing programme. Breeding practices included artificial insemination and natural matings which were undertaken following heat detection using aproned rams. Oestrus synchronization (treatment of ewes with progestagen pessaries for 12 days) and subsequent mating was sometimes used (Osinowo,1982). Breeding rams were selected from each lamb crop based on weaning weights adjusted for environmental factors, postweaning gain and fertility index of the dam. Mating ratio was about 1 ram to 15 ewes. All ewes and rams were properly identified by means of ear tags for record keeping. Following lambings, lambs were indvidually identified and weighed. They were weaned at about 90 days of age.

3.5 *The database*

A total of 2773 unedited records (2520 from 1983-1992 and 253 in 1993) available in the data base file were used. Lambing information included dam tag, date bred, sire tag, lambing date, lamb tag, parity, litter size, birth weight, weaning weight, date disposed and reason for disposal (dead, sold etc.). Weaning weights were later adjusted to 90 days of age for analytical and selection purposes. Records with uncertain date bred, date of birth and sire information were deleted.

3.6 *Statistical procedures*

Six data sets obtained for litter size, birth weight, litter birth weight, weaning weight, gestation length, lambing interval and age at first lambing (Table 13) were edited and analysed for environmental effects using Mixed Model Least-Squares and Maximum Likelihood computer program by Harvey (1990). The model used (Model 1), which is suitable for data with unequal subclasses included terms for parity (1,...,6), sex (1, 2, 3), litter size (1, 2), season of birth (1,..,4) and year of birth (1,...,11) as applied to the traits that were studied.

Table 13. *Mean, standard deviation (SD) and coefficient of variability (CV) of traits*

Trait	No.	Mean[a]	SD	CV (%)
Litter size	2204	1.17	0.38	31.71
Birth weight, kg	2490	2.51	0.55	19.87
Litter birth weight, kg	1225	2.99	0.96	22.37
Weaning weight, kg	1461	10.74	3.21	26.16
Gestation length, days	1196	151.25	2.36	1.48
Lambing interval, days	1204	246·79	62·77	20·01
Age at first lambing, days	247	599.88	123.76	20.22

[a] Arithmetic mean

In derivation of data sets, observations with litter size>2 and parity>6 were excluded, (across the traits considered) on the basis of fewer records compared to the lower subclasses. Table 13 summarizes the number of records, means, standard deviations and coefficient of variation of traits after editing the Yankasa sheep breeding file of 2773 parturitions.

3.6.1 *Litter size*

After data screening, only 2204 records were used for analysis of litter size, averaging (±SD) 1.17±0.38 (Table 13). The following fixed effects model was used:

$$L_{ijkl} = u + P_i + Z_j + Y_k + E_{ijkl} \quad ,$$

where L_{ijkl} - litter size of individual lambs, u - overall mean, P_i - fixed effect of i^{th} parity ($i = 1,...,6$), Z_j - fixed effect of j^{th} season of birth ($j = 1,..,4$), Y_k - fixed effect of k^{th} year of birth ($k = 1,...,11$) and E_{ijkl} - random error associated with each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.6.2 ***Birth weight and litter birth weight***

Taking birth weight into consideration a total of 2490 records averaging (±SD) 2.51±0.55 kg was examined according to the following linear model:

$$B_{ijklmn} = u + P_i + S_j + T_k + Z_l + Y_m + E_{ijklmn}$$

where B_{ijklmn} - birth weight of individual lambs in kg, u - overall mean, P_i - fixed effect of i^{th} parity (i = 1,...,6), S_j - fixed effect of j^{th} sex of lamb (j = 1, 2), T_k - fixed effect of k^{th} type of birth (k = 1, 2), Z_l - fixed effect of l^{th} season of birth (l = 1,...,4), Y_m - fixed effect of m^{th} year of birth (m = 1,...,11) and E_{ijklmn} - random error associated with each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

To analyse for litter birth weight a third class of sex was established for mixed sexes, taking into account the combined weight of lambs per dam for each parturition. A total of 1225 records averaging (±SD) 2.99±0.96 kg were examined for environmental effects using the following model:

$$B'_{ijklmn} = u + P_i + S_j + T_k + Z_l + Y_m + E_{ijlmn}$$

where B'_{ijklmn} - litter birth weight in kg for individual dam, u - overall mean, P_i - fixed effect of i^{th} parity (i = 1,...,6), S_j - fixed effect of j^{th} sex of lamb (j = 1, 2, 3), T_k - fixed effect of k^{th} type of birth (k = 1, 2) Z_l - fixed effect of l^{th} season of birth (l = 1,...,4), Y_m - fixed effect of m^{th} year of birth (m = 1,...,11) and E_{ijklmn} - random error peculiar to each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.6.3 *Weaning weight*

Age at which individual lambs were weaned ranged from 60-120 days, and were therefore corrected to 90 days of age. The following formula was used based on the assumption that growth curve of lamb is fairly linear between 60 and 120 days as reviewed by Osinowo et al. (1993a).

$$CW = (((WW - BW / WA) * 90) + BW)$$

where CW - 90-day corrected weaning weight in kg, WW - actual weaning weight in kg, BW - birth weight in kg and WA - weaning age in days. A total of 1461 records averaging (±SD) 10.74±3.21 kg were examined for effects of environmental factors in the following linear additive model:

$$W_{ijklmn} = u + P_i + S_j + T_k + Z_l + Y_m + E_{ijklmn}$$

where W_{ijklmn} - 90-day age-corrected weaning weight of an individual lamb in kg, u - overall mean, P_i - fixed effect of i^{th} parity (i = 1,...,6), S_j - fixed effect of j^{th} sex of lamb (j = 1, 2), T_k - fixed effect of k^{th} type of birth (k = 1, 2), Z_l - fixed effect of l^{th} season of birth (l = 1,...,4), Y_m - fixed effect of m^{th} year of birth (m = 1,...,11) and Eijklmn - random error associated with each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.6.4 *Gestation length*

Gestation length was computed as 'date lambed-date bred'. A third class of sex was established for mixed sexes and records of 1240 lambings averaged (±SD) 151.40±4.22 days with a range of 128-180 days. Records with gestation lengths less than the mean by 2SD or greater than the mean by 2 SD were considered as outliers and treated as follows:

Lower limit = 151.40 - 2(4.22) = 143 days

Upper limit = 151.40 + 2(4.22) = 160 days

Gestation lengths ranged from 143-160 days for 1193 records. These were examined for environmental effects using the following linear additive model:

$$G_{ijklmn} = u + P_i + S_j + T_k + Z_l + Y_m + E_{ijklmn}$$

where G_{ijklmn} - gestation length of individual dam in days, u - overall mean, P_i - fixed effect of i^{th} parity (i = 1,...,6), S_j - fixed effect of j^{th} sex of lamb (j = 1, 2, 3), T_k - fixed effect of k^{th} type of birth (k = 1, 2), Z_l - fixed effect of l^{th} season of birth (l = 1,...,4), Y_m - fixed effect of m^{th} year of birth (m = 1,...,11) and E_{ijklmn} - random error associated with each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.6.5 *Lambing interval*

In analysing for environmental effects on lambing interval, a third class of sex was established for mixed sexes. Lambing interval was calculated as follows:

I1 = DP2 - DP1

I2 = DP3 - DP2

I3 = DP4 - DP3

I4 = DP5 - DP4

I5 = DP6 - DP5

where I - interval between lambings and DP - date at various parities. Records of all primiparous ewes were deleted, as well as cases with lambing intervals of <160 days on the basis that pregnancy must have been aborted. Similarly, records with lambing intervals over and above two lambing opportunities (>400 days) were assumed to be barren, or must have failed to conceive due to other environmental factors and hence were excluded. Interval between lambings in the edited file ranged from 160-400 days and averaged (±SD) 246±62.74 . A total of 1204 records were examined for environmental effects using the following model:

$$I_{ijklmn} = u + P_i + S_j + T_k + Z_l + Y_m + E_{ijklmn}$$

where I_{ijklmn} - Interval between lambings of individual dam in days, u - overall mean, P_i - fixed effect of i^{th} parity of dam (i = 1,...,5), S_j - fixed effect of j^{th} sex of lamb (j = 1, 2, 3), T_k - fixed effect of k^{th} type of birth (k = 1, 2), Z_l - fixed effect of l^{th} season of birth (l = 1,...,4), Y_m - fixed effect of m^{th} year of birth (m = 1, ...,11) and E_{ijklmn} - random error associated to each dam record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.6.6 ***Age at first lambing***

Records of dam, namely: date of birth, sire, parity and litter size were obtained via relational database and age at first lambing calculated as "date at first lambing-date of birth of dam". Records of 247 lambings were analysed for environmental effects using the following linear model:

$$A_{ijklm} = u + P_i + T_j + Z_k + Y_l + E_{ijklm}$$

where A_{ijklm} - age at first lambing in days for individual dam, u - overall mean, P_i - fixed effect of i^{th} parity of dam (i = 1, ...,6), Tj - fixed effect of j^{th} type of birth (j = 1, 2), Z_k - fixed effect of k^{th} season of birth of dam (k = 1,....4), Y_l - fixed effect of l^{th} year of birth (l = 3,...,11), and E_{ijklm} - random error peculiar to each record, (normally, independently and identically distributed with mean, zero and variance, σ^2).

3.7 ***Derivation of additive adjustment factors for litter size, birth weight and 90-day weaning weight***

Additive adjustment factors were constructed for each lamb sub-class for litter size, birth weight, 90-day weaning weight. The base class was a female lamb born single to a fourth parity dam during the late wet season. Eventhough the best sub-class came from the

sixth parity for birth weight, fourth parity was considered more valid for the three traits because most animals are likely to approach fourth parity than sixth parity.

To derive adjustment factors for birth weight and 90-day weaning weight, least-squares constants for environmental effects were substituted in the following additive model:

$$a_{ijkl} = -(S'_i + P'_j + T'_k + Z'_l)$$

where a_{ijkl} - additive factor for i^{th} sex of lamb (i = 1, 2), j^{th} parity of dam (j = 1,...6), k^{th} type of birth (k = 1, 2), l^{th} season of birth (1,...,4) and S'_i, P'_j, T'_k, and Z'_l were additive constants estimates (deviations from S_i, P_j, T_k and Z_l) for i^{th} sex of lamb, j^{th} parity of dam, k^{th} type of birth and l^{th} season of birth, respectively.

Additive adjustment factors were similarly constructed for litter size as:

$$a_{ij} = -(P'_i + Z'_j)$$

where a_{ij} - additive factor for ith parity of dam (i = 1,...,6) and j^{th} season of birth (j = 1,...,4), P'_i and Z'_j were the additive constant estimates (deviations from P_i and Z_j) for i^{th} parity of dam and j^{th} season of birth of lamb, respectively.

3.8 *Estimation of Heritabilities, genetic, phenotypic and environmental correlations between reproductive traits*

Prior to estimation of heritabilities and correlations between traits, data sets were additively adjusted for environmental factors using least-squares constants (Table 22) generated from model 1 analyses.

i. *Heritability by offspring - dam regression*

Heritability (h^2) of litter size was estimated from the regression of offspring on dam as suggested by Wilkinson (1988).

The covariance of offspring with parents was calculated from the sum of the cross-products, and the heritability was expressed as twice the regression coefficient of offspring on parents, Thus:

$$\hat{h}^2 = \frac{2Cov\,(y,x)}{\sigma^2 x}$$

where $\hat{h}^2$ - heritability, Cov (y,x) - covariance of offspring (y), and parents (x), $\sigma^2 x$ - phenotypic variance of parents.

ii. *Heritability by half-sib analysis of variance*

The intra-class correlation method using half-sib was employed to obtain heritabilites and correlations between traits. The following one way model (Model 2) by Harvey (1990) was used:

$$Y_{ij} = u + S_i + E_{ij}$$

where Y_{ij} - j^{th} observation of each trait on i^{th} sire, u - common mean, S_i - random effect of i^{th} sire and E_{ij} - uncontrolled environmental and genetic deviation attributable to individuals within sires.

Table 14. *Analyses of variance for estimating variance components*

Source of variation	DF	SS	MS	EMS
Progeny between sires	s - 1	SSs	MSs	$\sigma^2 e + K\sigma^2 s$
Progeny within sires	s(k - 1)	SSe	MSe	$\sigma^2 e$

s - number of sires and k - number of offsprings per sire

The sources of variation were between ($\hat{\sigma}^2$s) and within sires ($\hat{\sigma}^2$e). Since sires were mated to random dams in the population, it was assumed that the between sire variance component estimate ($\hat{\sigma}^2$s) will contain 25% of additive genetic variance while the within sire variance component estimate ($\hat{\sigma}^2$e) will contain 75% of the additive genetic variance. Heritability was therefore estimated as follows:

$$\hat{h}^2 = \frac{4\hat{\sigma}^2 s}{\hat{\sigma}^2 s + \hat{\sigma}^2 e}$$

where $\hat{h}^2$ - heritability, $\hat{\sigma}^2$s - between sire variance component estimate, and $\hat{\sigma}^2$e - within sire variance component estimate.

iii. Genetic correlation (r_g)

Estimates of genetic correlations between traits were obtained by dividing the sire covariance component estimate for traits by the geometric mean of the two sire variance component estimates for the respective traits (Harvey, 1990). Thus,

$$r_g = \frac{\hat{\sigma}s(xy)}{[\hat{\sigma}^2 s(x)\ \hat{\sigma}^2 s(y)]^{1/2}}$$

where r_g - genetic correlation between two traits, x and y, $\hat{\sigma}^2$s(xy) - between sire covariance component estimate for trait x and y, $\hat{\sigma}^2$s(x) and $\hat{\sigma}^2$s(y) - between sire variance component estimate for traits x and y, respectively.

An approximate formula for the standard error, derived from Reeve (1955b) and Robertson (1959b) is as follows:

$$SE(r_g) = \frac{1-r^2 g}{(2)^{1/2}} \left[\frac{SE\, h^2(x)\ SE\, h^2(y)}{h^2(x)\, h^2(y)}\right]^{1/2}$$

where SE h^2 (x) and SE h^2(y) were the standard errors of heritabilities for traits x and y, respectively.

iv. Phenetypic correlations (r_p)

It was calculated using the following formula:

$$r_p = \frac{\hat{\sigma}e(xy) + \hat{\sigma}s(xy)}{[(\hat{\sigma}^2e(x) + \hat{\sigma}^2s(x)]\,[\hat{\sigma}^2e(y) + \hat{\sigma}^2s(y))]^{1/2}}$$

v. Environmental correlation (r_e)

It was similarly calculated thus:

$$r_e = \frac{\hat{\sigma}e(xy) + 1/3\hat{\sigma}s(xy)}{[(\hat{\sigma}^2e(x) - 1/3\hat{\sigma}^2s(x)]\,[\hat{\sigma}^2e(y) - 1/3\hat{\sigma}^2s(y))]^{1/2}}$$

where r_p and r_e - phenotypic and environmental correlations between traits x and y respectively.

$\hat{\sigma}s(xy)$ - between sire covariance component estimate for traits x and y,

$\hat{\sigma}e(xy)$ - within sire covariance component estimate for traits x and y,

$\hat{\sigma}^2s(x)$, $\hat{\sigma}^2s(y)$ - between sire variance component for traits x and y respectively, and

$\hat{\sigma}^2e(x)$, $\hat{\sigma}^2e(y)$ - within sire variance component for traits x and y respectively.

CHAPTER FOUR

RESULTS AND DISCUSSION

Tables 15 and 16 represent a summary of analyses of variance and least-squares means (±SE), respectively, for the effects of environmental factors on litter size, birth weight, litter birth weight and 90-day weaning weight obtained from this study.

Table 15. *Summary of analysis of variance for the effects of parity, litter size, sex, season and year of birth on litter size, birth weight, litter birth weight and 90-day weaning weight*

	Mean squares							
Source of variation	Litter size DF	MS	Birth weight DF	MS	Litter birth weight DF	MS	Weaning weight DF	MS
Parity	5	1.30***	5	5.03***	5	4.14***	5	103.63***
Litter size			1	70.99***	1	225.75***	1	1304.88***
Sex			1	8.69***	1	10.31***	1	220.41***
Season	3	0.95***	3	8.23***	3	3.37***	3	181.61***
Year	10	0.44***	10	1.29***	10	1.10**	10	90.60***
Error	2185	302.48	2469	0.25	1203	0.45	1440	7.90

***P<0.001, **P<0.01

Table 16. *Least-squares means (±SE) for litter size, birth weight, litter birth weight and 90-day weaning weight*

	Litter size			Birth weight (kg)			Litter birth weight (kg)			Weaning weight (kg)		
Class	No.	LSM	SE	No.	LSM	SE	No.	LSM	SE	No.	LSM	SE
Overall	2204	1.22	0.01	2490	2.48	0.01	1225	3.57	0.03	1461	10.58	0.11
Variable												
Parity 1	762	1.13	0.01	821	2.29	0.02	333	3.29	0.04	424	9.49	0.15
2	564	1.14	0.02	620	2.45	0.02	348	3.52	0.04	353	10.14	0.17
3	392	1.19	0.02	452	2.54	0.02	239	3.58	0.05	296	10.77	0.18
4	247	1.25	0.02	295	2.52	0.03	145	3.58	0.06	195	11.32	0.22
5	159	1.29	0.03	167	2.49	0.04	105	3.63	0.07	127	10.81	0.26
6	80	1.33	0.04	105	2.61	0.05	55	3.83	0.10	66	10.95	0.36
F. test	(P<0.001)			(P<0.001)			(P<0.001)			(P<0.001)		
Litter size												
Single				1756	2.68	0.02	978	2.88	0.04	1118	11.74	0.12
Twin				734	2.29	0.02	247	4.26	0.05	343	9.42	0.16
F. test				(P<0.001)			(P<0.001)			(P<0.001)		
Sex Male				1240	2.54	0.02	557	3.49	0.04	719	10.97	0.13
Female				1250	2.42	0.02	541	3.35	0.04	742	10.19	0.13
Mixed							127	3.87	0.07			
F.test				(P<0.005)			(P<0.001)			(P<0.001)		
Season												
J-M	568	1.25	0.02	646	2.32	0.02	275	3.41	0.05	446	9.81	0.17
A-J	568	1.27	0.02	660	2.49	0.02	331	3.58	0.05	304	10.76	0.20
Jl-S	449	1.15	0.02	491	2.65	0.03	229	3.76	0.06	227	11.07	0.20
O-D	619	1.23	0.02	693	2.45	0.02	390	3.52	0.05	434	10.07	0.17
F.test				(P<0.001)			(P<0.001)			(P<0.001)		
Year												
1983	73	1.32	0.05	87	2.44	0.06	68	3.41	0.10	41	10.77	0.48
1984	166	1.29	0.03	196	2.41	0.04	117	3.50	0.07	157	10.87	0.25
1985	157	1.21	0.03	190	2.52	0.04	154	3.58	0.06	139	10.70	0.24
1986	96	1.24	0.04	106	2.53	0.05	87	3.57	0.08	78	10.48	0.32
1987	197	1.22	0.03	213	2.50	0.04	88	3.71	0.08	87	12.72	0.34
1988	390	1.26	0.02	450	2.47	0.03	247	3.58	0.06	229	9.85	0.23
1989	238	1.16	0.03	251	2.42	0.03	75	3.58	0.09	134	9.86	0.26
1990	331	1.18	0.02	369	2.53	0.03	47	3.35	0.11	206	10.31	0.22
1991	269	1.17	0.02	308	2.66	0.03	171	3.75	0.06	179	11.30	0.23
1992	131	1.19	0.03	145	2.45	0.04	94	3.53	0.09	104	9.73	0.30
1993	156	1.21	0.03	175	2.40	0.04	107	3.72	0.07	106	9.58	0.30
F.test	(P<0.001)			(P<0.001)			(P<0.01)			(P<0.001)		

J-M, A-J, Jl-S, O-D = January-March, April-June, July-September and October-December .

4.1 ***Effects of environmental factors on litter size (LS)***

Effects of parity, season and year were highly significant (P<0.001; Table 15) accounting for 31.7% of total variation in litter size averaging 1.22±0.01 (Table 16).

The overall mean litter size of 1.22±0.01 obtained in this present study agrees with an estimate of 1.22±0.02 reported by Osinowo et al. (1988; 1992a) on the same farm, but lower than 1.17 estimated from a smaller data set (472 lambings) of Yanka ck (Osinowo et al., 1989). It appears that values obtained are determined by data si an extent. Nevertheless, Yankasa sheep is not a prolific breed (Osinowo et al., 1989), with about 22% twinning rate (Sackey et al., 1978). Its litter size is similar to 1.22 for Balami (Adu et al., 1978) but lower than 1.4 (1-3) for Nigerian Dwarf sheep (Orji et al., 1976).

i. *Effect of parity on LS*

The effect of parity on litter size was very highly significant (P<0.001; Table 15). Least-squares means (Table 16) indicate that the performance of dams improved with parity. Primiparous ewes tended to produce smaller litter size of average 1.13 which increased consistently up to 6th parity averaging 1.33. Thus 6th parity ewes were better than first parity ewes by 0.20 lamb.

Several reports have shown that prolificacy is significantly lower in first lambing ewes regardless of age at first lambing (Bradford, 1985; Hoeke and Visscher, 1987). Low prolificacy in primiparous ewes has been associated with the fact that features required for

successful litter bearing are not fully developed, while this has been attained in multiparous ewes. Montgomery et al. (1985) further noted that observed increase in ovulation rate with age was more closely associated with ewe's body weight. This is likely to account for the current observation.

ii. *Effect of season of birth on LS*

Season of lambing had a very highly significant ($P<0.001$) influence on litter size (Table 15). Ewes lambing in the late wet season had smaller litter sizes averaging 1.15 with a trend towards improvement from early dry, late dry to early wet seasons (1.23, 1.25, and 1.27, respectively; Table 16).

The observation that ewes lambing in the wet season produced significantly lower litter size than ewes lambing in the dry season confirms earlier finding by Osinowo et al. (1989). Abad et al. (1991) also observed that season of birth significantly influenced litter size in West African Dwarf (WAD) ewes in the tropics (Cote d'Ivoire). The present observation however conflicted with non-seasonal differences in litter size reported by Odubote (1992) for WAD at Ile-Ife, Nigeria. The effect of season arises from seasonal variation in the physical environment resulting from changes in weather conditions (including rainfall amounts, temperature and humidity) which directly affect feed availability (Inyangala et al., 1992). Ewes lambing in the dry season must have conceived in the rainy season normally associated with growth of highly nutritive forages (Osinowo et al., 1989). This is thought to increase ovulation rate secured by flushing, resulting from increase in the rate of gonadotropic hormones (Fraser and Stanp, 1968; Scaramuzzi and Radford, 1983). It is indicative of the observed increase in litter size especially in the late dry and early wet seasons. The reverse was true for ewes lambing in the late wet season, suggesting that pregnancy was established in the dry season characterized by feed scarcity. Generally, late

dry and early wet seasons were better in litter size performance than late wet and early dry seasons.

iii. *Effect of year on LS*

Year of birth was a very highly significant ($P<0.001$) source of variation for litter size (Table 15), with no clear-cut trend. Least-squares means (Table 16) show that 1983 witnessed the best performance in litter size averaging 1.32 as opposed to the least performance 1.16 recorded in 1989. There was however, a considerable improvement by 0.4 litter (1.17-1.21) over the last three years of study (1991-1993).

The importance of significant effect of year of birth on litter size has been indicated (Adu et al., 1985; Gates, 1990; Abad et al., 1991; Boujenane et al., 1991 and Odubote, 1992). As observed in the present study, Adu et al. (1985) and Odubote (1992) had no clear-cut trend in yearly variation. The former attributed it to considerable variation in climatic and nutritional management or general husbandry practices between years. That the last three years of study (1991-1993) witnessed an increase in performance in litter size could be as a result of conscious genetic improvement of the flock for the trait. From the foregoing methodology, Yankasa sheep has been maintained as a closed flock and breeding rams selected on yearly basis, a greater proportion (60%) of which are twin born ram lambs.

4.2 *Effects of environmental factors on birth weight (BWT), litter birth weight (LBWT), and 90-day weaning weight (WWT)*

Parity, litter size, sex of lamb, season and year of birth constituted very highly significant ($P<0.001$) sources of variation for all three traits studied (Table 15). They together accounted for 19.8, 22.37 and 26.16% of total variation in BWT, LBWT and

WWT, respectively. The corresponding overall mean values were respectively 2.48±0.01 kg, 3.57±0.03 kg and 10.58±0.11 kg.

The overall estimated mean BWT of 2.48±0.01 kg from the current study falls within the range of 2.32-2.68 kg given in literature for Yankasa sheep (Table 17). Adu and Ngere (1979) reported higher BWT estimated at 3.6 vs 3.0 kg for singles vs twin lambs in Yankasa sheep at Katsina. Location of breed has been suggested (Odubote, 1992) to have an effect on BWT, either as a result of differences in management systems or feeding regime and feedstuffs offered. Differences in estimates could to an extent be influenced by data size. Yankasa breed was found to be superior in BWT to WAD, and inferior with respect to Uda and Balami as illustrated in Table 17.

Table 17. *Mean (±SE) birth weight (BWT) and litter birth weight (LBWT) from literature and current study*

Breed	Location	No.	BWT/LBWT (kg)	Reference
Yankasa	Shika		3.2[s] 2.9[t]	Adu (1978)
"	Katsina		3.6[s] 3.0[t]	Adu and Ngere (1979)
"	Shika		2.68 (mixed)	Buvanendran et al. (1981)
"	"	357	2.51	Hassan (1987)
"	"	762	2.32±0.02	Osinowo et al. (1990)
"	"	2020	2.51±0.01	Osinowo et al. (1992a)
"	"	834	3.08±0.05[a]	Osinowo et al. (1993a)
Yankasa*	"	1225	3.57±0.03[a]	Current study*
Yankasa*	"	2490	2.48±0.01	"
Balami	"		3.3[s] 3.0[t]	Adu and Ngere (1979)
Uda	"		3.8[s] 3.4[t]	Adu (1978)
Nigerian Dwarf			2.58[s] 2.12[t]	Taiwo et al. (1982)

[a]LBWT, [s]Single, [t]Twin

LBWT, estimated at 3.57±0.03 kg was higher than 3.08±0.05 kg reported by Osinowo et al. (1993a) from 834 lambings on the same farm (Table 17). This could be partly accounted for by improvement in the trait over the year and partly due to differences in

data size. Observed LBWT was however inferior when compared with an estimate of 4.06 kg for WAD sheep (Odubote, 1992).

Average WWT of 10.8±0.11 kg was within reported range of 9.63-10.90 kg on the farm (Table 18). It was however comparable with 10.61 kg estimated by Guillen and Rondon (1987) in WAD.

Table 18. *Mean (±SE) weaning weight (WWT) from literature and current study*

Breed	Location	No.	WWT (kg)	Reference
Yankasa	Shika	357	10.90	Hassan (1987)
"	"	762	9.63	Osinowo et al. (1990)
"	"	1203	10.87±0.08	Osinowo et al. (1993b)
Yankasa*	"	1419	10.58±0.11	Current study*
WAD			10.61	Guillen and Rondon (1987)

i. *Effect of parity on body weights*

The effect of parity on BWT, LBWT and WWT was very highly significant ($P<0.001$; Table 15). Lambs of higher parities were generally heavier in weight for all three traits considered. Primiparous ewes tended to produce smaller lambs at birth and at weaning than multiparous ewes which were best represented at 6th parity for BWT and LBWT, and at 4th parity for WWT (Table 16). The mean body weights at 1st and 6th parities were: 2.29 vs 2.61 kg and 3.29 vs 3.83 kg for BWT and LBWT, respectively. This pattern of improvement was consistent for LBWT but not for BWT which dropped at 4th and 5th parities by 0.2 and 0.3 kg respectively. The best performance in weaning weight was at 4th parity (11.32 kg), with a decrease by 0.51 kg at 5th parity (10.81 kg) and 0.14 kg improvement at 6th parity (10.95 kg).

The observation that primiparous ewes tend to produce significantly lighter lambs at birth and at weaning than multiparous or older ewes has been demonstrated in Yankasa sheep (Hassan, 1987; Osinowo et al., 1990; 1992a). Ganai and Pandey (1990) and Kulkarni and Deshpande (1991) reported similar effect in Australian Merino and Deccani lambs, respectively. Hafez (1980) advanced an explanation that reproductive efficiency is not fully attained at first oestrus/breeding ewes. Young ewes are still growing and thus must provide for their own growth in addition to the foetal demand (Inyangala et al., 1992). Corresponding increases in WWT has been noted by Hamada (1976), working with Rahmany breed. It was observed that heavier lambs at birth were generally superior in vigour and tended to be superior in weights postnatally. Mothering ability, with more emphasis on milk production has been shown to increase with parity (Adu et al., 1985). Older ewes are large in body weight and better milkers, hence superior maternal environment of such ewes is expected to be translated into better lamb performance up to weaning (Inyangala et al., 1992), as the present study clearly indicated. The decrease in BWT and WWT at 4th and 5th parities could be associated with ageing effects.

ii. *Effect of litter size on body weights*

The influence of litter size on body weight was very highly significant ($P<0.001$; Table 15). BWT decreased by 0.39 kg from 2.68 kg for singles to 2.29 kg for twins. LBWT increased by 1.38 kg from 2.88 kg for singles to 4.26 kg for twins (Table 16). Lamb WWT similarly decreased by 2.26 kg from 11.74 kg for singles to 9.42 kg for twins.

Reports have shown that single born lambs are generally heavier than twin born lambs at birth and at weaning in Yankasa sheep (Adu, 1978; Adu and Ngere, 1979; Buvanendran et al., 1981; Hassan, 1987 and Osinowo, 1990; 1993b). This was true of the present study. Lighter body weight observed in twin lambs at birth has been attributed to limited uterine capacity and insufficient nutrient supply to meet individual lamb requirement for faster growth rate in utero. This is based on the reasoning that as number of foetuses increases,

the number of caruncles attached to each foetus decreases, thus reducing feed supply and hence birth weights of lambs (Robinson et al., 1977). The trend in performance is maintained postnatally and at weaning, as twin lambs are unable to recover from nutritional stress suffered in utero and during the suckling period (Buvanendran et al., 1981).

Taking litter birth weight into consideration, Odubote (1992) found out in WAD ewes that twin and triplets were heavier than singles. It was concluded that low birth weight for twins and triplets are offset by high litter weight as recorded in the present study. Buvanendran et al. (1981) further observed that these differences are quite notable and maintained to maturity.

iii. *Effects of sex of lamb on body weights*

Sex of lamb was a very highly significant ($P<0.001$) source of variation for BWT, LBWT and WWT (Table 15). Male lambs were found to be heavier than females at birth (2.54 vs 2.42 kg) and at weaning (10.97 vs 10.19 kg). The weight difference in favour of males was 0.12 kg at birth and 0.78 kg at weaning (Table 16).

Consistent superiority of male lambs at birth and at weaning confirm earlier results reported on the same farm (Hassan, 1987; Osinowo et al., 1990; 1993b). It has been attributed to hormonal differences between sexes and their resultant effect on growth (Review by Inyangala, 1992). Review by Hassan (1987) further suggested that male foetus starts secreting androgenic substances earlier in life which is thought to have a stimulatory effect on growth rate. This study confirms that the preponderance of males in litter birth weight led to an increase in LBWT and BWT (Odubote, 1992). Buvanendran et al. (1981) however, reported non-significant sex differences in Yankasa sheep.

iv. *Effect of season on body weights*

Season of birth had very highly significant ($P<0.001$) influence on BWT, LBWT and WWT (Table 15). Lambs born during the rainy season were generally heavier than those

born during the dry season for the three traits. Table 16 indicates that the best performance in body weights was recorded in the late wet season with mean values of 2.65, 3.76 and 11.67 kg for BWT, LBWT and WWT respectively. Mean body weights in the late dry season of 2.32, 3.41 and 9.81 kg for BWT, LBWT and WWT, respectively, were the poorest. The corresponding differences in favour of the wet season were 0.33, 0.35 and 1.86 kg. Between the two intermediate periods, performance was generally found to be better in the early wet than early dry seasons for these traits.

Significant influence of season on BWT and WWT has been favourably suported by Hassan (1987) and Osinowo et al. (1989; 1992a) in Yankasa sheep. The latter advanced that the difference in BWT between months apparently follow seasonal variation in forage availability. Seasonal influence on a trait such as BWT has been shown to operate through its effect on dam's uterine environment (Eltawil et al., 1970). This may explain the higher BWT of lambs born in the late wet season compared with lambs from dams that underwent a nutritionally stressfull period during gestation in the early dry to late dry seasons. Inyangala et al. (1992) further noted that season of birth plays an important role in growth performances indirectly through its influence on dam's nutrition and hence the amount of milk available to the unweaned lamb. It follows that ewes lambing in the late wet season are more likely to secrete more milk and will invariably produce more vigorous and heavier lambs at weaning (Hamada, 1976; Buvanendran et al., 1992 and Inyangala et al., 1992), as was similarly noted in this study.

v. *Effect of year on body weights*

Yearly variation was very highly significant ($P<0.001$) for BWT and WWT, and highly significant for LBWT ($P<0.01$) as shown in Table 15. The trend in variation was generally found to be inconsistent, except for the last 3 years of study (1991-1993) that witnessed a decline in performance for BWT and WWT. The least squares means for BWT for 1991-

1993 were 2.66, 2.45 and 2.40 kg, respectively, and 11.50, 9.73 and 9.58 kg, respectively for WWT (Table 16).

Significant yearly variation on BWT and WWT in Yankasa sheep has been documented (Hassan, 1987; Osinowo et al., 1992a) in agreement with the present study but conflicts with insignificant year effect earlier recorded by Osinowo et al. (1989). Inconsistent trend in variation was similarly observed by Katharaju et al. (1980), Adu et al. (1985), Buvanendran et al. (1992) and Osinowo et al. (1992a). It could be partly accounted for by variation in climate which directly influences water and feed availability, and slight differences in general husbandry practices between the years (Adu et al., 1985). The observed decrease in BWT and WWT during the last 3 and 2 years, respectively could be accounted for by improvement in litter size as earlier indicated over the last three years of study. Litter size has been shown to be negatively correlated with BWT (Odubote, 1992).

The summary of least-squares analyses of variance and least-squares means (±SE) for the effects of environmental factors on gestation length, lambing interval and age at first lambing are presented in Tables 19 and 20, respectively.

Table 19. *Summary of analysis of variance for the effects of parity, litter size, sex, season and year of lambing on gestation length, lambing interval and age at fisrt lambing*

	Mean squares					
	Gestation length		Lambing interval		Age at first lambing	
Source of variation	DF	MS	DF	MS	DF	MS
Parity	5	13.51*	5	1431.60	5	12432.88
Litter size	1	11.98	1	1349.36	1	51065.54*
Sex	2	12.05	2	1194.36		
Season	3	3.05	3	14798.27**	3	59321.82**
Year	10	49.72***	10	10561.37***	8	81784.76**
Remainder	1174	5.04	1183	2949.93	229	1281.66

*P<0.05, **P<0.01, ***P<0.001

Table 20. *Least-squares means (±SE) for gestation length, lambing interval and age at first lambing*

Class		Gestation length (days) No.	LSM	SE	Lambing interval (days) No.	LSM	SE	Age at first lambing (days) No.	LSM	SE
Overall		1196	151.37	0.10	1204	249.81	2.72	247	575.00	9.55
Variable										
Parity	1	326	150.54	0.15	447	251.66	3.40	58	603.92	16.63
	2	342	151.12	0.15	330	254.00	3.75	51	572.43	18.52
	3	228	151.59	0.17	214	249.67	4.29	50	575.00	17.74
	4	144	151.52	0.20	143	247.68	5.05	31	588.73	22.08
	5	102	151.37	0.24	70	246.05	6.89	32	564.65	22.05
	6	54	151.70	0.32				25	549.82	24.52
F.test			(P<0.05)			(P>0.05)			(P>0.05)	
Litter size										
Single		960	151.55	0.14	1106	247.98	3.51	175	558.35	10.27
Twin		236	151.20	0.17	198	251.64	4.35	72	593.17	15.13
F.test			(P>0.05)			(P>0.05)			(P<0.05)	
Sex										
Male		549	151.47	0.14	545	249.60	3.65			
Female		526	151.17	0.14	560	252.35	3.60			
Mixed		121	151.47	0.24	99	247.48	6.38			
F.test			(P>0.05)			(P>0.05)				
Season										
J-M		268	151.28	0.18	309	246.03	3.97	69	583.35	16.15
A-J		325	151.39	0.17	334	260.00	4.03	86	524.58	13.73
Jl-S		223	151.29	0.21	252	239.28	4.58	27	607.67	24.57
O-D		380	151.54	0.16	309	253.95	4.37	65	587.42	15.73
F.test			(P>0.05)			(P<0.01)			(P<0.01)	
Year										
1983		64	151.72	0.34	62	211.49	7.94			
1984		118	151.73	0.24	132	218.17	5.40			
1985		151	150.93	0.20	86	222.59	6.25	15	463.18	30.35
1986		83	150.37	0.26	42	224.08	8.67	27	532.78	22.34
1987		89	151.15	0.28	148	240.94	5.70	13	678.22	34.01
1988		243	150.74	0.20	258	220.54	4.47	17	603.14	30.81
1989		73	151.40	0.29	125	265.30	5.34	30	520.29	22.73
1990		46	150.82	0.38	172	263.54	4.69	39	538.77	20.76
1991		163	150.99	0.21	86	288.23	6.32	42	611.60	19.91
1992		60	152.24	0.32	64	330.45	7.40	24	659.27	26.27
1993		106	153.01	0.25	29	262.59	10.70	40	574.58	19.10
F.test			(P<0.001)			(P<0.001)			(P<0.01)	

J-M, A-J, Jl-S, O-D = January-March, April-June, July-September, October-December

4.3 ***Effects of environmental factors on gestation length (GL)***

Significant sources of variation were parity ($P<0.05$) and, year of birth ($P<0.001$), which accounted for 1.48% of total variation in GL (Table 19). Litter size, sex of lamb and season of birth did not affect GL significantly ($P>0.05$).

The overall mean gestation length estimated at 151.37±0.01 days (Table 20) compares with 154.44±0.13 days estimated from 438 lambings of Yankasa sheep (Trimnell et al., 1988), and 151.4 days from 834 records on the same farm (Osinowo et al., 1993a). It appears that pregnancy duration in Yankasa sheep varies within a very narrow limit, being largely influenced by the genetic component of the phenotypic variance; hence, the relative constancy in mean gestation length. Limited but definite variability has been shown to be accounted for by maternal, foetal and environmental factors (Trimnell et al., 1988). It can be deduced from the mean gestation length that Yankasa sheep is a slow maturing, and non-prolific breed of sheep since the estimate falls within 150-151 days, characteristic of slow maturing fine wool breeds - Merino or Rambouillet (Hafez, 1980). On the other hand, early maturing breeds (Southdown or Hampshire) and highly prolific breeds (Finnsheep or Romanov) have GL of 144-148 days which is comparatively lower than for Yankasa sheep.

i. *Effect of parity on GL*

Least-squares means (Table 20) indicate that GL significantly ($P<0.05$) increased with parity of ewe. Primiparous ewes had shorter mean GL (150.94 days) which increased up to 3rd parity with the longest pregnancy duration occuring at 6th parity (151.70 days).

The significant effect of parity on GL observed in the current study agrees with the findings of Trimnell et al. (1988) in Yankasa sheep on the same farm. It has been reported by Swamy (1978), Bocherov (1979), Elkarim and Owen (1987) and Sahani and Chand (1990) in other breeds. They hold a general view that ewes aged 1.5 years and below have

significantly shorter gestation length than older ewes which was the case with the current observation. Review by Osinowo et al. (1993a) showed that lambs of heavier birth weights tend to have longer gestation lengths. It is indicative of this study that the performance of lambs as far as BWT is concerned increased with parity. Hence, older ewes are more likely to carry their lambs for a longer period than younger ewes. The foregoing authors, however, did not find any significant effect of parity on gestation length.

ii. *Effect of litter size on GL*

Litter size did not significantly (P>0.05) affect GL (Tables 19 and 20). Eventhough twin bearing ewes have been shown to carry their lambs for a shorter period in Yankasa sheep (Osinowo et al., 1993a), and other breeds (Elkarim and Owen, 1987; Shrestha and Heaney, 1990), this study had similar observation but the difference was not significant. The size of data employed is likely to play a significant role. It could also be due to climatic variation between years mediated through water and feed availability.

iii. *Effect of sex on GL*

Female lambs to an insignificant extent (P>0.05) were associated with shorter GL (151.17 days) than males and mixed sexes (151.47 vs 151.47 days; Table 20).

Trimnell et al. (1988), working with Yankasa sheep found that males and mixed sexes were associated with significantly longer GL, agreeing with Elkarim and Owen (1987). This study together with reports by Shrestha and Heaney (1990), and Osinowo et al. (1993a) on the same farm did not find any significant sex differences. It appears that the role played by both sexes in determining pregnancy duration is essentially the same.

iv. *Effect of season on GL*

Seasonal variation did not affect GL significantly (P>0.05) as indicated in Tables 19 and 20. The effect of season has however, been shown to be significant on the same farm

(Trimnell et al., 1988). This was similarly observed by Swamy (1978) and Toteda et al. (1988) in other breeds. The current observation, in agreement with Osinowo et al. (1993a) showed no significant effect of season on gestation length. It is possible that the practice of feeding concentrates especially during the dry season (period of feed scarcity) offsets the effects of nutritional stress. In a preliminary analysis of seasonal effect on GL, Osinowo et al. (1993a) showed that significant seasonal effect on GL dissappeared with the inclusion of litter birth weight in the statistical model as a covariable.

v. *Effect of year on GL*

Gestation length was significantly ($P<0.001$) influenced by year of lambing (Table 19) with no consistent pattern of variation except for a general increase in GL over the last 4 years of study. The mean values (Table 20) were 150.82, 150.99, 152.25 and 153.01 days for 1990, 1991, 1992 and 1993 respectively.

Trimnell et al. (1988) and Osinowo et al. (1990; 1993a) agreed on significant influence of year as currently recorded in this study. It is likely that the practice of selecting for weaning weights as speculated by Osinowo et al. (1993a) to significantly improve birth weight might have contributed to the observed increases in gestation length over the last four years. Yearly variation in rainfall pattern and feed availability are suggested to have a significant contribution through their influence on birth weight.

4.4 ***Effects of environmental factors on lambing interval (LI)***

The overall mean LI was 249.81±2.72 days (Table 20). Significant effects of season ($P<0.01$) and year ($P<0.001$) accounted for 20.01% of total variability in LI (Table 19). Parity, litter size and sex of lamb were not significant ($P>0.05$).

Lambing interval, estimated at 249.81±2.27 days (indicating approximately 8 months LI) compares favourably with an estimate of 236 days for Yankasa sheep recorded by Ferguson (1964), but lower than 291 days estimated by Molokwu and Umunna (1980) on

the breed at Samaru. It is possible that location of breed and management practices adopted at various stations must have significantly contributed to these differences. Observed LI compares favourably with estimates for several indigenous breeds of sheep (Table 21).

Table 21. *Mean (±SE) lambing intervals from literature and current study*

Breed	Location	LI (days)	Reference
Yankasa	Shika	236	Ferguson (1964)
"	Samaru	291	Molokwu and Umunna (1980)
Yankasa*	Shika	249.81±2.72	*Current study**
Balami	Marguba	279	Adu et al.(1985)
"	"	238-308	Buvanendran and Adu (1987)
Uda	Shika	270	Ferguson (1964)
WAD		248-307	Review by Osinowo (1982)
"		194-255.4	Guillen and Rondon (1987)
WAD	Ibadan	234 (151-571)	Orji et al.(1976)

i. *Effects of parity on LI*

Lambing interval was not significantly affected by parity of ewe (P>0.05; Tables 19 and 20). This is perhaps accounted for by the fact that breeding is highly controlled and ewes are not allowed to run with the rams. Productivity in terms of lambing frequency is thought to be limited by this aspect of environmental control in that ewes that failed to conceive at the scheduled breeding period might not be given the opportunity to mate at their fertile period. This area of research has received very little attention, hence, there is no basis for comparison. Kabuga and Akowuah (1990) working with Djallonke, Sahelian and Crossbreds, and Hoeke and Visscher (1987) observed that LI was significanly affected by age of ewes.

ii. *Effect of litter size on LI*

The difference in LI associated with single and twin bearing ewes (247.98 vs 251.64 days) was not significant (P>0.05; Tables 19 and 20).

Relationship between litter size and LI in Ile-de-France, Finnish Landrace and reciprocal crosses showed that large litters were significantly associated with longer interval between lambings (Hoeke and Visscher, 1987). It is possible that the practice of controlled breeding within the herd might have contributed to the present observation.

iii. *Effect of sex of lamb on LI*

Sex differences insignificantly ($P>0.05$) influenced LI (Table 19), although female lambs were found to lengthen LI by 2.75 days compared with males, and 4.87 days compared with mixed sexes (Table 20). The mean LI were 252.35, 249.60 and 247.48 days for ewes bearing female lambs, male lambs and mixed sexes, respectively. Previous reports were not available to form a basis for comparison.

iv. *Effect of season of lambing on LI*

Seasonal variation significantly ($P<0.01$) influenced LI (Table 19). Shorter LI was obtained in the late wet season (239.28 days) while ewes lambing in the early wet season experienced the longest LI (260.00 days), a difference of 20.72 days (Table 20). On the average, ewes lambing in the wet seasons were associated with shorter LI than ewes lambing during the dry seasons (249.64 vs 249.99 days).

Significant seasonal effect has been reported in Balami at Marguba (Adu et al., 1985) and in Rambouillet (Urrutia et al., 1989) which is in line with the current finding. The former author observed that LI was shorter by 30 days for ewes lambing in the wet season. This study similarly demonstrated shorter LI in the late wet season than other seasons. Adu et al. (1985) advanced a possible explanation that ewes lambing in the wet season had a significantly higher litter size and shorter LI than ewes lambing in the dry season. Since it however conflicts with observed decrease in litter size in the wet season within the scope of this study, longer LI has been attributed to heavier foetal weights manifested by birth weights of lambs following improvement in the nutrition of dams

during this period. High estimates of LI observed in the early wet and dry seasons may be due to longer rebreeding interval associated with long nursing period of lambs by their ewes. It is assumed that lamb's growth rate will be retarded under nutritional stress of ewe during the dry season in the Savanna region, often characterized by feed scarcity. Lambs are therefore weaned at a much later age than the rainy season-born lambs, hence its effect on lambing interval.

v. *Effect of year of birth on LI*

Year of lambing significantly ($P<0.001$) influenced lambing interval (Table 19), with consistent increases in LI over the first 5 years of study (1983-1987). The lowest mean value (211.49 days) was recorded in 1983 as against 1992 which had the longest mean LI (330.45 days) indicated in Table 20. LI was generally found to increase over the latter years of the study.

Significant yearly variation noted in this study has been observed by Schoeman et al. (1991). A consistent decrease in LI during the first 5 years is an indication of decrease in productivity, probably due to yearly variation in forage availability and general management practices.

4.5 ***Effects of environmental factors on age at first lambing (AFL)***

It is clear from the least-squares analysis of variance (Table 19) that age at first lambing was significantly influenced by litter size ($P<0.05$), season of birth ($P<0.01$) and year of birth ($P<0.01$). These factors accounted for 20.22% of total variation in AFL. The effects of parity and sex were not significant ($P>0.05$).

The mean age at first lambing of 575±9.55 days (approximately 19.17 months; Table 20) in this study was higher than 15.5 months reported by Molokwu and Umunna (1980) for Yankasa sheep at Samaru. Breed location and management practices seem to have a considerable influence on the estimates. As expected, the current estimate of 19.17 months

was higher than 11.96 and 12.67 months recorded for Yankasa managed under transhumant and sedentary husbandry systems, respectively (Nig. Livestock Resources, 1992). The reason could be that Yankasa ewes at this station were not allowed to run with rams, irrespective of their fertile periods.

i. *Effect of parity of dam on AFL*

Parity of dam did not significantly ($P>0.05$) affect AFL (Tables 19 and 20). In the absence of literature, there was no basis for comparison of this observation with other records.

ii. *Effect of litter size on AFL*

Ewes born single to their dams lambed first at a significantly ($P<0.05$: Table 19) earlier age than twin born ewe lambs (558.35 vs 593.17 days), the difference in favour of single lambs being 34.82 days (Table 20). This was expected since single born lambs were heavier in weight and invariably associated with faster post weaning rate of gain (Hamada, 1976 and Buvanendran et al., 1981). It follows that attainment of sexual maturity and age at first lambing will be earlier in single born than twin born ewe lambs.

iii. *Effect of season of birth on AFL*

There was a highly significant ($P<0.01$) effect of season (Table 19) with early wet season born ewes lambing at a much earlier age (524.58 days) than late wet season born ewes (607.67 days). On the average, wet season born ewes lambed earlier by 19.27 days than dry season born ewes (Table 20).

Significant seasonal effects confirm similar observation by Abad et al. (1991) and Schoeman et al. (1991). Effect of season of birth has been shown to modulate age at puberty and hence, at first lambing (Ngere et al., 1983). Reasons were confounded in feed availability (Hafez, 1980; Lysandrides, 1981 and Forcada et al., 1992). The availability of

highly nutritive forages caused by the onset of rains offers better grazing materials for the gestating ewes which will invariably produce heavier lambs at birth. Hamada (1976) further observed that heavier lambs at birth are generally superior in vigor and weight postnatally, pointing to early attainment of age at sexual maturity as demonstrated by ewes born in the early wet season. The observation that late wet season born ewes attained age at first lambing much later was not expected and could not be explained.

v. *Effect of year of birth on AFL*

Year effect was highly significant ($P<0.001$) with no clear-cut trend in variation (Tables 19 and 20). The least AFL was recorded in 1985 (463.18 days) while 1987 witnessed ewes coming into lambing at much later age (678.22 days). A decrease in AFL (574.58 days) was recorded during the last year of study.

Significant yearly variation agreed with Schoeman et al. (1991). The inconsistent trend in variation could be due to the fact that the trait is largely subject to management decision, as in lambing interval.

4.6. ***Estimates of least-squares constants and additive correction factors for litter size, birth weight and 90-day weaning weight***

Table 22 represents additive least-squares constants for litter size, birth weight and 90-day weaning weight from which least-squares constants were derived.

Table 22. *Least-squares constants (LSC) for litter size, birth weight and 90-day weaning weight in Yankasa sheep*

Subclass		Litter size No.	Litter size LSC	Brth weight (kg) NO.	Brth weight (kg) LSC	Weaning weight (kg) No.	Weaning weight (kg) LSC
LSM (±SE)		1.22±0.01		2.48±0.01		10.58±0.11	
No. of obs.		2204		2490		1461	
Parity	1	762	-0.01	821	-0.20	424	-1.01
	2	564	-0.08	620	-0.03	353	-0.44
	3	392	-0.03	452	0.05	296	0.19
	4	247	0.03	295	0.04	195	0.74
	5	159	0.06	197	0.01	127	0.23
	6	80	0.11	105	0.12	66	0.34
Litter size							
	Single			1756	0.19	1118	1.16
	Twin			734	-1.19	343	-1.16
Sex							
	Male			1240	0.06	719	0.39
	Female			1250	-0.06	742	-0.39
Season							
	J-M	568	0.02	646	-0.16	446	0.76
	A-J	568	0.04	660	0.01	304	0.18
	Jl-S	449	-0.07	491	0.17	277	1.09
	O-D	619	0.01	493	-0.01	434	-0.51

Additive adjustment factors were further obtained from the least squares constants, in which case, records of litter size, birth weight and 90-day weaning weight were adjusted to the equivalent of a single female lamb born to a 4th parity ewe in the late wet season. Results are presented in Tables 23, 24 and 25, for litter size, birth weight and 90-day weaning weight, respectively. It was generally observed that number of observation within each subclass decreased with increase in parity.

Table 23. Least squares constants (LSC) and additive correction factors (ACF) for litter size in Yankasa sheep

	Season											
	LD			EW			LW*			ED		
Parity	No.	LSC	ACF	No.	LSC	ACF	No.	LSC	ACF	No.	LSC	ACF
1	170	-0.01	-0.05	234	-0.03	-0.07	125	0.08	0.04	233	0.00	-0.04
2	147	0.06	0.02	145	0.04	0.00	104	0.15	0.11	168	0.07	0.03
3	118	0.01	-0.03	76	-0.01	-0.05	85	0.10	0.06	113	0.02	-0.02
4	63	-0.05	-0.09	57	-0.07	-0.11	77	0.04*	0.00*	50	-0.04	0.00
5	46	-0.08	-0.12	37	-0.10	-0.14	42	0.01	0.03	34	0.07	0.03
6	24	-0.13	-0.17	19	-0.15	-0.19	16	-0.04	-0.08	21	0.12	0.16

**Base class = lambs born in the late wet season to a 4th parity dam*

LD, EW, LW, ED = late dry, early wet, late wet and early dry seasons respectively

Table 24. *Least-squares constants (LSC) and Additive correction factors (ACF) for birth weight (kg)*

			Male			Female		
Parity	Type of birth	Season[a]	No.	LSC	ACF	No.	LSC	ACF
1	Single	LD	80	0.11	0.45	62	0.23	0.57
		EW	89	-0.66	0.28	98	0.06	0.40
		LW	90	-0.22	0.12	49	-0.10	0.24
		ED	97	-0.04	0.30	94	0.08	0.42
	Twin	LD	16	0.49	0.83	26	0.61	0.95
		EW	35	0.32	0.66	33	0.44	0.78
		LW	14	-0.16	0.18	88	0.28	0.62
		ED	26	0.34	0.68	34	0.46	0.80
2	Single	LD	54	-0.06	0.28	71	0.06	0.40
		EW	62	-0.23	0.11	51	0.23	0.23
		LW	42	-0.39	-0.05	46	-0.27	0.07
		ED	63	-0.21	0.13	80	-0.09	0.25
	Twin	LD	13	0.32	0.66	19	0.44	0.78
		EW	22	0.15	0.49	34	0.27	0.61
		LW	12	-0.01	0.33	10	0.11	0.45
		ED	26	0.17	0.51	15	0.29	0.63
3	Single	LD	41	-0.14	0.20	50	-0.02	0.32
		EW	28	-0.31	0.03	28	-0.19	0.15
		LW	39	-0.47	-0.13	36	-0.35	-0.01
		ED	42	-0.29	0.05	46	-0.17	0.17
	Twin	LD	27	0.14	0.48	17	0.36	0.70
		EW	18	0.07	0.41	19	0.19	0.53
		LW	7	-0.09	0.25	10	0.03	0.37
		ED	19	0.09	0.43	25	0.21	0.55
4*	Single*	LD	24	-0.13	0.21	20	-2.01	0.33
		EW	19	-0.30	0.04	19	-0.18	0.16
		LW*	39	-0.46	-0.12	23	-0.34*	0.00*
		ED	21	-0.28	0.06	18	-0.16	0.18
	Twin	LD	15	0.25	0.59	18	0.37	0.71
		EW	18	0.08	0.42	18	0.20	0.54
		LW	15	-0.08	0.26	10	0.04	0.38
		ED	11	-0.10	0.24	7	0.22	0.56
5	Single	LD	12	-0.10	0.24	18	0.02	0.36
		EW	9	-0.27	0.07	16	-0.15	0.19
		LW	14	-0.45	-0.09	20	-0.31	0.03
		ED	13	-0.25	0.09	10	-0.13	0.21
	Twin	LD	17	0.28	0.62	13	0.40	0.74
		EW	11	0.11	0.45	9	0.23	0.57
		LW	10	-0.85	0.29	6	0.07	0.41
		ED	10	0.13	0.47	9	0.25	0.59
6	Single	LD	9	-0.21	0.13	4	-0.09	0.25
		EW	6	-0.38	-0.04	5	-0.26	0.08
		LW	6	-0.54	-0.20	8	-0.42	-0.08
		ED	9	-0.36	-0.02	6	-0.24	0.10
	Twin	LD	10	0.17	0.51	10	0.29	0.63
		EW	5	0.00	0.34	8	0.12	0.51
		LW	2	-0.16	0.18	5	-0.04	0.30
		ED	3	0.02	0.36	9	0.04	0.38

**Base class = Single female born in the late wet season to a 4th parity dam*

[a]Season: LW, EW, LW, ED = late dry, early wet, late wet and early dry seasons respectively

Table 25. *Least squares contants (LSC) and Additive correction factors (ACF) for 90-day weaning weight (kg)*

			Male			Female		
Parity	Type of birth	Season[a]	No.	LSC	ACF	No.	LSC	ACF
1	Single	LD	50	0.22	2.82	36	1.00	3.60
		EW	35	-0.72	1.88	42	0.06	2.66
		LW	33	-1.63	0.97	20	-0.85	1.75
		ED	61	0.03	2.63	57	0.75	3.35
	Twin	LD	10	2.54	5.04	14	3.32	5.92
		EW	13	1.60	4.20	14	2.38	4.89
		LW	1	0.69	3.29	4	1.47	4.07
		ED	11	2.29	4.89	13	3.07	5.67
2	Single	LD	40	-0.35	2.25	56	0.43	3.03
		EW	29	-1.29	1.31	29	-0.51	2.09
		LW	20	-2.20	0.40	24	-1.42	1.18
		ED	39	-0.60	2.00	48	0.18	2.78
	Twin	LD	4	1.97	4.57	7	2.57	5.17
		EW	10	1.03	3.63	9	1.81	4.41
		LW	3	0.12	2.27	4	0.90	3.50
		ED	7	1.72	4.32	6	2.50	5.10
3	Single	LD	39	-0.98	1.62	39	-0.20	2.40
		EW	12	-1.92	0.68	17	-1.14	1.40
		LW	28	-2.83	-0.23	21	-2.05	0.55
		ED	27	-1.23	1.37	35	-0.25	2.15
	Twin	LD	16	1.34	3.94	10	2.12	4.72
		EW	9	0.40	3.00	9	1.18	3.78
		LW	6	-0.51	2.09	3	0.27	2.87
		ED	8	1.09	3.69	13	1.87	4.47
4*	Single	LD	23	-1.53	1.07	18	-0.75	1.85
		EW	12	-2.47	0.13	12	-1.69	0.91
		LW*	29	-3.38	-0.78	16	-2.60	0.00*
		ED	13	-1.78	0.82	14	-1.00	1.65
	Twin	LD	8	0.79	3.39	12	1.57	4.17
		EW	5	-0.15	2.45	9	0.63	3.23
		LW	7	-1.06	1.54	6	-0.28	2.32
		ED	8	0.54	3.05	1	1.32	3.92
5	Single	LD	10	-1.02	1.58	17	-0.24	2.36
		EW	5	-1.96	0.64	8	-1.18	1.42
		LW	10	-2.87	0.27	13	-2.09	0.51
		ED	11	-1.27	1.33	8	-0.49	2.11
	Twin	LD	7	1.30	3.90	9	2.08	4.68
		EW	5	0.36	2.90	5	1.14	3.94
		LW	6	-0.55	2.05	1	0.23	2.83
		ED	5	1.05	3.65	4	1.83	4.43
6	Single	LD	7	-1.13	1.47	4	-0.35	2.25
		EW	5	-2.07	0.53	3	-1.29	1.31
		LW	3	-2.98	-0.38	3	-2.20	0.40
		ED	6	-1.38	1.22	3	-0.60	2.00
	Twin	LD	6	1.19	3.79	8	1.97	4.57
		EW	3	0.25	2.85	4	1.03	3.63
		LW	1	-0.66	1.94	0	0.12	2.72
		ED	2	0.94	3.54	7	1.72	4.32

**Base class = single female born in the late wet season to a 4th parity dam*

[a]Season: LD, EW, LW, ED = late dry, early wet, late wet cnd early dry seasons respectively

Accurately identifying genetically superior animals is not easy because the genotype of the animal is influenced to varying degrees by the environment as clearly demonstrated by this study. Measurements could only be made on the overall appearance of the animal, its phenotype (Croston and Pollot, 1985). The latter further observed that environmental influences are particularly important for prediction of breeding values. Litter size, birth weight and 90-day weaning weight currently studied were significantly ($P<0.005$) infuenced by parity, type of birth, sex of lamb, season and year of birth, accounting for 32.48%, 21.91% and 29.89% variation, respectively, as earlier indicated.

Review by Osinowo et al. (1993) showed that assessing genetic merit for lamb weights involves adjustments for dam's parity, lamb's sex and type of birth. The latter authors specified that an additional factor (season of birth) needs to be adjusted for since lambing frequently occur throughout the year.

Additive and multiplicative adjustment factors for these effects on 90-day weaning weights have been reported using a small data set in Yankasa sheep (Hassan, 1987 and Osinowo et al., 1993b). Both findings showed that the additive model yielded lower residual standard deviation than the multiplicative model, hence, its superiority. It was further recommended that these values will need to be revised as larger data sets become more available for Yankasa breed to increase their accuracy, pointing to the basis of this study.

Despite the fact that the heaviest lamb subclass came from male lambs born in the late wet season to sixth parity dams for birth weight, additive adjustment factors were derived to the equivalent of a single female lamb born to a fourth parity ewe in the late wet season. It is obvious from the number of observations within each subclass that most ewes are likely to approach fourth than sixth parity. Osinowo et al. (1993b) suggested single born females in the late wet season to fifth parity dams which compares favourably with the present observation, taking into cognizance that both groups identify with older ewes as literature indicates.

4.7 *Estimates of genetic and phenotypic parameters for reproductive traits*

Table 26 represents a summary of estimates of genetic and phenotypic parameters for reproductive traits obtained from this study.

Table 26. *Estimates of heritabilities (h^2), genetic (r_g), phenotypic (r_p) and environmental (r_e) correlations between reproductive traits in Yankasa sheep*

Trait	No.	h^2±SE	r_g±SE	r_p	r_e	Variance or covariance: Among	Within
Litter size (LS)	243	0.07[a]					
Birth weight (BWT)	1040	0.41±0.08[b]				0.03	0.47
Litter birth weight (LBWT)	1189	0.12±0.07[b]				0.04	0.89
Weaning weight (WWT)	1016	0.59±0.12[b]				1.49	8.66
Gestation length (GL)	1196	0.21±0.08[a]				0.26	1.81
Gestation length (GL)	269	0.15±0.12[a]				0.38	9.63
Lambing interval (LI)	232	0.73±0.26[b]				886.75	2951.8
Age at first lambing (AFL)	131	0.09±0.21[b]				2543.39	10841.5
LS and BWT	219		-0.08±0.35[b]	-0.14	-0.34	-0.002	-0.12
LS and WWT	219		-0.25±0.53[b]	-0.34	1.32	-0.05	-0.29
LS and GL	219		-0.11±0.32[b]	0.02	0.52	-0.03	0.05
BWT and WWT	1016		0.69±0.16[b]	0.36	0.21	0.09	0.48
LBW and GL	1185		0.07±0.27[b]	0.09	0.09	0.01	0.25

[x]Lamb trait, [y]Dam trait, [a]Heritability by daughter-dam regression, [b]Heritability by paternal half-sib analysis

4.7.1 *Estimates of heritability for reproductive traits*

Heritability for litter size was estimated at 0.07 by daughter-dam regression, taking litter size as trait of the dam. Estimates for birth weight, litter birth weight and weaning weight by intra-class correlation using paternal half-sibs were 0.41±0.08, 0.12±0.07 and 0.59±0.12, respectively. Taking gestation length as a dam trait, heritability, estimated at 0.15±0.12 was found to be lower than when estimated as a foetal trait (0.21±0.08). Considering lambing interval and age at first lambing as traits of the dam, paternal half-sibs

method yielded heritability estimates of 0.73±0.26 and 0.99±0.38, respectively. With the exception of birth weight and weaning weight, which gave high heritability estimates, most traits considered had moderate to low estimates, with particular reference to litter size.

i. *Heritability estimate for litter size*

Heritability for litter size, eventhough estimated at 0.07 by daughter-dam regression, was comparable with 0.11 earlier obtained for Yankasa sheep by paternal half-sib method, taking litter size as a trait of the foetus (Osinowo et al., 1993a). Comparatively, the estimate was fairly close to 0.04 obtained by daughter-dam regression for multiple births of a synthetic breed from Australian Dorset, Border Leicester and Suffolk (Fahmy, 1990) and 0.09±0.06 for D'man (Boujenane et al., 1990). As expected, estimated heritability for litter size in this study falls within the range 0.03-0.09 suggested for African small ruminants (Wilson et al., 1989). Fraser and Stamp (1968) noted that individual prolificacy in an ewe is just as much a phenotypical character as the shape of her ears and as such may not be inherited at all. The range of heritability estimates for litter size reported in most literature is very narrow, with a generally acceptable value of 0-25% (Spedding, 1970). It was suggested that selection programme may only achieve annual increases of the order of 4% in the number of lambs born per ewe lambing.

ii. *Heritability estimates for birth weight (BWT), litter birth weight (LBWT) and adjusted weaning weight (AWWT)*

The heritability estimate for LBWT (0.12±0.07) compares with an estimate of 0.05±0.09 on the same farm from a smaller data set using paternal half-sib method (Osinowo et al., 1993). There is a possibility that slight differences in estimates might have been accounted for by differences in number of observations employed.

Estimates of 0.41±0.08 for lamb birth weight closely agreed with estimate of 0.46±0.08 from 931 lambings of Yankasa sheep (Osinowo et al., 1993b), but higher than most estimates earlier obtained including: 0.21±0.19 (Buvanendran et al., 1981), 0.22 for 357 records (Hassan, 1987), and 0.27±0.003 for 529 records on the same farm (Osinowo et al., 1990), while a high figure of 0.693±0.224 has been reported in Patanwadi sheep (Queshi and Shukla, 1990).

The highest heritability estimate (0.59±0.14) recorded on AWWT was higher than an estimate of 0.45±0.003 for 529 lambings of Yankasa sheep (Osinowo et al., 1990) but compares favourably with a more recent estimate of 0.66±0.15 recorded for 931 lambings of the same flock (Osinowo et al., 1993b). Hassan (1987) however had an exceptionally high estimate (1.14) for unadjusted data for the same breed. The current estimate was found to coincide with 0.58 for Romanov (Maria, 1992) but higher than most estimates from literature (Table 5).

It is clear from these observations that BWT and AWWT generally had higher estimates than LBWT. It is an indication that environmental factors in relation to additive genetic factors had more influence on LBWT than BWT and AWWT. Several reasons that could be attributable to the differences in estimates between earlier and current observations for BWT and AWWT include:

- Uncontrollable enviromental factors might have been responsible for low heritability values obtained in most studies.
- Current reported estimates were based on reasonably large number of degrees of freedom which were considered more reliable than estimates from smaller data sets.
- Since heritability is a function of genetic variance, any change in gene frequency will probably alter its value. It is possible therefore, for estimates to change with time depending on such factors as the action of genes, selection intensity, genetic drift and mutation (Turner and Young, 1969). It was further suggested that periodic re-estimation

of heritabilty for traits of economic importance should be implemented particularly for flocks under artificial selection.

It is clear from this study and earlier reports on heritability estimates on body weights in Yankasa sheep that phenotypic differences among individuals in BWT and AWWT are highly heritable based on the reasoning that heritability estimates of ≥0.3 are considered high, according to an arbitrary classification by Turner and Young (1969). Osinowo et al. (1993a) suggested that moderate to high response for weaning weight can be expected in Yankasa sheep, and also that selection for weaning weight is likely to lead to improvement in birth weight.

iii. *Heritability estimates for gestation length*

Taking gestation length as a foetal trait, Osinowo et al. (1993a) derived 0.21±0.11 which compares with the recent estimate (0.21±0.08) on the same farm, while both dam and foetal heritability estimates (0.21±0.08 and 0.15±0.12, respectively) were similarly close to 0.18~0.05 observed in Finnish Landrace, Outaouais, Rideaux, Canadian Suffolk ewes by Shrestha and Heaney (1990).

In sheep, both dam and foetus have been shown to play a significant role in bringing about the termination of the pregnant state of the ewe (Review by Hafez, 1975; Nara and First, 1981). The foetal - hypothalamic - pituitary - adrenal axis secretes large quantites of corticosteroids which enter the maternal circulation and stimulate the production of prostaglandin and also increase the concentration of unconjugated oestrogens from the maternal plasma. This is thought to inhibit the secretion of progesterone by the placenta in sheep, thus leading to a fall in progesterone levels at the onset of labor.

Heritability estimates for both foetal and maternal organisms for gestation length showed that low to moderate responses could be achieved in selection, especially when considered as a trait of the foetus. This agrees with the finding of Osinowo et al. (1993a),

who indicated that gestation length is to a significant extent determined by the foetal genotype though the trait is measured on the dam.

iv. *Heritability estimates for lambing interval (LI) and age at first lambing (AFL)*

Heritability estimates of 0.73±0.26 and 0.99±0.38 for LI and AFL respectively, recorded in the current study were considered over-estimates eventhough literature for Yankasa sheep was lacking to form a basis for comparison. When compared with estimates for other breeds, Iniguez et al. (1986) estimated 0.06 and 0.31 for LI and AFL, respectively, in Morlam and Dorset ewes, and Peric et al. (1986) obtained 0.06±0.08 and 0.28±0.22 for AFL in mixed and twin born Merinos, respectively. These values were considerably lower than values obtained in this study. From the foregoing methodology, mating was higly controlled for management reasons. Hence, these estimates were not considered quite reasonable for prediction of breeding values of the ewes for LI and AFL since a considerabe proportion of the environmental variation could not be taken care of.

4.7.2 *Estimates of genetic correlations between reproductive traits*

Genetic correlation between birth weight and weaning weight, estimated by paternal half-sib method was high and positive (0.69±0.16) as indicated in Table 26. With the exception of low but positive genetic correlation between litter birth weight and gestation length (0.07±0.27), most correlations indicated a real antagonism between desirable genetic traits. Estimates for litter size and birth weight, litter size and weaning weight and litter size and gestation length were -0.08±0.35, -0.25±0.33 and -0.11±0.32, respectively. Genetic correlations between litter size and weaning weight and litter size and gestation length were considered moderate, but low for litter size and birth weight.

Reported correlation coefficient of -0.29±0.53 for gestation length and litter size measured on the flock was fairly close and of the same bearing with the current estimate, indicating that selection for increase litter size would be associated with decrease in

gestation length as reported by Osinowo et al. (1993a). Though litter size did not affect gestation length to any significant extent (P>0.05), twin lambs were found to be associated with shorter pregnancy duration than singles, thereby confirming this relationship.

Low to moderate but negative genetic correlations of -0.08±0.35 and -0.25±0.33 were expected for litter size and birth weight, and litter size and weaning weight, respectively, on account of the inverse relation that has been shown to exist between litter size and body weights. Single born lambs were identified to be consistently heavier than twin lambs at birth and at weaning by several reports and the current study. This antagonistic relationship is an indication that selection for higher litter size will invariably result to lighter birth and weaning weights, and vice versa.

Osinowo et al. (1993a) reported an estimate of 0.93±0.98 for genetic correlation between litter birth weight and gestation length which was comparatively higher than 0.07±0.27 from this finding. The difference could be attributed to differences in data size and the error term associated with the estimation, or uncontrollable environmental factors.

Genetic correlation between birth weight and weaning weight of 0.69±0.16 was considered higher than an estimate of 0.29 for a smaller data set of Yankasa lambs (Hassan, 1987), but closer to a more recent estimate of 0.55±0.15 for Yankasa lambs (Osinowo et al., 1993b), while El-Karim and Owen (1988) had higher estimate of >0.58 for Shugor and Watish ewes of Sudan. The differences in estimates for Yankasa flock could be attributed to a larger data set utilized for this study, and the likelihood of an expected change in the degree of correlation with selection intensity within years as suggested by Turner and Young (1969). The genetic fraction of correlation has been thought to arise from linkage of genes affecting two traits, or from pleiotropic action of genes, which is considered to be a property of single genes and the most important contributor to genetic correlation.

4.7.3 *Estimates of phenotypic correlations between reproductive traits*

Phenotypic correlation between birth weight and weaning weight was high and positive (0.36), Table 26. The magnitude was similar to that of litter size and weaning weight (-0.34), and litter size and birth weight (-0.14) but negatively correlated. There were however low but positive phenotypic correlations between litter size and gestation length (0.02) and litter birth weight and gestation length (0.09).

Phenotypic correlation between birth weight and weaning weight falls within the range of 0.17-0.47 indicated by several reports (Buvanendran et al., 1981; Hassan, 1987; Hassan et al., 1991 and Osinowo et al., 1993b). Estimates of the same magnitude have been recorded in other breeds: 0.55 in Uda (Buvanendran et al., 1981), while higher estimate (0.68) was reported for English Leicester (Review by Hassan, 1967). High phenotypic correlation between birth weight and weaning weight in Yankasa is expected as it has been widely demonstrated that lambs of higher birth weight are more vigorous and weigh heavier at weaning (Hamada, 1976). Hence, moderate to high response to selection for traits can be expected (Osinowo et al., 1993b).

Phenotypic correlations between litter size and birth weight and litter size and weaning weight estimated at -0.04 and -0.34, respectively, were moderate to high values and negative as expected, due to the inverse relationship that exist between both traits already indicated in literature and the present study. This is an indication that selection for large litters will be accompanied by a decrease in birth weight and weaning weight, the converse being true.

Very low and positive phenotypic correlations between litter size and gestation length, and litter birth weight and gestation length estimated at 0.02 and 0.09 respectively, conflicted with low and negative estimate (-0.04) for litter birth weight and gestation length in Yankasa sheep obtained by (Osinowo et al., 1993a). Eventhough data size is likely to play a significant role in the estimation, it appears that these traits are lowly

correlated, phenotypically, and as such, have very low potential for exploiting correlated response.

4.7.4 ***Estimates of environmental correlations between reproductive traits***

Table 26 indicates that environmental correlations between birth weight and weaning weight (0.21) was moderate and positive, high for litter size and weaning weight (1.32), and litter size and gestation length (0.52), while very low for litter birth weight and gestatiuon length (0.09). There was high but negative environmental correlation between litter size and birth weight (-0.34).

Genetic and environmental correlations between litter size and birth weight (0.08±0.35 vs -0.34), birth weight and weaning weight (0.69±0.16 vs 0.21), and litter birth weight and gestation length (0.07±0.27 vs 0.09) were the same in sign and not very different in magnitude, which is a more usual situation as stated by Falconer (1989). Reported values for litter birth weight and gestation length (0.93±0.98 vs -0.16) in Yankasa sheep were similar in magnitude (Osinowo et al., 1993a). Genetic and environmental correlations between litter size and weaning weight (-0.05±0.33 vs 1.32), and litter size and gestation length (-0.11±0.32 vs 0.52) were however, different in magnitude and sign. Falconer (1989) indicated that a large difference of sign shows that genetic and environmental sources of variation affect the character through different physiological mechanisms.

Generally, correlations resulting from environmental causes is the overall effect of all environmental factors that vary. Some may tend to cause a positive correlation, while others cause a negative correlation. Estimate of environmental correlation takes into consideration the correlation of environmental deviations togather with non-additive genetic deviations. The latter author observed that phenotypic correlation is mainly determined by environmental correlation when both characters have low heritabilities, while genetic correlation is more important when both characters have high heritabilities.

CONCLUSION

- Yankasa is slow maturing and a lowly prolific breed of sheep.
- The effect of parity, sex of lamb, type of birth and season of birth are more important in sheep productivity, in terms of litter size, birth weight, litter birth weight and weaning weight.
- Performance of dam improved with parity for litter size, birth weight, litter birth weight and weaning weight.
- Productivity in terms of number of lambs born per ewe lambing was better in the dry season than in the rainy season, while the converse was true for body weights.
- Single born lambs and males were consistently heavier at birth and at weaning than twin born lambs and females, respectively.
- Litter birth weight increased with increase in litter size signifying that multiple births are highly desirable.
- Younger ewes have shorter gestation lengths than older ewes.
- Selection for large litters will be accompanied by decrease in birth weight, weaning weight and gestation length.
- Response to selection for litter birth weight and gestation will be low due to moderate to low heritability estimates.
- Heritability estimate for litter size was very low, indicating low response to selection, while significant progress could be made in selecting for either birth weight or weaning weight due to high heritability estimates and correlated responses.

RECOMMENDATIONS

- Adjustment for environmental effects on litter size, birth weight, litter birth weight and weaning weight is neccessary to recognize their genetic differences for accuracy of selection in a breeding population.

- Breeding ewes should be exposed to rams in the late wet to early dry seasons such that lambing will preceed the rains, because of serious nutritional implication in the late dry season. It is thought that higher ovulation rate will be established during these seasons characterized by feed availability.

- More rapid improvement in litter size could be achieved through crossbreeding with high fecundity breeds.

- For estimates of additive adjustment factors to be more reliable, periodic re-estimation with larger data sets should be embarked upon. This also applies to genetic parameters since present estimates are subject to change depending on factors such as environmental changes, selection, genetic drift and mutation.

- For more accurate estimates of heritability for lambing interval and age at first lambing, it is suggested that a separate flock should be raised, whereby selected ram(s) will have access to breeding ewes throughout their reproductive life. This will check a greater proportion of the total variation accounted for by environmental control.

- Improvement in management practices with more emphasis on feeding and disease control should further increase productivity.

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