Institut für Nutztierwissenschaften
der Landwirtschaftlich-Gärtnerischen Fakultät
der Humboldt-Universität zu Berlin

DISSERTATION

Comparative performance evaluation of Horro and Menz sheep of Ethiopia under grazing and intensive feeding conditions

Zur Erlangung des akademischen Grades
doctor rerum agriculturarum (Dr. rer. agr.)

eingereicht an der Landwirtschaftlich-Gärtnerischen Fakultät
der Humboldt-Universität zu Berlin

von
Kassahun Awgichew
(M.Sc., Animal Science, University of Wales, UK)

Präsident der Humboldt-Universität zu Berlin
Prof. Dr. Jürgen Mlynek

Dekan der Landwirtschaftlich-Gärtnerischen Fakultät
Prof. Dr. Dr. h. c. E. Lindmann

Vorsitzender der Prüfungskommission
Prof. Dr. Konrad Hagedorn
Gutachter:1. Prof. Dr. K. J. Peters

2. Prof. Dr. G. Seeland
weitere Mitglieder der Prüfungskommission
1. Dr. Claudia Kijora
2. Dr. T. Hardge

Tag der mündlichen Prüfung: 20. 12. 2000

Dedication

This work is dedicated to my parents; my father Ato Awgichew Ayalew and my mother Woizero Elfinesh Kidanemariam and to my wife Woizero Etabezahu Eshetu and our children Henok, Mahlet and Bezaye.

ACKNOWLEDGEMENTS

I would like to express my deepest respect and most sincere gratitude to my supervisor, Prof. Dr. K. J. Peters, for his guidance and encouragement at all stages of my work. His constructive criticism and comments from the initial conception to the end of this work is highly appreciated. I am greatly indebted to his assistance and understanding in matters of non academic concern which have helped me endure some difficult times during my study period.

I am thankful to Prof. Dr. G. Seeland for willingly accepting to evaluate my Thesis and sit in the examination committee. I thank Dr. T. Hardge and Dr C. Kjora who were members of the examination committee and Prof. Dr. K. Hagedorn for willingly accepting to chair the committee.

I am very grateful to the International Livestock research Institute (ILRI) formerly ILCA, International Livestock Centre for Africa, for providing me the experimental animals and for allowing me to use its computer, library and laboratory facilities. My most sincere thanks and appreciation are also due to the staff of ILRI's experiment station at Debre Birhan for managing the experimental flock and for their tireless assistance in the data collection process. My heart felt thanks also go to the staff of the animal nutrition laboratory of ILRI in Addis Ababa for their kind assistance in analytical work.

My deep gratitude also goes to Dr. Ed Rege for his guidance and assistance as co-supervisor and for allowing his staff to help in the data collection and compilation.

My thanks and appreciation also go to the German Academic Exchange Service (DAAD) for giving me the scholarship which enabled me to undertake this study. The financial support I received from Humboldt University of Berlin at the latter part of my study is also highly appreciated. I am very grateful to Dr. Ursula Grawert of the International Students Office of Humboldt University for her kind consideration and support.

I am also deeply indebted to Dr. Ulrike Funke and Mr. Christian Funke for their constant encouragement and support throughout. Without their unreserved support completion of this work would not have been possible.

The support and encouragement I received from Dr. C. Kijora is highly appreciated. I would like to express my gratitude to Dr. Birgit Zumbach not only for her constant encouragement but also for reading and editing the manuscript, for her help in translating the summary to German and in the preparation of the transparencies required for the defence. My sincere thanks also go to Mrs. Friedlieb and Mr. Seekamp of the Faculty's computer centre in Dahlem for their help in data management.

I am also indebted to express my gratitude to Mrs F. Treitz, Mrs. J. Lenk, Mr. Patrik Simon and the other staff members of the department of Animal Breeding in the Tropics and sub-Tropics who have helped me in many ways throughout. I thank Mr. Solomon Melaku for reading and editing the manuscript. I also wish to thank Miss R. Döfler, Mr. N. Boonbrhan, Mr. M. B. Enoh for their encouragement. The support and encouragement I received from Mrs. M. Heller and all the other members of the Institute's animal nutrition laboratory is also highly appreciated.

My deep appreciation also goes to Dr. Getaneh Bitew and his wife Yeshifana Genet, Dr. Melesse Agegnehu, his wife Aberash Wolansa and their daughter Tsellot, Br. Seifu and his wife Misrak and all the other brothers and sisters at the Bethelehem church, who are many to name here, for their love and hospitality I received throughout. May GOD bless them all.

I also wish to express my heart felt thanks to Mr. Günther Fuhr for his unreserved help and services he gave not only for me but also to my friends and colleagues. My thanks also go to all my friends in Berlin, who are many to name here, for their support and encouragement.

I am also very grateful to all my friends and colleagues in Ethiopia, who have supported my wife and our children in many ways during my absence and made it possible for them to endure the loneliness they had for so long. My thanks specially go to Dr. Alemu G. Wold and his family, Mr. Tesfaye Zegeye and his family, Mr. Daniel Mamo and his family, Dr. Zinash Sileshi and her family, Mr. Siraj and his family, Mrs. Birhane Worku and her husband Mr. Tadesse, Mrs. Roman Venchezo and her family, Dr. Girma Abebe and his family and all the others who are many to name here for supporting my family while I am away.

A very special appreciation is due to my wife Etabezahu Eshetu not only for her constant encouragement but also for her patience and understanding throughout. May GOD bless her in all her endeavours because without her unreserved support, completion of this study would not have been possible. I am also greatly indebted to our son Henok and our daughters Mahlet and Bezaye for enduring my absence for so long and giving me their love and encouragement throughout.

Table of contents

List of Tables

List of figures

List of Abbreviations

A.O.A.C. = Association of Official Analytical Chemists
ADG = average daily gain
BL = body length
C = constant
C.V. = coefficient of variation
CATMOD = SAS procedure for categorical models
cc = cubic centimetre
CDM = dry matter of concentrate feed
cm = centimetre
CP = crude protein
CSA = Central statistics authority
D = number of fattening days
df = degrees of freedom
DNA = deoxyribonucleic acid
DM = dry matter
DMI = dry matter intake
EBW = empty body weight
EE = ether extract
FAO = Food and Agricultural Organization of the United Nation
FBW = fasted body weight
Fin. = Finish landrace
FWT = final body weight
g = gram
GIT = gastro-intestinal-tract
GDP = gross domestic product
GITEE = ether extract estimate of gastro-intestinal-tract
GLM = SAS procedure for general linear models
GUFEE = ether extract estimate of gut fat
HDM = dry matter of hay
HG = heart girth
I.A.R. = Institute of Agricultural Research
ID = identity number

ILCA = International Livestock Centre for Africa
Ile de Fr. = Ile de France
ILRI = International Livestock Research Institute
IMF = inter-muscular fat
IWT = initial body weight
KCF = kidney and channel fat
kg = kilogram
$kg^{0.75}$ =kilogram metabolic body weight
km = kilometre
LC = left carcass
LEANEE = ether extract estimate of lean
LSMEANS = least squares means
m.a.s.l. = meter above sea level
ME = metabolizable energy
MJ = mega joule
ml = millilitre
mm = millimetre
MT = Metric Tonnes
n = sample size
na = not available
Pr = probability
PROC = SAS procedure
r = correlation coefficient
R^2 = coefficient of determination
Ramb. = Rambouillet
Reg = regression
RENFEE = ether extract estimate of renal fat
RHDM = dry matter of refused hay
rpm = revolution per minute
RUMPFEE = ether extract estimate of rump fat
SAS = Statistical Analysis System
se = standard error
Sig. level = significance level
spp. = species
SUBCFEE = ether extract estimate of subcutaneous fat

Subcut. Fat = subcutaneous fat
Suff. = Suffolk
SUNDTEE = ether extract estimate of sundry trimmings
Tail V (l) = tail volume of live animal
Tail V (s) = skinned tail volume of slaughtered animal
TAILFEE = ether extract estimate of the tail
TL = tail length
TLRFWT = tail and rump fat weight
TOSFA = total subcutaneous fat
TOTEE = total Ether extract estimate
TOTFA = estimate of total dissectible body fat
Urogen. Fat = urogenital fat
UROGFEE = ether extract estimate of urogenital fat
VFC = voluntary feed consumption
Vol. = volume
vs = versus
WAD = West African Dwarf
WH = wither height
wt. = weight

1. INTRODUCTION

Locally available breeds of livestock are important economic resources since they are adapted to the existing production constraints such as feed shortages, prevalent diseases, etc. The productivity of indigenous breeds is low compared to temperate breeds, but their ability to survive and produce in the harsh and mostly unpredicted tropical environment is remarkable.

According to de Leeuw and Rey (1995), more than 55 % of the total livestock wealth of Africa is concentrated in Eastern Africa.

In Ethiopia livestock production accounts for nearly 15 % of the total GDP and about 40 % of the agricultural GDP (Sendros and Tesfaye, 1998). This does not include the contribution of livestock to the national economy in terms of draught power, manure and transport services.

Export of livestock and livestock by-products have also appreciable contribution to foreign exchange earnings of the country amounting to about 15 % and 70 % of all export earnings and earnings from agricultural exports excluding coffee respectively. The annual off take rate for sheep is estimated to be 40 % with an average carcass weight of about 10 kg (FAO, 1996) which is the second lowest amongst sub-Saharan African countries.

The highlands of Ethiopia account for not only over 60 % of the highlands of eastern and southern Africa, but also about 80 % of the livestock mass of the region (de Leeuw and Rey, 1995). They have also indicated that this is due to a larger proportion (more than 80 %) of cattle in the zone, the majority of which are oxen required for traction purposes.

Small ruminant production is an important agricultural enterprise in Ethiopia. It is estimated that Ethiopia has 25.4 million sheep (Beyene Kebede, 1998). However, a census conducted during the 1994/95 Agricultural Sample Survey by the Central Statistics Authority (CSA) indicates that there are only 12 million sheep (CSA, 1996). This survey excluded Eritrea and did not cover the entire Somali region of Ethiopia, which partly explains the lower estimate than the previous one. Since it is assumed that some 70-75 % of Ethiopia’s sheep population is found in the highlands (I. A. R., 1991; de Leeuw and Rey, 1995), Ethiopia’s current sheep population including the Somali region could be about 20 million.

Although the total annual mutton and lamb production in Ethiopia has been decreasing by about 5 % over the last eight years (Table 3), it is still the largest volume of meat produced (about 80000 MT) in major sheep producing countries except South Africa. This could mainly be attributed to the high population size rather than productivity per head.

The decrease in sheep population could mainly be due to the shrinking of available grazing land and the expansion of cropping area in intensively cultivated areas as a result of growing human population pressure. It could also be due to the effect of recurrent droughts in drier parts of the country; or simply due to unreliable estimates as there has not been any proper livestock population census conducted in the country.

In the highlands, sheep are kept in small flocks of about 5 sheep per household by nearly 40 % of all smallholders. However, at higher altitudes (2800-3000 m) one can find flocks with 30 to more than 100 sheep.

Sheep production in the crop/livestock production systems of the highland areas has a very important role in contributing to the food security as well as in generating direct cash income.

Although Ethiopia is endowed with the largest livestock genetic resource in Africa, so far very little has been done to identify and characterise the genotypes existing in the country (Setshwaelo, 1990).

This study was undertaken to make a comparative evaluation of two indigenous highland sheep breeds. Such an evaluation is particularly useful in generating information which could be used in characterising locally available breeds and to develop breed improvement strategies.

Among the local highland sheep population , Horro and Menz are the most important breeds. Therefore, it is assumed that the information generated through this study will contribute to the proper characterisation and evaluation of these two important highland sheep breeds of Ethiopia under two different management systems to estimate performance abilities and improvement potentials.

It is estimated (I. A. R., 1991) that most of the local sheep breeds have a very low post-weaning average daily gain of about 50 g. In Ethiopia, most sheep are slaughtered at about 12 months of age with live weights of 18-20 kg. This shows that there is scope for improvement through improved management practices such as improved feeding and health care practices.

The objectives for performance evaluation of tropical goat breeds stated by Peters (1988) could also be applied for other tropical breeds of livestock. It is assumed that the low productivity of livestock is a combined effect of poor management, limited feed resources and high disease pressure. In such circumstances, it may not even be possible to exploit the existing genetic potential.

As reported by Wilson (1988), the awareness in recognising the value and the contribution of small ruminant production to a stable and sustainable food production in Tropical Africa has grown quite substantially in the last decade. Such positive development efforts need to be supported through appropriate research and development activities to enhance productivity of locally available breeds by minimising the prevailing production constraints.

It is necessary to have an understanding of pertinent performance abilities of breeds through a comprehensive collection of information on the breeds or types of small ruminants to be improved in terms of the identified production parameters. Therefore this research has been carried out as part of an ILCA (now ILRI) Pan-African research programme designed to investigate and characterise genetic resistance to endoparasites in some indigenous small ruminants in sub-Saharan Africa.

Objectives

The overall objective of this study is to generate information on the relative performance of Horro and Menz sheep under station managed conditions.

The following specific objectives are considered.

i. **To estimate and compare between breed differences in:**
   Growth rate
   Linear body measurements
   Fattening performance of male Menz and Horro lambs
   Carcass and non-carcass parameters
   Fat deposition characteristics

ii. To relate linear body measurements to growth traits and carcass performances

2. LITERATURE REVIEW

2.1. Approaches to animal genetic resource evaluation

There are nearly 210 million sheep in the World (FAO, 1996). Sheep together with the other classes of livestock make a substantial contribution to the well being of multitudes of people around the World in the form of meat, milk, fibre and skin. As indicated by the FAO, (Tables 1, 2 and 3) sheep production contributes substantially to the agricultural economy of Sub-Saharan Africa. Their role is more prominent in developing countries than in developed ones. Ponzoni (1992), has reported that currently there seems to be a greater awareness of the need to identify, characterise, preserve and improve indigenous breeds which are thought to have some valuable attributes that could be used at present or some time in the future.

Man has, for a long time, been manipulating and altering the genetic composition of livestock through crossbreeding, selection and inbreeding. Recently, biotechnology is becoming more and more popular as a powerful tool for changing the genetic composition of animals (Madalena, 1993). However, genetic material cannot be synthesised and genetic improvements will still be dependent on the best possible combinations of existing DNA showing that animal genetic resources are invaluable natural resources which must be properly managed for efficient resource utilisation now and be preserved for future use.

According to Lahlou-Kassi (1987) and Peters (1989), a comparative small ruminant performance evaluation will address the following issues:

a) Adaptation traits- these are some of the most important phenotypic traits which in one way or another might influence the adaptability of the animal to the prevailing environmental conditions (tolerance to diseases, parasites, heat, etc.)

b) Reproductive traits (female reproduction performance such as age at puberty and first lambing, conception rate, prolificacy, male reproduction performance, etc.)

c) Production traits (birth and weaning weight, growth rate, carcass yield and quality, fibre yield and quality, etc.) and survival rate

The usefulness of genetic diversity among livestock breeds in enabling producers to meet new goals in animal production which arise from the changes in consumer demands and also changes in economics of livestock production has been known for long (Dickerson, 1969).

In developing countries, livestock genetic resources in general have not been adequately characterised, evaluated or fully utilised through selection and in some cases local populations are threatened with extinction before their genetic value is even properly described and studied (Madalena, 1993).

Although the principles on which to base accurate selection decision for determining the genetic merit of animals is a well established fact, the absence or inadequacy of a well documented genetic parameter estimation of indigenous breeds makes it very difficult to develop reliable and sustainable selection indices for livestock breeding in developing countries (Timon, 1993). Similar to the other classes of livestock, the genetic diversity in sheep can be expanded by the development of synthetic breeds through crossbreeding to combine the most important traits of economical and adaptation significance (Maijala and Terrill, 1991). The role played by geographic isolation in influencing between breed differences in relation to special products, characteristics, and phenotypic appearances has also been emphasised (Maijala and Terrill, 1991). They have stated that the most important between breed variation observed was the specific adaptability of breeds to the prevailing climatic and feeding conditions within ecosystems, and these ecosystems range from sparse to ample feed and forage, desert to high humidity, from sea level to high mountains, from the Equator to the northern- and southern hemispheres.

Developing countries including those in Africa have attempted to introduce improved breeds of both sheep and goats to bring about genetic improvement without even adequately investigating the merits of local breeds. According to Ponzoni (1992), this has resulted not only in the reduction of the population of the indigenous breeds but also in endangering the existence of the local genetic material.

The choice of the right type of animal to be raised in an area where it is best adapted results in higher productivity (Madalena, 1993). Therefore, the importance of environmental components such as improved management practices and nutrition in enhancing higher productivity should not be overlooked. Despite their low productivity, indigenous breeds not only survive but also produce under harsh and mostly uncertain environmental conditions.

Appropriate genotypes must be used in environments where they could best express their inherent genetic potential (Madalena, 1993). Attempts to improve the inherent genetic capacity of any livestock population beyond the scope of the nutritional or improved health care practices under which it is maintained will be counterproductive (Timon, 1993). As indicated by Laes-Fettback and Peters (1995) and Vercoe and Frisch (1987), it is necessary to identify the merit of available genetic resources, the possible integration of the animals into various production systems and to make effective use of their potential in order to quantify the existing breed differences in growth rate, growth potential and the response of the animals to different feeding challenges. Where feed supply is a major limiting factor, it is of paramount importance to look into both biological and economical factors affecting livestock productivity (Al Jassim et al. 1996).

The real value of indigenous breeds is often under-estimated mostly due to their poor appearance and relatively low productivity. As stated by Hodges (1990), developing countries in most cases opt for exotic breeds to increase animal productivity through crossbreeding or if conditions allow by breed substitution without properly investigating the production potential of the indigenous breeds. Peters (1989), has reported that there is an apparent lack of information regarding identifying production problems, possible intervention and performance of animals within the existing production systems to properly utilise the available genetic diversity to enhance production. This is particularly true in developing countries where breeds or types of livestock have not yet been fully identified and characterised, despite the fact that the indigenous breeds survive and produce under unfavourable environments and limited availability of feed, above all they are also parts of the prevailing production system.

Currently there is an understanding (Seré and Steinfeld, 1996) that introducing high-yielding breeds of livestock and specialised modes of production can lead to loss in genetic diversity among indigenous animals. However, in developing countries, the less intensive production systems are the mainstay of the existing species and breeds. It is, therefore, absolutely necessary to evaluate existing livestock genetic resources from a standpoint of bio-diversity and from the standpoint of matching available genotypes with the environment under which they are maintained.

2.2. Importance of small ruminant genetic resources in sub-Saharan Africa

Livestock production in the tropics and subtropics is mostly influenced by the seasonal scarcity and low quality of feed resources. African small ruminants make a substantial contribution to the well being of the people in the region through the supply of meat, milk, fibre, pelts draught power manure and cash (de Leeuw and Rey, 1995).

Table 1: Sheep population and production estimates for some sub-Saharan African countries1

Region/ Countries	Sheep population (‘000 head)				Mutton and Lamb production (‘000 MT)			
	1989-91	1993	1994	1995	1989-91	1993	1994	1995
Cameroon	3407	3770F	3780F	3800F	14	16F	16F	16F
Burkina F.	5049	5520	5686	5800F	11	11F	11F	11F
Ethiopia	23320	21700F	21700F	21700F	82	77F	78F	78F
Kenya	6447	5500F	5500F	5600F	25	22F	22F	22F
Mali	6072	4926	5173F	5173F	21	24F	24F	24F
Niger	3100	3465	3678F	3789	12	12F	13F	13F
Nigeria	12477	14000F	14000F	14000F	44	51F	51F	51F
Sudan	20179	22700F	22800F	23000F	70	75F	76F	76F
Somalia	12117	1100F	13000	13500F	30	26F	33F	34F
South Africa	32060	28930	29134	28784	133	125F	119	110
Tanzania	3551	3828*	3955*	3955F	10	11F	11F	11F
Uganda	1350	1760*	1850F	1900F	7	9F	9F	9F
Zimbabwe	584	420F	450F	487	1	na	na	na
Africa	201032	202856	207279	211612	893	930	947	950
World	1172331	1102221	1089749	1067566	6942	7047	7188	7012

[1] Source: FAO Yearbook. Production. Vol. 49, 1995; F = FAO estimate; * = unofficial figure; na = not available; MT = Metric Tonnes

Table 2: Estimate of annually slaughtered sheep and carcass yield per animal in some selected sub-Saharan African countries1

Region/ Countries	Mutton and Lamb production							
	Slaughtered ('000 head)				Carcass weight (kg/animal)			
	1989-91	1993	1994	1995	1989-91	1993	1994	1995
Cameroon	1183	1343F	1350F	1360F	12	12	12	12
Burkina F.	1205	1250F	1250F	1250F	9	9	9	9
Ethiopia	8173	7812F	7812F	7812F	10	10	10	10
Kenya	2116	1810F	1810F	1850F	12	12	12	12
Mali	1650	1900F	1950F	1950F	13	13	13	13
Niger	737	763F	782F	800F	17	16	16	16
Nigeria	4033	4600F	4600F	4600F	11	11	11	11
Sudan	4372	4700F	4750F	4800F	16	16	16	16
Somalia	2320	2000F	2500F	2600F	13	13	13	13
South Africa	10101	9754*	9565*	9400F	13	13	12	12
Tanzania	817	880F	910F	910F	12	12	12	12
Uganda	473	616*	648F	665F	14	14	14	14
Zimbabwe	42	34	35	35F	14	14	14	14
Africa	65936	68893	69998	70674	14	13	14	13
World	465307	472442	479525	477012	15	15	15	15

[1] Source: FAO Yearbook. Production. Vol. 49, 1995; F = FAO estimate; * = unofficial figure

Despite their relative low productivity due to genetics or environmental constraints or both, small ruminants play an important role in the agricultural economy of sub-Saharan Africa. As indicated by Winrock International (1983), small ruminants could be an important component of the mixed crop-livestock production system of Sub-Saharan Africa and other tropical regions.

Local livestock populations have adapted to the various ecological niches, thus, a large variety of regional breeds or types exist. They play a very important economic role particularly in regions where subsistence farming are practised due to the limitations in input supply capability in such systems.

Livestock production is an important enterprise in Eastern Africa where about 56 % of Africa's livestock wealth is maintained (Winrock International, 1992).

Table 3: Annual sheep productivity dynamics (Δ %) in some East African countries*

Country/ Region	Sheep Population			Mutton and lamb production					
				Total annual output			Yield/animal slaughtered		
	(‘000 head)	(Δ %)	(Δ %)	(‘000 MT)	(Δ %)	(Δ %)	kg/year	(Δ %)	(Δ %)
	1987	1989-91	1995	1987	1989-91	1995	1987	1989-91	1995
Ethiopia	23400	-0.34	-7.26	82	0.00	-4.88	9.5	+5.26	+5.26
Kenya	7200	-10.46	-22.22	26	-3.85	-15.38	12.3	-2.44	-2.44
Somalia	13195	-8.17	+2.31	32	-6.25	+6.25	17.2	-24.42	-24.42
Sudan	18500	+9.08	+24.32	102	-31.37	-25.49	18.5	-13.51	-13.51
Tanzania	4500	-21.09	-12.11	12	-16.67	-8.33	13.2	-9.09	-9.09
Uganda	1883	-28.31	+0.90	11	-36.36	-18.18	17.8	-21.35	-21.35

*Adapted from FAO (1995) and FAO (1996)

According to Seré and Steinfeld (1996), per capita beef and small ruminant meat production capacity in the highland zone of sub-Saharan Africa is only about 43 % and 50 % respectively of the World average which is 39.6 kg beef and buffalo and 6.8 kg sheep and goat meat per head/year. In the Mixed Rain-fed Temperate and Tropical Highlands System for which Ethiopia is a representative country, the per capita sheep and goat meat production is only 46 % (3.6 kg/head) compared to the World average of 7.8 kg/head.

Breed differences initially arise from adaptation to environmental circumstances. Further differences are caused by random drift, migration, mutation, natural selection or targeted selection. According to Bradford and Berger (1988), natural selection favours the development of animals with a balance among reproduction, growth rate, and maintenance requirements in environments where adaptation plays a critical role. Crossing locally available and well adapted breeds with selected high performance breeds could disturb the balance, leading to a loss of adaptation. Therefore, the possibility of altering the genetic potential of animals well adapted to a particular environment is limited unless environmental constraints are minimised.

In most African countries, the annual variation in rainfall and feed availability coupled with seasonal fluctuations in forage availability is highly substantial. This factor is believed to represent the highest check on livestock production and reproduction in the low-input and low-output traditional livestock production systems. In the dry areas, it is often difficult and sometimes uneconomical to make attempts to improve feed resources. It is therefore clear that most livestock production systems in Africa will continue to be primarily dependent on natural forages. In such circumstances, the extent to which productivity can be improved depends on the ability to identify breeds which are best adapted to the prevailing seasonality and also have the potential of economically important characteristics. Although the available data on African sheep studied clearly show their outstanding characteristics for adaptability to harsh environments as indicated by Turner (1991), more efforts must be done to identify and characterise indigenous breeds in terms of best adaptive performance abilities.

Since there are several limiting factors, economic, social or otherwise, to alter the livestock production environment for high yielding improved or temperate breeds, the continuous improvement of the indigenous breeds for higher productivity can never be over emphasised (Setshwaelo, 1990).

The economic benefit of sheep production could be enhanced by increasing the efficiency of growth to the desired market weight. As explained by Ruvuna et al. (1992), the existence of breed differences in carcass characteristics allows the choice of breeds to match specific production objectives. This would demand a strategic identification and improvement practices focussing on existing breeds.

It has been known for long (Bradford and Berger, 1988; Dickerson, 1969) that the most effective livestock improvement can best be attained by effectively using the animals already adapted to a particular environment. As defined by Terrill and Slee (1991), adaptability is the ability to survive and be productive under whatever environment or combination of environments at which the animals are maintained. Breed comparisons of adaptability and productivity should therefore be done in comparable conditions pertinent to the prevailing production environment.

The identification of adapted breeds, which are relatively superior in important productivity indices will provide means of enhancing production at no additional input costs. However, there will always be a need to address the whole question of the relationship between the nature of the production environment and the objective of breeding programmes in the context of the level of production and adaptation. Dickerson (1973) has reported that, multiple births and long breeding seasons in meat sheep can be beneficial and could also reduce costs of breeding flocks if appropriate nutrition, housing and labour are provided, but not under stressful range conditions.

Local breeds or types of livestock, particularly those in sub-Saharan Africa, should be compared under extensive roughage feeding condition to see if they have real differences in their response to the seasonality of pasture availability. Results from such studies will be useful in selection programmes through which animals may be identified which are highly adapted to the harsh environmental conditions and are most efficient producers. However, production potential could only be assessed under higher level of management practices whereby external stresses such as diseases, parasites, feed limitations, etc are curtailed or minimised.

The identification of adapted breeds, which are relatively superior in important productivity indices, will provide means of enhancing production at no additional input costs. However, there will always be a need to address the whole question of the relationship between the nature of the production environment and the objective of breeding programmes in the context of the level of production and adaptation.

2.3. Birth weight, lamb weight development and average daily weight gain (ADG)

2.3.1. Birth weight

Birth weight is strongly influenced by breed (genotype), sex of lamb, birth type, age of dam, feeding conditions, season of birth and production system (Gatenby et al. 1997; Rastogi et al. 1993; Gatenby, 1986; Tuah and Baah, 1985; Dickerson et al. 1972). Birth weight of animals is one of the most important factors influencing the pre-weaning growth of the young. Martinez (1983) has reported a positive correlation between birth weight and subsequent live body weight development in sheep. In another study (Gatenby, 1986), it is stated that lambs heavier at birth grow faster than light weight lambs. Lambs which are heavier at birth are usually singles or are those produced by ewes with larger body sizes and good feeding conditions. The indication is that lambs heavier at birth have larger adult weight and a higher growth capacity. Improvement in birth weight is known to have a positive influence on other productivity parameters. The significant effect of birth weight on weaning and six month weight, growth rate and on weight at slaughter has been reported by Khan and Bhat (1981) who have worked on Muzaffarnagris sheep and their crosses with the Corriedales.

Birth weight which itself is affected by dam size, dam body condition and litter size influences the survival rate and pre-weaning growth performance of offspring's as confirmed by Laes-Fettback and Peters (1995). They have observed that kids born to relatively heavier does and those which had heavier birth weight among the multiple born kids had a better chance of survival. Other researchers (Notter et al. 1991) have also reported that birth weight of lambs is greatly influenced by production system, lamb sex, ewe effects and ewe x season interaction.

2.3.2. Lamb weight development and average daily weight gain (ADG)

Growth in animals is defined by an increase in body cells and by growth and differentiation of body cells (Bathaei and Leroy, 1996; Orr,1982). Growth-rate and body size along with changes in body composition are of great economic importance for efficient production of meat animals. Berg and Walters (1983) have reported that fast growing lean cattle breeds are more efficient in converting feed energy to lean tissue than those which are slow growing fatter breeds. According to Bathaei and Leroy (1996), animal growth could be expressed as the positive change in body weight per unit of time or by plotting body weight against age. In another study (Gatenby, 1986), it is reported that growth in animals is mostly measured by the increase in live weight leading to changes in body form and composition. As stated by Orr (1982), live weight increase in livestock is the gross expression of the combined changes in carcass tissues, organs, viscera and gut fill. The increase in body mass of farm animals is primarily a reflection of the growth of carcass tissues consisting of lean, bone and fat.

Growth rate of lambs, particularly during the early stages of growth, is strongly influenced by breed (genotype), milk yield of the ewe, the environment under which the animals are maintained including the availability of adequate feed supply in terms of both quantity and quality (Bathaei and Leroy, 1996; Burfening and Kress, 1993; Gatenby, 1986; Notter and Copenhaver, 1980). In another study (Laes-Fettback and Peters, 1995), it has been reported that pre-weaning growth performance is also influenced by birth weight.

As stated by Owen (1976), growth rate of lambs increases until the point of inflection which is attained when the animals are between one and five months of age. After this point is reached, the animals continue to increase in weight but at a declining growth rate as they approach maturity.

Growth performance of different sheep breeds kept in different countries and under different management conditions are compiled in Tables 4 and 5. Body weight and rate of weight gain compiled in the above tables for the various breeds of sheep indicate that performance of animals is influenced by the type of management under which they are maintained. Lower performance levels and relatively longer growing phases under field conditions and the contrary under station conditions are indicative of seasonal influences on performance levels.

Table 4: Growth performance of some African and other sheep breeds and crosses under field and station management conditions

Breed/ Breed Cross	Location/ Country	Management Type	Birth wt.(kg)	Body weight at (Age range in days)				Source
				30-80	90-120	150-180	365	
African breeds								
Adal (Afar)	Ethiopia	Station	2.5	na	13.0	18.4	25.8	Galal, E.S.E. 1983
African Fat Tail	Rwanda	Station	2.6	6.3	11.9	17.0	31.0	Wilson and Murayi, 1988; Wilson, R.T. 1991
Blackhead Ogaden	Ethiopia	Station	2.7	na	14.2	17.7	24.8	Galal, E.S.E. 1983
Djallonke	West Africa	Station	2.0	4.7	10.0	10.9-16.6	18.6-23.2	Filius et al. 1985; Wunderlich, 1990
		Field	1.2-2.5	na	4.9-9.1	7.8-13.0	14.0-22.0	Filius et al. 1985; Wunderlich, 1990
Dorper	South Africa	Station	3.5-4.5	18.2	27.9	na	31.0-45.0	Schoeman and Burger, 1992
	Kenya*	Station	3.12	11.32	13.0	14.8	na	Bullerdieck, 1996
Horro	Ethiopia	Station	2.2-2.9	na	9.8-10.9	24.7	33.5	Yohannes Gojjam et al. 1998; Wilson, R.T. 1991
Macina	Mali	Station	2.7	5.9	10.3	14.4	24.4	Wilson, R.T. 1991
Four breeds (mean)	Mali	Field	2.8	6.0	11.8	16.1	27.2	Wilson, R.T. 1986
Menz	Ethiopia	Station	1.9-2.7	na	13.5	18.5	23.4	Mukasa-Mugerwa et al. 1994; Wilson, R.T. 1991
		Field	2.4	4.4	8.3	12.5	16.4	Niftalem Dibissa 1990
Mossi	Burkina Faso	Station	4.0	6.1	10.6	13.6	21.2	Wilson, R.T. 1991
Ossimi	Egypt	Station	2.0-4.0	na	18.9-19.4	na	33.5	Lahlou-Kassi 1987
Red Masai	Kenya	Station	2.7	6.1	10.5	13.7	22.6	Wilson, R.T. 1991
Other Breeds								
Barbados Blackbelly	Trinidad and Tobago	Station	2.8	na	11.2	na	na	Rastogi et al.. 1993
Blenheim grade	Trinidad and Tobago	Station	2.8	na	11.7	na	na	Rastogi et al.. 1993
Finn Sheep Crosses	USA	Station	3.9	16.7	na	42.5	na	Notter and Copenhaver, 1980
Merinolandschaf	Germany	Station	3.8-4.2	15.5	na	na	50.6	Mendel et al. 1989; Mendel 1988
Sumatra	Indonesia	Station	1.7	na	7.8	12.8	na	Gatenby et al. 1997
South Indian	Sri Lanka	Farm	1.8	na	6.6	11.8	19.3	Goonewardene et al. 1984

na= not available

In tropical and sub-tropical regions, where extensive grazing systems are practised, the growth rate of animals fluctuates because of the seasonality of forage availability. Forage based sheep production systems like those mostly found in the tropics and sub-tropics are usually associated with slower weight gains, but the total cost of gain may be less than those in the more intensive systems. To alleviate poor productivity performance or minimise the impact of fluctuations in seasonal forage growth patterns and feed availability, careful management practices are required. In such environments, lambs in their growing stages pass through weight gain and weight loss phases (Ehoche et al. 1992).

As expected, animals lose weight during the dry season where both the quantity and quality of forage available are limited (Velez et al. 1993). In his review, Wilson (1987) has observed that there exists very little information regarding factors affecting weight of small ruminants in sub-Saharan Africa. In his study on sheep and goats in Mali, he has indicated that these animals suffer less in seasonal feed fluctuations compared to cattle.

In another study, Vercoe and Frisch (1987) have reported that in tropical countries grazing animals have to withstand a range of environmental stresses which have supposedly multiple effects on growth. The authors suggest that in such circumstances, growth potential of animals under study could be estimated more accurately by measuring their growth rate under penned condition to minimise the environmental stresses. According to Vercoe and Frisch (1987), it is assumed that high growth potential is associated with low resistance to environmental stress and the nature of the relationship between the two factors need to be determined in order to enhance development of breeds that are tolerant or resistant to environmental stresses and which are economically productive. This could be realised through better management practices and select animals based on their weaning weight. The use of weaning weight as a selection index is reported by van Wyk et al. (1993). They have stated that the animal's weaning weight indicates its value at the desired marketing age.

Average daily weight gain and weaning weight are known to be significantly affected by the mothering ability of the dam. This is particularly important during the growth stages of lambs where there is more dependency on the milk production of the ewe rather than on forage. A similar trend was observed (Laes-Fettback and Peters, 1995) on Egyptian goats where breed and mothering ability of the doe have significantly influenced both the pre-weaning daily weight gain and the weight at 14 days of age.

A study on Caribbean sheep breeds (Rastogi et al. 1993) has indicated that average daily weight gain and weaning weight were significantly influenced by the mothering ability of the dam. Type of birth is also known to have significant influence on weaning weight and pre-weaning growth rate (Tuah and Baah, 1985).

The post-weaning growth rate of lambs is just as important as the pre-weaning growth performance. This should be particularly looked into if the main objective of the sheep industry is producing meat through lamb production. In general, it is considered (Gatenby, 1986) that if sheep did not reach their mature live weight, they will grow faster if provided with a better diet. In practice however, since the feed supply, particularly in the tropics is not constant throughout the year, growth rate of animals shows seasonal variation. This is more evident in the dry tropics where the growth curve for lambs is typically irregular due to losing and gaining of body weight.

In regions where nutrition is poor, a rapid growth potential of larger breeds will have no advantage since smaller breeds could grow as well or even better than lambs from large breeds (Gatenby, 1986).

Apart from breed, sex and castration are also known to affect growth-rate. Male lambs usually grow faster than females. Although castrated lambs seem to have a higher dressing % than entire lambs, castration at four weeks of age has resulted in a reduced growth-rate of lambs (Silva et al. 1980 cited by Gatenby, 1986).

Although there is very little information available comparatively evaluating average daily weight gain of lambs under station and farm rearing conditions, the summarised performance of some sheep breeds (Table 5) indicates that lambs show a better growth rate (Wunderlich, 1990; Filius et al. 1985; Wilson, 1991) under farm conditions. This could most probably due to heavier parasite burden and related health problems due to the confined husbandry in station rather than due to the inherent capability of the animals to grow fast.

Table 5: Average daily weight gain (ADG) of some African other sheep breeds and crosses under field and station management conditions

Breed/ Breed Cross	Location/ Country	Management Type	Birth wt.(kg)	Rate of average daily gain (g)			Source
				birth to3 months	3 to6 months	birth to12 months	
African breeds							
Adal(Afar)	Ethiopia	Station	2.5	116.7	60.0	63.8	Galal, E.S.E. 1983
		Field	2.4	na	na	92	Wilson, R.T. 1991
Blackhead Ogaden	Ethiopia	Station	2.7	127.8	38.9	60.5	Galal, E.S.E. 1983
Djallonke	West Africa	Station	2.0	39.0-120.0	0.6-25.5	na	Wunderlich, 1990
		Field	1.2-2.5	110.3	49.0-61.9	na	Filius et al. 1985; Wunderlich, 1990
Dorper	South Africa	Station	3.5-4.5	140	60.0	100.0	Schoeman and Burger, 1992
	Kenya*	Station	3.12	154	41	na	Bullerdieck, 1996
Horro	Ethiopia	Station	2.2-2.9	134.4	52.2	83.8	Yohannes Gojjam et al. 1998; Wilson, R.T. 1991
Macina	Mali	Station	2.7	84.4	na	59.5	Wilson, R.T. 1991
Four breeds (mean)	Mali	Field	2.8	na	na	66.9	Wilson, R.T. 1986
Menz	Ethiopia	Station	1.9-2.7	na	na	na	Mukasa-Mugerwa et al. 1994; Wilson, R.T. 1991
Mossi	Burkina Faso	Station	4.0	na	na	59.2	Wilson, R.T. 1991
Red Masai	Kenya	Station	2.7	73.0[a]	na	54.0	Wilson, R.T. 1991
Other Breeds							
Barbados Blackbelly	Trinidad and Tobago	Station	2.8	152.0[b]	na	na	Rastogi et al.. 1993
Blenheim grade	Trinidad and Tobago	Station	2.8	156.0[b]	na	na	Rastogi et al.. 1993
Finn Sheep Crosses	USA	Station	3.9	276.0[c]	241.6	na	Notter and Copenhaver, 1980; Notter et al. 1991
Merinolandschaf	Germany	Station	3.8-4.2	258.0[d]	na	na	Mendel et al. 1989; Mendel 1988
Sumatra	Indonesia	Station	1.7	67.8	55.6	na	Gatenby et al. 1997
South Indian	Sri Lanka	Farm	1.8	na	na	42.7	Goonewardene et al. 1984

ADG , birth to age (days): [a]150 ; [b] 56; [c]43; [d]42; na = not available; * = Least-squares means of body weight at birth, 60, 90,and 150 days of age

The first stage for improved productivity of the available sheep flock should focus on improving the feeding and reproductive management practices and provide better health services. Having done that, one could also plan for a long term genetic improvement through selection within the local flock or crossbreeding or both. To bring the changes anticipated, a better knowledge and understanding of the performance of the breeds available is necessary.

In order to maximise the utilisation of available breed resources, it will be highly beneficial if the performance of animals under investigation is tested within the prevailing production system (Peters, 1989; Lahlou-Kassi, 1987). However, this may not reflect the true genetic potential of the animals being studied. As reported by Peters (1989), it will be essential to study animals under controlled environment to quantify their genetic performance ability. On the other hand, livestock performance under the prevailing production environment could indicate the prospects for improved productivity, management variables, production constraints and helps to identify areas for improvement. Since small ruminants have to compete with other livestock species for available feed resources, their production performance should be as highly efficient as possible (Peters, 1989).

As indicated by Notter et al. (1991), lamb growth rates could not be equated directly to the profitability of the production system. The authors have reported that those systems that promote rapid lamb growth mostly achieve higher feed efficiency on the biological scale (kg gain/kg feed) and lambs in these systems require fewer days to reach market weights. It is obvious that such production systems also require the use of more expensive feed to attain the intended higher degree of weight gain efficiency. Supplementing animals with purchased feed is for the moment beyond the reach of farmers in tropical and sub-tropical regions.

Since the main aim of sheep rearing in most production system is to produce meat, farmers will always aim to have fast growing animals that could give the maximum possible lean meat in the shortest possible time. Expressing weight of lambs at a certain age (mostly at four months) as % of adult ewe weight or weight gain per day of age might also give a good indication as to how fast lambs are growing.

2.4. Lamb survival rate

Reproductive wastage is one of the main constraints to lamb productivity. As shown from literature results compiled in Table 6, lamb losses before one year of age vary from 49 % to 83 %. This could be a major influencing factor of productivity of a flock as confirmed by

Mukasa-Mugerwa and Lahlu-Kassi (1995), where it was reported that lamb losses represent a major problem by nullifying all the efforts made to make the ewe flock produce and rear lambs.

Lamb mortality rate varies from one flock to another depending mostly on management level.

Lamb losses also occur during the perinatal, pre-weaning and post-weaning phases of the reproduction process (Table 6). A direct comparison of lamb survival rates to various ages summarised in Table 6 will be difficult even within a region as lambs on farm and in experimental station are reared in different management practices and weaned at different ages.

Perinatal lamb deaths, which occur around parturition time, result in significant lamb losses. The extent of perinatal mortality depends mostly on the management system, and in production systems where prolific breeds of sheep are used, management practices have evolved to minimise perinatal lamb losses to a low level. According to Gatenby (1986), perinatal lamb losses could be greatly reduced by good management. In some tropical commercial sheep flocks in Brazil and South Africa, 20 % and 10 % of the lambs are stillborn in traditionally managed sheep production systems of the tropics, lamb mortality between birth and 150 days of age is estimated to be between 10-30 % (Gatenby, 1986).

The major factors affecting lamb survival include age of lamb, litter size, birth weight, season of birth, nutrition and parity of the ewe (Gatenby et al. 1997; Armbruster et al. 1991, Notter et al. 1991).

The nutritional and physiological status of the ewe during the gestation period and at the time of lambing affect the birth weight of the offspring as well as the milk production of the ewe, both of which are known to be critically very important particularly at the early age (birth to two weeks) of the lambs. According to Fitzhugh and Bradford (1983), improvement in ewe nutrition during pregnancy has reduced lamb mortality from 23 % to 11 %. The authors have also concluded that surviving the first week after birth (perinatal stage) does not ensure a lamb's survival because there are also other determining factors such as poor nutrition, diseases and parasite burden before and after weaning (postnatal stage) which influence the ultimate productivity of the animal.

The summary in Table 6 indicates that the type and level of management in a given production system has an influence on the survival of lambs at all stages of growth particularly during the perinatal growth stage. In most cases birth weight has a quadratic relationship with mortality rate whereby mortality tends to increase at extremely low or extremely high birth weights (Mendel et al. 1989; Cooper, 1982; Notter and Copenhaver, 1980). A similar conclusion was reached by Notter et al. (1991), who reported that the relationship between perinatal survival and birth weight of lambs was curvilinear. In a study carried out on Menz sheep, Mukasa-Mugerwa et al. (1994), have recommended that lambs have to be born with birth weights of 2.0 kg or more to have a perinatal survival rate of 90 %. The importance of birth weight both on the survival and pre-weaning growth performance of young animals has been reflected in a study carried out on goat kids born from Baladi, Zaraibi and Damascus goat breeds (Laes-Fettback and Peters, 1995). In this study it has been also shown that higher litter sizes have tremendously reduced birth weight and hence, survival of the kids. In another study (Gatenby et al. 1997) have reported a higher pre-weaning mortality rate (40 %) among triplets and quadruplets.

Table 6: Survival rate of some African and other sheep breeds and crosses under field and station management conditions

Breed/ Breed Cross	Location/ Country	Management type	Birth wt. (kg)	Survival Rate (%) to (Age in days)			Source
				Perinatal (0-14)	Postnatal (15-150)	151-365	
African breeds							
Adal(Afar)	Ethiopia	Station	2.5				Galal, E.S.E. 1983
African Fat Tail	Rwanda	Station	2.4		82.5	75.6	Wilson and Murayi, 1988
Blackhead Ogaden	Ethiopia	Station	2.7				Galal, E.S.E. 1983
Djallonke	West Africa	Station	2.0		50.0-94.0	68.0	Filius et al. 1985; Wunderlich, 1990
		Field	1.2-2.5		81.8-86.8	83.0	Filius et al. 1985; Wunderlich, 1990
Dorper	South Africa/ Kenya	Station/ Farm	3.5-4.5	92.0	87.1-94.0		Schoeman and Burger, 1992; Bullerdieck, P., 1996
Horro	Ethiopia	Station	2.2-2.9	88.3	67.0-71.4		Yohannes et al. 1995; Solomon Gizaw et al.. 1995; Wilson, R.T. 1991
Macina	Mali	Station	2.7				Wilson, R.T. 1991
Four breeds (mean)	Mali	Field	2.8	73.0	54.0	49.0	Wilson, R.T. 1986
Menz	Ethiopia	Station	1.9-2.7	80.2			Mukasa-Mugrewa and Lahlou-Kassi, 1995; Mukasa-Mugerwa et al. 1994; Wilson, R.T. 1991
		Field	2.4				Niftalem Dibissa 1990
Mossi	Burkina Faso	Station	4.0				Wilson, R.T. 1991
Ossimi	Egypt	Station	2.0-4.0		86.0		Lahlou-Kassi 1987
Red Masai	Kenya	Station	2.7				Wilson, R.T. 1991
Watish	Sudan	Station	4.1		65.3		Wilson, R.T. 1991
Other Breeds							
Barbados Blackbelly	Trinidad and Tobago	Station	2.8	97.5	83.2		Rastogi et al.. 1993
Blenheim grade	Trinidad and Tobago	Station	2.8	98.4	86.8		Rastogi et al.. 1993
Finn Sheep Crosses	USA	Station	3.9	94.0	na		Notter and Copenhaver, 1980
Mehraban	Iran	Farm	3.9				Bathaei and Leroy 1998
Merinolandschaf	Germany	Station	4.2	na	81.6; 84.2	na	Mendel et al. 1989
Suffolk Crosses	USA	Station	3.6-4.1	87.7	na	na	Notter et al. 1991
Sumatra	Indonesia	Station	1.7	88.6	75.3	56.8	Gatenby et al. 1997
South Indian	Sri Lanka	Farm	1.8	na	75.0	na	Goonewardene et al. 1984

na = not available

2.5. Linear body measurements

Body measurements are considered as qualitative growth indicators which reflect the conformational changes occurring during the life span of animals (El-Feel et al. 1990).

Although live body weight is an important growth and economic trait, it is not always possible to measure it due to mainly the lack of weighing scales, particularly in rural areas. However, body weight can be reasonably estimated from some linear body measurements (Mayaka et al. 1995). According to these authors, body weight of West African Dwarf (WAD) goats has been satisfactorily predicted by using heart girth as the only regressor.

Means of linear body measurements of various tropical and temperate breeds from which body weight could be reasonably estimated for the respective breeds are shown in Table 7.

Table 7: Means of body weight (kg) and linear body measurements (cm) of various tropical and temperate sheep breeds

Breed/ Breed Type	Location/ Country	Age (months)	Body wt. (kg)	Linear body measurements (cm)				Source
				HG	WH	BL	TL	
WAD x N	Ghana	8	11.9	52.1	53.4	52.8	na	Arthur and Ahunu, 1989
Sahel x WAD x N	Ghana	8	12.1	51.2	54.6	53.2	na	Arthur and Ahunu, 1989
West African Rams	Venezuela	mature	57.0	92.4	69.9	68.9	na	Stagnaro, C. G., 1983
Sudan Desert Rams	Sudan	mature	60.0	na	80.0	na	na	Wilson, R.T.,1991
Adal (Afar) Rams	Ethiopia	mature	38.0	na	66.0	na	na	Galal, E. S. E., 1983
Red Masai Rams	Kenya/ Tanzania	mature	41.0	na	70.0	na	na	Wilson, R. T., 1991
South Indian	Sri Lanka	mature	24.5	39.3	52.4	83.2	na	Goonewardene et al. 1984

WAD = West African Dwarf; N = Nungua Blackhead; na = not available; HG = heart girth, WH = wither height, BL = body length, TL = tail length

Linear body measurements have been also used to give information on differences in body proportion as well as short- term fluctuation of body proportion mainly due to weight loss and gut fill (Arthur and Ahunu, 1989). Indices using body measurements have been used to estimate shape which is usually difficult to quantify due to its subjectivity in comparison with size.

Body dimension measurements will be particularly useful when it is not possible to take direct measurements of the main meat production traits such as body weight and carcass traits (El-Feel et al. 1990). They have observed that weaning system has influenced some linear body measurements of cow calves and buffalo calves up to two years of age. This same study has also shown that birth season had an influence on body measurements of buffalo calves at six months of age. In a study on calves from dairy cows in Turkey, Tuzemen et al. (1993) have indicated that body weight could be predicted accurately from body measurements. The authors have also observed a positive and significant relationship between body weight and height at withers and heart girth on both types of calves. Through principal component analysis of body measurements (Arthur and Ahunu, 1989), it could be possible to identify a relatively small number of factors that can be used to describe relationship among sets of several interrelated variables. Factors developed through such techniques could also help to contrast animals of different shapes and sizes (Brown et al. 1973).

2.6. Fattening performance of Tropical sheep breeds

2.6.1. Carcass characteristics and composition

Before we attempt to optimise approaches to lean lamb production, it is essential to understand environmental and genetic factors influencing the lean : fat ratio. Characterisation of breeds for carcass composition is one such method through which potential genetic resources for lean lamb production could be identified. This will lead us to a better understanding of management alternatives required for different genotypes. The existence of genetic variation among breeds in growth and carcass characteristics have been described by Dickerson et al. (1972) and by Crouse et al. (1981).

Table 8: Carcass tissue proportions for various Temperate and Tropical sheep breeds and crosses

Breed/Breed cross	Location/ Country	Age (months)	Slaughter wt./ EBW^1 (kg)	Carcass composition (%)				Source
				Lean	Fat	Bone	Rest	
Awassi	Saudi Arabia	9	24.5	55.3	19.5	25.2	na	Gaili and El-Naiem 1992
Najdi	Saudi Arabia	9	32.0	54.3	20.3	25.4	na	Ibid
Baluchi	Iran	6.5	28.0	75.9	6.7	17.1	na	Farid 1991
Border Leicester	U.K.	na	35-40	56.1	25.4	na	na	Kempster et al. 1986
Crossbreds	Germany	na	>30	58.2	23.6	na	na	Streitz et al. 1994
Hampshire Down	U.K.	na	35-40	54.6	27.7	na	na	Kempster et al. 1986
Ile de France	U.K.	5	35	55.8	26.3	16.4	na	Wolf et al. 1980
Karakul	Iran	6.5	33.5	77.4	4.9	17.5	na	Farid 1991
Merino	Portugal	na	20-40	55.7	24.1	15.7	na	Teixeria and Delfa 1994
Oxford Down	U.K.	5	35	56.3	24.6	17.5	na	Wolf et al. 1980
Sudan Desert	Sudan	na	41.1	57.3	19.0	21.0	na	Khalafalla and El Khidir 1985
Suffolk	Portugal	na	20-40	55.5	23.8	16.0	na	Teixeria and Delfa 1994
Texel	U.K.	5	35	60.5	21.5	16.5	na	Wolf et al. 1980

na = not available; ^{1} EBW = Empty Body Weight

The proportion of muscle, fat and bone in carcasses change as animals grow. Relative to empty body weight, bone tissue matures early followed by muscle (lean) and the fat tissue maturing late (Afonso and Thompson,1996, Taylor et al. 1989, Orr, 1982). The review by Anous (1991) shows that the ratio between the weight of muscle (lean) and bone tissues is the most critical determinant of the value of carcasses. Tissue proportions of various sheep breeds and their crosses are compiled in Table 8. Most reports state a lean content of between 54 % and 58 %. Higher values are reported for Texel (60 %) and for Baluchi and Karakul (75 - 77 %). Colomer-Rocher et al. (1992), have reported that the mean muscle content of male New Zealand Saanen goats to be about 60 % and stated that this was higher than that normally found in sheep. Ruvuna et al. (1992) have reported a lean: fat: bone ratio of 73:9:18 for 14 ½ month old goats. A similar carcass composition is also reported by Farid (1991) for carcasses from Baluchi sheep (Table 8).

In meat production enterprises, lean is the most important economic component of the carcass. Producing and marketing of lean lamb to meet the consumer demand for less fat has become a challenge for livestock industry particularly in developed countries. As stated by Farid (1991), the relative merit of different sheep breeds for meat production is determined by a high proportion of lean, and a low proportion of fat and bone in the carcass.

While the tendency in developed countries is to produce meat animals with a decrease in fatness at the appropriate market weight and an increase in growth-rate and mature size, animals with higher degree of fatness regardless of size and weight fetch a higher premium in most tropical countries (Thatcher and Gaunt, 1992, Terrill and Maijala, 1991; Lee, 1986). This is particularly true in Ethiopia where during festivities, lambs and Wethers with higher fat cover are also priced high.

The commercial value of sheep carcasses is influenced by the proportion of muscle, fat and bone in a whole sale cut (Taylor et al. 1989). This is strongly governed by consumer preferences in the developing countries while the proportion of lean in carcasses play a lesser role in determining market price in less developed countries. The characteristics of a superior carcass are: high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover. According to the authors, the proportions are in turn influenced by breed, sex and could also be mostly influenced by the stage of maturity or mature size of the animal. Due to a strong breed influence on body composition (Taylor et al. 1989), there could be better opportunities to select among breeds for differences in this trait even at a similar maturity level in body weights.

As reported by Berg and Walters (1983), the proportion of muscle (lean) in a carcass varies indirectly with fat proportion whereby a higher fat proportion is associated with a lower proportion of muscle and vice versa (Table 8). The change in bone proportion is minimal. It is suggested (Berg and Walters, 1983) that in meat producing animals, the proportion of muscle to live weight could be a valuable index of yield since genetic differences appear to be of major importance.

Other factors influencing lean meat % are carcass weight, body conformation (muscling), dissection method, lean mass measuring method and procedure (Walstra and de Greef, 1995).

Tissue growth patterns and the resulting changes in chemical composition of the body are very much influenced by many interrelated environmental as well as genetic factors (Orr, 1982). According to the above author, animals of the same species mostly vary in their mature body size and weight which is also reflected in the differences of their carcass composition.

Fat deposition is believed to start out relatively slowly and to increase geometrically as the animal enters a fattening phase (Berg and Walters, 1983). The authors have also reported that there exist genetical differences in fat deposition exists among breeds due to different growth capacity and maturity. Plane of nutrition is also another major factor influencing the fat deposition pattern of animals whereby high plane of nutrition promotes earlier fattening while a low plane results in a delayed or slower fattening process.

Carcass composition could be used as a parameter in breed characterisation to identify potential genetic resources for lean lamb production and also to identify management alternatives for different breeds (Snowder et al. 1994). The authors have observed the existence of genetic variation among the American sheep breeds studied in growth rate and carcass characteristics. Some of the breeds had higher percentage of kidney, pelvic and subcutaneous fat while others like the Suffolk had higher growth rate and 22 % less kidney and pelvic fat. Snowder et al. (1994) have concluded that when slaughter weight is held constant, carcass characteristic differences of breeds contribute to the variation in quality of lamb meat. This suggests that a relatively late maturing sheep could produce heavier carcasses of higher lean percentage.

Breed effects are known to influence not only carcass composition and quality but also carcass conformation. Breed differences in carcass merits could influence the choice and development of breeds for specific production objectives. This could be realised through strategic identification and utilisation of existing breeds.

The other most important factors that are known to influence carcass composition are sex and feed. In a study undertaken by Cantón et al. (1992) it was observed that nutritional level is related to carcass yield, carcass quality, and fat tissue development and composition.

In a study on some Egyptian sheep breeds, El Karim and Owen (1987), have observed no significant breed type or sex differences in the proportion of lean, bone and fat in dissected sides of carcasses. However, they have observed that the fat content was more variable than either lean or bone percentage. According to this study, fat depth over the rib eye muscle was significantly influenced by breed and sex. This is in agreement with the findings of Snowder et al. (1994) where it was concluded that such differences in carcass characteristics are expected particularly if breeds differ in their physiological maturity.

Iason and Mantecon (1993), have reported that food restriction followed by compensatory growth delays growth and maturation of animals thereby affecting carcass composition. However, since body fat is mobilised to provide nutrients for body maintenance during periods of limitations in food intake, the performance of animals during and after a period of food restriction is likely to be affected (Afonso and Thompson, 1996).

A study on South African Merino sheep (Cronjé and Weites, 1990), has shown that carcass composition, expressed as a proportion of carcass weight, was found to be highly influenced by maize supplementation. They observed that the proportion of fat was doubled with a 200g per day allowance compared to the control.

In another study (Villete and Theriez, 1981), it is indicated that birth weight has an indirect effect on carcass composition by influencing age at slaughter. According to these authors, a study on some French sheep has shown that for every 1 kg increase in birth weight, there was a decrease by 13 days of slaughter age. It is possible to manipulate growth paths of lambs maintained on relatively poor quality pasture to produce carcasses of better quantity and quality (Thatcher and Gaunt, 1992).

Fat is deposited only if surplus nutrients are available. According to Gatenby (1986), the higher the level of nutrition or the lower the growth capacity, the more fat is deposited in lambs at any given age and body weight.

In carcass merit evaluation, dressing percentage is an important trait. However, according to the review by Ruvuna et al. (1992), dressing percent is known to be affected by breed, age, castration and it is also highly affected by feeding and degree of fattening.

They have also reported that proportion of lean and fat in carcasses increased with age while the proportion of bone decreased. Gruszecki et al. (1994) have reported that the carcass composition of Polish Lowland sheep and its crosses, whose slaughter weights range from 38-40 kg, to be in the range of 61-63 % lean, 17-20 % fat and 19-22 % bone. In a similar investigation on mutton-type lambs of diverse genetic background (Streitz et al. 1994), it was observed that lean and fat content of carcasses were 62.4 % and 16.8 % respectively for those lambs which had below 30 kg live weight and 58.2 % and 23.6 % respectively for those above 30 kg live weight.

In their observation on some seven British sheep breeds, Taylor et al. (1989), have concluded that as breed size increased, proportion of carcass muscle and bone has decreased. It was also observed that the breeds have not only differed in the proportion of carcass muscle, fat and bone but also in their distribution. As animals get older and heavier, their body composition also change. It has been reported (Gatenby, 1986; Berg and Walters, 1983) that the viscera, skin, head and feet of lambs grow relatively slower than the carcass tissues. The author has also stated that the ratio of fat to muscle and that of muscle to bone increase with age. However, according to Taylor et al. (1989) there might be no significant breed differences in the way the muscle, fat and bone distribution changed as animals grew older. Teixeira and Delfa (1994) have reported a carcass composition of 55.5 % and 55.7 % muscle, 23.8 % and 24.1 % fat, and 16.0 % and 15.7 % bone for Suffolk and Merino sheep carcasses respectively. A similar result (58.3 % lean, 24.3 % fat and 17.4 % bone), obtained through logarithmic regression, was reported by Taylor et al. (1989) for 7 British sheep breeds. In a study on some one year old Egyptian sheep breeds El Karim and Owen (1987) have reported a dressing percentage of 43.55-45.35 and a carcass composition of 58.13-59.24 % lean, 14.20-15.80 % fat and 18.92-19.95 % bone. The slaughter weight of these animals ranged between 25.67 and 33.80 kg.

Gaili (1979) and Gatenby (1986) have reported that tropical sheep tend to deposit more intramuscular and internal fat and less subcutaneous fat compared to temperate mutton breeds. There is evidence that tropical and temperate breeds do not differ in their carcass composition (Amegee, 1981 cited by Gatenby, 1986). However, according to the author, tropical and temperate breeds do differ in size and distribution of fat deposited in the body.

The development of fat depots over the growing-finishing period in cattle, pigs and sheep is consistent in indicating that subcutaneous fat grows faster than intermascular fat (Berg and Walters, 1983). On the other hand, the growth of kidney knob and channel fat in relation to the other fat depots is more variable. Kempster (1981) has reported that breeds of sheep also differ in fat partitioning whereby breeds which have been improved for fat lamb production tended to have a higher proportion of subcutaneous fat than those where adaptability and maternal performance have been important.

In wool sheep, body composition is known to be influenced by breed, sex and nutritional level (Cantón et al. 1992). Their review also shows that nutrition level is related to carcass yield, quality, fat deposition and composition while breed influences strongly carcass conformation, composition and quality. According to the review by Cantón et al. (1992), although nutritional influence on body composition is similar for wool and tropical hair sheep, the later have a different body conformation and composition compared to wool breeds. This is mainly attributed to their smaller mature body weight. In a study by Friggens et al. (1994) and Iason et al. (1992), the degree of maturity was observed to be an important predictor of carcass composition for some European breeds. This has been also conformed by Frutos et al. (1997) where it was reported that live bodyweight was the most effective means to predict body composition. Since large breeds of sheep reach their mature live weight at relatively older ages than smaller ones, differences in carcass composition will be observed between the two groups unless they are compared at a similar proportion of mature live weight (Iason et al. 1992). This is also supported by another study (McCutcheon et al. 1993) where it was observed that carcasses of similar weight had the same proportion of water, protein and fat.

Frutos et al. (1997) have also reported that individual breeds have a distinctly different fat distribution within the body. According to the review, the ability of sheep to retain and mobilise body reserves is of considerable importance in determining the productivity or even the survival of sheep, particularly in arid and semiarid environments where limitations in feed supply are more pronounced.

2.6.2. Feed intake and fat deposition in small ruminants

As reported by Gatenby (1986), the supply of animal feed in the tropics, except that in the humid zones, is not constant both in quantity and quality leading to seasonal variation in growth-rate of the animals.

In intensive livestock production systems where milk and meat are the main production objectives, feed costs account as a major component of the expenses.

Efficiency of feed utilisation is an important trait in meat production enterprises (Terrill and Maijala, 1991), and should be included in selection programmes for genetic improvement of animal performance (Parker et al. 1991). However, it has always been difficult to improve feed resources particularly in dry areas.

In sub-Saharan Africa, the main source of livestock feed is grazing on natural pasture which mostly suffers from seasonal variations both in quality and quantity. This is considered to be the most important constraint to livestock production and reproduction in traditional systems where the low economic input to the system is evident.

The existence of feed intake differences between genotypes has been reported in several studies (van Arendonk et al. 1991; Barlow et al. 1988; Wagner et al. 1986).

The relationship of intake to productivity is very complex and depends on several factors including nutrition and genetics. Genetic groups are known to have differences in feed intake (van Arendonk et al. 1991; Barlow et al. 1988) but very few studies show the amount of genetic variation between breeds in this trait. In his review, Black (1990) has reported that feed intake is closely correlated with both the amount of pasture available per animal per day and the digestibility of the forage selected. Another review by Said and Tolera (1993) shows that plant cell-wall is the major restrictive determinant of feed intake. However, the authors also indicated that the actual feed intake of an animal depends on its genotype and physiological state, the quality and quantity of the feed available during grazing. In an earlier study, Arnold and Birrel (1977) have reported that herbage intake of grazing sheep is influenced by age, size, weight and physiological state of the animal, climatic conditions and the availability and quality of the feed.

A feeding experiment on British Angora goats (Shahjalal et al. 1992) has indicated that growth and lean tissue deposition are influenced by both protein and energy intakes. Carstens et al. (1991) have reported that increase in dietary energy intake can enhance the proportion of body fat deposition in animals. In a similar investigation, Coleman et al. (1995) have observed that at the end of the growing phase steers fed grain had higher body weight and higher percentage fat in the empty body and carcass compared to those fed forages. By manipulating dry matter intake of animals, particularly in the finishing period, it may be possible to increase the proportion of lean in carcasses. In a study on bulls and steers, Steen and Kilpatrik (1995) have concluded that for animals maintained on high-forage diets and slaughtered at moderate levels of fatness, reducing dry matter intake during the finishing period by 20 % has reduced the carcass fat estimate and increased lean and bone contents. Kabbali et al. (1992) have concluded that weight loss of lambs during feed shortages results in the loss of weight in internal organs and such lambs recover the lost weight during realimentation through compensatory growth resulting in better feed efficiency and leaner carcasses.

In their study on restricted feeding and realimentation using lambs from Timahdit, D´man and Ile de France x D´mann sheep, Kabbali et al. (1992) have observed that feed efficiency was better in lambs that have gone through a phase of compensatory growth. A similar result was reported by Zervas et al. (1997) where it was stated that daily dry matter intake by lambs was influenced partly by the nature, energy and nutrient density of the available feed.

As stated by Kabbali et al. (1992), body composition is dynamic and changes always depending on environmental factors. This study shows that body composition changes occur in animals undergoing compensatory growth. In another study by Graham et al. (1991), it is reported that body protein gain was dependent on both voluntary feed consumption (VFC) and weight, whereas fat gain and wool growth were influenced by VFC alone. According to a review by Dulphy and Demarquilly (1994), voluntary feed intake of ruminants is determined by the ingestibility of the feed and the intake capacity of the animal. Daily feed intake is greatly influenced by the digestion rate of the digestible material and the rate of passage of indigestible material (Khandaker,et al. 1998; Dulphy and Demarquilly, 1994).

Level of nutrition is known to influence body or carcass composition significantly (Black, 1983; Butler-Hogg, 1984; Taylor and Murray, 1991). Supporting such theory, Aziz et al. (1992), have observed that the body fat of sheep serves as an immediate source of energy during under nutrition. This is particularly important during the dry seasons when both the quantity and quality of feed are in short supply. In an earlier study (Little and Sandland 1975), it was observed that during weight loss periods, the first body tissue to be mobilised is the subcutaneous fat. If the duration of the weight loss phase is prolonged, a greater proportion of muscle fat will be mobilised (Aziz et al. 1992).

Body weight is the main determinant of body composition of animals of the same breed and sex group regardless of age or nutritional level (Turgeon Jr. et al. 1986). They have observed that more fat and less protein has been deposited per unit of weight gain as growth rate increased giving an indication that body composition of weight gain is influenced more by growth rate. Body composition is also likely to be influenced by growth capacity. According to Nicholas et al. (1992), small-framed lambs were significantly fatter than the medium and large -framed Rambouillet lambs. The authors have recommended that there should be different management approaches for the various groups in order to fulfil the yield grade required by the market and obtain a premium value for the produce.

The review done by Cantón et al. (1992) shows that body composition is affected by sex, nutritional level and breed. They have also observed that tropical hair sheep have a different body conformation and body composition compared to wool breeds mainly due to their smaller mature body weight. The summary also shows that sex and nutrition have similar effects on body composition of both hair and wool sheep breeds. In another study (Marais et al. 1991) on compensatory growth, it was observed that body composition remained uniform at a specific body mass and was independent of feeding level. However, this study has involved only one breed type and a similar sex and age group. In another study (Villete and Theriez, 1981), it has been reported that an increase in birth weight has resulted in a decrease in perigastric and perirenal fat.

The idea to modify composition of weight gain through different levels of nutrition has been supported by Turgeon et al. (1986) who have concluded that slow growth rate restricts body fat deposition allowing a higher proportion of the gain to be deposited as protein. However the review made by Kabbali et al. (1992) indicates that there is no uniformity in the results of nutritional manipulation and compensatory growth. Some studies have shown increases in fat content, others have reported increases in protein and water and still others have reported no body composition changes in animals which have gone through a period of feed restriction followed by realimentation. The contradictory results are thought to be mainly due to the diversity of the factors involved in compensatory growth. This could indicate the true spectrum of the results which could be expected from studies on small sample size with highly variable body composition and under various conditions of nutritional restriction and realimentation. The changes in the rates of protein and fat deposition which occur as a result of changes in environmental temperature are naturally reflected in the body composition of the animal (Fuller, 1969). He has also indicated that protein deposition is proportionately less affected by environmental stress than fat deposition. According to Graham et al. (1991), it will be beneficial to the producer if it could be established where in the weight gain phase fat deposition starts. Once this is determined, it may be possible to manipulate the changes in weight gain to produce lambs of desired carcass composition. Prasad and Sinha (1992) have reported that subcutaneous fat increases with maturity of the animal. They also observed that the intermuscular fat was always more than subcutaneous fat at all maturity levels. According to their review, body weight at which lambs begin the fattening phase is related to the mature size.

The relative abundance of feed in tropical regions during wet seasons, is in most cases adequate to enable animals to deposit body fat. According to Ørskov (1998), ruminants are capable of adapting to seasonally fluctuating pasture forage quality and (or) availability by conserving energy from the lush period in the form of body fat. He has also indicated that fat deposition generated by high intakes of quality pasture could be an efficient way of conserving forage. The stored fat could then be mobilised to sustain growth, lactation or maintenance requirements.

Carcasses from lambs that have gone through weight loss/ weight gain (compensatory growth) phase were found to be leaner compared to those which went through a normal growth phase (Kabbali et al. 1992).

2.6.3. Feed influence on development of non-carcass tissues

In a study conducted on Dorset x (Border Leicester x Merino), Lee (1986) found no significant effect of nutrition on the weight of Omental, kidney plus channel or mesenteric fat depots. This is contrary to other findings (Taylor and Murray, 1991, Black, 1983; Butler-Hogg, 1984), where nutrition is known to have influenced fat deposition in all parts of the body and at all stages of weight gain.

In another study, Burrin et al. (1990) have reported that there exists a relationship between nutrition level and visceral organ size and metabolic activity whereby the level of feed intake changes the relative proportion of visceral organs to body mass (Table 9). On the other hand as suggested by Mehrez et al. (1977), feed intake could be reduced if the rumen ammonia concentration is limiting the rate of fermentation in the rumen.

In a study on some British sheep breeds, Wood and MacFie (1980) have observed that breed differences in partition and distribution of carcass fat deposition within and between breeds are smaller. On the otherhand, the authors also reported larger variation in the site of body fat deposition within an animal.

Fat content of carcasses could be also determined through chemical analysis. One such method is Ether extract. According to Snowder et al. (1994), a higher total chemical fat indicates a higher percentage of intermuscular fat. Farid (1991) has reported ether extract values of 26 %, 30 % and 32 % for untrimmed meat from Karakul, Mehraban and Baluchi sheep respectively. Wishmeyer et al. (1996), have reported ether extract values of 11.82 % - 30.52 % for whole body composition of Rambouillet Wether lambs. They have concluded that body weight is a better predictor of body chemical composition.

Table 9: Fresh weight of sheep non-carcass organs by breed or breed crosses and body weight

Breed/ Crosses Breed	Location/ Country	Slaughter wt. (kg)	Fresh non-carcass organ weight (g)								Source
			Liver	Heart	Kidneys	Lungs + Trachea	Spleen	Skin	Head	Feet	
Horro	Ethiopia	24.9	376.8	112.4	68.6	481.8	73.7	2200.0	1900.0	570.0	Ewnetu et al. 1998
Menz	Ethiopia	24.7	324.5	99.4	64.3	476.6	69.7	2700.0	535.1	585.4	Ibid
Blackbelly	Mexico	38.2	64.2	161.0	104.3	406.5	56.9	na	na	na	Cantón et al. 1992
Crossbred	USA	31.0	495.0	na	84.0	na	na	na	na	na	Burrin et al. 1990
D´man	Morocco	30.0	651.0	190.0	98.0	410.0	61.0	na	na	na	Kabbali et al. 1992
Ile de Fr.x D´man	Morocco	30.0	607.0	189.0	90.0	432.0	62.0	na	na	na	Ibid
Timahdit	Morocco	30.0	564.0	180.0	92.0	400.0	56.0	na	na	na	Ibid
Karakul	Canada	20.7	na	128.0	169.0	na	na	na	na	na	Kennedy et al. 1995
Merino	Australia	33.0	537.0	141.0	102.0	383.0	53.8	2316.0	874.0	1740.0	Aziz et al. 1993
Romney	New Zealand	42.5	669.1	219.2	126.2	463.2	50.7	na	na	na	McCutcheon et al. 1993
Suff. x Ramb.	USA	38.0	572.0	175.0	na	na	na	na	na	na	Turgeon, Jr. Et al. 1986
Suff.x Ramb. x Fin.	USA	34.0	887.0	171.0	149.0	na	65.0	na	na	na	Ferrell et al. 1986

Ile de Fr. = Ile de France, Suff. = Suffolk, Ramb. = Rambouillet, Fin. = Finnish Landrace, na = not available

3. MATERIAL AND METHODS

3.1. Experimental location and climate

This study was undertaken at the then ILCA (International Livestock Centre for Africa) now ILRI (International Livestock Research Institute) Debre Birhan Experiment Station. ILCA's Debre Birhan Experiment Station was established in 1979 and is located in the central highlands of Ethiopia, about 120 km north-east of Addis Ababa. The altitude is about 2780 *m. a. s. l.* with an average monthly minimum air temperature (at 0.5m) ranging from 2.4 ^{0}C in November to 8.5 ^{0}C in August (ILCA, 1992 and ILCA, 1993). The lowest temperature recorded so far at 0.5 m above the ground level is also reported to be -9.0 ^{0}C. Average monthly maximum air temperature at the same height ranges from 18.3 ^{0}C in September to 23 .3 ^{0}C in June (ILCA, 1992 and ILCA, 1993).

The rainfall pattern is characterised as biannual and generally the highlands have long dry seasons and a relatively cool temperate like climate. The average annual rainfall recorded between 1979 and 1992 was 920 mm. More than 70 % of the average annual rainfall is always recorded during the main rainy season (end of June to beginning of September). The small rains occur during February to April or sometimes May. The long dry period is from October to February with occasional night frosts occurring from November to January.

3.2. Soil and vegetation

Most of the station is bottomland with few upland areas. Due to the accumulation of run off soil or silt, the bottomland is comparatively rich in nutrients. However, this area is subjected to annual flooding during the main rainy season and problems of water logging and frost are often encountered.

The pasture at Debre Birhan Experiment Station is dominated by Andropogon grasses (*Andropogon longipes*) mixed with *Trifolium spp*. Depending on the site, pasture composition of the station based on dry matter bases is dominated by grass *spp*. (93 %) followed by broadleaf weeds (6 %).

The legume component is only 1 %. On dry matter bases, pasture yields range from 1.5 t/ha to about 4 t/ha depending on the season and the site. The crude protein yield is also highly variable, (37 - 110 g/kg DM) depending on the season and legume component of the pasture.

3.3. Breeds and management

3.3.1. Description of the local breeds used

Two indigenous Ethiopian fat tailed sheep breeds, Horro and Menz were used in this study. Both breeds are well known in the country and are of great economic importance in their respective areas of origin.

Horro sheep

This local breed belongs to the long fat tailed breed group. The Horro sheep is a hairy breed found widely distributed in the western highlands of Ethiopia. They are mostly uniform in colour having creamy white, dark tan or spotted short smooth hair. It is a large framed (tall and long) local breed. The fat tail is triangular in shape hanging down with sometimes a twisted end. Males develop a mane around the shoulder and brisket. The mature body weight of ewes is estimated to be between 35 and 40 kg (IAR, 1991).

Menz sheep

The Menz breed belong to the few indigenous woollen short fat tailed sheep population. They are predominantly found in Northern Shewa and Western Wollo regions of the country. They have amixed hair-wool fleece with an upper layer of long coarse hair and a woolly undercoat. This local sheep breed has no particular distinguishing colour. However, the dominating colour seems to be black or dark brown with some white spots on the head, neck and legs. Males have mostly long and twisted horns while females are predominantly polled. The Menz sheep are smaller, shorter and compact.

The mature body weight of Menz ewes is estimated to be between 30 and 35 kg.

As described by Galal (1983), the Menz sheep have a typically distinguishing tail characteristic with a fat tail which drops to the hock and has a slight upward twist at the end.

3.3.2. Mating

To assess the possible effect of season of birth, mating was planned in such a way that lambs would be born into the two main seasons (wet and dry). According to the mating practice of the station, breeding ewes were mated at the middle of the dry season (January/February) and at the beginning of the wet season (May/June) so that lambings could occur within the wet and dry seasons respectively.

Sires were randomly selected from rams kept for breeding purposes. The sires chosen were all over 25 kg and had at least two permanent teeth (incisors). Those selected were again physically checked for any scrotal deformity or any history of reproductive problems. Eleven rams per breed were then randomly picked for each mating season. Rams that were used in the May 1992 mating were also used for January 1993 mating. To facilitate linkage across years, some 30 % of the sires used in the previous two matings were used for the third mating period of May/June 1993.

Ewes within breed were assigned to sire groups by a stratified random sampling method taking body weight and parity into consideration. To obtain contemporary groups of lambs at the designated lambing periods, the oestrus of ewes were synchronised using progesterone impregnated intrauterine sponges (Intervet International B. V., Boxmeer, Holland). The sponges were removed after 10-12 days and ewes were randomly grouped for single sire mating for 30 days.

3.4. Experimental design and data collection

Between 240 to 248 ewes from each breed were mated per season, a total of about 845 lambings were recorded over the three lambing seasons. The number of sires used were 33 and 32 for Menz and Horro breeds, respectively. Only lambs of first and second parity dams were included in the study.

At lambing, lambs were identified with numbered plastic ear tags and birth date, weight at birth, dam ID, sire ID, mating group, season of birth and other relevant information were recorded.

The number of sires and ewes used over the three mating seasons are shown in Table 10. The distribution of lambs born in the three lambing periods is also indicated.

Table 10: Distribution of sires, ewes and lambs born by breed and season of birth

breed	Total		Lambs born in:						Total	
	Rams	Ewes*	Dry season/92		Wet season/93		Dry season/93			
			born	Included	born	included	born	included	born	included
Menz	19	366	153	146	232	193	203	122	588	461
Horro	19	315	136	136	116	116	144	143	396	395
Total	38	681	289	282	348	309	347	265	984	856

* 31 Menz ewes and 38 Horro ewes have lambed twice in the study period (Dry season'92 and '93)

3.4.1. Grazing management

Animals grazed natural pasture daily for about 7 hours and for shorter period on data measurement days. Ewes and lambs were herded together until weaning of lambs at 90 days of age. After weaning, female and male lambs were separated but grazed the same paddocks in a rotational grazing schedule.

3.4.2. Supplementary feeding and health care:

All groups were supplemented with hay and concentrate in the evening. Hay was offered *ad libitum* while concentrate was group fed at the rate of about 200g/head/day providing 10-12.5 MJ ME/kg dry matter. The crude protein content of hay was about 3.5 % .The concentrate composition was 66 % wheat bran, 33 % Noug cake (local oil seed cake), and 1 % salt.

Animals in the feeding experiment were individually fed 1500 g /head/day hay providing about 5.12 MJ ME/kg DM and 300 g concentrate/head/day (50 % wheat bran, 30 % maize, 20 % cotton seed cake) at the beginning of the experiment which was raised to 400 g two weeks into the four months fattening period providing about 18.01 % CP and 10-12.5 MJ ME/kg DM. They were also provided with mineral licks and water *ad libitum.*

All flocks were routinely checked for any health problems and when animals fell sick, the identification of the animal, the date and cause of illness were registered by the health group so that the number of times the animals fell sick and the health category to be calculated. Animals were drenched on regular basis against liver flukes using either Fasinex (Triclabendazole) or Ranide (Rafoxnide) and were also vaccinated for pox, pasteurellosis and clostridial infection. Lambs were also treated with Panacur (Fenbendazole) prior to or after weaning if the faecal egg count is above or equal to 2000 epg.

3.4 3. Measurements

3.4.3.1. Body weight and linear body measurements

Ewes and rams were weighed monthly in the last week of each month using a 0.1 kg precision scale. Lambs were weighed at birth and fortnightly thereafter up to weaning. After weaning at the age of about 90 days they were weighed monthly together with the rest of the flock. Lamb body weights were adjusted for age.

The average daily weight gain (ADG) was calculated using the following formula

$$ADG = \frac{(W2\,kg - W1\,kg)\ *1000}{A}$$

Where:

ADG *g* = Average Daily Gain in gram

W1 *kg* = Birth weight or weight at the preceding age

W2 *kg* = Weight at a given age

A = Age in days or days between weighing dates

Average daily gain was calculated for the following stages of growth:

a) ADG1 = Birth to Weight 30
b) ADG2 = Birth to Weight 90[a]
c) ADG3 = Weight 90 to Weight 180
d) ADG4 = Weight 180 to Weight 270
e) ADG5 = Weight 270 to Weight 365
f) ADG6 = Birth to Weight 365

[a] Weight 90 = Weaning Weight

Average daily weight gain of male lambs in the fattening experiment was also calculated using the following formula

$$ADG = \frac{(FWT - IWT)}{D}$$

Where:

FWT = Final body weight

IWT = Initial body weight

D = number of fattening days

Linear Body measurements were taken together with monthly weight measurements. All body measurements were taken with a measuring tape in centimetre and measured to the nearest 0.5 cm. The following linear body measurements were taken:

a) Heart girth (the circumference of the chest posterior to the forelegs at right angles to the body axis)

b) Wither height (the highest point measured as the vertical distance from the top of the shoulder to the ground)

c) Body length (the distance between the crown and the Sacrococcygeal joint)

d) Tail length (from the point of attachment to the tip)

e) Tail width (directly behind the *Tuber ichiad*)

f) Tail circumference (directly behind the *Tuber ichiad*)

g) Tail volume (estimated by water displacement)

Tail volume was measured only on lambs in the feeding experiment. A ten litre plastic beaker was filled with water and was put in a basin. The animal was held suspended by two people with its back facing the ground allowing the tail loose. The animal was then lowered slowly until the tail is immersed completely into the water. The amount of water displaced from the beaker is then collected from the basin and measured by a graduated cylinder. The displaced water measured in cubic centimetre (cc) is taken as the tail volume.

3.4.3.2. Feeding experiment

Thirty four Menz and twenty six Horro male lambs born in the first group (Dry'92) and which were 380 - 413 days of age at the start of the experiment were included in a feeding experiment for 123 days. The lambs were randomly assigned to 30 metabolic crates. The randomisation was done within breed. Each metabolic crate held two animals separated by a metal partition. The feeding troughs for hay and concentrate feeding were built inside the crates. Water was provided in buckets which were placed in front all the time. The lambs were adapted for two weeks before taking experimental measurements. Apart from water and the mineral blocks, the amount of hay and concentrate provided and refused was recorded. During the feeding experiment, faeces was collected for each animal and bulked for a weekly dry matter determination. Dry matter calculation of hay and concentrate was also done weekly.

Dry matter intake for each animal was calculated as

$$DMI = (HDM + CDM) - (RHDM + RCDM)$$

Where:

HDM = DM % of hay offered

CDM = DM % of concentrate offered

RHDM = DM % of refused hay

RCDM = DM % of refused concentrate

Dry matter digestibility was calculated as the difference between DMI minus faecal DM.

Dry matter (DM) determination of hay and concentrate feed was done after oven drying the sample at 105°C over night. Dry Matter determination of dissected carcass and non-carcass components and faeces samples was done after freeze drying the samples.

The following formula was used to calculate DM %

$$DM\,\% = \frac{(W3 + C2) - (W2 + C1) * 100}{W1}$$

Where:

W1 = weight of sample

W2 = weight of empty crucible

W3 = weight of crucible + oven dried sample

C1 = correction for W2 read from the balance (due to hot weighing)

C2 = correction for W3 (due to hot weighing)

Samples for the determination of ash were put in a furnace at 600°c over night to burn all organic matter. Ash is then the inorganic material which has not volatilised at the temperature indicated above.

The Ash % is then calculated using the following formula

$$Ash\% = \frac{(W3+C2)-(W2+C1)}{(W1*DM\ \%)} *100$$

Where:

W1 = weight of air dried sample

W2 = weight of empty crucible

W3 = weight of crucible + Ash

C1 = correction for W2 read from the balance (due to hot weighing)

C2 = correction for W3 read from the balance (due to hot weighing)

DM % = dry matter percentage of the sample

3.4.3.3. Carcass evaluation

All lambs of the fattening experiment were transported immediately after the end of the experiment to an abattoir in Debre Zeit city which is about 170km from the experimental site. At the abattoir, lambs were kept in a barn without feed and water for about 16 hours. Pre slaughter body weight was taken shortly before slaughtering. This weight was taken as the slaughter weight on which the calculation of dressing percentage was based. The lambs were slaughtered by severing the jugular vein and the carotid arteries.

After recording weight of fresh carcass and non carcass parameters, carcasses and internal organs were stored in a cold room at 4°C overnight. Each part of the gastro-intestinal tract was weighed with and without the contents and recorded. The content was then determined as the difference.

The following carcass and non-carcass measurements have been taken:

Carcass parameters measured

a) Undissected: Hot carcass weight, Cold carcass weight, Kidney and kidney fat, Weight of half carcasses

b) Dissected: lean, bone, fat, sundry trimmings

c) Composition of whole carcasses were estimated from the composition of the dissected side as follows

$$Cons\tan t = \frac{Cold\ carcass\,(whole)}{Left\ carcass\,(cold)}$$

- Total lean = Constnat x wt of lean from left carcass
- Total fat = Constnat x wt of fat from left carcass
- Total bone = (Constnat x wt of bone from left carcass) + tail bone
- Total sundry = Constnat x wt of sundry from left carcass

Non-carcass parameters measured

a) Mesenteric and Omental fat

b) Fore- and hind gut (full and empty)

3.4.4. Laboratory chemical determination

The following samples were retained for laboratory chemical analysis :

a) From the dissected left half carcasses: lean, subcutaneous fat, rump fat, sundry trimmings

b) Others: tail fat, gastro-intestinal tract, gut fat, kidney and channel fat, urogenital fat

All samples were separately minced in a meat processing plant and stored in deep freezers. Depending on the availability, all or up to 70 g of the minced samples were freeze dried by forced removal of moisture using a LABCONCO freeze dryer Model 75040-01. The freeze dried samples were milled by a cross mill beater type LAB MILL 8000 rpm with 2mm sieve size and stored for ether extraction.

Ether extract determination:

The number and type of carcass and non-carcass samples analysed for percent of ether extract (EE %) are shown in Table 11.

Table 11: Number and types of carcass and non-carcass samples analysed

Breed	Sample type									Sample total
	Lean meat	Subcut. fat	GIT[1]	Tail fat	Rump fat	KCF[2]	Urogen.[3] fat	Gut fat	Sundry trimmings	
Menz	62*	62	62	62	62	62	62	62	60	556
Horro	52	52	52	52	52	52	52	52	52	468
Total	114	114	114	114	114	114	114	114	112	1024

[1] G.I.T = Gastro intestinal tract; [2] KCF = Kidney and channel fat; [3] Urogen. fat = Urogenital fat; * indicates duplicate sample size

Ether was extracted in a conventional method (A.O.A.C., 1990; Harris, Lorin E., 1970 and ILCA, 1994) using Goldfish fat extraction apparatus. Each sample was analysed in duplicates and the average was taken as an EE % value for a particular sample. However, if the difference between the two values was more than 10 % the analysis was repeated to get a third value.

The procedure followed is described below:

a) 1.5 to 2.0 g freeze dried and milled carcass or non-carcass sample (W1) was transferred into a clean alundum thimble and covered with defatted cotton.

b) The thimble was then placed in a sample container and fixed under the condenser of the fat extraction apparatus.

c) Solvent beaker was dried in an oven at 105°c for 30 minutes, cooled in a desicater to room temperature and weighed (W2).

d) 30 to 40 ml di-ethyl-ether was poured into the solvent beaker and then placed on the condenser with a ring and hand tightened.

e) The water cooling system was turned on to cool the condenser.

f) The hot plates were then raised until they were in contact with the beakers, and the heater was turned on.

g) The apparatus was then left to operate for 8 hrs with occasional checks for ether leaks until extraction was complete.

h) After extraction was completed, the hot plates were lowered and the thimble was left to drain empty. The extracted samples were removed and ether reclaiming glass tubes were placed under the condenser. The hot plate was again raised to distil the ether into the reclaiming tubes.

i) The beakers were removed from the hot plate and left in the hood for some time to allow the remaining ether evaporate.

j) The ether extract was dried in a forced-draft oven at 105°c for 30 minutes, cooled in a desicater to room temperature and weighed (W3).

Ether extract values for all samples were calculated on dry matter (DM) bases using the following formula

$$Ether\ extract\left(EE\right)\% = \frac{\left(W3 - W2\right)*100}{W1*DM\ \%}$$

Where:

W1= weight of ground air dried sample

W2= weight of empty beaker

W3= weight of beaker + EE (Ether extract)

DM %= dry matter % of the extracted sample

Total ether extract of whole carcasses were estimated as follows:

TOTEE = LEANEE+SUBCFEE+TAILFEE+GITEE+RUMPFEE+GUFEE+UROGFEE+RENFEE+SUNDTEE

Where:

TOTEE = Total ether extract

LEANEE = Ether extract of total lean

SUBCFEE = Ether extract of subcutaneous and intermuscular fat

TAILFEE = Ether extract of tail fat

GITEE = Ether extract of the gastro-intestinal tract

RUMPFEE = Ether extract of total rump fat

GUFEE = Ether extract of gut fat

UROGFEE = Ether extract of uro-genital

RENFEE = Ether extract of renal fat

SUNDTEE = Ether extract of sundry trimming

3.5. Methods of statistical analysis

The PROC GLM procedure (SAS for Windows Release 6.11/12; 1989-1995) was used to analyse the data fitting breed, sex, birth type, season of birth, parity, and sire within breed as main effects in the model.

The independent variables include body weight, average daily weight gain, survival rates, linear body measurements, feed intake (on DM basis), carcass parameters, body composition, etc.

Assuming that the relation between body weight and the body measurements taken is linear and checking for outliers, linear models were found to be most appropriate for the analysis of body weight and linear body measurements. The Stepwise procedure Proc Reg of the SAS System for Windows Release 6.11/12 (1989-1995) was used to see the effects of additional variables in analysing the relationship between body weight and linear body measurements. Regression equations were then developed by using only those independent variables which contributed significantly in the stepwise regression analysis. Graphics were done using Microsoft Excel 97 programme (Microsoft Office 98).

The SAS CATMOD procedure (SAS for Windows Release 6.11/12 (1989-1995) was used to analyse survival rate of lambs. The CATMOD procedure analyses survival rate as a binomial variable (0 = dead, 1 = alive) with effects described in Model 2 and generate a frequency table showing the number of lambs survived from birth to the various stages of growth. The package also generates the Maximum-Likelihood Analysis of a chi-square Variance table. The estimated values from the analysis of Maximum-Likelihood will then be multiplied with the Covariance Matrix of the Maximum-Likelihood estimates using LOGMLVAR (Rege, 1992) to calculate the survival rates of lambs from birth to 15, 30, 90, 180, 270 and 365 days of age.

3.5.1. Models fitted for lamb growth and survival

Lamb growth rate was calculated from the fortnightly and monthly weight records. Mortality of lambs was also recorded. The following statistical models were used to analyse the data.

Model 1. Growth and Average Daily Gain (ADG) of all lambs (birth - 180 days of age):

$Y_{ijklmno} = µ + B_i + S_j + Bt_k + P_l + Bs_m + Sire(B)_{in} + (B \times Bs)_{ij} + e_{ijklmno}$

Where :

$Y_{ijklmno}$ = Body weight/ADG at different stages of growth (birth-12 months of age)

µ = Overall Mean

B_i = fixed effect of the i^{th} breed (i = Menz, Horro)

S_j = fixed effect of the $_j{}^{th}$ sex of lamb (j = male, female)

Bt_k = fixed effect of the $_k{}^{th}$ lamb birth type (k = single, twin)

P_l = fixed effect of the $_l{}^{th}$ dam parity (l = 1, 2)

Bs_m = fixed effect of the $_m{}^{th}$ birth season (m = Dry'92, Wet'93, Dry'93)

$Sire(B)_{in}$ = Nested effect of the $_n{}^{th}$ sire within breed

$(B \times Bs)_{ij}$ = breed by birth season interaction effect

$e_{ijklmno}$ = Effect of the o^{th} random error

Model 2. Growth and Average Daily Gain (ADG) of male lambs (birth - 365 days of age):

$Y_{ijklmno} = µ + B_i + Bt_j + P_k + Bs_l + Sire(B)_{mi} + (B \times Bs)_{ij} + e_{ijklmn}$

Where :

Y_{ijklmn} = Body weight/ADG at different stages of growth (birth-12 months of age)

µ = Overall Mean

B_i = fixed effect of the i^{th} breed (i = Menz, Horro)

Bt_j = fixed effect of the $_j{}^{th}$ lamb birth type (k = single, twin)

P_k = fixed effect of the $_k{}^{th}$ dam parity (l = 1, 2)

Bs_l = fixed effect of the $_l{}^{th}$ birth season (m = Dry'92, Wet'93, Dry'93)

$Sire(B)_{mi}$ = Nested effect of the $_m{}^{th}$ sire within breed

$(B \times Bs)_{ij}$ = breed by birth season interaction effect

e_{ijklmn} = Effect of the n^{th} random error

Model 3. Weight and linear body measurements of male lambs (180 - 365 days of age):

$Y_{ijklmno} = \mu + B_i + Bt_j + P_k + Bs_l + (B \times Bs)_{ij} + e_{ijklm}$

Where :

$Y_{ijklmno}$ = Body weight and linear body measurements at 180, 270 and 365 days of age

µ = Overall Mean

B_i = fixed effect of the i^{th} breed (i = Menz, Horro)

Bt_j = fixed effect of the $_j{}^{th}$ birth type (j = single, twins)

P_k = fixed effect of the $_k{}^{th}$ parity (k = 1, 2)

Bs_l = fixed effect of the $_l{}^{th}$ birth season (l = Dry'92, Wet'93, Dry'93)

$Sire(B)_{in}$ = Nested effect of the $_n{}^{th}$ sire within breed

$(B \times Bs)_{ij}$ = breed by birth season interaction effect

$e_{ijklmno}$ = Effect of the o^{th} random error

Model 4. Survival rate:

$Y_{ijklmno} = \mu + B_i + S_l + Bt_k + P_l + Bs_m + e_{ijklmn}$

Where :

$Y_{ijklmno}$ = Survival rate at various ages

µ = Mean

B_i = Effect of the $_i{}^{th}$ breed

S_j = Effect of the $_j{}^{th}$ sex of lamb

Bt_k = Effect of the $_k{}^{th}$ lamb birth type

P_l = Effect of the $_l{}^{th}$ dam parity

Bs_m = Effect of the $_m{}^{th}$ birth season

e_{ijklmn} = Effect of the o^{th} random error

3.5.2. Models fitted for lamb fattening performance

Model 5. Body weight gain, DM intake, carcass and non-carcass parameters:

$Y_{ijklmno} = \mu + B_i + Sire(B)_{ij} + e_{ijk}$

Where :

Y_{ijk} = Body weight gain, DM intake, carcass and non-carcass parameter

μ = Mean

B_i = Effect of the i^{th} breed

$Sire(B)_{ij}$ = Nested effect of the j^{th} sire within breed

e_{ijk} = Effect of the k^{th} random error

4. RESULTS AND DISCUSSION

4.1. Lamb performance traits

4.1.1. Weight development from birth to weaning (90 days)

Lamb birth weight and ewe post partum body weight was recorded within 24 hours after birth. Lambs were weaned at about 90 days of age. Although ewes were synchronised before mating in order to have concentrated lambing events, lambings during the three lambing seasons were spread as follows: a) First Group (Dry'92) : 28.09. – 07.11.92; b) Second Group (Wet'93): 29.05 – 12.07.93; c) Third Group (Dry'93): 21.10. – 30.11.93. In all three seasons, the lambing time was spread over a period of 5-6 weeks. Due to lack of records, stillborn lambs were excluded from the analysis of birth weight.

Table 12 shows the Least Squares means of birth and other weights until weaning (90 days). Horro lambs had significantly heavier (p <0.001) birth weight than Menz lambs (2.43 ± 0.03 kg vs 2.17 ± 0.03 kg, respectively). Males were heavier (p <0.001) at birth compared to females weighing 2.38 ± 0.03 vs 2.22 ± 0.02 kg respectively. Single born lambs were heavier (P <0.001) at birth (2.59 ± 0.02 kg) compared to twins (2.01 ± 0.03 kg). Lambs born from second parity ewes were also heavier (p <0.001) at birth than those born from ewes of first parity weighing 2.44 ± 0.03 kg and 2.16 ± 0.03 kg respectively.

Birth weights of lambs born in the three seasons (Dry season'92, Wet season'93 and Dry season'93) were 2.22 ± 0.04, 2.30±0.04 and 2.38 ± 0.04 respectively and were significantly different (p <0.05).

Lambs were weaned at about 90 days of age. To avoid a wide gap between weaning ages, lambs were weaned in two batches so that the majority of lambs are weaned at 90 ± 15 days of age.

Menz and Horro lambs did not differ significantly (p >0.05) in weaning weight at 90 days of age (8.03 ± 0.14 vs 8.22 ± 0.16 kg respectively). Males were significantly heavier (P <0.05) than females at weaning weighing 8.29 ± 0.14 and 7.96 ± 0.14 kg respectively.

Birth type has also influenced weaning weight significantly (p <0.001) as shown in Table 12 where single born lambs have maintained their weight superiority to weaning and beyond. Second parity ewes had also significantly heavier lambs at weaning (8.72 ± 0.13) compared to those born to first time lambers (7.53 ± 0.15) indicating the influence of relatively heavier and older ewes reflected probably through higher milk yield on pre-weaning lamb body weight. Lambs born in the third lambing season did not maintain their superiority in birth weight at all stages of growth (Table 12). Weaning weights of lambs born in the three seasons were 8.71 ± 0.19, 8.48 ± 0.20 and 7.19 ± 0.21 kg respectively; where lambs born in Dry season'92 and Wet season'93 had significantly higher (P <0.001) weaning weight than those born in Dry season'93.

Table 12: Body weight (kg) of Menz and Horro lambs from birth to 180 days of age

Sources of Variation	LS means(±SE) of body weight (kg) from birth to age(days):							
	n	birth	n	30	n	60	n	90
Overall	856	2.30 (±0.02)	798	5.04 (±0.06)	752	6.94 (±0.09)	709	8.12 (±0.12)
Breed		***		*		ns		ns
Menz	461	2.17 (±0.03)	439	4.88 (±0.08)	425	6.91 (±0.11)	411	8.03 (±0.12)
Horro	395	2.43 (±0.03)	359	5.20 (±0.08)	327	6.97 (±0.13)	298	8.21 (±0.13)
Sex		***		***		***		*
Female	427	2.22 (±0.02)	390	4.88 (±0.07)	366	6.75 (±0.11)	344	7.96 (±0.14)
Male	429	2.38 (±0.03)	408	5.20 (±0.07)	386	7.14 (±0.11)	365	8.29 (±0.14)
Birth Type		***		***		***		***
Single	668	2.59 (±0.02)	633	5.86 (±0.06)	608	8.13 (±0.09)	577	9.46 (±0.10)
Twins	188	2.01 (±0.03)	165	4.21 (±0.10)	144	5.75 (±0.16)	132	6.79 (±0.19)
Dam Parity		***		***		***		***
1	477	2.16 (±0.03)	435	4.56 (±0.08)	403	6.47 (±0.12)	372	7.53 (±0.15)
2	379	2.44 (±0.03)	363	5.51 (±0.07)	349	7.41 (±0.11)	337	8.72 (±0.13)
Birth Season		*		***		***		***
Dry'92	282	2.22^b (±0.04)	272	4.77^b (±0.11)	269	7.15^b (±0.16)	254	8.71^a (±0.19)
Wet'93	309	2.30^a (±0.04)	289	5.51^a (±0.11)	288	7.46^a (±0.16)	288	8.48^a (±0.20)
Dry'93	265	2.38^a (±0.04)	237	4.83^b (±0.11)	195	6.22^c (±0.16)	167	7.19^b (±0.21)
R^2		0.41		0.39		0.32		0.36
C.V. (%)		17.1		21.0		21.5		21.0

ns = not significant; * = $P < 0.05$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

4.1.2. Post weaning growth

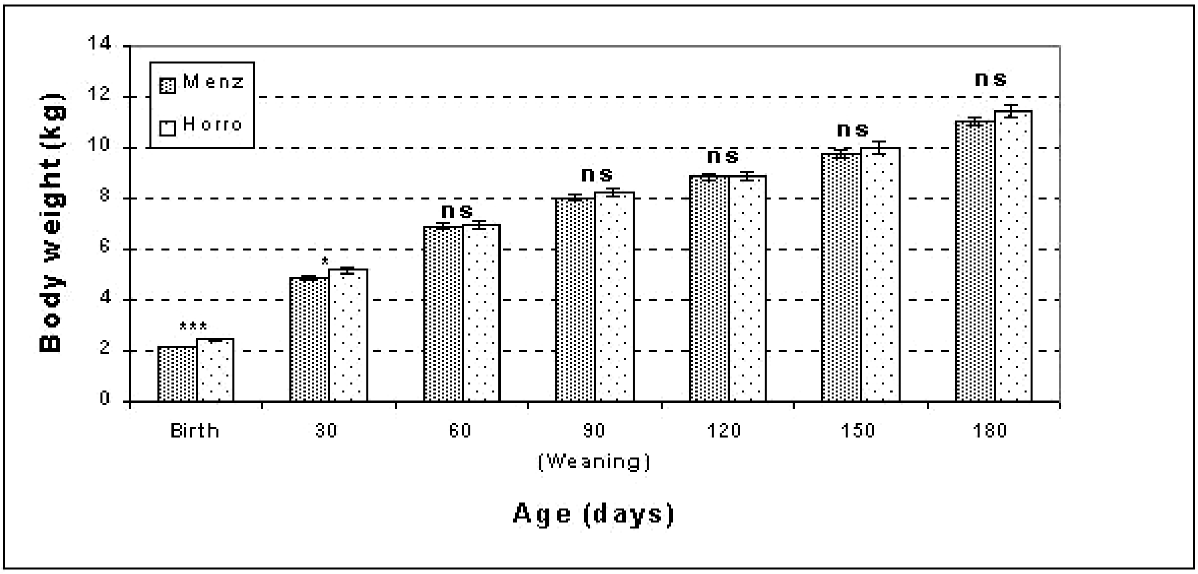
After weaning, the two breeds did not differ significantly (P >0.05) in weight up to 300 days of age (Tables 13). However, after 300 days of age Horro lambs tended to be heavier than Menz lambs as shown in Table 13. Effects of sex, birth type and birth season on weight were significant (p <0.001) even after weaning (Table 13). As shown in Figures 1 and 2, Horro and Menz lambs had a relatively similar growth curve.

Figure 3 shows that male lambs had maintained their weight superiority at birth throughout and the gap between body weights of male and female lambs tended to get wider after 120 days of age (Tables 12 and 13). So were also single born lambs compared to twins.

Lambs born to second parity ewes were heavier throughout (P <0.001) compared to those born from first time lambers (Tables 12 and 13).

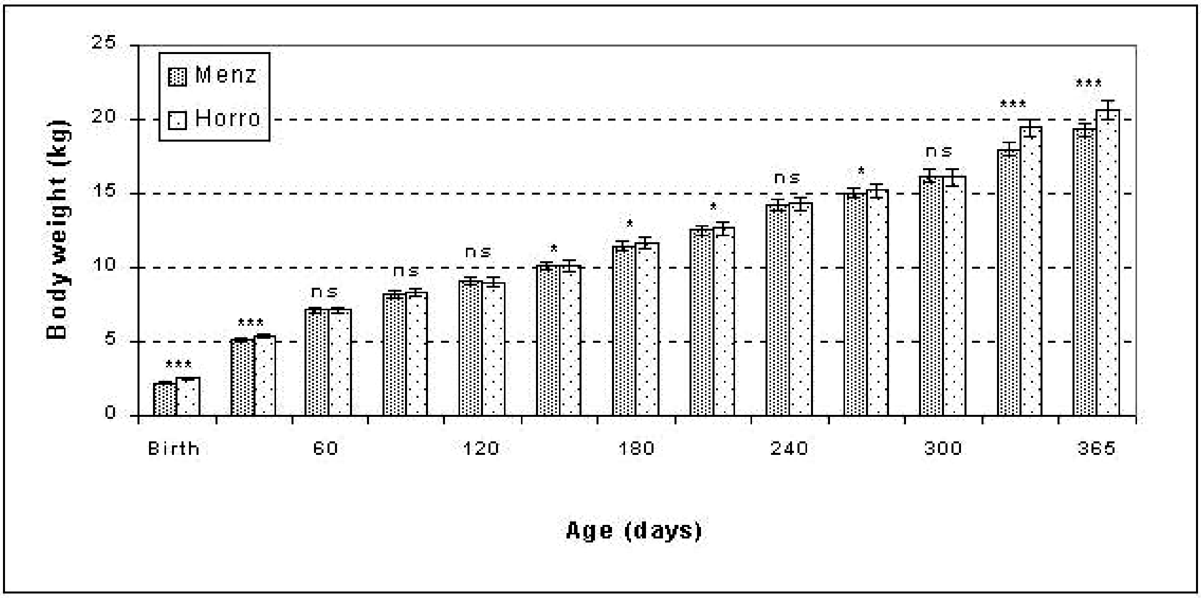
Season of birth has significantly (p <0.01) influenced lamb body weight at birth and at all stages of growth (Tables 12 and 13). Lambs born in the third season (Dry'93) were lighter at all stages except at birth compared to the other groups (Tables 12 and 13).

Figure 1: Body weight of Menz and Horro lambs from birth to 180 days of age (LSM ± SE)



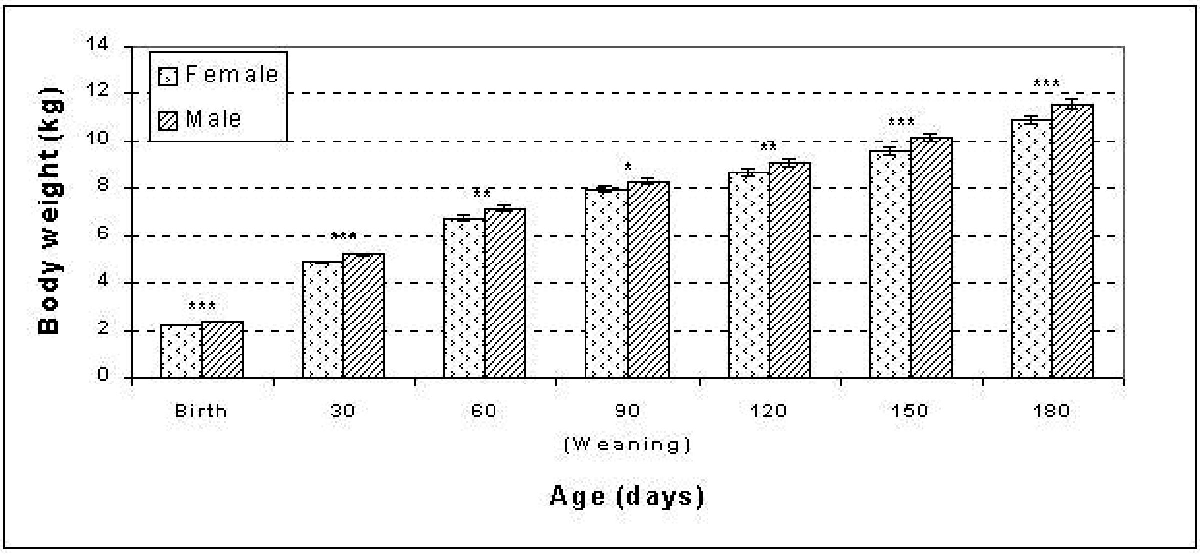
n at birth: 856 and at Age (days): 30: 798, 60: 752, 90 (weaning): 709, 120: 670, 150: 637, 180: 617, ns = not significant, * = P < 0.05, *** = P < 0.001

Figure 2: Body weight of male Menz and Horro lambs from birth to 365 days of age (LSM ± SE)



n at birth = 429 and at Age (days): 30 = 408, 60 = 386, 90 (weaning) = 365, 120 = 343, 150 = 325, 180 = 310, 210 = 292, 240 = 269, 270 = 258, 300 = 244, 330 = 234, 365 = 221, ns = not significant, * = P < 0.05, *** = P < 0.001

Figure 3: Body weight of Menz and Horro lambs from birth to 180 days of age by sex (LSM ± SE)



n at birth = 856 and at Age (days): 30 = 798, 60 = 752, 90 (weaning) = 709, 120 = 670, 150 = 637, 180 = 617, ns = not significant, * = P < 0.05, ** = P < 0.01, *** = P < 0.001

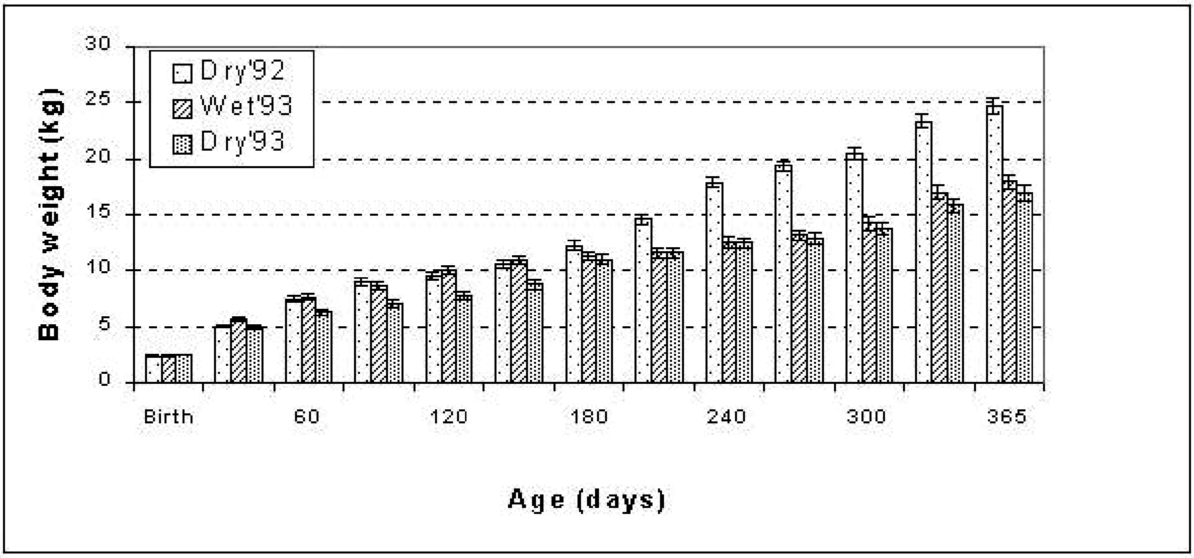
Table 13: Body weight (kg) of male Menz and Horro lambs from 120 to 365 days of age

Variation	LSMEANS(±SE) of Body Weight (kg) at Age(days):									
	n	120	n	180	n	240	n	300	n	365
Overall	343	9.09 (±0.22)	310	11.53 (±0.33)	269	14.28 (±0.41)	244	16.15 (±0.46)	221	19.41 (±0.55)
Breed		ns		ns		ns		ns		*
Menz	207	9.14 (±0.25)	201	11.45 (±0.28)	180	14.24 (±0.35)	162	16.21 (±0.40)	149	19.12 (±0.47)
Horro	136	9.03 (±0.33)	109	11.61 (±0.38)	89	14.32 (±0.47)	82	16.09 (±0.51)	72	19.70 (±0.63)
Birth Type		***		***		***		***		***
Single	287	10.35 (±0.20)	262	12.88 (±0.21)	233	15.76 (±0.25)	211	17.62 (±0.28)	191	21.59 (±0.33)
Twins	56	7.82 (±0.35)	48	10.18 (±0.42)	36	12.80 (±0.55)	33	14.68 (±0.62)	30	18.42 (±0.75)
Dam Parity		***		***		**		*		**
1	178	8.53 (±0.28)	161	10.96 (±0.32)	138	13.66 (±0.41)	125	15.71 (±0.46)	117	19.28 (±0.55)
2	265	9.64 (±0.24)	149	12.09 (±0.28)	131	14.90 (±0.35)	119	16.59 (±0.39)	104	20.73 (±0.47)
Birth Season		***		*		***		***		***
Dry'92	122	9.45^{b} (±0.35)	102	12.26^{a} (±0.40)	99	17.90^{a} (±0.48)	89	20.45^{a} (±0.53)	78	25.16^{a} (±0.67)
Wet'93	147	10.04^{a} (±0.34)	136	11.33^{b} (±0.39)	99	12.50^{b} (±0.50)	93	14.21^{b} (±0.56)	89	17.93^{b} (±0.67)
Dry'93	74	7.77^{c} (±0.36)	72	10.99^{b} (±0.42)	71	12.45^{b} (±0.50)	62	13.79^{b} (±0.57)	54	16.93^{b} (±0.70)
R^2		0.32		0.32		0.64		0.65		0.66
C.V. (%)		21.7		19.2		17.4		16.3		15.3

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Figure 4 shows growth curves for lambs born over the three lambing seasons. Lambs born in the Dry Season'92 and those born in the Wet Season'93 had relatively similar growth curves up to 150 days of age being significantly superior to that of lambs born in Dry Season'93 lambs. Dry Season'92 male lambs grew significantly ($P <0.001$) faster compared to male lambs from the other two groups (Wet Season'93 and Dry Season'93) which showed more or less a similar growth patern (Figure 4).

Figure 4: Body weight (LSM ± SE) of male Menz and Horro lambs from birth to 365 days of age by season of birth



n by birth = 429 and by Age (days): 30 = 408, 60 = 386, 90 (weaning) = 365, 120 = 343, 150 = 325, 180 = 310, 210 = 292, 240 = 269, 270 = 258, 300 = 244, 330 = 234, 365 = 221

4.1.3. Average daily weight gain (ADG)

Menz and Horro lambs did not differ significantly (p >0.05) in both preweaning and postweaning average daily gain (Tables 14 and 15). Horro lambs gained 89.25 ± 2.41 g compared to 89.22 ± 2.21 g for Menz lambs between birth and one month of age.

Table 14 shows that male lambs had a faster rate of weight gain compared to females between birth and 30 days of age (P <0.05) and between weaning (90 days of age) and 180 days of age (P <0.01). The difference in rate of weight gain between birth and weaning for the two groups was not significant (P >0.05). The rate of weight gains for male and female lambs of both breeds between the above age ranges are (91.79 ± 2.15 g vs 86.68 ± 2.07 g; 69.96 ± 1.55 g vs 67.62 ± 1.52 g; and 27.84 ± 1.19 g vs 24.62 ± 1.15 g, respectively).

Single born lambs had a significantly higher (P <0.001) average daily weight gain between birth and 30 days of age (109.06 ± 1.65 g) compared to twins (69.41 ± 2.87 g). As shown in Table 14, single born lambs have continued to grow faster (P <0.001) to weaning (90 days of age) compared to twins twins (81.34 ± 1.17 g for singles and 56.23 ± 2.14 g for twins, respectively).

Lambs born from ewes of second parity had a significantly faster (P <0.001) pre-weaning growth rate than those born from first time lambers (Tables 14 and 15).

Although the effect of season of birth on growth rate could not be conclusive due to the fact that the wet season lambing was not replicated, lambs born in the wet season had a slightly better pre-weaning growth rate compared to those born into the dry season (Tables 14 and 15) still indicating seasonal influence on growth performance. Lambs born at the first dry season lambing time (Dry'92), had performed well throughout compared to those born in the other two seasons.

Table 14: Average daily gain (ADG) of Menz and Horro lambs from birth to 180 days of age

Sources of Variation	LSMEANS(±SE) of ADG(g) Between Ages (Days)		
	Birth to 30	Birth to 90	90 to 180
	ADG1	ADG2	ADG3
Overall	89.24±1.75	68.79±1.31	26.23±1.01
Breed	ns	ns	ns
Menz	89.22±2.21	69.43±1.58	26.24±1.12
Horro	89.25±2.41	68.14±1.83	26.21±1.47
Sex	*	ns	**
Female	86.68±2.07	67.62±1.52	24.62±1.15
Male	91.79±2.15	69.96±1.55	27.84±1.19
Birth Type	***	***	ns
Single	109.06±1.65	81.34±1.17	25.50±0.86
Twins	69.41±2.87	56.23±2.14	26.96±1.65
Dam Parity	***	***	ns
1	80.40±2.21	63.28±1.67	26.53±1.27
2	98.07±2.09	74.29±1.46	25.93±1.10
Birth Season	***	*	***
Dry'92	97.83^{a}±3.01	74.21^{b} ±2.17	25.91^{b}±1.68
Wet'93	87.62^{b}±3.11	78.45^{a}±2.20	18.07^{c}±1.60
Dry'93	82.26^{b}±3.02	53.70^{c}±2.30	34.70^{a}±1.69
R^2	0.26	0.35	0.26
C.V. (%)	32.7	26.8	57.4

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Table 15: Average daily gain (ADG) of male Menz and Horro lambs from birth to 365 days of age

Sources of Variation	LSMEANS(±SE) of ADG(g) Between Ages (Days)					
	Birth to 30	Birth to 90	90 to 180	180 to 270	270 to 365	Birth to 365
	ADG1	ADG2	ADG3	ADG4	ADG5	ADG6
Overall	93.16±2.82	69.08±2.11	27.39±2.01	35.91±2.27	53.99±2.69	48.78±1.42
Breed	ns	ns	ns	ns	*	ns
Menz	94.42±3.70	70.92±2.51	27.65±1.72	35.96±1.95	50.62±2.20	47.31±1.17
Horro	91.91±3.73	67.25±2.99	27.12±2.30	35.86±2.59	57.36±3.17	50.25±1.68
Birth Type	***	***	ns	ns	ns	**
Single	114.62±2.58	82.42±1.85	28.08±1.29	37.94±1.38	53.16±1.62	52.01±0.86
Twins	71.71±4.53	55.75±3.34	26.69±2.54	33.88±3.07	54.83±3.75	45.56±1.99
Dam Parity	***	***	ns	ns	ns	*
1	84.42±3.59	63.24±2.70	28.31±1.95	35.85±2.27	54.00±2.73	47.34±1.45
2	101.91±3.18	74.93±2.24	26.46±1.69	35.97±1.95	53.99±2.34	50.22±1.24
Birth Season	**	***	*	***	***	***
Dry'92	105.52^{a}±4.53	74.93^{a}±3.31	27.64^{b}±2.42	71.87^{a}±2.68	62.41^{a}±3.33	62.02^{a}±1.76
Wet'93	91.81^{b}±4.61	78.30^{a}±3.30	17.70^{c}±2.33	17.52^{b}±2.79	52.23^{b}±3.31	43.55^{b}±1.75
Dry'93	82.17^{b}±4.58	54.02^{c}±3.52	36.81^{a}±2.55	18.34^{b}±2.78	47.35^{b}±3.53	40.78^{b}±1.87
R^2	0.31	0.37	0.32	0.81	0.29	0.63
C.V. (%)	33.0	27.5	54.0	36.2	31.4	16.8

ns = not significant; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

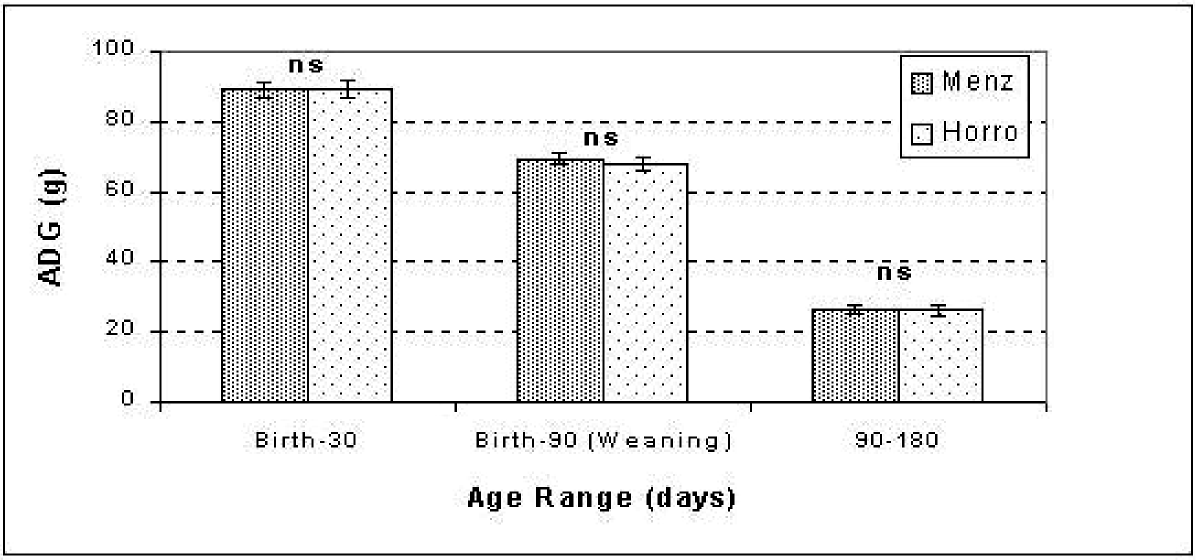
Though not significantly different (p >0.05), Menz lambs had a slightly better pre-weaning growth performance when weight gain between birth and weaning age (90 days) is considered (Tables 14 and 15). After 270 days of age, male Horro lambs seem to grow faster than male Menz lambs of the same age group (Table 15).

There was a sharp drop in rate of weight gain after weaning for all lambs (Figure 5) and for male lambs (Figure 6). This could partly be due to the weaning shock. The trend of recovery from the weaning shock for male lambs is shown in Figure 6.

As expected, the rate of growth before weaning (birth to 30 days of age) for all groups was relatively higher compared to that exhibited after weaning (Figures 5 and 6).

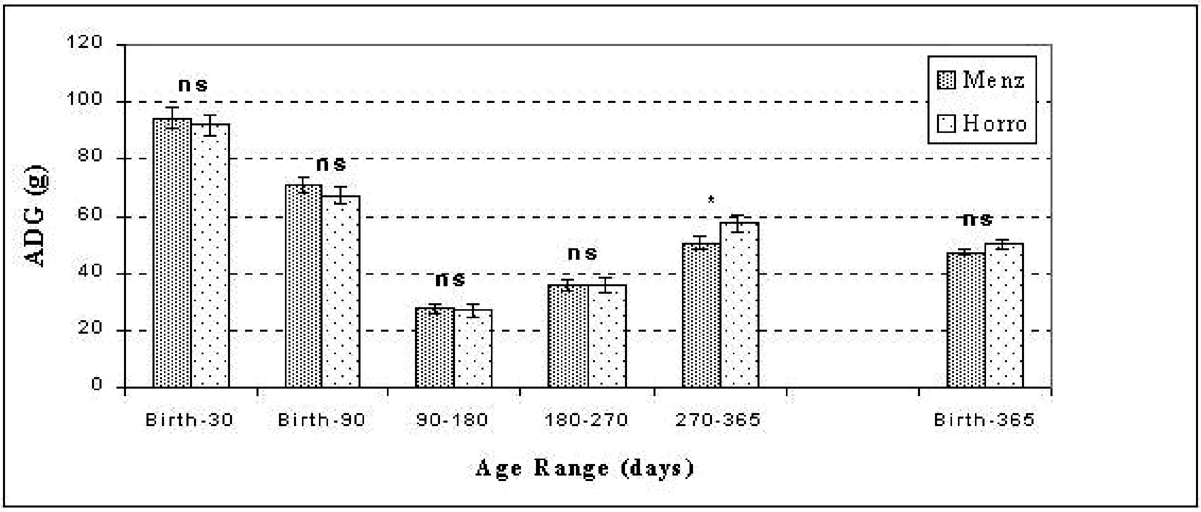
As shown in Table 15, the average daily body weight gain of male Menz and Horro lambs has increased after 180 days of age but at a reduced rate.

Figure 5: Average daily weight gain, ADG of Menz and Horro lambs between birth and 180 days of age (LSM ± SE)



ns = not significant

Figure 6: LSM ± SE of Average daily weight gain (ADG) of male Menz and Horro lambs between birth and 365 days of age

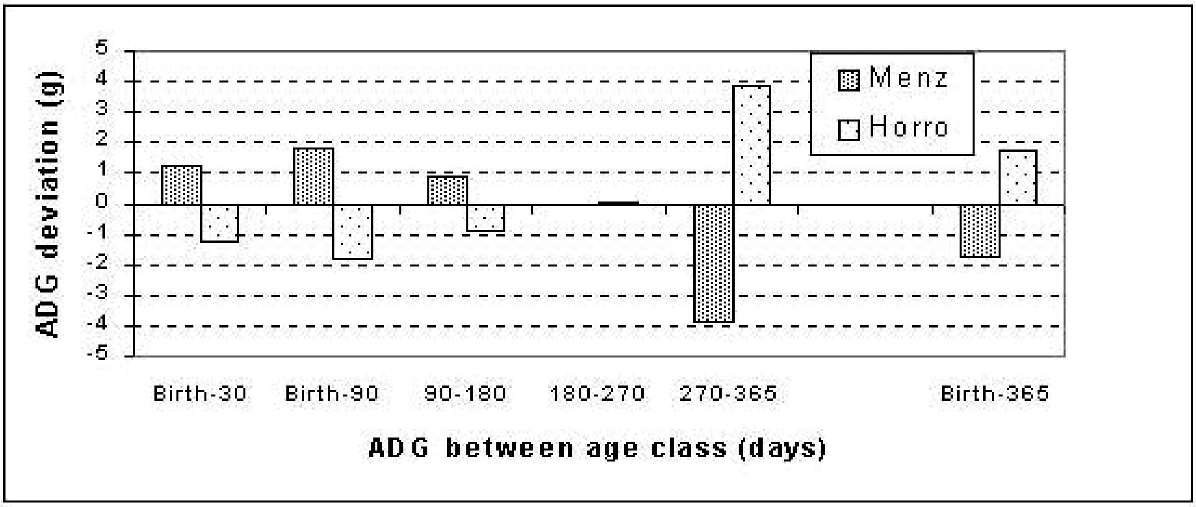


ns = not significant, * = P < 0.05

The relatively better performance of the Menz lambs at earlier age could be attributed to their adaptation to the environment of the experiment station, while the Horro sheep were brought from another region where environmental stresses particularly due to feed shortages and health challenges are not as high as those encountered in Debre Birhan area.

The magnitude of the difference in average daily weight gain of male Menz and Horro lambs at various stages of growth is shown by the deviation of the ADG Least Squares means of the two breeds from the overall mean (Figure 7).

Figure 7: Deviation in average daily body weight gain (ADG) of male Menz and Horro lambs between various stages of growth from birth (Constant = LS overall mean)



4.1.4. Lamb survival rate

Of the 856 lambs included in this analysis, 96.4 ± 0.01 % of Menz lambs and 93.5 ± 0.02 % Horro lambs survived to 15 days of age, the differences being not significantly different (P >0.05). As shown in Table 16, more (P <0.05) Menz lambs of those born have survived to the age of 30 days than the Horro (95.5 ± 0.02 % vs 91.2±0.02 %). Menz lambs had maintained their high survival rate at 90 180, 270 and 365 days of age. The survival rates observed were 89.4 ± 0.02, 81.3 ± 0.02, 71.5±0.02 and 62.4 ± 0.03 % for Menz lambs and 75.7 ± 0.03, 50.6 ± 0.03, 39.0 ± 0.03 and 37.3 ± 0.03 % for Horro lambs. The differences in survival rate at the respective age group between the two breeds are statistically significant (P <0.001). As shown in Figure 8, only some 50 % of Horro lambs born survived to 180 days of age and less than 40 % of the Horro lambs have survived to to the age of nine months.

Figure 8: Survival rate of Menz and Horro lambs to various stages of growth

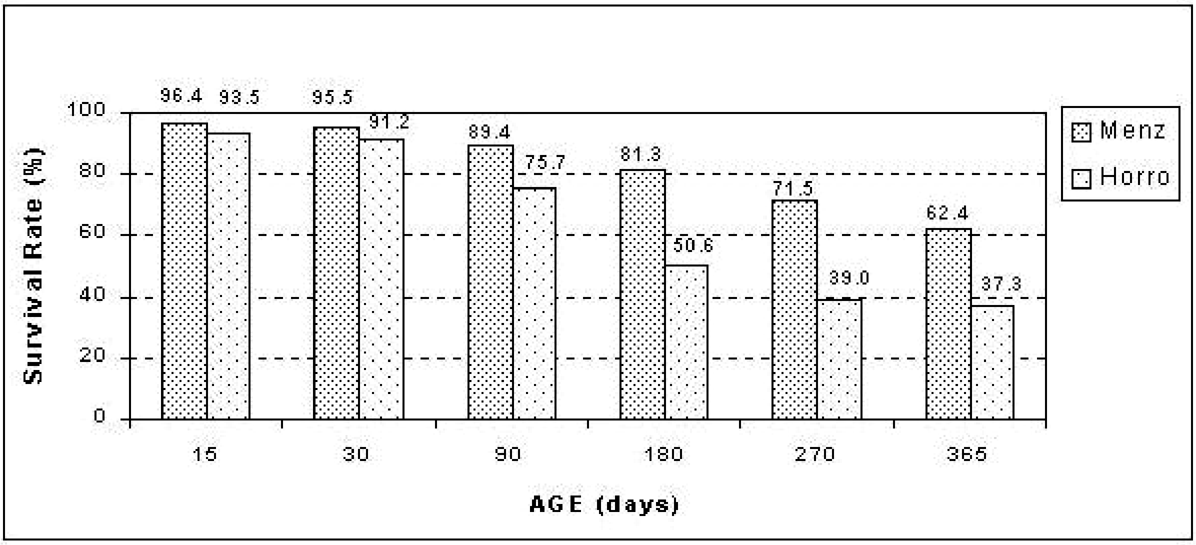


Table 16: Survival rate of Menz and Horro lambs from birth to 365 days of age

Sources of Variation		Survival Rate (%) from Birth to Age (days)					
	n (at birth)	15	30	90 (weaning)	180	270	365
Overall	856	95.2	93.7	83.7	67.8	55.8	49.5
		(±0.01)	(±0.01)	(±0.02)	(±0.02)	(±0.02)	(±0.02)
Breed		ns	*	***	***	***	***
Menz	461	96.4	95.5	89.4	81.3	71.5	62.4
		(±0.01)	(±0.02)	(±0.02)	(±0.02)	(±0.02)	(±0.03)
Horro	395	93.5	91.2	75.7	50.6	39.0	37.3
		(±0.02)	(±0.02)	(±0.03)	(±0.03)	(±0.03)	(±0.03)
Sex		ns	ns	ns	ns	***	***
Female	427	94.2	92.1	82.0	69.4	62.5	58.9
		(±0.01)	(±0.01)	(±0.02)	(±0.03)	(±0.03)	(±0.03)
Male	429	96.0	95.0	85.2	66.2	49.0	40.7
		(±0.01)	(±0.01)	(±0.02)	(±0.03)	(±0.03)	(±0.03)
Birth Type		***	***	***	***	***	***
Single	668	97.5	96.5	91.4	82.6	73.8	65.0
		(±0.01)	(±0.01)	(±0.01)	(±0.02)	(±0.02)	(±0.02)
Twins	188	91.0	88.8	71.2	48.4	36.2	34.7
		(±0.02)	(±0.02)	(±0.04)	(±0.04)	(±0.04)	(±0.04)
Parity		**	***	***	***	***	***
1	477	91.7	90.0	74.7	58.3	46.8	42.8
		(±0.02)	(±0.02)	(±0.03)	(±0.03)	(±0.03)	(±0.03)
2	379	97.3	96.1	89.9	76.1	64.5	56.8
		(±0.01)	(±0.01)	(±0.02)	(±0.03)	(±0.03)	(±0.03)
Birth Season		*	*	***	***	***	*
Dry'92	282	98.0^{a}	96.9^{a}	90.2^{a}	67.4^{b}	62.5^{a}	53.3^{b}
		(±0.01)	(±0.01)	(±0.02)	(±0.03)	(±0.03)	(±0.03)
Wet'93	309	93.6^{b}	91.9^{b}	91.1^{a}	83.6^{a}	64.2^{a}	61.3^{a}
		(±0.02)	(±0.02)	(±0.02)	(±0.02)	(±0.03)	(±0.03)
Dry'93	265	91.5^{b}	90.0^{b}	58.9^{b}	47.1^{c}	40.4^{b}	35.1^{c}
		(±0.02)	(±0.02)	(±0.04)	(±0.04)	(±0.04)	(±0.03)

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Male and female lambs did not have significantly different ($P > 0.05$) survival rates from birth to 15, 30, 90 and 180 days of age (Table 16). However, after 180 days of age, the survival rate of male lambs dropped drastically compared to that of the female ($P < 0.001$). This is most probably due to the preferential treatment of the ewe lambs in preparation to mating.

As expected, single born lambs had a better survival rate (p <0.001) than twins to 15, 30, 90, 180, 270 and 365 days of age (97.5 ± 0.01, 96.5 ± 0.01, 91.4 ± 0.01, 82.6 ± 0.02, 73.8 ± 0.02 % and 65.0 ± 0.02 vs 91.0 ± 0.02, 88.8 ± 0.02, 71.2 ± 0.04, 48.4 ± 0.04, 36.2 ± 0.04 and 34.7 ± 0.04 %, respectively). Major reduction in survival rate occurred between weaning (90 days of age) and 180 days of age.

Lambs born from ewes of second parity had a higher survival rate to all ages compared to those born from ewes of first parity (Table 16). The high loss of lambs born to first time lambers (first parity ewes), during the pre-weaning growth phase, indicates the influences of lower birth weight and probably lower milk producing ability of first parity ewes.

Birth season had influenced survival rate of lambs to the various ages significantly. Lambs born at the beginning of the dry season of 1992/93 had a better survival rate (p <0.05) from birth to 15 and 30 days of age compared to those born in the other seasons (Table 16). However, lambs born at the beginning of the wet season of 1993 (Wet'93) had a better survival rate after weaning (90 days of age) compared to the other two groups and this is probably due to the provision of quality pasture during the wet period.

The extremely drastic reduction in survival rates of lambs born in the Dry'93 season between weaning and 180 days indicates an exposure to a major disease challenge or a shortage of feed as lambs born in this season were weaned in the dry season.

4.2. Linear body measurements and their relation to body weight changes

The measures for size and body conformation of male Menz and Horro sheep are compared in Tables 17, 18, and 19 at 180, 270 and 365 days of age respectively.

Horro sheep are different in their body measurements from Menz, significantly only at the age of 365 days. They are taller and longer but have a comparable heart girth (Tables 19). Wither height at 180, 270 and 365 days of age were 50.93 cm, 55.13 cm, 59.89 cm for male Menz lambs and 52.06 cm, 57.86 cm, 61.91 for male Horro lambs, respectively.

As shown in Tables 17, 18 and 19, Horro lambs had also significantly longer tails than Menz lambs at 180, 270 and 365 days of age. Menz lambs on the other hand had wider (P <0.05) tail at 180 and 270 days of age compared to that of the Horro.

As shown in tables 21, 23 and 25, the best regressor of weight observed after a stepwise regression analysis was heart girth. In both breeds body weight at 6, 9 and 12 months of age could be fairly accurately estimated from heart girth measurements (Tables 21, 23, and 25). A similar analysis was made on body weight and linear body measurements of male lambs from both breeds which were born in the first season (Dry'92) and which were intensively fed for about 120 days. The relationship of weight and the linear body measurements considered above was similar to that described for all male lambs studied. As shown in Table 26, Horro lambs had a longer body length, had a taller wither height and had a longer tail compared to Menz lambs of the same age group at all stages. However, after the first eight weeks of fattening, Menz lambs exhibited larger ($p < 0.01$) tail width and tail circumference compared to the Horro indicating fat deposition characteristics. The two breeds did not differ significantly ($p > 0.05$) in heart girth and in tail volume measurements taken at all stages.

Table 17: Linear body measurements of male Menz and Horro lambs at 180 days of age

Sources of Variation	n	LSMEANS(±SE) of Measurements					
		Heart-girth (cm)	Wither-height (cm)	Body-length (cm)	Tail length (cm)	Tail width (cm)	Tail circumference (cm)
Breed		ns	ns	ns	**	**	**
Menz	201	50.94	50.93	50.37	17.13	8.41	9.61
		(±0.58)	(±0.56)	(±0.65)	(±0.54)	(±0.24)	(±0.29)
Horro	109	50.80	52.06	50.60	27.87	6.94	8.28
		(±0.77)	(±0.74)	(±0.86)	(±0.71)	(±0.32)	(±0.38)
Birth Type		**	**	*	ns	**	**
Single	262	52.72	53.20	51.66	23.02	8.50	9.56
		(±0.41)	(±0.39)	(±0.45)	(±0.38)	(±0.17)	(±0.20)
Twins	48	49.02	49.79	49.32	21.97	6.85	8.33
		(±0.93)	(±0.89)	(±1.03)	(±0.86)	(±0.38)	(±0.46)
Dam Parity		ns	ns	ns	ns	ns	ns
1	161	50.56	51.24	50.16	22.24	7.46	8.92
		(±0.62)	(±0.60)	(±0.69)	(±0.58)	(±0.26)	(±0.31)
2	149	51.18	51.75	50.82	22.75	7.89	8.97
		(±0.64)	(±0.62)	(±0.72)	(±0.59)	(±0.26)	(±0.32)
Birth Season		**	*	*	*	*	ns
Dry'92	102	53.09^a	52.88^b	49.89^b	22.79^a	7.80^a	9.79^a
		(±0.64)	(±0.61)	(±0.71)	(±0.59)	(±0.26)	(±0.32)
Wet'93	136	50.05^b	52.03^a	52.09^a	23.91^a	8.24^a	8.33^b
		(±1.04)	(±1.00)	(±1.16)	(±0.96)	(±0.43)	(±0.52)
Dry'93	72	49.48^b	49.57^b	49.49^b	20.80^b	6.99^b	8.72^b
		(±0.71)	(±0.69)	(±0.53)	(±0.66)	(±0.29)	(±0.36)
R^2		0.49	0.50	0.39	0.80	0.53	0.44
C.V. (%)		6.2	6.0	7.2	14.6	16.0	16.4

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Table 18: Linear body measurements of male Menz and Horro lambs at 270 days of age

Sources of Variation	n	LSMEANS(±SE) of Measurements					
		Heart-girth (cm)	Wither-height (cm)	Body-length (cm)	Tail		
					length (cm)	width (cm)	circumference (cm)
Breed		ns	**	ns	**	*	**
Menz	174	57.57	55.13	54.36	20.62	10.81	13.11
		(±0.49)	(±0.45)	(±0.64)	(±0.51)	(±0.27)	(±0.32)
Horro	84	56.39	57.86	55.01	32.53	9.95	11.16
		(±0.63)	(±0.58)	(±0.83)	(±0.66)	(±0.35)	(±0.41)
Birth Type		**	**	ns	ns	ns	**
Single	224	58.29	57.55	55.61	26.13	10.67	12.90
		(±0.35)	(±0.32)	(±0.45)	(±0.36)	(±0.19)	(±0.22)
Twins	34	55.67	55.45	53.76	27.02	10.09	11.36
		(±0.79)	(±0.73)	(±1.03)	(±0.82)	(±0.43)	(±0.51)
Dam Parity		ns	ns	ns	ns	ns	ns
1	132	56.79	56.23	54.81	26.66	10.21	12.02
		(±0.57)	(±0.52)	(±0.74)	(±0.59)	(±0.31)	(±0.37)
2	126	57.17	56.76	54.56	26.49	10.54	12.25
		(±0.50)	(±0.46)	(±0.65)	(±0.52)	(±0.27)	(±0.32)
Birth Season		**	**	**	**	*	*
Dry'92	96	62.32^a	59.92^a	58.57^a	29.15^a	12.71^a	15.14^a
		(±0.66)	(±0.61)	(±0.87)	(±0.69)	(±0.36)	(±0.43)
Wet'93	96	54.86^b	54.51^b	53.20^b	25.24^b	8.61^b	9.98^c
		(±0.71)	(±0.65)	(±0.92)	(±0.74)	(±0.39)	(±0.46)
Dry'93	66	53.76^b	55.05^b	52.28^b	25.34^b	9.82^c	11.27^b
		(±0.68)	(±0.63)	(±0.89)	(±0.71)	(±0.37)	(±0.44)
R^2		0.65	0.64	0.46	0.80	0.64	0.63
C.V. (%)		5.9	5.5	8.0	15.0	17.2	16.9

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Table 19: Linear body measurements of male Menz and Horro lambs at 365 days of age

Sources of Variation	n	LSMEANS(±SE) of Measurements					
		Heart-girth (cm)	Wither-height (cm)	Body-length (cm)	Tail length (cm)	Tail width (cm)	Tail circumference (cm)
Breed		ns	***	*	***	ns	ns
Menz	149	61.53	59.89	58.12	22.52	12.55	14.96
		(±0.50)	(±0.44)	(±0.67)	(±0.62)	(±0.32)	(±0.35)
Horro	72	61.11	61.91	60.38	36.28	11.82	14.37
		(±0.70)	(±0.62)	(±0.94)	(±0.87)	(±0.45)	(±0.49)
Birth Type		*	ns	ns	ns	ns	ns
Single	191	62.44	61.40	59.77	28.72	12.65	15.15
		(±0.36)	(±0.32)	(±0.49)	(±0.45)	(±0.24)	(±0.25)
Twins	30	60.19	60.40	58.73	30.08	11.72	14.18
		(±0.86)	(±0.77)	(±1.17)	(±1.07)	(±0.56)	(±0.61)
Dam Parity		ns	ns	ns	ns	ns	ns
1	117	61.09	61.13	59.57	29.34	12.23	14.64
		(±0.61)	(±0.55)	(±0.83)	(±0.76)	(±0.40)	(±0.43)
2	104	61.54	60.67	58.93	29.46	12.15	14.69
		(±0.35	(±0.47)	(±0.72)	(±0.66)	(±0.35)	(±0.38)
Birth Season		*	***	***	***	***	***
Dry'92	78	65.67^a	64.42^a	64.11^a	31.91^a	14.05^a	16.38^a
		(±0.75)	(±0.67)	(±1.01)	(±0.93)	(±0.49)	(±0.53)
Wet'93	89	60.23^b	59.72^b	56.94^b	28.52^b	11.64^b	14.34^b
		(±0.73)	(±0.65)	(±0.99)	(±0.91)	(±0.48)	(±0.51)
Dry'93	54	58.05^c	58.56^b	56.70^b	27.76^b	10.87^b	13.28^b
		(±0.80)	(±0.71)	(±1.08)	(±0.99)	(±0.52)	(±0.56)
R^2		0.60	0.63	0.54	0.79	0.42	0.38
C.V. (%)		5.4	4.9	7.7	15.9	17.0	15.4

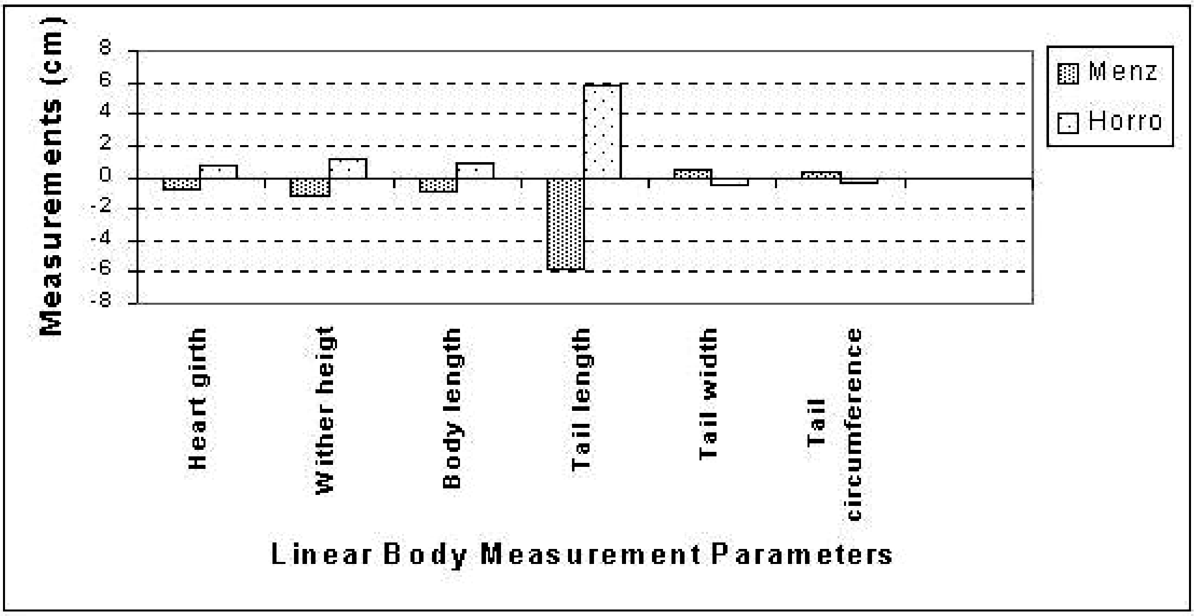
ns = not significant; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; Birth Season: Dry'92= born October/November 1992; Wet'93= born June/July 1993; Dry'93= born November/December 1993

Menz lambs had as expected a wider tail, hence, a larger tail circumference at 180, 270, and 365 days of age (Tables 17, 18 and 19). However, tail circumference measurements of Menz and Horro at 365 days of age (14.96 and 14.37 cm, respectively) were not significantly different (p >0.05).

The difference in heart girth between singles and twins was significant at 180 and 270 days of age (p <0.01) and at 365 days of age (p <0.05). This is more likely a reflection of the body condition status of the animals rather than the expression of birth type effect on heart girth.

The deviations of body weight and linear body measurements of Menz and Horro lambs from overall LS Means at 180 and 365 days of age are shown in Figures 9 and 10. These clearly reflect the differences explained above where Horro lambs had above average measurements except for tail width and tail circumference measurements. At all stages of growth, the two breeds differ greatly in tail length as the Horro sheep is characterised to have a long fat tail.

Figure 9: Deviation of linear body measurements (cm) from overall LS means for male Menz and Horro lambs at 180 days of age



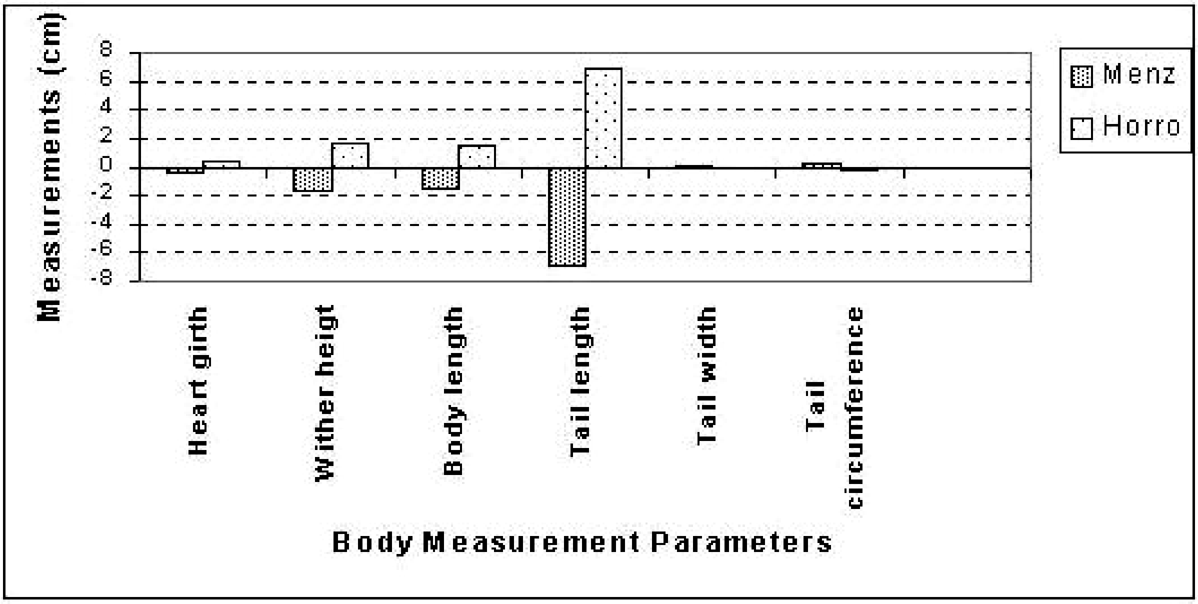


Figure 10: Deviation of linear body measurements (cm) from overall LS means for male Menz and Horro lambs at 365 days of age

The positive correlation observed between body weight and linear body measurements is highly significant (p <0.01) for both breeds (Tables 20, 22 and 24). As expected, heart girth measurement is the best regressor of body weight at various ages compared to the other linear body measurements for both Menz and Horro lambs.

The regression R^2 shows that these correlations are slightly higher for Menz lambs than for the Horro (Tables 21, 23, and 25). At the age of 6 months, body weight in Menz lambs can be fairly accurately estimated from heart girth, wither height and tail circumference measurements (Table 21). At the same age, however, the best possible body weight estimate for Horro lambs could be calculated using heart girth, body length and tail circumference measurements (Table 21). At 9 months of age (Tables 23), a slightly higher R^2 was observed and a relatively better weight estimate could be achieved by using heart girth, wither height and tail width measurements for Menz ($R^2=0.88$) and including heart girth, body length and tail circumference for Horro ($R^2=0.82$).

However, by including other linear body measurements such as wither height, body length, or some of the tail measurements depending on their significant contribution in the Stepwise regression analysis weight prediction could be substantially improved (Tables 21, 23 and 25).

Table 20: Correlation coefficients of body weight and linear body measurements for male Menz and Horro lambs at 6 months of age (n=129 and 67 respectively)

Menz (upper diagonal)/ Horro (lower diagonal)	Body weight	Heart girth	Wither height	Body length	Tail length	Tail width	Tail circumference
		***	***	***	***	***	***
Body weight	-	0.88	0.83	0.71	0.39	0.70	0.78
Heart girth	0.86	-	0.83	0.70	0.39	0.69	0.77
Wither height	0.67	0.67	-	0.69	0.41	0.68	0.67
Body length	0.63	0.57	0.64	-	0.39	0.63	0.54
Tail length	0.59	0.51	0.72	0.51	-	0.25	0.30
Tail width	0.68	0.53	0.55	0.48	0.67	-	0.77
Tail circumference	0.63	0.56	0.57	0.35	0.54	0.75	-

** *P < 0.001

Table 21: Regression models for predicting body weight of Menz and Horro ram lambs from some linear body measurements (HG, WH, BL, TC, TW)* at 180 days of age

Models and independent variables	a	b_1	b_2	b_3	R^2
Menz					
$a + b_1$HG	-14.9768	0.5204	--		0.77
$a + b_1$HG + b_2WH	-16.9601	0.3573	0.2024	--	0.80
$a + b_1$HG + b_2WH + b_3TC	-14.6564	0.2709	0.1914	0.2722	0.82
Horro					
$a + b_1$HG	-17.8938	0.5803	--		0.67
$a + b_1$HG + b_2BL	-21.4145	0.4719	0.1806	--	0.72
$a + b_1$HG + b_2BL + b_3TW	-19.7373	0.4204	0.1480	0.3695	0.74

*HG= Heart girth; WH= Wither height; BL= Body length; TW= Tail width; TC= Tail circumference

Table 22: Correlation coefficients of body weight and body linear measurements for male Menz and Horro lambs at 9 months of age (n=174 and 83 respectively)

Menz (upper diagonal)/ Horro (lower diagonal)	Body weight	Heart girth	Wither height	Body length	Tail length	Tail width	Tail circumference
		***	***	***	***	***	***
Body weight	-	0.89	0.86	0.80	0.49	0.82	0.85
Heart girth	0.84	-	0.87	0.76	0.49	0.78	0.84
Wither height	0.68	0.78	-	0.77	0.52	0.78	0.79
Body length	0.73	0.77	0.73	-	0.48	0.73	0.69
Tail length	0.66	0.75	0.68	0.74	-	0.58	0.56
Tail width	0.69	0.74	0.65	0.68	0.69	-	0.92
Tail circumference	0.74	0.81	0.65	0.67	0.73	0.87	-

** *P < 0.001

Table 23: Regression models for predicting body weight of Menz and Horro ram lambs from some linear body measurements (HG, WH, BL, TW, TC)* at 270 days of age

Models and independent variables	a	b_1	b_2	b_3	R^2
Menz					
$a + b_1$HG	-25.1949	0.7145	--		0.83
$a + b_1$HG + b_2TW	-18.1381	0.4903	0.5377	--	0.88
$a + b_1$HG + b_2WH + b_3TW	-21.3931	0.3931	0.1735	0.4650	0.88
Horro					
$a + b_1$HG	-28.7136	0.7778	--		0.82
$a + b_1$HG + b_2TC	-19.8443	0.5354	0.4257	--	0.87
$a + b_1$HG + b_2BL + b_3TC	-20.8628	0.4449	0.1178	0.3992	0.88

*HG= Heart girth; WH= Wither height; BL= Body length; TW= Tail width; TC= Tail circumference

Table 24: Correlation coefficients of body weight and body linear measurements for male Menz and Horro lambs at 12 months of age (n=150 and 71 respectively)

Menz (upper diagonal)/ Horro (lower diagonal)	Body weight	Heart girth	Wither height	Body length	Tail length	Tail width	Tail circumference
		***	***	***	***	***	***
Body weight	-	0.90	0.80	0.76	0.41	0.74	0.72
Heart girth	0.86	-	0.80	0.72	0.41	0.73	0.73
Wither height	0.78	0.79	-	0.74	0.43	0.62	0.60
Body length	0.77	0.77	0.75	-	0.47	0.56	0.52
Tail length	0.75	0.75	0.70	0.73	-	0.44	0.40
Tail width	0.76	0.74	0.72	0.71	0.75	-	0.89
Tail circumference	0.73	0.74	0.66	0.65	0.76	0.89	-

** *P < 0.001

Table 25: Regression models for predicting body weight of Menz and Horro ram lambs from some linear body measurements (HG, WH, BL, TL, TW, TC)* at 365 days of age

Models and independent variables	*a*	b_1	b_2	b_3	R^2
Menz					
$a + b_1$HG	-35.0606	0.8938	--		0.83
$a + b_1$HG + b_2BL	-36.2150	0.7209	0.2044	--	0.85
$a + b_1$HG + b_2BL + b_3TW	-31.4011	0.5734	0.1922	0.3919	0.88
Horro					
$a + b_1$HG	-40.3616	0.9947	--		0.81
$a + b_1$HG + b_2WH	-50.4522	0.7469	0.4061	--	0.84
$a + b_1$HG + b_2WH + b_3BL	-47.7159	0.6620	0.3159	0.1352	0.85

*HG= Heart girth; WH= Wither height; BL= Body length; TW= Tail width

Linear body measurements were also taken from male Menz and Horro lambs born during the first lambing season and which were in the fattening study (Table 26). All measurements were taken fortnightly. Menz lambs seem to have larger heart girth measurement than the Horro, though not significantly different (p >0.05). Wither height, body length and tail length have the same trend as that for all the groups and were significantly higher (p <0.01) for Horro compared to that of the Menz lambs (Table 26). Menz lambs had differed significantly (p <0.01) from Horro in tail width and tail circumference. The two breeds did not differ significantly (P >0.05) in tail volume measured by water displacement method.

Table 26: Weight and body linear measurements of Male Menz and Horro lambs during the fattening period

	LSMEANS (±SE) of Parameters Measured							
	Body Wt. kg	Heart-Girth cm	Wither Height cm	Body Length cm	Tail Length cm	Tail Width cm	Tail Circumf. cm	Tail Volume ml
Week 1								
	ns	ns	**	**	**	ns	ns	ns
Menz	26.4	71.6	61.6	61.6	23.2	15.2	16.4	730.3
	(±0.52)	(±0.58)	(±0.72)	(±0.43)	(±0.52)	(±0.33)	(±0.28)	(±34.77)
Horro	27.3	71.2	64.7	64.9	40.1	14.3	15.7	774.1
	(±0.68)	(±0.67)	(±0.83)	(±0.50)	(±0.60)	(±0.38)	(±0.33)	(±40.42)
R^2	0.44	0.39	0.38	0.61	0.92	0.33	0.42	0.25
C.V.(%)	11.1	4.6	6.5	3.9	9.6	12.7	10.0	26.4
Week 8								
	ns	ns	**	**	**	**	**	ns
Menz	29.8	74.9	63.2	61.8	27.7	19.9	22.9	1369.5
	(±0.53)	(±0.55)	(±0.52)	(±0.67)	(±0.63)	(±0.32)	(±0.35)	(±49.39)
Horro	31.2	73.8	66.4	67.0	42.4	16.8	21.2	1357.8
	(±0.64)	(±0.64)	(±0.61)	(±0.78)	(±0.73)	(±0.37)	(±0.35)	(±57.42)
R^2	0.46	0.33	0.50	0.56	0.86	0.57	0.35	0.20
C.V.(%)	9.8	4.2	4.6	6.0	10.4	9.7	9.0	20.6
Week 16								
	*	ns	**	**	**	**	**	ns
Menz	32.7	71.9	68.1	68.8	29.9	20.7	25.3	1895.3
	(±0.61)	(±0.46)	(±0.53)	(±0.36)	(±0.62)	(±0.32)	(±0.37)	(±55.35)
Horro	34.7	71.7	69.9	70.8	44.3	18.0	23.6	1881.0
	(±0.70)	(±0.51)	(±0.59)	(±1.40)	(±0.69)	(±0.35)	(±0.41)	(±61.13)
R^2	0.47	0.43	0.40	0.54	0.88	0.51	0.31	0.39
C.V.(%)	9.7	3.5	4.2	2.8	9.2	8.9	8.3	16.0

ns = not significant * = $P < 0.05$ ** = $P < 0.01$ Tail circumf. = Tail circumference

4.3. Fattening performance of male lambs

4.3.1. Weight gain and feed intake of male Menz and Horro lambs

At one year of age, all available male lambs (34 Menz and 26 Horro) born in the first lambing season of the programme were included in a fattening performance study. The study was undertaken for 123 days excluding two weeks of adaptation period.

Least Squares means and standard errors of initial body weight, unfasted final body weight, fasted final body weight (slaughter weight), age at slaughter, hot and cold carcass weight and dressing percentage are presented in Table 27.

There was no significant difference ($p > 0.05$) in body weight at the beginning of the experiment (Table 27). The mean initial body weights were 26.4 ± 0.52 kg and 27.3 ± 0.68 kg for Menz and Horro lambs respectively. However, at the end of the fattening study Horro lambs attained significantly heavier ($p < 0.05$) final weight compared to Menz lambs (34.7 ± 0.63 kg for Horro and 32.7 ± 0.57 kg Menz). This weight difference was also reflected in the slaughter weight which was taken after fasting the animals for 16 hours and prior to slaughter.

Despite the clear tendency of Horro lambs having a heavier hot and cold carcass weight, Horro lambs did not differ significantly ($P > 0.05$) from the Menz in dressing % and loss of carcass moisture (shrinking %) after an overnight cold room storage (Table 27). The slightly higher but not significantly different ($P > 0.05$) loss of moisture from Horro lamb carcasses compared to carcasses from Menz lambs indicates that carcasses from Menz lambs had a better fat cover.

Table 27: Fattening and carcass performance of Male Menz and Horro lambs

Parameters measured	LSMEANS(±SE) of parameters measured				
	Menz (n=34)[1]	Horro (n=26)	Level of significance	R²	C.V. (%)
Initial body weight, kg	26.5 (±0.63)	28.3 (±0.70)	ns	0.36	12.5
Final body weight, kg	32.1 (±0.54)	34.1 (±0.61)	*	0.49	9.0
Average daily gain, g	45.5 (±2.90)	47.3 (±3.81)	ns	0.47	34.3
Slaughter weight (FBW)[2], kg	28.9 (±0.56)	31.0 (±0.63)	*	0.44	10.3
Empty body weight, kg	23.1 (±0.46)	24.0 (±0.52)	**	0.36	10.8
Hot-carcass weight, kg	14.2 (±0.26)	14.8 (±0.29)	ns	0.42	9.9
Cold-carcass weight, kg	13.6 (±0.26)	14.2 (±0.29)	ns	0.41	10.3
Dressing %	49.1 (±0.57)	48.0 (±0.64)	ns	0.27	6.4
Shrinking %	3.8 (±0.17)	4.2 (±0.19)	ns	0.27	23.6
Age at slaughter, days	527.5 (±1.42)	528.2 (±1.60)	ns	0.41	1.5

ns = not significant; * = $P < 0.05$; ** = $P < 0.01$; [1] There were only 30 Menz lambs at slaughter time; [2] FBW= Fasted Body Weight

Menz and Horro lambs have also differed significantly in fresh weights and proportion to carcass of internal organs (GIT) as shown in Table 28. The fresh contents of the GIT were also weighed along with the corresponding GIT part. Horro lambs seem to have a significantly larger ($p < 0.01$) gastro-intestinal-tract compared to Menz (Table 28). The fresh GIT content in proportion to slaughter weight for Horro lambs was 15.2 ± 0.52 % compared to 13.3 ± 0.46 % for the Menz, the difference being significant ($P < 0.05$). This is also reflected in the amount of the dry matter intake by the two breeds where Horro lambs seem to have ingested more feed on dry matter basis than the Menz (Table 29). When the amount of dry matter intake is calculated on the basis of metabolic body weight, the intake of Horro was slightly higher (65.6 ± 1.72 per kg $W^{0.75}$ for Menz and 67.8 ± 1.95 per kg $W^{0.75}$ for Horro) but the difference was not significant. The faecal dry matter output was also higher ($p < 0.01$) in Horro than in Menz lambs (426.2 g vs 366.0 g respectively) indicating a lower ($p < 0.01$) digestibility estimate (51.6 % vs 54.0 %, respectively) as shown in Table 29.

Table 28: Fresh weight of different parts of the gastro-intestinal tract (GIT) from male Menz and Horro lambs

Gastro-Intestinal-Tract (GIT) Parts	LSMEANS (±SE) Menz	Horro	Level of significance	R²	C.V. (%)
Hindgut (empty), g	1111.8 (±34.18)	1273.0 (±38.27)	**	0.44	15.7
Hindgut content, g	560.0 (±48.52)	842.5 (±54.33)	**	0.45	38.3
Forgut (empty), g	856.4 (±15.41)	967.5 (±17.25)	**	0.66	9.3
Forgut content, g	3287.6 (±141.44)	3919.6 (±158.37)	**	0.43	21.6
Reticulo-rumen (empty), g	661.9 (±13.25)	745.2 (±14.84)	**	0.60	10.3
Reticulo-rumen content, g	3097.8 (±135.23)	3659.1 (±151.42)	**	0.44	22.0
Omasum-Abomasum (empty), g	194.5 (±4.89)	222.3 (±5.47)	**	0.61	12.8
Omasum-Abomasum content, g	189.7 (±12.64)	260.5 (±14.16)	**	0.43	31.0
GIT Content as % of slaughter weight, kg	13.3 (±0.46)	15.2 (±0.52)	*	0.41	17.1
GIT with content as % of slaughter weight, kg	20.1 (±0.47)	22.6 (±0.53)	***	0.45	11.6

GIT = Gastrointestinal Tract; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$;

Table 29: Feed intake and digestibility estimate of male Menz and Horro lambs during fattening period

Variables	LSMEANS (±SE)		Level of Significance	R²	C.V. (%)
	Menz	Horro			
Hay dry matter intake, g	435.1 (±9.28)	506.0 (±12.18)	**	0.62	11.1
Concentrate dry matter intake, g	367.1 (±1.42)	373.6 (±1.87)	**	0.40	2.1
Total dry matter intake, g	802.2 (±9.35)	879.6 (±12.27)	**	0.63	6.2
Dry matter intake, g/ kg $W^{0.75}$	65.6 (±1.72)	67.8 (±1.95)	ns	0.48	14.3
Faecal dry matter, g	366.0 (±6.62)	426.2 (±8.68)	**	0.66	9.4
Digestibility estimate (%)	54.0 (±0.01)	51.6 (±0.01)	**	0.53	5.4

** = $P < 0.01$

4.3.2. Carcass performance and body fat estimate of Male Horro and Menz lambs

4.3.2.1. Relative weights of carcasses and non-carcass components and dressing percentage

Although Horro lambs were heavier ($P < 0.05$) at slaughter than the Menz, they had lower but not significantly different ($P > 0.05$) dressing percent. The smaller and relatively compact Menz lambs on the other hand seem to have a slightly better dressing percentage. As indicated by Ruvuna et al. (1992), dressing percent is an important tool for evaluating carcass merit. However, since dressing percent is influenced by many factors such as breed, age, castration, feeding regime and fattening level (Ruvuna et al. 1992), care should be taken in interpreting results. Dressing percentages of Menz and Horro lambs (49.1 ± 0.57 % and 48.0 ± 0.64 %, respectively) observed in this study (Table 27) is in line with that reported by Enyew Negussie (1999) for one year old Menz and Horro lambs which is 48.7 ± 0.7 % for both breeds.

Soon after slaughter, hot (fresh) weight of carcasses and non-carcass parts were taken (Tables 27 and 28). Information on dissectible carcass composition for breeds was obtained by dissecting the left half of the carcasses after an overnight storage at 4^oC. Proportion of the various components of whole carcasses were then estimated and analysed. Least Squares means and standard errors of dissected carcass parts and proportion of dissectible carcass components are presented in Table 30 and Figure 11.

There was no significant difference observed between the two breeds in dissectible carcass parts except total bone weight. Horro lambs had heavier (P <0.01) total carcass bone weight compared to Menz lambs (3.31 ± 0.08 kg vs 2.99 ± 0.07 kg). This could be attributed to the comparative larger body frame of the Horro compared to Menz sheep. However, there was no significant difference (P >0.05) in bone proportion when only the composition of the dissected part is considered (Figure 11) indicating that the two breeds have similar proportion of carcass components.

Table 30: Least Squares Means (± SE) of estimated whole carcass components and proportion of whole carcass parts from male Menz and Horro lambs

Carcass parts	LSMEANS(±SE)			R²	C.V. (%)	Proportion of whole carcass parts (%)	
	Menz	Horro	Significance level			Menz	Horro
Total lean (dissectible), kg	8.55 (±0.19)	8.91 (±0.22)	ns	0.37	12.2	58.00	57.89
Total fat (dissectible), kg	2.88 (±0.11)	2.77 (±0.12)	ns	0.36	19.5	19.50	18.04
Total bone, kg	2.99 (±0.07)	3.31 (±0.08)	**	0.46	11.9	20.44	21.52
Total sundry, kg	0.30 (±0.04)	0.39 (±0.04)	ns	0.41	57.8	2.06	2.55
Total [a]	14.72	15.38				100	100

ns = not significant; * = P < 0.05; ** = P < 0.01; [a] The sum total of the carcass parts is higher than the actual carcass weight due to conversion and rounding up of figures

Figure 11: Carcass composition of the dissected left half carcasses of Menz and Horro lambs

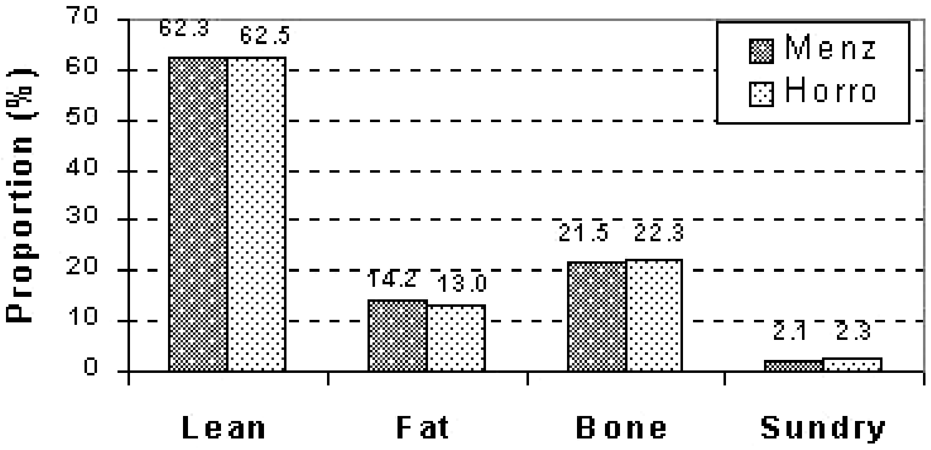


Table 31: Least Squares Means and SE of carcass composition of the dissected left half carcasses from male Menz and Horro lambs

Breed	n	Carcass Composition (%)			
		Lean (muscle)	dissectible fat[1]	bone	sundry
Menz	31	62.34±0.52	14.17±0.62	21.46±0.42	2.11±0.27
Horro	26	62.41±0.59	13.00±0.70	22.32±0.47	2.27±0.30
Significance		ns	ns	ns	ns
R^2		0.25	0.31	0.30	0.39
C.V. (%)		4.6	25.1	10.3	59.7

ns = not significantly different ; [1]does not include tail fat

Table 32: Lean /bone and lean/fat ratio of whole and dissected half carcasses

Breed	estimate for whole carcass		dissected half carcass	
	lean : bone	lean : fat	lean : bone	lean : fat
Menz	2.9±0.06	3.1±0.14	2.8±0.06	3.0±0.13
Horro	2.7±0.07	3.3±0.15	2.6±0.06	3.2±0.15
Significance	*	ns	*	ns
R^2	0.31	0.33	0.35	0.34
C. V. (%)	11.5	22.3	11.3	22.5

ns = not significantly different; * = $P < 0.05$

4.3.2.2. Direct and indirect estimation of total body fat

Based on the amount of dissectible body fat from the half carcasses, total dissectible body fat was estimated for both breeds (Tables 33). Least Squares means of body fat estimate in various carcass and non-carcass parts and proportion of the fat distribution (Figure 12 and Figure 13) show that both breeds have fairly similar body fat distribution.

However carcasses from Menz lambs had higher ($P < 0.05$) total Ether extract estimate compared to that of the Horro (Table 33).

Menz lambs had a significantly higher ($P < 0.05$) total ether extract estimate (Table 33) than the Horro. Dissectible fat in various carcass parts and other fat depots all indicate higher values for Menz sheep, though except for a significant difference ($P < 0.05$) in estimated total lean ether extract (Table 33), all other differences fail the 95 % confidence level. Menz and Horro lambs compare well in terms of fat distribution as estimated by the ether extract with 32.1 % and 31.5 % subcutaneous fat, 29.0 % and 30.8 % tail/rump fat, 16.5 % and 15.1 % lean fat, 11.4 % and 11.2 % GIT fat, 4.6 % and 3.9 % gut fat, respectively.

Table 33: Least Squares Means ± SE of Ether extract estimate (g) of whole carcasses and non-carcass body components of Menz and Horro lambs

Carcass and non-carcass component	LSMEAN(±SE)		Significance	R²	C.V.(%)
	Menz	Horro			
Subcutaneous fat + IMF[1]	983.15±57.79 (32.1)[2]	857.05±64.71 (31.5)	ns	0.36	34.8
Tail +Rump fat	885.37±30.14 (29.0)	838.37±33.75 (30.8)	ns	0.40	19.3
Lean fat	505.18±25.86 (16.5)	411.00±28.95 (15.1)	*	0.38	30.7
GIT[3] fat	347.79±20.81 (11.4)	303.60±23.30 (11.2)	ns	0.47	35.0
Gut fat	140.95±12.04 (4.6)	105.30±13.48 (3.9)	ns	0.68	53.6
Sundry Fat	92.06±13.73 (3.0)	114.73±15.37 (4.2)	ns	0.44	74.6
Renal fat	59.23±4.72 (1.9)	45.10±5.28 (1.7)	ns	0.50	49.0
Urogenital fat	45.97±4.98 (1.5)	43.55±5.57 (1.6)	ns	0.34	62.9
Total Ether extract	3059.70±95.20 (100.0)	2718.7±106.60 (100.0)	*	0.52	18.1
Lean Ether extract (%)	22.4 ± 0.89	18.1 ± 1.00	**	0.43	23.9

ns = not significant; * = P < 0.05; ** = P < 0.01; [1] IMF denotes Inter-Muscular Fat; [2] Figures in parenthesis show percent of total Ether extract estimate; [3] GIT is gastro-intestinal tract

Although the difference in the estimated total dissectible fat for the two breeds was not significant ($p > 0.05$), the estimated total ether extract for carcasses of Menz lambs was higher ($p < 0.05$) than that for Horro (Table 33). As shown in Table 33, the proportion of fat in the various carcass and non-carcass parts of both breeds were not significantly different ($p > 0.05$). However as shown in Table 33, lean from Menz lambs had significantly higher ($P < 0.01$) ether extract estimate on dry matter basis compared to that from Horro lambs (22.4±0.89 % and 18.1±1.00 %, respectively).

The higher lean ether extract estimate indicates that carcasses from Menz lambs have more inter- and intramuscular fat compared to that of the Horro. The correlations between tail volume measurements, tail weight, estimates of total fat in some carcass components and ether extract estimates are shown in Table 34. Total tail and rump fat estimates in Horro lambs had high correlation with tail volume measurements (ml) taken before slaughter (Tail V., l) and skinned tail volume measurement (Tail V., s) taken after slaughter. However in both breeds the correlation coefficients ($r = 0.66$ and 0.79 for Menz and $r = 0.78$ and 0.92 for Horro) between total tail/ rump fat and live tail volume and skinned tail volume, respectively were highly significant ($P < 0.001$).

There is fairly similar strong and positive relationship ($P < 0.001$) between subcutaneous fat and total dissectible fat and total ether extract estimate ($r = 0.92$ and 0.74 for Menz and $r = 0.92$ and 0.72 for Horro lambs, respectively). Tail and rump fat could be fairly accurately predicted in both breeds from tail volume measurements (Table 35). Nevertheless, as the regression equations in Table 35 indicate, tail volume measurements of Horro lambs could be used to estimate tail/rump weight as there is a very high correlation between the parameters compared to that of the Menz. On the other hand total body fat of Menz lambs could be predicted from tail /rump fat weight while total body fat in the Horro could be better predicted from tail volume (Table 36). As shown in Table 34, the relationship between total body fat, tail/rump fat weight and tail volume measurements does not seem to be strong. Therefore, it will be necessary to further investigate the usefulness of tail volume measurements for predicting body fat.

Table 34: Correlation of tail volume measurements, body fat depots and total body fat and Ether extract estimates

Menz/ (upper dgl.) Horro (lower dgl.)	Tail V. (l)	Tail V. (s)	TAILRU FAT	TOSFA	TOTFA	TOEE
Tail V. (l)	-	0.82 ***	0.66 ***	0.21 ns	0.40 *	0.17 ns
Tail V. (s)	0.65 ***	-	0.79 ***	0.26 ns	0.49 **	0.31 ns
TAILRU fat	0.78 ***	0.92 ***	-	0.19 ns	0.51 **	0.39 **
TOSFA	0.28 ns	0.08 ns	0.11 ns	-	0.91 ***	0.74 ***
TOTFA	0.50 **	0.32 ns	0.37 ns	0.94 ***	-	0.87 ***
TOEE	0.31 ns	0.15 ns	0.15 ns	0.72 ***	0.80 ***	-

ns = not significantly different; * = P <0.05; ** = P <0.01; *** = P <0.001; Tail V. (l) = Tail volume measured on live animal; Tail V. (s) = Skinned tail volume measured after slaughter; TAILRU fat = Total tail and rump fat wt; TOSFA = Total subcutaneous fat; TOTFA = The sum total of dissectible fat from the various carcass parts; TOEE = Total Ether extract (sum of ether extract estimates for the various carcass parts)

Figure 12: Carcass and non-carcass fat distribution of male Menz lambs

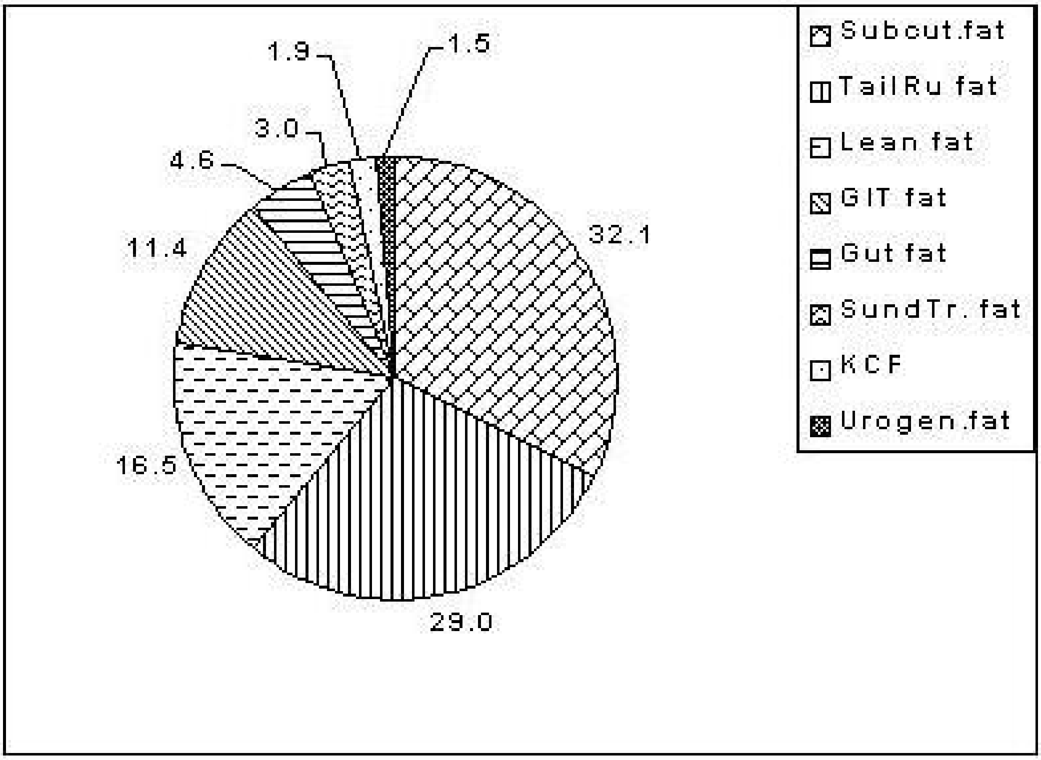


Figure 13: Carcass and non-carcass fat distribution of male Horro lambs

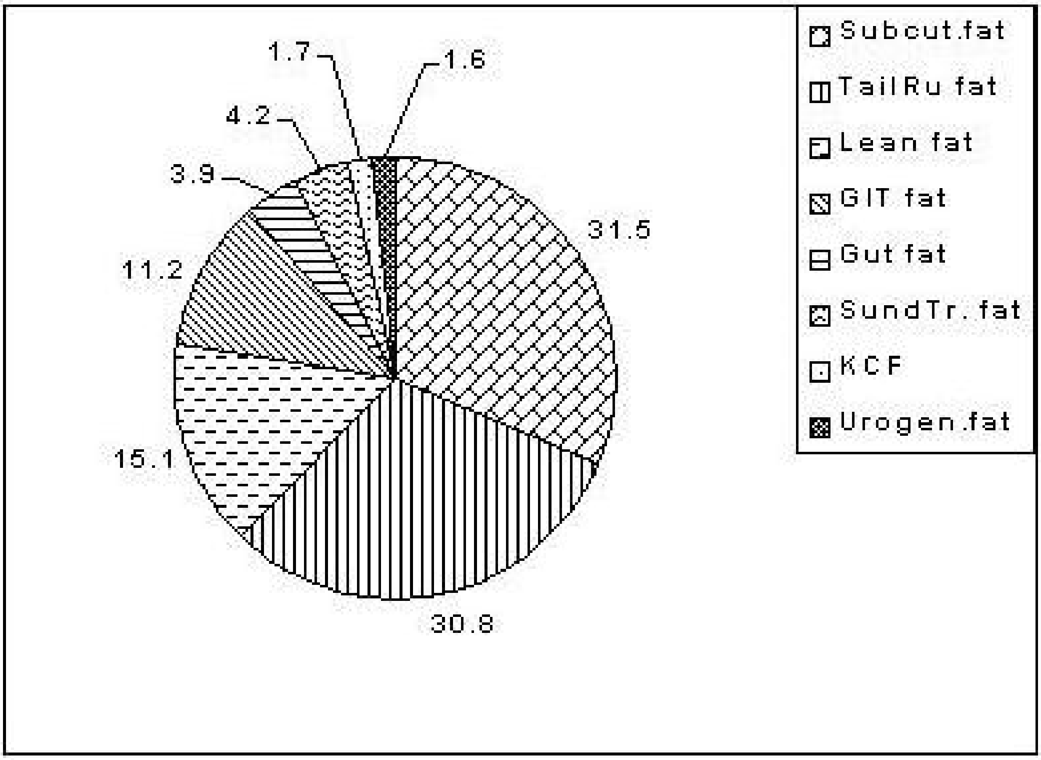


Table 35: Regression equations relating tail and rump fat weight (g) to tail volume measured on live animal (ml) and skinned tail volume (ml) taken after slaughter

Models and independent variables	*a*	b_1	b_2	Sig. Level	R²
Menz					
a + b_1 *TAIL VOLUME (skinned)*	293.9418	0.6951		***	0.62
Horro					
a + b_1 *TAIL VOLUME (skinned)*	165.3888	0.7956		***	0.84
a + b_1 *TAIL V. (live)* + b_1 *TAIL V. (skinned)*	-106.6380	0.2504	0.6128	***	0.90

*** = P <0.001

Table 36: Regression equations relating estimated total disectable body fat (g) to tail volume measured on live animal (ml) and tail/rump fat weight (g) and skinned tail volume (ml) taken after slaughter

Models and independent variables	*a*	b_1	*Sig. level*	R²
Menz				
a + b_1 *(TAILRU FAT)*	1450.9485	1.4691	**	0.26
Horro				
a + b_1 *TAIL VOLUME (live)*	781.0795	1.1158	**	0.25

TAILRU FAT = TAIL/RUMP Fat weight; ** = P <0.01

4.4. Discussion

4.4.1. Birth weight

Birth weight is one of the most important factors influencing particularly the pre-weaning growth rate of animals. Factors which influence birth weight include dam size, dam body condition (Laes-Fettback and Peters, 1995), management system, sex, litter size etc.(Notter et al. 1991), these should be properly addressed as both the pre-weaning survival and growth performance are greatly influenced by birth weight.

Birth weight of Horro lambs (2.43 ± 0.03 kg) and that of Menz lambs (2.17 ± 0.03 kg) observed in this study differ significantly (P <0.001). However, birth weight of Menz lambs reported here is lower than that reported for on-farm conditions by Niftalem Dibissa (1990). Both Horro and Menz lambs have birth weights comparable to birth weights of other tropical and sub-tropical breeds such as Adal (Galal, 1983), Djallonke (Filius et al. 1985 and Wunderlich, 1990), African fat tail sheep of Rwanda (Wilson and Murayi, 1988). Although Horro and Menz lambs have much lower birth weights when compared to larger tropical breeds like the Dorper or Mossi or large temperate breeds like Merinolandschaf, Finn sheep crosses etc., the birth weights of both breeds observed in this study are within the ranges reported from other studies (Table 4).

The condition of the ewe during the gestation period, breed size, sex, litter size, and age of dam are known to influence birth weight. It is also well documented that flock management practices undertaken, particularly management of the breeding ewes, greatly influence birth weight of lambs. Even when the same breed is studied under farm and station conditions, birth weight of the offspring from the two groups could most probably be different. Under optimal level of management, lambs born on station could have higher birth weights. However, under the given station condition with a heavy parasite burden and health problems resulting from overcrowding, lambs born under farm condition could have a higher birth weight compared to those born on station.

As expected, it is also observed in this study that male lambs had significantly higher (P <0.001) birth weights compared to females (2.38 ± 0.03 kg for males and 2.22 ± 0.02 kg for females. This is also in line with other research findings where males are mostly heavier than females.

Lambs born from ewes of second parity were heavier (P <0.001) than those born from ewes of first parity (2.44 ± 0.03 kg and 2.16 ± 0.03 kg respectively). This is a reflection of the influence of dam weight and size as ewes of second or higher parities are expected to be heavier than first parity ewes.

In this study, mating of ewes was planned in such a way that lambing occurred either at the end of the main rainy season (October/November) or at the beginning of the main rainy season (June/July). As shown in Table 12, lambs born at the three lambing periods (Dry'92, Wet'93 and Dry'93,) had significantly different (P <0.05) birth weights (2.22 ± 0.04 kg, 2.30 ± 0.04 kg and 2.38 ± 0.04 kg, respectively). Although lambs born at the beginning of the main rainy season of Dry'93 tended to be heavier at birth (Table 12), this could not be conclusive as the Wet season lambing was not replicated. However this could probably be true due to the fact that ewes had a better quality pasture during the last two to three months of their gestation period than those which have lambed at the beginning of the 1993 wet season (Wet'93). Season of birth has also influenced birth weight significantly (P <0.05).

Despite the expectation that lambs born at the end of the rainy season to be heavier than those born at the beginning of the dry season mainly due to a better provision of pasture for the pregnant ewes towards the end of their gestation period, this is true only to lambs that were born in the Dry Season lambing of 1993 which were significantly heavier at birth compared to those born in the previous two seasons. Although this is likely to be the influence of qualitatively as well as quantitatively better forage availability of the ewes at the latter part of the gestation period, the result could not be conclusive as the wet season lambing was not replicated. However, the results indicate birth weight differences between the three lambing seasons.

4.4.2. Weaning weight, growth and average daily live weight gain (ADG)

As stated by Bathaei and Leroy (1996) and Orr (1982), growth could also be defined as an increase in body size and mass of the whole or part of the animal.

Although Horro and lambs seem to have similar growth performance as shown in Figures 1 and 2, they have differed in certain aspects. Apart from birth weight, Menz and Horro lambs have also differed in body weight, where Horro lambs maintained their superiority in birth weight during the pre-weaning growth phase. However, they were significantly (P <0.001) different only at one month of age (5.23 ± 0.07 kg for Horro and 4.74 ± 0.06 kg for the Menz).

The body weights for Menz and Horro lambs at 60, 90 (weaning) and at 120 days of age were 6.91 ± 0.11, 8.03 ± 0.12 and 9.14 ± 0.25 kg for Menz and 6.97 ± 0.13, 8.21 ± 0.13 and 9.03 ± 0.33 kg for Horro, respectively. Horro lambs had also higher, though not significantly different (P >0.05), average pre-weaning daily weight gain compared to Menz. Mean ADG between birth and 30 of age were 90.61 ± 1.87 g for Horro and 86.06 ± 1.76 g for Menz lambs (Table 14). However, when the average daily weight gain of lambs from birth to weaning (90 days) is considered, Menz lambs seem to have gained weight slightly more (P >0.05) than Horro lambs (69.43 ± 1.58 g for Menz and 68.14 ± 1.83 g for Horro). Average daily weight gain of Horro lambs observed at all stages of growth was much lower than what is reported else where (Table 5). The Menz have attained about 25 % of the estimated mature weight of the breed compared to about 22 % for the Horro. It is important to note here that the low pre-weaninig and post-weaning growth rate of the lambs of both breeds seem to be far from their potential level. This indicates a possible genotype x environment interaction as Horro lambs have shown a better performance in their area of origin (Table 5) where Gojjam et al. (1998) have reported a pre-weaning average daily weight gain of over 130 g.

After weaning, the growth rate of both breeds dropped substantially and then improved slightly. As shown in Figure 6, Horro lambs had a slightly better growth rate (P <0.05) between 270 and 365 days of age than Menz lambs.

The two breeds had an average daily weight gain of less than 30 g between weaning and 180 days of age (Tables 14 and 15). As shown in Figure 1, Horro lambs have tended to be heavier than Menz lambs at all stages of growth between 60 and 180 days of age though not significantly different (P >0.05). This trend was unchanged when only male lambs were considered (Table 13 and Figure 2). From 270 to 365 days of age however, Horro lambs gained significantly more weight (P <0.05) than the Menz (57.36 ± 3.17 g vs 50.62 ± 2.20 g, respectively).

The effect of breed on birth weight and subsequent growth performance of lambs is well documented. The early stages of growth are known to be strongly influenced by breed size, milk producing ability of the dam, the environment under which lambs are maintained, notably availability of adequate feed supply (Bathaei and Leroy 1996, Burfening and Kress 1993, Gatenby 1986, Notter and Copenhaver 1980).

As indicated in Table 12 Horro lambs were heavier (P <0.001) at birth compared to Menz lambs and this could be mainly due to their relative bigger body frame than the Menz. However, despite their relative advantage of being adapted to the area, Menz lambs did not grow faster (P >0.05) than the Horro since Horro ewes have been brought from a highland location of warmer climate.

The weaning weights (at 90 days of age) of both Menz and Horro lambs reported here (8.03 ± 0.12 kg for Menz and 8.21 ± 0.13 kg) are lower than weaning weights reported for the same breeds in their respective area of origin (Table 4). The reason for lower weaning weight of Menz lambs investigated under station condition could be due to differences in management and probably due to a heavier internal parasite load, as lambs in this study were drenched to control mostly Fasciola. On the other hand the reason for the Horro lambs to have a lower weaning weight than that reported else where could be due to adaptation problems in addition to internal parasite problem other than liver fluke.

Vercoe and Frisch (1987) have stated that the nature of the relationship between high growth potential and low resistance to environmental stresses should be determined in order to alleviate problems associated with the development of economically productive breeds which are also tolerant or resistant to environmental stresses. The production environment under which Menz and Horro lambs have been maintained in this study, therefore, could not be described as stress free as the animals were also regularly subjected to other studies through faecal sampling, blood sampling, etc. The low body weight of both Menz and Horro lambs could, therefore, be due to other external factors rather than the inherent potential of the breeds.

If lambs could be maintained under better management practices, economically productive animals could be selected by using their weaning weight in a selection index (van Wyk et al. 1993). The authors have suggested that an animal's weaning weight indicates its value at the desired marketing age.

Body weight of Menz and Horro lambs at 6 and 12 months of age is much lower than that reported in their respective area of origin by others (Table 4). This could mostly be due to differences in management although possible breed variation in growth rate could not be ruled out. As indicated in Tables 4 and 5, lamb growth patterns are influenced by the type of production systems practised. Such disparity in body weight development indicates that there is scope for improvement. On the other hand Notter et al. (1991) have reported that lamb growth rates could not be equated directly to the profitability of a certain production system since systems that promote an accelerated lamb growth mostly attain a high level of weight gain efficiency on the biological scale (kg gain/kg feed). This is realised under a more intensive type of production which requires supplementary feeding and this in most cases is beyond the reach of farmers in the tropics and sub-tropics.

At 12 months of age, Horro lambs were significantly ($P < 0.05$) heavier than the Menz and this could be as indicated earlier due to the increase in size rather than improvement in body condition.

Male lambs maintained their weight superiority at birth compared to females until 180 days of age (Table 12 and Figure 3) which was significant (P <0.01) at all stages. After the age of 180 days, female lambs received a preferential treatment for a different experiment. Therefore, it was not possible to continue the comparative evaluation of body weight development between male and female lambs.

When the rate of weight gain of only male lambs is considered (Table 15), Menz lambs seem to have faster (though not significantly different) preweaning (birth to 90 days) and post-weaning (90 to 180 days) weight gain compared to Horro lambs.

The effect of birth type is consistent with other reports in the literature. The influence of birth type on growth performance is well documented by Tuah and Baah (1985). In this study as well, lambs born as singles had maintained their weight superiority at birth throughout the study period (Tables 12 and 13). Single born lambs were not only heavier at all stages of growth, they also had a higher pre-weaning rate of weight gain compared to twins. Single born lambs had average daily gains of 109.06 ± 1.65 g, 81.34 ± 1.34 g and 25.50 ± 0.86 g between birth and 30 days, birth and 90 days (weaning) and between weaning and 180 days respectively. The corresponding figures for twins are 69.41 ± 2.87 g, 56.23 ± 2.14 g and 26.96 ± 1.65 g, respectively. Single born lambs and twins were not significantly different (P >0.05) in post weaning average daily weight gain (Table 14). This confirms the influence birth weight, which is also related to birth type, has on subsequent growth performance of lambs. In areas where there is seasonal fluctuation in availability of fodder, it might be advantageous to aim for maintaining fast growing single born lambs that could reach marketable weights in the shortest possible time rather than attempting to improve prolificacy of ewes to increase the number of lambs born per parturition.

Dam parity had strongly influenced body weight at all stages of growth (Tables 12 and 13). This influence was more pronounced between birth and 30 days of age as well as between birth and weaning, where lambs from second parity ewes had higher (P <0.001) rates of daily weight gain than those born from first time lambers (98.07 ± 2.09 g vs 80.40 ± 2.21 g, respectively). The same was true when only male lambs were considered. Male lambs from second parity ewes were not only heavier at all stages of growth, they also had a higher rate of weight gain between birth and 30 days of age compared to lambs from first parity ewes (101.38 ± 3.27 g vs 83.66 ± 3.72 g, respectively). This could be due to a better mothering ability and milk production of multiparous ewes compared to first time lambers. A similar result was obtained from a study on Caribbean sheep breeds (Rastogi et al. 1993), where it was observed that the influence of mothering ability on average daily weight gain and weaning weight had been highly significant.

Lambs born into the wet season (Table 12) had a better pre-weaning growth performance compared to the other two groups. This could be also due to the availability of quality pasture at lambing time. Although the third group of lambs (Dry'93), were born at about the same period of the year as those in group one, their body weight (except that of birth and at 30 days of age) was significantly lower than the others (Tables 12 and 13). This could probably be due to the build up of internal parasite load rather than feed shortages as this group also had the lowest rate of survival (Table 16) at all stages of growth compared to the other two groups. As shown in Figure 4, male lambs born in the first group (Dry'92) had a relatively better growth performance compared to those male lambs born in Wet'93 and Dry'93 lambing seasons probably due to lesser parasite challenges in the first season.

However, the result shows no clear distinction between the effects of the two major lambing seasons (lambing into the wet season and into the dry season). Lambs born in the third season (Dry'93), which is supposed to be a replication of the first (Dry'92), had a much lower ($P < 0.05$) growth rate between birth and weaning compared to Wet'93, and even Dry'92, lambs. As Dry'93 lambs were born from the same ewe flock as Dry'92, the reason for their relatively poor performance could most probably be environmental stresses.

Where extensive grazing is used to rear small ruminants like in most tropical and sub-tropical countries, one way of reducing the impact of seasonal forage shortage is a careful management plan. This could be in the form of planning the mating period so that ewes could drop their lambs during the time of the year when there is a relatively better provision of feed. The other alternative could be reducing the number of non productive animals if that is culturally accepted.

Seasonal fluctuation in feed availability causes animals to pass through weight gain/weight loss phases (Velez et al. 1993, Ehoche et al. 1992). In another study, Wilson (1987) has reported that very little is known about factors influencing weight of small ruminants in sub-Saharan Africa. However, since his work involves only Malian sheep, which seem to be not affected by fluctuations in seasonal feed availability, this might not be true for other tropical or sub-tropical breeds.

As there are several assumptions regarding factors affecting growth of grazing animals in tropical countries, growth potential of animals in such environments could be better estimated by keeping the animals to be studied in pens (Vercoe and Frisch, 1987). The authors also assume that since growth potential is associated with low resistance to environmental stresses, it will be of paramount importance to first determine the nature of the relationship between the two. This might help to enhance the development or identification of breeds that might be tolerant or even resistant to environmental stresses and which could also be economically productive.

Pre-weaning average daily weight gain and weaning weight of animals are known to be strongly influenced by the mothering ability of the dam as young animals before weaning are more dependant on the dam's milk yield rather than foraging. In this respect it seems that Menz and Horro ewes seem to have no significant difference as their lambs had relatively similar pre-weaning growth rates (Tables 14 and 15).

Results from other studies (Laes-Fettback and Peters, 1995, Rastogi et al. 1993) show that the pre-weaning daily weight gain and body weight of the offspring to be significantly influenced by breed and mothering ability. However, careful considerations have to be made in implementing comparative breed evaluation particularly when breeds are exposed to new ecosystems for which they might have difficulties to adapt and acquire tolerance if new disease challenges occur. The relative poor performance of Horro sheep, compared to what is reported elsewhere (Solomon Abegeaz, 1998; Yohannes Gojjam et al., 1998) could be seen in this perspective. It can not be excluded that the Horro ewes were under severe biotic stress at the experiment station since a number of ecological factors differ from their original habitat.

In a sheep production system where the main objective is lamb meat production, post weaning growth rate of lambs is just as important as the pre-weaning growth rate. It is also in this stage that animals are subjected to various environmental stresses starting with the so called weaning shock to seasonal variation in feed availability. This is particularly evident in the dry tropics where growth curve is expected to be highly irregular due to weight gain/weight loss phases depending on the availability of forage both in terms of quantity and quality. In such situation it might be advantageous, as Gatenby (1986) suggested, to keep small size breeds which could grow as fast or even better than larger breeds.

4.4.3. Lamb survival rate

Both Menz and Horro lambs have differed significantly in survival rate from birth to various stages of growth except the period within two weeks of birth as shown in Table 16. High proportion ($P < 0.05$) of Menz lambs born have survived to 30 days of age compared to Horro lambs (95.5 ± 0.02 % vs. 91.2±0.02 %, respectively). As the lambs grow, the difference in survival rate between the two breeds was even more pronounced ($P < 0.001$). The survival rates of lambs of those born to 90 (weaning age), 180, 270 and 365 days of age were 89.4, 81.3, 71.5, 62.4 % for Menz and 75.7, 50.6, 39.0, 37.3 % for Horro lambs, respectively.

As sheep production is directly influenced by the number of lambs born and reared from a flock at a given time, it is highly important to identify the causes of lamb losses and take the appropriate measure to reduce it. There will be none or very little advantage in increasing the productivity of the existing ewe flock or introducing prolific breeds without taking the appropriate measures needed to minimise both prenatal and postnatal lamb mortality. Mukasa-Mugerwa and Lahlu-Kassi (1995) have reported that high lamb losses nullify the efforts made to improve the productivity of ewe flock. In another study, Gatenby (1986) has reported that prenatal lamb losses could be greatly reduced by improving management practices.

As shown in Figure 8, the survival rate of Horro lambs drastically decreased after 90 days of age (weaning) and only about 50 % of Horro lambs have survived to 180 days of age. This could be a reflection of environmental effects rather than inherent breed differences in survival rate as the Horro has been brought from a different ecosystem with different humidity, temperature and above all a different disease challenge.

Effects of sex, birth type and dam parity on survival rate are consistent with results from other studies where it was reported that males, single born lambs and lambs born from multiparous ewes had a better survival rate compared to females, multiple born lambs and lambs born from ewes of first parity respectively (Gatenby et al.1997, Armbruster et al. 1991, Notter et al. 1991). As shown in Table 16, twin lambs had a significantly low ($P <0.001$) pre-weaning and post weaning survival rate. The survival rate of single born lambs to weaning and to 180 days of age was 91.4±0.01 % and 82.6±0.02 % while the corresponding figure for twins was 71.2 ± 0.04 % and 48.4 ± 0.04 %, respectively.

Lambs born to ewes of second parity had a significantly better pre-weaning survival rate of about 90 % compared to about 75 % for those born to first time lambers (Table 16). This is could well be a reflection of a better mothering ability of the relatively older ewes compared to the first time lambers. The low post weaning survival of lambs born to ewes of first parity compared to those born from second parity ewes could be due to the combined effects of weaning shock and other environmental stresses like poor pasture quality and disease challenges.

Fitzhugh and Bradford (1983) have reported a reduction of lamb mortality from 23 % to 11 % by improving ewe nutrition during the gestation period. If proper management considerations are not taken, poor nutritional and physiological status of ewes during gestation period results in the birth of weak lambs with low birth weights. As indicated by Fitzhugh and Bradford (1983), ewes in such circumstances will have poor milk yield to feed their lambs leading to a high lamb mortality, particularly within the first two weeks of birth. The relationship between birth weight and mortality has been known for long. Several studies have indicated that birth weight has a quadratic type of relationship with mortality rate whereby lamb mortality tends to increase at extremely high or extremely low birth weight ranges (Mendel et al. 1989, Cooper 1982, Notter and Copenhaver 1980). In another study on goats Laes-Fettback and Peters 1995, have observed that survivability and the pre-weaning growth rate of goat kids are strongly influenced by birth weight.

Apart from low birth weight, causes of early lamb losses occurring within five days after birth could be birth stress, birth injuries, organ malfunctions, starvation or miss-mothering (Bullerdieck, 1996). Planning to make ewes lamb in groups within a narrow time frame will hamper the attention given to both ewes and lambs at lambing thus enhancing management induced miss-mothering and resulting in high neonatal lamb losses (Bullerdieck, 1996).

Table 16 shows that lambs born into the main rainy season and weaned at the end of the wet period (Wet'93) had relatively higher post-weaning survival rates compared to the other two groups (Dry'92 and Dry'93). One possible reason could be that this group was weaned at the end of the rainy season when there is still relatively adequate forage. On the other hand, group one and group 3 lambs were weaned in the dry season and their relative poor performance could be attributed to this. The extremely low post weaning survival of lambs born into the Dry'93 season compared to those born into the previous dry season (Dry'92) indicates that the former probably had a higher parasitic and disease challenges.

As the summary of breed performances (Table 6) in various areas indicate, the type and level of management followed greatly influences the survival of lambs, most importantly during the prenatal growth stage.

4.4.4. Linear body measurements and their relation to changes in body weight, body conformation and body composition

Qualitative body measurements will be more useful whenever it is difficult or impossible to take quantitative measurements. Besides, qualitative measurements could also be used as indicators of changes in body conformation of animals over a given life span (El-Feel et al. 1990). As shown in Tables 18 and 19, male Horro and Menz lambs were significantly different in wither height at 9 and 12 months of age ($p < 0.01$ and $p < 0.001$, respectively) when Horro lambs were taller at withers than the Menz. Although not significantly different ($p > 0.05$), male Menz lambs had a wider heart girth measurements at all stages compared to the Horro. This partially explains the physical differences of the two breeds where Menz sheep are deep bodied with rather short body and short legs indicating that the Menz is a compact breed probably with medium growth capacity. On the other hand, the Horro are tall and long bodied sheep with rather long legs and medium chest circumference probably with a relatively higher growth capacity.

Deviation of the linear body measurements from the overall LS Means as shown in Figures 9, and 10 indicate that as the lambs grow, their differences in wither height, body length and particularly the differences in tail length seem to get wider.

Linear body measurements could also indicate the changes in body proportion (Arthur and Ahunu, 1989). According to Arthur and Ahunu (1989), body size, as measured by weight, does not tell much regarding differences and fluctuations in body proportion caused by weight loss and gut fill.

Correlation coefficients among the various linear body measurements and live body weight of Menz and Horro lambs at 6, 9 and 12 months of age were strong and positive as shown in Tables 20, 22 and 24, respectively. Relationship between live body weight and heart girth has long been used to estimate the former from measurements of the latter. If there exists a positive and significant relationship between weight and linear body measurements like heart girth, wither height, etc., it could be possible to identify a relatively smaller number of factors which could be used to describe the relationship by doing principal component analysis of the body measurements considered (Arthur and Ahunu, 1989). According to Brown et al. (1973), such techniques could also be used to compare animals of different shapes and sizes.

4.4.5. Fattening performance, feed intake and weight gain

Since the supply of animal feed in the tropics is not constant in terms of both quantity and quality, particularly in arid and semiarid regions, one observes seasonal fluctuation in growth rate of animals in theses regions (Gatenby, 1986). This is particularly true in Sub-Saharan Africa where the main source of animal feed is grazing on natural pasture. To make use of whatever resource is available more economically, it will be advantageous to identify those breeds of animals which are more efficient meat producers (Terrill and Maijala, 1991) or animals which have high performance in feed conversion efficiency to produce saleable products (Parker at al. 1991).

Although Horro lambs were heavier at the end of the 123 days fattening period and also had a heavier slaughter weight than the Menz, Menz lambs had a relatively a better dressing % though not significantly different ($P > 0.05$). This could be an indication showing that Menz are relatively early maturing sheep compared to Horro. As shown in Table 27, the relatively higher carcass moisture loss for Horro lamb carcasses (4.2 %) compared to that for the Menz (3.8 %) indicates that Menz lamb carcasses have a better fat cover than the Horro.

During the feeding experiment, Horro lambs consumed more ($p < 0.01$) total dry matter daily compared to Menz lambs which were 879 ± 12.27 g vs. 802 ± 9.35 g respectively (Table 29). Several authors (van Arendonk et al. 1991, Barlow et al. 1988, Wagner et al. 1986) have reported the existence of breeds or genotypes differences in feed intake. The difference in feed intake between breeds is also reflected in the gut content. As reported by Ruvuna et al. (1992), gut content constitutes about 14-18 % of live weight. This is also conformed in the present study where the observed gut content as proportion of the slaughter weight was 15.2 ± 0.50 % for Horro and 13.2 ± 0.45 % for Menz (Table 24), the differences between the two being significant ($P < 0.01$).

Although Horro lambs seem to have a high dry matter intake per kg $W^{0.75}$, (67.8g for Horro lambs and 65.6 g for the Menz), though not significantly different ($P > 0.05$), the faecal dry matter estimate for Horro lambs was also significantly higher ($p < 0.01$) than that for Menz lambs (Table 29). It is therefore assumed that Horro lambs might have relatively poor feed retention ability than Menz lambs. This is also reflected in the digestibility estimate of feed for the two breeds whereby Menz lambs seem to have a better digestibility estimate ($p < 0.01$) than the Horro (Table 29).

In some other studies (Khandaker et al. 1998, Dulphy and Demarquilly, 1994, Wagner et al. 1986), it was reported that the daily feed intake of animals is influenced by the digestion rate of the digestible materials of the feed and the rate of passage of the indigestible part. In another study (Zervas et al. 1997), it was stated that dry matter intake by lambs was influenced partly by the nature, energy and nutrient density of the available feed. Dulphy and Demarquilly (1994) have also reported that voluntary feed intake of ruminants is determined by the ingestibility of the feed and the intake capacity of the animal. However the information regarding to the extent of the variation between breeds in this trait is very limited.

Feed intake is also closely correlated with the quantity of pasture available per head per day and the quality of the forage selected in terms of digestibility (Said and Tolera,1993, Black, 1990). In another study Mehrez et al. 1977 have reported that feed intake could be reduced if rumen ammonia concentration is limiting the feed fermentation rate in the rumen. It is not the type and physical characteristics of feed that influence its intake rate but also the animal's age, size, weight and physiological status and the prevailing climatic conditions (Arnold and Birrel, 1977).

In a study on some pure and crossbred sheep in Morocco (Kabbali et al. 1992), a better feed efficiency was observed in those animals which have gone through a weight loss and weight gain (compensatory growth) phase. The relatively high availability of green feed in tropical regions during wet seasons is thought to enhance body fat deposition. According to Ørskov (1998), ruminants are capable of adapting to seasonal fluctuations in forage availability in terms of both quantity and quality and conserve energy from the lush period in the form of body fat. The author has suggested that fat deposition generated by high quality pasture intake could even be an efficient form of conserving forage to be mobilised to sustain growth, lactation or maintenance requirements. Such ability of sheep to retain and then mobilise body reserves will be of paramount importance particularly in arid and semiarid environments for their productivity and survival (Frutos et al. 1997).

4.4.6. Relative weight of carcass and non-carcass components and dressing percentage

The higher, though not significantly different ($P > 0.05$), dressing % for Menz lambs (49.1 ± 0.57 %) compared to Horro (48.0 ± 0.64 %), could indicate that Menz lambs have advanced relatively nearer to slaughter maturity than the Horro. The value of carcasses is mostly determined by the lean (muscle) : bone ratio (Anous, 1991).

Proportion of muscle, fat and bone change as animals grow whereby the growth of bone reaches its peak first followed by muscle and adipose tissues respectively (Orr, 1982). This has also been conformed by Afonso and Thompson (1996) and Taylor et al. (1989). In both cases it was stated that relative to empty body weight, bone tissue matured early followed by muscle (lean) and fat tissues. There was no significant (P >0.05) difference observed between Menz and Horro lamb carcasses in dissectible lean and fat tissues (Table 27). However, Horro lambs had higher (P <0.01) estimated total bone weight compared to that of the Menz. When only the carcass components of the dissected left half carcasses are considered, there were no significant differences in proportions of carcass components between the two breeds (Table 28). The lean : fat : bone ratio observed in this study (3.1 : 1 for Menz and 3.3 : 1 for Horro lamb carcasses is within the range reported by several authors (Table 8) for various tropical and temperate breeds.

Since the management under which the various breeds were maintained and the age at which the animals were slaughtered vary considerably, it will not be appropriate to make direct comparison. However, the carcass composition of Menz and Horro lambs as observed in this study seems to be more or less in line with what is reported particularly for tropical breeds (Table 8). As reported by Anous (1991) and Taylor et al. (1989) muscle (lean) : bone ratio is the most critical determinant of carcass value. Since lean is the most important economic component of carcass in any meat production enterprise, the higher its ratio the better. The lean : bone ratio observed (Table 29) in this study for Menz and Horro lamb carcasses (2.8 : 1 and 2.6 : 1, respectively) for the dissected half carcasses was higher than that reported by Enyew Negussie (1999) which is 2.5 : 1 for Menz and 2.2 : 1 for Horro , (P <0.0001). The lean : bone ratios observed in this study for the two breeds were also significantly different (P <0.05), indicating that carcasses from Menz lambs tend to have a higher lean : bone ratio compared to Horro. One possible explanation for the differences in lean : bone ratio in the two studies could be that Menz and Horro lambs in the present study were slaughtered at a relatively older age (about 17 months) while those studied by Enyew Negussie (1999) were slaughtered at about one year of age and without any prior fattening.

There is evidence (Ruvuna et al. 1992) that proportion of lean and fat increase with age while the proportion of bone decrease. A similar result was obtained in an earlier study by Berg and Walters (1983) where it was reported that the ratio of fat to muscle and that of muscle to bone increased with age. This means that as animals mature they tend to deposit more fat than muscle. The slightly higher, though not significantly, fat to lean ratio for Menz lamb carcasses (0.34 : 1, respectively) compared to that of the Horro (0.31 : 1, respectively) could be an indication showing that Menz sheep are earlier maturing than Horro. However, according to Taylor et al. (1989) it is indicated that there might be no significant breed differences in lean (muscle), fat and bone distribution as affected by age.

Moisture loss in carcasses observed in this study (3.8 ± 0.17 % for Menz and 4.2 ± 0.19 %, P >0.05) is higher than that reported for castrated goat carcasses (1.6-1.9 %) by Ruvuna et al. (1992). A slightly lower (2 %) moisture loss or shrinkage of lamb carcasses has been also reported by Thompson et al. (1987) after a 24 hour storage.

Kempster et al. (1981) have reported a moisture loss of 2.27 % in pig carcasses after a 24 hours storage time. It is suggested that such information will help to account for the weight loss of hot carcasses between the point of slaughter and after a limited storage time. Therefore, the loss of carcass weight at storage for carcasses with higher fat cover could be less than carcasses with lower fat cover.

In another study (Farid, 1991), it was concluded that the relative merit of different sheep breeds for meat production is determined by a higher proportion of lean and low proportion of fat and bone in the carcasses. While this is very true for markets in developed countries, animals with a higher degree of fat cover, regardless of size and weight, fetch a higher premium in most tropical countries (Thatcher and Gaunt, 1992, Terril and Maijala, 1991, Lee 1986). This is particularly true in Ethiopia where during festivities, lambs and withers with high fat cover are priced highly.

On the other hand the characteristics of a superior carcass in developed countries are high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover (Taylor et al. 1989). The fact that the lean proportions of carcass is strongly influenced by breed, sex and stage of maturity or mature size of the animal is well documented (Taylor et al. 1989). Based on the preliminary result in this study, Menz and Horro lambs seem to differ in carcass lean and bone composition. It might be, therefore, possible to compare the two breeds at similar stages of maturity to establish the extent of breed influence on body composition.

Lean and fat are not mutually exclusive traits. In fact Berg and Walters (1983) have reported that a higher fat proportion is associated with a lower proportion of muscle and vice versa (see Table 8). According to Berg and Walters (1983), the proportion of muscle to live weight could be a useful index to select meat producing animals for higher carcass yield. In this study, Horro lambs had a higher proportion of lean to empty body weight (38.6 %) compared to Menz lambs (35.9 %). In another study Walstra and de Greef (1995) have stated that the proportion of lean in carcasses could be also influenced by carcass weight, dissection and lean mass measuring methods and procedures.

4.4.7. Fat deposition characteristics

Body composition in terms of both dissectible components (muscle, fat and bone) and chemical composition such as chemical fat, protein, ash and water change as animals grow from birth to maturity (Enyew Negussie, 1999, Snowder et al. 1994).

Carcass composition could be used as a tool to characterise breeds for possible identification of potential genetic resource for lean lamb production and also to identify management alternatives to suit different breeds (Snowder et al. 1994). Since breed is known to influence not only carcass composition and quality but also carcass conformation as well, differences in carcass merits between breeds is likely to govern the choice and development of breeds for specific production objectives. Apart from breed, carcass composition is also known to be influenced by sex (Cantón et al. 1992).

The major non genetic factor influencing carcass composition is nutrition. Several authors working on various breeds and species under various management and environmental conditions have observed that nutritional level and feeding regime have affected carcass yield and quality, fat tissue development and composition (Iason and Mantecon 1993, Cantón et al. 1992, Cronjé and Weiter 1990, Gatenby 1986).

The fact that breeds differ in dissectible carcass composition has been cited from various sources by Enyew Negussie (1999) where it was reported that breeds do not only differ in carcass components (muscle, fat bone) but also in their distribution. In this study no significant differences (P >0.05) was observed between Menz and Horro sheep carcasses in the estimated whole carcass composition of lean and fat after the 123 days of fattening. However, the two breeds have differed significantly (P <0.01) in the estimated total bone composition of whole carcasses (Table 30).

The whole carcass composition estimate was based on the observed dissectible half carcass composition. Whole carcass composition estimates of 58.0 %, 19.5 %, 20.4 % and 2.1 % lean or muscle, fat, bone and sundry in Menz and 57.9 %, 18.0 %, 21.5 % and 2.6 % in Horro, respectively were not significantly different (P >0.05). However, the figures show that Menz lamb carcasses tended to contain more fat (P >0.05) than carcasses of Horro lambs. The carcass proportion found in this study was not very much different from that reported by Gruszecki et al. (1994) for Polish lowland sheep and its crosses slaughtered between 38 and 40 kg (61-63 % lean, 17-20 % fat and 19-22 % bone). In another study (Streitz et al. 1994) a carcass composition of 58.2 % lean and 23.6 % fat was reported for mutton type lambs of diverse genetic background which had above 30 kg live weight at slaughter.

Taylor et al. (1989) have reported that larger breeds have higher proportions of carcass fat compared to smaller sized breeds. The authors have also observed a carcass composition of 58.3 % lean, 24.3 % fat and 17.4 % bone for seven British sheep breeds. A similar observation was also made by Teixeira and Delfa (1994) who reported a carcass composition of 55.5 % and 55.7 % muscle, 23.8 % and 24.1 % fat and 16.0 % and 15.7 % bone for Suffolk and Merino sheep carcasses, respectively. In contrast, El Karim and Owen (1987) have reported a carcass composition of 58-59 % lean, 14-16 % fat and 18-20 % bone for one year old Egyptian sheep weighing between 25 and 34 kg. The carcass composition observed in this study for the dissected part is in line with that reported by El Karim and Owen (1987) for one year old Egyptian sheep breeds which were slaughtered within the same body weight ranges as that for Menz and Horro lambs in the present study.

Although it is reported (Gaili, 1979, Gatenby, 1986) that tropical sheep tend to deposit more intramuscular and internal fat and less subcutaneous fat compared to temperate mutton breeds, there is evidence (Amegee, 1981 cited by Gatenby, 1986) that tropical and temperate breeds also differ in size and distribution of fat deposited in the body but not in their carcass composition.

4.4.8. Fat depot distribution in Menz and Horro lambs

It has been known for long that breeds and species differ in fat depot partitioning. According to Frutos et al. (1997) and Kempster (1981), sheep breeds developed for fat lamb production deposit more subcutaneous fat than those sheep breeds which are kept in areas where adaptability and maternal performance play a role in influencing productivity.

Fat depot distribution characteristic of the two breeds was measured directly by physical separation of dissectible fat from carcass and non-carcass components as well as indirectly by chemical analysis through ether extract. Tables 33 shows fat depot estimates for whole carcass components based on sample ether extract of the dissected part.

The result in this study shows that the two breeds differ significantly ($P < 0.05$) in total ether extract estimate (3059.5 ± 95.20 g for carcasses from Menz lambs and 2718.70 ± 106.60 g for Horro lamb carcasses). The higher ($P < 0.01$) ether extract estimate on dry matter basis for lean from Menz lamb carcasses (22.4 ± 0.89 %) indicates a higher proportion of intra- and inter-muscular fat compared to that of the Horro (18.1 ± 1.00 %). This indicates that carcasses from Menz sheep are also qualitatively better than those from the Horro as marbling is a sign of qualitative measure. However, Menz and Horro lambs did not differ significantly ($P > 0.05$) either in their fat deposition characteristics or fat depot distribution (Tables 33). In both breeds, the biggest proportion of fat depot was the sum of subcutaneous fat and the separable intermuscular fat.

The relatively high fat proportion in Menz lamb carcasses is also an indication that it is closer to maturity compared to the Horro. Since the Menz are shorter but relatively wider sheep than the Horro, they have a relatively better conformation. On the other hand, Horro sheep are relatively larger but have more bone and less flesh compared to the Menz and are likely to take longer time to reach slaughter maturity with acceptable carcass fat cover.

The next highest fat depot concentration in both breeds was the tail and around the rump area. Horro had slightly higher but not significantly different (P >0.05) proportion of rump and tail fat compared to Menz (30.8 % vs 29 %). The third and fourth highest concentration of fat for both Menz and Horro lambs was observed to be as intramuscular fat and Gastro-Intestinal-Tract (GIT) fat, respectively (Table 33). The least proportion of fat depot for both breeds was around the urogenital area. However, in all cases both breeds were not significantly different (P >0.05), though Menz lambs tended to have more fat depot in most parts except the tail and rump region. This is in agreement with the results obtained by Enyew Negussie (1999) in a study on the same breeds where it was observed that generally Menz lambs tended to have more body fat compared to Horro slaughtered at about the same age and stages of growth.

The carcass composition of the dissected left half carcasses in the present study (Table 28 and Figure 11) show a relatively higher proportion of lean than that interpolated for whole carcasses (Table 27). Though not significantly different (P >0.05), carcasses from Horro lambs tended to have higher proportion of lean (muscle) and bone than Menz lamb carcasses (Table 28). Due to the exclusion of tail fat from the dissected part, the proportion of fat in the left half of carcasses seems to be smaller than that estimated for whole carcasses.

The fact that fat is the most variable body tissue has been well documented (Negussie, 1999, Berg and Walters, 1993). Fat deposition is strongly influenced by genetic factors such as size and maturity and also by non genetic factors such as age or stage of maturity and by nutrition. Fat reserves or deposits influence meat quality and could also determine the survival of animals, particularly those in the tropics during periods of acute or prolonged feed shortages. In a study by Cantón et al. (1992) it was reported that nutrition influences carcass yield and quality, fat deposition and composition while breed effect was observed to be greatest in influencing carcass conformation as well as carcass composition. The authors have also indicated that hair sheep deposit more non-carcass fat internally (mesenteric, kidney knob and channel, et.) than wool sheep which in turn have a higher subcutaneous fat depot. This is also conformed in this study where Menz lambs, which are coarse wool bearing sheep, had relatively higher proportion of subcutaneous and intermuscular fat though not significantly different (P >0.05) compared to the Horro which are hair sheep. According to Kempster (1981), the fat depot distribution is also related to adaptability where he observed that animals kept under harsher hill environment tended to have higher internal fat depot.

In the present study, Menz lambs which are adapted to a harsher highland environment of Shewa region in Ethiopia tended to have relatively a higher amount of mesenteric and renal fat depots though not significantly different (P >0.05) than that of the Horro which originate from warmer and humid western highlands of the country.

Another factor known to influence carcass composition is the degree of maturity. Friggens et al. (1994) and Iason et al. (1992) have stated that maturity is an important predictor of carcass composition, particularly for some European breeds. In both studies it was observed that large breeds of sheep attain their maturity at a relatively older ages than smaller ones. It is, therefore, recommended (Iason et al. 1992) that such different groups should be compared at a similar proportion of mature live weight to avoid or minimise the differences in carcass composition arising from differences in maturity stage. A study by McCutcheon et al. (1993) supports such a recommendation where it was observed that carcasses of similar body weight showed similar proportions of water, protein and fat.

In contrast to what Negussie (1999) observed in his study on Menz and Horro lambs, the present study showed no significant differences in either fat deposition or fat distribution between the two breeds. He has also observed that Horro lambs had deposited relatively more internal fat than the Menz. However, this was not realised in the present study. In fact Menz lambs tended to have deposited more carcass and non-carcass fat as indicated in both the ether extract estimate for whole carcasses and various fat depots as shown in the dissected left half carcass composition (Table 32).

The relatively higher (P <0.01) ether extract of lean for Menz (22.4 %) compared to that of the Horro (18.1 %) indicates that Menz lamb carcasses have more inter- and intramuscular fat compared to that of the Horro (Table 33). As indicated by Frutos et al. (1997), individual breeds have a distinctly different fat distribution within the body. This result also indicates that Menz and Horro lambs seem to differ in body fat distribution. However, a more detailed investigation will be required to draw any conclusive results.

No matter in which way sheep deposit fat, their ability to retain and mobilise body reserves, particularly in arid and semiarid areas of the tropics where feed resource is a limiting factor, it will be of paramount importance to determine their productivity or even their survival. For such reasons, it will be useful to be able to determine body composition of animals particularly those maintained under extensive systems using the most simplest available methods as slaughtering will be expensive. One such method could be using leaner body measurements to estimate body composition. An attempt has been made to estimate tail fat weight using live tail volume measurements (Tables 34, 35 and 36).

The linear regression analysis (Table 36) show that in both breeds, total body fat could be fairly accurately estimated from tail weight and tail volume measurements. Since Horro is the larger of the two and since it has a relatively larger tail this might be an indication of the breeds characteristics in depositing body fat. Menz is also a fat tailed sheep but the size of the tail is relatively smaller than that of the Horro. However, further detailed investigation has to be made to reach a conclusive result since the data used for the current analysis is very limited as to whether tail measurements could be reliably used to estimate total body fat.

5. Conclusion and recommendations of this study

The area around Debre Birhan, where the present study has been undertaken, is known to have a long dry season and a short but intensive rainy season with a small and occasionally erratic wet period in between. The long dry season is characterised by shortage of adequate pasture in terms of both quantity and quality. This in turn affects the performance of livestock reared resulting in body weight losses unless the animals are supplemented if that is affordable.

On the other hand, although the provision of pasture during the wet season is much better than during the dry season, the grazing area will be mostly limited to high grounds due to water logging in the bottomland. This will lead to a high concentration of animals in a limited grazing area resulting in high parasite and disease challenges. In such circumstances, animals adapted to the area are expected to perform better than those which are brought from a different environment.

If, however, different breeds are studied under station management conditions where the effects of external environment could be minimised, it is assumed that differences in performance could be due to the inherent breed differences in the variables tested.

With such assumptions in mind and the results obtained in the present study, the following conclusions could be drawn:

1. Horro lambs were heavier at birth and at 30 days of age compared to the Menz (2.4 kg and 5.2 kg for Horro and 2.1 kg and 4.7 kg for Menz, respectively). Sex, birth type, and dam parity have also influenced lamb birth weight. Lambs born at the end of the rainy season tended to be heavier at birth compared to those born at the beginning of the rainy season. This could be due to the provision of qualitatively better forage for the ewes during the wet season which covers the later part of the gestation period.
2. Pre-weaning and post-weaning growth performances of both Horro and Menz lambs are in line with what is reported in the literature for tropical breeds. Both breeds had relatively similar rate of pre-weaning weight gain (birth to 90 days of age), 69.4 and 68.1 g for all groups and 70.9 and 67 g for male lambs, respectively). However, to draw a credible conclusion regarding the growth performance of Horro and Menz sheep with the objective of comparative breed evaluation, further studies will have to be carried out in Western highland region of Ethiopia, where the Horro sheep originates and around Debre Birhan which is near to the origin of the Menz sheep. This will allow to see whether there is a significant genetic environment interaction effect influencing growth and rate of weight gain performances of both breeds.

3. Survival of lambs within two weeks of birth observed in this study is higher than those reported by others for the same period (96 % for Menz and 94 % for Horro. This is probably a reflection of improved management practices. More Menz lambs (89 %) have survived to weaning (90 days of age) compared to Horro (76 %). There was a drastic decrease in Horro lamb survival after weaning while that of Menz lambs was relatively high. This is probably due to a high disease challenge indicating that Menz lambs, which are relatively adapted to the area, have tolerated the challenge better than the Horro. Lambs born in the wet season tended to have a higher survival rate probably due to a better pasture availability than those born in the dry season. Further investigation is needed to find out whether there exists a possible genotype x environment interaction effect on survival rate of lambs of the two breeds.
4. Linear body measurements are significantly and positively correlated to body weight in both breeds. It is observed that body weight could be fairly accurately estimated from heart girth ($r = 0.90$ for Menz and $r = 0.86$ for Horro) and from other linear body measurements for both breeds.
5. Male Horro and Menz lambs born in the first dry season of the study period had significantly different final weights and slaughter weights after a four month fattening period where Horro lambs were heavier ($P < 0.05$) than the Menz. Horro lambs also had a higher ($P < 0.01$) daily dry matter intake, larger and heavier gastrointestinal tract, and a higher proportion of GIT content. On the other hand Menz lambs had a lower daily faecal dry matter output and higher digestibility estimate compared to the Horro. The two breeds did not differ significantly in empty body weight (23.0 kg for the Menz and 24.0 kg for the Horro). The fact that Horro lambs had a higher daily dry matter intake compared to the Menz (880 g vs 800 g, respectively) and the higher daily faecal dry matter output (Table 29) indicates that Horro lambs have a low dry matter retention time in the rumen than Menz lambs. This seems to indicate that the Menz is probably more efficient in converting feed to meat because despite their higher dry matter intake, Horro lambs did not differ significantly from the Menz in average daily weight gain during the fattening period. It is necessary to do a study on solid and probably liquid out flow rate to estimate the minimum retention time of dry matter and liquid in the digestive system of both breeds to get conclusive results.

6. Horro and Menz lambs did not differ significantly (P >0.05) in all major carcass and non-carcass components. However, Horro lambs had a heavier (P <0.01) total bone estimate than Menz lambs. The two breeds did not differ significantly (P >0.05) in separable carcass composition of the left dissected side. However, carcasses from Menz lambs had a better (P <0.05) lean : bone ratio (2.9 : 1) than that of the Horro (2.7 : 1). Nevertheless, further studies under varying management and environmental conditions should be carried out to see if Menz and Horro sheep do differ in the economically important carcass traits.
7. In general there was no marked difference between Menz and Horro lambs regarding fat depot characteristics observed in this study based on the ether extract estimate except the EE estimate for lean (22.4 ± 0.89 for Menz and 18.1 ± 1.00 for Horro). The largest proportion of fat depot in both breeds was the sum of subcutaneous fat and inter-muscular fat followed by tail/rump fat. However there were no significant (P >0.05) breed differences. The high (P <0.01) ether extract estimate of lean component of carcass on dry matter bases indicates that the lean part of Menz lamb carcasses have possibly more inter- and intramuscular fat compared to carcasses of Horro lambs after the 123 days of fattening period. The combined tail and rump fat weight could be fairly accurately estimated for both breeds from live tail volume measurements (r = 0.78 for Horro and r = 0.66 for Menz). However due to the smallness of the sample size care should be taken in the interpretation of the present result as what observed in this study is not a strong indicator. To reach a definitive conclusion, further studies in this line should be undertaken, particularly to see if tail dimension measurements (length, volume, etc.) could be related to fat deposition characteristics of the breeds. Furthermore, detailed studies should be undertaken to identify whether the two breeds are significantly different in their fat deposition characteristics and mobilisation of body reserves.

6. SUMMARY

Keywords: Sheep, breed, characterisation, lamb, bodyweight, growth rate, survival rate, linear body measurements, carcass performance, fat deposition, body fat distribution, Ether extract

This study has been carried out at the former International Livestock Centre for Africa (ILCA), that is now the International Livestock Research Institute (ILRI) experiment station at Debre Birhan, Ethiopia.

This research is part of an ILCA (now ILRI) Pan-African research programme designed to investigate and characterise genetic resistance to endoparasites in some indigenous small ruminants in sub-Saharan Africa. The present study was, therefore, undertaken in an attempt to generate information that may contribute towards the understanding of the relative performance of two highland sheep (Horro and Menz) of Ethiopia under station management conditions.

Ewes were randomly divided into two groups to have dry season (October/November) and wet season (June/July) lambings. A total of 984 lambs (396 Horro and 588 Menz) were born over the three lambing periods (Dry'92, Wet'93 and Dry'93) covered by this study. However, due to differences in parity between ewes of the two breeds, where there were some Menz ewes which had lambed three or more times earlier, lambs born from such ewes were excluded from this study. Therefore, only 856 lambs born from first and second parity ewes of both breeds were included. Ewes and lambs were herded together until weaning at the age of about 90 days. Weaned female and male lambs were separated but were exposed to the same grazing paddocks in a rotational grazing system.

In addition to grazing, hay was offered ad libitum while concentrate was group fed at the rate of about 200 g per day providing 10-12.5 MJ ME/kg dry matter.

All flocks were routinely checked for any health problems and treated accordingly. Flocks were also drenched with Fasinex^R (triclabendazole) against Fasciola towards the end of the rainy season and in the middle of the dry season.

Male lambs born in the first lambing season of the program (Group one) were put into a fattening experiment at the age of about 12 months. During the fattening experiment, lambs were individually fed in metabolic crates. Hay was provided at the rate of 1500 g per day throughout. On the other hand concentrate supplementation was done in stages where lambs were given 300 g per day for the first two weeks including the two week adaptation period. The concentrate level was then raised to 400 g per day and this level was maintained until the end of the fattening experiment.

Horro lambs were significantly heavier (P <0.001) at birth than Menz lambs (2.43 ± 0.03 kg vs 2.17 ± 0.03 kg, respectively). Apart from breed, the other main effects which have influenced birth weight significantly (P <0.001) are sex, type of birth, dam parity and season of birth. Lambs born in the dry season from ewes mated at the beginning of the wet season tended to be heavier at birth than those born from ewes mated in the dry season. This is assumed to be linked to the availability of relatively better pasture in terms of both quality and quantity during the ewe's gestation period.

While there was no significant difference in weaning weight between Menz and Horro lambs (8.03 ± 0.12 kg vs 8.21 ± 0.13 kg, respectively), sex, birth type, dam parity and season of birth have all significantly (P <0.001) influenced weaning weight. Sex, birth type and season of birth remained to be significant sources of variation in body weight of male lambs of both breeds until one year of age.

The two breeds did not differ significantly in average daily weight gain between birth and weaning (90 days). Birth type, dam parity and season of birth have significantly (P < 0.01) influenced pre-weaning average daily weight gain (ADG). Single born male lambs gained 114.62 ± 2.58 g and 82.42 ± 1.85 g daily between birth and 30, birth and 90 days of age, respectively. The corresponding figures for twin born male lambs are 71.71 ± 4.53 g and 55.75 ± 3.34 g, respectively.

Lambs from second parity ewes had a higher rate of weight gain between birth and 30 days of age and between birth and weaning (90 days) compared to lambs born from ewes that have lambed for the first time, indicating a strong maternal influence of second parity ewes probably through higher milk production compared to the first time lambers. Lamb survival within two weeks of birth was strongly influenced by birth type, dam parity, and season of birth but not by breed and sex. More than 97 % of single born lambs survived to 15 days of age compared to 91 % for twins ($P < 0.001$). Likewise more (97 %) lambs born to second parity ewes survived to 15 days after birth as opposed to about 92 % for lambs born from ewes of first parity ($P <0.001$). The survival rate between birth and weaning (90 days) for Menz lambs (89 %) was significantly ($P < 0.001$) higher than that for the Horro (76 %). Menz lambs had also a much better post-weaning survival rate from birth to 180, 270 and 365 days of age (81, 71 and 62 %, respectively) compared to Horro (51, 39 and 37 %, respectively). This shows that Horro lambs might have adaptation problems as they are introduced from a different region of the country.

Horro and Menz lambs did not differ significantly in heart girth measurement. However Horro lambs were taller ($P < 0.001$) at withers at one year of age compared to Menz (61.91 ± 0.62 cm vs 59.89 ± 0.44 cm). The greatest difference observed between the two breeds is in tail length at all stages. Although both breeds are characterised as fat tailed sheep, Horro sheep have longer tail while Menz have a shorter and relatively wider tail.

A strong and significant ($P < 0.001$) correlation between body weight and the linear body measurements considered in this study was observed at all stages of growth. From what is observed in this study, body weight at one year of age for both breeds could be fairly accurately estimated from heart girth ($r = 0.90$ for Menz and $r = 0.86$ for Horro).

At the end of a 123 days fattening period, Horro lambs were significantly heavier ($P < 0.05$) than Menz lambs (34.7 ± 0.63 kg vs 32.7 ± 0.57 kg). While no significant difference ($P > 0.05$) was observed in rate of weight gain during the fattening period (45.5 ± 2.90 g for Menz and 47.3 ± 3.81 g for Horro). Horro lambs had a significantly higher ($P <0.01$) daily dry matter intake compared to the Menz (879.6 ± 12.27 g vs 802.2 ± 9.35 g respectively). However, the dry matter intake of both breeds based on metabolic body weight (kg $W^{0.75}$), 67.8 ± 1.95 g for Horro lambs and 65.6 ± 1.72 g for Menz, was not significantly different ($P > 0.05$). Horro lambs had a significantly higher ($P < 0.01$) proportion of the full Gastro-Intestinal-Tract than Menz lambs (22.6 ± 0.53 % vs 20.1 ± 0.47 %, respectively). The two breeds have also differed significantly in the GIT contents calculated as percent of the fasted slaughter weight compared (15.2 ± 0.52 % for Horro and 13.3 ± 0.46 % for Menz). Nevertheless, despite their higher dry matter intake, the apparent digestibility estimate for Horro was significantly lower ($P < 0.01$) than that for Menz lambs (51.6 ± 0.01 % vs 54.0 ± 0.01 % respectively).

Horro and Menz lambs were not significantly different (P > 0.05) in both hot and cold carcass weights (14.2 ± 0.26 kg for Horro and 14.8 ± 0.29 kg for the Menz, and 13.6 ± 0.26 kg for Horro and 14.2 ± 0.29 kg for the Menz, respectively). However, Menz lambs tended to have a better but not significantly different (P > 0.05) dressing % than the Horro (49 % vs 48.0 %). Horro lambs had a higher but not significantly different (P > 0.05) total dissectible lean estimate than Menz (8.91 ± 0.22 kg vs 8.55 ± 0.19 kg respectively).

On the other hand, Menz lambs tended to have slightly more but not significantly different (P > 0.05) dissectible body fat estimate compared to Horro (2.88 ± 0.11 kg vs 2.77 ± 0.12 kg respectively). The two breeds have differed significantly P <0.01) in total carcass bone estimate (3.31 ± 0.08 kg for Horro and 2.99 ± 0.07 kg for Menz) indicating that the Horro has a potential to put more weight than the Menz.

Fat deposition was estimated directly (by dissection) and indirectly (through ether extraction). The two breeds have fairly similar body fat distribution. However, lean from Menz lamb carcasses had significantly higher (P < 0.01) ether extract estimate on dry matter bases compared to that of the Horro (22.4 ± 0.89 % vs 18.1 ± 1.00 % respectively). This is also reflected in the total carcass lean ether extract estimate where the estimate for Menz lamb was significantly higher (P < 0.05) than that of the Horro (505 ± 25.86 g vs 411.00 ± 28.95 g, respectively). This is probably an indication showing that lean from Menz carcasses has more inter- and intramuscular fat than lean from Horro carcasses. Menz lambs also tended to have a better (P < 0.05) lean : bone ratio compared to Horro lambs (2.9 : 1 vs 2.7 :1, respectively). Considering the dressing percentage values, the higher proportion of intramuscular fat as indicated by a higher ether extract estimate of the lean part and a relatively higher lean : bone ratio, Menz lambs seem to be a relatively better meat breed compared to the Horro under the given experimental conditions. However more detailed studies need to be carried out for a conclusive result.

7. ZUSAMMENFASSUNG

Schlagworte: Schafe, Rasse, Charakterisierung, Lämmer, Körpergewicht, Körpermasseentwicklung, Überlebensrate, lineare Körpermaße, Schlachtleistung, Körperfettverteilung, Ätherextraktion

Die vorliegende Untersuchung wurde am International Livestock Centre for Africa (ILCA), jetzt International Livestock Research Institute (ILRI) auf der Versuchsstation Debre Birhan in Äthiopien durchgeführt. Diese Untersuchung ist Teil eines panafrikanischen ILRI-Forschungsprogramms zur Untersuchung und Charakterisierung einheimischer kleiner Wiederkäuer im Sub-Saharischen Afrika auf genetische Resistenz gegenüber Endoparasiten. Das Ziel dieser Arbeit bestand darin, Ergebnisse zu verschaffen, die zum Verständnis der relativen Leistung zweier äthiopischer Hochlandschafrassen (Horroschaf und Menzschaf) unter Stationsbedingungen dienen sollen. Die Mutterschafe wurden stochastisch in zwei Gruppen eingeteilt, um sowohl in der trockenen Jahreszeit (Oktober/November) als auch in der Regenzeit (Juni/Juli) Ablammungen zu bekommen.

Insgesamt wurden 984 Lämmer (396 Horro und 588 Menz) über die drei in dieser Arbeit betrachteten Ablammperioden (Dry'92, Wet'93 und Dry'93) geboren. Da es jedoch Unterschiede in der Wurfnummer der Mutterschafe zwischen den beiden Rassen gab, wurden Menzmuttern mit drei und mehr Ablammungen von der Analyse ausgeschlossen. Deshalb konnten insgesamt nur 856 Lämmer von erst- und zweitlammenden Mutterschafen berücksichtigt werden. Mutterschafe und Lämmer wurden bis zum Absetzen im Alter von 90 Tagen zusammen gehalten. Die abgesetzten Lämmer wurden nach Geschlecht getrennt, jedoch auf dieselben Weiden im Rotationsverfahren gebracht.

Zusätzlich zur Weide erhielten die Tiere Heu ad libitum und ca. 200 g Kraftfutter (10-12,5 MJ ME/kg TM) je Tier und Tag in Gruppenfütterung. Der Gesundheitszustand sämtlicher Herden wurde routinemäßig überprüft und kranke Tiere entsprechend behandelt. Ebenso wurden die Herden mit Fasinex^R (Wirkstoff, Triclabendazol) gegen Fasciola am Ende der Regenperiode und in der Mitte der Trockenzeit behandelt.

Die männlichen Lämmer, die während der ersten Ablammsaison geboren wurden (Gruppe 1), wurden im Alter von 12 Monaten einem Mastversuch unterzogen. Während dieser Mastphase wurden die Tier einzeln in Stoffwechselkäfigen gehalten. Den Tieren wurde über die gesamte Mastperiode hinweg täglich 1500 g Heu verabreicht. An Konzentrat erhielten die Tiere in der Adaptationsphase (zwei Wochen) und in den ersten beiden Wochen des Mastversuches 300 g pro Tag, anschließend 400 g pro Tag (12,5 MJ ME/kg TM) bis Versuchsende.

Horro-Lämmer (2,43±0,03 kg) waren signifikant (p<0,001) schwerer als Menz-Lämmer (2,17±0,03 kg). Außerdem beeinflußten auch die anderen Haupteffekte wie Geschlecht, Wurfgröße, Wurfnummer und Geburtssaison signifikant das Geburtsgewicht. Lämmer, die von zu Beginn der Regenzeit angepaarten Schafen geboren wurden, hatten tendenziell höhere Geburtsgewichte als solche, deren Mütter während der Trockenzeit angepaart wurden. Dies könnte auf die damit verbundene Verfügbarkeit von relativ besserem Futter hinsichtlich Qualität und Quantität während der Trächtigkeitsdauer der Mutterschafe zurückzuführen sein.

Während sich die beiden Rassen im Absetzgewicht nicht signifikant unterschieden (Horro, 8,03±0,12 kg, Menz, 8,21±0,13 kg), so waren die Effekte Geschlecht, Wurfgröße, Wurfnummer und Geburtssaison signifikant (p<0,001). Die Effekte Geschlecht, Wurfgröße und Geburtssaison erwiesen sich für die Körpermasseentwicklung bis zum Alter von einem Jahr als signifikant.

Bei der täglichen Zunahme von der Geburt bis zum Absetzen (90 Tage postpartum) konnte kein deutlicher Unterschied zwischen den Rassen nachgewiesen werden. Wurfgröße, Wurfnummer und Geburtssaison hingegen beeinflußten signifikant (p<0,01) die durchschnittlichen Tageszunahmen bis zum Absetzen. Von der Geburt bis zum Alter von 30 Tagen nahmen männliche Einzellämmer 114,01±2,70 g zu, Zwillingslämmer 71,2±4,63 g; Zwischen Geburt und Absetzen (90 Tage postpartum) lagen die Tageszunahmen bei 82,42±1,85 g für die einzeln geborenen und bei 55,75±3,34 g für die Zwillingslämmer.

Die aus dem zweiten Wurf stammenden Lämmer zeigten eine höhere Wachstumsrate von der Geburt bis zum Alter von 30 und 90 Tagen als solche, die im ersten Wurf geboren wurden. Dies deutet auf einen starken mütterlichen Einfluß zweitgebärender Mutterschafe in Form einer höheren Milchleistung im Vergleich zu den Erstlingsmutterschafen hin.

Die Überlebensrate der Lämmer innerhalb der ersten beiden Wochen nach der Geburt wurde deutlich von der Wurfgröße, Wurfnummer und der Geburtssaison beeinflußt, jedoch nicht von der Rasse und dem Geschlecht. Mehr als 97 % der einzeln geborenen Lämmer überlebten bis zum Alter von 15 Tagen, bei den Zwillingslämmern jedoch nur 91 %. Desgleichen war die Überlebensrate von aus zweiten Würfen stammenden Lämmern (97 %) deutlich (p<0,001) höher als die aus ersten Würfen stammenden Lämmern (92 %). Nach dem Absetzen im Alter von ca. 90 Tage, zeigten die Menzlämmer eine deutlich höhere Überlebensrate als die Horrolämmer. Dies könnte auf Adaptationsprobleme bei den Horroschafen hinweisen, da diese von einer anderen Region des Landes gebracht wurden.

Bei den Körpermaßen konnten keine signifikanten Unterschiede im Brustumfang zwischen Horro- und Menzschafen festgestellt werden. Jedoch war die Widerristhöhe von Horrolämmern (61,91±0,62 cm) deutlich größer ($p<0,001$) als die von Menzlämmern (59,89±0,44 cm). Der größte Unterschied zwischen den beiden Rassen war über den gesamten Untersuchungszeitraum hinweg die Schwanzlänge. Obwohl beide Rassen als Fettschwanzschafe gelten, haben Horroschafe einen längeren Schwanz, die Menzschafe hingegen einen kürzeren aber breiteren Schwanz.

Es konnte eine enge und signifikante Beziehung zwischen dem Körpergewicht und den linearen Körpermaßen, die in dieser Arbeit untersucht wurden, über alle Wachstumsstadien hinweg festgestellt wird. Es geht hervor, daß das Körpergewicht von beiden Rassen im Alter von einem Jahr ziemlich genau anhand des Brustumfangs geschätzt werden kann (Horro: $r=0,91$; Menz: $r=0,90$).

Am Ende der 123-tägigen Mastperiode waren die Horrolämmer (34,7±0,63 kg) signifikant ($p<0,05$) schwerer als die entsprechenden Menzlämmer (32,7±0,57 kg), während bei der Zunahmerate während dieser Mastphase keine deutlichen Unterschiede nachgewiesen werden konnten (Horrolämmer: 47,3±3,81 g; Menzlämmer: 45,5±2,90 g). Die absolute Trockenmasseaufnahme von Horrolämmern (879,6±12,27 g) lag signifikant ($p<0,01$) über der von Menzlämmern (802,2±9,35 g). Beim Bezug der Trockenaufnahme auf das metabolische Körpergewicht der Tiere jedoch konnten keine deutlichen Unterschiede zwischen den beiden Rassen (Horro: 67,8±1,95 g/kg $W^{0,75}$; Menz: 65,6±1,72 g/kg $W^{0,75}$) nachgewiesen werden. Der Anteil des vollen Gastro-Intestinal-Traktes am Schlachtkörpergewicht war bei Horrolämmern (22,6±0,53 %) signifikant höher als bei Menzlämmern (20,1±0,47 %), ebenso der Anteil dessen Inhalts (Horro: 15,2±0,52 %; Menz: 13,3±0,46 %). Dennoch war die scheinbare Verdaulichkeit der gesamten Trockenmasseaufnahme für Horrolämmer (51,6±0,01 %) deutlich niedriger als die von Menzlämmern (54,0±0,01 %).

Beim Schlachtkörpergewicht (warm und kalt) konnten keine signifikanten Unterschiede zwischen den beiden Rassen festgestellt werden (Horro: 14,2±0,26 kg und 13,6±0,26 kg; Menz: 14,8±0,29 kg und 14,2±0,29 kg). Der Ausschlachtungsanteil von Menzlämmern war in der Tendenz höher ($p>0,05$) als der von Horrolämmern. Ebenso tendenziell höher, aber statistisch nicht signifikant, war bei den Menzlämmern die geschätzte zerlegbare Fleischmasse (8,91±0,22 kg) im Vergleich zu den Horrolämmern (8,55±0,19 kg). Obwohl statistisch nicht nachweisbar, scheint auch der Schätzwert für das zerlegbare Körperfett bei Menzlämmern (2,88±0,11 kg) höher zu sein als bei Horrolämmern (2,77±0,12 kg). Die beiden Rassen unterscheiden sich jedoch signifikant in der geschätzten Knochenmasse (Horro: 3,31±0,08 kg; Menz: 2,99±0,07 kg), was auf ein höheres Mastpotential von Horrolämmern gegenüber Menzlämmern hinweisen könnte.

Der Verfettungsgrad wurde sowohl direkt (durch Zerlegen) als auch indirekt (durch Ätherextraktion) geschätzt. Beide Rassen zeigten eine ziemlich ähnliche Körperfettverteilung. Jedoch lag der Schätzwert für die Ätherextraktion auf Trockenmassebasis beim Fleisch von Menzlämmern (22,4±0,89 %) deutlich über dem von Horrolämmern (18,1±1,00 %). Dies zeigte sich auch im Schätzwert für den Ätherextrakt der Fleischmasse am gesamten Schlachtkörper, der bei Menzlämmern (505,00±25,86 g) signifikant höher war bei Horrolämmern (411,00±28,95 g). Dies könnte ein Indiz dafür sein, daß das Fleisch von Menzschlachtkörpern mehr inter- und intramuskuläres Fett enthält als das von Horroschlachtkörpern. Ebenso hatten Menzlämmer tendenziell ein besseres Fleisch : Knochen-Verhältnis als Horrolämmer (2,9±0,06 bzw. 2,7±0,06). Angesichts des höheren Ausschlachtungsgrades, des höheren Anteils an intramuskulärem Fett und dem relativ höheren Fleisch : Knochen-Verhältnis scheint das Menzschaf unter den gegebenen Versuchsbedingungen die bessere Fleischschafrasse zu sein im Vergleich zum Horroschaf.

8. BIBLIOGRAPHY

Afonso, J. and Thompson, J. m. (1996). Changes in body composition of sheep selected for high and low back fat thickness during periods of ad libitum and maintenance feeding. Animal Science, *63:* 395-406.

Al Jassim, R. A. M., Hassan, S. A. and Al-Ani, A. N. (1996). Metabolizable energy requirements for maintenance and growth of Awassi lambs. Small Ruminant Research, *20:* 239-245.

Amegee, Y. (1981). The Vogan sheep in Togo. II. Lamb carcass quality. Paper presented at the 12th Animal Science Symposium of the Ghana Animal Science Association. 26-28 August 1981. University of Ghana, Legon, Ghana.

Anous, M. R. (1991). A comparative study of muscle-bone relationship in the hind limb of goats and sheep. Animal Production. *53:*81-87.

A. O. A. C. (1990). Official method of analysis, 15 th ed. (Helrich, K., ed.), Pub. by Association of Official Analytical Chemists, Washington, DC.

Armbruster, T., Peters, K. J. and Hadji-Thomas, A. (1991). Productivity of sheep raising in the forest region of Ivory Coast. III. Mortality and productivity. Journal of Animal Breeding and Genetics. *108:* 220-226.

Arnold, G. W. and Birrell, H. A. (1977). Food intake and grazing behaviour of sheep varying in body condition. Animal Production. *24:* 343-353.

Arthur, P. F. and Ahunu, B. K. (1989). Changes in size and shape with time of crossbred West African hair sheep raised under tree-crop plantations. Livestock Production Science. 21*(3):* 235-249.

Aziz, N. N.; Murray, D. M. and Ball, R. O. (1992). The effect of live weight gain and live weight loss on body composition of Merino Wethers: Chemical composition of the dissected components. Journal of Animal Science. *70:* 3412-3420.

Aziz, N. N.; Murray, D. M. and Ball, R. O. (1993). The effect of live weight gain and live weight loss on body composition of Merino Wethers: non-carcass organs. Journal of Animal Science. *71:* 400-407.

Barlow, R.; Ellis, K. J.; Williamson, P. J.; Costigan, P.; Stephenson, P. D.; Rose, G. and Mears, P. T. (1988). Dry-matter intake of Hereford and first-cross cows measured by controlled release of chromic oxide on three pasture systems. Journal of Agricultural Sci. (Camb.). *110:*217-231.

Bathaei, S. S. and Leroy, P. L. (1996). Growth and mature weight of Mehraban Iranian fat-tailed sheep. Small Ruminant Research. *22:* 155-162.

Bathaei, S. S. and Leroy, P. L. (1998). Genetic and phenotypic aspects of the growth curve characteristics in Mehraban Iranian fat-tailed sheep. Small Ruminant Research. *29:* 261-269.

Berg, R. T. and Walters, L. E. (1983). The meat animal: Changes and challenges. Journal of Animal Science. 57 *(suppl. 2):* 133-146.

Beyne Kebede (1998). Looking ahead for sustainable livestock development. Keynote address. In: Proceedings of the fifth National Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia. ESAP. pp:9-10.

Black, J. L. (1983). Growth and development of lambs. In: Haresign, W. (ed.). Sheep production. Proc. of 35th Easter School in Agri. Sci., Univ. of Nottingham. pp: 21-58.

Black, J. L. (1990). Nutrition of the grazing ruminant. Proceedings of the New Zealand Society of Animal Production. *Vol. 50:* 7-27.

Bradford, G. E. and Berger, Y. M. (1988). Breeding strategies for small ruminants in arid and semi-arid areas. In: Thomson, E. F. and Thomson, F. S. (eds.). Increasing Small Ruminant Productivity in Semi-Arid Areas. Proc. Conf. held at ICARDA, Aleppo, Syria, Current Topics in Vet. Med. and Anim. Sci. *47:* 95 -109.

Brown, J. E., Brown, C. J. and Butts, W.T. (1973). Evaluating relationship among immature measures of size, shape and performance of beef bulls. I. Principle components as a measure of size and shape in young Hereford and Angus bulls. Journal of Animal Science. *36:* 1010-1020.

Bullerdieck, P. (1996). Appraisal of various management interventions in sheep production system with high gastrointestinal parasite challenge in a sub-humid tropical environment. Berichte aus der Agrarwissenschaft Zugl.: Berlin, Humboldt-University, Dissertation, Shaker Verlag, Aachen.

Burfening, P. J. and Kress, D. D. (1993). Direct and maternal effects on birth and weaning weight in sheep. Small Ruminant Research. *10:* 153-163.

Burrin, D. G., Ferrell, C. L., Britton, R. A. and Bauer Marc. (1990). Level of nutrition and visceral organ size and metabolic activity in sheep. British Journal of Nutrition. *64:* 439-448.

Butler-Hogg, B. W. (1984). Growth patterns in sheep: Changes in the chemical composition of the empty body and its constituent parts during weight loss and compensatory growth. J. Agri. Sci. (Camb.). *103:* 17-24.

Cantón, J. G.; Velázquez, M. A. and Castellanos, R. A. (1992). Body composition of pure and crossbred Blackbelly sheep. Small Ruminant Research, *7:* 61-66.

Carstens, G. E., Johnson, D. E., Ellenberger, M. A. and Tatum, J. D. (1991). Physical and chemical components of the empty body during compensatory growth in beef steers. Journal of Animal Science. *69:* 3251-3264.

Central Statistics Authority (CSA). (1996). Livestock resource and production statistics in Ethiopia. Proceedings of the Fourth National Conference of the Ethiopian Society of Animal Production (ESAP). 18-19 April 1996. Addis Ababa. ESAP. Addis Ababa, Ethiopia.

Coleman, S. W., Gallavan, R. H., Phllips, W. A., Volesky, J. D. and Rodriguez, S. (1995). Silage or limit-fed grain growing diets for steers. II. Empty body and carcass composition. Journal of Animal Science. *73:* 2621-2630.

Colomer-Rocher, F., Kirton, A. H., Merer, G. J. K. and Duganzich, D. M. (1992). Carcass composition of New Zealand Saanen goats slaughtered at different weights. Small Ruminant Research. *7:* 161-173.

Cooper, R. A. (1982). Animal production. Sheep. In: Halley, R. J. (ed.). The agricultural note book. 17th edition. Butterworths and Co. (Publishers) Ltd., London, pp. 375-390.

Cronjé, P. B. and Weites, E. (1990). Live mass, carcass and wool growth responses to supplementation of a roughage diet with sources of protein and energy in South African Merino lambs. South African Journal of Animal Science. 20*(4):* 161-168.

Crouse, J. D., Busboom, J. R., Field, R. A. and Ferrell, C. L. (1981). The effects of breed, diet, sex, location and slaughter weight on lamb growth, carcass composition and meat flavor. Journal of Animal Science. *53:* 376 - 386.

de Leeuw, P.N. and Rey, B. (1995). Analysis of current trends in the distribution patterns of ruminant livestock in tropical Africa. World Animal Review. *83*, pp. 47-59.

Dickerson, G. E. (1969). Experimental approaches in utilising breed resources. Animal Breeding Abstract. 37*(2):* 191-202.

Dickerson, G. E. (1973). Inbreeding and heterosis in animals. In: Proc. Anim. Breeding and Genetics Symp. Honour. J. L. Lush. Amer. Soc. Anim. Sci., Champaign, Illinois, USA. pp.54-77.

Dickerson, G. E., Glimp, H. A., Tuma, H. J. and Gregory, K. E. (1972). Genetic resources for efficient meat production in sheep. Growth and carcass characteristics of ram lambs of seven breeds. J. Anim. Sci. 34 *(6):* 940-951.

Dulphy, J. P. and Demarquilly, C. (1994). The regulation and prediction of feed intake in ruminants in relation to feed characteristics. Livestock Production Science. *39:* 1-12.

Ehoche, O. W., Alhassan, W. S., Umoh, J. E., Buvanendran, V. and Umunna, N. N. (1992). Growth performance and carcass characteristics following feed restriction and realimentation in zebu bulls. African Livestock Research, *1:* 24-30.

El-Feel, F. M. R., Sallam, M. T., Tawfik, E. S. and Abdel-Ghani, A. A. (1990). Body measurements of Buffalo and cow calves as affected by weaning, calving season and sex and their relation to body weight and carcass traits. Der Tropenlandwirt, 91. Jahrgang. Oktober, pp:119-132.

El Karim, A. I. A. and Owen, J. B. (1987). Post-weaning growth performance, carcass characteristics and preliminary heritability estimate for some carcass traits of two types of Sudan Desert sheep on intensive feeding. J. agric. Sci. (Camb.). *109:* 531-538.

Enyew Negussie (1999). Body composition and body reserves in indigenous Ethiopian fat-tailed sheep breeds. Tierwissenschaft. Dissertation (Dr. agr.), Institut für Tierwissenschaften, Lehrstuhl für Tierzucht, Technische Universität München. Typoskript-Edition, Hieronymus Buchreprouktions GmbH, München.

Ewnetu Ermias, Rege, J. E. O., Anindo, D. O., Hibret Amare and Alemu Yami (1998). Carcass and edible non-carcass component yields in Menz and Horro ram lambs. In: Women and Animal Production. Proceedings of the 6th annual conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia. pp. 217-222.

Farid, A. (1991). Carcass physical and chemical composition of three fat-tailed breeds of sheep. Meat Science. *29:* 109-120.

Ferrel, C. L., Koong, L. J. and Nienaber, J. A. (1986). Effect of previous nutrition on body composition and maintenance energy costs of growing lambs. British Journal of Nutrition. 56*(3):* 595-605.

Filius, P., Weniger, J. H. and Teuscher, T. (1985). Studies on the performance of Djallonke sheep. A contribution to information on a West African breed of sheep. Zeitschrift für Tierzuchtung und Zuchtungsbiologie. 105*(5):* 371-384.

Fitzhugh, H. A. and Bradford, G. E. (1983). Productivity of hair sheep and oportunities for improvement. In: Fitzhugh, H. A. and Bradford, G. E. (eds.). Hair sheep of Western Africa and the Americas. A genetic resource for the Tropics. A Winrock International Study. Westview Press/ Boulder, Colorado. pp. 23-52.

Food and Agricultural Organisation, FAO. (1996). FAO Yearbook. Production. 1995, Vol. 49.

Food and Agricultural Organisation, FAO. (1995). FAO Yearbook. Production. 1994, Vol. 48

Friggens, N., McClelland, T. H., Kyriazakis, I., Cropper, M.R., Zea, J., Zygoyiannis, D., Stamataris,C, and Katsaounis, N. (1994). The potential growth of nine small sized European sheep breeds: Factors affecting carcass composition. Paper presented at the 45th meeting of European Association for Animal Production (EAAP), 5-8 September 1994, Edinburgh, U. K., CS 3.7.

Frutos, P., Mantécon, A. R. and Giráldez, F. J. (1997). Relationship of body condition score and live weight with body composition in mature Churra ewes. Animal Science. *64:* 447-452.

Fuller, M. F. (1969). Climate and growth. In: Hafez, E. S. E. and Dyer, I. A. (eds.). Animal growth and nutrition. Lea and Febiger, Philadelphia (USA).

Gaili, E. S. E. (1979). Effect of breed-type on carcass weight and composition in sheep. Tropical Animal Health and Production. *11:* 191-198.

Gaili, E. S. E. and El-Naiem, A. A. (1992). Effects on performance and carcass quality of feeding date syrup in drinking water as a substitute for barley in rations for lambs. Indian Journal of Animal Sciences. 62*(8):* 785-786.

Galal, E. S. E. (1983). Sheep germplasm in Ethiopia. Animal Genetic Resources Information. FAO, 1/*83:* 4-12.

Gatenby, R. M. (1986). Sheep production in the Tropics and Sub-Tropics. Tropical Agriculture Series. Longman Group Limited.

Gatenby, R. M., Bradford, G. E., Doloksaribu, M., Romjali, E., Pitono, A. D. and Sakul, H. (1997). Comparison of Sumatra sheep and three hair sheep crossbreeds. I. Growth, mortality and wool cover of F1 lambs. Small Ruminant Research. *25:* 1-7.

Goonewardene, L. A., Ravindran, V., Nadarajah, K. and Rajamahendran, R. (1984). The native sheep of Sri Lanka. Animal Genetic Resources Information. 1/*84.* pp: 27-30.

Graham, N. McC.; Searle, T. W.; Margan, D. E.; Spencer, F. B. and Wynn, P. C. (1991). Physiological state of sheep before and during fattening. J. Agri. Sci. (Camb.). *117:* 371-379.

Gruszecki, T., Lipecka, C. and Wiercinski, J. (1994). The contents of fatty acids in the meat tissue of lambs of various genotypes. Paper presented at the 45th annual meeting of the European Association for Animal Production (EAAP), Edinburgh, U. K., 5-8 September 1994. SS 44.

Harris, L. E. (1970). Nutrition research techniques for domestic and wild animals. Animal Sci. Dept., Utah State University, Logan, Utah, p. 2301 Cited by ILCA (1992a).

Hodges, J. (1990). Conservation of animal genetic resource in developing countries. In: Alderson, L. (ed.). Genetic conservation of domestic livestock. C. A. B. International. pp: 128-145.

Iason, G. R. and Mantecon, A. R. (1993). The effects of dietary protein level during food restriction on carcass and non-carcass components, digestibility and subsequent compensatory growth in lambs. Animal Production. *56:* 93-100.

Iason, G. R., Mantecon, A. R. Milne, J. A., Sim, D. A., Smith, A. D. and White, I. R. (1992). The effect of pattern of food supply on performance, compensatory growth and carcass composition of Beulah and Welsh Mountain lambs. Animal Production, *54:* 235-241.

Institute of Agricultural Research, I. A. R. (1991). Strategic Planning for Livestock Research in the Institute of Agricultural Research (I. A. R.), unpublished, Addis Ababa, Ethiopia.

International Livestock Centre for Africa, I. L. C. A. (1994). Analytical Methods for Feeds, Animal Excrement and Animal Tissues. Adapted and Compiled by Mebrahtu Ogbai and Tenaye Sereke Berhan. Nutrition Laboratory Manual. I. L. C. A., Addis Ababa, Ethiopia.

International Livestock Centre for Africa, I. L. C. A. (1993). Climatic records for ILCA research sites 1992. March1993, I. L. C. A., AAddis Ababa, Ethiopia.

International Livestock Centre for Africa, I. L. C. A. (1992). Climatic records for ILCA research sites 1991. April 1992, I. L. C. A., AAddis Ababa, Ethiopia.

Kabali, A.; Johnson, W. L.; Johnson, D. W.; Godrich, R. D. and Allen, C. E. (1992). Effects of compensatory growth on some body component weights and carcass and non carcass composition of growing lambs. J. Anim. Sci. *70:* 2852-2858.

Kempster, A. J. (1981). Fat partition and distribution in the carcass of cattle, sheep and pigs: A review. Meat Science. *5:* 83-98.

Kempester, A. J., Jones, D. W. and Wolf, B. T. (1986). A comparison of alternative methods for predicting the carcass composition of crossbred lambs of different breeds and crosses. Meat Science. *18:* 89-110.

Kennedy, A. D., Gilson, T. L. and Posnikoff, J. (1995). Body and fat tail growth and carcass responses to clonidine in Karakul ram lambs. Small Ruminant Research. 15*(2):* 171-176.

Khalafalla, A. M. and El Khidir, O. A. (1985). A note on intensive fattening of Sudan Desert lambs. World Review of Animal Production. 21 *(3):* 41-43.

Khan, B. U. and Bhat, P. N. (1981). Genetic and non-genetic factors affecting live lamb traits in Muzaffarnagari and its half-breds with Corriedale. Indian Journal of Animal Science. 51*(1):* 39-48.

Khandaker, Z. H., Steingass, H. and Drochner, W. (1998). Supplementation of wheat straw with Sesbania on voluntary intake, digestibility and ruminal fermentation in sheep. Small Ruminant Research. *28:* 23-29.

Laes-Fettback, C. and Peters, K. J. (1995). A comparative study of performance of Egyptian goat breeds. II. Growth performance and productivity. Arch. Tierz., Dummerstorf. 38 *(5):* 563-575.

Lahlou-Kassi, A. (1987). Principles of indigenous sheep improvement in North Africa. In: Hodges, J. Animal genetic resources. Strategies for improved use and conservation. FAO Animal Production and Health Paper. *66:* 77-87.

Lee, G. J. (1986). Growth and carcass composition of ram and wether lambs fed at two levels of nutrition. Aust. J. Exp. Agric., *26:* 275-278.

Little, D. A. and Sandland, R. L. (1975). Studies on the distribution of the body fat in sheep during continuous growth and following nutritional restriction and rehabilitation. Aust. J. Agric. Res. *26:*363.

Madalena, F. (1993). The conservation of animal genetic resources in the developing countries: A practical way forward. In: Mack, S. (ed.). Strategies for sustainable animal agriculture in developing countries. FAO Animal Production and Health Paper. *107:* 77-83.

Maijala, K. and Terrill, C. E. (1991). Breed structure, dynamics and new breed development in sheep. In: Maijala, K. (ed.). Genetic Resources of pig, sheep and goat. World Animal Science, B8. Elsevier Science Publishers B. V. pp: 305-327.

Marais, P. G.; van der Merwe, H. J. and du Toit, J. E. J. (1991). The effect of compensatory growth on feed intake, growth rate, body composition and efficiency of feed utilisation in Dorper sheep. South Afr. J. Anim. Sci. 21 *(2):* 80-88.

Martinez, A. (1983). Reproduction and growth of hair sheep in an experimental flock in Venezuela. In: Fitzhugh, H. A. and Bradford, G. E. (eds.). Hair sheep of Western Africa and the Americas. A genetic resource for the Tropics. A Winrock International Study. Westview Press/ Boulder, Colorado. pp: 105-113.

Mayaka, T. B., Tchoumbone, J., Manjeli, Y. and Teguia, A. (1995). Estimation of live body weight in West African Dwarf goats from heart girth measurements. Tropical Animal Health and Production. *28:* 126-128.

McCutcheon, S. N., Blair, H. T. and Purchas, R. W. (1993). Body composition and organ weights in fleeceweight-selected and control Romney rams. New Zealand Journal of Agricultural Research. *Vol. 36:* 445-449.

Mehrez, A. Z., Ørskov, E. R. and McDonald, I. (1977). Rates of rumen fermentation in relation to ammonia concentration. British Journal of Nutrition. *38:* 437-443.

Mendel, C. (1988). Genetische, phsiologische und umweltbedingte Einfluesse auf die Fruchbarkeit von Bergschafen. Dissertation. Technischen Universität München.

Mendel, C.; Scholaut, W. and Pirchner, F. (1989). Performance of Merinolandschaf and Bergschaf under an Accelerated Lambing System. Livestock Production Science. *21:* 131-141.

Microsoft Office (1998). Microsoft Office 98, Microsoft Excel 97. Microsoft Corporation, Windows, USA.

Mukasa-Mugerwa, E. and Lahlou-Kassi, A. (1995). Reproductive performance and productivity of Menz sheep in the Ethiopian highlands. Small Ruminant Research. *17:* 167-177.

Mukasa-Mugerwa, E.; Said, A. N.; Lahlou-Kassi, A.; Sherington, J. and Mutiga, E. R. (1994). Birth weight as a risk factor for perinatal lamb mortality and the effects of stage of pregnant ewe supplementation and gestation weight gain in Ethiopian Menz sheep. Preventive Veterinary Medicine. 19 *(1):* 45-56.

Nicholas, M. E., Dolezal, H. G., Fitch, G. Q. and Phillips, W. A. (1992). Feedlot performance and carcass characteristics: Comparison of small, medium and large frame wethers backgrounded on wheat pasture. In: Proceedings, Western Section, American Society of Animal Science, July 8-10. *Vol. 43:* 196-199.

Niftalem Dibissa (1990). On-Farm study of the reproductive and growth performance of the Menz sheep in Debre Brehan-Ethiopia. M. Sc. Thesis. Alemaya University of Agriculture, The Graduate School, Alemaya, Ethiopia.

Notter, D. R. and Copenhaver, J. S. (1980). Performance of Finnish Landrace crossbred ewes under accelerated lambing. II. Lamb growth and survival. Journal of Animal Science. 51*(5):* 1043-1050.

Notter, D. R.; Kelly, R. F. and McClaugherty, F. S. (1991). Effects of ewe breed and management system on efficiency of lamb production. II. Lamb growth, survival and carcass characteristics. J. Anim. Sci. 69 *(1):* 22-33.

Orr, R. M. (1982). Animal production . Animal physiology. In: Haaley, R. T. (ed.) The Agricultural Note Book 17th edition. Butterworths and Co. (Publishers) Ltd., London. pp. 305-318.

Ørskov, E. R. (1998). Feed evaluation with emphasis on fibrous roughages and fluctuating supply of nutrients. A Review. Small Ruminant Research, *28:* 1-8.

Owen, J. B. (1976). Sheep Production. Bailliére Tindal, London, UK.

Parker, W. J., McCutcheon, S. N. and Wickham, G. A. (1991). Effect of administration and ruminal presence of chromic oxide controlled release capsules on herbage intake of sheep. New Zealand Journal of Agricultural Research. *Vol. 34:* 193-200.

Peters, K. J. (1988). Principles in evaluation of goat populations in tropical and sub-tropical environments. World Review of Animal Production. XXIV*(1):* 51-58.

Peters, K. J. (1989). Trends in On-Farm Performance Testing of Small Ruminants in sub-Saharan Africa. In: Wilson, R. T. and Azeb, M. (eds). African Small Ruminant Research and Development. I. L. C. A., Addis Ababa, Ethiopia. pp. 439-469.

Ponzoni, R. W. (1992). A global review of the genetic resources of sheep and goat breeds. In: Hodges, J. The management of global animal genetic resources. Proc. of an FAO Expert Consultation. FAO Animal Production Health Paper, Rome. *104:* 157-175.

Prasad, V. S. S. and Agnihotri, M. K. (1992). Relevance of frame size and fatness indices to live animal and carcass classification in goats. Indian Journal of Animal Sciences. 62*(5):* 461-466.

Prasad, V. S. S. and Sinha, N. K. (1992). Carcass and non-carcass traits of Muzaffarnagri lambs at different maturity levels. Indian Journal of Animal Science. 62*(2):* 159-164.

Rastogi, R. K., Keens-Dumas, M. J. and Lauckner, F. B. (1993). Comparative performance of several breeds of Caribean hair sheep in pure breeding and crossbreeding. Small Ruminant Research. *9:* 353-366.

Rege, J. E. O. (1992). Program LOGMLVAR. A Software Program to estimate predicted probabilities from Maximum Likelihood (ML) estimators. ILCA, Addis Ababa, Ethiopia

Ruvuna, F., Taylor, J. F., Okeyo, M., Wanyoike, M. and Ahuya, C. (1992). Effects of breed and castration on slaughter weight and carcass composition of goats. Small Ruminant Research. *7:* 175-183.

SAS (1990). Statitical Analysis Systems. SAS For Windows, Release 6.11 (1989-1995) SAS Institute Inc., Cary, North Carolina, USA.

Said, A. N. and Adugna Tolera (1993). The supplementary value of forage legume hays in sheep feeding. Feed intake, Nitrogen retention and body weight change. Livestock Production Science. *33:* 229-237.

Schoeman, S. J. and Burger, R. (1992). Performance of Dorper sheep under an accelerated lambing system. Small Ruminant Research. 9*(3):* 265-281.

Sendros Demeke and Tesfaye Kumsa (1998). Factors to be considered in the formulation of livestock breeding policy. In: Proceedings of The Fifth National Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa. ESAP. pp: 13-27.

Seré, C. and Steinfeld, H. (1996). World livestock production systems. Current status, issues and trends. FAO Animal Production and Health Paper. *127:* 1-48.

Setshwaelo, L. L. (1990). Live animal conservation projects in Africa. In: Wiener, G. (ed.). Animal genetic resources. A global programme for sustainable development. FAO Animal Production and Health Paper. *80:* 135-141.

Shahjalal, Md., Galbraith, H. and Topps, J. H. (1992). The effect of changes in dietary protein and energy on growth, body composition and mohair fibre characteristics of British Angora goats. Animal Production. *54:* 405-412.

Silva, P. M. da, Quitana, W. N. M., Teixeira, L. H. D., Costanzi, A. R. and Rogrigues, C. O. (1980). Effect of castration in sheep. In *Pesquisa em ovinos no Brasil* 1975-1979, p.101.

Simm, G. (1992). Selection for lean meat production in sheep. In: Speedy, A. W. (ed.). Progress in sheep and goat research. C. A. B. International, Redwood Press Ltd., Melksham, UK. pp: 193-215.

Snowder, G. D.; Glimp, H. A. and Field, R. A. (1994). Carcass characteristics and optimal slaughter weights in four breeds of sheep. Journal of Animal Science. *72:*932-937.

Solomon Abegaz (1998). Relationship between growth performance and subsequent productivity in Horro sheep. In: Proceedings of The Fifth National Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa. ESAP. pp: 93-100.

Solomon Gizaw, Solomon Abegaz, and Yohannes Gojam (1995). Factors affecting preweaning survival of Horro lambs at Bako Research Center. In: Proceedings of The Third National Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa. ESAP. pp: 140-145.

Stagnaro, C. G. (1983). Commercial hair sheep production in a semiarid region of Venezuela. In: Fitzugh, H. A. and Bradford, G. E. (eds.). Hair sheep of Western Africa and the Americas. A genetic resource for the Tropics. Westview Press, Boulder, Colorado. pp:85-104.

Steen, R. W. J. and Kilpatrik, D. J. (1995). Effects of plane of nutrition and slaughter weight on the carcass composition of serially slaughtered bulls, steers and heifers of three breed crosses. Livestock Production Science. *43:* 205-213.

Streitz, E., Baulain, U. and Kallweit, E. (1994). Estimation of body composition in live lambs by means of Magnetic Resonance Imaging (MRI). Paper presented at the 45th Annual meeting of the European Association for Animal Production (EAAP). 5-8 September, Edinburgh, UK.

Taylor, St. C. S. and Murray, J. I. (1991). Effect of feeding level, breed and milking potential on body tissues and organs of mature, non-lactating cows. Animal Production. *53:* 27-38.

Taylor, St. C. S., Murray, J. I. and Thonney, M. L. (1989). Breed and sex differences among equally mature sheep and goats. 4. Carcass muscle, fat and bone. Animal Production. *49:* 385-409.

Teixeira, A. and Delfa, R. (1994). Carcass composition and body fat depots of Galego Bragancano and crossbred lambs by Suffolk and Merino Precoce sire breeds. Paper presented at the 45th meeting of European Association for Animal Production (EAAP), 5-8 September 1994. Edingrugh, UK, CS 3.8.

Terrill, C. E. and Maijala, K. (1991). Breed comparisons for meat production in sheep. In: Maijala, K (ed.). 1991. Genetic resources of pig, sheep and goat. World Animal Science. *B8:* 257-276.

Terrill, C. E. and Slee, J. (1991). Breed differences in adaptation of sheep. In: Maijala, K. (ed.). Genetic Resources of pig, sheep and goat. World Animal Science, *B8.* Elsevier Science Publishers B. V. pp. 195-233.

Thatcher, L. P. and Gaunt, G. M. (1992). Effects of growth path and post-slaughter chilling regime on carcass composition and meat quality of ewe lambs. Australian J. Agri. Res. *43:* 819-830.

Thompson, J. M., O'Halloran, W. J., McNeill, D. M. J., Jackson-Hope, N. J. and May, T. J. (1987). The effect of fasting on live weight and carcass characteristics in lambs. Meat Science. *20:* 293-309.

Timon, V. M. (1993). Strategies for sustainable development of animal agriculture- an FAO Perspective. In: Mack, S. (ed.). Strategies for sustainable animal agriculture in developing countries. FAO Animal Production and Health Paper. *107:* 7-22.

Tuah, A. K. and Baah, J. (1985). Reproductive performance, pre-weaning growth rate and pre-weaning lamb mortality of Djallonke sheep in Ghana. Tropical Animal Health and Production. 17*(2):* 107-113.

Turgeon Jr., O. A.; Brink, D. R.; Barlte, S. J.; Klopfenstein, T. J. and Ferrell, C. L. (1986). Effects of growth rate and compensatory growth on body composition in lambs. Journal of Anim. Sci. *63:* 770-780.

Turner, H. N. (1991). Sheep production research: The development of small ruminants in developing countries. World Animal Review. 66 *(1):* 3-12.

Tuzemen, N., Yanar, M., Akbulut, O. and Ockerman, H. W. (1993). Prediction of body weights from body measurements in Brown Swiss calves reared in the Eastern region of Turkey. World Review of Animal Production. 28*(4):* 49-54.

van Arendonk, J. A. M.; Vos, H. and van der Werf, J. H. J. (1991). Genetic aspects of feed intake and efficiency in dairy cows. In: Proc. Aust. Assoc. Anim. Brd. and Genetics. *9:* 37-44.

van Wyk, J. B., Erasmus, G. J., Konstantinov, K. V. and van der Westhuizen, J. (1993). Relationships between early growth traits in the Elsenburg Dormer sheep stud. South Afr. J. Anim. Sci. 23 *(3/4):* 81-84.

Vélez, M., Raudales, J., Esnaola, M. A. and Murillo, B. (1993). Growth and carcass characteristics of lambs fed ammoniated corn straw and Gliricidia sepium or cotton-seed meal. Small Ruminant Research. *10:* 209-217.

Vercoe, J. E. and Frisch, J. E. (1987). Pre- and post-weaning growth of different breeds of beef cattle in the Tropics. In: Johnson, H. D. Bioclimatology and the adaptation of livestock. World Animal Science. *B5:* 59-68.

Villete, Y. and Theriez, M. (1981). Influence of birth weight on lamb performance at slaughter. 2. Carcass and chemical composition of lambs slaughtered at the same weight. Annales-de-Zootechnic. 30*(2):* 169-181.

Wagner, M. W.; Havstad, K. M.; Doornbos, D. E. and Ayers, E. L. (1986). Forage intake of rangeland beef cows with varying degrees of crossbred influence. Journal of Animal Science. *63:* 1484-1490.

Walstra, P. and de Greef, K. H. (1995). Aspects of development and body composition in pigs. In: Ender, K. (ed.). Proceedings of 2nd Dummerstorf muscle-workshop. Muscle growth and meat quality. Rostock, 17-19 May, 1995. pp. 183-190.

Wilson, R. T. (1991). Small ruminant production and the small ruminant genetic resource in Tropical Africa. FAO, Animal Production and Health Paper. Number 88, *XVIII.*

Wilson, R. T. (1988). Small ruminant production system in Tropical Africa. Small Ruminant Research *1:* 305-325.

Wilson, R. T. (1987). Livestock production in central Mali: Environmental factors affecting weight in traditionally managed goats and sheep. Anim. Prod. *45:* 223-232.

Wilson, R. T. (1986). Livestock production in central Mali: Long-term studies on cattle and small ruminants in the agropastoral system. International Livestock Centre for Africa, Addis Ababa, Ethiopia. ILCA Research Report. *14:* 65-103.

Wilson, R. T. and Murayi, Th. (1988). Production characteristics of African long-fat-tailed sheep in Rwanda. Small Ruminant Research. *1:* 3-17.

Winrock International (1992). Assessment of animal agriculture in sub-Saharan Africa. Winrock International, Morrilton. Ark., USA. Pp.125.

Winrock International (1983). Sheep and goats in developing countries: Their present and potential role. The World Bank, Washington, DC.

Wishmeyer, D. L., Snowder, G. D., Clark, D. H. and Cockett, N. E. (1996). Prediction of live lamb chemical composition utilising electromagnetic scanning (ToBEC^{TM})^{1}. Journal of Animal Science. *74:* 1864-1872.

Wolf, B. T., Smith, C. and Sales, D. I. (1980). Growth and carcass composition in the crossbred progeny of six terminal sire breeds of sheep. Animal Production. *31:* 307-313.

Wood, J. D., and MacFie, H. J. H. (1980). The significance of breed in the prediction of lamb carcass composition from fat thickness measurements. Animal Production. 31*(3):* 315-319.

Wunderlich, Angelika, (1990). Zur Problematik der Verbesserung von Schaf- und Ziegenhaltungssystemen am humedin Standort Westafrikas. Diplomarbeit im wissenschaftlichen Studiengang Agrarwissenschaftlichen an der Universität Göttingen. pp:58-67.

Yohannes Gojam, Solomon Abegaz and Gemeda Duguma (1998). Late pregnancy ewe feeding and its effect on lamb growth and survival to weaning and body weight changes of ewes in Horro sheep. In: Proceedings of the Fifth National Conference of Ethiopian Society of Animal Production(ESAP), Addis Ababa. pp: 110-116.

Yohannes Gojam, Solomon Gizaw, Thwaites, C. J. and Kassahun Awgichew. (1995). Influence of birth weight and postpartum age on lamb mortality in Ethiopian Horro sheep. In: Proceedings of the Fifth National Conference of Ethiopian Society of Animal Production(ESAP), Addis Ababa. pp: 219-222.

Zervas, G., Hadjigeorgiou, I., Zabeli, G., Koutsotolis, K. and Tziala, C. (1997). Evaluation of an intensive and extensive fattening system of lambs in Greece. Proceedings: 48th Annual meeting of the European Association for Animal Production. Commission on sheep and goat production. EVT. FEZ. EAAP. Wien. pp. 1-6.

9. APPENDICES

Appendix 9.1: ANOVA table for birth weight and preweaning growth performance of Horro and Menz lambs.

A9.1.1. Birth weight

Source of variation	df	Mean Square	Pr > F
Breed	1	8.0531	0.0001
Sex	1	4.8324	0.0001
Birth type	1	41.3768	0.0001
Dam parity	1	14.0915	0.0001
Birth season	2	0.8418	0.0072
Sire (breed)	36	0.2760	0.0113
Breed x Birth season	2	0.1968	0.3137
Error	811	0.1695	
R^2 0.41			
C.V. 17.1			

A9.1.2. Live body weight at 30 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	8.5077	0.0105
Sex	1	19.3586	0.0001
Birth type	1	299.7622	0.0001
Dam parity	1	151.2315	0.0001
Birth season	2	38.28518	0.0001
Sire (breed)	36	1.2623	0.5112
Breed x Birth season	2	3.6079	0.0620
Error	753	1.2929	
R^2 0.39			
C.V. 21.0			

A9.1.3. Live body weight at 60 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	0.3212	0.7276
Sex	1	26.5034	0.0016
Birth type	1	540.2941	0.0001
Dam parity	1	137.7056	0.0001
Birth season	2	32.3943	0.0001
Sire (breed)	36	3.0540	0.2482
Breed x Birth season	2	11.0684	0.0156
Error	707	2.6448	
R^2 0.32			
C.V. 21.5			

A9.1.4. Live body weight at 90 days of age (Weaning)

Source of variation	df	Mean Square	Pr > F
Breed	1	2.9572	0.3590
Sex	1	17.7254	0.0249
Birth type	1	621.8301	0.0001
Dam parity	1	206.5815	0.0001
Birth season	2	38.8815	0.0001
Sire (breed)	36	3.9533	0.2834
Breed x Birth season	2	19.8096	0.0037
Error	664	3.5092	
R^2 0.36			
C.V. 21.0			

A9.1.5 Live body weight at 120 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	0.1032	0.8704
Sex	1	27.5045	0.0079
Birth Type	1	455.6173	0.0001
Dam Parity	1	160.8132	0.0001
Birth season	2	67.5045	0.0001
Sire (Breed)	36	3.6717	0.5585
Breed x Birth season	2	25.9825	0.0013
Error	625	3.8741	
R^2 0.30			
C.V. 20.4			

A9.1.6 Live body weight at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	12.1724	0.1178
Sex	1	70.1576	0.0002
Birth type	1	369.8123	0.0001
Dam parity	1	161.4070	0.0001
Birth season	2	30.6119	0.0022
Sire (breed)	36	5.3828	0.3404
Breed x Birth season	2	20.3445	0.0170
Error	572	3.8741	
R^2 0.29			
C.V. 18.8			

Appendix 9.2: ANOVA table for preweaning and postweaning average daily weight gain (ADG) of Horro and Menz lambs to 180 days of age.

A9.2.1. Average daily weight gain between birth and 30 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	158.6076	0.6987
Sex	1	5037.3584	0.0294
Birth type	1	172754.5049	0.0001
Dam parity	1	53356.6974	0.0001
Birth season	2	9470.5966	0.0001
Sire (breed)	36	966.2831	0.6192
Breed x Birth season	2	4805.1000	0.0110
Error	753	1058.1478	
R^2 0.26 C.V. 32.7			

A9.2.2. Average daily weight gain between birth and 90 days of age (Weaning)

Source of variation	df	Mean Square	Pr > F
Breed	1	148.0944	0.5596
Sex	1	922.3679	0.1457
Birth type	1	54863.2253	0.0001
Dam parity	1	17650.4285	0.0001
Birth season	2	10491.3136	0.0001
Sire (breed)	36	538.4989	0.1625
Breed x Birth season	2	2263.2560	0.0057
Error	663	434.7242	
R^2 0.35 C.V. 26.8			

A9.2.3. Average daily weight gain between 90 and 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	0.0780	0.9841
Sex	1	1517.0873	0.0055
Birth type	1	145.7859	0.3883
Dam parity	1	46.2001	0.6272
Birth season	2	5927.0253	0.0001
Sire (breed)	36	251.4850	0.1266
Breed x Birth season	2	249.7787	0.2797
Error	572	195.6058	
R² 0.26			
C.V. 57.4			

Appendix 9.3: ANOVA table for growth performance of male Horro and Menz lambs from birth to one year of age.

A9.3.1. Birth weight

Source of Variation	df	Mean Square	Pr > F
Breed	1	4.5553	0.0001
Birth Type	1	20.3848	0.0001
Dam Parity	1	6.1089	0.0001
Birth season	2	0.2352	0.2743
Sire (Breed)	36	0.2750	0.0316
Breed x Birth Season	2	0.1235	0.5065
Error	385	0.1812	
R² 0.44			
C.V. 17.0			

A9.3.2. Live body weight at 30 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	3.4115	0.1251
Birth Type	1	161.5607	0.0001
Dam Parity	1	72.0465	0.0001
Birth season	2	14.6139	0.0001
Sire (Breed)	36	1.7902	0.1681
Breed x Birth Season	2	5.1874	0.0285
Error	364	1.4438	
R^2 0.39			
C.V. 21.4			

A9.3.3. Live body weight at 60 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.0208	0.9335
Birth Type	1	294.1015	0.0001
Dam Parity	1	67.9793	0.0001
Birth season	2	18.5871	0.0022
Sire (Breed)	36	2.9026	0.5174
Breed x Birth Season	2	9.9773	0.0365
Error	342	2.9838	
R^2 0.34			
C.V. 22.3			

A9.3.4. Live body weight at 90 days of age (Weaning)

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.2597	0.7957
Birth Type	1	350.7780	0.0001
Dam Parity	1	102.3814	0.0001
Birth season	2	30.1316	0.0005
Sire (Breed)	36	4.0868	0.3854
Breed x Birth Season	2	11.2556	0.0558
Error	321	3.8655	
R^2 0.39			
C.V. 21.6			

A9.3.5. Live body weight at 120 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.4029	0.7663
Birth Type	1	235.0801	0.0001
Dam Parity	1	80.6798	0.0001
Birth season	2	43.8822	0.0001
Sire (Breed)	36	4.7426	0.4090
Breed x Birth Season	2	13.3106	0.0553
Error	299	4.5524	
R^2 0.32			
C.V. 21.7			

A9.3.6. Live body weight at 150 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.0102	0.9632
Birth Type	1	220.7165	0.0001
Dam Parity	1	67.6152	0.0002
Birth season	2	36.0774	0.0006
Sire (Breed)	36	4.7399	0.4773
Breed x Birth Season	2	13.2543	0.0631
Error	282	4.7509	
R^2 0.34			
C.V. 19.8			

A9.3.7. Live body weight at 180 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.7555	0.7105
Birth Type	1	233.3257	0.0001
Dam Parity	1	76.8391	0.0002
Birth season	2	25.3568	0.0105
Sire (Breed)	36	4.9531	0.6253
Breed x Birth Season	2	14.9274	0.0671
Error	267	5.4704	
R^2 0.32			
C.V. 19.2			

A9.3.8 Live body weight at 210 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.3692	0.8031
Birth Type	1	227.5167	0.0001
Dam Parity	1	82.5494	0.0002
Birth season	2	213.1137	0.0001
Sire (Breed)	36	5.3931	0.6173
Breed x Birth Season	2	11.0448	0.1571
Error	249	5.9241	
R^2 0.47			
C.V. 18.3			

A9.3.9. Live body weight at 240 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.1977	0.8673
Birth Type	1	212.6541	0.0001
Dam Parity	1	78.0570	0.0010
Birth season	2	592.8021	0.0001
Sire (Breed)	36	9.6783	0.0916
Breed x Birth Season	2	20.5350	0.0567
Error	226	7.0662	
R^2 0.64			
C.V. 17.4			

A9.3.10. Live body weight at 270 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	1.0334	0.6849
Birth Type	1	212.4970	0.0001
Dam Parity	1	68.6771	0.0011
Birth season	2	766.7904	0.0001
Sire (Breed)	36	7.2730	0.2571
Breed x Birth Season	2	10.9517	0.1764
Error	215	6.2606	
R^2 0.71			
C.V. 15.4			

A9.3.11. Live body weight at 300 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	0.3390	0.8372
Birth Type	1	180.0984	0.0001
Dam Parity	1	34.3991	0.0396
Birth season	2	745.3745	0.0001
Sire (Breed)	36	6.6401	0.7411
Breed x Birth Season	2	19.9034	0.0860
Error	201	8.0133	
R^2 0.65			
C.V. 16.3			

A9.3.12. Live body weight at 330 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	51.8183	0.0186
Birth Type	1	253.0775	0.0001
Dam Parity	1	97.3402	0.0013
Birth season	2	767.8796	0.0001
Sire (Breed)	36	8.4261	0.6063
Breed x Birth Season	2	5.8455	0.5305
Error	191	9.1908	
R^2 0.66			
C.V. 15.2			

A9.3.13. Live body weight at 365 days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	44.1712	0.0388
Birth Type	1	186.3871	0.0001
Dam Parity	1	83.8077	0.0046
Birth season	2	900.8149	0.0001
Sire (Breed)	36	9.6729	0.5548
Breed x Birth Season	2	14.1748	0.2514
Error	178	10.1877	
R^2 0.66			
C.V. 15.3			

Appendix 9.4: ANOVA table for preweaning and postweaning average daily weight gain (ADG) of male Horro and Menz lambs to one year of age.

A9.4.1. Average daily weight gain between birth and 30 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	304.9490	0.6057
Birth type	1	92614.1440	0.0001
Dam parity	1	24529.9678	0.0001
Birth season	2	9333.1597	0.0003
Sire (breed)	36	1409.1668	0.1734
Breed x Birth season	2	7185.8765	0.0021
Error	364	1142.1511	
R² 0.31			
C.V. 33.0			

A9.4.2. Average daily weight gain between birth and 90 days of age (Weaning)

Source of variation	df	Mean Square	Pr > F
Breed	1	503.6516	0.3023
Birth type	1	29680.4870	0.0001
Dam parity	1	9564.9709	0.0001
Birth season	2	5181.8320	0.0001
Sire (breed)	36	527.7459	0.3010
Breed x Birth season	2	1145.5576	0.0899
Error	320	471.9098	
R² 0.37			
C.V. 27.5			

A9.4.3. Average daily weight gain between 90 and 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	8.5906	0.8356
Birth type	1	62.2241	0.5766
Dam parity	1	205.0141	0.3112
Birth season	2	4280.8940	0.0001
Sire (breed)	36	155.3700	0.8101
Breed x Birth season	2	36.1431	0.8341
Error	267	199.1464	
R² 0.32			
C.V. 54.0			

A9.4.4. Average daily weight gain between 180 and 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	0.2327	0.9734
Birth type	1	379.6498	0.1794
Dam parity	1	0.6829	0.9545
Birth season	2	57656.7586	0.0001
Sire (breed)	36	198.9508	0.5522
Breed x Birth season	2	136.0527	0.5229
Error	215	209.1997	
R² 0.81			
C.V. 36.3			

A9.4.5. Average daily weight gain between 270 and 365 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	1135.2220	0.0373
Birth type	1	52.0994	0.6536
Dam parity	1	0.0011	0.9983
Birth season	2	2062.0803	0.0005
Sire (breed)	36	304.7553	0.2411
Breed x Birth season	2	567.5686	0.1136
Error	178	257.7562	
R² 0.29			
C.V. 31.4			

A9.4.6. Average daily weight gain between birth and 365 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	217.8905	0.0844
Birth type	1	774.2239	0.0013
Dam parity	1	333.2472	0.0332
Birth season	2	5906.1776	0.0001
Sire (breed)	36	66.2086	0.6064
Breed x Birth season	2	75.3893	0.3548
Error	178	72.3387	
R^2 0.63			
C.V. 16.8			

Appendix 9.5: ANOVA table for body weight and linear body measurements of male Horro and Menz lambs at 180 days of age.

A9.5.1 Heart girth at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	59.5706	0.0309
Birth type	1	282.3305	0.0001
Dam parity	1	193.5450	0.0001
Birth season	2	104.6546	0.0003
Breed x Birth season	2	16.6919	0.2680
Error	188	12.5890	
R^2 0.25			
C.V. 6.7			

A9.5.2 Wither height at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	138.7744	0.0008
Birth type	1	329.8785	0.0001
Dam parity	1	157.8079	0.0004
Birth season	2	62.4452	0.0063
Breed x Birth season	2	26.5648	0.1117
Error	188	11.9797	
R^2 0.25			
C.V. 6.6			

A9.5.3 Body length at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	82.9263	0.0161
Birth type	1	205.6108	0.0002
Dam parity	1	163.8524	0.0008
Birth season	2	89.2473	0.0021
Breed x Birth season	2	22.6092	0.2029
Error	188	14.0534	
R^2 0.20			
C.V. 7.4			

A9.5.4 Tail length at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	3732.3316	0.0001
Birth type	1	30.6499	0.0846
Dam parity	1	84.0260	0.0046
Birth season	2	47.1740	0.0109
Breed x Birth season	2	38.0121	0.0258
Error	188	10.1941	
R^2 0.73			
C.V. 15.3			

A9.5.5 Tail width at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	25.2933	0.0004
Birth type	1	37.0007	0.0001
Dam parity	1	19.6518	0.0016
Birth season	2	19.1743	0.0001
Breed x Birth season	2	9.3345	0.0089
Error	188	1.9261	
R² 0.38			
C.V. 16.5			

A9.5.6 Tail circumference at 180 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	17.1735	0.0141
Birth type	1	28.4703	0.0017
Dam parity	1	6.9938	0.1156
Birth season	2	23.0979	0.0004
Breed x Birth season	2	6.5472	0.0992
Error	188	2.7982	
R² 0.26			
C.V. 16.8			

Appendix 9.6: ANOVA table for body weight and linear body measurements of male Horro and Menz lambs at 270 days of age.

A9.6.1 Heart girth at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	30.8582	0.1258
Birth type	1	368.1027	0.0001
Dam parity	1	207.8647	0.0001
Birth season	2	1277.3913	0.0001
Breed x Birth season	2	1.9898	0.8589
Error	249	13.0779	
R² 0.53			
C.V. 6.2			

A9.6.2 Wither height at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	717.7897	0.0001
Birth type	1	301.2173	0.0001
Dam parity	1	185.9625	0.0001
Birth season	2	704.2383	0.0001
Breed x Birth season	2	44.3206	0.0182
Error	249	10.8916	
R² 0.53			
C.V. 5.8			

A9.6.3 Body length at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	184.9449	0.0030
Birth type	1	211.8579	0.0015
Dam parity	1	117.4482	0.0175
Birth season	2	849.7901	0.0001
Breed x Birth season	2	9.8421	0.6198
Error	249	20.5360	
R² 0.33			
C.V. 8.2			

A9.6.4 Tail length at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	8332.8297	0.0001
Birth type	1	3.5336	0.6280
Dam parity	1	46.4851	0797
Birth season	2	395.8410	0.0001
Breed x Birth season	2	49.2783	0.0392
Error	249	15.0129	
R² 0.73			
C.V. 16.3			

A9.6.5 Tail width at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	3.4842	0.3345
Birth type	1	12.2492	0710
Dam parity	1	26.1793	0.0086
Birth season	2	390.1187	0.0001
Breed x Birth season	2	5.7573	0.2154
Error	249	3.7267	
R² 0.54 C.V. 17.8			

A9.6.6 Tail circumference at 270 days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	59.3280	0.0008
Birth type	1	59.9368	0.0008
Dam parity	1	20.3200	0.0484
Birth season	2	559.3630	0.0001
Breed x Birth season	2	0.6301	0.8852
Error	249	5.1653	
R² 0.53 C.V. 17.3			

Appendix 9.7: ANOVA tables for body weight and linear body measurements of male Horro and Menz lambs at 365 days of age.

A9.7.1 Heart girth at 365days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	26.3409	0.1569
Birth type	1	2293.6089	0.0001
Dam parity	1	225.0636	0.0001
Birth season	2	781.9826	0.0001
Breed x Birth season	2	12.9145	0.3735
Error	213	13.0516	
R² 0.44 C.V. 5.8			

A9.7.2 Wither height at 365days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	471.2646	0.0001
Birth type	1	199.0512	0.0001
Dam parity	1	105.4331	0.0021
Birth season	2	434.2610	0.0001
Breed x Birth season	2	3.2144	0.7444
Error	213	10.8746	
R² 0.44			
C.V. 5.4			

A9.7.3 Body length at 365days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	374.9267	0.0001
Birth type	1	243.1353	0.0010
Dam parity	1	67.4881	0.0812
Birth season	2	1068.9806	0.0001
Breed x Birth season	2	20.5839	0.3936
Error	213	21.9806	
R² 0.40			
C.V. 7.9			

A9.7.4 Tail length at 365days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	8567.3495	0.0001
Birth type	1	3.2075	0.6821
Dam parity	1	29.4522	0.2152
Birth season	2	346.7619	0.0001
Breed x Birth season	2	109.4727	0.0037
Error	213	19.0613	
R² 0.71			
C.V. 16.7			

A9.7.5 Tail width at 365days of age

Source of Variation	df	Mean Square	Pr > F
Breed	1	1.2211	0.6081
Birth type	1	29.1503	0.0128
Dam parity	1	4.7730	0.3111
Birth season	2	183.4849	0.0001
Breed x Birth season	2	11.7132	0.0820
Error	213	4.6297	
R^2 0.32			
C.V. 16.9			

A9.7.6 Tail circumference at 365days of age

Source of variation	df	Mean Square	Pr > F
Breed	1	2.5907	0.4866
Birth type	1	29.1559	0.0203
Dam parity	1	6.5426	0.2693
Birth season	2	191.8948	0.0001
Breed x Birth season	2	6.2218	0.3135
Error	213	5.3341	
R^2 0.28			
C.V. 15.1			

Appendix 9.8: Maximum-Likelihood analysis of variance table for survival rates at various ages

A9.8.1. ANOVA table for survival at 15 days of age

Sources of variation	df	Chi-Square	Probability
Intercept	1	210.73	0.000
Breed	1	3.64	0.0564
Sex	1	1.46	0.2270
Birth type	1	15.21	0.0001
Dam parity	1	10.03	0.0015
Birth season	2	10.05	0.0066
Likelihood ratio	39	37.61	0.5331

A9.8.2. ANOVA table for survival at 30 days of age

Sources of Variation	df	Chi-Square	Probability
Intercept	1	233.13	0.000
Breed	1	5.72	0.0167
Sex	1	2.64	0.1043
Birth type	1	15.67	0.0001
Dam parity	1	9.36	0.0022
Birth season	2	9.29	0.0096
Likelihood ratio	39	35.74	0.6195

A9.8.3. ANOVA table for survival at 90 days of age

Sources of variation	df	Chi-Square	Probability
Intercept	1	165.09	0.000
Breed	1	20.37	0.000
Sex	1	1.29	0.2565
Birth type	1	36.43	0.000
Dam parity	1	23.67	0.000
Birth season	2	82.60	0.000
Likelihood ratio	39	34.16	0.6900

A9.8.4. ANOVA table for survival at 180 days of age

Sources of variation	df	Chi-Square	Probability
Intercept	1	52.22	0.000
Breed	1	59.07	0.000
Sex	1	0.67	0.4113
Birth type	1	54.28	0.000
Dam parity	1	19.04	0.000
Birth season	2	59.35	0.000
Likelihood Ratio	39	32.02	0.7784

A9.8.5. ANOVA table for survival at 270 days of age

Sources of variation	df	Chi-Square	Probability
Intercept	1	6.26	0.0123
Breed	1	65.19	0.000
Sex	1	11.61	0.0007
Birth type	1	60.81	0.000
Dam parity	1	18.01	0.000
Birth season	2	31.03	0.000
Likelihood ratio	39	52.34	0.0750

A9.8.6. ANOVA table for survival at 365 days of age

Sources of variation	df	Chi-Square	Probability
Intercept	1	0.01	0.9359
Breed	1	42.81	0.000
Sex	1	22.88	0.000
Birth type	1	41.33	0.000
Dam parity	1	12.50	0.0004
Birth season	2	34.45	0.000
Likelihood ratio	39	41.88	0.3470

Appendix 9.9: ANOVA tables for fattening and carcass performance of male Horro and Menz lambs at 365 days of age.

A9.9.1. Initial body weight at the start of fattening experiment

Source of variation	df	Mean Square	Pr > F
Breed	1	44.3475	0.0590
Sire (breed)	16	13.5547	0.3424
Error	39	11.7169	
R^2 0.36 C.V. 12.5			

A9.9.2. Final body weight at the end of fattening experiment

Source of variation	df	Mean Square	Pr > F
Breed	1	55.7376	0.0166
Sire (breed)	16	16.3696	0.0603
Error	39	8.8891	
R^2 0.49			
C.V. 9.0			

A9.9.3. Overall average daily weight gain (ADG) during the fattening experiment

Source of variation	df	Mean Square	Pr > F
Breed	1	42.9543	0.6805
Sire (breed)	16	540.8679	0.0248
Error	39	249.6261	
R^2 0.47			
C.V. 34.3			

A9.9.4. Slaughter (fasted) weight taken shortly before slaughtering

Source of variation	df	Mean Square	Pr > F
Breed	1	58.1021	0.0172
Sire (breed)	16	13.9594	0.1543
Error	39	9.3883	
R^2 0.44			
C.V. 10.3			

A9.9.5. Empty fresh body weight taken at slaughter

Source of variation	df	Mean Square	Pr > F
Breed	1	11.0226	0.1977
Sire (breed)	16	8.0444	0.2745
Error	39	6.4185	
R^2 0.36			
C.V. 10.8			

A9.9.6. Hot carcass weight taken shortly after slaughter

Source of variation	df	Mean Square	Pr > F
Breed	1	5.5184	0.1093
Sire (breed)	16	3.2571	0.1195
Error	39	2.0542	
R² 0.42			
C.V. 9.9			

A9.9.7. Cold carcass weight taken after cold storage for 24 hours

Source of variation	df	Mean Square	Pr > F
Breed	1	3.9694	0.1704
Sire (breed)	16	3.0879	0.1425
Error	39	2.0344	
R² 0.41			
C.V. 10.3			

A9.9.8. Dressing % based on hot carcass weight

Source of variation	df	Mean Square	Pr > F
Breed	1	16.2251	0.2038
Sire (breed)	16	7.5704	0.6759
Error	39	9.9663	
R² 0.27			
C.V. 6.4			

A9.9.9. Gut fat

Source of variation	df	Mean Square	Pr > F
Breed	1	9991.8750	0.1436
Sire (breed)	16	21979.1630	0.0001
Error	39	4569.5330	
R² 0.68			
C.V. 40.9			

A9.9.10. Kidney fat

Source of variation	df	Mean Square	Pr > F
Breed	1	2553.5569	0.1657
Sire (breed)	16	2490.8915	0.0454
Error	39	1279.8272	
R^2 0.46			
C.V. 35.7			

A9.9.11. Ether extract estimate (g)for whole gastrointestinal tract

Source of variation	df	Mean Square	Pr > F
Breed	1	29195.5721	0.1476
Sire (breed)	16	22263.7108	0.0971
Error	39	13375.4202	
R^2 0.44			
C.V. 35.5			

A9.9.12. Ether extract estimate (g)for gut fat

Source of variation	df	Mean Square	Pr > F
Breed	1	16447.7633	0.0568
Sire (breed)	16	20031.8703	0.0001
Error	39	4267.3860	
R^2 0.67			
C.V. 53.1			

A9.9.13. Ether extract estimate (g)for renal fat

Source of variation	df	Mean Square	Pr > F
Breed	1	2839.7078	0.0468
Sire (breed)	16	1272.2930	0.0530
Error	39	673.3917	
R^2 0.48			
C.V. 49.2			

A9.9.14. Ether extract estimate (g)for whole carcass lean

Source of variation	df	Mean Square	Pr > F
Breed	1	125739.6411	0.0176
Sire (breed)	16	18725.8287	0.5590
Error	39	20457.3948	
R² 0.36			
C.V. 31.0			

A9.9.15. Ether extract estimate (g)for rump fat

Source of variation	df	Mean Square	Pr > F
Breed	1	3907.9624	0.4515
Sire (breed)	16	3942.7418	0.8770
Error	38	6755.9253	
R² 0.21			
C.V. 64.2			

A9.9.16. Ether extract estimate (g)for tail fat

Source of variation	df	Mean Square	Pr > F
Breed	1	16120.9483	0.4207
Sire (breed)	16	39005.0002	0.1143
Error	39	24341.2440	
R² 0.40			
C.V. 21.4			

A9.9.17. Ether extract estimate (g)for subcutaneous fat

Source of variation	df	Mean Square	Pr > F
Breed	1	220120.4807	0.1424
Sire (breed)	16	1188941.2814	0.3028
Error	39	98212.2599	
R² 0.36			
C.V. 34.4			

A9.9.18. Ether extract estimate (g)for Urogenital fat

Source of variation	df	Mean Square	Pr > F
Breed	1	80.4208	0.7406
Sire (breed)	16	924.5641	0.2589
Error	39	723.4034	
R^2 0.34			
C.V. 62.1			

A9.9.19. Ether extract estimate (g)for sundry trimming

Source of variation	df	Mean Square	Pr > F
Breed	1	5880.7409	0.3203
Sire (breed)	16	10115.0954	0.1040
Error	39	5804.0613	
R^2 0.41			
C.V. 75.6			

A9.9.20. Ether extract estimate (g)for whole carcass

Source of variation	df	Mean Square	Pr > F
Breed	1	168464.3519	0.0202
Sire (breed)	16	524078.3732	0.0632
Error	39	287226.2221	
R^2 0.48			
C.V. 18.6			

A9.9.21. Lean ether extract (g) on dry matter basis

Source of variation	df	Mean Square	Pr > F
Breed	1	125739.6411	0.0176
Sire (breed)	16	18725.8287	0.5590
Error	39	20457.3948	
R^2 0.43			
C.V. 23.9			

A9.9.22. Lean ether extract % on dry matter basis

Source of variation	df	Mean Square	Pr > F
Breed	1	248.0957	0.0025
Sire (breed)	16	28.3204	0.3197
Error	39	23.8521	
R² 0.43			
C.V. 23.9			

A9.9.23. Estimated lean : bon ratio of whole carcass

Source of variation	df	Mean Square	Pr > F
Breed	1	0.4152	0.0503
Sire (breed)	16	0.0796	0.6952
Error	39	0.1017	
R² 0.32			
C.V. 11.4			

A9.9.24. Estimated lean : fat ratio of whole carcass

Source of variation	df	Mean Square	Pr > F
Breed	1	1.0266	0.1661
Sire (breed)	16	0.5488	4178
Error	39	0.5155	
R² 0.32			
C.V. 22.3			

A9.9.25. Estimated total carcass bone

Source of variation	df	Mean Square	Pr > F
Breed	1	1307693.0951	0.0037
Sire (breed)	16	184564.9276	0.2190
Error	39	136997.5608	
R² 0.46			
C.V. 11.7			

A9.9.26. Gastro-intestinal-tract weight as % of the slaughter weight

Source of variation	df	Mean Square	Pr > F
Breed	1	89.2400	0.0004
Sire (breed)	16	6.1151	0.4579
Error	39	5.9948	
R² 0.45			
C.V. 11.5			

A9.9.27. Gastro-intestinal-tract content as % of the slaughter weight

Source of vVariation	df	Mean Square	Pr > F
Breed	1	63.5714	0.0022
Sire (breed)	16	5.2984	0.5766
Error	39	5.9009	
R² 0.39			
C.V. 17.1			

Erklärung

Ich erkläre hiermit, daß mir die geltenden Promotionsordnung der Humboldt-Universität zu Berlin (vom 16. August 1994) bekannt ist.

Kassahun Awgichew

(Promotionskandidat)

Berlin den 6. 11. 2000