ON-FARM STUDY OF THE GROWTH PERFORMANCE OF TOGGENBURG GOAT AND ITS CROSSES WITH THE SMALL EAST AFRICAN GOAT IN MOUNT ELGON AREA OF UGANDA.

BY

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APRIL 2008
DECLARATION

I Kauta Moses do hereby declare that this Dissertation is by my self and has never been submitted for the award of an MSc. Degree in any University.

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   ii
DEDICATION

This dissertation is dedicated to the Lord my Savior, who rescued me from the claws of Satan and delivered me with certainty to this level as was prophesized by Pastor, Rev. Stephen Okia. For the prophesy of God will always come to pass. Be exalted oh! My Lord Jesus.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>iv</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>ABBREVIATIONS AND ACRONYMS</td>
<td>ix</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>x</td>
</tr>
<tr>
<td>CHAPTER ONE</td>
<td>1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1. Background of study</td>
<td>1</td>
</tr>
<tr>
<td>1.2  Problem statement and justification</td>
<td>2</td>
</tr>
<tr>
<td>1.3  Objective</td>
<td>4</td>
</tr>
<tr>
<td>1.4  Hypothesis</td>
<td>4</td>
</tr>
<tr>
<td>CHAPTER TWO</td>
<td>5</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>5</td>
</tr>
<tr>
<td>2.1  Description of the goat breeds</td>
<td>5</td>
</tr>
<tr>
<td>2.1.1 The Small East African goats (SEA)</td>
<td>5</td>
</tr>
<tr>
<td>2.1.2 The Toggenburg</td>
<td>7</td>
</tr>
<tr>
<td>2.2  Production management systems of goats</td>
<td>8</td>
</tr>
<tr>
<td>2.2.1 Tethering system</td>
<td>8</td>
</tr>
<tr>
<td>2.2.2 Open grazing</td>
<td>9</td>
</tr>
<tr>
<td>2.2.3 Semi-intensive management system</td>
<td>9</td>
</tr>
<tr>
<td>2.2.4 Zero grazing</td>
<td>9</td>
</tr>
<tr>
<td>2.3  Goat breeding and selection</td>
<td>10</td>
</tr>
<tr>
<td>2.3.1 Breeding management system</td>
<td>10</td>
</tr>
<tr>
<td>2.3.1.1 Individual based</td>
<td>10</td>
</tr>
<tr>
<td>2.3.1.2 Community based initiatives</td>
<td>11</td>
</tr>
<tr>
<td>2.3.1.3 Institutional based approach</td>
<td>11</td>
</tr>
<tr>
<td>2.3.2 Cross breeding</td>
<td>13</td>
</tr>
<tr>
<td>2.3.3 Introduction of exotic goats and cross breeding</td>
<td>16</td>
</tr>
<tr>
<td>2.3.4 Potential of indigenous goats for genetic improvement through selection</td>
<td>17</td>
</tr>
<tr>
<td>2.3.5 Growth performance as basis for selection</td>
<td>19</td>
</tr>
<tr>
<td>2.3.6 Castration</td>
<td>21</td>
</tr>
<tr>
<td>2.3.7 Application of performance in genetic improvement</td>
<td>22</td>
</tr>
<tr>
<td>2.3.8 Prediction of breeding values</td>
<td>27</td>
</tr>
<tr>
<td>2.3.9 Open nucleus breeding schemes</td>
<td>27</td>
</tr>
<tr>
<td>2.3.10 Udder size and milk yield</td>
<td>30</td>
</tr>
<tr>
<td>2.3.11 Milk requirements for kids</td>
<td>30</td>
</tr>
</tbody>
</table>
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study area description
3.2 Study design
3.3 Husbandry practices
  3.3.1 Feeding management
  3.3.2 Housing management
  3.3.3 Breeding (mating) management
3.4 Data collection and recording
3.5 Data analysis and interpretation

CHAPTER FOUR
RESULTS

4.1 Effect of the different husbandry practices on the growth performance
4.2 The effect of genotype on growth performance.
4.3 (i) Effects of sex on the growth performance of pure Toggenburg
4.3 (ii) Effect of sex on the 75% Toggenburg crosses
4.4 Effect of litter size on the growth performance
4.5 Effect of disease management on the growth performance
4.6 Effect of season on the growth performance of Toggenburg and its crosses with the SEA.

CHAPTER FIVE
DISCUSSION

5.1 Effect of husbandry practices on growth performance
5.2 The effect of genotype on growth performance
5.3 Effect of sex on the growth performance of Toggenburg crosses
5.4 Effect of litter size on the growth performance
5.5 Disease management
5.6 Effect of season on growth performance of Toggenburg crosses with Small East African goats.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions
6.2 Recommendations
6.3 Areas for further research

REFERENCES

APPENDIXES

Appendix I: Data report cards
Appendix II: Map showing the geographical Study Area
Appendix III: Map of Mbale district showing the study area
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1: Showing the effect husbandry practices on live body weights</td>
<td>45</td>
</tr>
<tr>
<td>Figure 2: Showing the effect of genotype on live body weight</td>
<td>48</td>
</tr>
<tr>
<td>Figure 3: (i) Showing the effect of sex on pure Toggenburg</td>
<td>50</td>
</tr>
<tr>
<td>(ii) Showing the effect of sex on 75% Toggenburg</td>
<td>52</td>
</tr>
<tr>
<td>Figure 4: Showing the effect of litter size on live body weight</td>
<td>53</td>
</tr>
<tr>
<td>Figure 5: Showing the effect of disease management on live body weight</td>
<td>56</td>
</tr>
<tr>
<td>Figure 6: Showing the effect of season on live body weight</td>
<td>58</td>
</tr>
</tbody>
</table>
ABBREVIATIONS AND ACRONYMS

CT       Condensed Tannins
et al.    And Others
FAO      Food and Agriculture Organisation
FARM-Africa   Food and Research Management in Africa
F1       Fillial one Generation
GIT      Gastro Intestinal Truct
HIV/AIDS Human Immune Virus /Acquired Immune Deficiency Syndrome
Mt.      Mountain
SEA      Small East African Goat
SPSS     Scientific Package for Social Scientists
TTXSEA   Toggenburg Crosses with the Small East African Goat
ABSTRACT

Dairy goat production is considered one of the viable enterprises in poverty reduction and in the improvement of the health and nutrition of the rural poor. Pure exotic dairy goats such as the Toggenburg from the temperate regions have been imported into Uganda to improve milk production, but have not performed well to their production potential due to adverse local environment. An on-farm study was carried out in the Mt. Elgon area to establish the growth performance of the pure Toggenburg and its crosses with the local small East African goats under different husbandry regimes. It was found that good husbandry practices such as good nutrition, housing and disease control enhanced growth rates of the pure Toggenburg and its crosses. The SEA had a higher mean weight of 6.9 kg within the first 30 days of birth but was overtaken by the pure Toggenburg with 10.3 kg by day 6 up day 210 with 21.8 kg. The 75%5 toggenburg crosses steadily increased in weight gains to lead by day 240 with 25.5 kg ahead of F1s with 16.5 kg. It was also found that single kids had higher body weight gains than twins and triplets respectively, and females under all management practices had higher mean body weight gains and growth rates than males. Season affected the growth performances with goats having higher body weight gains in the wet season than in the dry season. The study concluded that good husbandry practices i.e. good housing, proper disease control and good nutrition were vital for the productive performances of the pure Toggenburg and its crosses with the SEA in the Mt. Elgon area.

It was recommended that cross breeding programme of the pure Toggenburg and the Small East African goats to obtain 75% stabilized crosses should be encouraged. Farmers should be sensitized and encouraged to adopt good husbandry practices (good housing, good nutrition and health care) for their goat
CHAPTER ONE
INTRODUCTION

1.1. Background of study

Uganda has a very high population growth rate of 3.5%, which in turn has exerted pressure on the limited food reserve to feed the population. The situation has been exacerbated by the HIV/AIDS pandemic, which still poses a great threat to the active working people, engaged in food production. Although once neglected, goats are considered the best animals to rear in meeting the ever-great demands of food to feed the population; especially in the provision of animal protein. Goats have advantages over other domestic livestock in that they are easier to raise, requiring less capital and are efficient producers of meat, milk and fiber (Gall, 1996).

One of the major challenges facing the government of Uganda, and other development partners is how to improve the quality of life of the rural poor and fight poverty. FARM-Africa, based in Mbale is one such institution committed to face the challenges of alleviating poverty among the rural community.

FARM-Africa promotes dairy goat rearing by using the pure Toggenburg to upgrade the local small East African goats for increased milk production. FARM-Africa realized that traditional husbandry system produced hardy
animals by natural selection whose potentials have not yet been exploited. However, within this husbandry system, the Toggenburg goats (which are of the temperate origin) cannot perform well.

Aware of this reality, FARM-Africa has made a systematic exploitation of indigenous resources, which serves as a good entry point. Selection of well adapted indigenous goats such as the Small East African goats is imperative so that their adaptation to parasitic infestation, nutritional and climatic stress can be fully exploited. This is then followed by education in modern husbandry practices. After farmers have built capacity in goat rearing or skills and techniques in goat management, group dynamics and leadership, suitable pure exotic dairy Toggenburg goats are given to them to keep while the pure male Toggenburg bucks are used to upgrade the local goats for breed genetic improvement.

1.2 Problem statement and justification
The true performance of indigenous, exotic and cross bred goats under the common and natural production environment and management conditions in Mt Elgon area is unknown. Absence of this information is largely due to lack of on-farm studies, absence of on-farm records and general lack of knowledge in modern management practices by the farming community (Kauta, 2005). An assessment of performance of the pure Toggenburg, its crosses with the Small East African goat under on farm production environment provides material in
Form of performance characteristics that are needed for selection of the stabilized 75% crosses needed in a breeding plan for practical genetic improvement of goat productivity by FARM-Africa.

Concrete data on the performance of exotic and crossbred goats resulting from the introduction of high grade Toggenburgs in the low input small holder farming system of Mt. Elgon is still lacking.

Lack of information on the performance of the goats under on-farm conditions in the different genotype in the project area has made it difficult to compare performance between population and individual within the genotypes (breeds). This has limited the identification and selection of suitable individuals for superior or elite performing in breed improvement programme. There is therefore need to obtain the mean population phenotypic values for performance traits under the real on-farm conditions in which the goats are managed in order to characterize them. Such information is also necessary for simulation of breeding plans for practical application in the real conditions.

The on farm study results on the performance of the Toggenburg and its crosses with SEA in Mt Elgon area will establish phenotypic values upon which selection of the elite and stabilized 75% genotype goats will be based, which result will enhance knowledge of the farmers on the relationship between the goat performance and management practices. It will also
generate information vital for developing appropriate breeding plan and policies by FARM-Africa of suitable selection strategies for management of goat productivity in the country. This will enable FARM-Africa produce many goats for their farmers who need them very badly.

1.3 Objective

The general objective of the study was to establish the growth performance of the pure Toggenburg offsprings and its crosses with the Small East African goats under on-farm conditions in Mt Elgon area.

The specific objectives were:

- To establish the growth performance of the pure Toggenburg and its crosses (F1s and 75%) with the Small East African goats under different management regimes
- To evaluate the management systems and their effects on the growth performance of the pure Toggenburg and its crosses with the Small East African goats.

1.4. Hypothesis

Management practices do not affect the growth performance of the pure Toggenburg goat and its crosses with the SEA.
CHAPTER TWO

REVIEW OF LITERATURE

2.1 Description of the goat breeds

2.1.1 The Small East African goats (SEA)

The Small East African goat is the most widely distributed breed in Uganda (NARO-ILRI, SRNE; 1996) and is predominately found in the Eastern and Northern areas of Uganda including Soroti, Kumi, Mbale, Sironko, Pallisa, Manafwa and Lira. It has various colour mixtures of white, black and brown with adults weighing from 20-25kg (Nsubuga, 1996). It is the smallest of the indigenous breeds in Uganda without or with little genetic improvement in any specific sphere. It is well adapted to the hot tropical climatic conditions. It makes up 53.2% of the indigenous goat populations in Uganda with Mubende 35.6% and Kigezi 11.2% (CMS/GAF, 1999).

Estimates of genetic parameters point to considerable genetic variations within indigenous population. This indicates the potential for genetic improvements through selections. There has been a tendency to over emphasize the low productivity of the indigenous SEA without consideration of some important characteristics of the breed when the small size of this breed and the harsh environmental conditions under which it is raised are taken into consideration, which make their productivity impressive. Comparative studies of indigenous and exotic breeds to determine the feed
utilization efficiency have not been conclusive. However, it is known that breeds with high maintenance requirements tend to lose weight and have the highest mortality rates under stress conditions such as drought (Frisch, 1984).

Most breed comparison studies have concentrated on quantifying performances (like live weights and milk production) but not inputs. The high performing temperate breeds cannot survive under traditional management in most African environments. Although, the performance of indigenous breeds under improved management has not been adequately assessed, there are indications that they respond to improved husbandry and this was the basis of this research on growth performance. The ability to survive under adverse environmental conditions with low inputs makes indigenous breeds a low risk choice. The low risk factor resistant breed is important where market prices are unstable or where the probability of death from environmental stress is high (Frisch, 1984).

In some cases low productivity is an adaptive mechanism for instance delayed age at first parturition and extended kidding interval in semi-arid environments are mechanisms for coping up with seasonal and often unreliable feed availability. In such cases, some flock owners deliberately delay first breeding (Wilson, et al., 1984). Poor nutrition increases the animal’s susceptibility to diseases.
Animals such as the SEA, that have low maintenance requirements and has the ability to make efficient use of poor quality forages, are therefore up for an assessment in terms of growth performance, together with an exotic Toggenburg and its crosses in the tropical environment, taking into account the input costs and product prices. The strategy, being cross breeding to take advantage of breed complementarily and or upgrading to allow gradual improvement in husbandry.

2.1.2 The Toggenburg

The British Toggenburg is one of the exotic dairy breeds that have been imported to Uganda for milk production. It originates from the Ober Toggenburg valley of Switzerland. The British Toggenburg has undergone genetic improvement in Britain with a higher milk production of up to 4.5kg per day under the temperate management conditions. The Toggenburg is a Swiss dairy goat that is also accredited as being the oldest known dairy goat breed. This breed is medium size, sturdy, vigorous and alert in appearance. Slightly smaller than the other dairy breeds, it does weigh about 55kg.

The hair is short or medium in length, soft, fine and lying flat. It grows a shaggier coat than other dairy goat breeds. Its colour is solid varying from light fawn to dark chocolate with dark spot in the middle; two white stripes down the face from above each eye to the muzzle; hind legs white from hocks to hooves; forelegs white from knees downward with a dark hair (band) below knee is acceptable; a white triangle on either side of the tail; white spot may
be present at root of wattles or in that area if no wattles are present. Varying degrees of cream markings instead of pure white is acceptable but not desirable. The ears are erect and carried forward, facial lines are white and the nose may be dished or straight, never Roman.

2.2 Production management systems of goats

In heavily cropped areas of Eastern Uganda, goats are kept in small flocks, under semi-intensive husbandry. They are tethered during the day and housed at night. In lightly cropped areas of Northern Uganda, goats may be grazed. Grazing is mainly attended by children and women, but sometimes by village herdsmen, (Dungu, 2001).

2.2.1 Tethering system

Sheep and goats are tethered using ropes of about 3m long on grass close to the homesteads. They may be shifted to new sites during the day. They are sometimes given feed supplements that include crop residues; notably banana peelings and sweet potato vines.

Tethering is associated with limited household labour (women and children) that is shared between crops and livestock. Hence, farmers rarely tether more than 5 goats per households. Animals are tethered to prevent them from destroying crops (Dungu, 2001).
2.2.2. Open grazing

Under this system, goats are allowed to graze or browse freely on uncultivated land or crop residues. The practice is limited to places where crop production is not important or in season when crops are out of production (Dungu, 2001).

2.2.3 Semi-intensive management system

This is a combined management system where goats are either tethered or grazed openly on some parts of the day and some , cut and carry feed is provided in some part of the day. It gives the goat chance to access natural vegetation (pasture and browse) and they may have plenty of choice. Herding protects them from wild animals and bad environment. Farmers also get time to do other husbandry activities, such as control of breeding and health management is made possible (Imaikorit, 2006).

2.2.4 Zero grazing

This involves keeping goats inside the house while feed is given to them there. The system is suitable for a few goats (3-10). It is a system for dairy goats' management that is especially good for highland areas like that of mountain Elgon where there is shortage of land (less than 1 acre) per household. The fodder can be grown or cut from the communal areas or fallow lands. Goats are usually fed on tree leaves and forbs besides the legume
pasture mixtures. Available literature shows that browse, as a feed is very important in goat nutrition and health.

In this system, goats are protected from bad environment, thieves and wild animals. The farmer can also get time to do other activities at the farm especially where crop production takes precedence. Controlled breeding and health management is also made possible (Imaikorit, 2006).

2.3 Goat breeding and selection

The genetic potential under optimal management for growth intensity and reproduction capacity is a valuable indicator of expected performance of animals. This potential is low in the indigenous goats as compared to that of the exotic temperate breeds under uniform on-station improved managed environment.

2.3.1 Breeding management system

There are many breeding management systems. Viz;

2.3.1.1 Individual based

Individual farmers are given or purchase dairy goats to keep and multiply for sale or pay back if these animals were given on an in-trust scheme.
2.3.1.2 **Community based initiatives**

This scheme aims at increasing the genetic productivity of the animals using the immediate stakeholders that is the small-scale poor resource livestock keepers as the main players in the programme.

2.3.1.3 **Institutional based approach**

In the absence of efficient private sector, government farms, livestock research centers/institutes, training institutes and universities embark on multiplications of dairy and meat goats.

For instance FARM-Africa introduced the Toggenburg goats for crossing with the SEA goat in Mt. Elgon area in 2003. In many situations the ideal producing milk goat is some intermediate between a tropical adapted and an improved temperate breed when intensively managed in the humid tropics (FAO, 1982). This intermediate goat can most easily be formed by cross breeding. When it has been established that in a given environment (including climate, disease situation, feeding and management systems) the most productive animal is one containing a proportion of local blood and a portion of imported genes, then an appropriate system must be chosen which will maintain its immediate type after the initial crossing, (FAO, 1982).

In the formation of a new breed, also called the formation of a gene pool, the 100% pure breed are mated to produce the first cross offspring (F1s) which
are mated back together to form F2 followed by F3, and so on. If the desired proportion of European blood is 75% the back cross is made before this mating starts. The advantage of this gene pool approach is that the population is self-replacing and after the initial crossing, no further outside blood is needed, (FAO, 1982).

However, breed improvement through selection consists of choosing the parents of the next generation so that they excel their parents’ generation in the average production characteristics (Falconer, 1989; Legates et al., 1990; Jindal, 1984). Selection can be based on pedigree, history or records, actual measurements on the individuals or on the progeny test. Measurements in individual animals in terms of body weight and linear body measurements such as heart girth, body length and height at withers have been used in many studies in characterizing body size among goat populations (Manson and Maule, 1960; Devendra and Burns, 1983; Oluka et al., 2004; Oluka, 1998; Oluka et al., 1999; Madubi et al., 1996; Katongole et al., 1985; Das et al., 1996.)

However, lack of pedigree records or reliance on history from farmer respondents and application of cumbersome measurements using weighing equipment have all very limited field applicability for mass selection. These limitations have been circumvented by using heart girth as indirect measurement of live body weights in selecting for large body size among Mubende goats (Oluka, 1998; Peacock, 1996). Among the various linear
measurements, the heart girth was found to be highly correlated to live body weight (Oluka et al. 1999; Jindal, 1984; Mejia and Casillo, 1991; Mourand and Anous, 1991; Worman et al., 1990). Body weight of pregnant females was however, found to be influenced by the pregnancy status (Ruvuna et al, 1991; Oluka, 1998).

2.3.2 Cross breeding

In goats, this is done to increase on milk production and body size in tropical Africa. Mishra, et al. (1976) calculated heterosis for Alpine and Beetal Cross breeds and obtained the following figures; age at first kidding:- 12.33%; dry period 12.09%. Negative heterosis for milk yield appears to have affected the Angora and Gaddit cross breeds (Pant, 1969). Adverse environmental conditions can easily obscure potential heterosis, as they may affect cross breeds more than the local parental types. This explains the negative heterosis for milk yield.

Ranah (1980) concluded that, on the basis of relative economic efficiency, the 50% French Alpine and 50% Beetal was the best genotype for the environmental conditions at Hissar, Northern India. Possibly the Toggenburg and SEA crosses can follow suit.
De Haas, (1978) reported the results of crossing the Boer goats with the SEA goats in Kenya, that the average daily weight gains were 32g for the local kids and 62g for cross breeds.

Nsubuga, (1996) carried out research on Boer goats and their crosses with the SEA and found that the crosses had a higher growth rate than either of the two parents.

In Cyprus, a long term plan to improve productivity of local goats was undertaken, just like FARM Africa, has been successful on a national scale. It was based on upgrading selected Damascus goats bred from carefully recorded stock at government stations. Imported Damascus goats were subjected to strict selection for production characteristics such as milk yield, prolificacy and the growth rates and the elite herds thus established were used to supply males of superior genetic potential for use by commercial farmers, usually on loan over 20 years. About 50% of the goats in Cyprus have been upgraded to the Damascus breed and their productivity greatly exceeds that of the unimproved cyprus goats. This appears to be the most successful reported attempt to improve the genetic potential of a national goat herd and involved long term scientific selection of the "improver" breed with coordinated veterinary and extension work (Louca, 1981; Constantinou, 1987). Louca and Hancock (1977) reported that genotype and environment
interaction for post weaning growth rate were not significant in the Damascus breed in Cyprus, and should not constitute a handicap to selection.

A totally unsuccessful attempt to improve milk yield in a herd of Barbari goats is described by Sukhatme (1945). The paper is valuable in emphasizing the fertility of long term experiments based on foundation stock inadequate in numbers and in genetic variability and potential. If a survey of the local breed reveals no individuals of exceptionally high productivity in the respect required, the necessary genetic potential should be introduced by cross breeding. The follow up of the growth rate of Toggenburg and its crosses in Farm Africa operational area was thus necessary to set the performance potentials.

The most successful results have been obtained by the infusion of blood of improved tropical breeds. Above all the Jamnapari from India has been used to improve milk yield and size (and hence meat production) in several countries in South East Asia. In Malaysia and Indonesia the majority of goats now show evidence of Jamnapari blood in their size and lop ears as well, as their milk production. The Jamnapari has also been used in the West Indies. The Anglo-Nubian has been used in the upgrading of indigenous stock in the West Indies, Mauritius, Malaysia and the Philippines (Devendra & Burns, 1982)
The Bhuj (from Gujarat, India) has been used to cross goats in the north east part of Brazil and it is now of great influence there. However, it has not been proved that its economic return is better, considering the reduced hardness that accompanies the crossing.

Crossing with Swiss breeds to improve milk production has been attempted in the Caribbean, East Africa, Malaysia, Fiji, Mauritius and Queensland. In West Malaysia, the Toggenburg was the least satisfactory. The Sannen and British Alpine crosses on to the local goats were superior to the local goats in milk but for all round performance the Anglo-Nubian was the most successful improver. Among the meat breeds, only the Boer (of south Africa) has a reputation but it has in fact not been very successful in East Africa (Devendra and Burns, 1982).

It can be concluded that with even more than with sheep, crossing with European breeds must be undertaken only with caution. For both milk and meat production, the need is for selection programme to produce tropical breeds which can be used for grading up populations for which such selection programmes is not possible.

### 2.3.3 Introduction of exotic goats and cross breeding

Introduction of exotic goats and sheep in Uganda started as early as in the 1960s with sheep breeding programme on government farms (Nsubuga, 1996). However, during the past decade, the introduction of exotic breeds and
their use for upgrading indigenous breeds has been widely adopted by the farmer communities including NGOs and government institutions as an alternative way of improving the low output of meat and milk among the indigenous goats. Almost all regions of the country have now exotic goat breeds or crossbreeds comprising of the Boer goats for meat and the Toggenburg, Saanen and Anglo-Nubian for milk production. The population of foreign goat genotypes and their crossbreed progeny as a result of production crossbreeding with indigenous breeds is increasing and was estimated to be about 5% of the national flock (MAAIF, 1996). However, since their introductions in the 1960s, to date, there is no information available to support the claim that exotic goats and their crossbred progeny do perform better than the local indigenous goats under on-farm low input production systems in Uganda. Farmers do not keep records, as they have no record keeping culture and prefer to keep records in memory form, which is of very limited use for breed improvement. The lack of record keeping is a major limitation to availability of useful information on the performance characteristics of various breeds of goats in the Mt. Elgon area for improvement in productivity.

2.3.4 Potential of indigenous goats for genetic improvement through selection

The indigenous goats in Uganda are principally meat goats. They are of low productivity and little opportunity has been availed to determine their
phenotypic, genetic and performance characteristics for improvement purposes. Three distinct indigenous breeds in Uganda are the Small East African (SEA), Mubende and Kigezi goats (Manson and Maule, 1960). These are distributed throughout the country but retained localized concentrations in certain districts and regions of origin where they have survived for many generations enabling development of specific characteristic adaptations suited to those local environment conditions closely associated with different agro-ecological zones of the country (CIAT, 1999).

Lack of pedigree records or reliance on history from farmer respondents and application of cumbersome measurements using weighing equipment have all very limited field applicability for mass selection. These limitations were circumvented by using heart girth as an indirect measurement of live body weight in selecting for large body size among Mubende goat populations (Oluka, 1998). Among the various linear measurements, heart girth was found to be highly correlated to live body weight (Oluka et al., 1999; Jindal, 1984; Meija and Casilo, 1991; Mourand and Anous, 1991; Worma et al., 1990). Body weight of pregnant females was however, found to be influenced by the pregnancy status (Ruvuna et al., 1991; Oluka, 1998).

For efficient selection, there must be sufficient variation especially with regards to economic production traits of metric characters like body weight and size. The heritabilities of these traits are useful in predicting effectiveness
of selection (Falconer, 1989; Jindal, 1984). The presence of a wide gap between observed and potential productivity of the small ruminants in developing countries has for long been recognized as an untapped opportunity for improvement of indigenous goats (Sawalha and Tabbaa, 2004; Hermiz et al., 1998; Tourrand and Landais, 1996; Johnson et al., 1986). Steel and Torrie, (1980) have, however cautioned that the sample sizes used in performance evaluations must be large enough and representative of the population if they are to lead to valid inferences or benefit from their statistics. Since the aim of breeding is to increase the mean of the variable being measured in a particular population through selection, that’s the mean of the normal curve, the normal distribution model, therefore, allows reliable probability statements to be made about the variables and enables their use and application of selection as a tool for genetic improvement (Falconer, 1989; Legates et al., 1990; Keller et al., 1990).

2.3.5 Growth performance as basis for selection

For every breeding season, the bucks should be changed and each buck should be mated to 12-13 does. For does to mate for seven times, the last offspring should be kidded at 5 years and four months. To meet this strategy, there is an urgent need to establish the growth rate, the age and weight at first kidding of the goats. The number of replacement does for every season is 14-15 taking into account of any death if the herd has 100 does. Since 100 females are born each kidding in case of twins, this represents a one in five selection
of the female. To select eight males from say 70 would mean a one in nine selection intensity. These selection intensities at times are not achieved because some does are culled after their second kidding. Kids are weighed at 120 days old. Since weaning is carried out at a set time than set age, the weaning weights should be corrected for age at weaning. To meet the demand of the goats for farmers, Farm-Africa has urgently instituted a research to establish the growth performance of the goats to meet the time requirements for ensuring the availability of goats at the time they are needed to be passed on to her beneficiaries.

Growth performance is also dependent on the birth type (litter size) and is necessary in guiding selection process/criteria; say grouping them either as males/females and then whether the kid is singleton, twin or triplicate. It is advisable to cull about 40-50% of the females at the young age and this might work out at 60% culling among the singletons and 40% among the twins.

The final selection is done at six months since weaning weight affects the measurement of growth. Relative growth is established by dividing the growth in this constant period by the weaning weights. Here a grouping into sires is desirable and the growth on all off springs including those culled at weaning is used to provide a progeny test of the sires for growth rates of their off springs.
It also helps in culling off springs that fall in the worst two or three bucks off springs and select for retention of the best off springs from the best sires. This will provide a herd of adult and replacement stock.

2.3.6 Castration

It is a requirement by FARM-Africa project that all the F\textsubscript{1} male goats are castrated. However, the effect of castration is not clear but there is limited evidence that it may be advantageous. One of the reasons for castration is to ensure the breeding policy is followed and also eliminates the strong male odour present in bucks, which affects the flavour of meat. Ueckermann (1969) could not detect any such flavour in castrated Boer goats in South Africa. Castration also affects growth rate and carcass composition. Hutchison (1964) reported an increased proportion of loin and hindquarters resulting from castration of cross breed Boer goats in Tanzania.

Owen \textit{et al.} (1977) found that castrated male Botswana goats developed larger and heavier carcasses than entire males, but the castrates had a higher proportion of both dissectible and total fat in the carcass (Owen \textit{et al}, 1978). Chawla and Nath, (1979) reported that live weight at nine months was significantly affected by castration in Beetal goats and their crosses with Alpine and Saanen.
Sidhar et al., (1978) also found that castration at 1-2 months old significantly (p>0.05) increased live weight at 12 months of age. Early castration (before six months of age) has a much greater effect on growth and development than late castration and male kids not required for breeding should be castrated at about three months of age both to obtain maximum growth and to prevent unwanted mating. However, the lean carcasses of entire male as well as a stronger flavour may be preferred in some markets. Hart and Jones (1975) pointed out that goats compared with other species show a usually high percentage of sexual activity after castration at a mature age.

2.3.7 Application of performance in genetic improvement

High genetic improvement in livestock depends on access to genetic variation and effective methods of exploiting this variation. Substantial improvement in animal production in developed countries is a result of breeding programs based on efficient performance recording (Rege, 1996). This is not possible in developing countries because of lack of infrastructure needed for efficient performance testing, small herd sizes and communal grazing devoid of systematic breeding and recording practices (Rege, 1996). Estimation of genetic parameters like heritability and repeatability requires good infrastructure for performance testing, large numbers of individuals and observed records of the traits under study and often long periods of continuous recording. It, therefore, means that such genetic parameters cannot be obtained under the local on-farm conditions even when recording
is undertaken because of the type of management systems of livestock in Uganda. However, in the presence of measurements on the phenotypic characters of economic traits such as growth and reproduction, heritability and repeatability values can be used to estimate breeding values and expected genetic progress in breeding programs.

Several studies have been conducted in various countries to estimate heritability and repeatability. They vary according to the environment and genotype. A total of 578 kid records from matings between 11 sires and 163 does for a period of 10 years were obtained for the estimation of genetic parameters among the West African Dwarf (WAD) goats (Odubote, 1996). The heritability and repeatability estimates for litter size were found to be 0.32 and 0.38, respectively, and 0.04 for kidding intervals for the sire-dam group (Odubote, 1996). This information indicates that selection for multiple births is likely to result in larger litter sizes and that culling of does for long kidding intervals should be based on more than two records. Results from 25 years of data collection on blended goats (55% Kamori, 30% Boer and 15% indigenous) totaling 4799 records indicated heritability estimates for kid birth weight, weaning weight and weight at 24 weeks to be 0.015, 0.099 and 0.0148, respectively (Das et al. 1996). Repeatability estimates for these goats for birth weight, weaning weight and weights at 24, 48 and 72 weeks of age were 0.202, 0.187, 0.533, 0.016 and 0.174, respectively. These results indicate high repeatability at 24 weeks (0.533) old as the best criterion for selection.
because it is less influenced by maternal effects which tend to obscure direct additive genetic effects at early pre-weaning periods (Das et al., 1996).

Heritability for birth weight for the Beetal goats was found to be 0.01 (Moulick and Syrstad, 1970). Repeatability for multiple births was found to be 0.29 for Baladi goats in Egypt and for the Beetal and Black Bengal goats as 0.22 and 0.50, respectively in India (Amble et al., 1964) and 0.06 for Mubende goats in Uganda (Sacker and Trail, 1966). The studies indicate that the performance of goats can be improved through management and that birth rate is a heritable trait.

However, Ali and Hasnath (1977) found the estimated sire component of birth weight in the same breed to be 0.75, surprisingly, birth weight in this study was not affected by sex. Mukundan and Bhat, (1978) reported that the $h^2$ of body weight was 0.4 at six months of age, and 0.3 at one year, in Malabari goats and their crosses with Saanen and Alpline. Nothing of this kind has been done to Toggenburg and their crosses.

Repeatability estimates for multiple births among the F$_1$ and F$_2$ crossbreed progeny of Anglo-Nubian and Katjang goats in Malaysia was found to be 0.14 and 0.20, respectively (Anuwar and Devendra, 1970). Heritability for milk production for the Saanen and Toggenburg milk goats were 0.32 and 0.17 respectively (Prakesh et al. 1971; Garcia, 1971). Much of what is known about heritability and repeatability estimates in goats is on milk production and less
on growth parameters (Devendra and McLeroy, 1988). Estimates of birth weight and weaning weight in Corriedale sheep in Chile under open nucleus breeding scheme indicated that maternal effects are particularly important for weaning weight where a strong antagonism between direct additive and maternal genetic effects was found. The heritabilities for birth weight were 0.32 (direct) and 0.24 (maternal) and for weaning weight, 0.37 (direct additive) and 0.38 (direct maternal). The genetic correlations between birth weight and weaning weight was 0.57 (direct additive) and -0.10 (direct maternal), the later being negative. This implies that when weaning weight is part of the selection objective or criterion, both direct and maternal components of variability must be taken into consideration to achieve optimum genetic progress (Jara et al., 1988).

Heritability is an important genetic parameter in the situation of the breeding value of an animal since it is an expression of the proportion of total variance that is attributed to the additive gene effect that is transferred from parent to the offspring. It also expresses the reliability of the observed phenotype value as a guide to the breeding value or the degree of correspondence between the phenotypic and breeding value (Falconer and Mackay, 1996). Heritability is thus a property not only of a character but also of the population, the environment in which the individual is subjected and the way in which the phenotype is measured (Falconer and Mackay, 1996). Characters with high heritability respond quickly to a selection process while those with low
heritability are associated with natural fitness and respond slowly and are often under influence of non-additive gene effects. Heterosis (hybrid vigor) results from "non-additive" gene effects. It is defined as the percentage of superiority expressed in a trait by crossbreed progeny over the average of the parent breeds in the cross. Heterosis is calculated by the following formula:

\[
\text{Heterosis} = \frac{P_{\text{crossbred}} - (P_1 + P_2)/2}{(P_1 + P_2)/2}
\]

Where \(P_{\text{crossbred}}\) is the phenotype of the crossbred and \(p_1\) and \(p_2\) are the phenotypes of the parents' breeds. The level of heterosis tends to be inversely proportional to heritability \(h^2\). In moderately to highly heritable traits, such as carcass characteristics, level of heterosis is low. On the other hand, in traits having low heritability, such as fertility and livability, heterosis is high. In general, heterosis is expressed to a greater degree in reproduction and in traits expressed up to weaning time. Heterosis is classified as either "individual" or "maternal". Individual heterosis is that expressed by the crossbred kid offspring, while maternal heterosis is that expressed by the crossbred dam. It is known that reproduction traits have low heritability and thus less readily changed through selection but can markedly be improved through crossbreeding effects of heterosis. Carcass traits that often exhibit little or no heterosis have been indicated to respond well to selection (Harlan et al. 1998).
2.3.8 Prediction of breeding values

The use of heritability and the prediction of breeding values constitute an integral part of most breeding programs where accuracy of prediction relies on the availability of records. Prediction of breeding values is made on the basis of individual records or information from relatives. The change produced by the process of selection that is of major interest is that change in the population is as a result of the selection. Prediction of breeding values can be made using population phenotypic mean values, heritabilities and observed records of individuals and relatives.

In general, response is positively related to intensity of selection and accuracy of selection and to the amount of genetic variation but it is negatively related to the generation interval (Gibson, 1992). Alteration of the breeding programme will often affect several parameters simultaneously and it is the effect of all these changes which determine the predicted response. Such changes and their effects on selection responses can be undertaken in simulation studies to test alternative breeding plans and appropriate ones identified for specific production systems on the basis of available information on the performance of animals and genetic parameters.

2.3.9 Open nucleus breeding schemes

Measurements from metric characters like heart girth and linear body measurements can be used for rapid selection of large size individuals among
populations in the field to enable establishment of an elite flock of does and bucks. However, sustainability of the selection program would rely on the participation of the farmer community. This entails the involvement of goat farmers themselves in the selection and subsequent multiplication of the elite performing goat flock. Kiwuwa ,(1990) has suggested two methods of selecting and multiplying the elite performing goats. These include the establishment of open nucleus breeder and participatory farmer flocks (ONEB-PF) and open nucleus elite breeder and multiplier flocks (ONEB-MF) systems.

The ONEB-MF system involves selection and purchase of elite goats from farmers, their collection and multiplication at a central station whereby high selection pressures are applied on dams, males and offspring. Improved sires from the central station would then be given back to farmers as high-grade animals being continuously produced at the station.

The ONEB-PF system, on the other hand, involves establishing co-operative farmer groups who participate directly in contributing top-performing females to the central station. The ONEB-PF system involves farmers who are already organized, literate and have reliable farm records available for use in the selection of elite performing individuals. In the present study, the ONEB-MF system would be of immediate application since FARM-Arica is in high gear preparations for the establishment of the breeding and buck stations for the stabilized 75% crossbred Toggenburg goats. Farmers have been
educated especially in record keeping and management practices which are prerequisite requirements in the adoption of the technology and establishment of the open-nucleus breeding schemes. Under this study, farmers are encouraged to keep records through continuous education and actual participation in the record keeping. The ONEB-MF system, when operational for some time, would graduate itself to the ONEB-PF system when the system of keeping farm records have been appreciated and adopted by the farmers and standards set for the potential of the stock assessed. The character of productivity of importance is the growth rate.

In genetic improvement, growth rate appear to be dependent on additives polymetric control rather than on single genes with major, effects. Such characters are measurable and vary between individuals and are almost very susceptible to environmental influence. Adverse circumstances, such as illnesses or malnutrition can prevent the full expression of additive gene. It was thus necessary to establish the performance of the Toggenburg crosses with the SEA goats. The genotype is determined at the time of fertilization and it does not change but its expression changes due to age, temporary environmental effects, and to an interaction between genotype and environment.
2.3.10 Udder size and milk yield

Correlation of udder and teat measurements to or with milk yields have also been reported by Das and Sidhur (1975) in two breeds in India. In the Barbari breed, all measurements were significantly correlated (0.465-0.866) with milk yield on the day of measurements. In the Black Beengal breed, only eight out of twelve measurements showed significant (0.373-0.866) correlation with milk yields. In both breeds, multiple correlations of four udder measurements (lengths, widths, circumference and depth) with daily milk yields were significant (0.749 for Barbari and 0.690 for Black Beengal).

In a further paper, the same authors found that udder and teat measurements tended to increase with most of the udder and teat traits measured. Given the above, the body dimensions within breed if undertaken early enough would reveal potential high milk yielder and thus selected for distribution to the poor. Determination of growth rates is not outrageous in this study but actually a vital necessity.

2.3.11 Milk requirements for kids

Louca et al., (1975) experimented on Damascus kids by having them suckle for two days and then reared them on milk replacements (dried skimmed cows milk, fats and carbohydrates from a vegetable origin) or suckled until weaned, (weaning both treatments was either at 35 or 70 days). Kids weaned at 35 days had a slower growth rates than those weaned at 70 days and between 35-70 days. The kid’s milk replacers (both given about 14% more
food) had a faster growth rate than the suckled kids. In Africa where suckling is the order of the day, growth rate turns out to be a problem especially when even the available milk is competed for between kids and humans for nutrition. Consequently, growth performance of kids is affected hence the need to establish it.

Gaona and Romero (1975) reported that the effect of housing on milk yield compared with those on free range was twice. Subsequently, this affects the growth rate of the kids; hence investigation of this phenomenon can only be done through monitoring the growth rate.

2.4 Goat health

Diseases in goats are a major constraint that limits the productivity of goats. Of major importance are parasitic, viral, bacterial and nutritional diseases.

2.4.1 Nutrition in relation to helminth infections

Urquhart et al.,(1988) reported that goats precluded from browsing and left to derive their food intake entirely from pasture, suffer more severe helminth infestation. This observation has also been reported by NRC (1981) in USA, who observed that field goats performed better than expected when allowed to browse and therefore suggested that more attention be given to browse feedstuffs. These observations have merit in view of the high crude protein content reported in browse feed combined with the potential benefit of
browse condensed tannin when consumed at low levels. Studies in Kenya for example have shown that GIT nematodes were the major health problem limiting performance of goats and sheep under the semi-arid conditions of northern Kenya (Field et al., 1984) and this was related to seasonal under-nutrition.

Excessive nematode parasite loads are particularly critical at the productive cycle when physiological requirements of animals are highest, such as during late pregnancy, lactation and early growth of weaned kids and lambs (Urquhart et al., 1988). Inadequate supply of nutrients is one of important factors curtailing the effectiveness of health care measures taken to improve livestock (goat) productivity in many SSA countries. Besides its immediate effect upon survival, growth and lactation, inadequate nutrition lowers the resistance of goats to infection and disease (Lebbie et al., 1996). Experiences in Mali show that vaccination against infectious diseases (Pasteurellosis, anthrax, Petite Peste des Ruminants) combined with deworming did not improve kid survival and growth due to poor goat management practices including inadequate feeding (Ba et al., 1996). It is known that the prevalence and incidence of helminth disease and its economic significance depends on the macro-and micro-environmental conditions of an area (Over et al., 1995). Most helminth infections are sub-clinical and can be considerably modified by host and environmental determinants. The disease is prevalent during rainy seasons due to increased worm burdens and favourable environmental
conditions for survival and development of eggs and larvae to effective stages (Urquhart et al., 1988). This is also the duration when most livestock come to delivery. Normally, there exists a balance between the parasite and the host. This balance may, however, be disturbed by stress factors such as malnutrition, physiological, parasitic and climatic stresses, and deworming. The key issue however, is that the pathogenicity of helminth parasites largely depends on the condition of the animal.

Nematode parasites such as Trichostrongylus, Cooperia and Oesophagostomum cause destruction of mucus membranes of the gut resulting in digestive disorders and malabsorption. Blood sucking nematode parasites like Bunostomum and haemonchus can cause severe blood loss and anaemia. Lungworms like Dictyocaulus and Muellerius can cause bronchitis and pneumonia. How the goat responds to these infections partly depends on its nutritional status. Malnourished individuals are more susceptible to heavy worm burdens (Chandra, 1980).

The immunological modulation and evasion of helminths and factors important in predisposition to helminths among individuals have been reviewed by Maizels et al., (1993). As previously mentioned, predisposition to heavy or light helminth infections in individuals is an important epidemiological factor, which is modulated by genetic, behavioral, environmental and/or nutritional factors either singly or in combination. Predisposition to helminths is more in the young than in the old. Observed differences in responses to individual
antigens among subjects with similar exposure experience is likely to be influenced by genetic, behavioral and nutritional components.

Worm burdens per individual in a goat population; reflect either difference in exposure, or in susceptibility to infection, or in the ability of the individuals to mount effective immunological responses. The goat’s ability to recognize and respond to particular parasite antigens is of great importance in determining whether the host is persistently susceptible or develops protective immunity. Incremental changes in the ability of the host to recognize or respond to a particular antigen can alter considerably the dynamical system and are therefore an important indicator of the trends in the development of protective immunity.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study area description

Mt. Elgon area comprises of Sironko, Mbale and Manafwa districts (Appendix 11 and 111). FARM-Africa projects are located in these districts. Rainfall pattern is bimodal with dry season/short rains in months of July-August and January to March. The wet season occurs during March-June and September to December. The annual average rainfall is about 1,191mm per annum. The temperatures are very low averaging 10°C – 24°C.

The vegetation in this region is natural grasses with predominatly *Digitaria scalarum, Cynodon dactytolon, Panicum maximum, Acacia spp* and other natural grasses. Browse commonly used include; *Avacado spp, Mango lera mangoes, Pisidium guajava, Artocarpus heterophyilus, Ficus nantalesis* among others are legumes like *Callindria spp, Leucaena spp Desmodium spp*. Afro alpine groundsels and lobelias are found on Mt. Elgon area. Forages for primary production do fluctuate in the dry season with the quality of many forage plants being too low to meet the goats maintenance requirements year round resulting in poor goat performance (FARM-Africa report, 2005).

The people in the study area are the Gisu who live on the slopes of Mt. Elgon. They are mixed farmers cultivating crops and rearing livestock. Land is
scarce in this area and the population density is very high. Land ownership is based on customary tenure system and land fragmentation is practiced to accommodate the ever-increasing population. Owing to land shortage, agriculture practiced is subsistence. Individual farms are too small to support cattle keeping. Therefore goats are the only viable livestock option for the people to rear and keep to provide them with meat and sometimes milk.

Livestock population in the area is varied, with cattle (250,099), goats (240,996), sheep (33,637) and pigs (33,054) respectively. Milk is mostly got from the zebu cattle and their crosses with the exotics and also from the pure exotics (Friesian, Guernsey and Jersey). They are kept by tethering and zero grazing management system of production, utilizing supplementary feeds on top of cut and carry or limited grazing (Mugisha, 2002). Housing is provided, to some goats, although most of the houses are not standard shelters. Genetic improvement in the region has been in cattle and pigs but not in goats. FARM-Africa has since August 2005 taken the lead in this direction using the Toggenburg goats.

3.2 Study design

Using the available baseline data at the farms, a sample of 261 goats for study was targeted but only 204 were achieved. This sample was got using a simple random sampling techniques from 810 goats (F1 crosses). The 75% Toggenburg crosses and pure Toggenburg were purposively selected. Only the female F1s and Small East African goats (SEA) were selected for study
while both sexes were considered for the 75% Toggenburg crosses and the pure Toggenburgs.

The sample size was calculated using the Fisher’s et al, (1983) formula at 0.05 confidence level as below:

\[ n = \frac{Z^2 PQ}{d^2} \]

Where

- \( n \) = the desired sample size
- \( Z \) = the standard normal deviation at the required confidence level.
- \( P \) = the proportion in the target population estimated to have Characteristics being measured (population 10,000)
- \( Q \) = 1 - \( p \)
- \( d \) = the level of statistical significance set

The proportion of the target population assumed to have the characteristics of interest was 50%.

\( Z – \text{Statistic} = 1.96 \)

Confidence level = 0.05

The sample size therefore was;

\[ n = \frac{(1-0.96)^2(0.50)(0.50)}{(0.05)^2} \]
\[ = 384 \]

But the target population was less than 10,000. Thus using the formula;

\[ n_f = \frac{n}{Hn/N} \]

Where

- \( n_f \) = the desired sample size (population <10,000)
- \( n \) = the desired sample size (population > 10,00)
N= the estimate of the population size

Sample size was;

\[
\frac{384}{1} + \frac{384}{810} = 261
\]

3.3 Husbandry practices

The households were categorized under three husbandry practices, viz; the good, average and poor husbandry practices. Good husbandry practices involved those households that had provided goats with a shelter having slates, (for good hygiene and protection from the harsh environmental conditions i.e cold, driving rains, draught, sunshine etc).

In this category, feeding involved giving the basal feeds (browse and grasses), legumes like *Calliandra spp*, *Leucaena spp* *Sesbania spp* and *Desmodium spp* and supplementation with maize bran and water provision. Stall feeding was practiced. There was proper disease control programme in place by the farmers.

In the average category, housing was provided with or without slates. The living and feeding conditions were bad. However husbandry practices involved a combination of stall feeding and tethering and at times restricted grazing. There was no proper disease control programme in place by the farmers.
In the poor practices, there was no evidence of a good goat house. Farmers were reluctant to put up shelters and farmers shared their residential houses with goats at night. Feeding was provided but the conditions were harsh for the welfare of goats. Tethering was practiced, supplemented with kitchen refuse. Disease control was not observed.

3.3.1 Feeding management

Goats were managed under several systems. Zero grazing which ensured continuous confinement with goats fed on fresh chopped green fodder, browse plants, supplemented with maize bran especially to the kids, pregnant and lactating dams. Feeding of those housed goats was mainly done using cut and carry method in which fodder was in the form of a mixture of grasses, tree leaves (shrubs, forbs, browse) and legumes.

Other farmers did not give supplementary feeds of maize bran to pregnant does to avoid having big kids which could cause difficult kidding. After delivery, kids were left to suckle their dams to get colostrums and were kept in the same pens where they were later exposed to green fodder. Other farmers kept them in residential houses in the first days of life to provide warmth and allowing kids to suckle their mothers. Other farmers practiced the combination of zero grazing and tethering.
In the wet season, during the peak days of garden work, they used zero grazing system and fed their goats mostly on banana leaves and pseudostems.

At times tree leaves from Mangofera mangoes, Avocado spp, Pisidium guajava, Artocarpus heterophylus and Ficus species were fed to the goats.

During the dry season, the goats were tethered. Other farmers also tethered their goats on non-rainy days when going for garden work.

Tethering was done in the morning to early afternoon hours because in the late afternoon to evening time, rains normally set in disrupting the days' activities.

3.3.2 Housing management

Constructed houses with separate pens for feeding and resting were provided for both breeding does and bucks. Breeding bucks were kept at the buck stations, used as the breeding units and the bucks were kept in separate pens from the breeding does.

Growing does and kids were kept with the dams if milking was done for home consumption but where milk was valued for sale, kids were kept in separate pens.

The houses were raised off the ground at the height of 1-2 feet on average with slated floor. Other houses did not have slated floor. Walls were made of
wooden timber or off cuts of timber or poles; others were made of mud and wattle.

The buck houses that doubled as breeding places had both the resting and feeding area used as breeding run. Each house, housing a buck had a raised slated floor. In the well managed goat houses drenching was done after every three months to control internal parasites. Spraying of goats was done on each other day to control external parasite infestations such as fleas and mites. Housing structures of goats were similary sprayed.

3.3.3 Breeding (mating) management

Estrus was detected in the local Small East African (SEA) goats and Toggenburg crosses with the SEA (F1s) by observing signs of heat on does, i.e red vulva with mucus, tail wagging and noisy female, moving close to male kids or to individual farmers and assuming a friendly or standing posture ready to be mounted. These signs and others like failure to feed were used in combination to take the goats for mating. Mating was then actively conducted when estrus was detected on does. The does on estrus were then taken to the breeding buck at the buck station for mating. The breeding bucks were allowed to mate at the age of 8-9 months when mature. The does were allowed to mate at the first time at the age of at least 12-14 months but could also be earlier if the goat attained at least 25 kg live weight. This was done to establish the age and weight at first kidding. The does taken for mating were
allowed to be served for 2-3 times and left at the buck stations for a day or two depending on the agreement between the buck keeper and the owner of the doe.

3.4 Data collection and recording

A Salter Scale was used to weigh the goats. This was done by putting each goat in a 100 kg polythene bag (kavera), which was then suspended on the scale measuring 100 kg, marked in 0.2 kg divisions. The scale was securely suspended at a fixed point and the scale pointer adjusted to point at zero. The polythene bag with a goat inside was then hooked on it and the goat's corresponding weights read and recorded. The scale readings were always adjusted at level with the eyesight level.

The heart girth was measured using an ordinary tailors tape calibrated in centimeters. Body weight, heart girth, height at withers and body lengths were taken simultaneously. These measurements of each goat were taken before body weight was taken. The animal to be measured was made to stand still by gently restraining to allow it stand erect and straight with all limbs firm and straight on a flat floor. The measuring tape was then wrapped around the chest circumference area just behind the fore legs. It was fitted firmly but not too tightly, around the chest and readings were taken and recorded accordingly. To measure the height at withers, the goat was made to stand in the same posture, a tape measure was run from the tip of the hoof to the edge
of the scapular bone at the withers, readings were also taken and recorded. Also with the body lengths, the tape measure was run from the crest of the head along the straight back line to the base of the tail and its readings taken and recorded accordingly. Measurements of kids were similarly done as the adults, using the 25kg weighing scale. The kid birth weights and the other measurements at birth were recorded as the starting point zero. Thereafter, each kid was weighed individually for eight months. The heart girth, height at withers and the body lengths were taken as routine but emphasis was on weight gain.

These measurements which included data records on health and nutrition, udder size and scrotal circumference were done from October 2006-June 2007. Data quality control was done by double entry, which checked the validity and reliability of the data. The birth weights were taken within 24 hours after birth whenever it was possible by the contact farmers during the study time while those found born, birth weights were obtained from farmers and contact farmers records. Other data recorded were date of birth of kids, sex, litter size, genotype, age and weight of weaning kid's age, weight at first service and age and weight at first kidding.
Kauta Moses and Mubekete Fred at Bumukwana hill, Mt. Elgon during data collection

3.5 Data analysis and interpretation

Data was analysed using SPSS 13.0 computer software programme. To test the hypothesis posed by the research questions, analysis of variance, student’s t-test and correlations were used. Results were presented in descriptive statistics and illustrated in graphs.
CHAPTER FOUR

RESULTS

4.1. Effect of the different husbandry practices on the growth performance

The mean body weight of the goats were affected by the various independent variables such as husbandry practices, genotypes, litter size, sex, disease management and seasons as summarized in Figures 1,2,3,4,5 and 6.

![Graph showing the effect of husbandry practices on live body weights](image)

Figure 1: Showing the effect husbandry practices on live body weights
Figure 1, shows the effects of different husbandry practices on body weight gains. Under good management (husbandry) practices, there was an increase in body weight gains in period 31-60 days by 2.8 kg as compared to 1.5kg and 1.8 kg in the average and poor husbandry practices respectively. The variations in weight gains were small in all cases of husbandry practices in the last periods of the trial. In good husbandry practice, weight gains increased proportionally with time up to 180 days then leveled till the end of the trial. Generally, in all management practices, the growth rate was higher in the early days of life than when the goats were older.

The study found that husbandry practices did not significantly (P>0.05) influence the body weights in the first period 1-30 days and 181-240 days, but significantly (P<0.05) influenced body weight gain from 31-180 days. Similarly, husbandry practices significantly (P<0.05) influenced the mean weight gains of the different genotypes under good and average management conditions but did not (P>0.05) influence it under poor management conditions.

The 75% Toggenburg crosses performed better under good management with a mean weaning weight. They also performed better under the average management with the mean weaning weight of 13.8kg better than F1, at 11.9kg, and pure at 1.3kg respectively, while under poor management, the
75% Toggenburg crosses mean weaning weight was 12.2kg; F1s was 12.3 kg and pures was 10.8kg respectively.

Husbandry practices had a significant effect (P<0.05) on the weaning weights but did not (P>0.05) affect the pre-weaning weights. The mean weights at weaning under good husbandry practices were 13.8kg while in the average and poor husbandry practices were 12.4kg and 11.6kg, respectively.

4.2 The effect of genotype on growth performance.

The effects of genotype on growth are shown in Figure 2 below. It shows that the SEA had a higher mean weight of 6.9kg in days 1-30 but was overtaken by the pures with 10.3kg at days 31-60 up to day 210 (21.8kg). The 75% Toggenburg crosses steadily increased weight gains to take the lead in the days 211-240 with 25.5kg ahead of the F1s with 16.5kg. However, in the period 1-30 days, genotype had a significant (P<0.05) effect on the growth performance but in the periods 31-90 days, it did not (P>.0.05) influence the growth rates. At weaning (91-120 days), genotype significantly (P<0.05) influenced the weaning weights through to post weaning weights.
Figure 2: Showing the effect of genotype on live body weight

Figure 2, shows that the 75% Toggenburg crosses had higher mean weaning weights followed by the F1s and then the pure Toggenburg and lastly the SEA.
Age at first kidding for the SEA, under poor husbandry practices was 16.1 months at 17.3kg, for the pure Toggenburg was 18.8 months with goats weighing 26.8 kg while F1 19.7 months with a weight of 27.5kg.

For F1s under the average husbandry practices, age at first kidding was 15.6 months with 21.8 kg while for the SEA, it was 20 months at 16.5kg and in the good husbandry practices it was 15.1 months at 20.2kg, Age at first kidding. There was no 75% Toggenburg crosses for comparison but generally, pure Toggenburg had a short time to first service with 13.4 months followed by F1s while the SEA had the longest. This only applied to the age and not weight at first kidding. There were positive correlations between the genotype and the age at first service and a perfect one in the weight at first service and a positive one with age and weight at first kidding and the kid weight.

The study showed that under good management practices, the 75% Toggenburg crosses performed better with the final body weight of 25.9 kg as opposed to F1s with 16.5 kg and pure Toggenburg with 22kg, respectively. Good management practices did not (P>0.05) affect the post weaning weights across the board. However, poor management practices significantly (P<0.05) affected the post weaning weights of the goats.

The results also showed that good and poor husbandry practices significantly (P<0.05) affected the weaning weights but the average husbandry practices did not (P>0.05. Under good management practices, the F1s reached the first
service at the age of 15.0 months with goats weighing 27.9 kg while the pure Toggenburg at 13.4 months with a mean weight of 23.0 kg, respectively. Under average and poor management practices, the F1 reached the first service at the age of 15.6 months and 15.1 months respectively. Under good husbandry practices, weights of kids at birth were 3.6 kg compared to 3.1 kg for weights of kids under average and poor husbandry practices, respectively.

4.3 (i) Effects of sex on the growth performance of pure Toggenburg

Figure 3(i), shows the effect of sex on the growth rate of the pure Toggenburg goats for the period 1-240 days. The female goats had a higher body weight gain all through compared to the male goats. In the period, (1-150 days), the females had a constant difference of about 1kg higher than the males, only to
be checked by period 150-180 where as mentioned earlier husbandry practices had a significant (P>0.05). Thereafter the growth rate declines with age.

The study showed that the F1 females were weaned at 4.4 months with an average weight of 12.2 kg while the 75\% crossbred Toggenburg males were weaned at 4.1 months, with an average weight of 13.5 kg. The 75\% Toggenburg females were weaned at 4.0 months with weight of 14.5 kg. In the pure Toggenburg however, males that were weaned at 4 months had a weaning weight of 11.3 kg while the females at the same age weighed 11.4 kg. The female SEA was weaned at 4.2 months with a weaning weight of 8.8 kg. These differences (age and weights) between sexes were not significant (P>0.05). The male F1 and SEA were not compared as they were excluded in the study.

The study showed that the females under good, average and poor management practices had a mean weight of 24.1 kg, 20.4 kg and 18.2 kg, respectively. Similarly, the males under good, average and poor management practices had a mean weight of 21.6 kg, 16.9 kg and 17.1 kg, respectively.
4.3 (ii) Effect of sex on the 75% Toggenburg crosses

Figure 3 (ii) Showing the effect of sex on the 75% Toggenburg crosses

The graph curves show the same growth rate trends like that of the pure Toggenburgs for the same reasons. However, genotype had a significant (p<0.05) effect on the growth performance in period, 1-30 days and the weaning 91-120 days, and through to the post weaning weights. Genotype also had significant (p<0.05) effect on the poor management systems.

Under good husbandry practices, the age at 1st kidding for the SEA was 16.1 months at 17.3 kg he while F1s was 15 months at 20.2kg.
In average husbandry practices, F1s was 15 months at 21.8kg while SEA was 20 months at 16.5 kg and pure Toggenburg was 18.8 months at 26.8 kg.

Poor husbandry practices significantly (P<0.05) affected the post weaning weights of all the genotypes.

Good and poor husbandry practices significantly (p<0.05) affected the weaning weights.

4.4 Effect of litter size on the growth performance

![Figure 4: Showing the effect of litter size on live body weight](image)

Figure 4: Showing the effect of litter size on live body weight
Figure 4, shows that singletons had a higher progressive live body weight gains than either the twins or triplets. This weight gain of the twins was lower than for the singletons.

**Differences in litter size effect to kid growth performance.**

The mean birth weight of the singletons for F1 was 2.6 kg and for the 75% was 3.0kg and 3.7 kg for pure Toggenburg and 2.1 kg for SEA. While the mean birth weight of the twins for F1 was 2.3 kg and 2.7 kg for 75% Toggenburg crosses and 3.2 for the pure Toggenburg and 2 kg for the local SEA. Lastly the mean birth weight of the triplets for the F1 was 1.67kg and 1.5kg for SEA. There was however, a significant (P<0.05) effect on the birth weight of F1 kids only.

The 75% females were weaned at 4.0 months while the males were at 4.1 months at 13.9kg while the F1 were weaned at 4 months with 12.2kg and for the pures were weaned at 4 months in both sexes at 11.4 kg for female and 11.3 for males. In all cases, sex did not have significant (p>0.05) effect on the growth performance.

Although, the triplets had the least live body weight of 2.8 kg as opposed to 6.6 kg for the singletons and 4.5 kg for the twins in the first 1-30 days, They
later surpassed the weight gain of both the twins and the singleton at the period 61-90 days reaching 12.2 kg. However, from the period 121-150 days, the singletons grew faster and gained more weights than either the twins or triplets. The differences of body weight gains between the litter size were significant (P<0.05) in the period 1-60 days, but not significant (p>0.05) from 61-240 days.

The study showed that the F1s singletons had a mean birth weight of 2.6 kg, twins had 2.3 kg, while triplets had 1.7 kg. The 75% Toggenburg crosses, singletons had a mean birth weight of 3.0kg and the twins had 2.7kg. Singleton pure Toggenburg had a mean birth weight of 3.7 kg and twins had 3.2 kg. The SEA singletons had 1.8 kg; twins had 2.0 kg while triplet had 1.5 Kg.

Litter size had a significant effect (P<0.05) on the birth weights in the F1 but did not have a significant (P>0.0.5) effect on birth weights of the 75% Toggenburg crosses, pure Toggenburg and the SEA, respectively. The results also showed that the weaning weights at 4 months old for the singletons was 12.9 kg, for twins was 11.2 kg and for triplets was 12.5 kg respectively. In the 5-6 months age group, the singleton had 14.7 kg body weight, while twins had 10.8 kg. The singletons in the 9-12 months category had a mean body weight of 14.5kg while twins had 11.6 kg. In the 13-27 months age group, the singletons had 14.7 kg body weight while the twins had 9.9 kg.
4.5 Effect of disease management on the growth performance

Figure 5: Showing the effect of disease management on live body weight
Figure 5, shows the effect of disease management practices on body weights gains of the goats. Goats under good disease management practices had a higher mean body weights and growth rates from period 1-240 days than goats under poor husbandry practices. The weight gains increased steadily up to 121-150 days then slackened up to 181-210 days but shot dramatically up to 211-240 days. Meanwhile, goats under poor disease management practices maintained a lower linear growth rates till the end of the trial at 211-240 days. There was however, no significant (P>0.05) effect of disease management on the body weights in the period 1-60 days but thereafter disease management significantly (P<0.05) affected the growth rates from period 61-240 days.

The study showed that the disease management significantly affected the growth performance of the F1s and 75% Toggenburg crosses but did not affect (P>0.05) the post weaning weights of the pure Toggenburg. However, the weaning weights of the F1s and 75% Toggenburg crosses were significantly (P<0.05) affected by the disease management.

Disease management entailed good health care practices like routine deworming, spraying and treatment when they fell sick.
4.6 Effect of season on the growth performance of Toggenburg and its crosses with the SEA.

**Figure 6: Showing the effect of season on live body weight**
Figure 6 shows the effects of season on the live body weighs of the goats. In the period 1-30 days in the wet season, the mean body weight was 5.9 kg higher than 4.9 kg in the dry season.

This trend showing a higher body weight in the wet season continued throughout the growing periods from 31-240 days.
5.1 Effect of husbandry practices on growth performance

Husbandry (management) practices did not significantly affect the body weight gains in the period of 1-30 days (Figure. 1) because the kids were still suckling and feeding on milk. This provided a balanced diet, which mitigated any nutritional stress that could have affected the growth rates. Milk consumption by kids was found to be adequate in meeting the nutritional requirements for normal growth (Farina, 1989). The influence of the dam maternal environment and direct additive genetic effects of the kid could be the other factors that cushioned weight gains in the 1-30 days from environmental influence (Kifaro et al., 1996). The factors like poor nutrition to the dam in the dry season have been found to reduce the growth rate and development of the embryo during intra uterine period (Gall, 1981; Singh and Singh, 1974). Singh et al. (2000) found that, the weight of the dam had a significant effect (P>0.05) on the kidding birth weight and suggested that improving nutrition of dams during pregnancy would improve growth rates of kids. The significant effect of management (feeding) on the growth rates for the period 31-180 days is consistent with Morand-Fehr and Sauvant, (1978) who found that towards weaning, kids increasingly depend on available feed and browse. The weaning period is a transition from milk to forage
consumption and is a period of stress when feed is inadequate in amount and quality, if weaning coincides with a prolonged dry season.

Under good husbandry practices (good housing, hygiene and feeding) there was increased growth rates (body weight gains) in the preweaning stages of 31-60 days. This was partly due to sufficient milk from the dams, besides the good environment the goats were reared in. However, after weaning 91-120 day period growth was reduced due to weaning stress and probably aggravated by helminths infestation. The high growth rates in the early periods agrees with Oluka, (2006) who observed that kids grow 2-3 times as fast as they do in the 3rd months while they grow 10 to 20% better in 2nd and 4th months. From 150-240 days, the body weight gains were reduced because growth rate and weight gain tend to reduce with age (Kifaro et al., 1996). This agrees with Oluka, (2006) who found that pre-weaning weights were found to increase with age, as average daily gain becomes correspondingly reduced.

In the average husbandry practices, there was increased weight gain up to 120 days although at a lower rate than in the good husbandry practices for the same reasons as mentioned earlier. Weaning stress normally reduces growth rate initially, but it recovers soon afterwards. In this study the body weight gains doubled in the period 211-240 days. This could have been due to females getting pregnant and males putting on more muscles. It is evident that
good housing and feeding management practices strongly influenced the
growth rates.

Under good and average husbandry practices the 75% crosses performed
better than the F1s. However the F1s performed better than the 75% crosses
under the poor husbandry practices. This could be explained that the closer
the genotype to the pure breed, the better the husbandry practices are
required for better performance. The F1s performed better under poor
husbandry conditions because of heterosis effect. This finding agrees with
Oluka (2006) and Haas (1978) that among Small East African goats and the
Boer crossbreds, the kid daily gains from birth to weaning and from weaning to
365 days averaged 114 and 65g respectively for crossbred versus 84g and
32g for the pure bred SEA, and the growth rates were due to heterosis effect.
Boer Huai F1, crossbred kids were found to grow and develop significantly
faster than the local Huai within one week after birth with weight gain from
birth to the age of 2 months (Ou-Guangzhi and Jian Zhong, 2001). Guangshen,
et al., (2001) found that growth rates for Boer X Huai F1 was always over
50% more than that of local goats which was also attributed to heterosis.
Similar studies have shown that crossbreeding increases kid body weight
from birth to 1 year of age and as well as daily gain to improve production
performance of native goats (Xiang long et al., 2001).
The good performance of the 75% Toggenburg crosses under good management over other genotype is in line with other findings by Nsubuga (1996) that the Boer goats and their crosses are superior to their indigenous tropical goat breeds and that if higher genetic proportion is targeted, the feeding and housing should be provided in adequate quantity and quality to the animal at all growth stages to cater for its growth, reproductive and other physiological needs. This observation is supported by a study on Boer goats crossed with the local Tunisian goats which showed that the F1 crosses had the best weaning performance (higher litter size and higher birth weight) and daily body weight gains and the adult crosses that survival had higher milk yields than the local goats although with reduced resistance (Steinbach, 1986).

In Libya, the Barbary goat has been improved in size, weight and fleece height, by crossing with the white Keraman goat from Turkey. In Egypt hybrid vigour was exhibited when the Ausimi and Rahmeni goats were crossed. In Iran the Shal breed has been improved by crossing with the Isreal Awash: heterosis was exhibited in lambing rate, litter size, milk yield and growth rate in all these cases (Yalcin, 1979).

In this study, the differences in performance of the genotype arising from differences in management practices as result of genotype environment interaction were clearly seen. The 75% Toggenburg crosses showed high vulnerability to poor management and that was why the relatively resistant
F1s performed better in poor husbandry practices than even the Small East African due to heterosis effect.

5.2 The effect of genotype on growth performance

The study showed that in the period 1-30 days the SEA offspring had a higher mean body weight than other genotypes (Figure 2). This was possible because the local dams were selected on the basis of body size. Big sized dams are said to significantly influence the kid birth weight. This argument is supported by some studies, which found that the dam's weight influences kid weight (Gall, 1980; Berhanv et al., 1991; Das, 1993; Kugonza, 2002; Oluka, 1999). Biswa et al. (1991) found that regression of dam's weight was highly significant for birth weight of Cheghu Pasmina goats. Related studies showed that kid birth weight depended on dam body weight (Morand-fehr, 1981; Devendra and Burn, 1983; Sanchez et al. 1994; Salah et al.1989) although birth weight also depends on other factors like litter size, but the fact remains that they have the potential for higher growth rates.

Under good management, purebred goats usually perform best. This potential is however challenged with the variation in levels of management. It is not surprising therefore to see the pures having higher growth rates for the period 31-210 days under good environment of housing and feeding making them attain a higher weight at a lower age for first service.
There was no 75% Toggenburg crosses that had been served although they had reached the breeding age due to delayed selection and establishment of the 75% stabilized breeding units and buck stations. But results showed that the F1s although performed lower than the pure toggenburgs were still above the SEA goats for age and weight at first service and kidding. This is in agreement with some studies that have been conducted which showed that crossbreeding increased both pre-weaning and post weaning body weights and growth rates of cross bred off springs (Abdelsalm, et. al., 1997; Darcan and Gunet, 2002; Guangshen et al., 2001; and Haas,1978). Similar studies concluded that crossbreeding using a Boer goat could improve growth of young kids and thus potentially increase economic returns for goat producers (Luo et al., 2000).

5.3 Effect of sex on the growth performance of toggenburg crosses

In the first 1-240 days, the study showed that females were heavier than females and sex difference had no significant (p>0.05) effect on growth rates. The high body weight gain of the males over the females by 80g right from period 1-30days implies that right from birth males weighed heavier than females. This observation disagreed with other authors who noted that male kids were 169g heavier than females (Oluka, 2006), 140g (Oluka, 1999) and 220g (Kugonza, 2002). In this study it was found that the birth weight influenced the growth rate (weight gain) in the subsequent periods. This finding is in agreement with other studies, which showed that male kids had
consistently higher body weight gains than females during the pre-weaning period (Oluka et al., 2004). Similar findings were also reported on Malawi goats (Karu and Banda, 1990). The male kids being heavier than females is a common phenomenon associated to hormonal differences between the two sexes (Eik et al., 1985; Kifaro et al. 1996; Morand-Fehr, 1981; Raghavan and Devendra, 1988; Karua and Banda, 1990).

The female goats to attain higher livebody weights was not surprising as FARM-Africa attached a lot of importance to female s being central in th breeding programme. They therefore did a lot of- farmers sensitization and trainng to give special attention to female goats for proper growth and development. Until recently F1 males were and are still being castrated and reared for meat (market) with no special attention given but now the 75% Toggenburg crosses are being well cared for breeding purposes. Even under such immense differences of weight and monthly gain, sex had no significant influence on the growth rate of the goats. It is clear that goats under good management and genotype had a higher growth rate than the same goats in poor management.

5.4 Effect of litter size on the growth performance

The singletons had a higher body weight gain than the twins and triplets (Figure 4). This is in agreement with other such study, which reported that singletons grew faster than twins and triplets, (Oluka 2006; Devendra and
Mcleroy, 1998; Das et al. 1989; Morand-fehr, 1981; Gall, 1980; Kugonza, 2002). Single born kids were heavier than twins by mean weights of 200g and 1kg for the triplets in the F1s respectively. In the 75% Toggenburg crosses and in the pure Toggenburg, singletons were heavier than twins by 200g and 400g respectively.

The singletons had the advantage over the twins and triplets due to absence of intra natal competition for the nutrients resulting in higher birth weight. But this could only be possible if the feeding management was up to date as provided in good husbandry management. But in the average and poor husbandry practices where cases of nutritional stress were encountered, either as a result of inadequate supply of energy and protein nutrients or due to complete lack of adequate feed resource as was the case in dry seasons, birth weights were likely to be affected, affecting the growth rates as well. In the good husbandry practices, singletons grew faster as was the case of Wedala William`s goat (a farmer) that had a birth weight of 3kg and had a weaning weight of 17 kg at 90-120 days and by 121-150 days it was 21.4 kg.

The study found that the litter size had a significant effect on growth in the first 1-60 days and thereafter it had no significant effect on growth rates of the singles, twins and triplets. As they advance with age, the twins and triplets tend to compensate in accelerated growth over the singles, that is why triplets had a higher body weight gain by 91-120 day period. However the
differences in weight gains between the singles, twins and triplets were not significant. However with good management, goats under poor husbandry practices achieved compensatory weight gain. The compensatory growth was also observed among Mubende goats (Kugonza et al. 2001; Oluka, 1998). Twins and triplets had compensatory growth over that of singles by one year. This was associated with the little size differences at birth enabling the multiple born kids to put on more body mass to compensate for the small body weights at birth. The differences in body weights at birth between sexes and litter size was due to competition for nutrients by fetuses during gestation. Providing adequate and good quality feeding as was the case in the good husbandry practices category along with disease management to the dam during pregnancy and post-natal could narrow this difference. Poor management practices worsen this already appalling situation.

5.5 Disease management
In this study it was shown that those goats under the good disease management practices had a higher growth rate than goats under the poor disease management practices. The increase in body weight gains in the first 1-60 days is a result of passive immunity passed from the dam. The fluctuations in weights are due to seasonal changes in feed availability and worm infestation. This study found that helminths were the most common parasites in small ruminants in the study area. This finding is in agreement with the findings in Northern Nigeria by Schillhorn Van Veen et al., (1974);
Fakae and Nwabusi (2000). There was a high correlation between the level of nutrition and health. Production losses (body weight gains, milk production) were due to scarcity of feed resources and management practices involved (Mack et. al. 1984). This explains the differences in body weight that were observed between those under good and poor disease management practices. Some studies on helminthes infestation in goats support this observation. Ocaido, (1995) reported high helminth faecal egg counts in goats whose feeding practice precluded browse. This is because browse contains condensed tannin (CT) which when fed to goats reduces GIT helminthes load burdens. Niezen et al. (1998) reported that feeding of lamb; with forages containing condensed tannins reduces GIT burdens. Urquhart, et al. (1988) found that goats precluded from browsing and left to derive their food intake entirely from pasture suffered more severe helminth infestation in the tropics and sub tropics. It is therefore advisable to feed goats with condensed tannins containing browse to reduce nutritional stress, which too reduces on undernourishment and its associated effects of weight loss and poor growth rate. Mineral supplementation is also required especially in highland areas where selenium is reported to be highly deficient (Kelly, 1984). Wesongah et.al., (1994) found that parasites affecting goats were helminths, cowdria ruminatium, ticks and Trypanosome spp. This study recommended a strategic 3-4 weeks anthelmintic administration into the rains and a good tick control programme of spraying at least once every two weeks and individual treatments for trypanosomisis. Mdachi (1994) and Pevegriene, (1994)
reported that chemotherapy is the most common method of controlling parasitic diseases such as gastrointestinal helminths. They further stated that helminths were the major hindrance to livestock industry and that frequent use of veterinary drugs in livestock led to the development of drug resistance under natural conditions. Disease management practices did not (p>0.05) affect the growth rate in the days 1-60 but significantly (P>0.05) affected the growth rate for the period 61-240 days. This calls for improvement in husbandry practices especially in feeding as it enhances the immunological system for protection of goats against disease. It is envisaged that improving productivity by improving management practices such as disease control will inevitably alleviate the prevailing poverty through increased household incomes.

In this study it was shown that, the 75% Toggenburg crossbred goats, weaned earlier than the F₁s with a higher weaning weight and a higher post weaning weights. The SEA had the least weaning weights because all of them were poorly managed. Other studies on health condition in goats also showed that worm infestations were identified as a big problem by 78.6% (Kabagambe et al., 1998). This study was at Mt. Elgon goat areas where the majority of goat farmers practiced average or poor disease management practices.
5.6 Effect of season on growth performance of Toggenburg crosses with Small East African goats.

In this study it was shown that there was a positive relationship between the growth performance of goats and the season, indicated by higher mean body weights in the wet season than in the dry season. This was attributed to abundance of good quality feeds in the wet season. Similar results were also found by Das et.al., (1989); Udo et al., (1991); Das, et.al., (1996); Oluka, (1996) and Kugonza, (2002). As a management practice, it is advisable to have a higher feeding regime during the last half of gestation to improve on foetal weights and enhance postnatal feeding to the dam to obviate nutritional stress arising from the loss of nutrients in milk production, which is necessary to enhance the pre-weaning growth rates. Early pre-weaning period is a test period to withstand aggregate effect of environmental and genetic factor.

In this study, it was found that the feeding management under good management was improved by feeding a mixture of elephant grass with natural and established legumes (as cut and carry feed) and supplementation of occasional maize bran to the kids and the dams. The supplementation in critical periods as it usually occurs in the dry season and at peak rainy season has alleviated feed shortage and its negative effect on growth. Peacock, (1982); Naik et al., (1985); Abuine, (1992); Das et al., (1996) also found pre-weaning weight of kid was affected by season related to availability of quality herbage to the dams.
CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusions

1. Goats under good housing, feeding and disease management practices exhibited a higher growth rates than those in the average and poor housing, feeding and disease management practices. These husbandry practices interacted with genotype to influence the growth rates of the goats.

2. Under neonatal and postnatal care, kids born and raised under poor husbandry practices of housing, feeding and disease management, severely suffered from parasitism, of which helminths and nutritional stress affected their growth performance. Those affected were mostly the pure Toggenburg and their crosses.

3. The 75% Toggenburg crosses weaned off earlier than the F1s and had a higher live body weight under good management.

4. Crossing of the Toggenburg dairy goat breed with the indigenous SEA goat meat breed produced crossbreeds that had better growth rates, than the SEA goats. The growth rates of goats achieved at the farms were comparative to growth rates at on-station implying that community based breed improvement programmes can be successful.

5. Selection decision can be made based on the phenotypic characteristics of the 75% Toggenburg crosses. This is one of the contributions this research has made.
6.2 Recommendations

1. Cross breeding programme of the pure Toggenburg and the Small East African goats to obtain 75% stabilised crosses should be encouraged to avail cheap goats of better genetic production potential for the rural farmers.

2. Farmers should be sensitized and encouraged to adopt good husbandry practices (good housing, good nutrition and health care) for their goats.

3. If improved livestock productivity is to be achieved, alternative and cheaper supplementary feed resources available in Mountain Elgon area should be sought.

4. The productivity of goats could be improved by feeding them with Browse supplements obtained freely from the farms. Browses are known to be good sources of protein, vitamins and minerals.

5. Identification of browses feeds available in each locality and management system, and understanding their nutritive potential and influence on animal performance, so as to integrate them in the proper feeding of goats and other ruminants is therefore essential.

6.3 Areas for further research

1. Feeding and nutrition are very central as a management factor to the eventual productivity of the goats; it is therefore highly recommended that research in providing year round feeds is important. This calls for
analyzing the nutritional values of the specific feeds available in the area, biomass determination (yield), frequency of cutting, height at and of cutting, grass /legume mixtures and other factors affecting yield and nutritional values of forages should equally be assessed.

2. Appropriate technologies of fodder conservation should also be developed that will comfortably suit the smallholder farmer away from undertaking the conventional underground huge and expensive silos.

3. On-station trial experimentation should be carried out on growth performance of the Toggenburg and its crosses with the Small East African goat for comparison with on-farm results.
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APPENDIX II: MAP SHOWING THE GEOGRAPHICAL STUDY AREA
APPENDIX III: MAP OF MBALE DISTRICT SHOWING THE STUDY AREA

Arrow shows the study area