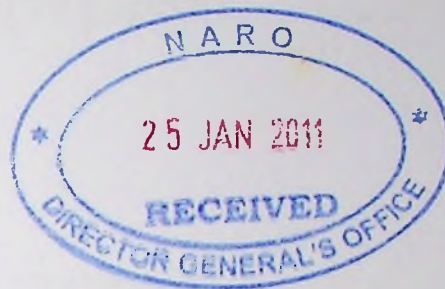


**PRODUCTION, BREEDING PRACTICES AND PHYSICAL TRAITS OF
ECONOMIC IMPORTANCE IN UGANDAN GOATS**

BY

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B.V.M (Mak)

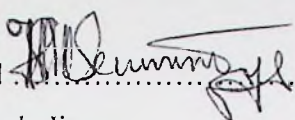


**A THESIS SUBMITTED IN PARTIAL FULLFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN
ANIMAL SCIENCE DEGREE OF MAKERERE UNIVERSITY**

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DECLARATION

This thesis is my original work and has never been presented for any degree in any other university for an award.

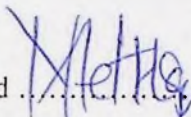
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DEDICATION

This work is dedicated to my dear parents, Mr and Mrs Semakula, my brothers and sisters.
May the almighty God bless you abundantly.

ACKNOWLEDGEMENT

This work has been supervised by Dr. D. Mutetikka and Dr. D.R. Kugonza. I sincerely thank them for the constructive criticism through out the study and their commitment in reading and correcting several drafts of this work.

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Last but not least, I thank the almighty God for the gift of life and the courage to move on when it seemed impossible.

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ABBREVIATIONS AND ACRONYMS

AGDP:	Agricultural Gross Domestic Product
ANOVA:	Analysis of variance
BL:	Body Length
CD:	Chest Depth
CD:	Chest Depth
CL:	Corpus Length
df:	Degrees of freedom
GDP:	Gross Domestic Product
GLM:	General Linear Model
HBW:	Hip Bone Width
HG:	Heart Girth
LBW:	Live Body Weight
MAAIF:	Ministry of Agriculture Animal Industry and Fisheries
NARO:	National Agricultural Research Organisation
NGO:	Non Government Organisation
R ² :	Coefficient of determination
RH:	Rump Height
RH:	Rump Height
SAS:	Statistical Analysis Systems
se:	Standard error of the mean
SEA:	Small East African
SRNET:	Small Ruminant Network
SSA:	Sub-Saharan Africa
SW:	Shoulder Width
WH:	Wither Height
ILCA:	International Livestock Centre for Africa
WAD:	West African Dwarf
AnGR:	Animal Genetic Resources
FAO:	Food and Agriculture Organization
UBOS:	Uganda Bureau of Statistics
IAASTD:	International Assessment of Agriculture Science and Technology for Development

GPA: Global Plan of Action
NARO: National Agricultural Research Organization
ILRI: International Livestock Research Institute

ABSTRACT

Two studies were conducted in the districts of Sembabule, Soroti and Arua in Uganda to characterise the goat production and breeding practices and to determine the variability in body measurements. In the first study a survey of goat farmers was conducted to collect information on production and breeding practices from 160 goat owners in one-visit-interviews. In the second study, data on Live body weight (LBW), Corpus length (CL), Height at withers (WH), Height at rump (RH), Heart girth (HG), Shoulder width (SW), Hip bone width (HBW) and Chest depth (CD) were collected from Mubende (n=198), SEA/Teso (n=188) and SEA/Lugware (n=188) goats kept by traditional farmers. The data were classified on the basis of breed, age, sex and coat colour pattern and regression analysis was carried out for LBW with all the linear body measurements.

More than 57 % of farmers in Sembabule showed livestock as their main activity, while all (100 %) in Soroti and Arua indicated mixed crop-livestock as the main production system. Goat keepers were generally sedentary with small flocks with isolated cases of semi-nomadic and/or transhumant farmers in Sembabule. In Soroti and Arua, management system was tethering in the cropping season with free range during the non-cropping season. Over 80 % of all the farmers gave supplements in form of crop residues mainly in the wet season. All provided water, mainly from spring wells and dams for Sembabule with maximum walking distance being 2 km for Soroti and Arua, and 4 km for Sembabule. Provision of salt was minimal. Women and children played a substantial role with regards to routine management activities but have little control on decision making. More than 75 % of farm labour was provided by family members while all capital to run the farm activities was from personal savings. Goats were mainly acquired by buying while removal was by selling. Goats have multi-functional roles, though mainly kept as a regular income source in all the three districts. Over 97 % of the farmers reported incidences of disease, especially respiratory disease,

helminthosis and tick-borne diseases. There was a wide coverage by veterinary services (100 %) across all districts. Mating was generally natural and uncontrolled. In each village, less than 20 % kept their own bucks. Breeding does were selected mainly because of performance, birth type and body size while bucks were chosen mainly on the basis of growth rate and body size across all districts. There seems to be a non quantifiable level of inbreeding depicted by the long duration (up to 4.0 years) buck owners take with their breeding bucks, coupled with poor record keeping. Tolerance to disease was the only adaptive trait merely reported as a little considered trait, as they tended to consider such traits as naturally given to indigenous livestock. Although majority of the goats kept were indigenous, there appears a clear trend from pure indigenous towards cross-breeds.

Breed, Age and sex significantly ($P < 0.05$) influenced all the body measurements. Coat colour pattern had no significant ($P > 0.05$) influence any measurement. Older animals were superior ($P < 0.05$) to the young ones in all measurements. In all age groups, sex significantly ($P < 0.05$) influenced live body weight and linear body measurements with males showing superiority. All measurements were significantly higher for the Mubende goats ($P < 0.05$) implying that this breed is bigger than SEA/Teso and SEA/Lugware. All linear body measurements and live body weight were highly ($P < 0.001$) and positively correlated for all ages except for the group with two pairs of permanent incisors. From the regression analysis, live body weight could be predicted with accuracy from some linear body measurements especially; heart girth, height at withers, corpus length and rump height.

It can be concluded that goat production in Uganda is still subsistence and that linear body measurements can be used to predict the live body weight of goats. Any programmes intended to actively and sustainably utilize and improve indigenous goat production levels should consider farmers as the first stakeholders.

CHAPTER ONE

INTRODUCTION

1.1 Background

In Uganda the livestock sub-sector is dominated by mixed farming smallholders and pastoralists who own over 90 % of the goats and almost all the small ruminants and poultry. It is this group of farmers who produce the bulk of the milk and meat for commercial and domestic consumption. At the national level, livestock are a major component of the Agricultural GDP, contributing 17 % and about 7 % of national GDP (UBOS, 2008). This excludes the contribution of livestock to the national economy in terms of draught power and manure (MAAIF, 2002).

Goats (*Capra hircus*) are important animals in the diversity of livestock production and are an integral part of tropical agricultural systems (Banerjee *et al.* 2000). The goat was among the first animals to be domesticated by humans about, 9,000 years ago (Coffey *et al.* 2004). Together with sheep they are known to survive in the marginal and drier areas of the world with considerable performance. Worldwide, goat meat production is higher than meat from goats or swine (Holcomb, 1994). Goats are adapted to the existing production constraints such as regular feed shortages (poor grazing areas) without compromising biological efficiency, because they are usually more proficient than other species at selecting the most nutritious parts of the plant (Hart, 2001). The productivity of indigenous breeds is low when compared to improved breeds, but they are much easier to manage, have ability to survive and perform a range of functions for their owners (LPPS and Köhler-Rollefson, 2005).

Of the world goat population, about 52 % are found in the developing countries of the tropics (FAO, 2003). Production of goats in developing countries is growing substantially (Morand-

Fehr and Boyazoglu, 1999). Goat numbers are growing fastest in the mixed farming system, and most rapidly in the humid/sub-humid areas (de Haan *et al.* 1996). Worldwide, about 26% of all goats are found in sub-Saharan Africa (FAO, 2003). It is estimated that Uganda has 8.1 million goats of which only 3.9 % are exotic types and the rest (96.1 %) are either pure indigenous or crossbreds with no clear distinction especially with crossing at lower levels (UBOS, 2008).

Globally the demand for animal products as well as higher standards to improve the quality and safety of the products in human diet will continue to increase (Seré *et al.* 2008). The main drivers of this dramatic increase in consumption of animal products are; economic development, population growth, urbanisation and changing patterns of consumption especially in the developing world a process termed as “livestock revolution” (IAASTD, 2007). In SSA small ruminants constitute more than 60 % of total livestock wealth (FAO, 2007). The annual livestock growth rate of production through 2020 was projected to be 0.7 % or less for each of the major livestock food commodities other than poultry in developed countries and 2.7 % for meat, and 3.2 % of milk in developing countries (Delgado *et al.* 1999). According to IAASTD (2007) consumption per capita of milk and meat is currently between two and four times higher in industrialised than in the developing world but, in absolute terms, demand is higher in the developing world. Contribution from sustainable increase in livestock production would thus be desirable in order to meet the demands of the soaring human population on the livestock populations and their products. The projected increased demand for livestock and livestock products in the developing world calls for the development of strategies of prudent management of animal genetic resources and for a strong and dynamic research system to develop and disseminate technologies that will sustain the increased demand.

1.2 Problem Statement

Many developing countries have responded to the pressure to satisfy the animal protein demand by setting up strategies and policies to use exotic breeds raised as straightbreds or utilised in crossing with indigenous breeds (Scherf, 2000). This is because low genetic potential among indigenous tropical goats is often assumed and breeding plans to replace these breeds by exotic breeds, or to cross them with exotic germplasm are often implemented unsystematically (Baker and Gray, 2003). This constrains farmers in the sense that they are forced by economic pressure to adopt germplasm for short-term benefit without properly accounting for longer-term sustainability (Kiwuwa, 1992). These breeds grow quickly and produce much milk, but they rely on good-quality feed and a constant flow of medicines to maintain their health. Further more the gene pool of high-performance breeds is becoming ever shallower: because of intensive selection, artificial insemination and other breeding techniques which have squeezed most of the diversity from these breeds (LPPS and Köhler-Rollefson, 2005). The biggest risk is the wiping out of such uniform herds in case of a disease catastrophe.

Other threats to indigenous genetic resources include; agricultural intensification, establishment of protected areas, lack of market demand, disappearance of traditional livelihoods, coupled with loss of indigenous knowledge and institutions and political conflicts and boundaries (FAO, 2008). These have also posed a threat of irrecoverable genetic erosion or even extinction (LPPS and Köhler-Rollefson, 2005). Of the world's livestock mammals, over 900 of 5330 breeds are extinct, and another 1500 breeds are thought to be endangered (Geerlings *et al.* 2002).

A number of opportunities exist to improve productivity, adaptation and welfare of indigenous animal genetic resources through within-breed selection (Njoro, 2001; Ayalew *et al.*, 2003; Baker and Gray, 2003). In Uganda recent efforts (Oluka, 1999 and Kugonza *et al.* 2001) have shown that improvement by selection of Ugandan goats is practical. However, these studies were only limited to Mubende goats and are only oriented to increasing productivity with little on characterization. Generally there is limited information on the characteristics of the indigenous goats in various systems. This coupled with the raging threats to indigenous genetic resources; pose a danger of losing pure breeds before actually being properly characterized.

1.3 Justification

The real value of indigenous breeds is often under-estimated mostly due to their poor appearance and relatively low productivity. Developing countries in most cases opt for exotic breeds to increase animal productivity through crossbreeding or if conditions allow by breed substitution without properly investigating the production potential of the indigenous breeds (LPPS and Köhler-Rollefson, 2005). There is an apparent lack of information regarding identifying production problems, possible intervention and performance of animals within the existing production systems to properly utilise the available genetic diversity to enhance production (Peters, 1989). This is particularly true in developing countries where breeds or types of livestock have not yet been fully identified and characterised, despite the fact that the indigenous breeds endure and produce under hostile environments and limited availability of feed.

Currently there is an understanding that introducing high-yielding breeds of livestock and specialised modes of production can lead to loss in genetic diversity among indigenous

animals (Seré and Steinfeld, 1996; LPPS and Köhler-Rollefson, 2005). However, in developing countries, the less intensive production systems are the mainstay of the existing species and breeds. It is, therefore, necessary to evaluate existing livestock genetic resources from a standpoint of bio-diversity and from the standpoint of matching available genotypes with the environment under which they are maintained.

For sustainable use, development and conservation of animal genetic resources, it is essential that the breeds are first identified and adequately documented, and the communities which keep the animals participate fully in conservation efforts (LPPS and Köhler-Rollefson, 2005). The Global Action Plan and the Interlaken declaration (FAO, 2008) point out four strategic areas in the animal genetic resources namely; (a) Characterization, Inventory and Monitoring, (b) Sustainable Use and Development, (c) Conservation, and (d) Policies, Institutions and Capacity-building.

The steps involved in the design and implementation of a breeding programme according to Baker and Gray (2003) include: a good understanding of the production systems and the relative importance of the different constraints in these systems; clear definition of the selected breeding goals supported by farmers; an accurate method of identifying and selecting superior genotypes and practical schemes which allow the superior genetic material to be used advantageously. For small ruminants, this can be achieved through, a comprehensive collection of information on the breeds or types to be improved in terms of the identified production parameters.

The information generated through this study will contribute to the proper characterization and evaluation of Mubende and Small East African (Teso and Lugware ecotypes) goat breeds

under different management systems to estimate performance abilities and improvement potentials. This will also be utilized by policy makers, plan better methods of increasing livestock survival and productivity by designing suitable breeding programmes and conservation strategies for some indigenous small ruminant breeds with desired characteristics preferred by farmers in the specific environment in Sub-Saharan Africa, notably Uganda on a sustainable and cost effective manner.

1.4 Main objective of the study

- To contribute to the genetic merit of Ugandan goats, through phenotypic characterization

1.5 Specific objectives of the study

- To evaluate the goat production and breeding practices by farmers in Humid, Semi-Humid and Semi-Arid ecological zones in Uganda
- To determine the variability in body measurements of Mubende and Small East African goat breeds

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of small ruminant genetic resources

2.1.1 Economic importance

Globally small ruminants make a substantial contribution to the well being of the people through the supply of meat, milk, fibre, pelts draught power, manure and cash (de Leeuw and Rey, 1995; Coffey *et al.* 2004). It has been reported that more profits are realised by farmers who keep animals for duo-purpose objectives than those with single purpose. (Kahi, 2000). Land grazed by both goats and goats is said to give more returns than land grazed only by goats (Hart, 2001). According to UBOS (2008), small ruminants are a source of protein and financial security to many families in Uganda. Goats' meat contributes about 14.4% of the total meat production in Uganda and is ranked second after cattle meat. In pastoral production systems in Kenya, goats are usually the only source of milk available for households in the dry season when both sheep and goats have migrated (Little, 1982). In Teso region of Uganda, farmers' revenue from goats was higher than that from other agricultural products with the exception of cotton and cattle where these were part of the households' activities (Kyeyune-Sendagi, 1970).

Because of their small size, goats provide more convenient sources of meat than goats (Bayer, 1982). It is generally more apt to slaughter a goat or a sheep to feed community members engaged in communally private field work than a cow. Likewise, while a 10 to 15 kg small ruminant carcass is easily handled by a rural household for either home consumption and/or sale without means of preservation, slaughtering even a steer (when it is available) for the same purposes is generally unpractical and uneconomical and is therefore a rare event. The health food sector prefers goat meat because of its superiority in terms of protein, fat and

calorie content, and potential use as therapeutic aids in diseases, including cardiovascular diseases (Gibson, 2002).

Where access to cash is limited and livestock marketing is not organized, small ruminants are directly exchanged for grain. Little (1982) observed that in remote areas of Kenya, up to forty per cent of local grain needs may be met by direct exchange of goats and sheep during the dry season. Small ruminants are often slaughtered in honour of a special guest, a visiting friend or relative, for festivities and religious rituals.

Small ruminants are also kept by poor rural households for ready cash income to meet immediate needs such as acquiring agricultural inputs, paying school fees and purchasing larger animals such as goats. In Uganda, a landlord may sell some part of his land to landless people in exchange for goats (Okello, 1985). In time of cash crisis, rural households find it easier to find a buyer for a goat or a sheep than goats. More importantly, small ruminants play a key role in stock association building between non-household members in rural areas. Little (1982) reported that destitute pastoralists in Kenya may call upon stock associates for food assistance or for rebuilding their herds after calamities. This is also true of farmers in Uganda (Okello, 1985), where small ruminants serve as a means to cement family relationship or social links which is extremely important for assistance in time of crisis.

Despite their relatively low productivity due to genetics or environmental constraints or both, goats play an important role in the agricultural economy of sub-Saharan Africa. Local livestock populations have adapted to the various ecological niches, thus, a large variety of regional breeds or types exist (LPPS and Köhler-Rollefson, 2005). They play a very important

economic role particularly in regions where subsistence farming is practised due to the limitations in input supply capability in such systems.

Effective livestock improvement can be attained by effectively using the animals already adapted to a particular environment. As defined by Terril and Slee (1991), adaptability is the ability to survive and be productive under whatever environment or combination of environments at which the animals are maintained. Breed comparisons of adaptability and productivity should therefore be done in comparable conditions pertinent to the prevailing production environment. The identification of adapted breeds, which are relatively superior in important productivity indices provide means of enhancing production at no additional input costs. However, there will always be a need to address the whole question of the relationship between the nature of the production environment and the objective of breeding programmes in the context of the level of production and adaptation.

2.1.2 Other roles of goats

Other than providing meat, milk, hair and skins, goats are valued for other functions that are worth mentioning especially in the context of their role in agricultural systems (Dossa *et al.* 2007). They are important means by which farmers earn supplementary income and accumulate capital. Goats create employment particularly for the landless peasants (Peters, 1988).

Goats are also used for performing cultural ceremonies like offering sacrifices and marriage. The waste and by-products of these animals such as dung and urine contribute to soil fertility. They act as insurance against crop failure in marginal cropping areas. Goats also assist in the economic utilization of non-marketable crop residues, by adding value to them (Peters, 1988).

The use of goats for controlling brushy and weedy species of vegetation has been documented though still underutilized in many communities (Hart, 2001). This biological means of controlling weeds should command a greater role especially in the light of increasing environmental concerns and increased costs of mechanical and chemical control methods.

2.2 State of world's goat genetic resources

There are nearly 746 million goats in the World (FAO, 2003). Goats together with the other classes of livestock make a substantial contribution to the well being of multitudes of people around the World in the form of meat, milk, fibre and skin. However the relative importance of the different breed categories may vary (FAO, 2008). Goat production contributes substantially to the agricultural economy of Sub-Saharan Africa and their role is more prominent in developing countries than in developed ones (Seré *et al.* 2008). Despite their role, the genetic diversity for many indigenous goats is faced by a number of threats which could lead to their possible genetic erosion. According to (FAO, 2008) these threats are; (i) globalization, intensification and mechanization , (ii) Changing cultural practices, erosion of customary institutions and social relations, (iii) Population pressure, loss of access to resources, overgrazing, resource degradation. LPPS and Köhler-Rollefson (2005) further elaborated these threats as:

Breeding programmes, by both governments and non-government organizations, have favoured the use of exotic breeds for crossbreeding, upgrading, or replacement. Although such programmes often fail to achieve their objectives (unless a stable supply of high inputs can be arranged) they have led to the dilution of indigenous breeds.

Wildlife sanctuaries, national parks and other types of protected areas almost always deprive livestock keepers of their pasture. Combined with efforts to persuade farmers to adopt high-input breeds, this contributes to the pressure on local breeds. The Ankole cattle have been greatly affected by the establishment of Mburu National park, in Uganda. Examples outside Uganda include the Kumbhalgarh Sanctuary in Rajasthan (which impinges on Nari goats and Marwari camel) and the Grizzled Grey Squirrel Sanctuary in Tamil Nadu (which causes problems for the Malaimadu goats breed) (Vivekanandan and Paulraj, 2002).

Replacement of bullocks by tractors is a prime cause for the gradual extinction of many of the famous Indian draft goats breeds, including the Nagori goats.

Making a living from keeping livestock is hard work that ties people down day in and day out. Many young people succumb to the attractions of city life. Animal-handling skills can disappear very quickly, within one generation. Village based breeding institutions, such as keeping a community bull, also deteriorate rapidly once economic returns are not sufficient or social networks break down. Once such institutions have disappeared, they are very difficult to resurrect.

Warfare has contributed to the disappearance of indigenous breeds. Moreover, new boundaries, such as the Indo-Pakistan border, also disrupt migration patterns and undermine animal-dependent livelihood strategies. This has affected the Tharparkar breed (Köhler-Rollefson, 2000).

2.3 Livestock Production systems

World wide, there are broadly three livestock production systems according to Sere *et al* (2008). Basing on the level of inputs, intensive and high-external input livestock production

systems are termed *industrial systems*, those based on relatively low investment inputs are *pastoral* and *crop-livestock systems*. Ssewanyana (2004) identified three types of systems in Uganda, based on the extent of inputs and outputs. He however, under scores two as the main important which are: the traditional system, with minimal input and correspondingly low outputs which depends on natural grazing and local breeds, and the improved systems which have some investment such as fencing, pasture and grassland improvement, provision of water and breed upgrading.

2.3.1 Crop-livestock (agro-pastoral) production systems

This is prevalent in humid, sub-humid and highland agro-ecological zones where goats are kept by smallholders and graze together with sheep and/or other livestock. Here goats are said to complement cattle or sheep rather than compete with them for feed, because of their ability to browse on a variety of plant species (Lebbie, 2004). Crop-livestock mixed farming systems comprise sedentary smallholder farmers carrying out mixed crop and livestock farming concurrently as the main activity. In the developing world, the mixed farming systems contain about 64% of the small ruminants of the world (de Haan *et al.* 1996). Goat and sheep numbers are growing fastest in the mixed farming system and most rapidly in the humid/sub-humid areas underscoring how human population pressure is reducing farm size and access to and use of resources (de Haan *et al.* 1996).

In the tropics the crop-livestock mixed farmers are found mainly in the medium-high potential areas (Rege, 1994) and they own small sizes of land. The animals are confined to small areas for feed (Gatenby, 1986). In some cases stall feeding, where grass is cut and carried to the animals is practiced. Stallholder farming is livelihood oriented. Unlike commercial farmers, smallholder farmers tend to keep animals for family needs, rather than purely as an economic

enterprise. Animals have intangible roles to the farmers (e.g. insurance, cultural and prestige, ceremonial and savings) and farmers expect their animals to fulfil these traditional functions (Ayalew *et al.* 2003).

Survival of the animals in face of many stresses (Heat, parasites and diseases and poor nutrition) is one of the most important traits, while increasing growth rate is of less value (Solkner *et al.* 1998). It is important to note that matings within smallholder flocks are largely uncontrolled and organized mating would naturally demand labour, which is a serious problem at the time of land preparation for sowing or harvesting of crops (Gatenby, 1986). In addition farmers may be keeping a mixture of breeds and would be difficult to sort out animals for pure breeding.

2.3.2 Pastoral and Agro-pastoral production systems

Pastoral and agro-pastoral farming systems are found mainly in the medium-to low potential areas where crop production is difficult due to low rainfall and high evapo-transpiration. In these areas livestock forms an integral part of socio-cultural life of the people. Pastoral farmers rely on livestock as the main source of livelihood and usually own relatively large numbers of animals under extensive or communal grazing and management. Most of the livelihood is derived from livestock use and sales or exchange (Wurzinger *et al.* 2007). The animals thus have to fit into the production system. Nomadic life, low productivity and over grazing are common features of pastoral systems especially in the arid areas.

In recent times pastoral communities, especially in the medium potential areas have changed a lot and are now tending towards sedentarized agro-pastoral systems compared to previously when they purely kept livestock (Coppock, 1994; Seré *et al.* 2008). Encroachment of crop

farmers from other communities and adoption of crop-based foods by the pastoral communities, are now evident in some areas of the tropics.

Risk avoidance is an important integral part of breeding objectives in the marginal areas (Sölkner *et al.* 1998). Due to the fluctuating harsh environment, both individual and flock survival rate are important. The farmers adopt a two-pronged approach. First in addition to stock diversification (Adams and Kaufmann, 2002; Seré *et al.* 2008), pastoral communities use mobility to encounter problems of uncertainty in the timing and distribution of rainfall and availability of forage and incidence of diseases (Adu and Lapkin, 1988). Secondly, farmers use adapted breeds that survive and thrive in the environment (Mason and Buvanendran, 1982). Thus survival (e.g. pre-weaning, post-weaning and adult animals) traits and reproductive traits (e.g. litter size and kidding frequency) are important in this system many of the pastoral communities have their own breeding methods (Gatenby, 1986) and have different sets of cultural and social values used to judge, appraise and decide on animals used to breed (Sölkner *et al.* 1998).

2.3.3 Dynamics of livestock production systems, drivers of change and prospects for animal genetic resources

Production systems have evolved over time to suit the agro-ecological zones and the socio-economic setting. A number of factors are cited as being responsible for this according to Seré *et al.* (2008). These include; (i) economic development and globalization, (ii) market demand for livestock products due to “*the livestock revolution*”, (iii) environmental effects of livestock production and (iv) science and technology drivers of change aspects in relation to animal breeding and genetics.

2.4 Distribution, ownership and flock size of small ruminants in Africa

The distribution of goats and sheep in Africa is not even, and the numbers tend to be higher in the drier areas. Consequently, flock sizes are larger in the drier than the humid areas. Therefore in some areas, e.g. in West Africa, flock sizes decrease from north to south (Otchere *et al.* 1985). In East Africa flocks are smaller in the highlands compared with the lowlands (Wilson, 1982). Flock sizes are also said to be larger in the pastoral and smaller in the humid agricultural regions (Bayer, 1984). In Uganda, the majority of small ruminants are owned by individuals or families in the rural settings and the number per group is very small (Okello and Obwolo, 1984). According to (Sumberg, 1985) the small flock size appears to be typical of sheep and goat production in developing countries and is comparable to flock sizes of 3.5 goats and 2.5 sheep in Southern Nigeria. Wilson (1983) states that there is a tendency for larger numbers in mixed flocks as compared to sole individual species. Females seem to dominate their male counterparts in most flocks. Malata and Banda, (2009) reported that farmers tend to keep more females than males in Malawian communities. According to Wilson (1983) females make up more than two-thirds of most small ruminant flocks with as many as 80 % of the females in derived savannah areas and 83 % in true forest areas. Small stocks nevertheless form an integral part in the farming system (Wilson, 1982).

In many African countries goat husbandry appears to be more casual rather than an organized activity. This is because: (a) animals have no benefit of prophylactic or curative medicinal treatment; (b) little or no supplementary feeding is offered; (c) bad flock management is being practiced; (d) poor housing; (e) tethering of animals during the planting season so as to avoid crop damage (Otchere *et al.* 1985). He further asserts that the above criticism will seem to apply to all small ruminant production in traditional systems throughout the tropical Africa. According to Wilson (1982) however, Africans who keep small flock rarely do so for

irrational reasons and that such reasons are perfectly in keeping with the problems encountered and the specific objectives of the owner.

2.5 Goat productivity in tropical Africa

Small ruminants are widely distributed and are of great importance as a major source of livelihood of many smallholder farmers and the landless in the rural communities in tropical Africa. Indications however suggest that the productivity of small ruminants in this system is low and that there is ample opportunity for improvement especially under improved management. According to (Oluka, 1999) through supplementally feeding, body weights of up to 50 Kg can be realized in Mubende goats.

Age at first parturition, parturition interval and litter size determine lifetime productivity as well as efficiency of production. Genetic improvement and or efficiency of production can be more easily ameliorated in small ruminants because they have a faster population turnover rate. Such progress would be achieved if increased selection pressure is effectively applied. Several of these production parameters can be improved because they are under the influence of the environmental and ecological factors. Kakusya (1976) suggested that reproductive efficiency of small ruminants in tropical Africa is reasonably high and hence fertility enhancement would not be recommended for improvement unless present nutritional, health and management constraints are removed.

2.5.1 General management and nutrition

Small ruminant production in Africa is not well developed. The fact that holdings are small seems not to give owners incentives for improved husbandry practices. In arable cropping

areas, small stocks are tethered during the cropping season in an attempt to prevent crop damage (Okell and Obwolo, 1985; Ssewanyana *et al.* 2004).

In sub-Saharan Africa, the main source of livestock feed is grazing on natural pasture which mostly suffers from seasonal variations both in quality and quantity. This may be the most important constraint to livestock production and reproduction in traditional systems where the low economic input to the system is evident. It is normally reflected in reduced live weights, perpetual low animal productivity, greater age at first parturition, increased parturition intervals, prolonged non-productive life and high mortalities. In most areas, natural pastures are the major feed resource and its utilisation is through continuous grazing while thickets provide the meals for browsers (Rege, 2001). This could be due to the shortage of herding labour as farming activities are at their peak. Moreover, tethered animals are able to obtain sufficient access to pasture during this period of the year. Tethering allows better control of animals that could otherwise stray onto other people's farms.

In northern Nigeria, Adu and Ngere (1979) described a compound system practiced by Hausa who are settled and keep their small stock tethered in their compounds and feed them silage in the rainy season. Elsewhere the Fulanis in Giwa district of Nigeria allow sheep to accompany goats for grazing but tethered their goats under shelter (Otchere *et al.* 1985). These goats were fed cut-and-carry green forage in the rainy season. They further explain that the general consensus is that, after crops have been harvested; small flocks are let loose to feed on crop residues.

Improved animals nutrition appears to be more critical in increasing small stock productivity. Native rangelands provide the cheapest source of nutrients for ruminants. It is however an

accepted fact that for a greater part of the year, grasslands in the tropics do not provide sufficient nutrients to stock for greater productivity (Gatenby, 1986). However, supplementation of natural forage with agro-industrial by-products cannot be overemphasized since not all of them are well balanced with nutrients.

Feed conservation is commonly practiced in the form of crop residues (cereal straws) and hay, from native pastures. These conserved feeds are fed to animals during the dry season, to work oxen during the cropping season and to in-calf and lactating cows. Supplementation of the indigenous breeds using high energy and protein concentrates is rarely practiced in the rural areas. Equally rare is the provision of mineral licks as part of livestock diets, so animals have to exploit various natural salt deposits that exist in the grazing fields.

2.5.2 Breeding management

Availability of animals with good genetic potential is a constraint to improved productivity of small ruminants in the tropics. There are a large proportion of extensive farmers with flocks of indigenous breeds which provides a potential for good genetic material. According to Kosgey (2004), majority of the farmers in the tropics acquire their males through inheritance and rear them for breeding purposes or buy or borrow them. He further asserts that natural uncontrolled mating in traditional farming systems is predominant compared to artificial insemination. This coupled with the small flock sizes in smallholder production, as reported by Seleka (2001), increases the level of inbreeding. Communal herding which allows the mixing of females with males from different flocks, can minimize inbreeding (Jaitner *et al.* 2001), but this appears to be rarely practiced among farmers in the tropics (Kosgey, 2004). Another remedy for controlling inbreeding is not to keep the breeding male for long. According to Kosgey (2004) and Ssewanyana *et al.* (2004) some breeders in the tropics are

reported to keep their males for up to 4-8 years which may increase chances of males mating with their own offsprings.

2.5.2.1 Selection criteria of breeding stock

Among indigenous livestock populations, little or practically no deliberate selection seems to have been done. According to Srystad (1994), in many temperate breeds, immense livestock improvement through selection has been achieved. Thus, there should also be better prospects for improvement by selection in the tropics. Selective breeding has been pointed out as one of the most important approach which could contribute towards improving production of goats in Uganda (Kugonza, 2002). According to Knights and Knights (2005), regardless of the method of insemination, selection of bucks should emphasize growth rate and muscling, while reproductive traits should be emphasized more in does. This therefore requires a good understanding of the performance parameters in terms of fertility, prolificacy, growth rates, and live weights for breeding. Even if it is generally accepted that cross breeding is at present, the method most likely to rapidly improve the productivity of tropical livestock, selection programmes are still required. Scherf (2000) stated that many countries in the developing world have placed their indigenous livestock populations at risk of genetic erosion/dilution or even extinction through exotic breed importation and/or uncontrolled cross breeding programmes.

In selection of breeding stock, size, and performance and true to breed type are some of the factors considered. In this aspect introduced pure breeds are generally considered better in size, growth rate, shape and fertility than the indigenous ones. However the former are rated poor in terms of draught and heat tolerance, traits that are more important in harsh feed and temperature conditions of the tropics (Ayalew *et al.* 2003). There is a possibility of selecting

for faster growth rate, good size and conformation within indigenous breeds while maintaining the superiority of their adaptability traits.

2.5.3 Reproductive performance of goats

2.5.3.1 Fertility and kidding interval

Devendra and Burns (1970) who defined fertility as the number of services required per conception for the male observed that the parameter is difficult to measure. ILCA (1979) expresses fertility as per cent parturitions per/dam/year while Gatenby (1986) defines it as per cent does kidding of does available for mating. Awotwi and Fynn (1992) express it as the percentage of females giving birth of females exposed to males. A more accurate definition of fertility is probably the number of parturitions per female of breeding age and per specified time period. For sound managerial decision making, annual specification appears to be highly indicated. Where breeding is not organized, as it is the case in most SSA traditional production systems, the average annual number of females of breeding age actually present in the herd should be used. In the continuous breeding system, all females are exposed provided that breeding males are available in the flocks. In the controlled breeding system, only females of breeding age are exposed.

Kyeyune-Sendagi, (1970) stated that fertility estimates averaged at 71.4 % for many goats in Uganda while for the WAD goats in Ghana it was 160% (Oppong and Yebuah, 1981). Data available per ecological zone indicates that fertility ranges are 124-155 % for the humid zone, 80 - 124.5 % for semi-arid zone, 71.4 - 160 % for sub-humid zone.

Kidding interval is defined as the number of days between successive kiddings (Steele, 1996). It is an indicator of reproductive performance and is reported to be affected by nutrition,

suckling, parity of the doe and breed (Banerje *et al.* 2000). Tropical goats are known to generally produce on the average three lamb/kid crops in two years (Devendra and Burns, 1970). For this to be realised, kidding intervals should not exceed 8 months (245 days). In most tropical breeds, kidding interval varies from 180-300 days (Wilson, 1991)

2.5.3.2 Age at first kidding

Where breeding males are available in the flocks, age at first parturition is a good indicator of early sexual maturity in does. It is an economically important trait as greater population turnover and more rapid genetic progress can be obtained when goats and sheep produce their first progenies at an earlier rather than later age. Early maturing females are also known to have a relatively long and fruitful reproductive life. Among the most important parameters affecting age at sexual maturity are genotype and various management components. In SSA, most estimates of age at first parturition are between 303.7 and 555.8 days with Small East African goats of Kenya (Wilson, 1984). However, Peacock (1996) states that many of the African breeds give to their first kid at 12 – 18 months.

2.5.4 Health and Adaptability

Health is still a major constraint to efficient livestock production. Maximum productivity in any given system of production emerges when disease control is optimal (Gatenby, 1986). Therefore health should be considered before genetic improvement programmes can be contemplated. The effect of disease out breaks on goat productivity is emphasized in goats in the tropics (Dossa *et al.* 2007; Kosgey *et al.* 2008). Community based animal health programmes may be one way and wider utilization of indigenous breeds tolerant to diseases another (Baker and Gray, 2004). Recent studies showed the small East African goats to be

more tolerant than the introduced breeds in coastal Kenya (Baker and Gray, 2004). However, farmers do not discriminate between breeds in terms of disease tolerance (Kosgey, 2004).

Although there is sufficient knowledge about the deficiencies and disease problems, the control and prevention effort has been less successful than expected. Among health related problems that are widespread in tropical Africa, helminthosis, pneumonia or respiratory disease and ectoparasitosis are known to seriously affect the productivity of small ruminants (Kosgey *et al.* 2008; Anaeto *et al.* 2009).

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

In most African countries, the annual variation in rainfall and feed availability coupled with seasonal fluctuations in forage availability is highly substantial. This factor is believed to represent the highest check on livestock production and reproduction in the low-input and low-output traditional livestock production systems. In the dry areas, it is often difficult and sometimes uneconomical to make attempts to improve feed resources. It is therefore clear that most livestock production systems in Africa will continue to be primarily dependent on

natural forages. In such circumstances, the extent to which productivity can be improved depends on the ability to identify breeds which are best adapted to the prevailing seasonality and also have the potential of economically important characteristics. Although the available data on indigenous animals studied clearly show their outstanding characteristics for adaptability to harsh environments (LPPS and Köhler-Rollefson, 2005), more efforts must be done to identify and characterise indigenous breeds in terms of best adaptive performance abilities.

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

2.6 Breeds of goats kept in Uganda

Over 99 % of the goat population comprises the indigenous breeds (Ssewanyana, 2004). There are three distinct breed types namely; the small East African (SEA) goat comprising 53.2 % of the total population; the Mubende goats comprising 35.6 %, and the Kigezi goats comprising 11.2 % (Ssewanyana, 2004).

The Small East Africa goats comprise Teso, Sebei, Karamoja and other goat types identified and named according to the communities that keep them, location and farming system (NARO-ILRI-SRNET, 1995). The SEA goats are the smallest in body size with an average body weight of 20 - 30 kg (Devendra and Mcleroy, 1990; Nsubuga, 1996). They are slow growers attaining sexual maturity at about 7 months with weights of 14 - 15 kg when under good management (Katongole and Gombe, 1985). Twinning is said to constitute 5 – 15 % of

births with an average gestation period of 146.5 days while breeding goes throughout the year with 2.3 services per conception per year (NARO-ILRI-SRNET, 1995).

The second type is described as the Mubende goat. Mubende goats are found in the humid southern and central regions and particularly concentrated in the Mubende district where it derives the name, though found in other districts. The breed is however adapted other ecological zones in other districts. This is a large animal of 30 - 35 kg live weight. It is renowned for its popular skin on the international market. The skin is called "Kampala skin" in trade circles (Nsubuga, 1996). This breed is also known for its good reproductive and growth characteristics having a twinning rate reaching 30 % and are able to get adult male and female live weights of 40 kg and 30 kg respectively (Sacker and Trail, 1966) with some males even reaching 50 kg (Okello, 1994). Fecundity rates of 1.5 young per litter with kidding intervals of 300 days have been reported (Mason and Maule, 1960).

The third type falls in between the first two in live weight, 25-30 kg. Its typical ecological niche is in Kabale, Kisoro and Rukungiri in the former Kigezi District of South Western Uganda and is referred to as the Kigezi goat.

The colour of the three types above ranges between pure white to pure black and includes all shades between those two colours. For the three types, the incidence of twinning is rather low, estimated at 30 % (Nsubuga, 1996). Milk yields are sufficient to satisfactorily raise one kid. In case of twins, there is often poor initial growth which points to an inadequate supply of milk. Local goats owned by communities in developing countries are regarded as meat goats because they are not purposely selected in any specific direction and vary much in size and

other physical characteristics but are popularly known as major providers of meat, skins and sometimes fibre to their owners.

There are introduced goat breeds. These together with their crossbreds are estimated at not more than 5,000 in number. They include; Toggenburg, Anglonubian, Saneen, Alpine and Boer breeds (Ssewanyana, 2004).

2.7 Body Morphometric measurements

2.7.1 Importance and application of body morphometric measurements

The outward appearance is of vital importance in indigenous animals as a criteria to characterise and distinguish breeds among livestock keepers and can hint on important differences, which are not obvious to outsiders. It is widely accepted that different breeds have unique body measurements at different ages, which can be used as a basis for characterization of animal breeds or populations (Devendra and Burns, 1970). Although live body weight is an important growth and economic trait, it is not always possible to measure it due to mainly the lack of weighing scales, particularly in rural areas. Thus, under field conditions, measurement of external body features should be simpler and a cheaper means than using weighing scales.

2.7.2 Factors affecting body measurements

A number of authors (Essein and Adesope, 2003; Kamalzadeh *et al.* 1998) have reported that breed, sex, age, type of birth, season of year, plane of nutrition, physiological state of the animal (i.e. pregnancy and gut fill) and permanent environment affect body measurements. Sharma (1977), working with Muzaffarnagari crosses reported that body length, and height at withers were not affected by breed, but that chest girth was. Heart girth among Mubende goats

highly correlates with live body weight, although during pregnancy, accuracy of body weight estimates reduces (Oluka, 1999).

Body measurements in goats are also influenced by sex. Male Mubende goats were reported to have had larger heart girths than females throughout a two year period (Oluka, 1999). Work on Tanzanian goats and their crosses only showed significance of sex on heart girth and body width (Kyomo, 1978) and Abunie, 1992). In Beetal, Red Sokoto, White Sokoto and Borno goats, all values for linear body measurements were higher in males than in females (Hamayun *et al.* 2006; Adeyinka and Mohamed, 2006). For White Fulani and Gudali Zebu cattle, significant variations due to sex were only observed for heart girth (Olutogun *et al.* 2003). However, in WAD goats, females were found to be more superior in live body weight and other linear measures (Fajemilehin and Salako, 2008).

Age and birth type also affect the body measurements. Among Tanzanian goats and their crosses, birth type was a significant factor on heart girth and withers height, where singles were larger than twins when ages were pooled (Kyomo, 1978). Older animals are usually superior in most measurements than young ones. Fajemilehin and Salako (2008) and Hamayun *et al* (2006) have reported variability in body measurements as age increased especially in live body weight.

Physiological state of the animal greatly influences the accuracy of body measurements. Salako (2006), while working on WAD and Yankasa goat breeds suggested that gut fill has an effect on girth. Pregnancy is another obvious factor that affects live body weight (Oluka, 1999).

2.7.3 Linear measurements and their role in assessing animal performance

Linear measurements can be used in assessing growth rate, body weight, feed utilization, and carcass characteristics in farm animals (Brown *et al.* 1973). Linear measurements are divided into skeletal and tissue measurements. According to Blackmore *et al.* (1995), skeletal measurements include all the height and length measurements while tissue measurements include heart girth, chest depth, punch girth and hip width. These body measurements are further subdivided into horizontal measurements like body length, and head to shoulder and vertical measurements like height at withers and chest depth. Indices and/or slopes using body measurements have been used to estimate shape which is usually difficult to quantify due to its subjectivity in comparison with size (Salako, 2006).

2.7.4 Relation between live body weight and linear body measurements

Body weight is a very important parameter in breeding, marketing and veterinary care. To increase meat yield from an animal requires improvement of its live weight. Proper measurement of this trait, which is often hard in villages due to lack of weighing scales (Hamayun *et al.* 2006), is requisite for achieving this goal. The need for estimation of the trait from simple and more easily measurable variables such as linear body measurements therefore arises. Body weight is closely associated with linear body measurements. Any strong relationship between body weight and any other linear body parameters should be exploited to develop simple indicators of live weight. This relationship enables prediction of body weight from body measurements especially under field conditions (Gizaw, 1995; Hamayun *et al.* 1995).

A number of body measurements have been used to predict live body weight. They include: Height at Withers, Heart girth, Body length, Corpus length, Height at rump, Chest depth,

shoulder width, Hip bone width among others (Adeyinka and Mohammed, 2006; Hamayun *et al.* 2006). Body weight of West African Dwarf (WAD) goats has been satisfactorily predicted by using heart girth as the only regressor (Mayaka *et al.* 1995). The possibility of estimating body weight of a large animal from its physical conformation is not new. Original efforts in this regard were put forward by Brody (1945) who developed the following equation to compare live weight and heart girth:

$$W = a X^b$$

Where W is the live body weight, a and b are constants, and X is the linear body measurement. Abunie (1992) further modified the quadratic equation into a logarithmic expression of the form: $\text{Log } W = \text{Log } a + b \text{ Log } X$. In which case by simple regression of log W on log X, both a and b can be estimated.

Studies regarding linear body measurements of goats have been carried out elsewhere in the world and their possible use for estimating the animals live weights (Hamayun *et al.* 2006). In Beetal goats a high and significant correlation between height at withers, heart girth and body weight at 4 to 18 months of age reported (Hamayun *et al.* 2006), suggest that either these variables or their combination would provide a good estimate for predicting live body weight in such goats at an early stage.

Kyomo (1978) working with Tanzanian goats and their crosses found that body weight is more related to heart girth, body length, width and height at withers combined than when each was considered separately. When each measurement was considered singly, heart girth was found to be the most closely related variable to live weight at all ages. According to Berhanu *et al.* (1991) and Mukherjee *et al.* 1986, heart girth was the best predictor accounting for 78 % of the variation in body weight, while body length was the least predictor accounting

for 72 % of the variation in body weight. They further reported that when heart girth, body length, height at shoulders and width at the hind quarter are considered together, 87 % of the total variation in body weight was accounted for. However, Hamayun *et al.* (2006) slightly contrasted the findings when they stated that at later stages (from 19 months and onward) the body length assumes more importance as an indicator of live weight ($r = 0.701$).

However, contrasting findings showed that Height at withers is the best live body weight predictor (Aziz and Sharaby, 1993). It was argued that, it is because height at withers is repeatable and is not influenced by the amount of fat cover. A tendency for body weight-linear body measurements correlation to increase with age was observed by Misra (1980).

Gizaw (1995) found that the relationship between body weight and linear body measurements could be influenced by some factors such as age and conformation of the animal, which in turn depends on level of management. Age dependent sexual differences in body dimensions were also reported by Katongole *et al.* (1996). The accuracy of prediction equations depends on accuracy in taking the measurements, and the sample size used to develop them, considering that small samples may yield equations of less meaning and applicability (Chalya, 1998).

CHAPTER THREE

VARIATIONS IN GOAT PRODUCTION AND BREEDING PRACTICES IN THREE ECOLOGICAL ZONES OF UGANDA

3.1 Introduction

Goats are widely spread in the tropics and are important to the subsistence, economic and social livelihoods of the human population in these areas. Goats are especially important to women, children and the aged who are often the most disadvantaged members of the society in terms of under-nutrition and poverty. The agricultural potential in the tropics varies, and consequently, a wide array of livestock production systems with different production objectives and priorities, management strategies and practices are found (Lebbie and Ramsay, 1999). The major ones in Uganda according to Mbuza (1995) are the smallholders, found mainly in medium-to high-potential areas, who practice mixed crop-livestock farming.

The pastoral farmers are found mainly in the medium to low-potential areas and rely on livestock as the main source of livelihood. In traditional production systems, goats play a big role in providing both the tangible benefits (i.e. cash income from animal sales, meat for home consumption, manure, skins and fibre) and intangible benefits (e.g. savings, an insurance, cultural and ceremonial purposes among others) (Jaitner *et al.* 2001, Dossa *et al.* 2007; Kosgey *et al.* 2008). In addition, goats play a complementary role to other livestock in the utilization of available feed resources and provide one of the practical means of using vast areas of natural rangelands in regions where crop production is impractical (Rege, 1994; Coffey *et al.* 2004). Despite their importance, few studies have elaborated on sustainable improvement programmes for the goats in Uganda and the tropics at large. In addition the relative importance of tangible and intangible benefits is poorly understood.

In a submission to increase livestock productivity and through experience, farmers have come to understand that the best results are obtained by crossing the best local goats with exotic breeds (Kiwuwa *et al.* 1992). This has raised concern over the fate of Mubende and SEA types and efforts for their conservation for both present and future use. This concern is inspired by the fact that the genotypes of the improved indigenous breeds may be required to upgrade or replace low producing goats in harsh nomadic environments where exotic goats cannot survive. Another cause for concern is the fact that the directions of future demand cannot be predicted with any certainty.

Having realized the need to ensure that livestock production becomes more efficient, sustainable and responding to economic pressures, FAO initiated the Global Programme and Strategy for Animal Genetic Resources. The programme aims to overcome the erosion of animal genetic resources through better development and use. Active and sustainable utilization (i.e. in-situ conservation), together with improving the production levels of adaptive breeds are central to the better management/conservation of AnGR (FAO 2007). Therefore, improvement programmes are necessary to increase and sustain the productivity of these goat breeds to meet the demands of the human population.

Most genetic improvement programs tend to focus on single market driven traits such as milk or meat production in isolation from environmental constraints and broader livestock system functions which livestock perform in developing countries (Ouma *et al.* 2005). It is extremely mandatory that farmers get involved early in the process of breed improvement, in order to ensure that their breeding perceptions are taken into account and that they provide the support needed for the programme to work (Dossa *et al.* 2006). In addition, the development of genetic improvement programmes for livestock will only be successful when accompanied by

a good understanding of the production systems and when simultaneously addressing several constraints - e.g.; feeding, health control and management (Baker and Gray, 2003).

The study attempts to provide a better understanding of the variations in production and breeding practices under which Ugandan goats are kept and complements previous studies (Kugonza *et al.* 2001; Ssewanyana *et al.* 2004). This will help in the documentation of indigenous knowledge with a focus on production system and breeding aspects with special emphasis on selection criteria and to use such information to provide a basis on which subsequent sustainable breed improvement programme of this peculiar genetic resource might be realized.

3.2 Materials and Methods

3.2.1.1 Area of study, location and climate

The study was conducted in the districts of Soroti, Arua and Sembabule. Sembabule is located in the semi-arid area, Arua in the humid area, while Soroti is located in the sub-humid area (FAO, 2001). Both Sembabule and Soroti districts form part of the cattle corridor. According to Cook (2007), Sembabule lies in the central part of Uganda at an altitude of 1200 m – 1500 m and between latitude 31°25'E and longitude 0°. Soroti is located in the East-Northeast of the country at altitude of 1036 m – 1127 m, latitude 33°35'E and longitude 1°45'N while Arua lies in the North West of Uganda forming part of River Nile's basin at an altitude of 610 m – 1388 m and between latitude 31°15'E and longitude 2° 55'N. All the three districts receive a bimodal rainfall and prolonged dry season from December to March (MAAIF, 1995). The inhabitants of Sembabule mainly are the Baganda, Banyakole and Banyarwanda. Soroti is inhabited by the Iteso. While Arua is occupied by the Lugbara, Madi and Kakwa people. In all these areas, the communities are characterised as agro-pastoralists with production systems.

characterized by minimal management inputs in terms of breeding, nutrition and disease control and are mainly traditional and subsistence oriented.

3.2.1 Sampling and questionnaire methodology

A household survey was undertaken through questionnaire guided interviews with goat owners in the districts of Soroti (SEA/Teso goat dominant), Arua (SEA/Lugware goat dominant) and Sembabule (Mubende goat dominant) in Uganda. The survey was carried out from May to July 2008. The survey areas within each district were replicated at 2 levels, i.e., two sub-counties and two villages per parish were picked in each district using prior information obtained from the field staff. A total of 6 sub-counties, 6 parishes and 12 villages were sampled. This was based on ease of accessibility to the areas and flocks. Due to the limited number of buck keepers in these villages, all buck keepers were interviewed, while doe owners were selected at random. A minimum of five households per village that owned goats were sampled. Some guiding data on households in the villages were obtained from local authorities.

3.2.1.2 Data collection

A total of 160 households were interviewed using a set of structured questions (Appendix 2) which are a slight modification of those designed for livestock breed survey in the Southern African region (Rowlands *et al.* 2003). They included 40 households from the district of Sembabule, 60 from Soroti and 60 from Arua. Most questions were open ended. The responses by the farmer was ticked against a prepared list in the questionnaire, and then, where appropriate, asked the farmer to rank them. For some exceptions, the enumerator went through a list of predetermined traits one by one and asked the farmer to rank them. Personal observation was used to supplement the responses were recorded.

Information was collected on general household characteristics, purposes of keeping goats, traits of importance, breeding management and selection criteria, flock sizes and structures, animals' health, feeding management and socio-economic conditions of the farmers. To obtain information on reasons for keeping goats, selection criterion for breeding goats, ways of acquisition and ways of removal, goat keepers were asked to rank the most important.

3.2.2 Data analysis

Data was analysed using the Statistical Package for Social Sciences (SPSS version 9) software to generate frequencies, means and cross tabulations. The level of agreement between respondents of the same district was assessed using Kendall's coefficient (W). In order to be able to calculate the sizes of mixed herds, all classes (bucks, does, and kids) of pure local breeds for Mubende, Local/Teso or Local/Lugware, and other pure bred and crosses were summed.

The reason for keeping goats, selection criteria, ways of acquisition and removal of goats in a household were expressed as an average rank. Means were compared using the Least Significance Difference procedures at a $P < 0.05$ level of significance. Based on the average rank of each trait, a hierarchical order was then made within each region.

3.3 Results and Discussion

3.3.1 General household information

Male household heads dominated (73 %), followed by spouse (9 %), son of household head (7 %), daughter to the household head and other family relatives (5 %). The largest household sizes are found in Sembabule with an average of 13 ± 2 persons, followed by Arua with 11 ± 1

persons and Soroti had the smallest household with on average 9 ± 2 persons. Women and children played a very profound role in goat husbandry although major decisions concerning breeding, purchase and selling are made mainly by male household heads (Table 5).

In Soroti and Arua, all respondents ranked livestock and crop production as equally important in contributing to their income while in Sembabule, majority (57.5 %) mentioned livestock production as the major source of income. This is comparable to (60 %) reported by Kugonza *et al.* (2001) during characterization of meat goat management in Sembabule.

The majority of the farmers were sedentary with the exception of Sembabule district where there were some remnants of transhumance. Pasture scarcity due to drought was cited as the main reason for moving. The few unsettled farmers mentioned some of the challenges they encounter during movement which included, the unfavourable land tenure system, hostilities from other communities especially those involved in crop production, movement permits from one area to another, transmission of animal diseases and sometimes family break-ups.

3.3.2 Flock management

Poor nutrition is one of the major problems affecting livestock productivity in the tropics. This is reflected in reduced live weights, low animal productivity, greater age at first parturition, increased parturition intervals, prolonged non-productive life and high mortalities.

Table 3.1 summarizes the production and grazing systems in the different districts. Most farmers in Soroti and Arua (> 87 %) tethered their animals. Tethering is mainly during the wet/cropping season due to the shortage of herding labour as crop farming activities are at their peak. Tethering is a widely practiced management system because it protects growing crops and is much used during the rainy season when the bulk of the available labour is

required for cultivation and planting crops. It also ensures security against thefts, disease spread and predation. There is however, limited grazing space leading to chronic malnutrition which results in poor growth, increased risk of helminthiosis and high mortalities especially due to predation and strangling by the tight ropes. Farmers, who tether during the wet season, leave their goats to roam around the villages during the dry season getting a chance to feed on the crop residues from the harvest. This allows goats to survive and grow better than in the dry season.

Majority of farmers in Sembabule (66 %) however, practiced herding (open grazing) given the large pieces of land they owned. Systems that did not involve tethering were most often adopted by farmers with relatively large flocks of animals. Sembabule farmers (52 %) are mainly on extensive livestock keeping with minimum crop activity, while in both Soroti (100 %) and Arua (100 %) farmers are mainly on mixed crop-livestock production system.

Natural pastures and shrubs are the major feed resources utilized through continuous grazing and browsing. Feed conservation is limited to occasional use of crop residues (cereal straws) during the dry season. Supplementation of the indigenous breeds using high energy and protein concentrates is rarely practiced. The common way of supplementing is by use of crop residues. Equally rare is the provision of mineral licks as part of goat diets. Thus, animals have to exploit various natural salt deposits that exist in the grazing fields.

Table 3 1 Production and grazing system of goats in three districts

	District		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
	Proportion of households (%)		
Production system			
Pastoral/extensive	52.5	0.0	0.0
Mixed crop-livestock	42.5	100	100
Transhumance	5.0	-	-
Grazing system			
<i>Wet season</i>			
Holding	56	23.3	26.7
Tethering	30	66.7	65
Free range	10	6.7	5.0
Stall fed	4	3.3	3.3
<i>Dry season</i>			
Tethering	37.5	16.6	11.6
Paddock	17.5	-	-
Stall fed	7.5	6.6	5
Free range	37.5	73.3	70.0
Use of feed crop residue supplements			
Yes	67.5	85	70

Water provision, frequency, source, quality and distance from source across the districts are presented in Table 3.2. Water was provided at least once a day. Water was mainly fresh and drawn from spring wells in both Soroti and Arua while that of Sembabule was mainly drawn from manmade dams and wells. Maximum walking distance to water source was 2 km for Arua and Soroti farmers while Sembabule farmers walked up to 4 km. This means that access to safe water in the sampled districts is still a problem. These finding are in concordance with those reported by Ssewannyana *et al.* (2004), when they characterised rural goat production systems in Uganda.

Table 3 2 Water provision, frequency, source, quality and distance from homestead

Practice	District		
	Sembabule (n = 32)	Soroti (n = 56)	Arua (n = 60)
	Proportion of households (%)		
Water provision			
Yes	100	95.0	98.0
Frequency of watering			
Once a day	90.0	60.0	81.7
twice a day	10.0	33.3	8.3
Adlib	-	6.7	10.0
Water source			
Dam	60.0	-	-
Protected well	20.0	80.0	80.0
Swamp	15.0	18.3	16.7
Borehole	5.0	1.7	3.3
Water distance from homestead (km)	0.05 - 4.0	0.1 - 2.0	0.1 - 2.0

Findings on goat housing, record keeping, source of labour and capital across districts are summarized in Table 3.3. The form of housing varied depending on the way farmers perceived it. Farmers in Soroti and Arua had temporal structures and sheds under house or chicken verandas for housing. Majority of the goat keepers in Sembabule provided their goats with roofed pens (60%) while respondents in Soroti (43.0%) and Arua (49%) did not provide proper housing as they tied animals with ropes around the verandas of the house. Lack of proper housing is indicative of poor management given to local goats and this could possibly be due to lack of knowledge on the importance of housing. Housing is essential in protecting animals from conditions like rains, coldness and predation. This in turn could lead to increased productivity.

The culture of keeping records was uncommon although, some efforts were being put up especially in Sembabule district. The culture of record keeping is still lacking in many developing countries, owing to the fact that production is still at subsistence level. All labour (100 %) for looking after goats was offered by the family members in Soroti and Arua, without any report of hired labour. Sembabule on the other hand had family labour (75 %),

some cases of hired labour (5 %) and/or both family and hired (20 %). All farmers (100 %) in the study areas used own capital to manage their goats.

Table 3 3 Provision of housing, housing type, record keeping, source of labour and source of capital

	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
	Proportion of households (%)		
Provide housing			
Yes	100	73.3	60
Housing type			
Roofed pen	60	38.6	6.1
Kraal	32.5	9.1	9.1
Veranda of the house	5.0	43.2	48.5
Indoor at human dwelling place	2.5	9.1	36.4
Record keeping			
Yes	27.5	7.0	6.3
Source of labour			
Family	75.0	100	100
Both	20.0	-	-
Hired	5.0	-	-
Source of capital investment			
Own	100	100	100

Table 3.3 gives a summary of roles in goat management by gender and district. Regarding responsibilities related to decision making on sales, breeding or even purchasing of goats, a pattern of dominance by men can be seen in all the districts. Flocks were mainly owned by men in Sembabule (55 %) and Soroti (38 %), otherwise joint ownership was also very common with fewer cases of women and children having independent ownership. In Arua, ownership was mainly by women (42 %) and children (30 %), despite the fact that these have little control on the binding decisions taken on their goats. Similarly in Soroti and Arua, women and children cared for goats (watering, cleaning, tethering) more than men, but had minimal influence on decision making. Similar observations have been reported on gender relations in livestock management (Semenye *et al.* 1989; Ssewanyana *et al.* 2004). Semenyne *et al* (1989), attributes the increase in the share of livestock labour carried out by women to three factors. In recent years men have increasingly directed their labour toward off-farm

wage-earning opportunities, leaving women responsible for much of the farm work. Second, with the advent of compulsory education, children now are available to help with the care of livestock only in the late afternoon, on weekends, and during holidays. Third, the intensification process itself, which focuses labour on feed crop production and the provision of cut-and-carry feeds to animals tethered in the household compound, has brought the livestock care more closely into the sphere of female responsibility. The findings of the study show that labour for tasks carried out by women has increased while those tasks that were traditionally the responsibility of men (such as herding, watering and tethering the animals in fallow fields) have steadily declined in importance. This has put the bulk of the burden of managing livestock and producing dual-purpose crops to support them, heavily on women.

Table 3 4 Gender issues in goat management

District	Task	Men	Women	Children	All family
Sembabule	Decision making on sales, give away and breeding	65.0	10.0	2.5	22.5
	Water provision	62.5	2.5	25.0	10.0
	Ownership of goats	55.0	10.0	2.5	32.5
	House cleaning	17.5	40.0	32.5	10.0
Soroti	Decision making on sales, give away and breeding	50.0	15.0	8.3	26.7
	Ownership of goats	38.3	20.0	8.3	33.3
	Water provision	2.5	42.5	7.5	47.5
	House cleaning	1.7	75	23.3	-
Arua	Decision making on sales, give away and breeding	43.3	20.0	6.7	30.0
	Ownership of goats	16.7	41.7	30.0	11.7
	Water provision	8.3	46.7	11.6	33.3
	House cleaning	3.3	53.3	41.7	5.0

3.3.3 Livestock importance and goat flock composition

Relative importance of the main livestock species in the surveyed areas is presented in Table 3.5. Goat production was ranked second to goats citing the enormous functions both tangible and intangible. The ranks indicate the relative importance of each species as mentioned by the farmers using a scale of 1 for the most important.

Table 3 5 Importance of main livestock species in surveyed areas

Livestock species	Sembabule		Soroti		Arua	
	Households ^a (n=40)	Mean rank ^b	Households ^a (n=45)	Mean rank ^b	Households ^a (n=34)	Mean Rank ^b
Goats	35.0	1.13	42.0	1.07	30.0	1.06
Goat	5.0	1.62	2.0	1.98	3.0	1.94
Sheep	-	3.00	1.0	2.96	1.0	2.94

^aHouseholds ranking livestock species first^bMean rank of importance (the lower the rank the greater the importance)

The average flock size of pure indigenous goats, mixed flocks (pure indigenous, crossbreds and other pure breeds) and the range of flock sizes for each district are presented in Table 3.6. Generally mixed flocks have the biggest number of animals. The ratios for number of goats in a mixed flock to those in a pure indigenous flock were; 1.2, 1.8 and 1.7 for Sembabule, Soroti and Arua respectively. The ratios of crossbreds to pure indigenous in the districts were; 0.6, 0.4 and 0.1 for Sembabule, Soroti and Arua respectively. Pure exotic goats were few in all districts, with highest numbers in Sembabule.

Table 3 6 Least Square means $\pm$ standard error for flock composition and size by breed

Flock composition	Breed		
	Mubende	SEA/Teso	SEA/Lugware
	Average number of goats per flock		
Mixed flocks	21.4 $\pm$ 6.3 ^a (2-231)	11.8 $\pm$ 0.98 ^b (3-40)	9.4 $\pm$ 1.15 ^b (4-24)
Pure indigenous goats	17.9 $\pm$ 3.0 ^a (6-72)	6.4 $\pm$ 1.72 ^b (3-20)	5.4 $\pm$ 1.21 ^c (3-24)
Crossbred	10.7 $\pm$ 2.2 ^a (1-150)	4.2 $\pm$ 0.55 ^b (0-40)	3.3 $\pm$ 0.15 ^b (0-11)
Pure exotic breeds	2.0 $\pm$ 0.6 (1-3)	-	-

^{a,b,c} Values with different superscript letters differ significantly ($P < 0.05$) for breed between different district/Agro-ecological zone. Numbers in brackets are minimum and maximum flock sizes per Household.

The average flock sizes are characteristic of subsistence farming and provide limited scope for a commercially oriented approach to production. A market oriented approach requires substantial cash input to purchase more animals, better housing, improved pastures and the necessary infrastructure. Most goat keepers in Soroti and Arua can be categorized as poor

households, whose annual cash income is too low to meet these costs. Farmers in Sembabule had more wealth and could afford comparably larger flocks. This is supported by the fact that, a number of them owned improved goats and are involved in cross breeding activities.

The small flock sizes observed in this study are typical of goat production in developing countries (Sumberg, 1985). According to Bayer (1984), flock sizes are generally larger in the pastoral/extensive systems and smaller in the humid agricultural regions. Mixed flocks however, have a tendency to have larger numbers (Ndamukong *et al*, 1989). The tendency for larger numbers in mixed flocks has also been reported by Wilson (1983). In his earlier work, Wilson (1982) reported that farmers who keep small stock rarely do so for irrational reasons and that such reasons are perfectly in keeping with the problems encountered and the specific objectives of the owners.

The dominance of females agrees with earlier observations that females make up more than two-third of most small ruminant flocks with as many as 80 % of females in derived Savannah areas and 83 % in true forest areas (Wilson, 1982). The relatively big number of crossbreds coupled with the high level of uncontrolled mating in Sembabule poses a threat to the fate of pure indigenous goats in that area. The same threat is expected in the other districts of Uganda given their anticipated future breeding practices of crossing for genetic improvement and government programmes like NAADs. This is in agreement with Scherf (2000). The mostly used exotic breed for crossbreeding across all districts is the Boer. This is possibly due to its promotion by the government extension officials and NGOs. In Soroti and Arua the level of crossbreeding was still low to pose any threat to indigenous goats.

3.3.4 Purpose of keeping, acquisition and disposal of goats

Reasons of keeping goats and the ranking of these purposes by breed type are presented in Table 3.7. Indigenous goat breeds serve several functions that differ across and within districts. In all districts, farmers mainly kept the indigenous goats for home consumption and sale. Majority of the goat keepers in all study areas consider the primary reason for keeping goats to generate income from the sales of the animals. There was a significantly ($P < 0.001$) high level of agreement (0.83, 0.78 and 0.72) in Sembabule, Soroti and Arua, respectively observed among respondents for the ranks. Similar findings have been reported by Kugonza *et al.* (2001); and Dossa *et al.* (2007).

Across all districts, goats are a direct source of income, which is realized by exchange for cash. However, disposal of goats when in money crisis indicates most farmers sell goats without proper planning. Meat production is very important and was ranked between 3.45 and 5.08. Meat production was generally ranked third and/or below provision of regular cash income. This indicates the importance of inclusion of meat production traits in any breeding programme aimed at goats in these areas.

Customary norms and wealth accumulation or as an insurance against financial constraints, skin production and manure are other important roles performed by goats in these areas. Milk production was least important, with average ranking between 7.83 and 7.97 among the goat farmers across the three breed types (Table 3.7).

Table 3.7 Reasons for keeping goats as ranked by respondents

Reason	Rank (mean rank) ¹		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
Regular cash income	1 (1.00)	1 (1.66)	1 (1.90)
Wealth accumulation	2 (1.90)	4 (3.98)	5 (5.04)
Meat for consumption	3 (3.45)	3 (3.08)	3 (2.98)
Customary norm	4 (4.21)	5 (5.06)	4 (4.06)
Insurance	5 (4.38)	2 (1.95)	2 (2.02)
Skins	6 (6.03)	7 (7.02)	6 (6.06)
Manure	7 (7.10)	6 (5.90)	7 (6.96)
Milk	8 (7.83)	8 (7.97)	8 (7.94)
Kendall's coefficient (W) ²	0.83**	0.78**	0.74**

¹Means of rankings (the lower the rank the greater the importance) of the reason for keeping goats.

²W ranges from 0 (no agreement) to 1 (Total agreement) and the higher the value the higher the level of agreement between respondents in a district.

** P < 0.001

Insurance, customary norm and wealth accumulation were highly ranked emphasizing the goats' role of intangible functions. Insurance plays a vital role especially among SEA/Soroti (average rank, 1.95) and SEA/Arua (average rank, 2.02) goat keepers. In Sembabule, it ranked relatively (average rank, 4.38) lower (only fifth in importance). Milk production was unpopular across all the surveyed areas and the few individuals milking their goats seemed to do it for the children and for the sick as such milk is said to be more nutritious than goats milk.

The use of indigenous goat breeds as a source of manure was reported in Soroti and Arua districts. In Sembabule district the goat manure was not important compared to goats manure since their goats herd sizes were relatively larger to provide enough manure for both construction and fuel.

The use of indigenous goat breeds as multi-purpose animals has been demonstrated in East Africa (FAO, 2001). This has arisen from the need to extract more than just meat and milk, in

the quest to maximise output from these animals that can survive and reproduce under the harsh environmental conditions of the tropics. The development of specialised single purpose breeds, for the exclusive production of either meat or milk, is not a suitable option for the areas used in the study or for other areas where indigenous goats are popular. Most livestock development strategies target solely either milk or meat production while ignoring the farmers' primary interest in livestock as providers of several functions may not attract committed farmer participation. Further, the bio-energetic efficiency of multipurpose livestock production would be overlooked by such developments giving rise to misplaced objectives. Duo-purpose objectives other than those with single purpose (meat) have been reported to give higher profits in breeding programmes in goats (Kahi, 2000). The functions required of indigenous animals, influence the traits desired by farmers from the viewpoint of genetic improvement. Therefore, the component traits/attributes need to be identified carefully before deciding what breeding or livestock development objectives should be adopted.

Knowledge about ways of acquisition of breeding stock and disposal is important in assessing the breeding practices of farmers. Methods used to acquire goats included; new births, buying, inheritance, exchange of other livestock or food crop, dowry and gifts (Table 3.8). Generally the ways were similar in all districts except for exchange of other food crop and dowry which were more done in Soroti and Arua. Similar ways of acquisition have been reported among goat keepers in Uganda (Ssewanyana *et al.* 2004). Across all study areas most households (72 %) reported that they sold goats within the 12 months preceding the interview. Significantly ($P < 0.001$) high and positive degree of agreement (0.64, 0.48 and 0.55) in Sembabule, Soroti and Arua, respectively, were seen among the respondents for their ranks.

Disposal of goats (Table 3.9) was by sales, slaughter, deaths, exchange for other livestock and crops, thefts and donations in that order. Donations were generally ranked low in terms of

either acquisition and/or removal in all districts. Variations among districts were on slaughter which was more in Sembabule, while Soroti and Arua superseded Sembabule on dowry. Goats were disposed in form of sales, slaughter, deaths, donations, thefts and exchange. The mode of expenditure across all districts was similar. Level of agreement was significant ($P < 0.001$) and positive i.e. (0.61, 0.53 and 0.60) in Sembabule, Soroti and Arua, respectively, for the ranks.

Table 3.8 Ways of acquiring goats as ranked by their owners.

Way of acquiring	Rank (mean rank) ¹		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
Born	1 (1.14)	1 (1.00)	1 (1.00)
Bought	2 (1.66)	2 (2.00)	2 (2.00)
Inherit	3 (3.00)	3 (3.00)	3 (3.04)
Bride price	4 (4.00)	5 (5.00)	4 (4.00)
Exchange for food crops	5 (5.00)	6 (6.00)	6 (5.96)
Exchange for other livestock	6 (6.00)	4 (4.00)	5 (5.00)
Caring for others	7 (7.00)	7 (7.00)	7 (7.00)
Gifts	8 (8.41)	8 (8.11)	8 (8.02)
Loans	9 (8.85)	9 (8.89)	9 (8.98)
Kendall's coefficient (W) ²	0.64**	0.48**	0.55**

¹ Means of rankings (the lower the rank the greater the importance) of the way of acquiring goats.

² W ranges from 0 (no agreement) to 1 (Total agreement) and the higher the value the higher the level of agreement between respondents in a district.

** $P < 0.001$

Table 3.9 Way of removal of goats from the farm as ranked by owners.

Way of removal	Rank (mean rank) ¹		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
Sold	1 (1.00)	1 (1.00)	1 (1.00)
Died	2 (2.20)	2 (2.06)	2 (2.06)
Slaughtered for ceremonies	3 (3.00)	5 (5.00)	6 (6.96)
Bride price	4 (4.03)	3 (3.00)	3 (3.00)
Exchange	5 (4.97)	4 (4.00)	4 (4.00)
Stolen	6 (6.17)	7 (6.56)	7 (6.68)
Slaughtered for home use	7 (6.86)	6 (6.08)	5 (6.00)
Given out as gifts	8 (7.97)	8 (8.00)	8 (7.80)
Kendall's coefficient (W) ²	0.61**	0.53**	0.60**

¹Means of rankings (the lower the rank the greater the importance) of the way of removal of goats.

²W ranges from 0 (no agreement) to 1 (Total agreement) and the higher the value the higher the level of agreement between respondents in a district.

** P < 0.001

3.3.4 Reproductive performance

Reproductive traits including age at first mating, age at first parturition, kidding interval, lactation length, prolificacy and major kidding season are shown in Table 3.10. Although data on milk production was unavailable in all the three districts, Sembabule goats (Mubende) had a significantly ($P < 0.05$) longer lactation period, lower age at first mating, shorter kidding interval and the least number of services per conception than SEA/Soroti and SEA/Arua. Males and female kids were reported to reach sexual maturity at about 8.5 months for Sembabule farmers and 10 months for both Soroti/SEA and Arua/SEA. The reported age at first parturition was 14.2 months for Mubende, 16.4 months for SEA/Teso and 16.6 months for SEA/Lugware. Lactation length values were; 4.4 months for Mubende, 4.3 months for SEA/Teso and 4.1 months for SEA/Lugware. The conception rates averaged between 1.5 services per conception, 1.7 for SEA/Soroti and 1.8 for SEA/Arua goats while kidding intervals were 6.6 months for Mubende, 7.7 months for SEA/Soroti and 7.8 months for SEA/Arua respectively. All breed groups were prolific with multiple births reported.

Twinning rates in all study areas were above 30 % with respondents in Soroti (34.1%) reporting the highest rates while triple births were minimal.

Table 3.101 Reproductive Parameters, prolificacy and major kidding season by district

Index	District		
	Sembabule	Soroti	Arua
Age at first parturition (Months)	14.2±0.3 ^b (11-24)	16.4±0.3 ^a (11-25)	16.6±0.4 ^a (12-28)
Age at first mating (Months)	8.5±0.3 ^b (8-12)	10.8±0.4 ^a (10-18)	11.1±0.4 ^a (10-18)
Kidding interval (Months)	6.6±0.0 ^b (6-8)	7.7±0.3 ^a (6-12)	7.8±0.2 ^a (6-13)
Lactation length (Months)	4.4±0.1 ^a (3.5-6)	4.3±0.1 ^{ab} (3-6)	4.3±0.1 ^b (3.5-5)
No. Services per conception	1.5±0.0 ^b (1-3)	1.7±0.1 ^a (1-4)	1.8±0.1 ^a (1-4)
<i>Prolificacy (%)</i>			
Singles	63.3	62.9	67.0
Twinning	32.6	34.4	30.0
Triple	4.1	2.7	3.0
<i>Major kidding season (% respondents)</i>			
Wet	60	69.5	69.9
Dry	40	32.5	30.1

^{a,b,c} Values with different superscript letters differ ($P < 0.05$) within each row
Numbers in brackets show minimum and maximum values

Reproductive performance data and indices indicate that goats in Sembabule are slightly superior to those in other districts, but Soroti and Arua, goats were not significantly ($P > 0.05$, χ^2 test) distinct. Fertility and prolificacy for the three goat types did not differ ($p > 0.05$, X^2 tests). Calculated fertility values were 135 %, 118 % and 125 % for goats in Sembabule, Soroti and Arua while prolificacy values were 1.40, 1.35 and 1.36 per birth for the respective districts. Of a total of 1211 births reported, on average, 64.4 % were singles, 32.4 % twins and 3.3 % triplets (Table 3.10). The high incidence of multiple births affirms the relatively good prolificacy for Ugandan goats. Wilson (1982) reported average fertility rates of 130 % among Mubende goats under village conditions which is slightly lower than from this study. However, the values were lower than 150 % reported by Bayer (1982) in WAD goats in

Nigeria under village conditions. Murayi *et al.* (1987), reported fertility of 148 % in Rwandan goats under on-station.

Kidding was reported to happen throughout the year across all study areas, though most frequent kiddings were reported to occur in the months of August and November, the wet season with the main rains in most parts of Uganda. This could be an adaptation as during this time there is plenty of grass for the lactating mothers.

The significant differences between the performances of Mubende goats and the other two breeds are indicative that the former is a superior breed. There is however a wider scope for performance potential exploitation of Mubende, SEA/Teso and SEA/Arua goat with the improvement of the production system. According to Oluka *et al* (2003) and Ssewanyana *et al* (2004), improved goat performance could be obtained under good management practices.

3.3.5 Breeding, mating systems and selection criteria

Households owning indigenous breeds were predominant across all the study areas, followed by their crosses (Table 3.11). The pure exotic were the least in number. At the time of the survey, pure breeding of indigenous goats was predominant across all the districts. Soroti and Arua dominated with 95.6 % and 87.9 % respectively, while Sembabule district had the lowest percentage for pure indigenous matings (43.9 %). Cross breeding was most practiced in Sembabule district (41.9 %) which was far greater than for Arua and Soroti districts (12.1% and 4.4 %) respectively. Pure exotic breeding system was not popular as was only noticed in Sembabule district, by only 14.5% of the respondents. Results on prospects for future breeding systems indicated a likely shift from pure indigenous to crossbreeding. Sembabule farmers topped the list with 87.2 %, Arua with 66.7 % and 53.3 % for Soroti district. This means that crossbreeding is likely to increase twice as much in Sembabule district, 12 times for Soroti and 10 times for Arua goat farmers. Given the high levels of uncontrolled mating

this might expose the indigenous breeds to genetic erosion or even extinction. The low level for adoption of pure exotic breeding system is explained by their poor adaptability to the harsh environment and hence not easy to manage.

Natural mating was the predominant mating system (100 %) with virtually no AI services among the goat keepers (Table 3.12). Unplanned mating explains the parturition throughout the year. An advantage of natural uncontrolled mating is that it allows for all year round breeding. Communal/uncontrolled mating was ranked second in all the districts (67.7 %, 84.4 % and 78.8 %) for Sembabule, Soroti and Arua districts respectively while, AI was uncommon or nonexistent. For natural controlled mating, the breeding bucks used were mainly owned individually for pure indigenous, while bucks used for crossbreeding were either owned by the relatively rich farmers or were group bucks rotated among the resource poor farmers. Uncontrolled mating, small herd sizes together with poor record keeping on pedigree is expected to result in severe inbreeding in these flocks (Kosgey, 2004). Communal grazing which is an affordable remedy for inbreeding (Jaitner *et al.* 2001) was rarely practiced by farmers in the survey.

The mating ratios were 18.5 ± 2.8 , 10.0 ± 1.0 and 8.1 ± 0.8 females to 1 male Each in Sembabule, Soroti and Arua respectively. The very high ratio for Sembabule could show that there were a relatively limited number of bucks as compared to those of Soroti and Arua.

The current study revealed that most farmers used their own breeding bucks, though in some cases borrowed from neighbours and/or used communal group bucks given by NAADS and NGOs. Farmers who kept pure exotic and/or their crosses practiced controlled mating (group mating) in which a group of does is left with one or more bucks to mate for a given period of time or taken to the buck centre at oestrus.

Table 3.11 Goat breeding system by district

Current breeding system	District		
	Sembabule (n = 37)	Soroti (n= 60)	Arua (n =60)
	Proportion of households (%)		
Pure Indigenous	43.9	95.6	87.9
Crossbreeding	41.9	4.4	12.1
Pure Exotic	14.3	0.0	0.0
Future (Planned) breeding system			
Crossbreeding	87.2	53.3	66.7
Pure Indigenous	7.7	44.4	24.2
Pure Exotic	5.1	2.2	9.1

Table 3.12 Mating system, mating ratio, source of breeding buck and duration of breeding buck on-farm reported in the last 12 months by district

Variate	District		
	Sembabule	Soroti	Arua
Mating system (proportion of households (%))			
Natural uncontrolled	67.7	84.4	78.8
Natural controlled	32.3	15.6	21.2
Buck source (proportion of households (%))			
Own	86.3	70.7	64.2
Neighbour	9.7	21.6	23.3
Borrowed	4.0	7.7	12.5
Mating ratio	18.5±2.8 ^a	10.0 ±1.0 ^b	8.1±0.8 ^b
Duration the breeding buck stays on-farm (months)	24 – 36	24 – 48	24 – 54

Selection criteria for goats are shown in table 3.13 and 3.14. Production traits i.e. body size, growth and reproductive performance, were ranked higher than adaptive traits. Major criteria for selection of breeding bucks were (Table 3.13) body size, fast growth rate, fertility and temperament in that order with very little variation between districts and/or breed types. Body size was the most highly ranked, with values ranging between 9.24 and 9.55. Body size and ability to sire twins have been reported as main criteria for selecting breeding bucks in rural goat production (Ssewanyana *et al.* 2004). Breeding does were selected (Table 3.14) mainly basing on body size, birth type, fertility and kid survival.

Table 3.13 Selection criteria for a breeding buck

Trait	Rank (mean rank) ¹		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
Body size	1 (1.17)	1 (1.00)	1 (1.02)
Growth rate	2 (1.97)	3 (2.73)	3 (3.09)
Fertility	3 (2.86)	2 (2.31)	2 (2.08)
Temperament	4 (4.07)	7 (7.05)	5 (4.96)
Colour	5 (5.00)	4 (4.06)	4 (4.08)
Body conformation	6 (6.00)	5 (4.92)	6 (6.04)
Tolerance to diseases/parasites	7 (6.84)	7 (6.05)	7 (6.92)
Horns	8 (7.95)	8 (7.94)	8 (8.00)
Kendall's coefficient (W) ²	0.86**	0.68**	0.74**

¹Means of rankings (the lower the rank the greater the importance) of the reason for keeping goats.

²W ranges from 0 (no agreement) to 1 (Total agreement) and the higher the value the higher the level of agreement between respondents in a district.

** P < 0.001

The selection criteria for does and bucks, was parallel across all districts and systems. Production/quantitative traits were more important (Table 3.13, 3.14). This is in tandem with Knights and Knights (2005) who emphasize growth and reproductive traits in selection. Beauty-related and adaptation traits were considered less important in selection of breeding stock. Adaptation traits were considered as given for indigenous goats thus the little consideration when selecting breeding stock. Across all districts size and performance in terms of fertility were preferred in all sexes. Larger animals in particular were preferred as they fetched better market prices, had better growth rates and reached market weights sooner.

Selection of breeding stock by farmers is based on their indigenous knowledge. They depended on information about the performance of potential buck/doe dams and growth performance, information from relatives/ancestor and assessment of young buck and/or doe. There were no records on performance of individuals and their pedigree. Identification was mainly by phenotypic appearance. Lack of animal records and identification has very serious implications, as no effective selection and breeding programmes can be applied in the absence

of records. In addition some owners of breeding bucks kept them for up to 4.5 years in Arua. Such long duration suggests a high though non quantifiable level of inbreeding in the study areas. The finding are in line with Ssewanyana *et al.* (2004) who reported that rural goat farmers in Uganda kept breeding bucks between 3-5years.

The majority of farmers, indicated that they obtained their breeding material from their own farms with selection of both male and female animals being practiced by a majority of farmers in all districts. While the farmers practice selection of breeding animals, they did not keep records, other than those of numbers, which are committed to memory. This is similar to what was observed by Dersch (1986) in the Debre Birhan area of Ethiopia.

The majority of the farmers in this study expressed the wish of introducing exotic meat goats and crossbred goats as a means of improving the performance of their goats. Pure exotic and crossbreds have been reported to be poorly adapted to the low-input traditional production systems of the tropics (Ayalew *et al.* 2003).

Table 3.14 Selection criteria for breeding does as ranked by owners of goats

Trait	Rank (mean rank) ¹		
	Sembabule (n = 40)	Soroti (n = 60)	Arua (n = 60)
Body size	1 (1.14)	1 (1.08)	1 (1.00)
Fertility	3 (2.86)	3 (2.92)	2 (2.22)
Birth type	2 (2.03)	2 (2.00)	3 (2.00)
Growth rate	4 (4.24)	4 (4.05)	4 (4.06)
Colour	5 (4.97)	5 (4.95)	5 (4.94)
Horns	7 (7.55)	9 (8.73)	9 (9.00)
Tolerance to diseases/parasites	6 (6.34)	7 (7.02)	7 (7.04)
Body conformation	7 (7.79)	8 (8.02)	6 (6.00)
Temperament	9 (8.34)	6 (6.24)	9 (9.00)
Kendall's coefficient (W) ²	0.67**	0.71**	0.84**

¹Means of rankings (the lower the rank the greater the importance) of the reason for keeping goats.

²W ranges from 0 (no agreement) to 1 (Total agreement) and the higher the value the higher the level of agreement between respondents in a district.

** P < 0.001

3.3.6 Health

More than thirty (30) disease conditions were reported to have occurred 97% of the households within the previous 12 months (Table 3.15). Respiratory diseases (63%), diarrhoea (59%) helminthosis (58%) and tick born diseases (51%) were cited as the major disease conditions in the study areas. Other important diseases/problems were emaciation, lameness, foot rot, foot-and-mouth disease (FMD), eye disease, sudden death and skin diseases. All these conditions were common in all districts, and possess the same position of importance, though the severity differed ($P < 0.05$) with cases being more severe in Soroti and Arua districts than in Sembabule. While working on sheep and goats in Ogun State in Nigeria, Anaeto *et al.* (2009) reported a similar trend of disease events. However tick borne diseases seemed to be the most important health threat in the study areas.

Table 3.15 Major prevalent diseases as reported by farmers (within 1 year period) given as percentages of respondents in each district (Sembabule, Soroti and Arua)

	% Sembabule n=40	% Soroti n= 60	% Arua n= 60
Disease condition/symptoms	Proportion of households		
Respiratory diseases/Pneumonia	52.5	65.0	68.3
Tick borne	52	47.2	54.1
Diarrhoea	48.4	60.1	65.5
Helminthosis	42.0	65.0	66.0
Emaciation	35.0	53.0	59.0
Abortions	23.2	22.0	28.1
Skin diseases	22.5	53.4	61.3
Lameness	20.2	23.0	18.1
Foot rot	18.9	14.3	5.2
Foot and Mouth Disease	10.3	6.6	2.2
Sudden death	5.3	18.0	24.6
Eye diseases	2.7	37.4	4.5
Solutions to health problems			
Call vet	75.0	81.7	88.3
Use vet drugs from shop my self	20.0	11.7	1.7
Local herbs	5.0	6.6	10.0

Variations in morbidities and mortality rates across all the districts may be due managerial differences among the different production systems and households. Several factors have been reported to affect mortality in small stock in various areas in tropical Africa. Among them are season and type of birth (Peacock, 1982), length of the previous parturition interval (Wilson, 1981), parturition number (Fall *et al.* 1982) and disease (Mark, 1982). All these effects are related to health and management.

Diarrhoea is a salient feature of helminth infestation in livestock. However, pathogens including *Escherichia coli*, *Clostridium perfringens* or rotavirus are potential aetiological agents. Endoparasites (Helminthosis) and ectoparasites are pandemic in Tropical Africa and both are known to slow productivity in livestock. Helminthosis is more serious towards the end of the rainy season whereas ectoparasites cause more damage during the rains to early dry season. Respiratory disease manifested by nasal discharge and cough was second most important ailment across all districts. This might be due to the improper housing exposing goats to night chills. Nasal discharges and cough could also be associated with *Oestrus ovis* infestation while cough per se can be due to lung worm infestation. Skin lesions observed were those associated with mange, lice or flea infestation. Emaciation was either as a result of malnutrition due to tethering or parasitic infestation.

Majority of the farmers reported that they approached vet staff to treat or solve goat health related problems and some few used local medication in form of herbs and other concoctions. Anthelmintics and acaricides were the most common forms of treatment used by farmers themselves. Control of internal parasites was by use of anthelmintics at least once a year especially during the wet season, while external parasites were controlled by use of acaricides mainly by spraying. The treatment and preventive measures taken in all districts are not

different. In general, management of animal health in the study areas was a very simplified practice typified by very low levels of inputs. Vaccinations, other than through government interventions, are rarely administered (26 %). Access to veterinary services was generally good in all the districts with coverage of 100 % in all districts. This could imply that goat health care is affordable in these rural settings and thus goat farming could be a good venture worth undertaking. The use of local medication in the treatment of disease conditions in goats forms an opportunity for further research as this indigenous knowledge could be more affordable.

3.5 Conclusions

From the study it can be concluded that the goat production and breeding practices in the study areas were similar. The production systems in all these areas were generally characterised as subsistence and small scale. In Sembabule production was mainly characterised by livestock production while in both Soroti and Arua it was mainly mixed-livestock. The differences in performance of goats in Sembabule (Mubende goats) vis-à-vis Soroti and Arua (SEA) could be on the genetic basis as the management practices are not very different. Therefore the good reproductive indices and growth rates of Mubende goats are good indicators of their potential under semi-arid conditions of Sembabule and use to improve other local breeds.

Indigenous goats contribute tremendously towards income sources, nutritional status and social aspects, despite their low productivity. They thus play an integral part in peoples, livelihoods especially in poverty eradication among resource poor farmers. The study established indigenous knowledge with respect to goat production and breeding practices especially indigenous selection criteria. Though not considered as important as production traits, adaptive traits play a big role in the harsh production environment.

Breeding practices of goat producers in the surveyed areas reflect the importance of multi-functional roles that goats play in these systems. In a number of cases, the traditional selection criteria were realistic and unswerving with what commercial goat keepers would prefer.

3.6 Recommendations

- More emphasis needs to be placed on the improvement of Mubende and SEA goats given their significant contribution to peoples' livelihoods are their ability to thrive in extreme environments
- Effective breeding strategies and policies targeting goat keepers in the study areas should incorporate the multi-functional roles and indigenous knowledge of the traditional choice attributes of goats as a basis for selection criteria in their production systems.
- To reduce losses and improve productivity, there is need for more farmer capacity strengthening through, training in proper management, provision of credit facilities and formation of farmers' cooperative alliances to facilitate easy acquisition of inputs and disposal of out puts.
- There is need for proper identification and diagnosis of disease conditions for curative treatment to be given.

CHAPTER FOUR

VARIABILITY IN BODY MORPHOMETRIC MEASUREMENTS OF MUBENDE AND SMALL EAST AFRICAN GOAT BREEDS OF UGANDA

4.1 Introduction

The goat is a multi functional animal and plays a significant role in the economy and nutrition of landless, small and marginal farmers in Uganda. Goat rearing is an enterprise which has been practiced by a large section of the population in rural areas especially the resource poor farmers. In comparison with other domestic animals, goats are the victims of prejudice and neglect, but they have nevertheless fulfilled a most useful task in supplying a part of human population with milk, meat, hair, leather and other products (Coffey *et al.* 2004; Fisher, 1983). In spite of their importance, limited reliable information is available on the performance of indigenous Ugandan goats.

Uganda is endowed with a number of goat breeds whose value is in meat and skin production (Nsubuga, 1996; Ssewanyana, 2004). However, these breeds assumed to have low genetic potential (Kiwuwa, 1992). Previous studies with indigenous goats have concentrated around improving their productivity (Oluka *et al.* 1999; Kugonza, 2002), with little on characterization. For genetic improvement one may need to explore the possibility of selection before attempting to crossbreed or introgression. However the first step towards improvement and/or even conservation is characterisation of the breed (FAO, 2008, LPPS and Köhler-Rollefson, 2005).

Increasing meat yield from indigenous breeds requires genetic improvement of their live weights. Proper measurement of this trait, which is often hard in rural areas due to lack of

weighing scales, is requisite for achieving this goal. There is a growing need to study variations among goat populations through breed characters so as to facilitate their efficient use (Salako and Ngere, 2002). The capacity of producers and buyers to relate the live animal measurements to growth parameters is necessary for optimum and sustainable production and value-based trading system. Linear body measurements can be used as a way of estimating weight and market value in terms of cost of the animals (Gerald, 1994). There is a need for estimation of the trait from simple and more easily measurable variables such as linear body measurements. Studies regarding the linear body measurements of goats have been carried out in other regions of the world, for their possible use for estimating the animals live weights (Singh, 2004 and Hamayun *et al.* 2006).

The present study was carried out to determine variability in body measurements and relate live weights to linear body measurements in Mubende, SEA/Teso and SEA/Lugware goats. The effects of age, sex and breed as a step towards employing such in body weight estimation for selection and other purposes were considered.

4.2 Materials and Methods

Body measurements were taken from at least four female and four male goats from each of the surveyed household. Measurements were taken on a total of 575 goats comprising 197 male and 378 female goats (Table 4.1).

Sets of measurement were taken for the eight traits considered in this study as described by Brown *et al.* (1983) and adopted by Adeyinka and Mohammed, (2006) and Hamayun *et al.* (2006). Body weight (BW) was taken using the Salter® hanging spring type scale and measured to the nearest 0.5 kg. Heart girth (HG) was measured by taking the circumference of

the chest using a tailor's tape calibrated in cm, taken as the circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body. A rigid tape measure was used to determine; Corpus length (CL), measured as the distance from the point at the top behind the scapular to the base of the tail, height at withers (HW), measured as the distance from the ground to the withers and height at rump (RH), measured as the distance from the ground to the rump.

Using callipers, Hip bone width (HBW) was taken as the distance between the two pelvic bones (*Tubercosae*), across the dorsum. Shoulder width (SW) was measured as distance between the shoulders, i.e. widest point of shoulders. Chest depth (CD) was measured as the distance between the top behind the scapular and the floor of the sternum (taken to be the depth of brisket) immediately behind the forelegs. Plates 1 and 2 show some of the procedures taken.

The coat colour for each animal was scored using a standard colour descriptor manual (SADC, 2001). Each animal was identified by breed group, sex and estimated age class based on dentition according to the methods of Peacock (1996) using permanent teeth eruption. All measurement were taken early in the morning before the animals were fed, with the animals standing on a flat surface with head held up. Visibly pregnant animals were excluded from the study.



Figure 2. Corpus length being taken using a tape measure



Figure 3 Body weight being taken with a weighing scale



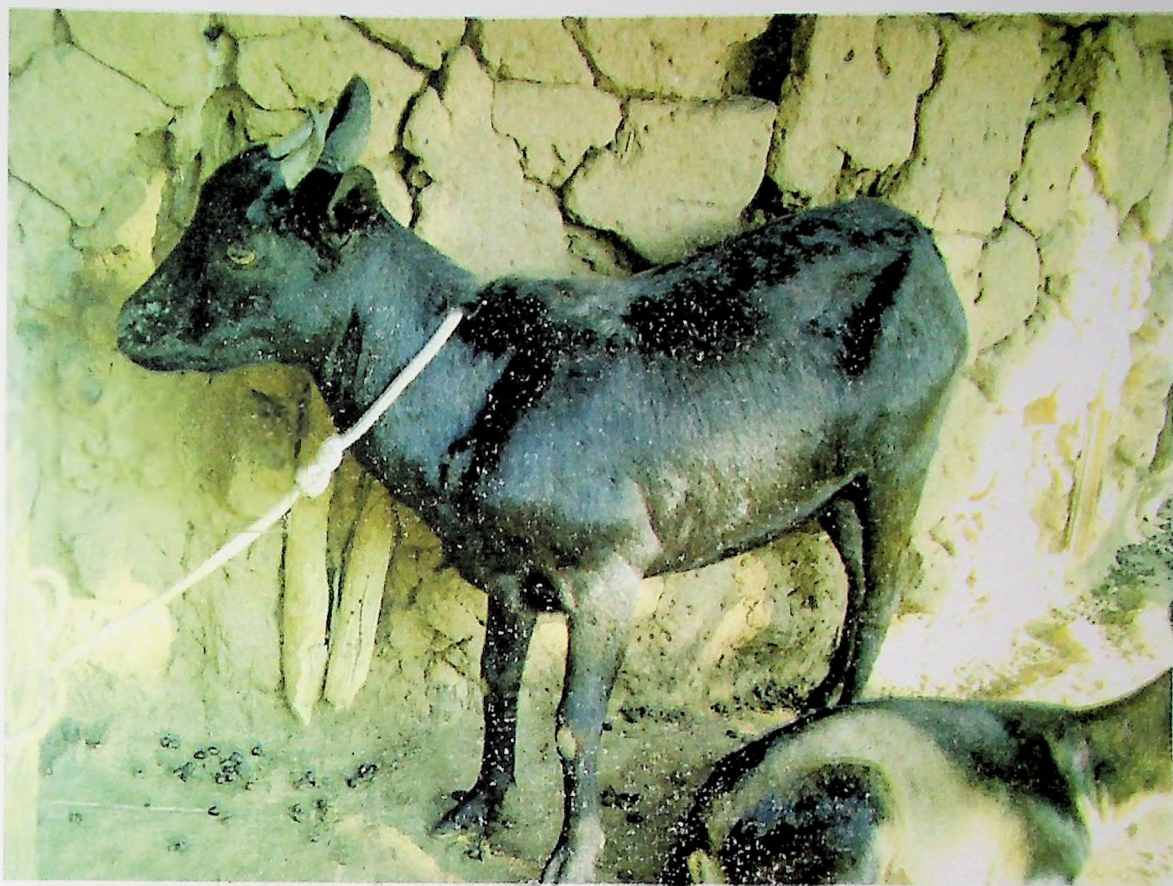
Mubende Buck



Mubende Doe



SEA/Teso Buck



SEA/Teso Doe



SEA/Lugware Buck



SEA/Lugware Doe

Table 4.1 Sample sizes by age group, breed group and sex for the goats studied.

Age (Dentition)	Mubende			Teso			Lugware		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Milk	30	26	56	34	37	71	36	35	71
First Pair	24	32	56	15	29	34	14	28	42
Second pair	16	30	46	12	27	33	10	27	37
Third pair	03	20	23	01	13	24	01	18	18
Fourth pair	01	16	17	00	20	31	00	20	20
Total	74	124	198	62	126	188	61	129	188

4.3 Methods of statistical analysis

The General Linear Models (GLM) procedure of SAS (2003) were used to analyse the data fitting breed, age, sex, and coat colour pattern as main effects in the model. Means and standard errors were computed for each body measurement. The means were separated using Duncan's Least Significant Difference (LSD). The statistical model for the linear body measurements included; breed group, sex, and age-group as fixed effects. The statistical model was,

$$Y = \mu + b_i + s_j + a_k + (b_i * s_j) + (b_i * a_k) + (s_j * a_k) + e$$

Where y = the vector of N observations on an animal of a given breed, sex, age group and coat colour pattern for a given variable (BW, HG, CD, BL, etc); μ = population mean; b_i = i^{th} breed; s_j = j^{th} sex; a_k = k^{th} age group; the interaction effects represent two-way combinations of these factors (e.g., i^{th} breed and j^{th} sex); and e = residual effect which is independently and evenly distributed with mean = 0 and variance = δ^2 .

Relationship between live body weights and linear body measurements were estimated by simple correlation and regression using Pearson correlation method.

4.4 Results and Discussion

Table 4.1 shows that more female animals than males were available for the exercise. The number of available males dwindled as age increased. This could be because farmers would want to keep females goats in preference to males to cut feeding costs and to increase production efficiency or to maintain the sex ratio. Negative selection could be another possibility where bigger males are sold or consumed. Fajemilehin and Salako (2008) reported that in the forest zone of South western Nigeria, goat farmers kept more females than male goats because, majority of the males are preferably castrated or fattened for sale as meat and source of income before their first or second birth day. The end result is that relatively fewer males are available at ages above 2 years. A similar observation has been reported in Malawi by Malata and Banda (2009).

The comparisons in the study were mainly across age group, breed and sex, on morphometric trait dimensions to provide evidence of breed type and existing relationship between live body weight and linear body measurements. A number of measurements like; wither height and rump height, have been used for describing goats in beef show classes, but with much preference for rump height (Alderson, 1999).

Skeletal measurements such as ulna length, body height and length and chest depth are less affected by nutrition and thus indicate inherent size better than dimensions related to deposition of fat and muscle, such as width and girth measurements and body weights (Kamalzadeh *et al.* 1998). The measurements related to deposition of fat and muscles are also affected by gut-fill and pregnancy in females. Larger effects of nutrition on length than on height were documented in beef goats by Lawrence and Pearce (1964). Coleman and Evans

(1985) reported that restricted nutrition suppressed the growth of height and body length during the growing phase in goats.

A summary description of the analyses of variance based on mean squares is presented in Table 4.2. Linear measurements and live body weight were influenced significantly ($P < 0.05$) by breed, age and sex, but not coat colour class (Table 4.2). Hair coat colour is under the control of single or few genes acting in a simple Mendelian way and could not have significant influence on quantitative traits.

Table 4.2 Analysis of variance tables for body measurements in the three Ugandan goat breeds.

Source of variation	Df	Body measurement mean square values							
		Wither height (WH)	Rump height (RH)	Corpus length (CL)	Heart girth (HG)	Chest depth (CD)	Shoulder width (SW)	Hip bone width (HBW)	Live body weight (LBW)
Breed	2	1880.2 ^a	1849.4 ^a	493.8 ^a	1288.7 ^a	158.5 ^a	77.9 ^a	78.3 ^a	1596.9 ^a
Age	4	1861.9 ^a	1957.2 ^a	2024.4 ^a	4029.6 ^a	178.4 ^a	150.9 ^a	150.5 ^a	3655.3 ^a
Sex	1	670.3 ^a	286.8 ^a	254.2 ^a	93.9 ^c	27.4 ^b	5.6 ^c	176.5 ^a	52.5 ^b
Breed x Sex	2	273.3 ^b	105.0 ^b	61.5 ^c	99.4 ^c	7.3 ^c	17.9 ^a	17.8 ^a	41.2 ^b
Breed x age	8	36.4 ^d	5.8 ^d	26.4 ^d	36.7 ^d	2.9 ^c	1.2 ^d	1.1 ^d	19.3 ^c
Sex x age	4	162.1 ^c	44.8 ^d	31.4 ^c	55.3 ^d	46.0 ^c	5.2 ^b	3.9 ^b	100.6 ^b
Residual	551	17.1	17.0	15.1	27.1	1.3	1.3	1.3	17.7

Notes: 1. ^a significant at ($P < 0.001$); ^b Significant at ($P < 0.01$); ^c Significant at ($P < 0.05$); ^d not significant at ($P > 0.05$)

4.4. 2 Effect of age on body weight and linear body measurements

Results of the overall effect of age on all body measurements are summarized in Table 4.3. Appendices 3, 4 and 5 summarize the least squares means and their associated standard errors for live body weight and linear body measurements in different age groups and sex for each breed of goat (*Appendix 3*). Age strongly influenced ($P < 0.05$) live body weight and ($P < 0.01$) linear body measurements in all breeds of goats, depicted by the consistent increases in all the measurements as the age of the animal increased.

Table 4.3 Least square means for live body weight (kg) and linear body measurements (cm) for goats (male + female) as affected by age group.

Age	Measurement							
	WH	RH	CL	CD	SW	HBW	HG	LBW
Milk	46.96 ^c	48.73 ^d	38.35 ^d	19.64 ^d	9.32 ^d	9.37 ^d	52.20 ^d	13.64 ^d
First pair	52.54 ^b	54.43 ^c	43.54 ^c	22.24 ^c	10.52 ^c	10.59 ^c	59.00 ^c	18.96 ^c
Second pair	55.49 ^a	57.39 ^b	45.12 ^c	23.88 ^b	11.29 ^b	11.32 ^b	63.57 ^b	23.62 ^b
Third pair	57.00 ^a	59.19 ^{ab}	47.57 ^b	25.51 ^a	13.85 ^a	12.46 ^a	66.56 ^a	26.77 ^a
Fourth pair	57.13 ^a	59.46 ^a	49.97 ^a	25.57 ^a	13.93 ^a	12.53 ^a	66.60 ^a	27.55 ^a
LSD	1.30	1.33	1.12	0.69	0.38	0.40	1.45	1.48

^{a, b, c, d} Means carrying the same superscript within a column are not significantly different ($P>0.05$). LSD = Least Significant Difference
WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

This is expected since as the animal grows, size and shape are also expected to increase with age. There was variability in body measurements as the animal age increased especially in live body weight. This is in agreement with the earlier reports by Fajemilehin and Salako, (2008); Hamayun *et al.* (2006) in goats. The variability however,

reduced sharply between 3 to 4 pairs of permanent incisor teeth in all the trait measurements examined most probably because the animals had almost attained full growth. Fajemilehin and Salako (2008) reported similar findings and added that at maturity, linear body measurements are essentially a constant, thereby reflecting heritable size of the skeleton. The fact that skeletal measurements like wither height and tissue measurements (circumference) like girths were increasing consistently as the animal aged reflects that the studied animals could be said to have normal skeletal development and normal body condition. Fajemilehin and Salako, (2008) reported that height at withers at any given time reflects the animal's skeletal size and that heart girth reflects body condition.

4.4.2 Effect of Breed on body weight and linear body measurements

Table 4.4 summarizes the overall body weight and linear body measurements for goats above 1 year of age across breed type. The live body weight of Mubende was significantly ($P < 0.05$) higher than for either SEA/Teso and/or SEA/Lugware at all age groups. Generally the body dimensions for Mubende were significantly ($P < 0.05$) greater than those for both Teso and Lugware except ($P > 0.05$) for SW and CL (50.48 ± 0.9) where they didn't differ with SEA/Teso (49.57 ± 0.8). This is indicative of a clear cut distinction between Mubende goat and the two other types in the study. This is as stated by Ssewanyana (2004). Breed difference in body measurements have been reported elsewhere (Hamayun *et al.* 2006; Adeyinka and Mohammed, 2006; Mwacharo *et al.* 2006).

For both SEA/Teso and SEA/Lugware goats, there were no other significant ($P < 0.05$) breed differences in the body measurements. It is however, worth pointing out that although the differences were not statistically significant, generally the body measurements for Teso goats were slightly or marginary higher than those for Lugware goats. The observed between-breed and within breed variations in live body weight and linear body measurements clearly indicate the large genetic diversity which exists in the East African goats, with well defined breeds.

Table 4.4 Least square means for live body weight (kg) and linear body measurements (cm) for goats above one year as affected by breed.

Trait	Breed			LSD
	Mubende (n = 198)	SEA/Teso (n = 188)	SEA/Lugware (n = 188)	
WH	56.4 ^a	50.1 ^b	49.4 ^b	1.29
RH	58.6 ^a	51.4 ^b	51.4 ^b	1.37
CL	45.6 ^a	41.6 ^b	41.6 ^b	1.25
CD	24.4 ^a	21.4 ^b	21.3 ^b	0.71
SW	13.3 ^a	12.8 ^b	12.9 ^b	0.34
HBW	12.8 ^a	11.4 ^b	11.2 ^b	0.37
HG	62.7 ^a	57.9 ^b	56.6 ^b	1.69
LBW	23.5 ^a	18.8 ^b	17.6 ^b	1.48

^{a, b, c, d} Means carrying the same superscript within a row are not significantly different ($P > 0.05$).

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

The magnitudes of linear body measurements for mature animals are indicated in Table 4.4. WH values for Mubende goats, are above (56.0cm) those stated by Devendra and McLeroy (1990) (50 cm) for Mubende goats of Uganda. SEA/Teso (50.1cm) and SEA/Lugware (49.4cm) however, had WH values approximating those reported for Mubende goats. The three breeds of Uganda are taller than the Red Sokoto (40.9 cm), White Borno (43.9 cm) (Adeyinka and Mohammed, 2006). The three breeds are however, shorter than the Kigezi (65 cm), and Somali (62 cm) (Devendra and McLeroy, 1990). The

values of both HG and BL for Teso and Lugware were slightly below those for Mubende, however, the three are superior to both Red Sokoto and White Borno of Nigeria whose HG and BL values were; 40.4cm, 43.7cm and 43.7cm, 46.7cm for Red Sokoto and White Borno respectively.

All the three goat breeds stood higher at the rump than wither, sloping forwards from the posterior and all are shown to be longer than shorter (i.e. body length versus height). The girths of the three breed groups were proportional to their size; however for the measurement, the accuracy of this generalization can be affected by gut-fill.

4.4.3 Effect of sex on body weight and linear body measurements

This study revealed that sex is an important source of variation for live body weight and linear body measurements at all the age groups (Table 4.5). Goats have been reported to exhibit sexual dimorphism in body weight (Adeyinka and Mohammed, 2006). Male goats were heavier than females at all age groups. This is in consonance with studies elsewhere (Ifut *et al.* 1991; Hamayun *et al.* 2006; Adeyinka and Mohammed, 2006). However, work with West African Dwarf goats reported contrary findings with females being superior to males in body weight and linear measures (Fajemilehin and Salako, 2008). The sex-related differences are a function of the between-sex differential hormonal effects on growth. However, Olutogun *et al.* (2003) reported a non-significant effect of sex on body weight and linear body measurements except for girth in White Fulani and Gubali goats in Nigeria. They further explained that the difference in girth was because animals measured were brought for sale and thus were probably made to appear robust by

watering them and feeding them ad libitum, so as to attract good prices at the market, for their false weights.

Table 4.5 Least square means for live body weight (kg) and linear body measurements (cm) for goats over one year old.

Trait	Sex		LSD
	Male (n = 44)	Female (n = 191)	
WH	51.9 ^a	49.9 ^b	1.17
RH	53.9 ^a	51.9 ^b	1.20
CL	43.7 ^a	42.4 ^b	1.05
CD	22.4 ^a	22.3 ^a	0.62
SW	12.6 ^a	12.5 ^a	0.30
HBW	11.2 ^a	10.1 ^b	0.30
HG	59.8 ^a	57.9 ^b	1.45
LBW	20.6 ^a	18.7 ^b	1.29

^{a, b, c, d} Means carrying the same superscript within a row are not significantly different ($P > 0.05$).

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Table 4.6 and Appendices (6, 7 and 8) show the correlation coefficients between live body weight and linear body measurements for Mubende, SEA/Teso and SEA/Lugware goat. The high correlation coefficient values between most linear body measurements and body weight, indicates that any of these traits can be measured easily to give an indication of the other, especially in body weight estimation.

Tables 4.6 showing correlation coefficients between live body weight (kg) and linear body measurements (cm) for 4th pair of incisors for all three breeds

Breed	Measurement						
	WH	RH	CL	CD	SW	HBW	HG
Mubende	0.86**	0.79**	0.78**	0.76**	0.73**	0.62*	0.69*
SEA/Teso	0.56*	0.88**	0.65*	0.81**	0.79**	0.80**	0.52*
SEA/Lugware	0.66*	0.79**	0.59*	0.76**	0.73**	0.80**	0.41

**Significant at ($P < 0.01$); * Significant at ($P < 0.05$).

The high and significant correlation coefficient between live body weight and linear body measurements at milk teeth and first pair of permanent incisor age groups suggests that these variables, especially HG or their combination would provide a good estimate for predicting live body weight in Mubende and SEA goats at an early stage. Hamayun *et al.* 2006; and Mukherjee *et al.* (1986) reported a high and significant correlation value of body weight with Heart girth in brown Bengal does, Beetal goats and grey Bengal goats, respectively. Similar results have been reported on Red Sokoto and Borno goats (Adeyinka and Mohammed, 2006; Moruppa and Ngere, 1986; Osinowo *et al.* 1989). At later stages (three pairs and four pairs of permanent incisors) however, WH and CL became more important as indicators of live body weight across all breed types. In Beetal goats at later stages (from 19 - 24months and on ward) the body length assumed more importance as an indicator of live body weight (Hamayun *et al.* 2006).

The relationship between LBW and some linear body measurements for each breed-type is presented in Table 4.7. SEA/Teso and SEA/Lugware were not different in all the measurements, indicating the possibility of using a common prediction equation to estimate the live body weight measurements from some linear body measurements. WH, RH, CL and HG had R^2 values above 0.7 and are presented as most appropriate regressors. HG had the highest R^2 value and so supporting earlier reports (Mayaka *et al.* 1995; Kyomo, 1978) that it could be used as a single regressor. The levels of significance ($P < 0.001$) between the regression coefficients for the three breeds is indicative of sizable differences in live body weights and the linear measurements and hence of

significant breed differences. Combining the traits improved the R^2 value to 0.91 and there fore accuracy of estimation could however be further improved when these traits are combined in multiple regression.

Table 4.7 Prediction equations for overall live body weight (kg) from some linear body measurements (cm) in Mubende, SEA (Teso and Lugware) goats.

Breed	Dependent	Independent	Regression equation	P Value	Adjusted R^2
Mubende	LBW	WH	$Y = - (39.48 \pm 3.35) + 1.12x$	$P < 0.001$	0.80
	LBW	RH	$Y = - (40.42 \pm 3.50) + 1.09x$	$P < 0.001$	0.79
	LBW	CL	$Y = - (27.63 \pm 3.41) + 1.12x$	$P < 0.001$	0.72
	LBW	HG	$Y = - (35.39 \pm 2.08) + 0.94x$	$P < 0.001$	0.90
SEA (Teso/Lugware)	LBW	WH	$Y = - (28.85 \pm 2.15) + 0.94x$	$P < 0.001$	0.76
	LBW	RH	$Y = - (30.56 \pm 2.09) + 0.94x$	$P < 0.001$	0.79
	LBW	CL	$Y = - (23.08 \pm 1.75) + 0.98x$	$P < 0.001$	0.73
	LBW	HG	$Y = - (25.85 \pm 1.19) + 0.76x$	$P < 0.001$	0.88

WH=Wither height, RH=Rump height, CL=Corpus length, LBW=Live body weight and HG=Heart girth

4.4.4 Conclusions

From the study it can be concluded that there was considerable variability within and between breed types, sex and age of Ugandan goats. This variability in body measurements could point to the genetic diversity in indigenous Ugandan goats. This could be tapped for selective improvement of Mubende and the Small East African goats. The results support the idea that the Mubende goat is a distinct breed from the other SEA goats under the study.

Body measurements had high correlation with the body weight. This may be used as selection criteria. Of the traits measured heart girth would be the best estimator of body

weight in goats. For a more accurate and dependable estimate of body weight, a number of morphometric traits should be combined in a regression equation.

Recommendations

- The large variability within the breed types could be tapped to improve goat production through selection.
- The generated live body weight predictor equations could be used to determine the live body weights of goats in Uganda. This will improve farmers' bargaining power.
- A separate tape measure for any of the linear body measurements, should be calibrated for each of the two distinct goat breed types. i.e for Mubende and Small East Africa.
- Correlation of traits with body weight were maximum milk teeth age thus more appropriate to select for weight before goats make it to the first pair of incisor age.
- Further studies are needed to investigate the relationship between morphometric measurements in the same and other breeds of goats in different regions of the country with maximum number of observations.
- The effect of season and parity on the morphometric traits should also be established.
- A comprehensive study to establish the relationship between carcass characteristics and the linear body measurements in the breeds should be carried out.

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6.0 APPENDICES

Appendix 1: Map of Uganda showing the sampled districts



Source

Appendix 2: Questionnaire used in Survey

QUESTIONNAIRE FOR PRODUCTION, BREEDING PRACTICES AND PHYSICAL TRAITS OF ECONOMIC IMPORTANCE IN UGANDAN GOATS.

1.1 Farm location:

District _____
County _____
Sub-County _____
Parish _____
Village _____
GPS _____

1.2 Respondents information:

Respondent's name _____
Respondent's relation to Household Head _____

1.3 Household Head information:

Name of Household Head _____

Sex	
Age	
Education	
Marital status	
Main farm activity (Crop, livestock, both)	
Profession (if employed)	
Other source(s) of income	

Household structure

Category	Number of males	Number of females	Total
Elderly (>60 yrs)			
Adults (35-60 yrs)			
Youth (>18-35 yrs)			
Adolescent(>12-18 yrs)			
Children (<12 yrs)			
Total			

2.0 FARM ENVIRONMENT DESCRIPTION

2.1 Physical environment

2.1.1 Farm location: Rural ☐1, Peri-Urban ☐2, Urban ☐3

2.1.2 How far is the farm from the district headquarters (km) _____

2.1.3 What is the total area size of the farm (acres) _____

- 2.1.4 Which of the following best describes the position of the farm?
On hill 1, on a slope 2, in a valley 3, on a flat plane 4, other specify 5 _____
- 2.1.5 Which of the following best describes the vegetation of the farm?
Forest 1, Thorny bushes 2, Woodland 3, Grassland 4,
Other (specify) 5 _____
- 2.1.6 What is the drainage condition of the farm?
Well drained 1, Water logged 2, Others e.g. Water logged in rainy season 3 _____
- 2.1.7 Soil types found on this farm
- | | | |
|------------------------|------------------|------------------|
| Sandy 1 | Sandy loam 2 | Woodland 7 |
| Loam 2 | Sandy clay 5 | poorly drained 8 |
| Clay 3 | Saline (salty) 6 | Shallow 9 |
| Other specify 10 _____ | | |
- 2.1.8 Describe the soil fertility of the farm
Fertile 1 Moderately fertile 2 Poor fertility 3

2.2 Production environment

- 2.2.1 Do you feed your goats? Yes 1 No 2
- 2.2.1.1 Who feeds the goats Man 1 Woman 2 Children 3 All 4 Others 5
- 2.2.1.2 Circle all types of feeds used on the farm for goats in order of importance
- | | |
|--------------------|----------------------------|
| Natural pastures 1 | Industrial by-products 5 |
| Forage crops 2 | Improved (sown) pastures 6 |
| Crop residues 3 | Concentrates 7 |
| Minerals 4 | Others specify 8 |
- KEY rank the first top three as follows: 1, 2 and 3.**

- 2.2.2 What are the main sources of feeds used on the farm?
- Grasses: _____
- Legumes: _____
- Trees: _____

- 2.2.2.1 Do you give water to your goats? Yes 1 No 2
- 2.2.2.2 Who waters the goats Man 1 Woman 2 Children 3 All 4 Others 5

- 2.2.3 What are the main sources and distances of water on the farm?
- | | | | |
|-------------------|------------------|---------------------|------------------|
| Lake 1 _____ km | River 2 _____ km | Dam 3 _____ km | Well 4 _____ km |
| Piped 5 _____ km | Rain 6 _____ km | borehole 7 _____ km | ponds 8 _____ km |
| Spring 9 _____ km | Other _____ | 10 _____ km | |

- 2.2.4 How do you grade the quality of water on the farm?
Fresh 1 Salty 2
- 2.2.4 How much water is available during the dry season for the farm?
Adequate 1 Inadequate 2 major cause of inadequacy _____

- 2.2.5 How much water is available during the rainy season for the farm?
Adequate 1 Inadequate 2 major cause of inadequacy _____
- 2.2.6 Do you harvest water for livestock during scarcity or dry season?
Yes 1 If yes, which method _____
No 2 If not, what is the cause _____
- 2.2.7 The most dry months _____
- 2.2.8 The most wet months _____
- 2.2.9 What is the source of labour on farm? (Rank in order of importance: 1=most common
2=moderate, 3=none)
Family 1, Hired 2, Other specify 3 _____
- 2.2.10 What is the major source of capital on farm
Own 1 Borrowed 2 Other specify 3 _____
- 2.3 Management environment**
- 2.3.1 Are your goats housed? Yes 1 No 2
- 2.3.1.1 What is the type of housing?
Kraal 1 Roofed pen/barn 2 Indoors at dwelling house 3 None 4
Other specify 5 _____
- 2.3.2 For housed animals is shelter provided through out the year?
Yes 1 No 2
- 2.3.2.1 Who constructed the house? Man 1 Woman 2 Children 3 Other 4
- 2.3.2.2 Do you clean the house? Yes 1 No 2
- 2.3.2.3 Who cleans the house? Man 1 Woman 2 Children 3 Other 4
- 2.3.3 What grazing/feeding system is practiced?
Free range 1 Herding 2 Confined/Zero-grazing 3 Tethering 4
Other 5 _____
- 2.3.4 Do you conserve feed?
Yes 1 No 2
- 2.3.5 If yes what type of feed is conserved?
Hay 1 Silage 2 Crop residues 3 Fodder banks 4 Other specify 5 _____
- 2.3.6 Do you grow improved pastures?
Yes 1 No 2
- 2.3.7 If yes what types and species?
Grass (names) _____
Legume (names) _____
Trees (names) _____
- 2.3.8 How would you generally characterize the production system on this farm?
1 Nomadisms (unsettled continuous movement of livestock in search of water and feed)
2 Transhumance (settled livestock keeping but only move out for feed and water but return)

- 3 Intensive livestock keeping (only livestock keeping with very limited crop production)
- 4 Mixed crop-livestock (balanced crop production and livestock keeping)
- 5 Other (specify) _____

2.3.9 Does farmer keep records?

If yes, what type of records _____?

If not, what are the reasons _____?

3.0 SECTION 3: LIVESTOCK NUMBERS AND HERD STRUCTURE

3.1 Livestock numbers by species in the household

Species	Numbers				State the trend (increasing=1, stable=2 and decreasing=3)
	Indigenous	Crossbred	Exotic	Total	
Goats					
Goats					
Sheep					
Pigs					
Chicken					
Ducks					
Turkeys					
Rabbits					
Others.....					

4.0 Goat numbers by age and sex structure

Category and age	Tend*	Numbers		Totals
		Mubende	SEA	
Adult females >1 years (old)				
Adult intact males >1 years (old)				
Adult castrates >1 years (old)				
Young intact males ½-1 year (Weaners)				
Young females ½-1 year (Weaners)				
Immature males < ½- year (Calves)				
Immature females < ½ year (Calves)				
Totals				

*Trends indicate 1=increasing, 2=stable, 3=decreasing numbers of animals

4.1 Goat population trends at 10 year intervals

In the farmers observation, could the farmer indicate the trends in the numbers of goats now compared to 10 years ago and also his/her expectation of the numbers 10 years later from now	Current	☐ 1	☐ 2	☐ 3	KEY: tick the box in each column how the farmers estimate goat numbers i.e. High=1, Same=2 or Low=3
	10 yrs ago	☐ 1	☐ 2	☐ 3	
	10 yrs from now	☐ 1	☐ 2	☐ 3	

4.3 Goat breeding systems and choice attributes of animals

4.3.1 Breeding and mating systems

4.3.1.1 Indicate the type of breeding system(s) the farmer is involved in currently

1 Pure indigenous 2 crossbreeding 3 pure exotic

4.3.1.2 Indicate the type of breeding system(s) the farmer is planning for the future

1 Pure indigenous 2 crossbreeding 3 pure exotic

4.3.1.3 If cross breeding is the farmer's future interest, WHY and WHAT is the expected source of the breeding buck?

4.3.1.4 What mating systems are used?

1 communal/village buck (not controlled) 2 Natural controlled (on fenced farm)

3 AI (indigenous semen) 4 AI (exotic semen)

4.3.1.5 If the farmer uses natural mating, what is the source of the breeding buck?

1 Own 2 Hire private bull stays on the farm 3 Group bull rotated among farmers

4 fees paid for services of bull not staying on the farm 5 Other specify _____

4.3.1.6 If the farmer owns a buck(s) for mating, what breed is it

1 pure exotic meat breed (name) _____

2 pure exotic milk breed (name) _____

3 crossbred meat (name) _____

4 crossbred milk (name) _____

5 Other (specify) (name) _____

4.3.1.7 If farmer uses own natural controlled mating, what is the mating ratio of females to males?

Number of breeding females	Number of breeding males
	1

4.3.1.8 Do you practice selection of breeding stock in your goat flock?

Yes 1 No 2

4.3.1.8.1 For how long do u keep your breeding buck (years) _____

4.3.1.9 What are the basic traits and choice attributes farmer uses to select desirable animals for breeding?

Trait*	Sex	
	Male	Female
Qualitative		
Coat colour		
Shape and size of horns		
Meat taste/quality/colour good		
Shape and size of body good		
Small manageable size		
Large body size		
Others (specify)		
Others (specify)		
Quantitative		
Milk production		
Body size		

Fertility		
Docile/good temperament		
Twinning		
Tolerance to diseases		
Tolerance to parasites		
Heat tolerance		
Kid survival		
Others (specify)		
Others (specify)		
Other (specify)		

*Note: Rank attributes: 1=Major, 2=Moderate and 3=Minor

4.4 Reproductive performance

4.4.1 Indicate the age at first mating and first Kidding for the breeds

Breed / Genotype	Average age at first mating (years)	Average age at first parturition (years)	Comment
Mubende			
SEA			

4.4.2 Indicate the average Kidding interval for the cows

Breed / Genotype	Average Kidding interval (months)	Comment (source of mating bull)
Mubende		
SEA		

4.4.3 Prolificacy: Indicate the frequency of multiple births during the past 3 years for the goat breed

Breed / Genotype	Number of multiple births occurred 3 years ago		Comment
	Twin	Triplet	
Mubende			
SEA			

4.4.4 Indicate any seasonality by goats breed

Breed / Genotype	Major kidding season	Months
Mubende		
SEA		

4.5 Milk production characteristics

4.5.1 Indicate average milk production by goats

Breed	Average daily milk production (litres/day) for first kidding		Most recently completed month of lactation	Average monthly yield
	1 st month of lactation	Peak lactation		
Mubende				
SEA				

4.5.2 What is the length of the lactation?

Breed	Lactation length (months)		Comment
	Average	Range	
Mubende			
SEA			

4.6 Body size characteristics of goats

4.6.1 Comparison of body size among kids at birth, weaning age and adult age of goats

Breed	Size of animal			Comment on mortality of each category
	Kids at birth	Weaners (4-12 months)	Adults (2-3 years)	
Mubende				
SEA				

Note compare by indicating with 1=small, 2=medium and 3= large.

(Use *Mubende goat as reference breed*)

4.6.2 Estimate the live body weight at birth, weaning age and adult animal

Breed	Estimated live weight of animal (kg)			Comment
	at birth	Weaners (6-12 months)	Adults (3-5 years)	
Mubende	Male=	Male=	Male=	
	Female=	Female=	Female=	
SEA	Male=	Male=	Male=	
	Female=	Female=	Female=	

Note: compare by indicating with 1=small, 2=medium and 3=large

(Use *Mubende goat as reference breed*)

4.6.3 Udder size as observed for an adult female (Make assessment from observing several adult animals)

Breed	Udder		Teats	Comments
	Length	Overall size	Size	
Mubende				
SEA				

4.6.4 Testicle measurements of adult males (Make assessment from observing several adult animals)

Breed	Testicle observed size		Comments
	Length	Overall size	
Mubende			
SEA			

Note: Compare by indicating with 1=small, 2=medium and 3=large. (Mubende goat as a reference breed)

4.7 Use and choice attributes of goats

4.7.1 Why do you keep goats?

Use	Mubende	SEA
Milk		
Meat		
Manure		
Wealth accumulation		
Customary norm		

Insurance		
Skins		
Milk products (gee)		
Other (specify)		

Tick all applicable answers and Rank only top three as 1, 2, and 3 least

4.7.2 How were the goats acquired?

Way of acquiring	Mubende	SEA
Bought		
Bride price		
Exchange for food crops		
Sale/exchange of other livestock		
Gift		
Other		

Tick all applicable answers and Rank only top three as 1, 2, and 3 least

4.7.3 Which breeds of goats would you like to keep in the future?

Breed	Rank	Reasons and number of animals
SEA/Teso		
Mubende		
Kigezi		
Toggenburg		
Boer		
Saanen		
Milk exotic/cross or pure		
Meat exotic/cross or pure		
Other specify		

Tick all applicable answers and rank only top three as 1, 2 and 3

4.7.4. How many animals have entered the herd of the household in the last 6 months including new born calves

Mode of entry	Mubende	Rank	SEA	Rank
Born				
Bought (also in kind)				
Loan (unpaid)				
Lease (paid)				
Exchange (goats for goats)				
Gift				
Dowry				
Other (specify)				

Tick all applicable answers and rank in order of importance where 1=most important...3= least

4.7.5. How many animals have left the herd in the last 6 months? (Including calves!)

Mode of removal	Mubende	Rank	SEA	Rank
Sold				
Slaughtered for Home consumption				
Slaughtered for ceremony				
Given out as gifts				
Bride price				
Stolen				
Dowry				
Exchange				
Other (specify)				

Tick all applicable answers and rank in order of importance where 1=most important...3= least

6.0 ADAPTATION

6.1 Diseases

6.1.1 Indicate which major disease(s) affect the goat on the farm and indicate any seasonal effect

Disease	Breed and most prevalent season for the disease (Tick)			
	Mubende		SEA	
	Wet	Dry	Wet	Dry

6.1.2 How does the farmer control the diseases mentioned above?

6.1.3 In absence of veterinary services and western medicines, state the traditional methods of treating diseases mentioned above?

6.2 External parasites

6.2.1 Indicate which major external parasite(s) affect the goat by breed on the farm and the season of prevalence

External parasite/pest	Breed and most prevalent season for the disease (Tick)			
	Mubende		SEA	
	Wet	Dry	Wet	Dry

6.2.2 How does the farmer control the external parasites/pest mentioned above?

6.2.3 In absence of veterinary services and western medicines, state the traditional methods of treating the external parasites/pest mentioned above?

6.3 Internal parasites and worms

6.3.1 Indicate which major internal parasite(s) and worms affect the goat by breed on the farm and the season of prevalence

Internal parasites	Breed and most prevalent season for the disease (Tick)			
	Mubende		SEA	
	Wet	Dry	Wet	Dry

6.3.2 How does the farmer control the internal parasites/worm mentioned above?

6.3.3 In absence of veterinary services and western medicines, state the traditional methods of treating the internal parasites/worms mentioned above?

Other problems

6.4.1 Indicate other major health and social problems and risks that affect the goat breed on the farm and the season of prevalence

Other health problems	Breed and most prevalent season for the disease (Tick)			
	Mubende		SEA	
	Wet	Dry	Wet	Dry

Use local names as well as (nutritional, wild predators, wild life, thieves and poisoning)

6.4.2 How does the farmer cope with the problem stated above?

6.4.3 Indicate the disease, parasites or health problems that the breed shows tolerance?

Breed	Tolerance exhibited on the factor				
	Disease	External parasite	Internal parasite	Water scarcity	Feed scarcity
Mubende					
SEA/					

Indicate for diseases and parasites by 1=very tolerant, 2=tolerant and 3=not tolerant
For water scarcity and feed scarcity by V=very sensitive, S=sensitive and NS=not sensitive

6.4.4 Did the farmer consider tolerance and sensitivity of the animals as an important factor for choosing to keep the goat breed owned?

- Yes 1
- No 2

6.4.5 If yes which is the most important criteria (Rank 1=most important, 2=important, 3=not important

Reason	Tick applicable reasons	Rank
Tolerance to ticks		
Tolerance to tick born diseases		
Tolerance to internal parasites		
Tolerance to water scarcity		
Tolerance to feed scarcity		
Tolerance to dry hot conditions		
Tolerance to wet cold conditions		
Tolerance to other conditions (specify)		

7.0 Physical characteristics

Farm location:

District _____
County _____
Sub-County _____
Parish _____
Village _____
GPS reading _____

Breed, group, Sex and Dentition

Sex	Dentition**	Breed***

* use 1 = female and 2 = male ** 1= Milk teeth, 2=one pair of incisors, 3= two pairs of incisors, 4= three pairs of incisors and 5= four pairs of incisors. *** Use1=Mubende, 2=Teso, 3=Lugware

Qualitative physical characteristics

4.7.1.1 Coat color, hair type and face profile

Main physical characteristics											
Major coat colours (%)					Hair			Face profile			
Black	White	Brown	grey	others	Short	long	Long curly	Flat	Concave	Convex	Roman

4.7.1.2 Horns and ears

Main physical characteristics										
Horns					Ears					
Short	long	Curved	spiral	Poll	Small erect	Small horiz	Small droopy	Large horiz	Large droopy	

4.7.1.3 Body size and shape, legs and temperament

Main physical characteristics										
Body size			Body shape		Legs			Temperament		
Small	Large	Med	Block	Angular	Short	Med	Long	Docile	Average	Aggressive

Quantitative physical measurements

measurements with a tape measure

Wither Height	Rump Height	Body length	Corpus Length

Weight (Kg)

Using a weighing scale

measurements with a caliper

Chest depth	Chest width	Rump depth	Hip bone width	Scrotal circumf

Heart girth

Take actual measurements with a heart girth tape

Colour Enter number(s) from colour chart. Complete both halves of double box if animals have more than one colour, main colour first; first half only if uniform. Enter in order of frequency of colour combination in flock. For individual animals

Body

1		
2		
3		

Rank

Head

1		
2		
3		

Rank

Hoof

1		
2		
3		

Rank them

Muzzle

1		
2		
3		

Rank them

Appendix 3: Means for body measurements of goats by age for Mubende goats

Dentition	Sex	Number	Measurement (cm) $\pm$ s.e							
			WH	RH	CL	CD	SW	HBW	LBW	HG
Milk	F	36	49.04 $\pm$ 1.61	50.69 $\pm$ 1.67	38.87 $\pm$ 1.17	20.31 $\pm$ 0.78	11.87 $\pm$ 0.41	10.07 $\pm$ 0.41	14.71 $\pm$ 1.30	53.58 $\pm$ 1.63
	M	20	55.52 $\pm$ 1.09	56.61 $\pm$ 1.03	42.12 $\pm$ 0.81	22.20 $\pm$ 0.50	12.47 $\pm$ 0.25	9.68 $\pm$ 0.24	17.93 $\pm$ 1.14	56.57 $\pm$ 1.19
First pair	F	18	56.15 $\pm$ 0.85	57.80 $\pm$ 0.86	46.30 $\pm$ 0.63	24.45 $\pm$ 0.29	12.76 $\pm$ 0.24	12.73 $\pm$ 1.14	21.30 $\pm$ 0.93	61.91 $\pm$ 1.00
	M	13	58.42 $\pm$ 1.04	60.47 $\pm$ 1.06	47.28 $\pm$ 0.98	24.93 $\pm$ 0.34	13.75 $\pm$ 0.37	9.90 $\pm$ 0.24	27.30 $\pm$ 1.74	66.28 $\pm$ 1.55
Second Pair	F	13	58.70 $\pm$ 0.94	60.71 $\pm$ 0.98	47.57 $\pm$ 0.81	25.74 $\pm$ 0.50	14.30 $\pm$ 0.51	13.30 $\pm$ 0.24	25.70 $\pm$ 1.69	67.27 $\pm$ 1.20
	M	13	60.10 $\pm$ 1.02	60.90 $\pm$ 0.88	48.30 $\pm$ 0.75	25.98 $\pm$ 0.35	14.53 $\pm$ 0.34	10.90 $\pm$ 0.37	28.20 $\pm$ 1.07	67.40 $\pm$ 0.72
Third Pair	F	16	59.80 $\pm$ 0.63	62.46 $\pm$ 0.60	48.59 $\pm$ 0.77	26.02 $\pm$ 0.29	15.13 $\pm$ 0.20	13.21 $\pm$ 0.21	27.73 $\pm$ 1.01	67.72 $\pm$ 0.80
Fourth Pair	F	20	60.32 $\pm$ 0.98	62.24 $\pm$ 1.01	50.72 $\pm$ 1.21	26.22 $\pm$ 0.52	15.01 $\pm$ 0.21	13.65 $\pm$ 0.23	28.91 $\pm$ 1.47	68.01 $\pm$ 1.43

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Appendix 4: Means for body measurements of goats by age for SEA/Teso goats

Dentition	Sex	Number	Measurement (cm) $\pm$ s.e							
			WH	RH	CL	CD	SW	HBW	LBW	HG
Milk	F	37	44.18 $\pm$ 1.10	46.12 $\pm$ 1.09	37.77 $\pm$ 1.01	18.65 $\pm$ 0.55	10.90 $\pm$ 0.26	9.09 $\pm$ 0.26	13.01 $\pm$ 0.84	50.75 $\pm$ 1.49
	M	34	50.90 $\pm$ 0.97	51.67 $\pm$ 0.97	41.68 $\pm$ 0.97	20.64 $\pm$ 0.50	11.68 $\pm$ 0.21	8.88 $\pm$ 0.21	16.25 $\pm$ 0.93	54.43 $\pm$ 1.41
First pair	F	19	50.97 $\pm$ 0.70	53.70 $\pm$ 0.60	42.78 $\pm$ 0.54	21.36 $\pm$ 0.60	12.04 $\pm$ 0.19	10.25 $\pm$ 0.19	18.76 $\pm$ 0.79	58.10 $\pm$ 0.83
	M	15	54.08 $\pm$ 0.42	54.76 $\pm$ 0.50	44.16 $\pm$ 0.65	21.19 $\pm$ 0.38	12.84 $\pm$ 0.24	10.04 $\pm$ 0.24	17.23 $\pm$ 0.34	58.36 $\pm$ 0.60
Second Pair	F	25	53.78 $\pm$ 0.70	55.42 $\pm$ 0.66	46.61 $\pm$ 0.50	22.32 $\pm$ 0.57	12.63 $\pm$ 0.29	10.83 $\pm$ 0.28	22.21 $\pm$ 1.04	62.49 $\pm$ 0.88
	M	08	56.15 $\pm$ 0.43	57.33 $\pm$ 0.52	49.62 $\pm$ 0.32	23.50 $\pm$ 0.22	13.47 $\pm$ 0.09	10.58 $\pm$ 0.10	19.91 $\pm$ 0.27	63.67 $\pm$ 0.62
Third Pair	F	13	54.70 $\pm$ 0.53	56.43 $\pm$ 0.54	48.23 $\pm$ 0.90	24.85 $\pm$ 0.29	13.23 $\pm$ 0.20	11.71 $\pm$ 0.40	25.46 $\pm$ 0.71	65.74 $\pm$ 0.70
Fourth Pair	F	10	54.36 $\pm$ 0.69	57.38 $\pm$ 0.56	49.93 $\pm$ 0.32	25.95 $\pm$ 0.33	13.76 $\pm$ 0.24	11.76 $\pm$ 0.23	26.05 $\pm$ 0.70	65.19 $\pm$ 1.01

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Appendix5: Means for body measurements of goats by age for Mubende goats

			Measurement (cm) $\pm$ s.e							
Dentition	Sex	Number	WH	RH	CL	CD	SW	HBW	LBW	HG
Milk	F	35	45.36 $\pm$ 0.84	46.68 $\pm$ 0.91	37.71 $\pm$ 0.73	19.06 $\pm$ 0.38	11.15 $\pm$ 0.18	9.35 $\pm$ 0.20	11.15 $\pm$ 0.20	50.18 $\pm$ 1.08
	M	36	47.64 $\pm$ 0.91	48.13 $\pm$ 0.87	38.86 $\pm$ 0.80	19.26 $\pm$ 0.44	11.58 $\pm$ 0.20	8.58 $\pm$ 0.18	12.93 $\pm$ 0.58	50.71 $\pm$ 1.03
First pair	F	28	49.69 $\pm$ 0.68	51.85 $\pm$ 0.69	41.27 $\pm$ 0.47	20.52 $\pm$ 0.67	12.01 $\pm$ 0.18	10.55 $\pm$ 0.18	15.83 $\pm$ 0.64	55.64 $\pm$ 0.88
	M	14	51.96 $\pm$ 1.11	51.89 $\pm$ 1.05	43.03 $\pm$ 0.99	21.95 $\pm$ 0.61	12.35 $\pm$ 0.20	9.22 $\pm$ 0.16	16.17 $\pm$ 0.89	56.88 $\pm$ 1.13
Second Pair	F	27	52.90 $\pm$ 0.54	54.70 $\pm$ 0.58	45.78 $\pm$ 0.79	23.09 $\pm$ 0.31	12.53 $\pm$ 0.19	11.70 $\pm$ 0.21	21.31 $\pm$ 0.75	61.05 $\pm$ 0.83
	M	10	55.20 $\pm$ 0.60	56.41 $\pm$ 0.46	46.95 $\pm$ 0.90	23.85 $\pm$ 0.50	13.50 $\pm$ 0.21	9.73 $\pm$ 0.19	20.60 $\pm$ 1.22	61.70 $\pm$ 1.31
Third Pair	F	22	53.91 $\pm$ 0.80	55.89 $\pm$ 0.89	45.64 $\pm$ 0.83	23.76 $\pm$ 0.46	13.14 $\pm$ 0.25	12.49 $\pm$ 0.30	23.76 $\pm$ 0.36	63.58 $\pm$ 0.85
	F	18	54.77 $\pm$ 0.60	56.21 $\pm$ 0.58	47.06 $\pm$ 0.61	24.36 $\pm$ 0.62	13.71 $\pm$ 0.42	12.46 $\pm$ 0.17	24.36 $\pm$ 0.68	63.84 $\pm$ 0.74

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Appendix 6: Correlations coefficients between body weight (kg) and linear body measurements (cm) in Mubende goats

Age group	Sex	Measurement						
		WH	RH	CL	CD	SW	HBW	HG
Milk	F	0.75**	0.70**	0.86**	0.67*	0.51*	0.68**	0.92**
	M	0.77**	0.73**	0.79**	0.43	0.36	0.66*	0.87**
First pair	F	0.50*	0.63*	0.41	0.31	0.26	0.15	0.59*
	M	0.33	0.24	0.47	0.39	0.12	0.55*	0.24
Second pair	F	0.53*	0.36	0.56*	0.47	0.45	0.28	0.80**
	M	0.75**	0.77**	0.73**	0.56*	0.55*	0.46	0.79**
Third pair	F	0.78**	0.80**	0.60*	0.52*	0.53*	0.65*	0.42
Fourth pair	F	0.86**	0.79**	0.78**	0.76**	0.73**	0.63*	0.59*

** Significant at ($P < 0.01$); * Significant at ($P < 0.05$).

WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Appendix 7: Correlation coefficients between body weight (kg) and linear body measurements (cm) in SEA/Teso

Age group	Sex	Measurement						
		WH	RH	CL	CD	SW	HBW	HG
Milk	F	0.74**	0.87**	0.85**	0.54*	0.638*	0.782**	0.79**
	M	0.54*	0.69**	0.79**	0.77**	0.672*	0.571*	0.82**
First pair	F	0.48	0.61*	0.12	0.65*	0.45	0.433	0.73**
	M	0.617*	0.54*	0.44	0.18	0.010	0.325	0.92**
Second pair	F	0.75**	0.46	0.70**	0.03	0.552*	0.622*	0.68**
	M	0.72**	0.67*	0.67**	0.46	0.503*	0.340	0.75**
Third pair	F	0.60*	0.42	0.58*	0.66*	0.718**	0.761**	0.302
Fourth pair	F	0.56*	0.88**	0.65*	0.81**	0.794**	0.802**	0.52*

** Significant at ($P < 0.01$); * Significant at ($P < 0.05$). WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth

Appendix 8: Correlation coefficients between body weight (kg) and linear body measurements (cm) in SEA/Lugware

Age group	Sex	Measurement						
		WH	RH	CL	CD	SW	HBW	HG
Milk	F	0.92**	0.90**	0.96**	0.93**	0.90**	0.96**	0.91**
	M	0.83**	0.87**	0.85**	0.76**	0.86**	0.84**	0.87**
First pair	F	0.30	0.47	0.42	0.81**	0.46	0.37	0.76**
	M	0.63*	0.51*	0.77**	0.67*	0.60*	0.23	0.53*
Second pair	F	0.77**	0.76**	0.54*	0.24	0.32	0.58*	0.93**
	M	0.55*	0.73**	0.90**	0.37	0.46	0.37	0.59*
Third pair	F	0.60*	0.32	0.60*	0.62*	0.71**	0.85**	0.24
	F	0.66*	0.79**	0.59*	0.76**	0.73**	0.80**	0.41

** Significant at ($P < 0.01$); * Significant at ($P < 0.05$). WH=Wither height, RH=Rump height, CL=Corpus length, CD=Chest depth, SW=Shoulder width, HBW=Hip bone width, LBW=Live body weight and HG=Heart girth