PHENOTYPIC CHARACTERISATION OF UKEREWE AND BUNDA TANGANYIKA SHORTHORN ZEBU CATTLE IN THE LAKE VICTORIA BASIN

GODFREY LUCAS CHASAMA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

A study was carried out to characterise phenotypically the Ukerewe TSZ strain in order to know if it differs from the Bunda TSZ strain. Respondents from 46 households were interviewed on sources of income and food, number and species of livestock kept, ranking of livestock, usage of cattle, age at first calving, calving interval and lifetime number of calving. A total of 169 adult TSZ cattle were examined for coat colour pattern, and colours of coat, skin, muzzle, eyelid and hoof. Other traits that were examined are horn shape and sizes of udder, dewlap, testicle, navel-flap and prepuce. Physical body measurements namely body weight, heart girth, body length, withers height, horn length, ear length, muzzle circumference, hock circumference and tail length were taken for each cattle. The SPSS and SAS computer packages were used to analyse qualitative and quantitative data, respectively. Ukerewe TSZ cattle were observed to be significantly ($p<0.05$) heavier and calving earlier than Bunda TSZ cattle, whereas calving interval and lifetime number of calving revealed insignificant ($p>0.05$) differences between the two strains. Black colour occurred at significantly ($p<0.05$) higher frequency for the Ukerewe TSZ strain than for the Bunda TSZ strain. The Ukerewe TSZ strain was also found to have significantly ($p<0.05$) bigger heart girth and shorter horn length than the Bunda TSZ strain. The rest of the physical measurements and all external body appendages showed insignificant ($p>0.05$) differences between the two strains. With the exception of ear length and muzzle circumference, all measurements were positively and highly significantly ($P<0.01$) correlated with the body weight estimated from heart girth. Thus, the strains under the study differed remarkably in phenotype. Advanced characterisation

of the strains using microsatellite DNA markers is recommended in order to establish if they could have a common origin.

DECLARATION

I, **Godfrey Lucas Chasama,** do hereby declare to the Senate of Sokoine University of Agriculture that this is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted in any other Institution.

_______________________________ _____________________

Godfrey Lucas Chasama Date

(MSc Student)

The above declaration is confirmed

_______________________________ _____________________

Prof. Katule, A. Date

(Supervisor)

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DEDICATION

To my father Lucas Bartazar Chasama, mother Alivera Steven Mayunga and daughter Brigitte Godfrey Chasama.

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LIST OF ABBREVIATIONS

BC	Before Christ
DALDO	District Agriculture and Livestock Development Officer
DASP	Department of Animal Science and Production
EASZ	East African Shorthorn Zebu
FAO	Food and Agriculture Organisation
MLDF	Ministry of Livestock Development and Fisheries
SAS	Statistical Analysis System
SEAZ	Small East African Zebu
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
TALIRI	Tanzania Livestock Research Institute
TAP	Tropical Animal Production
TSZ	Tanganyika Shorthorn Zebu
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

It is well known that the African continent is endowed with a big number of indigenous cattle. The cattle are of different types, one of them being Zebu. African Zebu cattle are believed to have descended from the secondary cattle domestication in the arid areas of the 'Fertile Crescent' about 5000 BC (Payne and Wilson, 1999). In the continent cattle of this type are represented by 75 breeds (Rege, 1999), which are classified into breed groups. One of the breed groups is the Small East African Zebu (SEAZ), which is also called the East African Shorthorn Zebu (EASZ). Tanganyika Shorthorn Zebu (TSZ) is one of the breeds comprising SEAZ group.

The TSZ breed constitutes over 95% of the indigenous cattle population in Tanzania (MLDF, 2009). About 94% of the TSZ cattle are kept in the agro-pastoral and pastoral systems of the country (URT, 2006), where they play important socio-economic roles. TSZ cattle serve as a source of food, income, employment, draught power, hides, manure and fuel (Scarpa *et al.*, 2003). The cattle serve also as an important form of insurance and accumulation of wealth for many rural households. Nonetheless, the TSZ breed is an important cattle germplasm resource in crossbreeding programmes (Valle-Zarate, 1996).

Many years back the TSZ breed was being regarded as an indiscriminately mixed population with inferior genetic potential (Scholtz, 1988). It is only in recent years that the breed has attracted attention as a genetic resource with great improvement potential for inclusion in the development of stress tolerant cattle. This has followed from the recent recognition of the breed's high diversity and adaptability to environmental rigours commonly found in the tropics. These desirable features have been the main focus in the characterisation of its subpopulations, which are scattered in different production environments within Tanzania mainland.

The TSZ breed is known to include the Maasai, Mkalama Dun, Singida White, Mbulu, Gogo, Pare, Chagga, Iringa Red and Tarime strains (Das and Mkonyi, 2003). There are initiatives currently being undertaken by the government to conserve these strains (Tungu, G.B. personal communication, 2012). However, some of the TSZ breed subpopulations, including those found in Lake Victoria islands comprising Ukerewe District are still non-descript. These subpopulations might be subject to epizootics, famine and civil strife. Genetic erosion in these subpopulations might also result from a lack of systematic breed development programmes (Wurzinger *et al*., 2006).

There is an urgent need to systematically characterise the non-descript TSZ subpopulations before taking measures aimed at rescuing them from a multitude of threats. If the non-descript TSZ subpopulations are characterised and their descriptions inventoried, more informed decisions can be made regarding their conservation, improvement and utilisation. In doing so, attention has to be paid more to strains which appear to be uniquely adapted, especially those which are isolated since in localised disaster situations such strains can be easily lost (Carson *et al.*, 2009).

Ukerewe District separated from the mainland more than fifty years ago. There have also been notions from local sources pointing to the existence of morphological differentiation and performance superiority of the Ukerewe TSZ strain over TSZ subpopulations kept in neighbouring mainland areas (Kaswahili, W.B. personal communication, 2009). These have been suggesting that the Ukerewe TSZ strain is distinguishable from other TSZ subpopulations.

It is likely that the Ukerewe TSZ strain has emerged as a separate TSZ subpopulation after undergoing unique adaptation. The adaptation might have occurred in response to the influence of the production environment (Rege and Tawah, 1999). It is also likely that long time selection practiced according to specific breeding preferences have had considerable influence on the phenotype of the Ukerewe TSZ strain (Msanga *et al*., 2001). Phenotypic differentiation in the strain might have also resulted from the reduction of other cattle migration into Ukerewe District after the occurrence of land separation (Beate, 2000).

It is possible that Ukerewe TSZ strain has originated from an EASZ breed other than the TSZ. This is because geographically Ukerewe District has a direct connection with the neighbouring countries of Kenya and Uganda, and there is evidence of long time communication between Ukerewe District and Lake Victoria shore regions of these neighbouring countries (Kaswahili, W.B. personal communication, 2009).

According to FAO (2011), primary phenotypic characterisation can be used successfully to evaluate differences between the Ukerewe TSZ strain and other strains of TSZ breed. Standard morphological, colour and performance data of the Ukerewe TSZ strain can be used to rank it phylogenetically (Gatesy and Arctander, 2000). This then can allow for the establishment of the relationships between Ukerewe TSZ strain and other cattle populations. Ultimately the information can be an important input in the planning and evaluation of breeding goals (Zechner *et al.*, 2001). Therefore besides facilitating advanced characterisation of the Ukerewe TSZ strain, the characterisation study sought to provide important information required for its conservation and improvement.

This study was undertaken with the overall objective of elucidating phenotypic differences between the Ukerewe TSZ strain in Ukerewe District and the Bunda TSZ strain in Bunda District. The study was specifically intended to compare phenotypic characteristics of the Ukerewe TSZ strain and those of the Bunda TSZ strain and to relate the differences with respective environments and socio-economic characteristics of the herders.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Animal Genetic Resources

Worldwide there are about 6379 documented breed populations of some 30 species of livestock that have been developed in the last 12 thousand years since the first livestock species were domesticated (Beate, 2000). The different livestock breeds occurred as different communities managed their livestock populations in their respective habitats according to their own preferences and needs (Kohler-Rollefson, 2003).

Apparently, a large proportion of indigenous livestock populations of the developing world, where most animal genetic resources are found today have yet to be described (Hanotte and Jianlin, 2006). Furthermore, the non-descript livestock populations appear to form homogenous groups distinguishable on the basis of identifiable and stable features that warrant their being distinguished with separate identities (FAO, 2011).

Identification and inventorying of local livestock breeds and strains in developing countries is therefore not exhaustive and new breeds and strains continue to be identified (Wuletaw *et al*., 2008). There is a need for further work to be done to explore highly diverse breeds of the developing world so that more breeds and strains can be identified and inventoried to allow their conservation and rational utilisation. Determining whether or not a non-descript population is distinguishable from neighbouring populations on the basis of identifiable and stable phenotypic characteristics (among which may be unique and valuable attributes) that warrant their being distinguished as separate breeds is one of the roles of phenotypic characterisation (FAO, 2011).

As a strategy for effecting increased pace of animal genetic resource characterisation, a few years ago FAO initiated a major country driven documentation exercise that targeted immediate actions for conservation of livestock genetic resources. Developing countries have to support the initiative by characterising more and more non-descript indigenous populations. This applies to Tanzania, a country which is home to the well adapted and highly diverse TSZ cattle breed. However, while the TSZ breed is so qualified and hence valued as a genetic resource for cattle breeding (Perry *et al.*, 2002), phenotypic data on its subpopulations from different agro-ecological systems in which they are found within the country are still limited.

2.2 Indigenous Knowledge on Animal Breeding

In traditional communities which keep livestock, local indigenous knowledge provides the best preliminary information available about breed identity (FAO, 2011). The communities have been the custodians of indigenous breeds for many centuries and they tend to keep animals in a ‘pure’ state as they fulfil religious, ritual and subsistence purposes (Köhler-Rollefson, 2004). Over a long time the livestock herder communities have developed strains that suited best their various economic and cultural requirements**.** Such strategies and mechanisms used by livestock breeders to manipulate genetic constitution of livestock herds are an integral part of indigenous knowledge on animal breeding. Therefore, characterisation of such local livestock populations has to be done with the aid of indigenous knowledge of their herders.

2.3 Livestock Adaptation

Adaptation refers to the complex of processes by which an animal switches itself to cope with the environment in which it has to live (Williamson and Payne, 1965). The processes normally occur in response to environmental influence and are associated with development of adaptive features which capacitate the animals to live in the environment (Baker and Gray, 2004). Adaptive features can be behavioural, anatomical or physiological and either temporary or permanent. The permanent changes can be inheritable or not (Williamson and Payne, 1965). Adaptive features possessed by livestock are normally favourable and therefore farmers normally select and breed for them through generations.

Geographical isolation of a livestock population in a unique production environment over a long time allows for retention of the features within the population and restricts introgression from others, thus leading to differentiation (Rege and Tawah, 1999). As farmers select and breed, inbreeding occurs and contributes substantially to stabilise the developed adaptive characteristics (Mwacharo *et al*., 2006). The composition of livestock herds within Africa is also greatly influenced by constant movements of their herders which ensure continual mixing of gene pool and place considerable selection pressures to tolerate local stresses. Failure to circumvent barriers at some points is one of the important causes of differential morphological and physiological evolution (Beate, 2000).

2.4 The Influence of Physical Environment on Cattle Phenotype

2.4.1 The influence of climate

(i) Temperature

Air temperature is the most influential climatic factor affecting animals in the tropics with direct and indirect effects on cattle phenotype (Williamson and Payne, 1965). Under high environmental temperatures above the comfortable zone (10 to 27^{o} C for tropical cattle) the metabolic rate of cattle is lowered to depress appetite (Williamson and Payne, 1965). This results in lowering of the rate of feed intake and grazing time which in turn affect performance as measured by mature size, growth rate, milk yield and fertility (Williamson and Payne, 1965). Indirect effects of air temperature are mediated through plane of nutrition. Herbage which is the main feed for cattle has optimum range of temperature for growth and development. Environmental temperature also has effect on effective precipitation and hence herbage growth which eventually have effect on plane of nutrition (Williamson and Payne, 1965).

The possession of large sized ears, dewlap, muzzle and hump in cattle confers the animals with high thermo-regulatory ability as the features increase the surface area per unit body weight and thereby enhance heat dissipation from the body core (FAO, 2011). Relative changes in feed and water intake of cattle which also vary with air temperatures can as well effect changes in body depth (Williamson and Payne, 1965).

Elevations in testicular temperature which may result from high air temperatures can influence cattle hormonal system and impede spermatogenesis (Setchell, 1978), thus lowering fertility in bulls. High air temperatures are also known to impede embryonic development directly (Roth and Hansen, 2004) or indirectly through plane of nutrition of breeding bulls and cows. Therefore, environmental temperature can have both direct and indirect effects on reproductive performance of cattle.

TSZ cattle are better able to regulate body temperature in response to heat stress than are cattle from a variety of *Bos taurus* breeds (Hansen, 2004). The thermo-tolerance is contributed by their reduced rates of intake and metabolism resulting from reduced growth rates and milk yields, which lead to lower production of heat than temperate breeds (Hansen, 2004). The localisation of body fat in the hump makes their bodies more efficient in dissipating heat than hump-less cattle breeds (FAO, 1987). Another adaptive feature that contributes to TSZ thermo-tolerance is their small body size. This enlarges their surface to body mass ratio which imparts in them a greater efficiency in dissipating excess heat than large breeds (FAO, 1987).

(ii) Radiation

Intense solar radiation is another critical climatic factor affecting cattle phenotype in the tropics. At levels above the optimum range solar radiation causes heat load which results in reduced intake and hence lowered performance (Williamson and Payne, 1965). However, the effect of solar radiation varies with cattle type and some breeds are known to be tolerant because of adaptation.

In common with other African Zebu breeds, TSZ breed is tolerant to intense solar radiation. The breed’s tolerance to extreme levels of solar radiation has been linked to high reflectivity of the body coat. Light-coloured, sleek and shiny hair coats of TSZ cattle enable them to reflect a greater proportion of incident solar radiation than those reflected by dark coloured breeds (Hansen, 1990). Zebu cattle also have higher sweat gland density than temperate cattle breeds, a feature that make them more efficient in evaporative cooling (FAO, 1987).

2.4.2 The influence of management practices on cattle phenotype

Variations in phenotypic features observed among SEAZ subpopulations is also known to stem from differences in management practices (Mwacharo *et al*., 2006). Tethering in cattle reduces chances for contracting communicable diseases transmitted during grazing. The management practice also lowers maintenance energy requirement of cattle and this leaves a relatively big energy balance for growth, production and reproduction. From the reduced expenditure of energy, feed conversion efficiency is also increased and this together with better health promotes animal performance (Richardson and Smith, 2006). For that reason tethered cattle can perform higher than others of the same genetic potential which have to graze extensively in search of herbage. Utilisation of cattle for draught power lowers performance in growth, production and reproduction because exploitation of power in traction lowers energy balance for these processes.

2.5 Socio-economic Characteristics of Cattle Herders and Usage of Cattle

In the Lake Victoria basin most smallholder livestock farmers opt to keep multipurpose animals, capable of providing a wide range of products and services (Ndumu *et al.,* 2008). Cattle are often kept in largest numbers, and this suggests their high ranking in importance (Ngowi *et al*., 2008). Consequently, cattle constitute the backbone of the livestock socio-economy and genetic resource base.

The farmers' well known sources of income in the Lake Victoria basin area include agriculture, off-farm business, fishing and pension, with agriculture by far being the main stay of the inhabitants (Odada *et al.,* 2006). Among the different livestock species raised, cattle are regarded as the major contributor to household income through selling of live animals and livestock products, mainly milk, butter and hides (Ngowi *et al*., 2008).

Cattle have a significant contribution to food security in the agro-pastoral systems (Odada *et al.*, 2006). They supply farmer households with milk, meat, manure and draught power. Cattle play a crucial role in coping with risk and providing livelihood options in the face of increasing climate unreliability (Krishna *et al.*, 2004). Live cattle or their products can be sold to generate cash for buying cereals. Live cattle contribute to food security also through supplying manure and draught power. The contribution of cattle in food security in the Lake Victoria basin was estimated by Ngowi *et al*. (2008) at 48.3%.

2.6 Performance Characteristics of TSZ

Performance is an important phenotypic attribute in livestock characterisation especially because it directly reflects productivity of the animals (FAO, 2011). Critical performance characteristics for beef cattle include body weight, age at first calving, calving interval and lifetime number of calving.

Under normal circumstances body weight at maturity is the most important trait of beef cattle. The trait has also been used extensively to describe cattle breeds and strains (FAO, 2011). It was reported by Mpiri (1994) that mature weight of TSZ cattle varies from 219 to 432 kilogrammes. Recently, Fipa TSZ cattle weighing as low as 116 kilogrammes have been reported by Msanga *et al.* (2012) and others weighing up to 447 kilogrammes have been observed by Mwambene *et al*. (2012). Another recent study that involved a specific TSZ strain and covered mature weight is that by Chenyambuga *et al.* (2008) in which average body weight of fully matured Tarime TSZ cattle was estimated to be 292 kilogrammes for entire males and 249 kilogrammes for females. The live weight of mature TSZ cattle can therefore be said to range from 116 to 447 kilogrammes and this indicates high within breed diversity.

Age at first calving is an important measure of the reproductive efficiency of cattle. It was reported by Mwacharo and Rege (2002) that for Kenyan Shorthorn Zebu cattle age at first calving ranges between 36 and 44 months. Mpiri (1994) reported that for TSZ breed age at first calving ranges from 33 to 54 months. For Iringa Red TSZ strain, Sungael (2005) observed that age at first calving averages at 48 months. Fipa TSZ strain has average age at first calving of 47 months (Msanga *et al*., 2012).

Reproductive performance of cows can also be expressed in form of calving interval. Calving interval is a trait related to cow's fertility as it measures frequency of delivering calves as farm off-takes. Mwacharo and Rege (2002) reported a value of 475 days as the average calving interval for EASZ whereas Mulindwa *et al*. (2006) obtained a mean calving interval of 452 days for Teso Zebu of Uganda. According to Chenyambuga *et al.* (2008) calving interval of Tarime TSZ cattle ranges from 375 to 681 days. Fipa TSZ and Iringa Red TSZ strains have been reported by Msanga *et al*. (2012) to exhibit calving intervals of 16 and 18 months, respectively.

Fertility of cows can also be expressed in terms of lifetime number of calving. This trait reflects the ability of a cow to conceive and produce viable calves (Richardson and Smith, 2006). One of the studies on EASZ that involved this trait is that by Sungael (2005) which came up with an estimated value of 7.68 for the Iringa Red TSZ strain. Msanga *et al*. (2012) estimated average lifetime number of calving of Fipa TSZ cattle to be 4.

2.7 Colour Characteristics of Cattle

External colours constitute an important group of qualitative traits for cattle characterisation. Colour characteristics have widely been used by farmers to define livestock breeds (Nsoso *et al*., 2004). Colour traits are also useful for animal identification in situations where permanent identification of individual animals is otherwise impractical (FAO, 2011).

Coat colour traits are closely related to animal's ability to dissipate excess heat (FAO, 2011). In general it can be said that the darker the coat colour, the lower is the ability to tolerate heat stress and sunburn, and the converse is true. According to Msanga *et al*. (2001) body coat colour traits are among the most variable phenotypic traits in TSZ breed and are still widely used in identification and characterisation of its subpopulations.

Another important body coat colour trait that has been used extensively to characterise TSZ strains is body coat colour pattern. For example it was reported by Kurwijila and Kifaro (2001) that there is a tendency of Maasai TSZ to be predominantly of plain or patchy coat colour pattern. Features like speckles, spots and splashes also have been used to describe African Zebu cattle breeds and strains. For example the Nyalawi Zebu of Sudan possesses speckles (Alsiddig *et al.*, 2010).

Other external colour traits that can be used in phenotypic characterisation of cattle include coat colour type, skin colour, muzzle colour, eyelid colour, hoof colour and horn colour (FAO, 2011). The use of these in description of indigenous cattle has not been as extensive as that of hair coat colour type and hair coat colour pattern. According to Mason and Maule (1960), the Mkalama Dun and Singida White strains of TSZ have black coloured skins. Chenyambuga *et al.* (2008) reported that in most Tarime TSZ cattle muzzles are brown while hooves are grey.

Horn colour and eyelid colour are also important traits in characterisation of indigenous cattle of the developing world (FAO, 2011). However, so far there has been no documented literature on the use of these characteristics in describing African indigenous cattle.

2.8 External Body Appendages

Traits related to external body appendages in cattle include horn shape, horn size, horn orientation, udder size, testicle size, prepuce size, navel-flap size, dewlap size and hump size. Udder size and prepuce size may have relationship with milk production and reproductive functions respectively where as horn shape is important in animal identification. Body extremity size traits are related to efficiency of heat dissipation (FAO, 2011). In general it can be said that the larger and the more extended the body extremity is, the higher is its efficiency in dissipating body heat from interior and the more is the ability of the animal to ameliorate heat stress.

Generally SEAZ cattle are characterised by curved horns. However in some SEAZ breeds lyre shaped horns have been noticed in situations which suggest Sanga influence. Lyre shaped horns have been observed in North Somali Zebu strain of Somali group of SEAZ (Rege and Tawah, 1999).

Mason and Maule (1960) described TSZ as cattle with light frame and sloping sacrum whereby the dewlap and navel flap are moderate in size. Testicle size and prepuce size are other important morphological characteristics of cattle. However, there is still no literature documenting their use in characterisation of African Zebu cattle. Among the recent Zebu cattle characterisation studies that covered external appendages are those by Chenyambuga *et al.* (2008) and Alsiddig *et al*. (2010) which involved Tarime TSZ cattle and Baggara type of Sudan Zebu, respectively. Chenyambuga *et al*. (2008) observed that in Tarime TSZ cattle navel flap was either absent (69.0%) or small (28.6%), and for the majority of the animals' dewlaps were medium in size (83.3%) and udders were small in size (92.3%). Alsiddig *et al*. (2010) reported that the majority of Baggara cattle have crescent shaped horns, well developed dewlaps and slightly developed prepuces.

2.9 *Physical Body Measurements*

Physical body measurements are of very common use in husbandry and phenotypic characterisation of cattle. Common physical body measurements used in phenotypic characterisation of cattle include body weight, heart girth, withers height, body length, ear length, horn length, muzzle circumference, hock circumference and tail length. Being based on relatively large numbers of loci, body measurements have a continuous expression and may be directly correlated to body size and associated production traits (FAO, 2011). Linear body measurements provide a convenient way of estimating body weight (Madubi, 1997) and their relative magnitudes can provide evidence of breed relationships (Mwacharo *et al.*, 2006). At a specific age, physical body measurements can be used in studying genetic diversity and adaptability of cattle as they are employed in their characterisation (Udeh *et al*., 2003). Data on correlations among linear body measurements are however scarce especially for TSZ cattle.

Heart girth may simply be defined as the circumference measurement taken immediately posterior to the shoulder (Udeh *et al*., 2003). Abdelhadi and Babiker (2009) studied Baggara Zebu in western Sudan and recorded 266 centimetres as the average heart girth at maturity for these cattle. TSZ cattle (4 years of age and above) were measured in Morogoro Tanzania and average heart girth values were estimated to be 161 centimetres and 156 centimetres for males and females, respectively (Kashoma *et al*., 2011). Sungael (2005) observed the heart girth mean values of Iringa Red TSZ strain for males, females and castrates to be 146, 140 and 163 centimetres, respectively. Kashoma *et al.* (2011) reported that the correlation coefficient between body weight and heart girth in TSZ cattle varies between 0.65 and 0.94 and the coefficient gets higher as age increases. Mwacharo *et al.* (2006) reported the correlation between heart girth and withers height in adult Maasai and Kamba Zebu to be 0.91 for adult males and 0.79 for adult females.

Withers height may simply be defined as the distance from the platform on which the animal stands to the point of its shoulder (Udeh *et al*., 2003). Being a skeletal measurement, at maturity stages withers height is almost unaffected by nutrition and thus indicates inherent size better than measurements that are affected by muscle and fat deposition (Kamalzadeh *et al.*, 1998). Sungael (2005) showed that Iringa Red TSZ cattle have an average withers height of 108 centimetres whereas Mwacharo *et al*. (2006) estimated withers height of Kamba and Maasai Zebu of Kenya to be 111 and 115.15 centimetres, respectively.

For Baggara Zebu, Alsiddig *et al*. (2010) found that body weight is highly correlated to withers height. Mwacharo *et al*. (2006) observed in Maasai and Kamba Zebu cattle that withers height varies with sex and reported mean correlations to body length of 0.89 and 0.65 for males and females, respectively. For Ankole breed, Kugonza *et al.* (2011) reported that the correlation between withers height and horn length was significant and averaged at 0.66 while that between withers height and ear length was significant and averaged at 0.62 in adult animals.

Udeh *et al*. (2003) defined body length of cattle as the shortest distance between the joint of scapular and pin bone. In common with other linear measurements, body length is influenced significantly by breed, sex and age (Mwacharo *et al.*, 2006). Lawrence and Pearce (1964) found larger effects of nutrition on length than on height measurements for beef cattle. Mwacharo *et al.* (2006) reported average values of 123 and 122 centimetres as average body length values for fully matured Maasai and Kamba Kenyan Zebu, respectively. For Iringa Red strain of TSZ, Sungael (2005) obtained body length estimates of 123, 119 and 133 centimetres for fully matured males, females and castrates, respectively. There is no documented literature on the correlation between body weight and body length in TSZ. Kugonza *et al*. (2011) observed in Ankole cattle that body length was a relatively good proxy trait for estimation of body weight after observing a fairly high correlation between the two traits.

Ear length refers to the external length from the ear base to the apex (Sungael, 2005). With regard to this trait SEAZ breeds may not show sexual dimorphism but the trait is significantly influenced by genetic constitution and age (Mwacharo *et al.,* 2006). Sungael (2005) obtained a value of 13.97 centimetres as the average ear length for Iringa Red strain of TSZ. Mwacharo *et al*. (2006) observed ear length of Maasai and Kamba Zebu breeds to be 20.15 and 20.90 centimetres, respectively. Kugonza *et al.* (2011) reported for Ankole cattle in Uganda the correlation between body weight and ear length to be negative and high.

Horn length measures distance between the base and the apex of the horn (Sungael, 2005). Sungael (2005) reported that Iringa Red strain of TSZ has mean horn length of 16.37 centimetres while for Kamba Zebu Mwacharo *et al*. (2006) obtained a mean horn length value of 23.5 centimetres. No correlation has been reported between body weight and horn length for TSZ, but Kugonza *et al.* (2011) reported that for Ankole cattle body weight is highly and positively correlated to horn length.

Muzzle circumference is taken immediately posterior to the muzzle where it is assumed to form a circle. It was used by Ndumu *et al*. (2008) to describe the morphology of Ankole cattle with the aim of separating subpopulations, in which it showed to be a reliable trait for that purpose. Though limited work has been done to characterise cattle using muzzle circumference in East Africa inclusion of muzzle circumference can be useful in this characterisation study.

Hock circumference is also a recommended linear body measurement for characterisation of cattle (FA0, 2011). The circumference is taken just above the hock joint. For unknown reasons however, there has not been any cattle characterisation study yet in east Africa that has involved hock circumference.

Tail length may be defined as the distance between the base and the apex of the tail. Tail length has been gaining popularity as a trait for characterising beef cattle especially in assessing adaptability of animals to external parasite infestation (FAO, 2011). Mwacharo *et al.* (2006) reported average tail lengths for Maasai and Kamba breeds to be 99.9 and 98.15 centimetres, respectively.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.*1 Study Area Description*

This study was conducted in Ukerewe and Bunda Districts which are found in the Lake Victoria Basin of Tanzania (Fig. 1). Ukerewe on one hand is one of the eight districts of Mwanza Region. This district comprises 38 islands in the Lake Victoria part which lies on Tanzania side. Ukerewe District lies between Longitude 31^{o}30' and 32^{o}5' East of the Greenwich, and between Latitude 1^{o}30' and 2^{o}20' South of the Equator. Altitude in Ukerewe ranges from 1150 to 1667 meters above sea level. This district covers a total area of 6400 kilometres square out of which 640 kilometres square constitute land surface and the rest is Lake Victoria water surface. Ukerewe District has a total population of 260 831 people. Of these 128 842 are males and 131 989 are females. There are 52 287 cattle in the district, of which 52 137 are indigenous Zebu and 150 are exotic cattle (DALDO Ukerewe).

Bunda on the other hand is one of the six districts of Mara region. It lies between Longitude 33º30' and 34º5' East of the Greenwich, and between Latitude 1º30' and 2º45' South of Equator. The district is at an average altitude of 1300 metres above sea level. The district has a total area of 3088 kilometres square, out of which 200 kilometres square are covered by Lake Victoria water. Of the total area, 2888 kilometres square form a dry land of which 2408 kilometres square form an arable land suitable for crop production and livestock keeping. The total human population in the district is 361 598 people.

The district has 221 474 cattle of which 221 078 are indigenous and 396 are dairy crossbreds (DALDO Bunda).

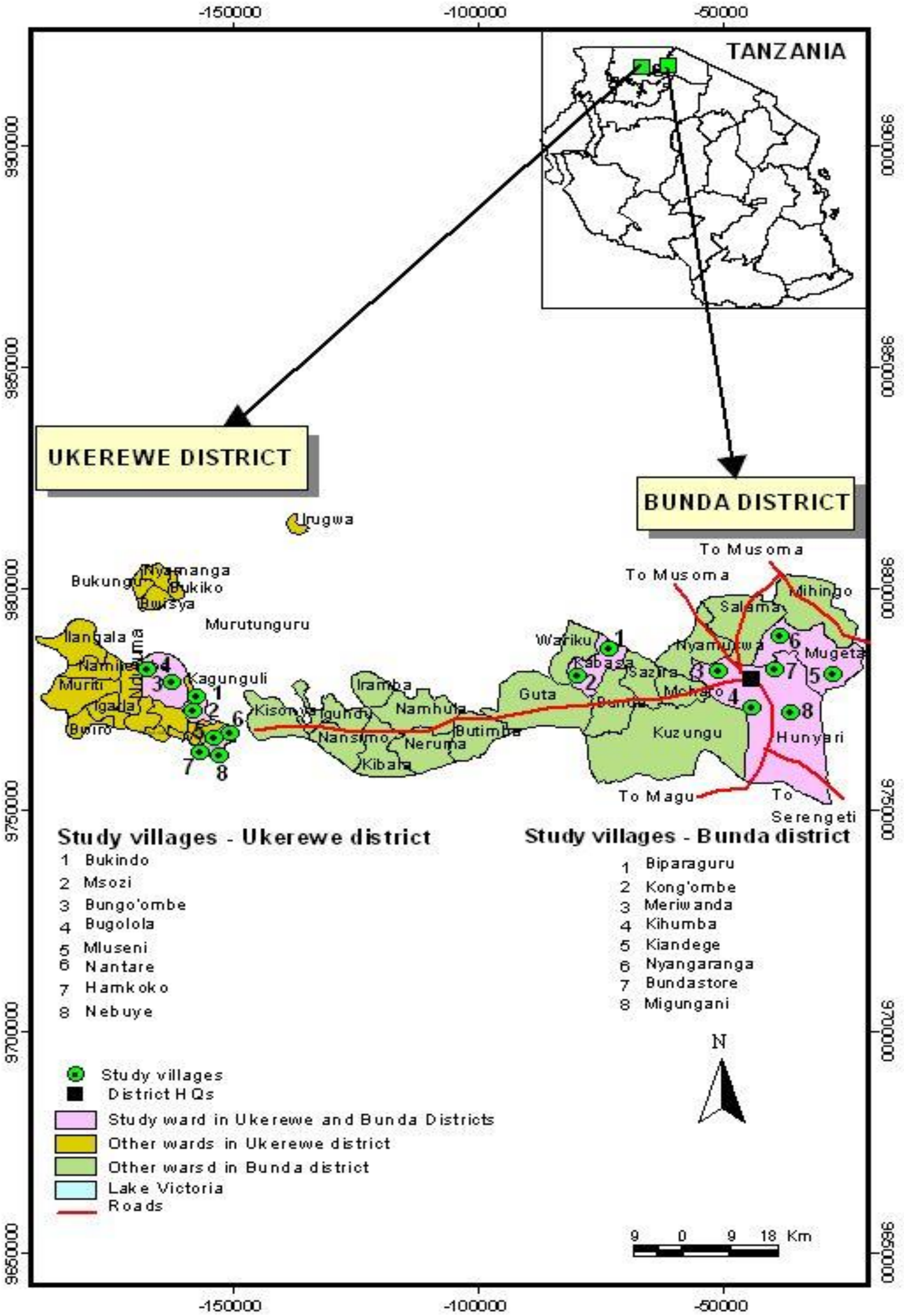

Figure 1: A map of Ukerewe and Bunda Districts showing the study area

3.2 Data Collection

3.2.1 Sampling

In order to strike eco-zone balance and also to ensure that sufficient samples are obtained, purposive sampling was applied in a multi-stage process in each district to sample 2 divisions, in each division to sample 2 wards, and in each ward to sample 2 villages. In each village households which had been keeping zebu cattle in the last 10 years were identified, from which 23 households per district were selected randomly to make a total of 46 households across the study area. The sample size was set low because the time allowed to collect data from the cattle herds before they were taken to graze in the morning was very short. From each of the selected households, one representative member was then picked for interviewing.

Further, a total of 169 fully adult (non-pregnant for cows) zebu cattle maintained in their typical production environments was randomly picked from the villages for detailed on-site observations and physical body measurements. Of these 80 cattle (26 bulls and 54 cows) were from Ukerewe District and 89 (30 bulls and 59 cows) were from Bunda District.

3.2.2 *Interviews*

Data on socio-economic characteristics of TSZ cattle farmers and functions and performance characteristics of TSZ cattle were collected through interviews using a structured questionnaire. The questionnaire was aimed at extracting information on sources of income and food, species and numbers of livestock kept, ranking of livestock species by socio-economic importance and usage of cattle at household level. Information was also inquired on age at first calving, calving interval and lifetime number of calving of TSZ cattle.

3.2.3 On-site *observations and physical body measurements*

On-site colour examination was done on the 169 sampled TSZ cattle. Traits that were assessed included coat colour pattern, coat colour type, skin colour, muzzle colour, eyelid colour and hoof colour. External body appendages characteristics namely horn shape, udder size, dewlap size, testicle size, navel flap size and prepuce size were assessed.

Some pictures of Ukerewe TSZ cattle in their production environment were also taken by using video cameras. A well designed colour and morphology recording form was used to record all the colour and morphological traits of the examined animals. For each of the 169 sampled cattle body weight, heart girth, body length, withers height, horn length, ear length, muzzle circumference, hock circumference and tail length were taken early in the morning.

Body weight was estimated from heart girth using a length-weight transforming band and recorded to the nearest 0.5 kilogramme in the colour and morphology recording form. Heart girth was measured using a tailor's tape as the circumference of the body immediately posterior to the shoulder. Body length was taken using a tailor's tape as the length from shoulder point to pin bone. Withers height was measured using a vertical standard wooden plank and ruler as the distance from the platform on which the animals stands to the point of its shoulder. Horn length was taken using a tailor's tape as the distance between the tip and the base of the horn. Ear length was measured by using a tailor's tape as the distance between the tip and the base of the ear. Muzzle circumference was taken using a tailor's tape as the circumference immediately posterior to the muzzle. Hock circumference was measured as the circumference just above the hock joint. Lastly, tail length was measured by using a tailor's tape as the distance between the tip and the base of the tail. All linear measurements were recorded to the nearest 0.5 centimetre in the colour and morphology recording form.

3.2.4 Secondary data

Data on location, altitude, area size, land distribution and utilisation, climatic variables, human and livestock population of Ukerewe and Bunda Districts were extracted from district profile documents obtained from District Agriculture and Livestock Development Offices (DALDOs) of the two districts.

3.3 Data Analysis

Primary data were coded and entered into four separate spreadsheets for socio-economic data, performance data, qualitative colour and morphology data, and quantitative morphology data. Household socio-economic data were analysed using Statistical Package for Social Sciences (SPSS, 2006) to generate frequencies and percentages. Data on household socio-economic characteristics and usage of cattle, together with those on performance, colour and external body appendages were firstly analysed using Statistical Package for Social Sciences (SPSS, 2006) to generate frequencies and percentages before conducting manually chi-square tests for independence. Secondary data were summarised manually.

All primary quantitative data were analysed using the General Linear Models Procedures of the Statistical Analysis Systems (SAS, 2000), with the MANOVA option for calculating partial correlation coefficients among the various body measurement variables. District and sex were used as fixed effects and villages within district as nested effects. The statistical model used for the body measurements took the form:

$Y_{ijkl} = \mu + D_i + S_j + (DS)_{ij} + D_i V_k + \varepsilon_{ijkl}$, where

$Yijkl$= measurement on the lth animal of the jth sex from the ith district and kth village;

μ= general mean common to all animals considered in the study;

D_i= effect of the i^{th} district (i = Ukerewe or Bunda);

S_j= effect of the j^{th} sex (j = male or female);

$(DS)_{ij}$= interaction between the i^{th} district and the j^{th} sex;

$D_i(V_k)$= effect of k^{th} village within the i^{th} district; and

ε_{ijkl} is the random effect peculiar to each animal.

CHAPTER FOUR

4.0 RESULTS

4.1 Household Characteristics of TSZ Cattle Farmers

4.1.1 Household sources of income and food

Table 1 shows results on the sources of income and food in Zebu cattle raising households of Ukerewe and Bunda Districts. In Ukerewe and Bunda Districts crops and livestock were regarded as the leading sources of income by 37.3% and 44.9% of the respondents, respectively. Fishing was observed to be the third important source of income, mentioned by 18.5% of the respondents in Ukerewe District whereas this source was not mentioned at all by the respondents in Bunda District. Salary and business were reported by very few respondents in Ukerewe and Bunda as major sources of income.

The results further show that in Ukerewe District crops were the leading source of household food (reported by 40% of the respondents) followed very closely by livestock (reported by 38% of the respondents) and then fishing (reported by 22.4% of the respondents). In Bunda crops and livestock were regarded to be of equal importance (by 48% of the respondents each) as sources of food followed far by fishing (4% of the respondents). Chi-square test results summarized in Appendix 1 and Appendix 2 show that there were significant ($p<0.05$) associations between districts and sources of income and food, respectively.

Table 1: Frequencies and percentages of households identifying specific items as main sources of income and food occurring in Ukerewe and Bunda

Source	Ukerewe		Bunda		Overall	
	n	%	n	%	n	%
Income						
Fishing	11	18.5	0	0	11	10.1
Crops	22	37.3	22	44.9	44	40.4
Livestock	22	37.3	22	44.9	44	40.4
Salary	4	6.7	2	4.1	6	5.5
Business	1	1.7	3	6.8	4	3.7
Food						
Fishing	13	22.4	2	4.2	15	14.2
Crops	23	39.7	23	48.0	46	43.4
Livestock	22	37.9	23	48.0	45	42.5

Note: n= number of observations based on multiple responses

4.1.2 Number and species of livestock kept

Table 2 shows the number of the different livestock species kept by interviewed farmers. It was observed that in all cases the average numbers of animals of each species kept per household is higher in Bunda than in Ukerewe. The results further show that cattle were kept in relatively larger numbers in Bunda District where per household herd size was 67.3 cattle than in Ukerewe where per household size was 5.3 cattle. Therefore, on average number of cattle owned by households in Ukerewe is 13 times lower than that in Bunda.

It was also observed that the average number of goats owned by a household in Bunda (30.1±20.3) was seven times that of Ukerewe (4.3±3). Though not found in Ukerewe, sheep were the third most numerous species in Bunda where the average number kept per household was 29.9±29.5. The numbers of chicken kept by households were more or less similar in Ukerewe (10.7±8.2) and Bunda (14.2±8.7). Pigs and ducks were kept by very few farmers in both districts.

Table 2: Numbers per household of different livestock species kept in Ukerewe and Bunda

Species	Ukerewe			Bunda			Overall		
	Mean ± sd	**Min**	**Max**	**Mean ± sd**	**Min**	**Max**	**Mean ± sd**	**Min**	**Max**
Cattle	5.3 ± 4.3	1	20	67.3 ± 63.4	8	212	36.3 ± 54.4	1	212
Goats	4.3 ± 3.0	1	12	30.1 ± 20.3	4	70	16.8 ± 19.2	1	70
Sheep	0	0	0	29.9 ± 29.5	2	100	29.9 ± 29.5	2	100
Chicken	10.7 ± 8.2	2	30	14.2 ± 8.7	3	37	12.5 ± 8.5	2	37
Ducks	12.5 ± 13.4	3	22	0	0	0	12.5 ± 13.4	3	22
Pigs	4.0	4	4	0	0	0	4.0	4	4

Note: Mean= mean number, sd= standard deviation, Min= minimum number, Max= maximum number

4.1.3 Ranking of livestoc*k species*

Table 3 presents in summary results of ranking the different livestock species kept in Ukerewe and Bunda Districts according to their importance as were judged by the livestock keepers. Results show that cattle, goats and chicken were the livestock species kept by most respondents in both districts.

The results also show that 34.4% of the respondents in Ukerewe and 27.7% of the respondents in Bunda ranked cattle first in order of importance. Furthermore, 23.4% of the respondents in Ukerewe and 19.3% of the respondents in Bunda ranked goats second in importance. Chicken were ranked fourth. However, sheep were recorded in a significant number in Bunda District only, where they ranked above chicken and sometimes above goats. Ducks and pigs were few in Ukerewe District only, where they ranked the least in importance. Chi-square test results summarized in Appendix 3 and 4 show that ranks were significantly ($p<0.05$) associated with species and districts, respectively.

Table 3: Ranking in order of importance of livestock kept in Ukerewe and Bunda

Species	Rank	Ukerewe		Bunda		Overall	
		n	**%**	**n**	**%**	**n**	**%**
Cattle	1	22	34.4	23	27.7	45	30.6
	2	1	1.5	0	0	1	0.6
Goats	2	15	23.4	16	19.3	31	21.0
	3	3	4.7	2	2.4	5	3.4
Sheep	2	0	0	6	7.2	6	4.1
	3	0	0	14	16.9	14	9.5
Ducks	3	2	3.0	0	0	2	1.4
Chicken	1	1	1.5	0	0	1	0.6
	2	5	7.8	2	2.4	7	4.8
	3	13	20.3	2	2.4	15	10.2
	4	1	1.5	18	21.7	19	12.9
Pigs	3	1	1.5	0	0	1	0.6

Note: n= number of observations based on multiple responses

4.1.4 Usage *of TSZ cattle*

Table 4 presents a summary of results on usage of Zebu cattle in Ukerewe and Bunda Districts. The results show that there were various usages of cattle and all of them were socio-economic in nature. In both of the districts highest proportions of the respondents (45.6% in Ukerewe and 29.2% in Bunda) reported income generation to be the main purpose for keeping Zebu cattle. Another 31.8% of the respondents in Ukerewe District and 23.7% in Bunda said that milk was an important benefit from keeping Zebu cattle. Draught power was reported as an important role performed by Zebu cattle by a considerable percentage of the respondents (20.8%) in Bunda District only. Chi-square test results summarized in Appendix 5 show that there was significant ($p<0.05$) association between districts and usages of TSZ cattle.

Table 4: Frequencies and percentages of functions of keeping TSZ cattle existing in Ukerewe and Bunda

Functions	Ukerewe		Bunda		Overall	
	n	%	n	%	n	%
Meat	1	2.2	5	6.9	6	4.7
Milk	14	31.8	17	23.7	31	24.2
Draught Power	0	0	15	20.8	15	11.7
Income	20	45.6	21	29.2	41	32.0
Manure	9	19.6	4	5.6	13	10.2
Prestige	0	0	4	5.6	4	3.1
Dowry payment	0	0	6	8.3	6	4.7
School fees	0	0	1	1.4	1	0.8

Note: n= number of observations based on multiple responses

4.2 Performance Characteristics of Ukerewe and Bunda TSZ Cattle

The mean performance levels of TSZ cattle in Ukerewe and Bunda in terms of body weight, age at first calving, calving interval, and lifetime number of calving were as presented in Table 5. TSZ cattle in Ukerewe were observed to have significantly ($P<0.05$) larger body weight at maturity and lower age at first calving than those in Bunda. For calving interval and lifetime numbers of calving non-significant differences were observed between TSZ cattle of the two districts.

Table 5: Least squares means (±se) for performance traits of TSZ cattle in Ukerewe and Bunda

Trait	Ukerewe	Bunda
Body weight at maturity	227.9 ± 4.7^{a}	212.5 ± 4.4^{b}
Age at First Calving (months)	38.2 ± 6.0^{a}	45.9 ± 9.3^{b}

Calving Interval (days)	458.3 ± 33.4	448.3 ± 34.1
Lifetime Number of Calving	5.6 ± 2.1	6.7 ± 2.0

Note: se= standard error. Least squares means with different superscripts within a row are significantly different at P ≤ 0.05

4.3 *Body Colour Characteristics of Ukerewe and Bunda TSZ Cattle*

In Table 6 are the occurrences of external colour characteristics of sampled cattle in Ukerewe and Bunda Districts. The results show that majority of the cattle (63.8% in Ukerewe and 67.4% in Bunda) had a plain hair coat colour pattern. With regard to the occurrence of body colour therefore, the differences between the two districts was not significant (p>0.05). The occurrence of hair coat colour type differed highly significantly (p<0.001) between the two locations. In Ukerewe black colour type occurred with the highest frequency (26.2%) whereas in Bunda it was brown coat colour type that occurred with the highest frequency (41.6%).

Skin colour types occurred in only two dominant colours with frequencies that differed significantly (p<0.5) between the districts. In Ukerewe District 59% of the observed cattle had black coloured skins and the remaining 41.2% had brown coloured skins. In Bunda District 59.6% of the observed cattle had brown skin colour and the remaining (40 %) had black skin colour.

The results for muzzle colour indicated that 65% of the cattle examined in Ukerewe had black muzzles and 35% had brown muzzles. Contrary to this, only 39.3% of the cattle examined in Bunda had black muzzles and 61% had brown muzzles. The difference in occurrence of muzzle colours between Ukerewe and Bunda TSZ was very highly significant (p<0.001).

The Ukerewe and Bunda TSZ cattle were observed to differ highly significantly (p<0.01) with regard to frequencies of occurrence of eyelid colours and hoof colours. This is because 63.8% of the cattle examined in Ukerewe had black eyelids and 36.2% had brown eyelids whereas 42.7% of the cattle examined in Bunda had black eyelids and 57.3% had brown eyelids. It was also observed that 60% of the cattle examined in Ukerewe had black hooves and 40% had brown hooves whereas 39.3% of the cattle examined in Bunda had black hooves and 60.7 % had brown hooves.

Table 6: Frequencies and percentages of occurrence of body colour characteristics of TSZ cattle in Ukerewe and Bunda districts

Trait	Ukerewe		Bunda		Overall	
	n	%	n	%	n	%
Colour pattern						
Shaded	9	11.2	9	10.1	18	10.7
Plain	51	63.8	60	67.4	111	65.7
Patchy	15	18.8	14	15.7	29	17.2
Spotted	5	6.2	6	6.7	11	6.5
	X^2 value (df= 3)= 0.4^{ns}					
Coat colour						
Brown	18	22.5	37	41.6	55	32.5
White	4	5.0	15	16.9	19	11.2
Black	21	26.2	3	3.4	24	14.2
Grey	4	5.0	0	0	4	2.4
Cream	4	5.0	5	5.6	9	5.3
Brown & white	16	20.0	20	22.5	36	21.3
Cream & white	1	1.2	0	0	1	0.6
Brown& black	5	6.2	5	5.6	10	5.9
Black & white	7	8.8	4	4.5	11	6.5
	X^2 value (df= 11)= 36.2***					
Skin colour						
Black	47	58.8	36	40.4	83	49.1
Brown	33	41.2	53	59.6	86	50.9
	X^2 value (df= 1)= 5.7*					
Muzzle colour						
Black	52	65.0	35	39.3	87	51.5
Brown	28	35.0	54	60.7	82	48.5
	X^2 value (df= 1)= 11.1**					

Eyelid colour						
Black	51	63.8	38	42.7	89	52.7
Brown	29	36.2	51	57.3	80	47.3
	X^2 value (df= 1)= 7.5**					
Hoof colour						
Grey	48	60.0	35	39.3	83	49.1
Brown	32	40.0	54	60.7	86	50.9
	X^2 value (df= 1)= 7.21**					

Note: n= number of observations; df= degrees of freedom; * significant at P < 0.05; ** highly significant at P < 0.01; *** very highly significant at P < 0.001; ns not significant at P > 0.05

Plate 1: Ukerewe TSZ cattle showing colour and morphology

4.4 *External Body Appendages of Ukerewe and Bunda TSZ Cattle*

In Table 7 is a summary of the various body appendages characteristics of Zebu cattle observed in Ukerewe and Bunda. Though it can be said that the majority of the cattle in both districts had curved horns, the frequency of curved horns in Ukerewe was highly significantly (p<0.001) lower than that in Bunda (63.8% vs 97.8%). Straight horns were observed in Ukerewe while they were almost absent in Bunda.

Udder sizes in the majority of cows were small (i.e. 84.2% in Ukerewe and 74.2% in Bunda). Medium sized udders were rarely observed in both districts. Dewlap sizes in the majority of the cattle (65% in Ukerewe and 73% in Bunda) were observed to be small. Both medium and large sized dewlaps were rare in both districts. Therefore, with respect to dewlap size, TSZ cattle subpopulations in the districts were not significantly (p>0.5) different.

Table 7: Frequencies of occurrence of external appendage characteristics for TSZ cattle populations in Ukerewe and Bunda

Trait	Ukerewe		Bunda		Overall	
	n	%	n	%	n	%
Horn shape						
Curved	51	63.8	87	97.8	138	81.7
Straight	29	36.2	2	2.2	31	18.3
		X^2 value (df= 1)= 32.5***				
Udder size						
Small	48	84.2	46	74.2	94	79.0
Medium	9	15.8	16	25.8	25	21.0
		X^2 value (df= 2)= 2.3^{ns}				
Dewlap size						
Small	52	65.0	65	73.0	117	69.0
Medium	23	28.8	19	21.3	42	24.9
Large	5	6.2	5	5.6	10	5.9
		X^2 value (df= 2)= 1.4^{ns}				
Testicle size						
Small	13	48.1	11	36.7	24	42.1
Medium	14	51.9	19	63.3	33	57.9
		X^2 value (df= 2)= 4.0^{ns}				
Navel flap size						
Small	58	72.5	78	87.6	136	80.5
Medium	22	27.5	11	12.4	33	19.5
		X^2 value (df= 2)= 6.2*				
Prepuce size						
Small	18	66.7	20	71.4	38	69.4
Medium	9	33.3	8	28.6	17	30.9
		X^2 value (df= 2)= 1.3^{ns}				

Note: n= number of observations; df= degrees of freedom; * significant at P < 0.05; ** highly significant at P < 0.01; *** very highly significant at P < 0.001; ns not significant at P > 0.05.

The results for testicle size show that TSZ cattle in the two districts also didn't differ significantly ($p>0.5$) with regard to this attribute. In the majority of the cattle (51.9% in Ukerewe and 63.3% in Bunda) testicle sizes were found to be medium. The results also show that small sized testicles were also common in both districts (48.1% in Ukerewe and 36.7% in Bunda).

A significant ($p<0.5$) difference between the two TSZ cattle subpopulations was observed in the size of the navel flap although the majority of the cattle examined had small-sized navel flaps (72.5% in Ukerewe and 87.6% in Bunda. Prepuce size was also small in the majority of the cattle (66.4% in Ukerewe and 71.4% in Bunda) and the difference between the two districts was not significant ($p>0.05$). Medium sized prepuces were also common (33.3% in Ukerewe and 28.6% in Bunda).

4.5 *Physical Body Measurements of Ukerewe and Bunda TSZ Cattle*

Results for the various physical body measurements of Ukerewe and Bunda TSZ cattle are presented in Table 8. The results show that TSZ cattle in Ukerewe have significantly ($p<0.01$) shorter horn length than those of the TSZ cattle in Bunda. The results also show that the TSZ cattle in Ukerewe have significantly ($P<0.05$) bigger body weight and heart girth than those of the TSZ cattle in Bunda. The rest of the physical body measurements under study (withers height, body length, ear length, muzzle circumference, hock circumference and tail length) differed insignificantly ($p>0.05$) between Ukerewe and Bunda.

Among the physical body measurements under the study, horn length, heart girth and body weight differed significantly with sex of cattle (Appendix 6). Males were observed to have significantly ($p<0.05$) bigger values for body weight, heart girth and horn length than females. Interactions between district and sex were significant ($p<0.05$) for horn length, heart girth, body length and body weight. For the rest of the measurements, the interactions were not significant. The results show also that between villages (within districts) differences were significant ($p<0.05$) with regard to body weight, heart girth and body length. For the other measurements between villages differences were not significant.

The results for the partial correlations among the various physical body measurements are presented in Table 9. In all cases the correlations were positive. Body weight and heart girth correlated significantly ($p<0.01$) to all physical body measurements except ear length and muzzle circumference. Among the physical measurements under the study, withers height correlated significantly ($p<0.01$) to all except body length which correlated significantly ($p<0.05$) to all the physical measurements except ear length, muzzle circumference and hock circumference.

Ear length correlated significantly to muzzle circumference and hock circumference and non-significantly ($p>0.05$) to horn length and tail length, while horn length correlated significantly ($p<0.05$) to muzzle circumference and hock circumference and non-significantly ($p<0.05$) to tail length. Tail length correlated significantly ($p<0.05$) to muzzle circumference and hock circumference. There was also a significant ($p<0.05$) correlation between muzzle circumference and hock circumference.

Table 8: Least square means (±s.e.) for cattle physical body measurements in Ukerewe and Bunda

Factor	BW (kg)	HG (cm)	WH (cm)	BL (cm)	EL (cm)	HL (cm)	MC (cm)	HC (cm)	TL (cm)
Overall	223.2±6.4	137.2±1.4	104.3±1.4	108.9±1.8	18.1±0.4	17.8±1.1	39.1±1	30.8±0.5	71.9±1.3
Location									
Ukerewe	227.9±4.7	137.9±1.0	105.1±1.0	108.2±1.3	17.8±0.3	12.1±0.8	40.4±0.8	30.6±0.4	72.8±1.0
Bunda	212.5±4.4	135.0±1.0	104.0±1.0	108.1±1.2	18.5±0.3	21.3±0.8	38.3±0.7	31.2±0.3	70.6±1.0
	*	*	ns	ns	ns	***	ns	ns	ns
Sex									
Male	230.4±3.7	139.0±0.8	103.7±0.8	110.3±1.0	18.0±0.2	19.3±0.7	38.6±0.6	30.7±0.3	72.4±0.8
Female	209.9±5.3	133.8±1.2	105.4±1.2	106.0±1.6	18.3±0.3	14.1±0.9	40.2±0.9	31.1±0.4	71.0±1.0
	*	**	ns	ns	ns	***	ns	ns	ns

Note: se=standard error; * significant at P < 0.05; ** highly significant at P < 0.01; *** very highly significant at P < 0.001; ns not significant at P > 0.05. BW= mature weight; HG= heart girth; WH= withers height; BL= body length; EL= ear length; HL= horn length; MC= muzzle circumference; HC= hock circumference; TL= tail length.

Table 9: Partial correlation coefficients and significance levels among various physical body measurements of TSZ cattle in Ukerewe and Bunda

Traits	BW	HG	WH	BL	EL	HL	MC	HC	TL
BW		0.97***	O.29***	0.44***	0.02^{ns}	0.23**	0.11^{ns}	0.33***	0.38***
HG			0.29***	0.45***	0.02^{ns}	0.21**	0.12^{ns}	0.33***	0.41***
WH				0.07^{ns}	0.22**	0.23**	0.42***	0.45***	0.29***
BL					0.11^{ns}	0.36***	0.13^{ns}	0.1^{ns}	0.17*
EL						0.07^{ns}	0.4***	0.15*	0.1^{ns}
HL							0.19*	0.21**	0.1^{ns}
MC								0.45***	0.22**
HC									0.22**
TL									

Note: * significant at P < 0.05; ** highly significant at P < 0.01; *** very highly significant at P < 0.001; ns not significant at P > 0.05. BW= mature weight; HG= heart girth; WH= withers height; BL= body length; EL= ear length; HL= horn length; MC= muzzle circumference; HC= hock circumference; TL= tail length

4.6 Production Environments of Ukerewe and Bunda TSZ Cattle

Presented in Table 10 are results on production environment for TSZ cattle in Ukerewe and Bunda Districts. Climatically, Ukerewe District is cooler and has more rain than Bunda District. The dominant vegetation types in Ukerewe and Bunda Districts are closed shrubland and grassland, respectively. In Ukerewe TSZ cattle are tethered while in Bunda the animals graze extensively.

Table 10: **Characteristics of production environment for TSZ cattle in Ukerewe and Bunda**

Characteristic	**Ukerewe**	**Bunda**
Annual daily mean temperature	24.5^{o}C	28^{o}C
Mean annual rainfall	1350 millimetres per annum	975 millimetres per annum
Dominant vegetation cover	Closed shrub-land	Grassland
Grazing system	Tethering	Extensive

Source: DALDO Ukerewe; DALDO Bunda

Plate 2: Ukerewe TSZ cattle grazing while tethered at Bukindo

CHAPTER FIVE

5.0 DISCUSSION

5.1 Socio-economic Characteristics of TSZ Cattle Farmers

5.1.1 *Sources of income and food*

The results of this study have shown that crops and livestock are the major sources of income for the inhabitants of Ukerewe and Bunda Districts. In this regard the results are in agreement with those of Ngowi *et al.* (2008) who reported that crops and livestock have the highest contribution to household income in the agro-pastoral systems of Tanzania. Nevertheless, the contribution of fishing as a source of income in Ukerewe can't be neglected. This observation supports the statement by Odada et *al*. (2006) that fishing is among the important sources of income in the Lake Victoria basin.

The results of the study further show that crops and livestock are also the major sources of food in both Ukerewe and Bunda. As is the case for income, the contribution of fishing to household food supply in Ukerewe can't be ignored, and the relatively low importance of crops and livestock in Ukerewe as sources of food is again attributed to the effect of fishing. The difference in place of fishing as a source of income and food is at least in part attributable to the observed association between district and income and food sources.

As food and income are among the prime livelihood determinants in subsistence systems, these findings agree with Kohler-Rollefson (2004) who concluded that livestock in the developing world fulfil subsistence purposes. It is likely that TSZ cattle farmers in the two districts have been selecting for traits related to income and food. This suggests further that the TSZ strains under the study harness economically viable adaptation.

From the observed higher dependence on TSZ cattle as a source of income and food in Bunda than in Ukerewe, it is possible that there has been more selection and hence greater genetic progress of TSZ cattle for traits related to income and food in Bunda than in Ukerewe. Therefore, under similar or harsher environment Bunda TSZ are expected to outperform Ukerewe TSZ in traits with relevance to food production and income generation.

If the two strains are swapped, the performance of Bunda TSZ in Ukerewe is likely to be above that exhibited by Ukerewe TSZ. Contrary to this, the performance of Ukerewe TSZ in Bunda is likely to be below that exhibited by Bunda TSZ. However, Ukerewe TSZ cattle will be able to restore the performance level if a production environment similar to that in Ukerewe is created.

5.1.2 ***Numbers and species of livestock kept***

In both districts it is common for households to diversify livestock species. Similar results have been reported by Ndumu *et al*. (2008) who concluded that in agro-pastoral systems of Tanzania farmers normally diversify livestock species they keep for various reasons, which include widening the scope of livestock uses and coping with variable environmental conditions. The observation that there was recorded a considerable number of sheep in Bunda but none in Ukerewe suggests the existence of cultural factors limiting sheep production in Ukerewe District. The observed very small numbers of pigs and ducks suggest that the livestock species are not traditional in both Ukerewe and Bunda.

5.1.3 *Ranking of livestock species*

The results of this study show that cattle were the most highly valued livestock species by the farmers of both Ukerewe and Bunda Districts. Similar results have been reported by Ngowi *et al.* (2009) who suggested that in agro-pastoral systems of Tanzania, cattle are the most highly valued livestock species. For this reason the farmers are most likely to respond well to initiatives aimed at improving or conserving this indigenous genetic resource if approached well.

There is however a remarkable difference between Ukerewe and Bunda farmers with regard to the values they place on sheep. This is at least one factor that has lead to significant dependency of ranking on both species and district. The results show that about 30% of the respondents in Bunda District ranked sheep as being the second most important livestock species whereas in Ukerewe District the species was not valued at all. This difference is attributed to the lack of cultural uses of sheep for mutton and rituals in Ukerewe, (Kaswahili, W.B. personal communication, 2009). Therefore, sheep are unlikely to be accepted by Ukerewe TSZ cattle farmers. With the on-going depletion of fish resources in Lake Victoria, dependence on fish is likely to decline in Ukerewe. This in turn is expected to stabilise Ukerewe TSZ cattle in the highest rank in Ukerewe.

5.1.4 *Usage of Zebu cattle*

The results of the study further indicate that, although Zebu cattle were required for multiple roles, their main function was income generation. Therefore income generation is the major purpose for keeping Zebu cattle. A similar view has been expressed by

Ngowi *et al.* (2008) who concluded that cattle in Mara region were kept for sale so as to generate income for various household expenditures. However, the results also show that the dairying potential of the cattle is also recognised by their keepers in both districts. This suggests that milk production should be considered in improvement programmes for the cattle in the study area.

There is a big difference between the two districts with regard to the utilisation of the animals for draught power. Utilisation of Zebu cattle for draught power is common in Bunda while in Ukerewe it is not common. This is possibly one of the potential contributors to the significant association between districts and functions of cattle observed in this study. In Bunda there might have been selection of cattle for longhorns because the attribute is linked to fitness for draught power utilization. With their shorter horns than Bunda TSZ therefore, Ukerewe TSZ cattle are likely to be disliked by Bunda farmers. However, diversity in TSZ strains is high and since normally only a small fraction of the herd is used for draught power, the purpose would still be met. To Ukerewe TSZ farmers, fitness for draught power is not an issue and therefore the relatively longhorn Bunda TSZ cattle can be fairly accepted by Ukerewe TSZ farmers.

5.2 Performance of Ukerewe and Bunda TSZ Cattle

The observed mean body weight values for both Ukerewe TSZ strain and Bunda TSZ strain lie within the range (116-447 kg) reported in the past studies (Mpiri 1994; Chenyambuda *et al.*, 2008; Msanga *et al*., 2012; Mwambene *et al*., 2012). This evidences that the two cattle populations under the study are subpopulations of TSZ breed. Observation of significantly higher mean body weight values for the Ukerewe TSZ strain than for the Bunda TSZ strain, further evidences that the two cattle populations under the study differ. As the strains under the study are from adjacent districts, this observation supports the idea of existence of high diversity within TSZ breed.

The observed average values of age at first calving for the Ukerewe TSZ strain and the Bunda TSZ strain lie within the range of 33 to 54 months that was reported by Mpiri (1994) for TSZ breed. This also supports that the strains under the study are subpopulations of TSZ breed. Results on age at first calving obtained in this study show that the performance of Ukerewe TSZ strain in age at first calving is significantly higher than that of Bunda TSZ strain also observed in this study and those of Fipa and Iringa Red TSZ strains reported by Msanga *et al.* (2012). Therefore, similar to body weight, this trait indicates existence of high diversity within TSZ breed.

However, just from these observations it can't be concluded that meat production potential of the Ukerewe TSZ strain is higher than that of the Bunda TSZ strain. This is because body weight and age at first calving are highly influenced by climatic condition, health and degree of activity (Williamson and Payne, 1965). The factors affect primarily body condition and physiological maturation of animals. The production environment in Ukerewe is less stressing and healthier than that in Bunda. Also cattle of the Ukerewe TSZ strain in Ukerewe are less active than those of the Bunda TSZ strain in Bunda. This is because in Ukerewe cattle are tethered and are not utilized for draught power while in Bunda the opposite of these prevail.

The production environments are therefore considered to promote higher growth rate and earlier physiological maturation in the Ukerewe TSZ strain than in the Bunda TSZ cattle. The significant differences in body weight and age at first calving between the Ukerewe TSZ strain and the Bunda TSZ strain can therefore be attributed to the differences between Ukerewe and Bunda Districts with regard to climatic stress, health, management system and utilisation of cattle.

Because the Bunda TSZ strain has been subjected to more stressing environment than the Ukerewe TSZ strain, they can be considered to be more adapted to rigorous production environment. For this reason, if the two TSZ strains under the study are swapped, performance of the Ukerewe TSZ strain in Bunda might be lower than the one currently being exhibited by the Bunda TSZ strain in Bunda. On the other hand, the performance of the Bunda TSZ strain in Ukerewe might be higher than the one currently being exhibited by the Ukerewe TSZ strain.

Calving interval was essentially invariable between the Ukerewe TSZ strain and the Bunda TSZ strain. Because the production environment is more favourable in Ukerewe District than in Bunda District when these strains are swapped the performance gap in calving interval between the strains under the study might widen. This is because from the higher adaptability of Bunda TSZ strain to harsh environment than Ukerewe TSZ strain, performance of Ukerewe TSZ strain in Bunda District is expected to deteriorate while that of Bunda TSZ strain is expected to improve.

The calving interval value observed for the Ukerewe TSZ strain is closer to the value of 452±1.06 days that was reported by Mulindwa *et al.* (2006) for Teso Zebu cattle of eastern Uganda than to the value obtained in this study for the Bunda TSZ strain. Probably, there is greater similarity in production environment between Ukerewe District and Teso District in Uganda than between Ukerewe and Bunda Districts. The estimated values of calving interval for both Ukerewe and Bunda TSZ strains are lower than the values of 16 months and 18 months for the Fipa and the Iringa Red TSZ strains, respectively that were reported by Msanga *et al*. (2012). Perhaps the TSZ strains under the study have higher potential than the Fipa and the Iringa Red TSZ strains with regard to this trait.

The average values of lifetime number of calving obtained for both the Ukerewe TSZ strain and Bunda TSZ strain are lower than the value of 7.68 that was reported by Sungael (2005) for the Iringa Red TSZ but are higher than the value of 4 that was reported by Msanga *et al.* (2012) for Fipa cattle. This is further surprising given that from the age at first calving and calving interval obtained in this study there should be a larger lifetime number of calving than that which has been reported for the Iringa Red TSZ strain. This is because the life time number of calving normally increases with decreasing age at first calving and calving interval.

5.3 Body C*olour Characteristics of Ukerewe and Bunda TSZ Cattle*

It was observed that there exists non-significant difference between Ukerewe and Bunda TSZ with regard to coat colour pattern. According to FAO (2011) this suggests that local communities keeping the cattle have had common coat colour pattern preferences.

Significant differences were observed between TSZ subpopulations of the two districts with regard to coat, skin, muzzle, eyelid and hoof colours with black dominating in Ukerewe TSZ and brown dominating in Bunda TSZ. The predominance of brown colour type in Bunda TSZ is possibly a result of introgression from the brown coloured Ankole cattle which immigrated into Bunda from the west and could not proceed to Ukerewe because of water barrier.

The observation that there exist many types of hair coat colour in both of the districts indicates that there is high variability with respect to the trait. This is therefore in agreement with Msanga *et al.* (2001) who reported that TSZ strains exhibit high coat colour variability. The results on muzzle and hoof colour indicate that the Ukerewe TSZ cattle are different from Tarime TSZ cattle that were reported by Chenyambuga *et al.* (2008) to have predominantly brown muzzles and hooves.

The differences in colour characteristics between the TSZ subpopulations under the study also could probably be due to differences in adaptive pathways related to these attributes in the two districts. One major difference in cattle management between Ukerewe and Bunda Districts is that in the former district the animals are tethered while in the later district the animals graze extensively. It is to be considered that heat stress to the animals could be relatively lower in Ukerewe than in Bunda District since in the former district air temperature is lower and exposure to direct sunlight and degree of animal activity are also relatively lower in Ukerewe than in Bunda district. In Ukerewe District the posts for tethering cattle are mostly big trees which also provide big shade to the cattle.

If the TSZ strains under the study are taken to a warmer environment Bunda TSZ cattle are expected to be less affected than Ukerewe TSZ. If the strains are swapped, Bunda TSZ on one hand will be more comfortable in Ukerewe and that would probably boost their performance in production. On the other hand Ukerewe TSZ would be highly stressed in Bunda. However, thermal comfortability as well as performance of Ukerewe TSZ in Bunda could be improved by creating micro-environment that reduces solar radiation incidence.

5.4 *Characteristics of External Body Appendages of Ukerewe and Bunda TSZ Cattle*

Of the external body appendages under study, horn shape and navel flap size have shown to differ significantly between Ukerewe and Bunda TSZ. Since the two traits are highly heritable then these results suggest that the Ukerewe and the Bunda TSZ differ at genetic level. The genetic difference is most likely due to differential artificial selection that has happened in the two locations over a long time.

It is apparent from the results of this study that there were no differences between Ukerewe and Bunda TSZ with respect to the sizes of their udders, dewlaps, testicles and prepuces. The predominant occurrence of small sized udders, dewlaps, testicles and prepuces is a well known characteristic of the small sized TSZ breed. Results on udder size observed in this work are similar to those reported by Chenyambuga *et al*. (2008) for Tarime cattle.

5.5 Physical Body Measurements of Ukerewe and Bunda TSZ Cattle

From the results of this study, it is apparent that of all the physical body measurements considered in the study only body weight, heart girth and horn length differ between the Ukerewe TSZ and the Bunda TSZ. The differences in performance between the two TSZ subpopulations with respect to body weight and heart girth are in part due to differences in health status and degree of activity of the animals. These favour heavier and deeper bodies for Ukerewe TSZ than Bunda TSZ. Since the animals in Ukerewe are tethered and are not used for draught power, they also tend to be healthier with lower degree of activity than those in Bunda which graze and are used for draught power extensively. It is also a fact that in Bunda TSZ farmers castrated fast growing male animals for use in draught power and in that way selected for slow growth rate and hence smaller mature weight than in Ukerewe where TSZ farmers don't select for draught power.

Bunda TSZ cattle are considered to have developed long horns also as a result of introgression from the long-horned Ankole cattle. The TSZ subpopulations in the two locations don't differ with respect to body length, muzzle circumference, hock circumference, tail length and withers height. Mean values for body length and withers height obtained in both of the locations are lower than those of the Iringa Red reported by Sungael (2005) and those of Kamba and Maasai zebu reported by Mwacharo *et al.* (2006). This suggests further that the TSZ cattle in Ukerewe and Bunda are relatively small sized. It is probable that the TSZ cattle in Ukerewe and Bunda acquired small body sizes in adaptation to relatively hot climatic condition of the region covered in the study. The mean values for ear length in both Ukerewe and Bunda were larger than those reported by Sungael (2005) for Iringa Red. This again suggests some adaptation to relatively hot climatic condition of the region covered in the study. It is contended that large sized ears would enhance body heat dissipation.

The observed significant differences between males and females with respect to body weight, heart girth and horn length are consistent with findings from many other similar studies. According to Mwacharo *et al*. (2006), the differences are attributed to sexual dimorphism. This is normally associated with differences in cell number and hormonal balances which in mammals are well known to promote larger body sizes in males than females. The significant interaction between sex district can be explained by the existence of larger sex effects on body weight, heart girth, and horn length in Ukerewe than in Bunda. This is because in Ukerewe bulls are not used for draught power and they therefore tend to be fatter than those in Bunda.

Within Ukerewe and Bunda there are remarkable environmental differences between villages to which are attributed the observed differences between villages in physical body measurements. For instance in Ukerewe, the climate in the western part is cooler and forage is denser than in the eastern part. Therefore the TSZ cattle in villages found in the western part are on a higher plane of nutrition than those in the eastern zone and consequently they tend to be in better condition than those in the eastern part. In Bunda the plane of nutrition decreases and cattle condition deteriorates as one move away from the lake shore. This is because forage density decreases and stocking rate increases with distance from the lake.

The observed highest correlation between heart girth and body weight in this study is in line with findings by Kashoma *et al*. (2011). This also applies to correlation of body weight with withers height and body length a point which was observed by Mwacharo *et* *al.* (2006). Based on its correlation with body weight, body length seems to be the second best estimator of body weight after heart girth. Correlation between horn length and body weight observed in this study was significant but lower than that reported by Kugonza *et al*. (2011) for Ankole cattle. This may suggest that correlation between body weight and horn length increases as horn length increases across cattle types.

It was also observed in this study that hock circumference and tail length are moderately correlated to body weight in the population under the study. This indicates that these two linear measurements are fairly good predictors of body weight. However, from their insignificant correlations to body weight, muzzle circumference and ear length are not good predictors of body weight for Ukerewe and Bunda TSZ cattle. The correlation results observed in this study between body weight and ear length are contrary to those reported by Kugonza *et al*. (2011) who reported significant correlation between body weight and ear length in Ankole cattle. The difference is probably due to breed differences.

The correlations between withers height and ear and horn length observed in this study agree with those reported by Kugonza *et al.* (2011) for females but not for males. Probably this is because in the sample population cows (which constituted 67%) were predominantly many more than bulls (which constituted 33%) by number. The significant correlation between body length and horn length observed in this study is a result which differs from the insignificant correlation between the linear measurements that was reported by Kugonza *et al*. (2011). This may also be due to breed difference. The observation that there is insignificant correlation between body length and ear length is similar to what was observed by Kugonza *et al.* (2011) despite the breeds being different. Since ear length, horn length and tail length were all observed to be significantly correlated to muzzle circumference and hock circumference in TSZ cattle in the area of study then the former three measurements can be used to estimate with reasonable accuracy the later two measurements.

5.6 Production Environments of Ukerewe and Bunda TSZ Cattle

In general the production environment of TSZ cattle is more favourable in Ukerewe than in Bunda. The differences in vegetation cover, rainfall and grazing system favour higher mature weight, longer heart girth and shorter age at first calving in Ukerewe TSZ cattle than in Bunda TSZ cattle as it was described in earlier sections. The lower environmental temperature and exposure to direct sunlight (which occurs as tethering often uses trees which provide shade) in Ukerewe than in Bunda (where cattle graze openly and extensively) are possible causes of the higher occurrence of black coat colours in Ukerewe than in Bunda. This is because according to Hansen (1990), black coat colour in Zebu cattle is an indication of low adaptability to high ambient temperature and solar radiation.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Several differences were observed between the Ukerewe TSZ strain and the Bunda TSZ strain with regard to their performance, colour and morphology. The performance of Ukerewe TSZ strain in terms of body weight and age at first calving was higher than that of Bunda TSZ strain. This is because in Ukerewe District there is lower heat stress, higher fodder availability, healthier environment and lower energy expenditure for grazing than in Bunda District. The finding suggests also that the lower performance of Bunda TSZ than that of Ukerewe TSZ resulted from culling for draught power use in Bunda which didn’t happen in Ukerewe. Castration of fast growing and developing male animals for draught power use in Bunda allowed inferior ones to breed leading to deterioration in the potential for mature size and age at first calving.

Black is the dominant body colour for the Ukerewe TSZ strain while brown is the dominant body colour for the Bunda TSZ strain. This finding suggests higher influence of the Ankole breed in Bunda TSZ strain than in Ukerewe TSZ strain. The finding also suggests differential adaptation by the TSZ strains under the study to ambient temperature and solar radiation. The low temperature and solar radiation allow black coated animals to survive in large proportions in Ukerewe while in such colour would have less survival advantage in Bunda.

It was found that the Ukerewe TSZ strain has remarkably longer heart girth and shorter horn length than the Bunda TSZ strain. The difference in heart girth is due to differential influence of the environmental and management factors and selection to which the TSZ strains have been subjected over a long time. The difference in horn length between Ukerewe TSZ strain and Bunda TSZ strain is due to the higher influence of Ankole breed in Bunda TSZ strain than in Ukerewe TSZ strain.

The performance superiority that was exhibited by the Ukerewe TSZ strain over the Bunda strain is related to differences in socio-economic characteristics between Ukerewe and Bunda TSZ farmers. The non-use of TSZ cattle for draught power purpose in Ukerewe allowed for conservation of energy for production hence higher performance and body thickness (longer heart girth) in Ukerewe than in Bunda.

It is therefore concluded that Ukerewe and Bunda TSZ strains are distinguishable by colour and morphological characteristics. Differences in production environment of cattle and socio-economic characteristics of farmers between Ukerewe and Bunda districts are attributable to the observed phenotypic differences between the TSZ strains under the study.

6.2 Recommendations

It has been found that the Ukerewe TSZ strain differs remarkably from the Bunda TSZ strain with regard to a number of standard morphological, colour and performance traits. In order to establish if the two strains could have a common origin, there is a need to undertake advanced characterisation with a closer look at the differences highlighted in this study. That will need the use of more sensitive tools so as to analyse the differences more precisely. Genetic characterization through the use of molecular markers is highly recommended.

REFERENCES

Abdelhadi, O. M. A. and Babiker, S. A. (2009). Prediction of Zebu cattle live weight using live animal measurements. [http://www.Irrd.org/Irrd21/8abde21133.htm] site visited on 5/3/2012.

Alsiddig, M. A., Babiker, M. S., Galal, M. Y. and Mohammed, A. M. (2010). Phenotypic characterization of Sudan Zebu cattle. *Research Journal of Animal and Veterinary Science* 5: 10 – 17.

Beate, D. S. (Ed.) (2000). *World Watch List for Domestic Animal Diversity.* FAO, Rome, Italy. 726pp.

Baker, R. L. and Gray, G. D. (2004). *Appropriate Breeds and Breeding Schemes for Sheep and Goats in the Tropics*. In: (Edited by Sani, R. A. *et al*.), Worm Control for Small Ruminants in Tropical Asia. ACIAR, Canberra. 33pp.

Carson, A., Elliot, M., Groom, J., Winter, A. and Bowles, D. (2009). Geographical isolation of native sheep breeds in the United Kingdom: Evidence of endemism as a risk factor to genetic resources. *Livestock Science* 123: 288 - 299.

Chenyambuga, S. W., Ngowi, E. E., Gwakisa, P. S. and Mbaga, S. H. (2008). Phenotypic description and productive performance of Tarime Zebu cattle in Tanzania. *Tanzania Veterinary Journal* 25: 60 – 74.

Das, S. M. and Mkonyi, J. I. (2003). Important aspects of conservation of indigenous cattle in Tanzania. In: *Proceedings of the 30th Scientific Conference of the Tanzania Society of Animal Production.* (Edited by Kifaro, G. C. *et al*.), 28 - 30 October 2003, Tanga, Tanzania. pp. 59 – 70.

Food and Agriculture Organisation (2011). Draft guidelines on phenotypic characterization of animal genetic resources. In: *Proceeding of Commission of Genetic Resources for Food and Agriculture*, 18 – 22 July 2011, Rome, Italy. pp. 85 – 88.

Food and Agriculture Organisation (1987). *Crossbreeding Bos Indicus and Bos Taurus for Milk Production in the Tropics*. (Edited by Cunningham, E. P. and Syrstad, O.), Animal Production and Health, Rome, Italy. 45pp.

Gatesy, J. and Arctander, P. (2000). Hidden morphological support for the phylogenetic placement of *Pseudoryx ngetinhensis* with bovine bovids: A combined analysis of gross anatomical evidence and DNA sequences from five genes. *Systematic Biology* 49: 515 – 538.

Hanotte, O. and Jianlin, H. (2006). *Genetic Characterisation of Livestock Populations and Its Use in Conservation Decision Making.* In: (Edited by Ruane, J. and

Sonniro, A.), The Role of Biotechnology in Exploring and Protecting Agricultural Genetic Resources. FAO, Rome, Italy. 96pp.

Hansen, P. J. (1990). Effects of coat colour on physiological and milk production responses to solar radiation in Holsteins. *Veterinary Records* 127: 333 – 337.

Hansen, P. J. (2004). Physiological and cellular adaptations of Zebu cattle to thermal stress. *Animal Reproduction Science* 83: 349 – 360.

Kamalzadeh, A., Koops, W. J. and Van Bruchem, J. (1998). Feed quality restriction and compensatory growth in growing sheep: Modelling changes in body dimensions. *Livestock Production Science* 53: 57 – 67.

Kashoma, I. P. B., Luziga, C., Werema, C. W., Shirima, G. A., and Ndossi, D. (2011). Predicting body weight of Tanzania shorthorn Zebu cattle using heart girth measurements. [http://www.Irrd.org/Irrd23/4/kash23094.htm]site visited on 18/6/2012.

Kurwijila, R. L. and Kifaro, G. C. (2001). An overview of biodiversity of livestock in Tanzania. In: *Proceedings of SUA-MU ENRECA Project Workshop.* (Edited by Kifaro, G. C. *et al*.). 6 August 2001, Morogoro Tanzania. pp. 1 – 26.

Kohler-Rollefson, I. (2003). Community-based management of animal genetic resources with special reference to pastoralists. In: *Proceedings of Community-Based*

Management of Animal Genetic Resources Workshop. (Edited by Vilakati, D. *et al*.). 7 – 11 May 2001, Mbabane Swaziland. pp. 13 – 25.

Köhler-Rollefson, I. (2004). *Farm Animal Genetic Resources.* Safeguarding National Assets for Food Security and Trade. GTZ/FAO/CTA, Exborn. 54pp.

Krishna, A., Kristjanson, P., Radeny, M. and Nindo, W. (2004). Escaping poverty and becoming poor in twenty Kenyan villages. *Human Development* 5: 211 – 226.

Kugonza , D. R., Nabasirye, M., Mpairwe, D., Hanotte, O. and Okeyo, A. M. (2011). Productivity and morphology of Ankole cattle in three livestock production systems in Uganda. *Animal Genetic Resources* 48: 13 – 22.

Lawrence, T. and Pearce, J. (1964). Some effects of wintering beef cattle on different planes of nutrition I: Live weight gain, food consumption and body measurement changes during the winter period and the subsequent grazing period. *Journal of Agricultural Science* 63: 5 – 20.

Madubi, M. A. (1997). Physical characterization of three strains of Small East African goats in Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 146pp.

Mason, I. L. and Maule, J. P**.** **(**1960). *The Indigenous Livestock of Eastern and Southern Africa.* Common Agricultural Bureaux, Bucks. 151pp.

Ministry of Livestock Development and Fisheries (2009). Budget Speech. [http://www .mifugo.go.tz/] site visited on 14/12/2011.

Mpiri, D. B. (1994). *Improving Cattle Productivity in Tanzania*. Uyole Agricultural Centre Press, Mbeya. 251pp.

Msanga, Y. N., Mbaga, S. H. and Msechu, J. K. (2001). Farm animal breeds and strains of Tanzania. In: *Proceedings of SUA - MU ENRECA Project Workshop*. (Edited by Kifaro, G. C. *et al*.), 6 August 2001, Morogoro, Tanzania. pp. 36 – 49.

Msanga, Y. N., Mwakilembe, P. L. and Sendalo, D. (2012). The indigenous cattle of the Southern Highlands of Tanzania: Distinct phenotypic features, performance and uses. *Livestock Research for Rural Development* 110: 1 – 24.

Mulindwa, H. E., Ssewannyana, E. and Kifaro, G. C. (2006). Extracted milk yield and reproductive performance of Teso cattle and their crosses with Sahiwal and Boran at Serere, Uganda. *Uganda Journal of Agricultural Sciences* 12(2): 36 – 45.

Mwacharo, J. M. and Rege, J. E. O. (2002). On-farm characterization of the indigenous Small East African Shorthorn Zebu Cattle in the Southern rangelands of Kenya. *Animal Genetic Resources* 32: 73 – 86.

Mwacharo, J. M., Okeyo, A. M., Kamande, G. K. and Rege, J. E. O. (2006). The small East African shorthorn Zebu cows in Kenya I: Linear body measurements. *Tropical Animal Health and Production* 38: 65 – 74.

Mwambene, P. L., Katule, A. M., Chenyambuga, S. W., Mwakilembe, P. A. A. (2012). Fipa cattle in the South-western highlands of Tanzania: Morphometric and physical characteristics. *Animal Genetic Resources* 51: 15 – 29.

Ndumu, D. B., Baumung, R., Hanotte, O., Wurzinger, M., Jianlin, H., Kibogo, H., Okeyo, A. M. and So¨lkner. J. (2008). Genetic and morphological characterisation of the Ankole longhorn cattle in the African great lakes region. *Genetics Selection Evolution* 40: 467 – 490.

Ngowi, E. E., Chenyambuga, S. W. and Gwakisa, P. S. (2008). Socio-economic values and traditional management practices of Tarime Zebu cattle in Tanzania. [http//: www.Lrrd.org/lrrd 20/6/ngow20094.htm] site visited on 18/06/2012.

Nsoso, S. J., Podisi, B., Otsogile, E., Mokhutshwane, B. S. and Ahmadu, B. (2004). Phenotypic characterisation of indigenous Tswana goats and sheep in Botswana: Categorical traits. *Tropical Animal Health and Production* 36: 789 – 800.

Odada, E. O., Olago, D. O. and Ochola, W. (2006). Environment for Development: An Ecosystems Assessment of Lake Victoria Basin, UNEP/PASS. [http://start.

org/download/publications/environment-development.pdf] site visited on 3/9/2012.

Payne, J. A. and Wilson, T. R. (1999). *An Introduction to Animal Husbandry in the Tropics.* Blackwell Science Limited, Oxford. 815pp.

Perry, B. D., Randolf, T. F., McDermott, J. J., Sones, K. R. and Thornton, P. K. (2002). *Investing in Animal Health Research to Alleviate Poverty*. ILRI, Nairobi. 148pp.

Rege, J. E. O. and Tawah, C. L. (1999). The state of African cattle genetic resources II: Geographical distribution, characteristics and uses of present-day breeds and strains. *Animal Genetic Resources* 26: 1 – 25.

Rege, J. E. O. (1999). The state of African cattle genetic resources I: Sanga, Zenga, recent derivatives, threatened and extinct breeds. *Journal of Animal Genetic Resources Information* 25:1 – 25.

Richardson, D. and Smith, A. J. (2006). *The Tropical Agriculturalist.* McMillan Publishers Limited, Wageningen. 120pp.

Roth, Z. and Hansen, P. J. (2004). Sphingosine-1-phosphate protects cultured bovine oocytes from physiologically relevant thermal stress. *Reproduction Fertility and Development* 16: 279 – 282.

Statistical Analysis Software (2000). *Statistical Analysis Institute*. Cary Incorporation, North Carolina. 1028pp.

Scarpa, R., Ruto, E. S. K., Kristjanso, P., Radeny, M., Drucker, A. G. and Rege, J. E. O. (2003). Valuing indigenous cattle breeds in Kenya. *Ecological Economics* 45: 409 – 426.

Scholtz, M. M. (1988). Selection possibilities of hardy beef breeds in Africa: The Nguni examples. In: *Proceedings of 3rd World Congress on Sheep and Beef Cattle Breeds.* 19 – 23 June 1988, Paris, France. pp. 303 – 319.

Setchell, B.P. (1978). *The Mammalian Testis.* Cornell University Press, Ithaca. 450pp.

Statistical Package for Social Sciences (2006). *Brief Guide.* SPSS Incorporation, Chicago, USA. 179pp.

Sungael, M. N. (2005). Phenotypic characterization and slaughter characteristics of Iringa Red Zebu Cattle. Dissertation for MSc Degree Award at Sokoine University of Agriculture, Morogoro, Tanzania, 140pp.

Udeh, I., Akporhuarho, P. O. and Onogbe, C. O. (2003). Phenotypic correlations among body measurements and physiological parameters in Muturu and Zebu cattle. *Journal of Agricultural and Biological Science* 6(4): 1 – 4.

United Republic of Tanzania (2006). National Livestock Policy. [http://www.tzonline.org/policies.asp] site visited on 28/9/2012.

Valle-Zarate, A. (1996). Breeding strategies for marginal regions in the Tropics and Sub-Tropics. *Animal Research and Development* 43: 99 – 118.

Williamson, G. and Payne, W. J. A. (1965). *An Introduction to Animal Husbandry in The Tropics.* Longmans Green and Company Limited, London. 447pp.

Wuletaw, Z., Ayalew, W. and Soelkner, J**. (**2008). The Mahibere-Silassie composite: A new cattle breed type in north-western Ethiopia. *Ethiopian Journal of Animal Production* 8(1): 39 – 51.

Wurzinger, M., Ndumu, D., Baumung, R., Drucker, A., Okeyo, A. M., Semambo, D. K., Yamungu, N. and So¨lkner, J. (2006). Comparison of production systems and selection criteria of Ankole cattle by breeders in Burundi, Rwanda, Tanzania and Uganda. *Tropical Animal Health and Production* 38: 571 – 581.

Zechner, P., Zohman, F., So¨lkner, J., Bodo, I., Habe, F., Marti, E. and Brem, G. (2001). Morphological description of the Lipizzan horse population. *Livestock Production Science* 69(2): 163 – 177.

APPENDICES

Appendix 1: Chi-square test for association between district and households sources of income

Income source	Ukerewe n	Bunda n	Total n
Fishing	11(6)	0(4.9)	11
Crops	22(24)	22(20)	44
Livestock	22(24)	22(20)	44
Salary	4(3.3)	2(2.7)	6
Business	1(2.2)	3(1.8)	4
Total	60	49	109
	X^2value (df= 4)= 11.59*		

Note: n=number of observation; df= degrees of freedom; * significant ($p<0.05$). Figures in parentheses indicate expected numbers

Appendix 2: Chi-square test for association between district and households sources of food

Food source	Ukerewe n	Bunda n	Total n
Fishing	13(8.2)	2(6.8)	15
Crops	23(25.2)	23(20.8)	46
Livestock	22(24.6)	23(20.8)	45
Total	**58**	**48**	**106**
	X^2 value (df= 2)= 7.1*		

Note: n=number of observations; df= degrees of freedom; * significant ($p<0.05$). Figures in parentheses indicate expected numbers

Appendix 3: Chi-square test for independence of ranking from species

	Rank				
Species	**1**	**2**	**3**	**4**	**Total**
	n	**n**	**n**	**n**	**n**
Cattle	45(14.4)	1(14)	0(11.6)	0(5.9)	46
Goats	0(11.3)	31(11)	5(9)	0(4.7)	36
Sheep	0(6.3)	6(6.1)	14(5)	0(2.5)	20
Ducks	0(0.6)	0(0.6)	2(0.5)	0(0.3)	2
Chicken	1(13)	7(12.8)	15(10.6)	19(5.4)	42
Pigs	0(0.3)	0(0.3)	1(0.3)	0(0.1)	1
Total	46	45	37	19	147

X^2value (df= 15)= 232.5***

Note: n= number of observations, df= degrees of freedom, *** very highly significant (p<0.001). Figures in parentheses indicate expected numbers

Appendix 4: Chi-square test for independence of ranking from district

		Rank			
District	**1**	**2**	**3**	**4**	**Total**
	n	**n**	**n**	**n**	**n**
Ukerewe	23(19.8)	21(19.4)	18(15.5)	1(8.2)	63
Bunda	23(26.2)	24(25.6)	18(20.5)	18(10.8)	83
Total	46	45	36	19	146
		X^2(df=3) = 14.4**			

Note: n=number of observation; df=degrees of freedom; *** highly significant (p<0.01). Figures in parentheses indicate expected numbers.

Appendix 5: Chi-square test for independence of districts from usage of TSZ cattle

Usage	**Ukerewe**	**Bunda**	**Total**
	n	n	n
Meat	1(2.2)	5(3.8)	6
Milk	14(11.6)	17(19.4)	31
Draught power	0(5.6)	15(9.4)	15
Income	2(15.3)	21(25.7)	41
Manure	9(4.8)	4(8.2)	13
Prestige	0(1.5)	4(2.5)	4
Dowry payment	0(2.2)	6(3.8)	6
School fees	0(0.4)	1(0.6)	1
Rituals	0(0.4)	1(0.6)	1
Total	44	74	118
	X^2value (df= 8)= 26.3**		

Note: n= number of observations, df= degrees of freedom, *** highly significant (p<0.001). Figures in parentheses indicate expected numbers.

Appendix 6: ANOVA for various physical body measurements

Source of variation	df	Means Square for Physical body measurements								
		BW	**BL**	**HG**	**WH**	**MZ**	**HC**	**HL**	**EL**	**TL**
District	1	6701.51*	6.86^{ns}	217.08*	49.5^{ns}	164.41^{ns}	13.51^{ns}	3216.37***	22.64^{ns}	161.31^{ns}
Sex	1	6455.24*	437.3^{ns}	481.89**	182.64^{ns}	67.95^{ns}	3.52^{ns}	952.25***	0.48^{ns}	17.78^{ns}
District*sex	1	5454.15*	1228.9*	374.55**	95.11^{ns}	0.93^{ns}	0.03^{ns}	544.08**	6.79^{ns}	190.86^{ns}
Village (district)	6	12180.71***	374.75**	610.2***	127.18^{ns}	17.88^{ns}	16.35^{ns}	63.35^{ns}	8.85^{ns}	74.31^{ns}
Residual	159	1160	124.97	53.52	79.51	42.81	8.60	48.55	6.18	64.8

Note: df= degrees of freedom; *** Very highly significant ($P < 0.001$); ** highly significant ($P < 0.01$); * significant ($P \leq 0.05$); ns non-significant ($P > 0.05$). BW= mature weight; HG= heart girth; WH= withers height; BL= body length; EL= ear length; HL= horn length; MC= muzzle circumference; HC= hock circumference; TL= tail length