EVALUATION OF PERFORMANCE OF NORWEGIAN DAIRY GOATS IN MGETA MOROGORO

VALERY SILVERY SONOLA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT 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

This study was conducted to evaluate the performance of different crosses of Norwegian dairy goats raised by farmers in Mgeta, Morogoro using data collected for three years. Growth of goats, age at first kidding (AFK), kidding interval (KI) and lactation traits were evaluated. The general linear model (GLM) procedure of the statistical analysis system (SAS) was used in data analysis. Correlations between the factors were assessed by using a multivariate analysis of variance (MANOVA). Overall mean body weights at birth, weaning (3 months), 6 and 9 months were 3.27±0.04kg, 12.79±0.09kg, 20.98±0.17 kg and 28.33±0.19 kg respectively. Male kids were heavier (3.51±0.07 kg) at birth than the females (3.20±0.07 kg). In terms of growth, males had higher growth rate (100.84 g/day) compared to the females (82.14 g/day). The mean values of AFK and KI were 17.25±0.14 months and 10.17±0.19 months respectively. Twin born does kidded later (17.64±0.25 months) than the single does (16.37±0.24 months). The estimated twinning rate (TR) was 52.19%. Regarding the lactation (LMY) and monthly milk yields (MMY), about 322.24±7.15 litres and 42.82±0.78 litres were obtained respectively. The average lactation length (LL) and dry off periods (DP) were 7.15±0.14 months and 84.47±3.64 days respectively. The overall pre and post-weaning mortality rates were 14.49% and 5.6% respectively with fewer mortalities during the dry season (August and September). Genetic improvement of the goats should not exceed 75% of Norwegian blood level for optimum performance.

DECLARATION

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

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VALERY SILVERY SONOLA **Date**

(MSc. Candidate)

The above declaration is confirmed by:

________________________ ___________________

Prof. G. C. Kifaro **Date**

(Supervisor)

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DEDICATION

This piece of work is dedicated to my parents, Silvery Sonola and Laurencia Mangaganga who sacrificed their little saving for my education and well being. May the Almight GOD bless them abundantly.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFK	Age at first kidding
COSTECH	Tanzania Commission for Science and Technology
DASP	Department of Animal Science and Production
df	Degree of freedom
DP	Dry Period
EPINAV	Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value Chains
FARM-Africa	Food and Agricultural Research Management in Africa
FCE	Food Conversion Efficiency
GLM	General linear model
GR	Growth Rate
HIT	Heifer International in Tanzania
KI	Kidding interval
LL	Lactation Length
LMY	Lactation Milk Yield
MANOVA	Multivariate analysis of variance
MLFD	Ministry of Livestock and Fisheries Development
MMY	Monthly Milk Yield
MR	Mortality rate
n	Number of observations
NGOs	Non-governmental organizations
NS	Not significant
r	Coefficient of correlation

SAS	Statistical Analysis System
SE	Standard error
SUA	Sokoine University of Agriculture
TR	Twinning rate
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

In Tanzania, dairy goats' production dates back to 1960s when the government imported pure breeds of Saanen, Anglo-Nubian and Toggenburg (Das and Sendalo, 1991). During that time, dairy goats were accepted in missionaries and government institutions as a way to alleviate poverty. In the early 1980s, non-governmental organizations (NGOs), Christian centers, universities and research institutions started importing European breeds of dairy goats in various rural areas of Tanzania (Kiango, 1996). Heifer International in Tanzania (HIT), FARM-Africa and Sokoine University of Agriculture (SUA) were among the first organizations to import and distribute dairy goats to rural farmers for upgrading the local breeds.

All organizations had a general goal of improving productivity of the local goats and increase food security and income for the vulnerable families (Peacock, 2008). The population of goats in Tanzania is estimated at 16.7 million (URT, 2015). Of these, dairy goats are about 419 533 (URT, 2012) divided into several breeds including; Toggenburg, Saanen, Anglonubian, Alpine and Norwegian (URT, 2006). The most predominant breeds are Norwegian and Toggenburgs.

Currently, dairy goats from Mgeta are serving as a potential source of Norwegian breed to other places of the country through various dairy goat projects. Goats are reliable producers under difficult climatic conditions and fast breeders with lower nutritional requirements as compared to cattle because of their small body size (Escareno *et al.,* 2013). Dairy goats are smaller and easier to manage than cattle. This makes them more accessible and manageable to rural people with low income (Peacock, 2005). They can easily be converted into cash and this has made them to be regarded as traditional banks for the low income people.

Goats' husbandry operations have great potential to support economic growth to rural women and increase gender equality (Odero-Wanga *et al.,* 2009). Dairy goats form an economic opportunity to rural farmers because by selling one goat a farmer can buy enough grains to feed a family of 5 people for about 3 months (Peacock, 2005). The goat manure has higher nitrogen content as compared to that of sheep or cattle and being in pellet form retains nutrients much better and releases them more slowly therefore ensuring better soil fertility (Okeyo, 1998). The increasing land pressure and urbanization makes dairy goats an attractive and sustainable option for small holders in rural and semi-urban areas (Fagerholm *et al.,* 2011). In systems where farmers cut and carry forages for their goats, manure can easily be collected and spread in vegetable gardens or nearby fields, increasing soil organic matter and fertility (Juma and Pica-Ciamarra, 2013). Dairy goat projects have significantly enhanced economic growth of poor farmers from sales of milk, meat, live animals, skin and manure (Chenyambuga *et al.,* 2012). Poor farmers in rural areas have managed the costs of food and education for their children due to income from dairy goats (World Bank, 2001).

Goat milk contains a wide range of vitamins, minerals, trace elements, electrolytes, enzymes, proteins and fatty acids which are easily assimilated by the human body (Haenlein, 2004; Abbas *et al.,* 2014). Goat milk has shown therapeutic effects for people with dietetic problems, therefore physicians have been recommending goat milk for infants and others allergic to cow milk (Kumar *et al.,* 2012). Due to small size of their fat globules, goat milk can be easily digested and assimilated even by lactose intolerant people and children. The superiority of goat to cow milk is due to high fat and protein digestibility, its significantly higher mineral and vitamins composition and lower incidences of allergy to people (Belewu and Aiyegbus*,* 2002). This makes it able to relieve stress and constipation in humans (Haenlein, 2004).

In 1988, a selected group of farmers in Mgeta was introduced to dairy goat keeping and provided with animals through a project at SUA. Since then, the population of dairy goats in Mgeta has increased to over 2000 in 2014. The lactation yield per goat has been improving with increased level of Norwegian blood (Kiango, 1996). Performance evaluation of Norwegian dairy goats in Mgeta, has not been done for the past 18 years. The first evaluation done by Kiango (1996) reported average age at first kidding, kidding interval, twinning rate, litter size and survival rates to be 527.1 days, 338 days, 48%, 1.5 kids and 74.1 % respectively. Furthermore, average daily milk yields of 0.87 kg/day, lactation yield of 141.02 kg, lactation length of 258.3 days, pre-weaning growth rate of 92.16 g/day and post-weaning growth rate of 76.07 g/day were reported.

There was a need to carry out a study to find out whether the same status of production is persisting or changes have taken place. Dairy goats in Mgeta have been raised for the past 26 years with a lot of breeding interventions being done. The prevailing assumption is that, farmers have enough experience of raising dairy goats. Moreover, better genetic materials have been introduced in the area through importation of bucks and artificial insemination done in 2002, 2008 and 2012. Since September 2012, dairy goats were monitored monthly providing adequate information for effective evaluation. This study was therefore carried out to evaluate the production performance of different traits of economic importance in the crosses of Norwegian dairy goats. These traits included body weights and growth rates, mortality rates, reproductive and lactation performance. The information obtained identifies areas for further research that can be developed reflecting the practical situation present in dairy goat farms of Mgeta. The main objective of this study was therefore to determine growth, reproductive and lactation performance of dairy goats in Mgeta. Three specific objectives were designed.

i) To evaluate growth, reproductive and lactation performance of dairy goats in Mgeta.
ii) To evaluate the influence of genetic and non-genetic factors on the above mentioned traits.
iii) To determine pre and post weaning mortalities of dairy goats.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Growth Performance in Dairy Goats

Growth of an animal can be defined as an increase in live weight and body size while growth rate is the rate of increase in weight and body size during specific intervals of time. Growth rate of an animal directly influences the feed conversion efficiency (FCE) and the economics of dairy goat husbandry. The higher the growth rates of goats the greater their feed conversion efficiency. Similarly, growth rate affects the expected output through its influence on time required to attain the targeted market weight. The rate of growth in goats is mainly influenced by breed, sex, nutrition, season of birth, type of birth, management and diseases (Hamad, 2001).

2.1.1 Effect of sex on growth performance of dairy goats

Male goats have significantly higher daily weight gains as compared to females from birth up to 24 weeks of age (Bera *et al.,* 2008; Eik *et al.,* 2008). Various authors have reported significant influence of sex on weights at birth and growth of kids (Ruvuna *et al.,* 1988; Kuchtick and Sedlackova, 2005). At birth, male kids have been found to be heavier (2.37 kg) than females which weighed 2.21 kg (Ibnelbachyr *et al.,* 2014). Zeleke (2007) reported a higher mean birth weight in males (3.35 kg) than in females (3.04 kg). Bushara *et al. (*2013) observed a higher mean birth weight in males (2.21 kg) than in female kids (1.92 kg) whereas at weaning males weighed 8.38 kg as compared to 7.12 kg in females. A study on Osmanabad goats reported that male kids were heavier (2.6 kg) than females (2.35 kg) at birth (Harikrishna *et al.,* 2013). Kezić *et al.* (2005) found significantly higher average daily weight gains in males (174.01 g) than in female (129.17 g) Alpine kids and in male (161.64 g) and female (139.13 g) kids of Croatian white goats.

Furthermore, Bharathidhasan *et al.* (2009) reported higher birth weights in male (1.92 kg) than in female kids (1.84 kg) and the average weaning weight of female kids (6.85 kg) was lower than that of males (7.01 kg). This difference in growth rates between sexes is attributed to the anabolic effect of male sexual hormones and their aggressive nature of suckling and feeding (Bushara *et al.,* 2013). The difference in growth rates between males and females increases along with the goats' age as a result of increased production of androgens which have growth potential in male animals. Also, male animals have relatively larger number of muscle cells than females at birth.

2.1.2 Effect of type of birth on growth performance of dairy goat kids

Birth type has been reported to affect growth rate significantly. A study in Morocco observed higher body weights in single born kids at all ages which grew faster than those born as multiples whereby single kids were superior to multiples by 0.34 kg, 0.97 kg and 1.67 kg at birth, 30 days and 90 days respectively (Ibnelbachyr *et al.,* 2014). Jimenez-Badillo *et al. (*2009) observed that single born kids were 0.41 kg heavier than multiples at 30 days age and their average daily gains exceeded that of multiples by 12.2 g. A study in Sudan has reported significantly higher mean body weights for single kids (2.10 kg: 8.63 kg) than twins (2.02 kg: 8.11 kg) and triplets (1.79 kg: 7.41 kg) at birth and at weaning respectively (Bushara *et al.,* 2013). This trend influenced higher growth rate in single kids (72.55 g/day) than in twins (67.67 g/day) and triplets (62.44 g/day). The difference in birth weights between single and multiple born kids has been associated with the uterine environment which is shared by multiple foetuses. Since, single born kids do not compete for space and nutrients in their dams' uterus (Jimenez-Badillo *et al.,* 2009), can grow faster than the multiples whose dams have limited capacity to provide them with prenatal nourishment (Ebangi *et al.,* 1996; Zahraddeen *et al.*, 2008).

2.1.3 Effect of dam age or parity on growth performance of kids

Studies have revealed a significant influence of age of dam on weight at birth, at weaning and age at first kidding (Dadi *et al.,* 2008). Age of dam affects average daily gains from birth to 72 weeks of age. The highest weights have been reported for kids born from does of more than 3 years old which were superior by 0.31 kg at birth, 0.57 kg at 1 month and 0.72 kg at 3 months than those from young does (Ibnelbachyr *et al.,* 2014). The unfavourable effects of young dams on their kids suggest the importance of feeding and management during mating and pregnancy (Wenzhong *et al.,* 2005). A similar effect has also been reported by Boujenane and El-Hazzab (2008) who found significant effect of dam age on weights at birth and at 1 month of age. This variation in birth weights has been associated with the fact that mothering ability and milk production increase with age of the dam (Mia *et al.,* 2013).

Parity of dams has significant effect on kids' weight at birth, weaning (3 months) and on litter size where these variables increase with parity (Zelekie, 2007; Dadi *et al.,* 2008). Kids born in the first parity have been reported to have lower mean weight at birth (3.19 kg) and at weaning (18.98 kg) as compared to those born in the second (3.21 kg: 18.24 kg) and third parity (3.25 kg: 19.38 kg) respectively (Ahuya *et al.,* 2009). Kids born in the second (90.58 g/day) and third (88.28 g/day) parities have been reported to have higher mean growth rates than kids born during the first (86.80 g/day) parity (Zahraddeen *et al.,* 2008). The same effect of parity of dam on growth performance of kids has been documented in literature (Zeleke, 2007; Dadi *et al.,* 2008; Jimenez-Badillo *et al.,* 2009; Deribe and Taye, 2013). Furthermore, lower birth weights of kids born in the first parity were previously reported by other authors (Amoah *et al.,* 1996; McManus *et al.,* 2008). This can be due to the fact that, young dams continue growing during pregnancy and lactation hence competing with their foetus and kids respectively for the available nutrients. Also, mothering ability increases with age or parity and is related to body size and milk production which is reflected on kids live body weights (Kiango, 1996; Deribe and Taye, 2013). Physiologically mature does normally produce heavier kids than younger dams. However, kids born from parity 5 and above have been reported to have low birth weights than those born from dams of first to fourth parity, this is possibly due to loss of body condition of dams and hence retarded growth rate of foetus (Zeleke, 2007).

2.1.4 Effect of the year of kidding on growth of goats

Year of birth affects many traits in dairy goats including growth rate. Studies have reported significant influence of year of kidding on mean body weight and growth rate of dairy goats at different ages (Gbangboche *et al.,* 2006; Mabrouk *et al.,* 2010). Significantly higher effects of year of kidding on body weights of goats were observed from birth to about 150 days of age (Mabrouk *et al.,* 2010). A similar effect of kidding year on growth of kids was reported by Ndlovu and Simela (1996) in Zimbabwe. This effect has been associated with annual variations in availability of feedstuffs due to variable productivity of range lands (Najari *et al.,* 2007). The scarcity and irregularity of rainfalls are the main factors affecting growth of animals particularly young kids (Mabrouk *et al.,* 2010). This is because, a fluctuation of annual precipitations affects feed availability to the goats which consequently causes variation in body weights and growth rates between years (Najari *et al.,* 2007; Dadi *et al.,* 2008). The influence of year of birth on growth performance of goats particularly in areas with difficult climatic conditions has also been reported by Zhang *et al.* (2009). Furthermore, year of kidding can affect management and body condition score of dams which can indirectly influence birth weight in dairy goat kids.

2.1.5 Effect of season of birth on growth performance of kids

Significant influence of season of birth on weaning weights (3 months) was reported by Dadi *et al.* (2008) but had little effect on subsequent live weights. Effects due to season of birth have been widely reported to affect body weights from birth to 5 months of age (Wenzhong *et al.*, 2005; Mabrouk *et al*., 2010). This effect has been attributed to different feeding conditions generated in each season by irregular climatic conditions (Gaddour *et al.,* 2007). Forages change easily from one season to another and for the same season from one year to another, thus directly affecting feed intake of the kids and milk production of the doe is indirectly affected (Sajlu *et al.,* 1999; Najari *et al.,* 2007). Kids born in wet season were found superior to those born in dry season by 0.16 kg at birth, 2.77 kg at weaning and 2.09 kg at 6 months of age (Deribe and Taye, 2013). This was related to the nutritional status of the does during late stage of pregnancy. Does kidding in wet season have better browses and green forages at late gestation than those kidding in dry season. Dunn and Moss (1992) reported that rapid foetal growth rate occurs at late stage of pregnancy during which, nutritional stress can result into lower birth weights and increased risks of abortions.

However, one previous study has reported that, kids born in the dry season were heavier at 60 and 90 days of age than those born in wet season (Ndlovu and Simela, 1996). Dadi *et al*. (2008) observed that kids born in dry season had 0.8 kg more live weight at 3 months of age than those born in the wet season despite the higher availability of feedstuff. Lower weaning weights in wet season have been associated with forages being too succulent (low dry matter) and the system of confining goats to prevent damage of crops which limit feed intake and forage selectivity (Solomon *et al*., 2005). Also, higher possibility of disease occurrence especially worms in rainy seasons can possibly result into low weaning weights of the goats. In some studies, season of birth did not significantly affect the birth weights of kids (Mourad *et al.,* 2000). However, in most highlands and semi-arid areas, diseases can be less pronounced in wet seasons as compared to humid areas and succulence of forages is for a very short period (Dadi *et al.,* 2008), hence lower effect on body weights. Furthermore, variation of dairy goats in body weights in different seasons of birth can partly be related to differences in management between farms (Zhang *et al.,* 2008).

2.1.6 Effect of blood level on growth performance of dairy goats

Growth rates in crosses of Norwegian dairy goats from birth to 9 months has been reported to vary with blood level, being 65, 82 and 85 g/day for 100%, 75% and 50% Norwegian blood respectively (Eik *et al.,* 2008). A report has shown significantly higher growth rates in 50% Norwegian dairy goats as compared to the pure local goats' counterparts (Safari *et al.,* 2005). Kids with 75%N blood were found with higher body weights and growth rates at all stages than the other genetic groups (83-97% and 100%). Lower birth weights of 100%N goats have been associated with poor management of the pure Norwegian pregnant does (Kiango, 1996). This is caused by lack of dry period in lactating does which are continuously milked till the next lactation resulting into low nutrient uptake of the doe to meet the requirements for pregnancy and maintenance hence low birth weights.

2.2 Reproductive Performance in Dairy Goats

Reproductive performance of goats is a major determinant of productivity and economic viability of dairy goats' enterprises (Mellado *et al.,* 2008), which is regulated by genetic and environmental factors (Notter, 2012). Reproduction in goats is influenced by nutrition (pre and post-partum), body condition, breeding technologies, management and age in dairy goats. Delayed reproduction causes economic losses due to reduced volumes of milk sales and lack of young stock for replacement (Hamad, 2001). Reproductive performance is evaluated by traits like; age at first kidding, kidding interval, litter size, fecundity and prolificacy.

2.2.1 Litter size and twinning rate

Litter size can be defined as the number of young goats kidded by a particular number of does during a specific period. Multiple births occur when more than one kid is born by the doe at one time. They can be twins, triplets and quadruplets and in some rare cases five kids. Twinning rate is the percentage of twin births expressed out of the total number of kiddings. Litter size is the potential factor which measures the reproductive efficiency of any farm. Goats are the most prolific animals among all domestic ruminants (Dereje *et al.,* 2015), due to higher possibility of large litter sizes. Litter size in dairy goats is significantly affected by age or parity of dam, days open and level of nutrition (Kiango, 1996).

One study has reported a highly significant effect of parity on litter size, in which larger litter size of 2.1 was realized in the sixth parity while the overall mean litter size was 1.6 (Dadi *et al.,* 2008). The same effect of parity was reported by Haldar *et al. (*2014) in a study in which average litter size was 1.75. Litter size increases with age and is more related to body weight of the doe than age (Sangaré and Pandey, 2000). This is because, the hormonal status, metabolic activity, secretory cells and feed intake, all of which support milk synthesis for satisfying multiple kids, increase with age of the animal (Hansen *et al.,* 2006; Carnicella *et al.,* 2008). This can explain the increase of litter size at birth with increase of parity or age of the dam. Also, type of kidding has a significant effect on litter size and twinning rate whereby does with single kids have lower milk yields as compared to those with multiples (Arguello *et al.,* 2005). Higher lactogenic activities in pregnant does maximize development of mammary gland and increase the potential for milk synthesis resulting into higher milk yield in does to support multiple kids (Salama *et al.,* 2005).

Season of kidding can significantly affect litter size in goats. This is more related to the fluctuation in feed availability which ultimately influences ovulation and eventually conception rate. The doe is more likely to conceive when well fed particularly 2 months before mating which is possible under high plane of nutrition (Dadi *et al.,* 2008). Several other factors are known to influence litter size in dairy goats. Distance between tuber coxae bones, neck length, body length, croup height, body weight and age of dam have been reported to influence multiple births (Haldar *et al.,* 2014). Body condition score, higher body weights and physical strength are associated with multiple births in does (Mellado *et al.,* 2008). In addition to higher body weight, previous litter size and parity, higher age have positive influence on multiple births in goats (Amoah *et al.,* 1996). Also, some genes have been reported to influence litter size in goats (Chu *et al.,* 2011; Feng *et al.,* 2011).

Higher litter sizes and twinning rates in goats have been widely documented in literature. A study on reproduction of Black Bengal goats has reported a mean litter size of 1.75 and twinning rate of 61.70 % (Haldar *et al.,* 2014). These values are close to those of the most prolific goat breeds in the world which include Nubian, Pygmy, American Alpine, French Alpine, Saanen and Toggenburg whose mean litter sizes are 2.0, 1.9, 1.7, 1.7 and 1.6 respectively (Halder *et al.,* 2014). Several authors have reported different values of twinning rates in dairy goats such as 41.1 % (Mellado *et al.,* 2011), 56.3 % (Hassan *et al.,* 2007) and 57.84 % (Bolacali and Kucuk, 2012).

2.2.2 Age at first kidding (AFK)

AFK is considered as a function of growth rate of an animal which eventually affects the time taken to attain the required body weight for onset of puberty (Kiango, 1996). It is influenced by type of birth and breed level. Does born single reached first kidding earlier than those born twins while does with 50% blood level were older at first kidding than those with 75 % and 100 % blood of Toggenburg (Jackson, 2013). In some places, the extent of farmers sharing milk with goat kids without creep feeding them causes inadequate feeding and low growth rates of the goats resulting into delayed sexual maturity (Weppert and Hayes, 2004).

A high demand for breeding females by other farmers has been a cause of selling many young females before kidding resulting into negative selection on growth and AFK (Ahuya *et al.,* 2009). This is due to selling of the fast growing females first and retaining those with slow growth rates. Studies have reported various values of AFK in goats. Ahuya *et al.* (2009) in a study on Toggenburg goats in Kenya found AFK of 25.5 months which was higher than 15.5 months in Saanen goats in Sudan (Safaa *et al.,* 2015). A previous work on reproduction of goats in Ethiopia presented AFK of 28 months (Dadi *et al.,* 2008). Although earlier findings in Tanzania reported AFK of 32.8 months in Norwegian crossbreds (Mtenga *et al.,* 1994), several studies have reported different ages at first kidding such as 13.9 months (Yalmaz *et al.,* 2011) and 20.93 months (Cicero *et al.,* 2011). Generally, higher values of AFK indicate a delayed sexual maturity which is associated mainly with poor management particularly feeding and lack of selection for fast growth rate. A very late AFK is not recommended as it shows that, poor resource farmers are keeping dairy goats with no economic returns for a long time.

2.2.3 Kidding interval (KI)

KI is the period between two consecutive kiddings. It is a reproductive trait in animal production which can affect the population turnover rate and the total output per year. Shorter KI are highly recommended as they result into fast population turnover rate which eventually increases product output and high intensity of selection (Hamad, 2001). Long KI are not recommended due to losses they cause on milk production, few kids born and increased cost of replacement. KI is affected by change in the quality and quantity of forages, which occur during various seasons of the year as the forages are the main sources of goats' diet (Dadi *et al*., 2008). A recent study has reported a mean KI of 10.5 months which was significantly affected by season and year of kidding (Safaa *et al.,* 2015). Getahum (2008) observed that a dairy goat can kid three times in 2 years if low kidding intervals are maintained. However, most of the studies have reported a range of 11 to 14 months KI (Berhane and Eik, 2006; Mahlet, 2008).

2.3 Lactation Performance in Dairy Goats

2.3.1 Lactation length (LL)

Lactation length is a period in which a doe is producing milk. LL has been reported to vary between parities of does, breeds, years and seasons of kidding and diets (Mourad, 2000; Ahuya *et al.,* 2009). Despite the existing variation of LL, most of the dairy does lactate within a range of 8 to 10 months. Studies on dairy goats in Tanzania have reported different mean lactation periods such as 8.61 months for Norwegian crosses in Mgeta (Kiango, 1996) and 6.93 months for similar goats at SUA (Hamad, 2001). An average lactation length of 10 months was reported by Eik *et al.* (2008) in Mgeta dairy goats while Safari *et al.* (2008) observed a mean period of 8 month in Gairo and Jackson *et al.* (2013) obtained a value of 5.4 months for Saanen goats in Kongwa. A study on Toggenburg goats in Kenya reported a mean lactation period of 7.5 months (Ahuya *et al.,*

2009) while Guney *et al.* (2006) reported 8.45 months for dairy goats of Cyprus. LL is associated with the milk producing ability of the doe and the persistence of lactation. Studies have revealed that, good milk producers lactate for a long time (Salama *et al.,* 2005). Goats with twin kids have been reported to have higher milk yield and longer lactations (Carnicella *et al.,* 2008). The relationship between lactation length and milk yield can probably be explained by the physiological changes in the number and activity of secretory cells within the mammary gland (Al Khouri, 1996; Mourad, 2000). Lactation periods have been reported to vary between seasons of kidding where longer periods were evident in wet as compared to dry season (Mioč *et al.,* 2008). The effect of season and year of kidding on LL has been associated with the variability in climatic conditions which results into fluctuations in availability of nutrients (Ishag *et al.,* 2012).

2.3.2 Milk yield (MY)

Milk yield in dairy goats is influenced by a combination of factors such as using improved breeds selected for milk production (Malau-Aduli *et al.,* 2004), stage of lactation, parity, season of kidding (Mioč *et al*., 2008), type of birth and management (Kiango, 1996). However, breed of goat is the most influencing factor on milk yield (Abdel-Salam *et al.,* 2000). Studies have reported variation in milk yield between breeds for goats of the same length of lactation, being higher in Saanen than in Alpine (Mioč *et al.,* 2008). In crossbred dairy goats, milk yield increases with blood level of the breed (Kiango, 1996). The average daily milk yield in crosses of Norwegian goats has been reported to vary with level of blood, being 1 kg/day in pure (100 %), 0.9 kg/day in 75 % and 0.7 kg/day in 50 % dairy goats (Eik *et al.,* 2008). Milk yield has been reported to vary between parities. Hansen *et al.* (2006) found that milk yield increased with advance in parity from first to third and milk production increased at a decreasing rate up to fifth parity. As the number of parity increases, the animal attains maturity and energy competition between growth and milk synthesis is minimized hence high milk yield (Mellado *et al.,* 2003). This effect has been associated with the fact that, during first kidding, does have low body weights which contribute to low daily milk yield (Krajinovic *et al.,* 2011). This explains the increase in milk yield with advancing age or parity of the doe. The progressive increase in milk yield with the parity until the third lactation has been attributed to the differences in AFK and DP of the does (Assan*,* 2015). Milk yield has been reported to vary significantly between types of kidding. Ciappesoni *et al.* (2004) reported higher mean daily milk yield of 3.59 litres for does with multiple kids as compared to those with single kids (3.49 litres).

Moreover, previous studies revealed that goats with multiple kids have longer lactations and produce more milk and milk fat (Subires *et al.,* 1988). The influence of type of kidding on milk yield has been associated with the presence of hormones; placental lactogen, progesterone and prolactin during pregnancies, which stimulate the mammary glands of the does (Assan*,* 2015). The influence of these hormones varies in quantity according to the type of gestation (single or multiple) and they can affect milk production during lactation or with concurrent pregnancies (Browning *et al.,* 1995).

Significant effects of year and season of kidding on milk yield traits have been reported and associated with the variability in climatic conditions, fluctuations in availability of nutrients between years (Ishag *et al.,* 2012). Higher milk production during lower temperature periods have been attributed to higher feed intake, availability of feeds and lower incidences of diseases, while low milk production in hot periods may be due to stress of high temperatures and humidity, prevalence of external and internal parasites and scarcity of feed stuffs (Assan, 2015). Higher milk yield in goats kidding during the dry season than those kidding in wet season was previously reported in Tanzania and it was associated with high dry matter intake, increased browsing time and low occurrence of diseases in the dry season (Hamad, 2001).

2.3.3 Dry period (DP)

This is the period during which the doe is not producing milk. It is an important phase of a dairy goat's lactation cycle, in which the doe and her udder are preparing for next lactation. This period is necessary for the remodeling processes of the mammary glands which covers regression, proliferation and differentiation of mammary epithelial cells to ensure high yield in the subsequent lactation (Dallard *et al.,* 2010). Milk yield depends on the activity and number of mammary epithelial cells (Knight, 2010). The number of mammary cells is determined by the rates of apoptosis and proliferation which occur in the mammary glands throughout lactation resulting into turnover of mammary cells (Capuco *et al.,* 2001). The duration of dry period does not affect mammary cells turn over in the next lactation but, omitting the dry period between lactations reduces both the quantity of milk produced and quality of colostrums (Caja *et al.,* 2006). Renewal of mammary epithelial cells is suppressed in continuously lactating glands which results in smaller population of mammary epithelial cells in the subsequent lactation (Safayi *et al.,* 2010), hence low milk yield.

Studies have reported that, goats dried off spontaneously for 27 days produce more milk than goats dried off for 56 days, showing that a dry off period of less than 2 months is sufficient in practice (Caja *et al.,* 2006). Previous studies in Tanzania reported longer dry off periods of up to 127 days in dairy goats (Kiango, 1996). In the same report it was shown that, the longer dry off period was associated with changes in environmental conditions and management. In another study a mean dry off period of 138.8 days was reported (Hamad, 2001). In that study dry off periods varied between types of birth being longer in single than in multiple kidders. This was associated with comparative high milk production in multiple kidders. Any abnormalities during DP have negative effect on the goats' health and milk production in the next lactation.

2.4 Kids' Mortality

Mortality of kids can be defined as the death of young goats from birth to 9 months of age. It is the major factor limiting production efficiency of dairy goats in the tropics. Mortality rate of kids is mainly influenced by climatic conditions, disease incidences, season of kidding, breed level, sex of kids and year of birth (Kiango, 1996; Jackson, 2013). Other factors include; low milk production by the doe, parity of the doe, predators and accidents (Kamal and Nikhaila, 2009). Higher kid mortality rates of 44.6 % (Aganga *et al.,* 2005) and 63 % (Ershaduzzaman *et al.,* 2007) have been reported. Type of kidding has been reported to affect kids' mortality rates. A study in Ethiopia has reported lower mortality rates in single born (28.0 %) kids as compared to twins (39.6 %) and triplets (60.7 %) which had higher mortalities (Petros *et al.,* 2014). This effect is in agreement with the results presented by different authors (Hailu *et al.,* 2006; Snyman, 2010). The effect of type of kidding on mortality rate has been associated with the competition of kids for nutrients before birth resulting into low birth weights making the kids weak and can easily die if inadequately fed. The same effect has been presented by Petros *et al.* (2014) who associated it with insufficiency of milk of dam to satisfy multiple kids. This finding is in agreement with the results of other authors (Mtenga *et al.,* 1994; Hailu *et al.,* 2006; Snyman, 2010).

There is a significant effect of breed on death rates of kids which increases with increasing level of exotic blood in goats. This can possibly be due to indigenous goats being much more resistant to diseases and environmental stresses than the exotic goats

(Barbind and Dandewar, 2004). Death rate has also been reported to vary between sexes, where females died more (30 %) than male (9.4 %) kids (Bushara *et al.,* 2013). A similar finding was reported by Debele *et al.* (2011) where more females (67.5 %) died than male (32.5 %) kids raised under the same environment. This has been supported by results from other studies (Alexander *et al.,* 1999; Dohare *et al.,* 2013). This indicates that males had better rate of survival as compared to females possibly due to their relatively higher birth weights than females. On the other hand, Aganga *et al.* (2005) reported significant effect of sex on mortality rate whereby males (60.7 %) died more than female (39.3 %) kids. The same effect was found by Hailu *et al.* (2006) who observed higher mortality rates in male kids as compared to females. Studies have reported higher mortality rates during pre weaning (14.7 %) than post weaning (4.3 %) stage (Bushara *et al.,* 2013). Different mortality rates were previously reported by several authors; 14.5 % in Nigeria (Ikwuegbu *et al.*, 1996), 40.6 % in Tanzania (Mtenga *et al.*, 1994) and 46.8 % in Ethiopia (Petros *et al.,* 2014) which was much higher than 34.2 % and 26.7 % reported by Debele *et al.* (2011) during pre and post-weaning stages respectively. Hamad (2001) reported a death rate of 31.69 % in crosses of Norwegian dairy goats at SUA while the mortality for the same type of goats in Mgeta observed by (Kiango, 1996) was 27 % which varied significantly between years of kidding and was caused by variation in management, feeding and disease occurrence.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

Mgeta is one of the divisions in Mvomero district located about 60 km south west of Morogoro Municipality in the western slopes of Uluguru Mountains at an altitude of 1550-1750 metres above sea level. This area has an annual temperature ranging from 16 to 20 ° C which decreases with altitude. The annual rainfall in Mgeta is about 1400 mm. The area is densely populated with small holder farmers, 84 % of whom practice both crop farming and livestock husbandry. The arable land on the hill sides is intensively cultivated with little possibility for expansion. Farmers in Mgeta grow maize, beans, vegetables (cabbages, onions, tomatoes, spinach, cauliflower, leeks) and fruits (peaches, plums and pears). Small scale pig keeping is a common practice in Mgeta. Each household has 3 to 5 indigenous goats whereas cattle production is not common in the area. This study involved 61 dairy goats keepers from 6 villages of Mgeta division including; Nyandira, Mwarazi, Kibuko, Tchenzema, Ndugutu and Kibagala.

3.2 Data Collection

Secondary data were obtained by using the farmers recording cards in Mgeta which were verified with the information recorded by the dairy goat up-scaling project under Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value Chains (EPINAV) programme at SUA. Records on production and reproduction parameters such as live weights at birth, weaning (3 months), 6 and 9 months, daily milk yields, kidding dates, parturition number and number of goats died from 2012 to 2014 were used to evaluate the performance of dairy goats.

3.3 Parameters Studied

3.3.1 Growth traits

During growth evaluation, data for weights at birth and weights at weaning (3 months), 6 and 9 months were used. Both pre-weaning and post-weaning growth rates were estimated. Weights at 3 (weaning), 6 and 9 months were adjusted for age before being used to compute average daily gains of the goats. The growth rates at various age intervals (pre-weaning and post-weaning) were calculated by using the following formulae;

$GR= (W_2-W_1) / (T_2-T_1)$……………………………………………………………...….(1)

Where; GR = Growth rate, W_2= Current weight of a goat, W_1= Weight of a goat at previous age and T_2-T_1 = Time interval between the two dates in days.

The weaning (3 months) weights were adjusted by using the following formula;

Adjusted WW = [(Actual weaning weight-Birth weight / T_2-T_1 x 90) + Birth weight], where;

T2-T1=Time interval between birth and actual weaning date in days.

3.3.2 Reproductive traits

The reproductive performance of the goats was assessed by using the following traits; AFK, KI and TR. AFK was expressed as the number of days from birth to the first kidding date**.** KI was the number of days between one kidding and the next. TR was computed as the total number of twin births divided by the total number of live births expressed as a percentage.

3.3.3 Lactation traits

Lactation performance traits such as lactation milk yields (LMY), monthly milk yields (MMY), lactation lengths (LL) and dry of periods (DP) were assessed. Milk recording was done once per week on a day determined by the farmer. MMY were calculated by adding the 4 weekly milk yields times 28.

MMY= (MY1+MY2+MY3+MY4) x 28 ………………………………………….....…(2)

where; MMY = monthly milk yield, MY=Milk yield recorded in week 1, 2, 3 and 4 respectively and 28= one month in days.

Lactation milk yield (LMY) was the sum of the weekly milk yields recorded once per week for the entire lactation period times 7.

LMY= [ΣWMY] x 7 …………………………………………………….……………(3)

where WMY= weekly milk yields; 7 = days in a week. Lactation length (LL) was the total number of months from kidding to dry off date.

Dry period (DP) was calculated as the difference in time between the drying off date and the subsequent kidding date (in days).

3.3.4 Mortality rates of kids

Mortality rates were computed as pre-weaning and post-weaning mortality rates. i) Pre-weaning mortality rate was the proportion of kids dying up to weaning age to the total number of kids born alive. ii) Post-weaning mortality rate was the proportion of kids dying from weaning (3 months) up to 9 months of age to the number of goats present at weaning age.

3.4 Classification of Independent Variables

After compiling the required information which was gathered for a period of 30 months (September 2012 to April 2015), data were analyzed by using the following six (6) independent variables; (1) Year of kidding: 1=September 2012-August 2013, 2=September 2013-August 2014 and 3= September 2014-April 2015. (2) Blood level: 1=50%N (Norwegian dairy goat breed), 2=75%N, 3=87.5%N, 4=93.75%N, 5=96.875%N and 6=100%N. (3) Season of kidding: 1=Dry (June-December), 2= Wet (January-May). (4) Sex of kids: 1=Male, 2= Female, (5) Kidding type: 1= Single and 2= Multiple. (6) Parity: 1=1st, 2=2nd, 3=3rd, 4=4th and 5=5th and above kiddings.

3.5 Statistical Analyses

Dependent variables were analyzed by the General Linear Model (GLM) procedure of SAS (2004) program by using the following models:

i) Growth traits (weight at birth, 3, 6 and 9 months; pre and post weaning growth rates)

$Y_{ijkml}=\mu + A_i + B_j + C_k + D_l + E_m + F_n + e_{ijklmnp}$ ………………………………………(4)

Where;

$Y_{ijklmnp}$ = an individual dependent observation (weight at birth, 3, 6, 9, pre and post weaning growth rates) of the p^{th} goat of i^{th} sex, j^{th} blood level born in k^{th} year and l^{th} season which is of m^{th} birth type in the n^{th} parity of the doe.

μ = general mean

A_i = effect of i^{th} sex

B_j = effect of j^{th} blood level

C_k = effect of k^{th} year of birth

D_l = effect of l^{th} season of birth

E_m = effect of m^{th} birth type

F_n = effect of n^{th} parity of the doe

$e_{ijklmnp}$ = random error

ii) Reproductive traits (AFK and KI) analysis model was;

$Y_{ijklm}=\mu + B_i + Y_j + S_k + T_l + e_{ijklm}$…………………………………………………..(5)

Where;

Y_{ijklm} = Age at first kidding and kidding interval of the m^{th} doe of i^{th} blood level, born in

j^{th} year of birth, k^{th} season of birth with l^{th} birth type

μ = general mean

B_i = effect of i^{th} blood level

Y_j = effect of j^{th} year of birth

S_k = effect of k^{th} season of birth

T_l = effect of l^{th} birth type

e_{ijklm} = random error

iii) Lactation traits were analyzed using the following model:

$Y_{ijklmn}=\mu + B_i + Y_j + S_k + P_l + T_m + e_{ijklmn}$ ……………………..……………………(6)

Where;

Y_{ijklmn} = Lactation milk yield, monthly milk yield, lactation length and dry off period of the n^{th} doe of i^{th} blood level, kidding in j^{th} year, k^{th} season and l^{th} parity with m^{th} birth type.

μ = general mean

B_i = effect of i^{th} blood level

Y_j = effect of j^{th} year of birth

S_k = effect of k^{th} season of birth

P_l = effect of l^{th} parity

T_m = effect of n^{th} birth type

E_{ijklmn} = random error

iv) Chi-square ($\chi^{2)}$ values for the analysis of twinning and mortality rates were computed by using the following formula:

$\chi^2 = \Sigma(O-E)^2/E$ ………………………………………………………….………………(7)

Where;

χ^2 = Chi-square value

O = Observed value

E= Expected value

v) Phenotypic correlations between growth variables were assessed by using a multivariate analysis of variance (MANOVA).

CHAPTER FOUR

4.0 RESULTS

4.1 Growth Performance

4.1.1 Birth weights

The analysis of variance for the factors affecting birth weights is shown in Appendix 1 while the least square means and their standard errors are presented in Table 1. The overall mean birth weight was 3.27±0.04 kg. Birth weights were significantly affected by sex ($P<0.01$), blood level ($P<0.001$), parity ($P<0.05$), season ($P<0.01$) and type of birth ($P<0.001$). Male kids were heavier (3.51±0.07 kg) at birth than the females (3.20±0.07 kg). Birth weights were increasing with an increase in level of Norwegian blood from 2.56 kg for 50 % N (Norwegian) goats up to 3.81 kg for the 100 % N blood goats. Mean kids' body weight at birth were increasing as the number of parity increased from 3.11 kg in the first parity up to 3.70 kg for those in the fifth parity. Goats born during the wet season had higher body weights (3.53±0.08 kg) at birth than those born during dry season (3.18±0.06 kg). The mean birth weight for the single born kids was 0.51 kg higher than that of their multiple counterparts. In this study, birth weights were not significantly influenced by years of kidding.

4.1.2 Weaning weights

The analysis of variance for the effects of year of kidding, sex, blood level, season and type of birth on body weights at weaning age is shown in Appendix 1. Least squares means and their standard errors for factors affecting weaning weight are shown in Tables 2. The overall mean weight at weaning was 12.79 ±0.09 kg which varied significantly between years of birth ($P<0.01$), sexes ($P<0.001$), blood levels ($P<0.001$), season of kidding ($P<0.001$) and type of birth ($P<0.05$). The effect of parity on body weights at weaning was not significant (P>0.05). At weaning, female kids had lower body weights (12.28±0.15 kg) as compared to males (13.97±0.14 kg) (Figure 1). The body weights at weaning increased from 11.92 kg in 50 % crosses to 13.38 kg in 93.75 % crosses. Kids born during the wet season were heavier (13.55±0.17 kg) than those born in the dry season (12.70±0.14 kg) (Figure 2). Multiple born kids were lighter (12.91±0.15 kg) than those born single (13.40±0.41 kg) as shown in Figure 3.

Table 1: Least squares means (± SE kg) for the factors affecting body weights at birth of Norwegian dairy goats and their crosses in Mgeta

Factor	n	Birth weight (kg)	Factor	n	Birth weight (kg)
Overall mean	211	3.27 ± 0.04			
Year of birth		NS	**Parity**		*
2012	82	3.42 ± 0.08	1	33	3.11 ± 0.12[a]
2013	98	3.24 ± 0.07	2	52	3.21 ± 0.09[ab]
2014	31	3.40 ± 0.11	3	62	3.32 ± 0.08[b]
Sex		**	4	43	3.43 ± 0.09[bc]
Females	103	3.20 ± 0.07[a]	5	21	3.70 ± 0.14[c]
Males	108	3.51 ± 0.07[b]	**Season**		**
Blood level (%)		***	Dry	142	3.18 ± 0.06[a]
50	34	2.56 ± 0.12[a]	Wet	69	3.53 ± 0.08[b]
75	30	3.38 ± 0.12[a]	**Birth type**		***
87.5	55	3.41 ± 0.09[ab]	Single	107	3.61 ± 0.06[b]
93.75	42	3.58 ± 0.10[bc]	Multiple	104	3.10 ± 0.07[a]
96.875	20	3.59 ± 0.14[bc]			
100	30	3.81 ± 0.12[c]			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

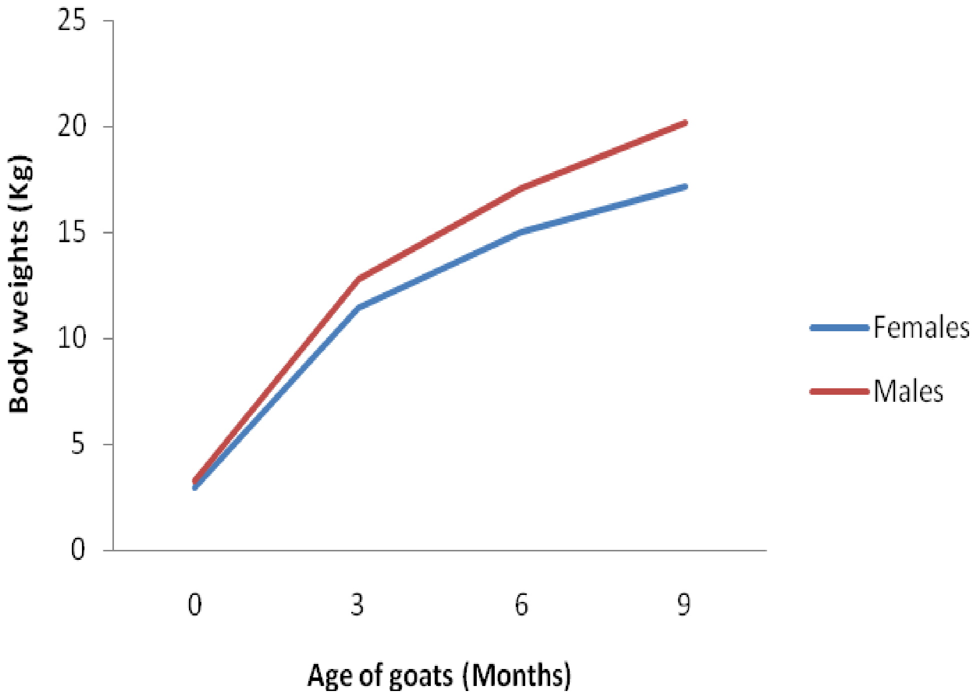

Figure 1: Effect of sex on growth of kids

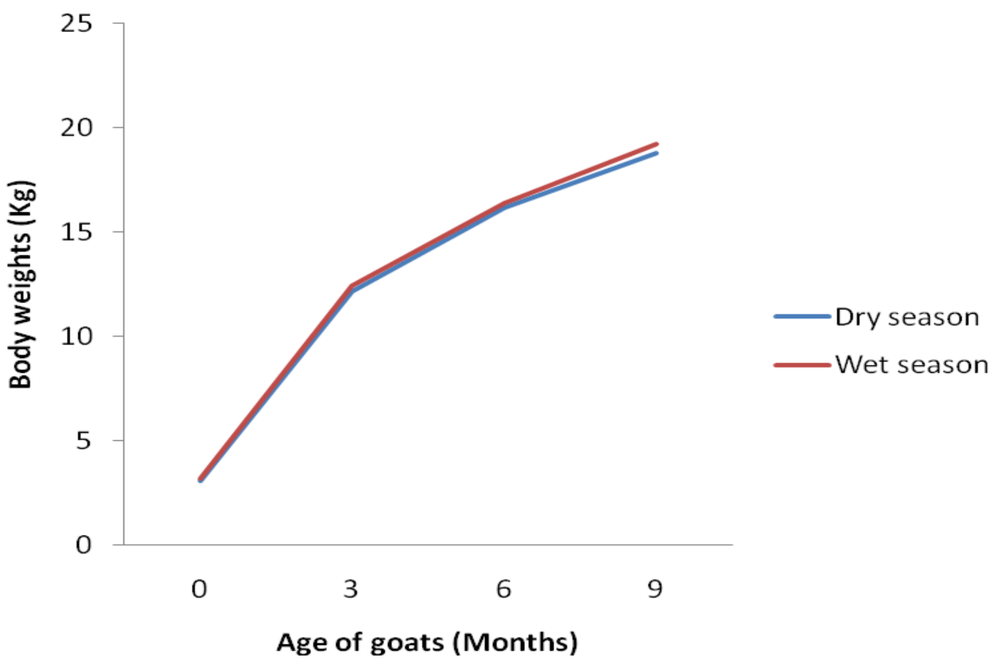

Figure 2: Effect of season of birth on growth of kids

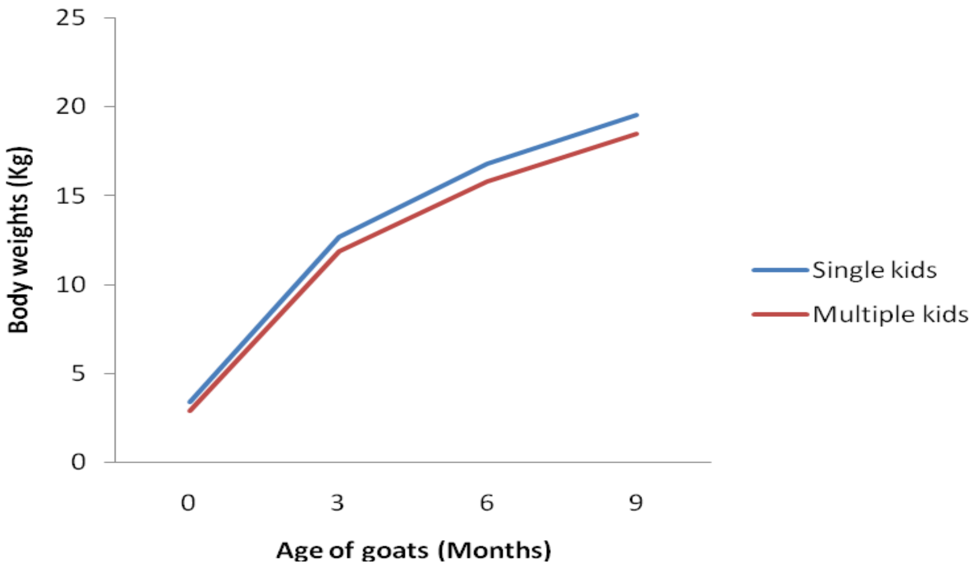

Figure 3: Effect of type of birth on growth of kids

Table 2: Least squares means (± SE kg) for the factors affecting body weights at weaning of Norwegian dairy goats and their crosses in Mgeta

Factor	n	Weaning weight (kg)	Factor	n	Weaning weight (kg)
Overall mean	191	12.79 ± 0.09			
Year of birth		**	**Parity**		**NS**
2012	75	12.82 ± 0.17[a]	1	30	12.78 ± 0.25
2013	86	12.72 ± 0.14[a]	2	47	13.00 ± 0.19
2014	30	13.84 ± 0.24[b]	3	57	13.15 ± 0.17
Sex		***	4	39	13.44 ± 0.20
Females	94	12.28 ± 0.15[a]	5	18	13.26 ± 0.31
Males	97	13.97 ± 0.14[b]	**Season**		***
Blood level (%)		***	Dry	131	12.70 ± 0.14[a]
50	29	11.92 ± 0.25[a]	Wet	60	13.55 ± 0.17[b]
75	27	13.01 ± 0.25[ab]	**Birth type**		*
87.5	54	13.11 ± 0.18[ab]	Single	93	13.40 ± 0.41[b]
93.75	38	13.38 ± 0.22[bc]	Multiple	98	12.91 ± 0.15[a]
96.875	16	13.20 ± 0.32[b]			
100	27	14.14 ± 0.25[c]			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

4.1.3 Weights at 6 months

The overall mean weight of goats at 6 months was 20.98±0.17 kg (Table 3). Significant effects of sex (P<0.001), blood level (P<0.001), season (P<0.01) and type of birth (P<0.01) on body weights at 6 months of age were observed (Appendix 1). Years of kidding and parity of does did not significantly (P>0.05) influence the body weights of goats at 6 months. Male goats weighed 3.23 kg more compared to females and their body weights were increasing with increase in blood level from 50% (weighed 18.12 kg) up to 93.75 % which weighed 21.85 kg. There was a decrease in six months weight after this blood level. Goats born in the wet season had higher body weights (21.76±0.38 kg) than those born in dry season (20.15±0.26 kg) and single born kids weighed 1.31 kg more compared to the multiple born kids.

Table 3: Least squares means (± SE kg) for the factors affecting body weights at 6 months of dairy goats and their crosses in Mgeta

Factor	n	Weight at 6 months (kg)	Factor	n	Weight at 6 months (kg)
Overall mean	141	20.98 ± 0.17			
Year of birth		**NS**	**Parity**		**NS**
2012	55	21.19 ± 0.36	1	21	20.39 ± 0.53
2013	61	21.22 ± 0.29	2	37	20.62 ± 0.37
2014	25	20.44 ± 0.45	3	38	21.65 ± 0.38
Sex		***	4	29	21.19 ± 0.42
Females	63	19.34 ± 0.30[a]	5	16	20.83 ± 0.59
Males	78	22.57 ± 0.28[b]	**Season**		**
Blood level (%)		***	Dry	105	20.15 ± 0.26[a]
50	19	18.12 ± 0.52[a]	Wet	36	21.76 ± 0.38[b]
75	18	21.39 ± 0.57[b]	**Birth type**		**
87.5	41	21.49 ± 0.37[b]	Single	65	21.61 ± 0.28[b]
93.75	26	21.85 ± 0.45[b]	Multiple	76	20.30 ± 0.29[a]
96.875	12	21.48 ± 0.62[b]			
100	25	21.40 ± 0.45[b]			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

4.1.4 Weights at 9 months

The overall mean body weight of goats at 9 months was 28.33±0.19 kg (Table 4). Significant influences of sex (P<0.001), blood level (0.01), season of kidding (P<0.01) and kidding type (P<0.05) were observed (Appendix 1). Male goats were heavier (30.86±0.31 kg) than the females (25.65±0.34 kg). The body weights at 9 months were increasing with blood level from 25.71 kg (for 50 % N goats) up to 29.28 kg for pure Norwegian goats. Goats born in the dry season had lower weights (27.35±0.29 kg) as compared to their counterparts born in wet (29.16±0.44 kg) season (Table 5). Further, at this stage single born kids were heavier (28.90±0.33 kg) than those from multiple births (27.61±0.32 kg).

Table 4: Least squares means (± SE kg) for the factors affecting body weights at 9 months of dairy goats and their crosses in Mgeta

Factor	n	Weight at 9 months (kg)	Factor	n	Weight at 9 months (kg)
Overall mean	132	28.33 ± 0.19			
Year of birth		NS	**Parity**		NS
2012	52	28.37 ± 0.40	1	20	27.84 ± 0.60
2013	57	28.85 ± 0.34	2	31	27.94 ± 0.44
2014	23	27.55 ± 0.52	3	36	28.73 ± 0.43
Sex		***	4	29	28.81 ± 0.46
Females	59	25.65 ± 0.34[a]	5	16	28.05 ± 0.50
Males	73	30.86 ± 0.31[b]	**Season**		**
Blood level (%)		**	Dry	99	27.35 ± 0.29[a]
50	15	25.71 ± 0.64[a]	Wet	33	29.16 ± 0.44[b]
75	16	28.02 ± 0.66[b]	**Birth type**		*
87.5	38	28.38 ± 0.42[b]	Single	56	28.90 ± 0.33[b]
93.75	26	29.05 ± 0.50[b]	Multiple	76	27.61 ± 0.32[a]
96.875	12	29.08 ± 0.67[b]			
100	25	29.28 ± 0.50[b]			

*****=significant at 5% level ******=significant at 1% level *******=significant at 0.1% level and **NS**=Not significant

4.1.5 Growth rates

4.1.5.1 Pre-weaning growth rate

Appendix 2 shows the analysis of variance testing the effects of year of kidding, sex, blood level, season and type of kidding on pre-weaning growth rates. The overall mean growth rate during pre-weaning stage was 105.66±0.03 g/day (Table 5). At this stage, growth rates were significantly affected by year of kidding (P<0.01), sex (P<0.001) and season of kidding (P<0.05). Pre-weaning growth rates were not significantly (P>0.05) influenced by blood level, parity and type of birth. Growth rate was increasing with the years of kidding from 103.84±1.89 g/day in 2012 to 104.39±1.57 g/day (2013) and eventually 115.91±2.59 g/day in 2014. Male kids were growing faster (115.78±1.57 g/day) than the females (100.32±1.62 g/day). Kids born in wet season were growing relatively faster (110.56±1.90 g/day) as compared to those born during the dry season (105.53±1.48 g/day) as shown in Figure 2.

Table 5: Least squares means (± SE kg) for the factors affecting pre-weaning growth rate of dairy goats in Mgeta

Factor	n	Pre-weaning growth rate (g/day)	Factor	n	Pre-weaning growth rate (g/day)
Overall mean	191	105.66 ± 0.03	**Parity**		**NS**
Year of birth		**	1	30	106.23 ± 2.79
2012	75	103.84 ± 1.89[a]	2	47	107.89 ± 2.14
2013	86	104.39 ± 1.57[a]	3	57	109.24 ± 1.96
2014	30	115.91 ± 2.59[b]	4	39	110.85 ± 2.24
Sex		***	5	18	106.02 ± 3.41
Females	94	110.32 ± 1.62[a]	**Season**		*
Males	97	115.78 ± 1.57[b]	Dry	131	105.53 ± 1.48[a]
Blood level (%)		**NS**	Wet	60	110.56 ± 1.90[b]
50	29	103.24 ± 2.76	**Type of birth**		**NS**
75	27	108.20 ± 2.75	Single	98	107.36 ± 1.55
87.5	54	107.83 ± 2.02	Multiple	93	108.73 ± 1.66
93.75	38	109.26 ± 2.37			
96.875	16	106.23 ± 3.48			
100	27	113.54 ± 2.78			

*⁼significant at 5% level **=significant at 1% level ***=significant at 0.1% level and

NS=Not significant

4.1.5.2 Post-weaning growth rate

Table 6 shows the least squares means and their standard errors for the factors affecting post-weaning growth rates. The analysis of variance for this trait is presented in Appendix 2. The overall mean growth rate during this stage was 88.80±0.05 g/day. The growth rates were significantly influenced by year of kidding (P<0.01), sex (P<0.001), blood level (P<0.01) and type of birth (P<0.05). However, parity and season of kidding did not significantly (P>0.05) affect the growth rates during this stage. There was a tendency for post-weaning growth rates to decrease as the years of kidding went by from 91.80±3.39 g/day in 2012 to 73.58±2.56 g/day in 2014. Male goats were growing faster (94.80±2.56 g/day) than the females (76.31±2.76 g/day). Post-weaning growth rates were found to increase with rise in Norwegian blood level from 66.44±4.87 g/day in 50 %N goats up to 94.75±5.27 g/day in 75 % N goats thereafter the rate of growth decreased gradually from 90.27±3.48 g/day in 87.5 %N to 81.74±4.21 g/day in 100 % N goats. Single born kids had higher growth rates (89.59±2.68 g/day) than those born multiples (81.52±2.72 g/day).

Table 6: Least squares means (± SE kg) for the factors affecting post-weaning growth rate of dairy goats in Mgeta

Factor	n	Post-weaning growth rate (g/day)	Factor	n	Post-weaning growth rate (g/day)
Overall mean	141	88.80 ± 0.05	**Parity**		**NS**
Year of birth		**	1	21	85.56 ± 4.92
2012	55	91.80 ± 3.39[a]	2	37	84.23 ± 3.47
2013	61	91.29 ± 2.74[a]	3	38	90.79 ± 3.49
2014	25	73.58 ± 4.14[b]	4	29	85.85 ± 3.89
Sex		***	5	16	81.05 ± 5.48
Females	63	76.31 ± 2.76[a]	**Season**		**NS**
Males	78	94.80 ± 2.56[b]	Dry	105	82.70 ± 2.37
Blood level (%)		**	Wet	36	88.41 ± 3.55
50	19	66.44 ± 4.87[a]	**Type of birth**		*
75	18	94.75 ± 2.56[c]	Single	65	89.59 ± 2.68[b]
87.5	41	90.27 ± 3.48[bc]	Multiple	76	81.52 ± 2.72[a]
93.75	26	90.20 ± 4.22[bc]			
96.875	12	89.93 ± 5.72[bc]			
100	25	81.74 ± 4.21[b]			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

4.1.5.3 Overall growth rate

The overall mean growth rate was 92.47±0.02 g/day (Table 7) and growth rate varied significantly between sexes (P<0.001), levels of blood (P<0.01) and seasons of kidding (P<0.05). Years of kidding, parity and type of kidding were not important (P>0.05) sources of variation on overall growth rates (Appendix 2). Male goats were generally growing at a higher rate (100.84±1.13 g/day) than females (82.14±1.23 g/day) from birth to 9 months of age. The overall growth rates increased with blood level from 83.50 g/day in 50 %N goats up to 94.24 g/day in 96.875 %N goats then decreased to 93.91 g/day in 100 %N goats. Goats born during the wet season had higher overall growth rate (93.99±1.59 g/day) than those born in the dry season (89.00±1.04 g/day).

Table 7: Least squares means (± SE kg) for the factors affecting overall growth rate of dairy goats and their crosses in Mgeta

Factor	n	Overall growth rate (g/day)	Factor	n	Overall growth rate (g/day)
Overall mean	132	92.47 ± 0.02	**Parity**		**NS**
Year of birth		**NS**	1	20	90.56 ± 2.15
2012	52	91.75 ± 1.46	2	31	90.28 ± 1.61
2013	57	93.76 ± 1.22	3	36	93.66 ± 1.54
2014	23	88.97 ± 1.87	4	29	93.21 ± 1.67
Sex		***	5	16	89.76 ± 2.35
Females	59	82.14 ± 1.23[a]	**Season**		*
Males	73	100.84 ± 1.13[b]	Dry	99	89.00 ± 1.04[a]
Blood level (%)		**	Wet	33	93.99 ± 1.59[b]
50	15	83.50 ± 2.36[a]	**Type of birth**		**NS**
75	16	91.31 ± 2.39[b]	Single	56	92.56 ± 1.21
87.5	38	92.08 ± 1.53[b]	Multiple	76	90.44 ± 1.18
93.75	26	93.92 ± 1.79[b]			
96.875	12	94.24 ± 2.44[b]			
100	25	93.91 ± 1.80[b]			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

4.1.6 Phenotypic correlations

The phenotypic correlations among the body weights and growth rates at various ages of the goats have been shown in Table 8. There were significant correlations among growth traits studied except birth weight and weights at 3, 6 and 9 months. The highest, positive and significant correlations were found between weaning weight and pre-weaning growth rate (r=0.8673), weight at 6 months and post-weaning growth rate (r=0.8408) and weight at 9 months and the overall growth rate (r=0.9689). Surprisingly, birth weight was significantly but negatively associated with pre-weaning growth rate.

Table 8: Phenotypic correlations between body weights (kg) and growth rates (g/day)

Variable		2	3	4	5	6	7
Birth weight	1	0.0764^{NS}	0.1558^{NS}	0.1764^{NS}	-0.4294***	0.1249^{NS}	0.0699^{NS}
Weight at 3 months	2	-	0.4497***	0.3945***	0.8673***	-0.1053^{NS}	0.3799***
Weight at 6 months	3	-	-	0.5442***	0.3257**	0.8408***	0.5128***
Weight at 9 months	4	-	-	-	0.2696**	0.3674***	0.9689***
Pre weaning growth rate	5	-	-	-	-	-0.1619^{NS}	0.3794***
Post weaning growth rate	6	-	-	-	-	-	0.3416**
Overall growth rate	7	-	-	-	-	-	-

df=117

4.2 Reproductive Performance

4.2.1 Age at first kidding

The overall mean age at first kidding was 17.25±0.14 months (Table 9). Type of birth (P<0.001) and blood level (P<0.001) had significant influence on AFK (Appendix 3). Does born single were 1.27 months younger at first kidding than those born multiples. The ages at first kidding were gradually decreasing with increase in blood level from 20.09 months in 50 %N goats up to 14.85 months in 100 % N goats. The ages of the does at first kidding were not significantly (P>0.05) influenced by years of kidding, parity of their dams and season of kidding of the dams.

Table 9: Least squares means (± SE months) for the factors affecting age at first kidding of dairy goats in Mgeta

Factor	n	Age at first kidding (months)	Factor	n	Age at first kidding (months)
Overall	163	17.25 ± 0.14	**Parity**		**NS**
Year of birth		**NS**	1	57	16.79 ± 0.30
2012	81	16.92 ± 0.28	2	38	17.14 ± 0.33
2013	63	16.64 ± 0.25	3	36	16.93 ± 0.34
2014	19	17.44 ± 0.42	4-5	23	17.15 ± 0.33
Type of birth		***	**Season**		**NS**
Single	83	16.37 ± 0.24^{b}	Dry	136	17.08 ± 0.21
Multiple	80	17.64 ± 0.25^{a}	Wet	27	16.92 ± 0.36
Blood level (%)		***			
50	38	20.09 ± 0.32^{d}			
75	29	17.96 ± 0.35^{c}			
87.5	30	16.91 ± 0.36^{ab}			
93.75	22	16.06 ± 0.42^{ab}			
96.875	25	16.14 ± 0.38^{ab}			
100	19	14.85 ± 0.45^{a}			

*=significant at 5% level **=significant at 1% level ***=significant at 0.1% level and **NS**=Not significant

4.2.2 Kidding interval

The overall mean kidding interval was 10.17±0.19 months (Table 10). Factors affecting kidding interval namely year of kidding, type of kidding, blood level, parity and season of kidding were subjected to analysis of variance as summarized in Appendix 3. With an exception of year of kidding (P<0.01) and blood level (P<0.05), all the factors had no significant (P>0.05) influence on length of kidding interval. The highest kidding interval (11.04±0.52 months) was observed in 2012 which decreased in 2013 (8.91±0.46 months) and became high again in 2014 (10.36±1.50 months). The kidding interval increased with blood level from 9.41 months (50 % N goats) up to 11.89 months (87.5% N goats) and thereafter decreased to 9.29 months in 100 % N goats.

Table 10: Least squares means (± SE months) for the factors affecting kidding interval of dairy goats in Mgeta

Factor	n	Kidding interval (months)	Factor	n	Kidding interval (months)
Overall	98	10.17 ± 0.19			**NS**
Year of birth		**	**Parity**	29	10.51 ± 0.76
2012	62	11.04± 0.52[b]	1	26	9.98 ± 0.67
2013	33	8.91 ± 0.46[a]	2	26	9.54 ± 0.74
2014	3	10.36 ± 1.50[ab]	3	16	10.40 ± 0.78
Type of birth		**NS**	4-5		**NS**
Single	47	10.34 ± 0.68	**Season**	85	9.82 ± 0.55
Multiple	51	9.87 ± 0.58	Dry	13	10.39 ± 0.87
Blood level (%)		*	Wet		
50	13	9.43 ± 0.75[a]			
75	22	10.21 ± 0.73[a]			
87.5	19	11.89 ± 0.81[b]			
93.75	15	10.03 ± 0.89[a]			
96.875	15	9.78± 0.82[a]			
100	14	9.29 ± 0.89[a]			

*=significant at 5% level **=significant at 1% level and **NS**=Not significant

The distribution of all kiddings across the years is plotted in Figure 4. Many of the kiddings took place from April to October with a peak in August and September indicating that high conception rates were taking place between March and April which are wet season months. There were very few kiddings in February and March.

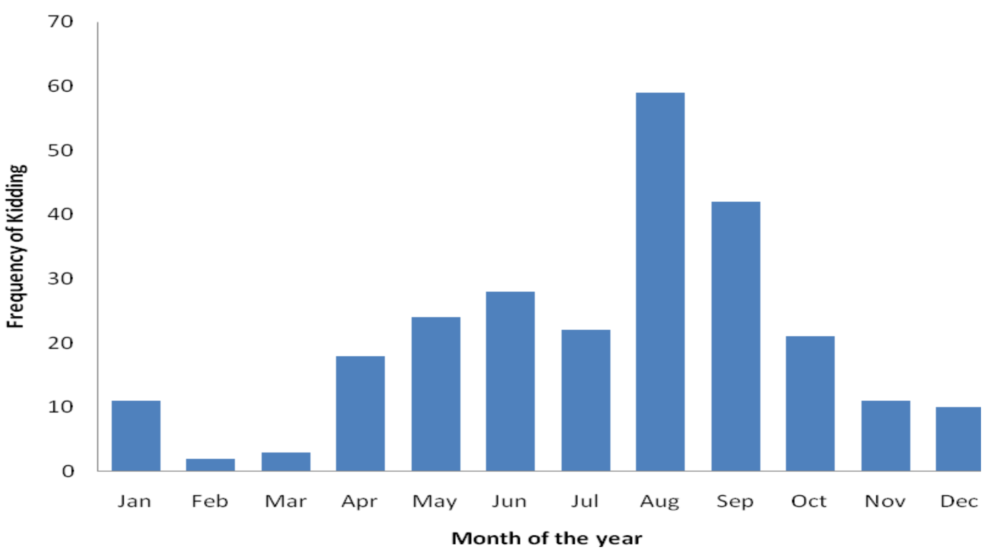

Figure 4: Frequency distribution of kiddings throughout the year

4.2.3 Twinning rate

The overall twinning rate was 52.19 %. The Chi-square values to test the differences in twinning rate between years of birth, levels of blood, parity and season are shown in Appendix 4 and Table 11 shows their summary. Significant effects of year of kidding ($P<0.05$), blood level ($P<0.001$), parity of doe ($P<0.001$) and season of kidding ($P<0.05$) were observed. There was a tendency of twinning rate to increase with year of kidding from 41.86 % in 2012 up to 67.44 % in 2014. Twinning rates were also, increasing with increase in blood level from 34.09 % in 50% N crosses to 75 % in 100% N blood does. Twinning rates increased as the number of parity was advancing from 17.31 % in first kidders to an un-expected high twinning rate of 93.18 % in the fifth kidding does. The does that kidded during the wet season had more twin births (64.15 %) than those kidding in dry season (48.99 %).

Table 11: Twinning rates of the Norwegian dairy goats in Mgeta

	Births		TR%	Chi- quare
Factor	**Total**	**Twins**		
Overall	251	131	52.19	
Year of birth				
2012	86	36	41.86	
2013	122	66	54.10	7.86*
2014	43	29	67.44	
Blood level				
50%	44	15	34.09	
75%	40	17	42.50	
87.5%	50	18	36.00	26.97***
93.75%	38	25	65.79	
96.875%	39	26	66.67	
100%	40	30	75.00	
Parity				
1	52	9	17.31	
2	65	14	21.54	
3	50	32	64.00	102.24***
4	40	35	87.50	
5	44	41	93.18	
Season				
Dry	198	97	48.99	
Wet	53	34	64.15	3.85*

TR=Twinning rate *=significant at 5% level **=significant at 1% level ***=significant at 0.1% level

4.3 Lactation Performance

4.3.1 Lactation milk yield

The overall mean lactation milk yield was 322.24±7.15 liters (Table 12). Does that kidded multiple kids produced more milk (365.57±11.37 litres) as compared to those with singles (319.21±10.86 litres). Lactation milk yield was increasing with increase in blood level from 248.67 litres in 50 % Norwegian crosses to 417.93 litres in pure Norwegian goats. Also, lactation milk yield increased from 232.25 litres in first parity to 376.63 litres in the third parturition and then decreased. Does that kidded in wet season produced 72.10 litres more milk than those which kidded during the dry season. LMY were significantly influenced by birth type ($P<0.001$), blood level ($P<0.001$), parity of doe ($P<0.05$) and season of kidding ($P<0.001$). Year of kidding had no significant ($P>0.05$) effect on lactation milk yield (Appendix 5).

Table 12: Least squares means (±SE litres) for factors affecting lactation and monthly milk yield

Factor	n	Lactation milk yield (Litres)	n	Monthly milk yield (Litres)
Overall	251	322.24±7.15	1795	42.82±0.78
Year of Kidding		**NS**		**NS**
2012	86	347.92±14.50	615	44.24±1.58
2013	122	350.33±10.89	872	44.86±1.19
2014	43	328.91±16.26	308	46.10±1.78
Type of kidding		***		***
Single	120	319.21±10.86^{a}	858	42.09±1.19^{a}
Multiple	131	365.57±11.37^{b}	937	48.05±1.24^{b}
Blood level		***		***
50%	49	248.67±16.20^{a}	350	35.44±1.77^{a}
75%	47	324.09±16.22^{a}	336	43.58±1.78^{a}
87.5%	45	335.73±16.88^{ab}	322	47.49±1.85^{ab}
93.75%	37	368.01±18.32^{ab}	265	46.72±2.00^{ab}
96.875%	40	359.90±17.28^{ab}	286	46.48±1.89^{ab}
100%	33	417.93±19.49^{b}	236	50.71±2.13^{b}
Parity		*		**
1	57	332.25±15.82^{ab}	407	43.60±1.73^{ab}
2	64	351.41±14.36^{bcd}	458	45.95±1.57^{bc}
3	60	376.63±14.52^{d}	429	49.61±1.59^{c}
4	46	350.91±16.25^{abc}	329	46.62±1.78^{bc}
5	24	300.74±21.87^{a}	172	39.58±2.39^{a}
Season of kidding		***		***
Dry	198	306.35±8.77^{a}	1416	41.63±0.96^{a}
Wet	53	378.45±15.26^{b}	379	48.51±1.67^{b}

*=significant at 5% level **=significant at 1% level ***=significant at 0.1 % level and NS=not significant

4.3.2 Monthly milk yield

Least squares means and standard errors of monthly production are presented in Table 12. The overall mean monthly milk yield was 42.82±0.78 litres. Monthly milk production was significantly affected by type of kidding (P<0.001), blood level (P<0.001), parity of doe (P<0.01) and season of kidding (P<0.001). Year of kidding was not a significant (P>0.05) source of variation on monthly milk yields as shown in Figure 5. A summary of analysis of variance for the effects of year of kidding, type of kidding, level of blood, season and parity are shown in Appendix 5.

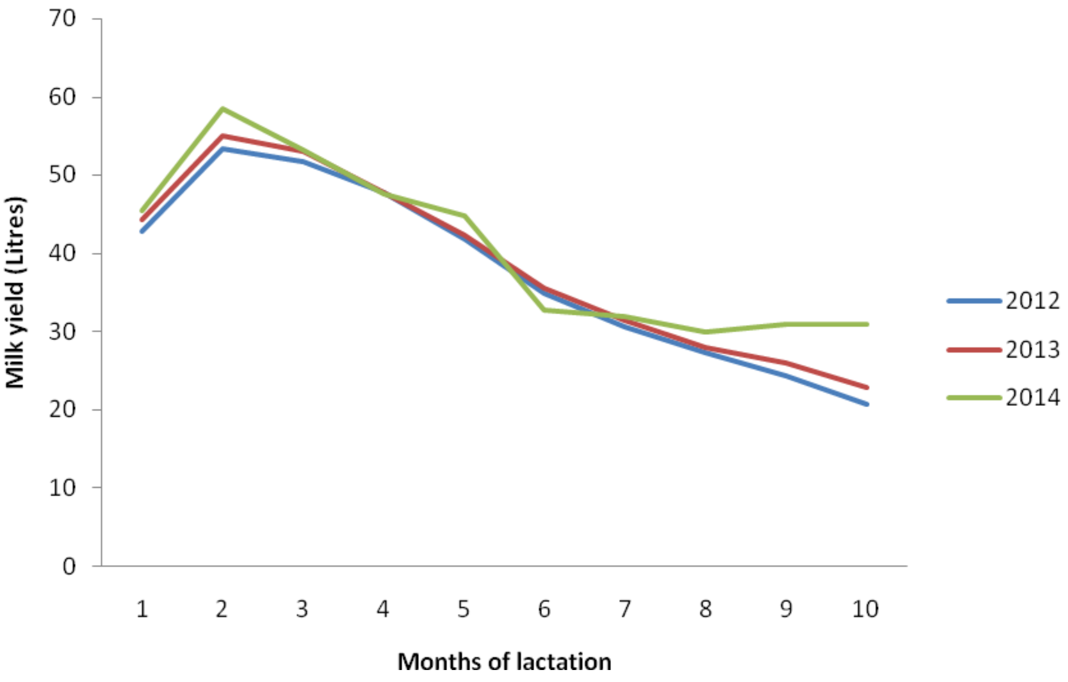

Figure 5: Effect of year of kidding on lactation curves

Does with multiple kids had higher milk yield (48.05±1.24 liters) per month than those with singles (42.09±1.19 litres). This trend was also true for the whole lactation period as shown in Figure 6.

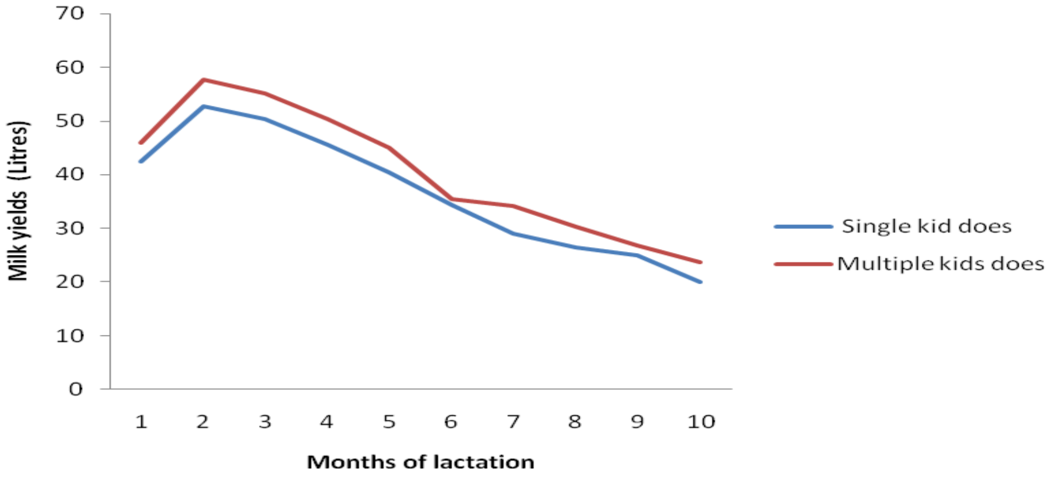

Figure 6: Effect of type of birth on lactation curves

Monthly milk yields were found to increase with increase in blood level up to 87.5 % level (47.49 litres) but 100 % N blood does produced the highest monthly milk yield of 50.71 litres. Monthly milk yields increased with increase in parity order or age of the doe from 43.60 litres in the first up to 49.61 litres in the third and then decreased to 39.58 in the fifth parity (Figure 7).

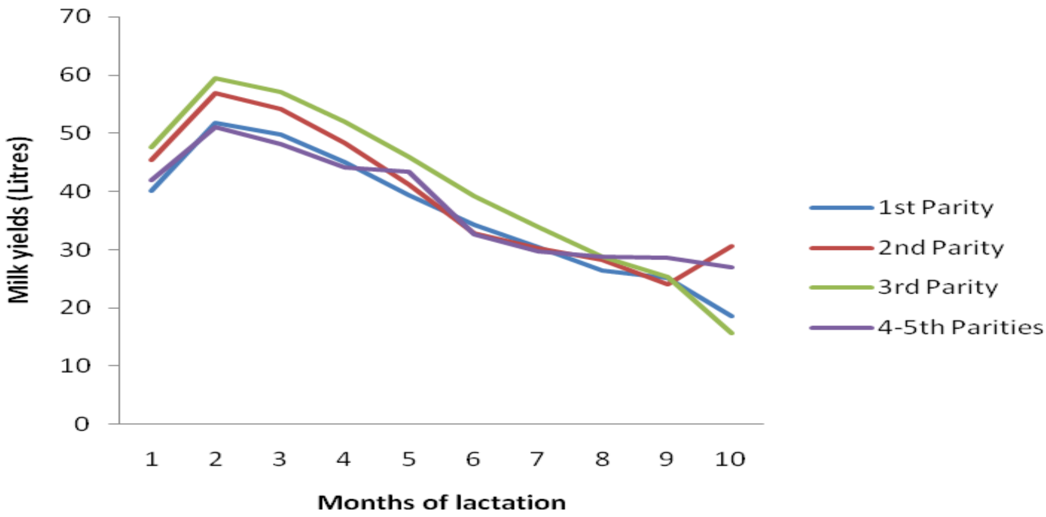

Figure 7: Effect of parity on lactation curves

Does that kidded in the wet season produced more milk per month (48.51±1.67 liters) than those which had their young kids in the dry season (41.63±0.96 liters) and this trend is clearly illustrated by Figure 8.

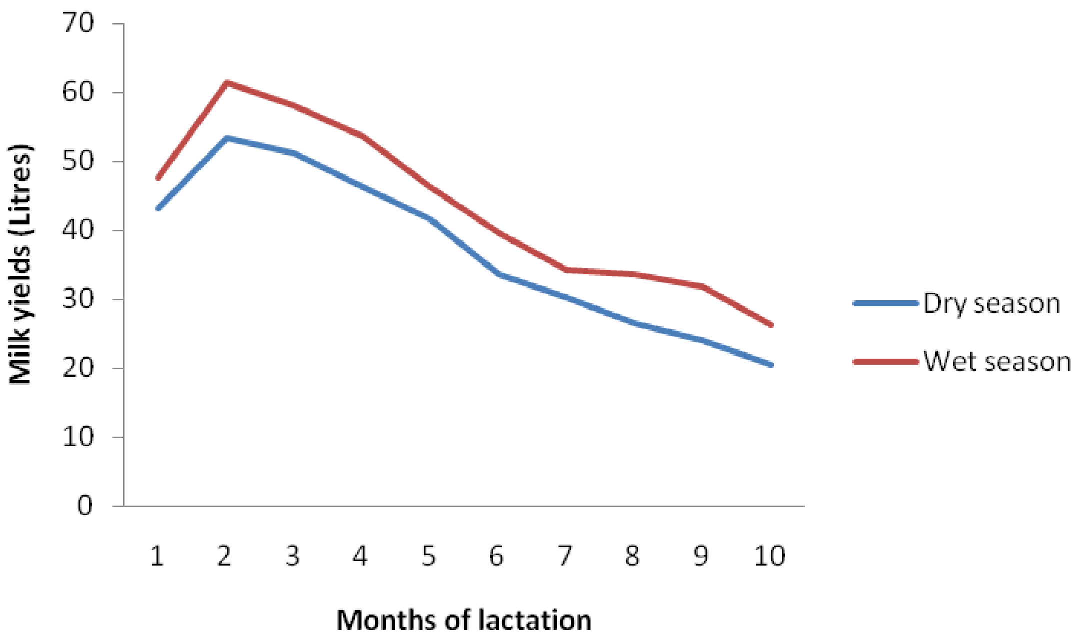

Figure 8: Effect of season of kidding on lactation curves

4.3.3 Lactation length

The effects of year of kidding, type of birth, level of blood, season and parity on lactation length of the crosses of Norwegian dairy goats have been summarized in Table 13 and their analyses of variance in Appendix 5. The overall mean for lactation length was 7.15±0.14 months. LL was significantly affected by blood level ($P<0.05$) only. All other fixed effects included in the model had no significant ($P>0.05$) influence on lactation lengths. LL tended to increase with blood level up to 93.75 % and then decreased.

Table 13: Least squares means (±SE) for factors affecting lactation length (months) and dry period (days)

Factor	n	Lactation length (months)	n	Dry period (days)
Overall	251	7.15±0.32	88	84.47±16.04
Year of Kidding		**NS**		*
2012	86	7.39±0.31	50	104.94 ±14.47[a]
2013	122	7.32±0.23	30	65.79 ±14.42[b]
2014	43	6.41±0.35	8	86.63 ± 21.74[ab]
Type of kidding		**NS**		**NS**
Single	137	7.13±0.23	45	84.48±13.72
Multiple	114	6.95±0.24	43	87.10±12.94
Blood level		*		**NS**
50%	49	6.36±0.35[a]	12	80.03±20.14
75%	47	6.68±0.35[ac]	19	107.23±17.27
87.5%	45	6.62±0.35[a]	15	96.34±16.54
93.75%	37	7.87±0.39[b]	13	97.40±18.26
96.875%	40	7.13±0.37[bc]	15	63.22±17.39
100%	33	7.59±0.42[bc]	14	70.50±19.50
Parity		**NS**		**NS**
1	57	6.89±0.34	29	107.28±15.70
2	64	7.13±0.31	20	75.47±13.47
3	60	7.30±0.31	23	63.15±13.14
4	46	7.33±0.35	15	83.12±17.05
5	24	6.66±0.47	1	99.92±13.17
Season		**NS**		**NS**
Dry	198	6.99±0.18	76	75.53±11.37
Wet	53	7.09±0.32	12	96.04±18.44

*=significant at 5% level and NS=not significant

4.3.4 Dry period

The overall mean dry period was 84.47±16.04 days. DP was only significantly ($P<0.05$) affected by years of kidding. The mean dry period in 2012 was longer (104.94 days) than that of 2013 (65.79 days) and 2014 (86.63 days). Appendix 5 shows the analysis of variance testing the effects of year of kidding, type of kidding, blood level, season of kidding and parity of doe on dry period. The least squares means and standard errors of are shown in Table 13.

4.4 Mortality Rates of Norwegian dairy goats in Mgeta

Pre and post-weaning mortalities were compared between sexes, years of kidding, type of birth, blood level and season of kidding (Appendix 6 and 7). The overall pre and post-weaning mortality rates of the goats were 14.49 % and 5.93 % respectively. Pre-weaning deaths were significantly influenced by sex (P<0.001), type of birth (P<0.001), blood level (P<0.001) and season (P<0.001) (Table 14 and 15). Male kids died more (32.11 %) before their weaning age as compared to females (10.16 %). Kids that were born multiples died more (21.02 %) during pre-weaning stage than those born single (7.00%).

Table 14: Effects of sex, year of birth and type of birth on pre-weaning mortality rates

Factor	Level	Pre-weaning mortality				
		Live	Died	Total	MR%	Chi-square
Overall		472	80	552	14.49	
Sex	Female	398	45	443	10.16	32.02***
	Male	74	35	109	32.11	
Year of birth	2012	171	23	194	11.86	
	2013	206	44	250	11.60	3.56^{NS}
	2014	95	13	108	12.04	
Type of birth	Single	239	18	257	7.00	21.76***
	Multiple	233	62	295	21.02	

MR=Mortality rate ***=significant at 0.1 % level and NS=not significant

Pre-weaning mortality rate was increasing as the blood level increased from 1.54 % in 50% N goats up to 36.79 % in 100 % N goats. There was a very big difference in mortality rate between seasons. Kids that were born during the wet season died more (44.44 %) as compared to those born in the dry (1.05 %) season. Pre-weaning mortality rate was not significantly (P>0.05) affected by year of birth. The post-weaning mortality rates were significantly influenced by sex (P<0.01), type of birth (P<0.001), blood level (P<0.05) and season of birth (P<0.05). There was no association (P>0.05) between post-weaning mortality rate and the year in which the kid was born.

Table 15: Effects of blood level and season of birth on pre-weaning mortality rates

Factor	Level	Pre-weaning mortality				
		Live	Died	Total	MR%	Chi-square
Blood level	50%	64	1	65	1.54	
	75%	67	5	72	6.94	
	87.5%	123	8	131	6.11	62.34***
	93.75%	74	12	86	13.95	
	96.875%	77	15	92	16.30	
	100%	67	39	106	36.79	
Season	Dry	377	4	381	1.05	179.35***
	Wet	95	76	171	44.44	

MR=Mortality rate and ***=significant at 0.1 % level

Multiple born kids died more (10.73 %) in post-weaning stage than the singles (1.26 %) (Table 16). Post-weaning mortality rate was higher in males (13.51 %) than in females (4.52 %).

Table 16: Effects of sex, year of birth and type of birth on post-weaning mortality rates

Factor	Level	Post-weaning mortality				
		Live	Died	Total	MR%	Chi-square
Overall		444	28	472	5.93	
Sex	Female	380	18	398	4.52	9.04**
	Male	64	10	74	13.51	
Year of birth	2012	163	8	171	4.68	
	2013	193	13	206	6.31	0.88^{NS}
	2014	88	7	95	7.37	
Type of birth	Single	236	3	239	1.26	18.98***
	Multiple	208	25	233	10.73	

MR=Mortality rate **=significant at 1% level ***=significant at 0.1 % level and NS=not significant

The post-weaning mortality rates were increasing with advance in blood level from 3.13 % in 50 % N goats up to 13.43 % in 100 % N goats. Goats born during the wet season died more (10.53 %) than those born in dry season (4.77 %) in the post-weaning stage.

Table 17: Effects of blood level and season of birth on post-weaning mortality rates

Factor	Level	Post-weaning mortality				
		Live	Died	Total	MR%	Chi-square
Blood level	50%	62	2	64	3.13	
	75%	65	2	67	2.99	
	87.5%	118	5	123	4.07	13.61*
	93.75%	72	2	74	2.70	
	96.875%	69	8	77	10.39	
	100%	58	9	67	13.43	
Season of birth	Dry	359	18	377	4.77	4.49*
	Wet	85	10	95	10.53	

MR=Mortality rate *=significant at 5% level

CHAPTER FIVE

5.0 DISCUSSION

5.1 Growth Performance

5.1.1 Birth weights

The overall mean birth weight in this study is higher than those reported by other authors like 2.1 kg (Hamad, 2001), 2.6 kg (Kiango, 1996; Eik *et al.,* 2008) and 2.4 kg (Masawe, 2010). The mean birth weight of the crosses of Norwegian goats reported here is lower than those reported by other several studies including 3.56 kg in Saanen and 4.11 kg in Alpine dairy goats (Pavic *et al.,* 1998). In a more earlier study, Majid *et al.* (1993) reported a mean birth weight of 3.8 kg in both Alpine and Saanen and 3.5 kg in Toggenburg dairy goats all of which were higher than the mean birth weight found in this study. The difference between the mean birth weight found in this study and those of other studies can possibly be due to breed differences and management particularly nutrition during the dry period.

In this study, significantly higher birth weights were observed in male kids than in females. Some studies have reported non-significant effects of sex on birth weight of kids (Mioč *et al.,* 2011). The observed significant influence of sex on birth weight is in line with other findings reported by Mavrogenis *et al.* (1984), Ruvuna *et al.* (1988) and Kuchtik and Sedlackova (2005) in which males were heavier than females. The superiority of male kids can be explained by the fact that inherently, males have larger number of muscle cells than females at birth and during mitotic cell division they favourably obtain higher muscle mass than females resulting into significantly higher birth weight as opposed to females. Significant effect of blood level on birth weights observed in this study is in agreement with findings of Mtenga and Kifaro (1992).

However, the authors observed that birth weight increased with increase in blood level except at 100 % blood level (pure breed), where pure Norwegian goats had lowest birth weight. Some studies have reported non-significant effects of blood level on birth weight (Eik *et al.*, 2008; Zahraddeen *et al.,* 2008). The increase in birth weight with increase in blood level observed in this study can be attributed to higher genetic potential for birth weight of exotic dairy goats. According to Ahuya *et al.* (2009), genetic improvement of a particular breed by cross breeding, results into heavier and fast growing goats. Therefore, increasing the level of Norwegian blood in dairy goats in Mgeta gradually induced higher birth weights of kids up to 100 % N blood level.

This study observed a significant influence of type of birth on birth weights of kids in which single born kids were heavier than those born more than one. Previous studies have reported higher birth weights in single born kids than in multiple kids (Todaro *et al.,* 2004; Lehloenya *et al.,* 2005). However, a non-significant effect of type of birth on birth weights was observed by Baiden (2007). The effect of birth type on birth weights of kids is possibly due to the fact that multiple fetuses compete for space and nutrients in the uterus resulting into physiological starvation which leads to kids being born with lower energy reserves hence low birth weights. Also, low body weights and mothering ability of dams can result into low birth weights of kids.

Kids that were born during the wet season in Mgeta were heavier at birth than those born in the dry season. A similar observation has been documented by other authors (Melo lima *et al.,* 1993; Harikrishina *et al.,* 2013). This has been opposed by Zahraddeen *et al.* (2008) who reported higher birth weights in kids born during dry the season than those born in the wet period. However, earlier studies presented non-significant influence of season on birth weights of kids (Garcia *et al.,* 1986; Raza *et al.,* 1998). The effect of season of kidding on birth weights of kids that was observed in this study is more attributed to higher maternal effect of the dam on the kids. Assuming that kids and the dam have similar genotype, the differences between birth weights of kids born in rainy and those born in dry season highly depends on the mothers' weights during late pregnancy which also relies on the availability of forages and supplementation levels practiced.

5.1.2 Weaning weights

The overall mean body weight at weaning in this study was higher than those reported in other studies (Kiango, 1996; Deribe, 2013) which ranged from 6.84 to 11.11 kg. It is also lower than 22.10 kg reported by Bushara *et al.* (2013) and 23 kg by Mioč *et al.* (2011). These differences could be due to breed, growth rates and age at which the kids were weaned. In this study, male kids were significantly heavier at weaning than females. A similar finding has also been observed by different authors (Browning *et al.,* 2004; Zahraddeen *et al.,* 2008). A few studies have reported significantly higher weaning weights in female kids as compared to males (eg. Bharathidhasan *et al.,* 2009). However, in another study, sex did not significantly influence weights of goats at weaning (Hussain *et al.,* 2013). Higher weaning weights in male kids than in the females as observed in this study can be due to higher birth weights in males as compared to females, presence of androgens in males which favour their fast growth and males being more aggressive than females hence easy access to more milk leading to higher weaning weights than females.

The increase in weaning weight as the blood level increases from 50 % up to 100 % which was found in this study has been documented in literature (Butswat *et al.,* 1998; Eik *et al.,* 2008). The increasing weights at weaning with increase in blood level can be related to the response to selection on fast growth rate in Norwegian dairy goats which has been supported by high feed conversion efficiency. Significantly higher weaning weights of kids born in wet season as found in this study have also been reported by other authors (Dadi *et al.,* 2008; Jimenez-Badillo *et al.,* 2009). These findings have been opposed by some studies which reported higher weaning weights of kids born in dry season as compared to those born in the wet season (Hamad, 2001; Zahraddeen *et al.,* 2008). However, non-significant influence of season on body weights of kids at weaning has been reported by Zeleke (2007) and Andries (2013). Higher weaning weights of kids born during the rainy season in Mgeta can be due to high plain of nutrition available to the dams which indirectly ensures adequate nutrients to the kids hence higher weights at weaning.

Single born kids were found with higher body weights at weaning compared to their multiple counterparts. Comparable results have been widely documented in several studies (Bharathidhasan *et al.,* 2009; Petrovic *et al.,* 2011; Roshanfekr *et al.,* 2011). Contrary, non-significant difference in weaning weights between single and multiple born kids have been reported by Jimenez-Badillo *et al.* (2009). Higher weaning weights of single born kids observed in Mgeta dairy goats can be attributed to the fact that single kids are more active (because they are born with higher birth weight) and capable of suckling their mothers than the multiple kids. Such effective utilization of nutrients from their mothers makes them gain more weight than the multiple kids during pre-weaning stage. Lower weights of multiple born kids at weaning can be due to lower birth weights and the competition between them for limited milk available in their dams.

5.1.3 Weights at 6 and 9 months

The overall means of the goats' body weights at 6 and 9 months in the present study were higher than 14.7 kg and 17.7 kg respectively, reported by Kiango (1996). The mean body weight at 6 months was higher than 18.26 kg observed previously by Nagpal and Chawla (1984). Deribe *et al.* (2013) found body weights of 9.13 kg and 16.42 kg at 6 and 9 months respectively in Ethiopia. The mean weight of dairy goats at 9 months in this study was lower than 34 kg reported in Saanen dairy goats (Freitas *et al.,* 2004). The study observed higher body weights in males than in females at both 6 and 9 months. This finding is in agreement with results of other authors (Matika *et al.,* 2003; Zinat-Mahal *et al.,* 2013).

Non-significant effects of sex on body weights at 6 and 9 months of dairy goats were previously observed by Khan and Sahni (1983). The significant difference between sexes observed in dairy goats of Mgeta can be due to the influence of androgens which induces growth in males than in females. The effect of sex may also be related to higher birth weights in males than in females. This study observed an increase of weights at 6 and 9 months as the blood level was increasing from 50 % to 93.75 % then decreased. This finding complies with the results reported in other studies (Mtenga and Kifaro, 1992; Eik *et al.,* 2008). However, non-significant effects of blood level at 6 and 9 months were reported by Zahraddeen *et al.* (2008). The increase in body weights with rise in blood level can be attributed to the potential of fast growth attained through selection but also the higher milk yield of their dams. The lower weights of the pure (100 %) Norwegian goats at 6 and 9 months can possibly be due to the fact that these goats have high genetic potential for growth but if they are not adequately fed to meet their requirements, then growth rate is negatively affected.

The significantly higher body weights of the goats born in wet season than those born in dry season conforms to the findings reported by different authors (Yaqoob *et al.,* 2009; Harikrishina *et al.,* 2013). However, Zahraddeen *et al.* (2008) found higher body weight of goats born in dry season during pre-weaning stage, but at 6 and 9 months age the effect of season on body weights became non-significant. The higher body weights of goats at 6 and 9 months for those born in wet season can be explained by the fact that; the goats were sufficiently nourished during their pre-weaning stage as a result of their dams being under high plane of nutrition (adequate green forages in wet season). This influenced higher weaning weights, probably due to stable body immunity which influenced higher weight gains during post-weaning growth stage (6 and 9 months) as compared to their counterparts born in dry the season.

Single born kids were heavier at both 6 and 9 months of age as compared to those born multiples. Several studies (Zeshmarani *et al.,* 2007; Yaqoob *et al.,* 2009; Bushara *et al.,* 2013) have reported higher body weight of single born kids than multiple kids during their post-weaning growth stage (at 6 and 9 months age). Zahraddeen *et al.* (2008) found that kids born single were not significantly heavier than their twin counterparts from 3 to 9 months age. The effect of birth type on body weights of dairy goats at 6 and 9 months as observed in this study can be associated with the carry over effect from weaning.

5.1.4 Growth rates

5.1.4.1 Pre-weaning growth rate

This study revealed that the dairy goats in Mgeta had higher pre-weaning growth rates than those reported in previous studies (Kiango, 1996; Hamad, 2001; Eik *et al.,* 2008) in crosses of Norwegian dairy goats in Tanzania and (Deribe and Taye, 2013) in Abergele goats in Ethiopia. The growth rate is also, lower than the values documented by other authors (Mioč *et al.,* 2011; Sodiq, 2012; Galaviz-Rodriguez *et al.,* 2014) which ranged from 110 to 140 g/day. Significantly higher growth rates in males than in females were observed from birth to weaning stage. Different studies (Vargas *et al.,* 2007; Sodiq *et al.,* 2010; Mioč *et al.,* 2011) have reported similar effect of sex on pre-weaning growth rate. The effect of sex on pre-weaning growth rate of dairy goats in Mgeta can be due to the influence of sex on birth weights where males were heavier (3.54 kg) than females (3.17 kg). This was possibly caused by higher number of muscle cells in males as compared to females. Also, the anabolic effect of male sex hormones favoured fast growth in males.

The significantly higher pre-weaning growth rate for kids that were born in the wet season as compared to those born in the dry season is in agreement with the results reported in other studies (Dadi *et al.,* 2008; Jimenez-Badillo *et al.,* 2009; Andries, 2013; Deribe *et al.,* 2013). The difference in pre-weaning growth rates between seasons observed in Mgeta can be attributed to adequate nutrition of the dams at kidding in the wet season which in turn was reflected in growth of the kids. Fast growth rate of kids has been related with high milk production of the dams in the wet season (Sodiq, 2012).

5.1.4.2 Post-weaning growth rate

The overall mean post-weaning growth rate of the goats found in this study was higher than 76.07 g/day observed by Kiango (1996) and 38.96 g/day by Hamad (2001) in Norwegian dairy goat crosses in Tanzania. It is also lower than 115.43 g/day reported by Mioč *et al.* (2011). The significant effect of year of birth on post-weaning growth performance has been reported by Dadi *et al.* (2008). This effect can be associated with the differences in availability of forages among the kidding years due to the fluctuation in total annual precipitation and distribution of rainfall plus disease incidences. Male goats were found with higher post-weaning growth rate than females. This finding complies with results reported by different authors (Ballal *et al.,* 2008; Otumwa and Osakwe, 2008; El-Abid, 2008), which revealed that sex differences in growth rates were increasing with age of the goats. The significant effect of sex on growth after weaning can have been caused by the influence of sexual hormones during animal development which affects body dimensions and fat deposits as well as muscles and bones.

In this study, post-weaning growth rate was significantly affected by blood level. The increase in level of Norwegian blood induced fast growth rate in goats from 50 % up to 93.75 % blood level. Similar effect of blood level has been reported by Eik *et al.* (2008), although in some studies blood level did not affect the post-weaning growth rate (Zahraddeen *et al.,* 2008). The current significant effect of blood level can be a result of response to selection on fast growth rate in dairy goats which increases with increase of blood level. Low growth rate of pure (100%) Norwegian dairy goats in Mgeta can be associated with their higher body weights which increases their nutrient requirements. Therefore, if not well fed, they will grow slowly as discussed earlier in section 5.1.4.

This study observed significantly higher post-weaning growth rates in single born goats than in those born multiples. The same effect of birth type has been documented in literature (Hailu *et al.,* 2005; Yaqoob *et al.,* 2009). In another study on dairy goats, Kuchtic and Sedlackova (2005) revealed that the difference in growth rates between single born kids and twins was significant. Higher growth rate in single kids than in multiples was also reported in a previous work by Portolano *et al.* (2002). The observed influence of type of birth on post-weaning growth rate can be attributed to the difference in their initial weight gains. Also, compensatory growth was not realized on the goats during their post-weaning stage due to shortage of feedstuffs in the study area.

5.1.4.3 Overall growth rate

Significantly higher overall growth rates in male goats than in females were observed in this study. Various studies (Hyder *et al.,* 2002; Mioč *et al.,* 2011) have documented the same effect of sex on overall growth rate in dairy goats. This effect of sex can be attributed to the differences in birth weights of the goats where males had higher weights. It can also be a function of sexual hormones which influence body dimensions by affecting fat deposits and growth of muscles and bones causing variation in terms of body weights between male and female goats. The observed effect of blood level on overall growth rate in this study was also previously reported by some authors (Mtenga *et al.,* 1994; Safari *et al.,* 2008; Eik *et al.,* 2008). The increase in overall growth rate of the goats with increased blood level is associated mostly with genetic potential of the Norwegian breed for fast growth. The observed lower growth rates for 100% Norwegian dairy goats in Mgeta complies with the results of other different studies (Eik *et al.,* 2008; Safari *et al.,* 2008). Non-significant effects of blood level on average daily gains in goats have been reported by Zahraddeen *et al.* (2008). The lower growth rate of the pure Norwegian goats in Mgeta can be related to the lower ability of the pure exotic breeds to withstand the difficult conditions in the tropics therefore demanding extra high quality management which is expensive and not always affordable by most of the farmers in rural areas.

Kids born in the wet season were found to grow faster as compared to those born in the dry season. Similar effect of season on growth rate of kids has been reported in other studies (Dadi *et al.,* 2008; Jimenez-Badillo *et al.,* 2009; Tsado and Adama, 2012; Deribe *et al.,* 2013; Andries *et al.,* 2013). Non-significant effects of season on growth rate of kids have been documented in literature (Garcia *et al.,* 1986; Raza *et al.,* 1998). However, a different study observed kids born in dry season growing faster than those born in wet season during their first month of life. Thereafter, the difference in growth rate up to 4 months age was not significant and from 4 months up to 1 year, the wet season kids had higher growth rate as compared to their counterparts born in dry season (Zahraddeen *et* *al.,* 2008). The difference in overall growth rate between dry and wet season kids in Mgeta, can be associated with the fluctuation in availability of feeds or nutrients to the goats which is determined by seasons (more forages in the rainy season and more scarce when it is dry).

5.1.5 Correlations among body weights and growth rates

The phenotypic correlations observed in this study are in agreement with the range of 0.64 to 0.97 reported by several authors (Mokhtari *et al.,* 2008; Rashid *et al.,* 2008; Jafaroghli *et al.,* 2010; Thiruvenkadan *et al.,* 2011). The significantly higher and positive correlation (r=0.8673) between weaning (3 months) weight and pre-weaning growth rate was also reported by Hamad (2001) who obtained a value of 0.974 at SUA. Moreover, body weights at 6 months were found to be highly correlated to post-weaning growth rate (r=0.841). This shows that goats that had higher body weights at 6 months were those that were growing very fast.

The correlations between birth weight and weaning weight; birth weight and pre-weaning growth rate and birth weight and overall growth rate were 0.076, -0.429 and 0.069, respectively. Similar low and non-significant correlations among these traits have been documented in literature (Harricharan *et al.,* 1987; Kuthu *et al.,* 2015). The phenotypic correlation between body weights at 6 and 9 months in this study was 0.5442. This was in agreement with the values reported by other studies; 0.79 in Markhoz goats (Rashid *et al.,* 2008) and 0.64 in Tellichery goats (Thiruvenkadan *et al.,* 2009). The higher correlation between weights at 6 and 9 months indicates a strong and positive genetic relationship existing between the traits. However, the two traits were measured at 3 months interval making them adjacent variables with high correlation because they are influenced by the same environmental factors. Also, significantly higher and positive correlations between overall growth rate and weights at 6 (r=0.5128) and at 9 months (r=0.9689) reflect that, selection of the goats based on 6 and 9 months weights can have best genetic response on growth rate.

5.2 Reproductive Performance

5.2.1 Age at first kidding

This study obtained lower mean of AFK than those reported in other studies (Kiango, 1996; Hamad, 2001; Patel and Pandey, 2013; Ahuya *et al.,* 2009) which varied between 17.53 and 25.30 months. However, the average AFK is higher than those found in literature (Song *et al.,* 2006; Ince, 2010; Safaa *et al.,* 2015) which ranged from 12.9 to 15.27 months. In this study the single born doelings were found significantly younger (16.37 months) at first kidding compared to their multiple born (17.64 months) counterparts. Similar effect of birth type on age at first kidding has been documented in other studies (Marai *et al.,* 2002; Zeshmarani *et al.,* 2007; Bushara *et al.,* 2013). The superiority of single born does can be associated with the absence of competition between single and multiple births for the available nutritional resources from their mothers whereby the single born are always advantaged and grow faster compared to the multiple does. Due to slow growth rate, multiple born does were mated late and were therefore relatively older at first kidding.

Ages at first kidding were decreasing with increase in Norwegian blood level in the goats. Different authors (Safari *et al.,* 2005; Zahraddeen *et al.,* 2008) have reported similar effect of blood level on AFK in dairy goats. The difference in time used by the goats in Mgeta to get their first kids can be attributed to their variation in growth rates between blood levels which was decreasing with increase in blood level. The improvement in blood level had positive effect on the growth performance of does and therefore the genetic groups with low blood level delayed to reach their first kidding as compared to those with high blood levels.

5.2.2 Kidding interval

The observed mean KI was close to that of 10.50 months reported by Safaa *et al. (*2015). However, the KI is lower than 12.43 months and 12.9 months found in Toggenberg and Saanen dairy goats respectively (Garcia-Peniche *et al.,* 2012). It is also, higher than 9.3 months reported by Jackson (2013). The difference in KI between years of kidding might have been caused by variation in plane of nutrition (availability of adequate forages) to support reproductive functions, availability of bucks and failure of farmers to detect signs of *oestrus* on time. The kidding frequency observed in this study indicates all year round kidding with highest frequency occurring in August. This shows that most of the does conceived in March in which the long rains influenced the availability of forages to the goats providing them with better and adequate nutrients. These nutrients could induce *oestrus* activities in does resulting in increased ovulation rate and subsequently higher twinning rates.

5.2.3 Twinning rate

The twinning rate obtained in this work is lower than the values reported in other studies (Ince, 2000; Bolacali and Kucuk, 2012; Akar, 2013) in Saanen goats which ranged from 54 % to 71.43 %. A study on reproductive performance of native goats in Korea found twinning rates of 59 % in a natural flock and 66% in does kept intensively (Song *et al.,* 2006). However, the value is higher than those reported in different studies like 41.1 % (Mellado *et al.,* 2011), 31.69 % in crosses of Norwegian goats at SUA (Hamad, 2001) and 48 % in the same goats in Mgeta (Kiango, 1996). The twinning rate which increased from 41.86 % in 2012 up to 67.44 % in 2014 showed a similar trend to those presented in different studies (Moaeen-ud-Din *et al.,* 2008; Ceyhan and Karadag, 2009), most of which argued that; variation in availability of feeds as a function of climatic condition can considerably affect reproduction. In years with relatively high rainfall there are more pastures produced which stimulate *oestrous* activity in does leading to high fecundity reflected by high twinning rate than in the years with sparse rainfall.

The twinning rate was increasing with increase in blood level from 41.86 % in 50 % N goats up to 75.00 % in pure (100 %) Norwegian goats. Various studies have reported on the increasing twinning rate with genetic improvement of the breed (Hamad, 2001; Mellado *et al.,* 2008). It has been further concluded that, the process of reproduction in goats is a function of genetic and environmental factors (Allexandre *et al.,* 2010; Notter, 2012). This can be a reason for breed being a potential factor influencing litter size in goats on top of other factors (Holtz, 2005; Mellado *et al.,* 2008). The increase in blood level in goats of this study had positive effect on twinning rate due to the fact that, pure Norwegian goats have great genetic potential of high fecundity due to long time selection on reproductive performance.

Does that kidded in parity one had the lowest (17.31%) twinning rate which increased as the number of parity was increasing up to 93.18 % in the fifth parity. The same effect of parity on twinning rate has been reported by different authors (Hailu *et al.,* 2006; Halder *et al.,* 2014). The significant effect of parity in this study can possibly be due to increasing age and body weight of the goats which are necessary to meet the metabolic requirements that can influence the hormonal system for more ovulation and eventually higher twinning rate. Does that kidded in the wet season had higher twinning rate (64.15 %) as compared to those kidded in dry season (48.99 %). A similar effect of season on twinning rate has been documented in literature (Dadi *et al.,* 2008; Bushara *et al.,* 2013).

The higher twinning rate for goats kidding in wet season was probably due to availability of adequate green forages and other browsing material which influence higher body condition score, the required body weight at mating and higher ovulation rate (Amoah *et al.,* 1996; Bushara *et al.,* 2013). This increased conception rate with multiple fetuses.

5.3 Lactation Performance

5.3.1 Lactation milk yield

The overall mean milk yield per lactation obtained in this study was equal to 322 litres reported by Ogola *et al*. (2010) in Nyanza dairy goats in Kenya. The mean yield is higher than different values found in literature; 89.18 kg in Nubian goats of Sudan (El-Abid and Nikhaila, 2010), 176.28 litres in crosses of Norwegian goats in Mgeta (Kiango, 1996), 126.11 litres in the same goats at SUA (Hamad, 2001) and 241.4 and 266.6 litres in Toggenburg and Saanen in Kongwa and Babati respectively (Jackson, 2013). The current lactation milk yield is however, lower than several others reported by different authors; 489.4 kg in Damascus does of Cyprus (Guney *et al.,* 2006), 340.78 kg in Saanen goats in Sudan (Ishag *et al.,* 2012), 365 litres in Kenya (Ogola *et al.,* 2010), 450 litres in Shami goats and 445 litres in Saanen goats in Lebanon (Khazaal, 2009). Highest mean lactation milk yield of 706 litres were recorded in Saanen goats in South Africa (Donkin and Boyazoglu, 2000).

There was significantly higher milk yield per lactation in does that had multiple kids (365.47 litres) as compared to those with single kids (319.21 litres). Several authors (Ciappeson *et al.,* 2004; Arguello *et al.,* 2005; Bernacka and Siminska, 2009) have documented similar effect of birth type on lactation milk yield. A recent study on crosses of Norwegian dairy goats in Tanzania has documented higher milk production in does with multiple kids than those with singles (Ketto *et al.,* 2014). The significant difference in milk yield per lactation between does with single kids and those with multiples can be associated with increased lactogenic activities in pregnant does (carrying multiples) which maximize the development of mammary gland and increase milk synthesis resulting into higher milk yield than in does with single kids.

It has been observed that lactation milk yield has been increasing with an increase in level of Norwegian blood of the does. The lowest yield was found in does with 50 % blood level while the pure (100 %) Norwegian goats had the highest milk yield per lactation. Ogola *et al.* (2010) reported a similar effect of blood level on lactation milk yield which was higher in pure breeds than the value which was previously reported in crossbreds by Mtenga and Kifaro (1992) and Onim (1992). Generally, pure breeds of dairy goats have been confirmed to have higher milk production with longer lactation periods of 9-10 months than their crosses (Donkin and Boyazoglu, 2000). In the present study, the significant influence of blood level on lactation milk yield can be due to the genetic potential of the pure Norwegian dairy goats for milk production.

The present study has observed a significant effect of parity of the doe on lactation milk yield. Different studies (Ciappeson *et al.,* 2004; Muller, 2005; Singh and Rai, 2006) have reported similar effect of parity on lactation milk yield in dairy goats. The increase in body weight with age of the doe causes expansion of the udder and stomach volume which induces high feed intake resulting into higher milk yield (Ketto *et al.,* 2014). The effect of parity can be due to the fact that; older does always have greater udder volume than those of the first parity. Therefore, the proportion of mammary alveoli that were developed in the previous lactations do not undergo complete regression instead are added to those developed in subsequent lactations to increase the number of secretory cells in the udder resulting into higher milk yield as the parity order increases. The significantly higher lactation milk yield in the wet season has been reported in other studies (Ishag *et al.,* 2012; Assan *et al.,* 2015). Higher lactation milk yields for does kidding in wet season were reported in previous studies and associated it with the availability of adequate forages for the lactating does (Carnicella *et al.,* 2008; Mia *et al.,* 2014). The difference in milk yield per lactation between does that kidded in the wet season and those kidded during dry season can be due to plenty of forages and vegetable residues in Mgeta available for the goats during that period. These could provide most of the nutrients required for lactation maintenance. However, low milk yield in the dry season might have been due to scarcity of animal feeds including low concentrate supplementation.

5.3.2 Monthly milk yields

The present study found that the mean monthly milk yield was lower than 51.3 litres reported by Jackson (2013) in Toggenburg goats. It is also higher than 16.73 litres observed by Hamad (2001). Monthly milk production was higher in does with multiple kids (48.05 litres) as compared to those with singles (42.09 litres). Similar higher yields in does with multiple kids have been documented in literature (Browning *et al.,* 1995; Milersk, 2001; Ciappesoni *et al.,* 2004; Krajinović *et al.,* 2011). The effect of birth type on monthly milk yield in this study can be associated with the presence of placental lactogenic hormones such as *progesterone* and *prolactin* during pregnancies, which stimulate the mammary gland to produce more milk hence, higher milk yield per month in does with multiples than those with singles. Monthly milk yields were increasing with increase in blood level. Similar effect of breed improvement on milk yield has been reported by other authors (Beyene and Seifu, 2005; Zahraddeen *et al.,* 2007). The explanation given under lactation milk yield also applies here.

The significant influence of parity on monthly milk yield has also been reported by other different studies (Peris *et al.,* 1997; Hansen *et al.,* 2006; Carnicella *et al.,* 2008). The effect of parity can be attributed to the fact that; as the age of the doe increases, the hormonal status of the animal body, metabolic activity, secretory cells and feed intake which are necessary in milk synthesis also increase. The monthly milk yield of does that kidded in wet season (48.51 litres) was higher compared to that from dry season (41.63 litres) kidders. Different studies (Gipson and Grossman, 1989; Ruvuna *et al.,* 1995; Akpa *et al.,* 2001) have reported a similar effect of season of kidding on monthly milk yield. The variability in climatic conditions which cause fluctuations in availability of nutrients has been related with the influence of kidding season on monthly milk yield (Ishag *et al.,* 2012). The significant difference of monthly milk yields is due to the same explanation as for lactation milk yields.

5.3.3 Lactation length

The overall mean lactation period obtained is close to 6.9 months reported by Kiango (1996) in crosses of Norwegian dairy goats in Mgeta, 6.93 months for the same goats at SUA (Hamad, 2001) and 6.8 months in Saanen goats in Sudan (Ishag *et al.,* 2012). LL is lower than the periods observed in other studies; 7.67 months (Pesce-Delfino *et al.,* 2011) and 9.1 months (Bolacali and Kucuk, 2012). The differences could be due to breed differences, varied milk production potentials and management levels. The observed variation of lactation lengths between kidding years has also been reported by Ahuya *et al.* (2009) in a study on Toggenburg goats and by Ishag *et al.* (2012) on Saanen goats. The influence of kidding year can be due to the variation in climatic conditions which cause fluctuations in availability of nutrients. The slight increase in lactation length from 6.36 months in 50 % N goats up to 7.13 months in 93.75 % N goats has been reported in various studies (Al Khouri,1996; Mourad, 2000; Prasad and Sengar, 2002) and was associated with genotypic differences between groups and the heterotic effect of cross-breeding.

Lactation length has influence on milk yield of the doe due to the duration of physiological changes in number and activity of secretory cells within the mammary gland (Güler *et al.,* 2007). The significant difference in duration of lactation between years of kidding as observed in this study might have been caused by the variation of lactation milk yields under influence of availability of feed stuffs which depends on climatic conditions. The years with relatively high rainfall had adequate nutrients for the does which produced more milk hence long lactation periods than the years with low annual rainfall but in this study data on amounts of rainfall were not available. However, the significant effect of blood level on lactation length found in this study can be associated with the gradual increase in milk yield with blood level which influenced an increase in lactation period. This is because lactation length is determined by the milk producing ability of the doe and persistence on lactation.

5.3.4 Dry period

The overall mean dry period in this study is higher than 56 days reported by Caja *et al.* (2006) in Granadina dairy goats and 63 days in Toggenburg (Jackson, 2013). It is also, lower than 138.8 days reported at SUA (Hamad, 2001) and almost similar to 84 days reported in Saanen goats by Jackson (2013). Similar influence of year of kidding on dry off period was previously reported by Hamad (2001) who associated it with variation in management. Various authors (Pezeshki *et al.,* 2007; Watters *et al.,* 2008) have attributed short dry periods to higher milk yield and persistence of does on lactation (Atashi *et al.,* 2013). Complete omission of dry period reduces milk production in the next lactation (Annen *et al.,* 2004; Andersen *et al.,* 2005; Madsen *et al.,* 2008; Steeneveld *et al.,* 2013) and can affect colostrum quality (Rastani *et al.,* 2005; Caja *et al.,* 2006). The observed effect of year of kidding in this study can be related to the fluctuation in climatic conditions which affects availability of nutrients and supplementation levels to the does resulting into variation in lactation milk yields between years of kidding.

5.4 Mortality Rates

5.4.1 Pre-weaning mortality rate

The overall pre-weaning mortality rate in this study is lower than the values reported by different studies such as 46.8 % (Petros *et al.,* 2014), 25 % for Borana and Arsi-Bale kids in Ethiopia (Hailu *et al.,* 2006), 34.2 % among Arsi-Bale goats in Ethiopia (Debele *et al.,* 2011) and 40.6 % for crosses of Norwegian dairy goats in Tanzania (Mtenga *et al.,* 1994). The present value is also higher than the mortality rates presented by other authors such as 8.4 % (Bushara and Nikhaila, 2012) and 7.9 % (Eik *et al.,* 2008). Significantly higher pre-weaning mortality rates were observed in males (32.11 %) than in females (10.11 %). Similar higher death rates among males of dairy goats have been reported by other authors (Perez-Razo *et al.,* 1998; Aganga *et al.,* 2005; Hailu *et al.,* 2006).

However, Debele *et al.* (2011) documented higher death rates in females than in male Arsi-Bale kids in Ethiopia. The significantly higher death rates of male kids than females in this study can be due to preference of farmers on females as replacement stock. Male kids are considered less important under a controlled breeding program in which only project bucks are used or artificial insemination is applied. Therefore, male kids are the expected culls to avoid inbreeding and females are prioritized in terms of management leaving high risk to male kids. Also, due to the above reason, having a large number of female kids and a few males in a population with equal chances of dying, the proportion of deaths of males will outweigh that of females. This study realized higher death rate of multiple born kids (21.02 %) as compared to single kids (7 %). The same finding has been reported by different authors (Mtenga *et al.,* 1994; Hamad, 2001; Hailu *et al.,* 2006; Snyman, 2010; Petros *et al.,* 2014). The difference in pre-weaning mortality rates between single and multiple kids as noted in this study may have been due to insufficiency of milk to satisfy multiple kids which causes relatively low pre-weaning growth rates than in single born kids. Given their lower birth weights, multiple kids continue being weak and in case of any stress they are more pre-disposed to deaths than single kids.

The death rates prior to weaning were observed to increase with an increase in blood level. Seriously higher mortality rate (36.79 %) was noted in the genetic group with 100 % blood level while the lowest death rate (1.54 %) was occurring in goats with 50 % blood level. This indicates that susceptibility to diseases and parasites was increasing as the level of Norwegian blood increased. Different studies (Mtenga and Kifaro, 1992; Eik *et al.,* 2008; Zahraddeen *et al.,* 2008) have reported high susceptibility of exotic goat breeds to difficult climatic conditions leading to high mortalities. The effect of blood level on mortality rate has been reported to increase with increasing level of exotic blood in goats (Barbind and Dandewar, 2004). The variation of mortality rates between genetic groups can be due to the fact that the increase in blood level which had positive effects on birth weights, growth rates and milk yield in goats was also related to poor resistance to diseases. This justifies the necessity of good management so that the genetically improved dairy goats can survive and produce as expected.

There was a significantly higher pre-weaning mortality rate for kids that were born during wet season (44.44 %) as compared to those born in the dry season (1.05 %). Various studies (Ikwuegbu *et al.,* 1996; Kusina *et al.,* 2000; Bushara *et al.,* 2013) have reported the same influence of season on pre-weaning death rates of goats with most of the deaths occurring in wet season. The higher death rates in the wet season can be attributed to rainfall and high humidity which promote diseases such as pneumonia and parasitic infections.

5.4.2 Post-weaning mortality rate

The results of this study revealed that the post-weaning mortality rate is equal to 5.9 % reported by Deribe and Taye (2013) but lower than the values reported by other studies such as 14 % (Bushara and Nikhaila, 2012), 25.7 % (Mtenga *et al.,* 1994) and 23.22 % (Hamad, 2001). However, this post-weaning death rate is higher than 4.3 % found by EL imam (2013). Males died more (13.51 %) than female goats (4.52 %) during the post-weaning stage. Other studies have reported similar findings (Aganga *et al.,* 2005; Hailu *et al.,* 2006). This could be due to less care given to males than females because under controlled breeding, males of dairy goats are considered less important as compared to females which are the expected breeding does and always fetch higher market prices during selling. The observed higher mortality rate in multiples (10.73 %) than in single kids (1.26 %) is in agreement with reports of other different authors (Mtenga *et al.,* 1994; Hussain *et al.,* 1995; Awemu *et al.,* 1999; Snyman, 2010). Limited ability of the dam to provide adequate milk for multiples poses a nutritional stress to the kids such that after weaning their body weaknesses predisposes them to disease susceptibility.

There was an increase in post-weaning mortality with increase in blood level. Other studies have reported higher mortality rates in genetically improved goats as compared to pure local animals (Mtenga *et al.,* 1994; Belay *et al.,* 2014). This is associated with poor adaptation of the purebred dairy goats to difficult tropical environments and their increased susceptibility to diseases as compared to those with lower blood levels. Goats with 50 % blood level had the lowest post-weaning mortalities due to their relatively higher disease resistance as compared to the pure Norwegian goats that suffered higher mortalities. Significantly higher post-weaning mortality rate was realized in goats born during the wet season (10.53 %) as compared to those born in the dry season (4.77 %). A similar scenario has been reported by several studies (Malik *et al.,* 1999; Awemu *et al.,* 1999; Debele *et al.,* 2011). The higher post-weaning mortalities for goats born in the wet season can possibly be due to parasites, infectious diseases and cold stresses which are more common in the wet period than in dry season.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. The growth performance of dairy goats in Mgeta is better at present compared to the previous evaluation conducted in 1996. However, the pure Norwegian goats grow slowly at 6 and 9 months compared to other genetic groups.

ii. Dairy goats in Mgeta are highly prolific, although they delay to get their first kids. Their mean AFK is unnecessarily higher compared to other dairy goat breeds in Tanzania. The goats have moderate KI with high TR. Also, most of the does kid in August and September indicating that there is high conception rate around March and April.

iii. The current status of milk production is good but the goats can still produce more. The mean duration of lactation and dry off period are considered moderate to support optimum lactation milk yield.

iv. Blood level was an important source of variation for all the traits. Growth performance was affected by sex of kids and season of birth while lactation traits were more influenced by birth type and season of kidding. Reproductive performance was mainly affected by birth type. Sex, season and type of birth had influence on mortalities of the goats. Parity of the doe had no effect on goats' performance.

v. There are seriously higher mortalities for kids born during the wet season as compared to dry season kids particularly before weaning.

6.2 Recommendations

i. In this study, it has been observed that crosses of Norwegian dairy goats still have a potential for fast growth than their current status. Therefore, farmers and researchers can effectively achieve this through selection based on any of the following variables; weaning weight or weights at 6 months of age especially for 75 % Norwegian goats.

ii. Genetic improvement of the goats through cross breeding should not exceed 75% of Norwegian blood level if good response is expected on growth performance. This is due to low ability of pure dairy goats to adapt the challenging conditions of Mgeta. Also, these goats need high level of management to meet their production requirements of which most farmers cannot afford.

iii. It seems that, the dairy goats in Mgeta can produce more milk than their present performance. Farmers should improve the management practices such as nutrition, health and housing so as to support the efforts of genetic improvement which are currently in place.

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APPENDICES

Appendix 1: Analyses of variance for factors affecting body weights at different stages[1, 2]

Source	df	Mean squares Birth wt	Weaning wt	6months wt	9month wt
Year of kidding	2	0.753^{NS}	12.619**	4.528^{NS}	12.358^{NS}
Sex	1	4.717**	128.808***	347.597***	854.885***
Blood level	5	5.693***	13.969***	35.363***	139.330**
Parity	4	1.204*	2.024^{NS}	7.198^{NS}	4.787^{NS}
Season of kidding	1	4.336**	23.779***	49.929**	57.588**
Birth type	1	7.793***	7.793*	53.396**	47.890*
Error		0.356 (196)	1.47 (176)	4.210 (126)	4.996 (118)

[1]=Figures in parenthesis are degrees of freedom for the respective source of variation
[2]=In all the appendix Tables, *, ** and ***=Significant at P<0.05, P<0.01 and P<0.001 respectively. **NS**=Not significant at P>0.05

Appendix 2: Analyses of variance for factors affecting growth rates at different stages[1, 2]

Source	df	Mean squares Pre-weaning GR	Post-weaning GR	Overall GR
Year of kidding	2	1.475**	2.586**	0.172^{NS}
Sex	1	10.803***	11.434***	10.971***
Blood level	5	0.127^{NS}	1.821**	0.242**
Parity	4	0.586^{NS}	0.277^{NS}	0.075^{NS}
Season of kidding	1	0.033*	0.622^{NS}	0.437*
Birth type	1	0.501^{NS}	2.024*	0.133^{NS}
Error		0.178 (176)	0.363 (126)	0.065 (117)

[1]=Figures in parenthesis are degrees of freedom for the respective error terms
[2]=In all the appendix Tables, *, ** and ***=Significant at P<0.05, P<0.01 and P<0.001 respectively, **NS**=Not significant at P>0.05 GR= growth rate

Appendix 3: Summary of analyses of variance for factors affecting age at first kidding and kidding interval

Source	df	Mean Squares	
		Age at first kidding	Kidding interval
Year of kidding	2	4.998^{NS}	35.051**
Birth type	1	60.850***	3.998^{NS}
Blood level	5	461.095***	13.782*
Parity	4	0.997^{NS}	3.944^{NS}
Season of kidding	1	0.606^{NS}	1.824^{NS}
Error		3.105 (149)	5.753 (84)

[1]=In parenthesis are degrees of freedom for error

Appendix 4: Summary of Chi-square (χ2) analyses for factors affecting twinning rate

Source	Births		df	Chi-square	TR%
	Singles	Multiples			
Year of kidding					
2012	50 (41.12)	36 (44.88)	2	7.86*	41.86
2013	56 (58.33)	66 (63.67)			54.10
2014	14 (20.56)	29 (22.44)			67.44
Blood level					
50%	19 (21.04)	15 (22.97)	5	26.97***	34.09
75%	23 (19.12)	17 (20.88)			42.50
87.5%	32 (23.90)	18 (26.10)			36.00
93.75%	13 (18.18)	25 (19.83)			65.79
96.875%	13 (18.65)	26 (20.36)			66.67
100%	10 (19.12)	30 (20.88)			75.00
Parity					
1	43 (24.86)	9 (27.14)	4	102.24***	17.31
2	51 (31.08)	14 (33.92)			21.54
3	18 (23.90)	32 (26.10)			64.00
4	5 (19.12)	35 (20.88)			87.50
5	3 (21.04)	41 (22.96)			93.18
Season					
Dry	101 (94.66)	97 (103.34)	1	3.85*	48.99
Wet	19 (25.34)	34 (27.66)			64.15

In parenthesis are the expected values TR= Twinning rate

Appendix 5: Analyses of variance for the factors affecting lactation traits[1]

Source	df	Mean Squares			
		Lactation milk yield	Monthly milk yield	Lactation length	Dry period
Year of kidding	2	6656.723^{NS}	39.694^{NS}	13.208^{NS}	27970.930*
Birth type	1	122828.002***	2030.488***	1.960^{NS}	39.996^{NS}
Blood level	5	128762.228***	1194.000***	13.641*	6993.747^{NS}
Parity	4	282.76.701*	503.430**	2.460^{NS}	7666.240^{NS}
Kidding season	1	178768.065***	1625.357***	0.353^{NS}	6540.714^{NS}
Error		10787 (237)	129.528 (237)	1195.644 (237)	3331.222 (75)

[1]Figures in parenthesis are degrees of freedom for the respective source of variation

Appendix 6: Summary of chi-square analyses for factors affecting pre-weaning mortality rate in dairy goats

Factor	Pre-weaning mortality				
	Live	Died	MR%	df	Chi-square
Sex					
Female	398 (378.8)	45 (64.20)	10.16	1	32.02***
Male	74 (93.20)	35 (15.80)	32.11		
Year of birth					
2012	171 (165.88)	23 (28.12)	11.86	2	3.56^{NS}
2013	206 (213.77)	44 (36.23)	11.60		
2015	95 (92.35)	13 (15.65)	12.04		
Type of birth					
Single	239 (219.75)	18 (37.25)	7.00	1	21.76***
Multiple	233 (252.25)	62 (42.75)	21.02		
Blood level					
50%	64 (55.58)	1 (9.42)	1.54		62.34***
75%	67 (61.53)	5 (10.44)	6.94	5	
87.5%	123 (112.01)	8 (18.99)	6.11		
93.75%	74 (73.54)	12 (12.46)	13.95		
96.875%	77 (78.67)	15 (13.33)	16.30		
100%	67 (90.638)	39 (15.36)	36.79		
Season					
Dry	377 (325.78)	4 (55.22)	1.05	1	179.35***
Wet	95 (146.22)	76 (24.78)	44.44		

In parenthesis are the expected values

Appendix 7: Summary of chi-square analyses for factors affecting post- weaning mortality rate in dairy goats

Factor	Post-weaning mortality				
	Live	Died	MR%	df	Chi-square
Sex					
Female	380 (374.39)	18 (23.61)	4.52	1	9.04**
Male	64 (69.61)	10 (4.39)	13.51		
Year of birth					
2012	163 (160.86)	8 (10.14)	4.68	2	0.88[NS]
2013	193 (193.78)	13 (12.22)	6.31		
2015	88 (89.36)	7 (5.64)	7.37		
Type of birth					
Single	236 (224.82)	3(14.18)	1.26	1	18.99***
Multiple	208 (219.18)	25(13.82)	10.73		
Blood level					
50%	62 (60.20)	2 (3.97)	3.13		13.61*
75%	65 (63.03)	2 (3.86)	2.99	5	
87.5%	118 (115.70)	5 (7.30)	4.07		
93.75%	72 (69.61)	2 (4.39)	2.70		
96.875%	69 (72.43)	8 (4.57)	10.39		
100%	58 (63.03)	9 (3.97)	13.43		
Season					
Dry	359 (354.64)	18 (22.36)	4.77	1	4.49*
Wet	85 (89.36)	10 (5.64)	10.53		

In parenthesis are the expected values