THE IMPACT OF ENHANCED NUTRITIONAL AND FEEDING PRACTICES ON GROWTH AND HEALTH OF DAIRY CALVES IN MUKURWEINI DISTRICT OF KENYA

A thesis submitted in partial fulfillment of requirements for **Masters of Veterinary Medicine** of University of Nairobi (**M. Vet. Med**)

Situma Silvia Nafula, (BVM)

(University of Nairobi)

University of Nairobi

Faculty of veterinary medicine

Department of Clinical Studies

2013

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

Signed ________________________________Date ___________________________

Silvia Nafula Situma, (BVM).

This thesis has been submitted for examination with our approval as University supervisors:

Signed________________________________Date____________________________

Prof. G.K Gitau, (BVM, Msc, PhD)

Signed________________________________Date____________________________

Prof. C.M Mulei, (BVM, PhD)

Signed________________________________Date ___________________________

Prof .J. VanLeeuwen, (DVM, Msc, PhD)

DEDICATION

To my parents: Edwin and Beatrice Situma and my siblings; Sammy, Maureen, Stella and Joan. You are the ones that truly inspire in me the determination and faith to pursue what is good, beautiful and trueé I love you!

ACKNOWLEDGEMENTS

I thank the almighty God for his grace and unfailing love. My profound appreciation goes to my supervisors, Prof. G.K Gitau; Prof. C. M. Mulei of Clinical studies Department, University of Nairobi and Prof. J. VanLeeuwen Atlanta Veterinary College, University of Prince Edward for their wise counsel, helpful criticisms and very constructive discussions throughout the period of this project. The supervisors have been very resourceful and have left a lasting impression in me and were vital in making it possible for me to effectively complete my study.

Special thanks to Drs. Maureen and Jeff Witchel for technical assistance towards this project in Mukurweini and Mr. Matere for assistance in thorough evaluation of the data for the write up of this thesis. Many thanks to my colleagues Pauline Mbeere, Jennifer Huizen and Morgan Findlay who laboured with me in this project. I am deeply indebted to The University of Nairobi for giving me a scholarship to pursue this degree, Prince Edward Island University for having extended generous financial assistance towards this project and Wakulima Dairy Limited and the farmers for the outstanding support given to me while carrying out my research project at their farms.

I am particularly indebted to my family members for their love and encouragement during the entire period of my postgraduate program.

Last but not least I owe insurmountable respect and special thanks to my friends and colleagues Christine Mbindyo, Nabi Oki, Hannah Chege, Lilyan Mathai, Paul Okumu and Dhaval Shah for their constant encouragement during the period of my course.

TABLE OF CONTENTS

Contents **page**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ANOVA	Analysis of Variance
DMWG	Daily Mean Weight Gain
^{0}C	Degree Celsius
BW	Body weight
BCS	Body Condition Score
COMESA	Common Market for Eastern and Southern Africa
GDP	Gross Domestic Product
GoK	Government of Kenya
DCAD	Dietary Cation Anion Difference
DLPO	District Livestock Production Officer
FAO	Food Agricultural Organization
i.e.	That is
IgG	Immunoglobulin
ILRI	International Livestock Research Institute
MOLD	Ministry of Livestock Development
MSc	Master of Science
Kg	Kilogram
Km	Kilometers
RCT	Randomized Controlled Trial
Ppm	parts per million
SDP	Strategic Development Plan
WDL	Wakulima Dairy Limited

ABSTRACT

A pilot observational study and randomized control feeding trial were conducted in Mukurweini District, Nyeri County, Kenya over a period of eight weeks between May and August 2012, to determine the effects of nine feed intervention groups on the performance and growth of dairy calves.

A total of 36 Kenyan smallholder farmers were purposively selected to participate based on Wakulima Dairy Limited records of artificial insemination (AI) that projected that the farms were likely to have a newborn calf (< 1 week old) and farmers willingness to participate. The newborn calves were randomly allocated to a 3×3 factorial arrangement of feed intervention groups with 4 calves per group. The 9 feed groups were based on two possible groups of Calf Starter Intake and Milk Intake i.e., control, half and full-proper. Full calf starter intake was defined as lead feeding to achieve up to 1 kg/day consumption at weaning, half calf starter was to maximize intake at 0.5 kg/day consumption at weaning while control calf starter intake was whatever calf starter intake the farmer normally offered (0-0.2 kg/day). Full milk intake was defined as 4 Liters/day; and half milk intake was 2 Liters/day while control milk intake was whatever milk the farmer normally offered this ranged from (2-5 liters/day). Measurements were taken on the calves on a weekly basis for a period of eight weeks at ages ranging from 3 days old to 60 days old. Data were collected on the heart girth (converted to body weight) and height at the withers of the calves (along with gender), and converted to average daily gain in weight for the week. Data collected was analyzed using analysis of variance under the general linear model procedure at $p \leq 0.05$ to determine feed group effect and interaction on calf performance. In addition, the relationship between parameters studied was adjusted by the Bonferroni post-hoc test. Means and Standard deviations for weight and height were determined for ages 1 to 8 weeks using the means procedure in SAS (version 9.1.3 portable). Observed data lines/curves were plotted to help visualize the increases in mean weekly weight as well as mean weekly height gain over the various time points. The results of this study show that the feed intervention groups had an overall positive effect on the outcomes i.e. increase in weight and height at F=5.88 and P=<0.0001. The results of the study further show significant difference in the weight and height means across the different feed intervention groups at P<0.05. The full Calf Starter + control Milk Intake (7) recorded weights and heights significantly higher from the rest of the feed interventions at the start and end of the trial, while the half Calf Starter and half Milk Intake (5) had weight and height gains significantly lower from the rest of the feed intervention groups from week 3 to the end of the study period at p=<0.05. The sex of the study calves had a significant effect on the weight gain with F = 5.33 and P = 0.02, even though the male calves were more in number (22/35) their weight mean was lower than that of the female calves (13/35) at 58.7 kg and 55.8 kg respectively. Sex had no effect on the height gain with F = 0.72 and P = 0.39, with the male calves recording mean heights of 79.0 cm, but 79.6 cm for the female calves. Morbidity was highest in the female calves and lowest in the male calves at 22.7 percent (5/22) and 7.7 percent (1/13), respectively, but the mortality was only recorded in the male calves at 9.1 percent (2/22) the affected calves were distributed across different feed intervention groups. The results of this study showed that a combination of milk and calf starter given to the dairy calves had an overall positive effect on daily weight gains.

Keywords: Dairy calf. Feed intervention.Weight gain. Height gain. Kenya

CHAPTER ONE

1.0 INTRODUCTION

1.1Background information to the study

The approximated number of dairy heads of cattle in Kenya is 3.5million cattle which comprise of pure breeds and their crosses (Wakhungu, 2001; MOLFD 2006; KNBS 2009, Gitonga 2010). Over the years, dairy farming in Kenya has evolved from the colonial era through the state owned era of the 1960s to the present smallholder farms, Orodho (2006). The evolution was due to changes in vegetation cover from forest to derived grassland and changes in land use and tenure, Orodho (2006). During the colonial era, dairy production in Kenya was purely large scale farming and was mainly done by the white settlers in the Kenyan highlands of high agricultural potential (Muriuki *et al*., 2003, Ngigi, 2004, Orodho, 2006, Gitonga, 2010).

In Kenya Livestock production is a means of sustainable income, employment and nutrition (Wambugu *et al*., 2011). There is a great potential toward increasing livestock production and it is not yet fully tapped. This potential can only be sustainably and securely achieved through a series of comprehensive studies of the current livestock production systems and analytical evaluation of the constraints that hinder improvement and full exploitation of this potential. Only then can problem oriented approaches toward an optimal performance and results in the current livestock production systems be achieved and applied to overcome the constraints (Gitau *et al*., 1994a and b; De Jong 1996, Lanyasunya *et al*., 1999).

Smallholder dairy production system in Kenya has however gradually overtaken the medium and large scale dairy production systems and has become established as the main dairy production system (Ngigi, 2004; Owen *et al*., 2005). The development of the smallholder units was as a result of favorable climate and soils whereby human settlement and pressure on land from increase in population caused farming systems to change from large units to medium units and finally the smallholder units that integrated crop and livestock production, Orodho (2006).

Currently in Kenya smallholder units are approximated to be about 660,000 with about 3.5 million dairy cattle (Owen *et al*., 2005; Lanyasunya *et al*., 2006, Gitonga, 2010). Smallholder dairying in eastern Africa is classified as either intensive or semi-intensive, Orodho (2006).

Smallholder farmers are reported to raise about two to three dairy cows on a land area that is less than one hectare in the intensively farmed areas and about five to 10 cows on a land area that is about two and a half hectares in the extensively farmed areas (Wakhungu, 2001; Gitonga, 2010).

The small scale dairy production units make an approximated contribution of up to 80percent of the total produced and marketed milk in Kenya (Wakhungu, 2001; Muriuki *et al*., 2003; Owen *et al*., 2005; Gitonga, 2010). This however does not match up to the reported average daily milk production per cow of about seven liters per day, as this is considered to be low production levels (Owen *et al*., 2005; MOLFD 2006). This low production is attributed to several factors among which are poor animal husbandry practices; management and nutrition, lack of effective disease control and poor breeding programs (Peeler and Omore, 1997; Owen *et al*., 2005).The medium and large scale dairy farms on the other hand are reported to be under better management with investments on improved herd genetics as compared to the smallholder dairy units (Odima, 1994; Gachuiri *et al*., 1998; Wakhungu, 2001). The land sizes of medium and large scale dairy farms range between 600 to more than 1000 hectares per farm with approximately 30 to 1000 heads of cattle (Wakhungu, 2001; Gitonga, 2010).

A study carried out by Moran (2011) reported that the high temperatures and humidity in some tropical regions are not ideal to rear young dairy stock due to propagation and introduction of many potential disease causing organisms to milk fed calves. McLean (2001) and Moran (2011) also cite smallholder dairy farming system and lack of awareness of long term implications of poorly reared stock as major challenges hindering these farmers from having optimal performance in their farms and this is because they are not encouraged to pay close attention to their calf rearing systems. Inability of livestock producers to feed animals adequately throughout the year is reported as the most widespread constraint to improving animal productivity and achieving optimal performance and production in Africa (Bebe *et al*.,2003a) : Orodho (2006). The climate in the medium and high altitude areas of Central Kenya is also an influential factor with severe frost and dry spells being reported as factors that limit the optimal growth and production potential of Napier grass and other tropical grass species (Kiragu *et al.,* 2008). These challenges have resulted in missed opportunities by farmers to benefit from the high cost of milk in certain seasons for instance the dry seasons usually have high prices of milk and this is the period which the main challenge to the livestock producer is inadequate feeding that is due to feed shortages resulting in reduced dairy production, (Kiragu *et al.,* 2008).

Concentrate feeding of calves is not a common practice in the rural areas due to the associated or assumed high cost as well as their erratic supply that is influenced by season and cost as a result in poor growth rate and late weaning of calves (Bebe *et al*., 2002; Lyimo *et al*., 2004; Ayantunde *et al*., 2005; Lukuyu *et al*., 2010; Lyimo *et al*., 2010). Inadequate quantity and quality of feeds is reported to be as a result of the unavailability of forage due to low or poor production and high costs of commercial concentrates and this is especially so during the dry season (Valk, 1990; Omore *et al*., 1998; Moran 2002; Bebe *et al*., 2003a: Orodho, 2006). This unavailability is accentuated by the fact that the quantity of forage is generally insufficient for the number of livestock due to the small land sizes, cost of purchase and adverse climate in some seasons. Therefore farmers supplemented animals with purchased forages and concentrates (Bebe *et al*., 2003a; Orodho2006).There are periods in which the feed supplies maybe ample but the forages are of poor quality, and usually deficient in protein and mineral nutrients (Bebe *et al*.,2003a: Orodho 2006).

There are alternatives to unavailable pasture i.e., crop residues and agro-industrial by-products such as maize stover and brewerॅs grain that can be fed to livestock. The poor infrastructure for transport and processing or lack of appropriate processing technologies hinders the use of alternatives leading to wastage (Valk, 1990; Omore *et al*., 1998; Moran 2002: Orodho, 2006).

Moran (2002) reported that milk is an expensive source of energy for growing calves as compared to the use of concentrates and he further reported that it is more expensive than grazed pasture, therefore the most effective way of minimising costs of feed for optimal growth of young calves and maximum production is through early weaning which results in a reduction of the milk intake.In order to have a long lasting solution to the challenge of feed unavailability, (Lusby *et al*., 1981; Peterson *et al*., 1987; Myers *et al*., 1999), deduced that early weaning of dairy calves could be a possible solution to the constraint of short-term supply of good quality forage and concentrates production shortfalls.

Current feeding practices of cattle in Kenya have been evaluated by VanLeeuwen *et al*., (2012), and he reported that smallholder farmers in the central highlands of Kenya feed Napier grass, other grasses such as (*Pennisetum clandestinum, Chloris gayana*) sweet potato vines and banana leaves. In the same study it was noted that cow size especially of Friesian breed was lower than expected, which was partially attributed to the fact that Holstein cattle were crossbred with local cattle but also due to the fact that these animals were underfeed during the growth phase resulting in poor growth rates as calves.

Under-nutrition due to inadequate and seasonal availability of feed, low quality and quantity of feed and low dry matter intake has been reported as some of the other major constraints in the smallholder production system (Valk, 1990; Omore *et al*., 1998; Moran 2002; Bebe *et al*., 2003a; Orodho, 2006). The harsh tropical climate is also a challenge in raising optimal performing calves as it encourages proliferation of several disease organisms hence causing animal health issues to the dairy stock, particularly the young growing calves (Aiumlamai, 1999; Moran, 2005; 2009; 2011). The dairy production system in some of the tropical countries is generally poorly resourced leading to poorly raised calves, Moran (2009); Moran (2011).

The trend toward importing temperate dairy stock, that are poorly adapted to the tropical climate, has resulted in an urgent need for well planned and conducted farmer extension programs into young stock management, Moran (2005). This is because the progeny of these high grade exotic dairy cows are highly susceptible to environmental and managerial stresses of tropical small holder dairy farming than local, more adapted calves, Vaccaro (1990). The performance of young stock on most tropical and subtropical dairy farms is sub-optimal as compared to that of those in temperate countries, Moran (2011). The high investment costs on dairy calf rearing therefore justify greater attention than they currently receive. In order to rule in or out the possibility of a relationship between the proportion of heifers to cows and farmer own produced feeds as compared to purchased feeds, and the resultant animal performance such as milk yields it was essential to carry out this study since the values associated to the above mentioned factors in livestock production had not been quantified in earlier studies which mainly focused on dairy heifer rearing on smallholder farms (Gitau *et al*., 1994a and b: De Jong 1996, Lanyasunya *et al*., 1999).

In Australia, early weaning is a common management practice because it is reported to improve the reproductive performance (Giorgetti *et al*., 2006; Kugler *et al*., 2008; Fernández *et al*., 2012).

1.2. Justification of the study

Appropriate nutrition is fundamental for the growth of calves and for a generally profitable calf-rearing enterprise (Lanyasunya *et al*., 2006; Changâa *et al*., 2010). The tropics have calf-feeding regimes that depend primarily on tropical grasses, making it difficult for the calves to obtain a balanced nutrient supply because most of this pasture has low protein, digestibility, and mineral content due to late harvesting and maturation (Mero and Uden 1998: Mtengeti *et al*., 2008: Changâa *et al*., 2010).

Growth in young animals is generally regulated a system of metabolic interactions, and nutrition plays a very essential role. During the lactating period, calf nutrition is critical for ruminant growth and maintenance of adequate calf average daily weight gains (ADWG) after birth, (Breier *et al*., 1986: Kugler *et al*., 2002: Fernández *et al*., 2012).The nutritional status during the neonatal period has an effect on growth and responsiveness of calves to various hormones in adult life, Drackley and Bartlett (2002). In order to have a better understanding of both the short and long term impacts of nutrition during the first sixty days of life it is necessary to optimize lifetime productivity through adequate early weaning practices, Drackley and Bartlett (2002). Scientific literature available regarding the effects of energy and protein contents during solid feed consumption, growth, blood metabolites and health parameters is limited in pre- and post-weaned calves (Fernández *et al*., 2012). Neither is it available in documentation on the effects of neonatal nutrition on responses in later life among dairy cattle (Holemans *et al*., 1996: Desai and Hales, 1997: Lyimo *et al*., 2010).

An improvement in the management strategies of rearing dairy calves and heifers for replacement stock would definitely lead to reduced calving intervals, increased calving rates, reduced still born and pre-weaned calf mortalities and fewer non pregnant heifers can supply many more dairy herd replacements than currently occurs. These strategies can increase the overall number of replacement stock in the herd from 15 to over 35 percent, thus allowing farmers to increase their herd sizes through natural increases (Moran 2011). Management procedures such as adequate intake of good quality colostrum within the first 12 hours of life, housing and good hygiene minimize disease transfer, providing clean drinking water, developing appropriate feeding protocols encourage early rumen development and paying closer attention to climate control and animal health can all lead to improved calf vigor and performance (Moran 2011).

This study is therefore of importance because most of the technologies that have been developed for calf rearing are basically based on on-station studies i.e., calves reared in training agricultural centres and institutes (Lyimo *et al*., 2004; 2010) the current study may give adequate outcomes that are comparable to smallholder farm conditions for calf optimal performance. Studies done on-station in Tanzania (Lyimo 2006; Lyimo *et al*., 2010; Laswai *et al.,* 2007) indicate an improvement on calf performance through feeding of balanced concentrate formulated locally. This study was therefore undertaken in order to gain insights on the prospects on performance efficiency among smallholder producers if they practice early weaning and attain optimal growth rates in their growing dairy calves using specific feed interventions

1.3. General objective of the study

The broad objective of the study was todetermine the impact of selected nutritional and feeding practices in calves on their size, health and productivity on smallholder dairy farms in Mukurweini District, Nyeri County, Kenya.

1.3.1. Specific objectives of the study

(1)To determine the calf feeding and nutritional practices on dairy farms on smallholder dairy farms in Mukurweini District, Nyeri County, Kenya

(2) To determine the relationship between three calf feeding and nutritional interventions on growth and health of calves raised on smallholder dairy farms in Mukurweini District, Nyeri County, Kenya

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical background

The original tradition on dairy production in Kenya was basically for home consumption and mainly involved production from indigenous cattle (zebu) (Mudavadi *et al*., 2001). The commercial dairy farming in Kenya however dates back to between 1900 and 1953 and was practiced by the white settlers who imported into the country purebred dairy stock from Europe, with the aim of initiating large scale dairy production for urban and export markets (Peeler and Omore, 1997; Mudavadi *et al*., 2001; Ngigi, 2004). Indigenous Kenyans were not permitted to engage in commercial agriculture until 1954 (Peeler and Omore, 1997; Wakhungu, 2001).

The development of the African smallholder dairy production was as a result of the Swynnerton Plan of 1954 which introduced policy reforms that included consolidation of land and adjudication, cash crop growing, provision of credit and other infrastructural services which promoted dairy development (Mudavadi *et al*., 2001). Generally smallholder and family farming agriculture are considered as the key leading sectors in overall economic development especially for the developing countries Quan (2011). According to Quan (2011), other than producing staple crops for domestic market, smallholder farmers produce large shares of traditional exports in these countries. This shows that the economy of many developing countries rely heavily on smallholder-based agriculture.

In East African countries like Kenya, Ethiopia, Uganda and Tanzania, for example, smallholder farming accounts for about 75 percent of agricultural production (Salami *et al*., 2010). Uganda, Kenya, Tanzania, and Ethiopia have achieved high GDP growth rates in recent years, respectively totaling 6.5, 7.0, 7.3, and 11.4 percent in 2008, (Kenya National Bureau of Statistics 2009).

Dairy farming is among the main income generating economic activity in Mukurweini District. It is normally practiced on a small scale; though this is essentially carried out on modern zero grazing units in most farms. Marketing of the milk is normally through Dairy Cooperative societies owned and managed by the farmers themselves. Smallholder dairy farms practice mixed farming for both home consumption and for sale (Mukurweini Constituency Strategic Plan 2007-2012)

Over many years, early weaning of calves has been reported to have several benefits that include improving reproduction and reducing feed inputs (Moran, 2011). In North America, the practical application of early weaning is limited by the management of the early weaned calf hence the calves born in spring are managed through a drylot feeding program for management of the calves (Lusby *et al*., 1981; Fluharty *et al*., 1996; Weder, 1996; Myers *et al*., 1999).

Early weaning:

2.2. Current status of Dairy farming in Kenya

In Africa, small scale farming is recognized as an important instrument for socio-economic improvement through poverty alleviation (Kurwijila *et al*., 1995; Lyimo *et al*., 2010)**.**

Kenya is the only country, after South Africa that produces milk that is sufficient for both domestic consumption and export, making her a hub for one of the largest dairy industries in sub-Saharan Africa (Wambugu *et al*., 2011).

Conversely, in the Common Market for Eastern and Southern Africa (COMESA), Sudan is reported to be the largest producer of milk. However her production is mainly for home consumption and not for export (Government of Kenya, 2008).

The dairy industry in Kenya is reported to be the single largest agricultural sub-sector which contributes an agricultural GDP of 14 percent and a total GDP of 3.5 percent (Government of Kenya, 2008). This has made this industry dynamic as it plays an essential economic and nutrition role in most of the livelihoods (Government of Kenya, 2008). The dairy industry in Kenya is very well developed and it is especially practiced in the medium and high rainfall areas mainly in the Central highlands, Rift Valley, Eastern and Coastal lowlands (MOLD, 2006).The current official cattle population as reported by the national 2009 population census stands at 17.4 million (Kenya National Bureau of Statistics, 2009). The total dairy herd is estimated at 3.5 million heads (Government of Kenya, 2008: Kenya National Bureau of Statistics 2010).

The dairy production systems in Kenya are influenced by the agro climatic characteristics of a particular area, land productivity potential and prevalence of animal diseases (Thorpe *et al.*, 2000). The cattle on smallholder production system are stall fed mainly using cut Napier grass and crop residues especially from maize, sweet potato vines and bananas and supplemented with portentous forage gathered from around the farm (Bebe *et al*., 2003).

Although Kenyaǿs dairy sector has a significant contribution to the national economy, household incomes and food security, the industry faces a number of technical, economic and institutional problems in milk production, processing and marketing (Karanja, 2003). Specifically, some of the main constraints to increased milk production in Kenya have been identified as seasonality in production, inadequate quantity and quality of feed, including limited use of commercial cattle feeds, and lack of good quality animal husbandry and farming practices (SDP, 2005).

Most of the Kenyan urban and peri-urban smallholder farmers practicing dairy farming and generally keep one to five animals of which between one to two are adult cows mostly Holstein Fresian or Ayrshire which comprise 50percent of the herd and the other half consisting of female calves and or heifers which are also referred to as replacement stock (Staal *et al*., 1997).

Central Province of Kenya is an area where smallholder dairy production system is highly developed compared to the rest of the country. This enterprise provides employment and livelihood to thousands of people and remarkably high quality milk for consumption. The feed supply and disease control in this region are much better although the area has been marked by declining farm size, upgrading of dairy breeds and an increasing reliance on purchased feeds, both concentrates and forage (Staal *et al*., 1997: Staal *et al*., 1998 a: 1998b).

Therefore, purchased feeds are very critical for instance, the area planted with fodder for sale is equal to the area planted with maize, the staple food crop. Due to the declining land sizes, farms are small; cattle are confined and fed through a cut-and-carry system in which feed materials are brought to the animals (Baltenweck *et a*l., 1998: Staal *et al*., 1998 a: 1998b, Staal *et al*., 1999).

The combined effect of climate change induced droughts and limited land for forage production, has resulted in inadequate forages of livestock nutrition, poor animal performance and eventually low productivity/profitability of smallholder dairy production enterprises. Integration of drought tolerant and high yielding forages per unit of available land can help to offset the feed security problem emanating from limited availability of land resources and climate change induced droughts.

Wakulima Dairy Limited (WDL) in Mukurweini District, Nyeri County, Kenya, was selected for the study because it is an organization owned by farmers in the region with an aim of networking as well as assisting each other to boost their animal's productivity in the region hence the reason why it was selected for the study. The members had a major concern in terms of nutrition of their dairy cattle on smallholder farms. The current feeding practices are zero grazing meaning the cattle are housed in sheds 24 hours a day (zerograzed) and feed must be brought to them after being cut from pastures and roadsides. Zerograzing is used for a variety of reasons such as the dense and growing human population in the highlands in Kenya (Bebe *et al.*, 2003), but also because of the health benefits to cattle from reduced exposure to parasites from grazing on infested pasture, and tickborne diseases acquired through grazing.

2.3. The definition of the calf

The calf is defined as a bovine animal in the age group of young cattle that range from birth to six and nine months of age (West, 1995; Wudu, 2004). A calf has also been defined as bovine animals of up to six month of age after which in natural circumstances, it is expected to be self-sufficient (Webster, 1984; Wudu, 2004). In the less intensive production system, a calf may generally include bovine species that are older than the age indicated in the above definitions (Wudu, 2004). In the more intensive systems of production, the proportion of calves weaned before six months of age increases as compared to those that are raised in the less intensive systems (ILRI, 1996; Wudu, 2004).

Generally, newborn calves have a poorly developed defense mechanism system this is because they are born without circulating antibodies to combat infection, yet they must survive in highly contaminated environment, Wudu (2004). The newborn calves have specialized intestinal epithelium that is capable of engulfing soluble proteins, this capacity however is lost within 24 hours after birth (Cunningham, 1992; Wudu, 2004). There are other chemical and physical components of digestive system which develop with age as the calf is exposed to a variety of different feeds (Heinrichs and Radostits, 2001, Wudu, 2004).The importance of high level of serum immunoglobulins in reducing risk of morbidity and mortality in calves have been demonstrated in many studies (Virtala *et al*., 1999; Amoki, 2001; Wudu, 2004). The acquisition of passive immunity in newborn calves can be compromised by deficiencies in the colostrum, ingestion failure, absorption failure or a combination of all these factors. Each of these factors are influenced by a range of diverse calf and dam, as well as environmental and management factors (Aldridge *et al.,* 1992: Wudu, 2004).

2.3.1. Dairy calf nutrition

Good calf rearing practice is an integral part in raising healthy newborn calves and ascertaining availability of a future replacement stock, (Lanyasunya *et al*., 2006; Drackley, 2011). Dairy calf feeding and management practices directly impact on their survival and their future milk production. Some of the studies that have followed calves through their first lactation have shown a positive relationship between early life nutrient intake and first lactation milk production (Omore *et al*., 1996: Lanyasunya *et al*., 2006).

Studies done on calf feeding regimes have shown that most of the farmers are not aware of the recommended and adequate dairy calf feed quality and quantities. Calves should be fed on milk quantities that are equivalent to (10 -15) percent of their birth weight on a daily basis (Osuji *et al.,* 1995; Lanyasunya *et al*., 2006; Lukuyu *et al*., 2011). Based on this recommendation, it is evident that most farmers underfeed their calves by using the feeding regime of amounts equivalent to between 7-10 percent of birth weight to estimate the quantity of milk fed to calves leading to poor growth rates in most areas (Osuji *et al.,* 1995: Lanyasunya *et al*., 2006: Lukuyu *et al*., 2011).

Early calf nutrition is essential for the optimal growth, health and immune status of calves as well as the development of milk production potential and metabolic imprinting in a calfθs early life, Drackley (2000). During the first two to three weeks of life, higher intakes of nutrients are likely to improve immune status of calves. This is because the digestive system of the calf has specialized cells that allow absorption of antibodies and is designed to digest milk-based nutrients efficiently Drackley (2011).

Nonneche *et al.,* (2000) demonstrated higher growth rates in calves on enhanced feeding regime as a result of increased production of nitric oxide and gamma interferon from mononuclear leukocytes compared with the growth in mononuclear leukocytes cells from calves on conventionally fed regimes. This immunity is from significant amounts of non-immunoglobulin immune factors that include leucocytes and cytokines that are also present in colostrum, (Quigley and Drewry, 1998).

A high nutrition plane in early life may have a long term positive effect on the development of calves. Pollock *et al*., (1993) reported an improved response of cell mediated immunity and decreased skin response to antigens when calves were fed a higher plane of nutrition of 1000 grams of calf starter per day as compared to 400 grams of calf starter per day or dry matter intake. There is a decrease in lymphocyte proliferation response is in calves that are fed on calf starter quantities that are below the calvesô maintenance level compared to calves that are adequately fed (Griebel *et al*., 1987). Brown *et al*., (2002) reported a growth rate of 670 grams per day in the period between two to eight weeks followed by 440 grams per day in the period between nine to 14 weeks. An Israeli study by Bar-Peled *et al.,* (1997) found that calves which were on a high plane of nutrition for the first six weeks of life calved 30 days earlier and produced 450 kg more milk in their first lactation compared to calves fed on a conventional amount of calf milk replacer. Drackley and Van Amburgh, (2005) reported that calves will have a faster growth rate when the milk intake is increased to above maintenance levels. This is because the calfôs protein needs increase with the growth rate.

2.3.2. Colostrum and its Role in Neonatal Calf Management

Colostrum is defined as the first milk produced by the cow at calving (Garry *et al*., 1993; Davis and Drackley, 1998; Kmicikewycz, 2011). Colostrum has two important properties which are source of immunity and highly nutritious balanced diet for newborn calves. This immunity obtained is composed of maternal immunoglobulin, immuno-active substances and active immune responsive cells (Garry *et al*., 1993, Davis and Drackley, 1998; Kmicikewycz, 2011). The colostrum produced by cows and the technique of its administration to calves during the first day of life are the main factors determining the efficiency of colostrum immunoglobulin absorption, and therefore the level of calvesô passive anti-infectious immunity (Godden , 2008; Godden *et al*., 2009).

The highest absorption of immunoglobulin occurs within six hours after birth in order to acquire maximum protection against infection during this period and by 24 hours most of absorption capability is lost (Bath *et al*., 1985; Wells *et al*., 1996; Tyler *et al*., 1998). In cattle the placenta is syndesmochorial and this prevents the fetus from receiving immunoglobulins in *utero* therefore the newly born calves have a poorly developed immune system (Weaver *et al*., 2000). Neonates therefore possess mechanism that enable them acquire maternally derived immune factors in order to compensate for this situation. This is referred to as passive transfer of immunity and it is based on an immediate postpartum ingestion of antibody rich colostrum, Tizard (1995; Davis and Drackley, 1998; Weaver *et al*., 2000; Barrington and Parish, 2001; National Animal Health Monitoring System, 2007).

Inadequate administration of colostrum results in failure of passive transfer of immunoglobulins to the new born calves and as a result there associated increase in morbidity and mortality (Wittum and Perrino,1995; Dewell *et al*., 2006). Many studies have demonstrated the importance of high level of serum immunoglobulin in reducing risk of morbidity and mortality in calves (Virtala *et al*., 1999; Amoki, 2001). There are also some studies which failed to demonstrate strong association between immunoglobulin status and morbidity and mortality (Cadlow, 1988; Sivula *et al*., 1996a). The single most important management factor that is required in order to achieve optimal health and survival in calves is timely and adequate intake of high quality colostrum, (Kmicikewycz, 2011). In order to achieve adequate immunity it is very important that the calf should receive colostrum within the first six hours of life (Scientific Veterinary Committee, 1995).

Based on the convincing evidence of previous studies it has been concluded that total serum protein or immunoglobulins has strong relationship with low incidence of calf morbidity and mortality in herds with higher disease incidences. This relationship was less pronounced in herds with low disease incidence. Passive acquisition of immunity can be compromised by colostral deficiencies, ingestion failure, absorption failure or a combination thereof. Each one of these are influenced by a range of diverse calf characteristics that is age, sex, breed and dam this include dam parity, and environmental and management factors that is housing, time and technique of colostrum provision (Aldridge *et al.,* 1992).

2.3.3. Weaning of the dairy calf

The practice of feeding dairy calves has traditionally been to feed milk or replacer at an amount of approximately 10percent of their body weight (BW) per day (Jasper and Weary 2002). This is referred to as restricted feeding. This allows only for purposes of maintenance requirements and minimal weight gain (National Research Council, 2001). This regime of feeding was introduced to encourage early weaning of calves in order to minimize the costs for feeding milk. Starter concentrate intake started in the first week following birth increases after the first three weeks of life and as a result, the calves start to grow rapidly (Kertz *et al*., 1979).

The worldwide interests in early calf nutrition have been heightened, based on research from (Diaz *et al*., 2001; Jasper and Weary, 2002). Calves that have been allowed to suckle freely or are fed ad libitum ingest about 20 percent of body weight (BW) daily and can gain up to 1 Kg daily (Flower and Weary, 2001). Studies done in the past have reported that in the first three weeks of life, starter concentrate intake is negligible therefore; calves on restricted feeding regimes are at most only able to achieve 20-30 percent of their biologically normal growth (Appleby *et al*., 2001).

There are no reports that indicate the overall economic benefits of various calf feeding systems. During the phase of active growth i.e. the first three months of life, the volume of milk that is approximately 15 percent of body weight is sufficient to allow calves to reach over 50percent of their growth capacity (National Research Council, 2001).

Drackley (2002) reported that no comparative studies have been conducted between calves fed on enhanced early nutrition programs and calves on conventional early weaning programs. These studies are necessary because the differences in the nature of the absorbed end products from the diet (more volatile fatty acids and less glucose and fat in transitioning and weaned calves) might modify the quantitative results; there is no reason to expect that the general relationships would be different from calves fed only milk replacer. However, it is important that appropriate experiments be conducted to verify these relationships in calves fed both milk replacer and calf starter.

Once or twice daily feeding of milk or milk replacer to calves on restricted feeding system does not cause any difference in calf performance (Gleeson *et al*., 2007).There is a possibility of upsetting the digestive system due to overloading the abomasum with milk if the calves are fed large amounts (>4 Liters) of milk once per day in the first few weeks of life (Scientific Veterinary Committee, 1995: Davis and Drackley 1998).

Independent provision of concentrates and water to calves at all times enhances the development of ruminal digestion therefore the amount of milk fed can then be reduced to 10percent of BW at three weeks of age without any known negative impact (Khan *et al*., 2007; Khan *et al*., 2007). Nutritional diarrhoea in dairy calves is a consequence of either inadequate quality of the liquid feed or of management failures (Diaz *et al*., 2001; Nonnecke *et al*., 2003). Animal welfare is reported to be compromised when the average growth of dairy calves is reduced substantially, for example a 50 percent reduction (Scientific Veterinary Committee, 1995).
Davis and Drackley, (1998) reported that calves can be weaned once they can consistently consume 1 kg of concentrates or calf starter per day, a level of intake that is usually reached at the age of five to six weeks if the calves access palatable calf starter and water is available *ad libitum*.

2.3.4. Calf morbidity and mortality

Calf morbidity and mortality are perennial problems for dairy producers worldwide because they are of great economic importance to all dairy producers. Most of the time, morbidity statistics of dairy calves are not available, when available are not as reliable as those in mortality because they depend on the producersô diagnosis, amount of time spent observing the animal, degree of illness expressed by the animal, and tendency of producers not to record every illness event (Bruning-Fann and Keneene, 1992).

In a survey of dairy calf morbidity and mortality in Holstein dairy herds, 20 percent of live-born calves were treated for diarrhea and 15 percent treated for pneumonia before weaning (Waltner-Toews *et al*., 1986b). In one study in Swedish dairy herds a morbidity rate of 7 percent was found. Available literature on global dairy calf mortality from birth to weaning indicates a wide variation from about 1 to 30 percent and even higher (Heinrichs and Radostits, 2001). In a typical commercial dairy herds of 50-200 lactating cows in North America, the population mortality rate of all live born calves from birth to weaning ranges from 5 to 10 percent from year to year and varies from 3 to 30 percent among individual herds from year to year (Heinrichs and Radostits, 2001). A survey on morbidity and mortality of cattle in smallholder dairy farmers in Zimbabwe indicated a mortality rate of 35percent in calves of less one-year of age, which was five times higher than adults (French *et al*., 2001). Similarly, a study on large-scale dairy farms in Tanzania showed mortality rate of up to 20 percent (Kifaro and Temba, 1991). Mortality and morbidity in Kenya.

2.3.5. Calf management practices

All sorts of combinations of feeding, housing and husbandry can be successful adequately implemented when rearing calves (Moran, 1997). In the last 30 years, efforts to improve cost efficiency and rearing systems have changed markedly. Since the 1980ôs there trend was moving towards reduced milk and increased concentrates consumption in an effort to reduce labour requirements while promoting early rumen development (Macdonald, 1999).

Intensified or enhanced early nutrition programs referred to ñacceleratedò growth programs for dairy calves and the worldwide interests in these programs continue to increase. These programs are based on greater than ñconventionalò rates of liquid feeding, approximately twice the dry solids intakes. In turn, rates of body weight gain and stature change are greater (Drackley and Bartlett 2002).

The possible advantages of these programs include better early health, shortened time to first calving, and enhanced future production ability. Disadvantages include greater cost during the young calf period and challenges in transitioning to solid feed intake. While goals of the programs are consistent with normal biological growth when milk is not limited, long-term outcome data needed to evaluate overall profitability are not yet available (Drackley and Bartlett, 2002).

Dairy production in the tropics and more so in East Africa is generally influenced by seasonality in feed availability and quality. Stall-feeding of crop residues, natural (mostly Kikuyu, Star and Rhodes grass) and planted fodder (mostly Napier grass), is common and increasing in importance, particularly in peri-urban dairy keeping households and districts with high human population density. Common crop residues are maize Stover, wheat straw and horticultural crop residues. The fodder (Napier grass or hay) that is used is purchased, some of which originates from roadsides, is commonly practiced by farmers in the most intensive farming areas such as Kiambu District (Staal *et al*., 1998a: 1998b).

There are several management factors that contribute to calf growth and performance and these include animal genetics, feeding of colostrum i.e. the time frame in which it is provided and the quantity as well as hygiene this is necessary for passive transfer of immunity and influences the morbidity and mortality. The feeding system management and housing is also important Hoffman (2003a).

Several workers have described a relationship between housing and health during the rearing period (Gitau *et al*., 1994; Wudu *et al*., 2008). The cleanliness of the barn influences calf health, as calves housed in unclean barns are at higher risk of disease than calves housed in clean barns (Wudu *et al*., 2008).

The reported calf growth rates are low at mean weight gain only 0.24 kg per day up to 5 months of age and high annual calf (up to one year of life) morbidity and mortality that is mostly due to diarrhoea) of 27 and 22percent, respectively, in intensive systems (Gitau *et al.*, 1994b). This poor growth rates result in late age at first calving averaging 41 months (Odima *et al.*, 1994). The low dam milk production is also an important constraint to optimal calf growth.

2.3.6. Dam Nutrition in periparturient period

Dairy cows in the dry period are offered mineral and vitamin mixes in order to prevent issues associated with deficiency in both the cow and the calf. Maternal deficiency of trace minerals and Vitamin E in late pregnancy can compromise the immune system of the calf. This may increase susceptibility to scour, pneumonia, navel-ill and joint-ill among other diseases. It is generally advised to feed dry cow mineral and vitamins for approximately six weeks pre-calving. This is in order to combat deficiencies in the total dietary intake (Emer and Lewis, 2011).

Dry cow nutrition may affect the quality of colostrum (Dann *et al*., 2006, Winkelman *et al.,* 2008). Nutrition and management of the dam throughout the dry period are crucial factors for the metabolic status of the dam and the health of the newborn calves (Davis and Drackley 1998). During the last three weeks of gestation, 60 percent of the total fetal weight is gained and colostrum is synthesized, thus nutrient demand is greater as compared to the far-off period. Cow immune system during transition period is severely suppressed and a restriction of the maternal diet may alter the transfer of passive immunity to calves (Hough *et al*., 1990; Goff 2006).

In the last trimester, adequate energy and protein should be provided while avoiding overfeeding in heifers in order to prevent foetal oversize, excess adipose deposition in the birth canal and resultant dystocia (Mee, 2008). During pregnancy, a developing foetal calf is usually afforded a high priority for maternal nutrients. However, foetal requirements for energy and protein are significant at the latter stages of gestation, for example in late pregnancy, energy requirements increase to about 1.3-1.5 times that required for maintenance (Emer and Lewis, 2011).

The target body condition score in heifers prior to calving is between 2.75 and 3.0 on a scale of 1 to 5. Excess body condition score (BCS) in heifers prior to calving has a significant depreciative effect on both the duration of parturition and incidence of perinatal mortality (Chassagne *et al*., 1999; Dimitrov *et al*., 2000). However there is a contrast in that cows losing excessive BCS may be carrying twins and these require an early dry off as well as feeding to maintain body condition and monitoring in case of obstetrical complications at calving. Placing heifers and cows on a straw diet pre-partum to prevent potential dystocia can lower the immune status of both their colostrum and of their calves (McGee *et al*., 2006).

Basal diets consisting of home-grown forage may necessitate additional supplementation of micronutrients to ensure adequate foetal nutrition (Mee *et al*., 1995). In dairy herds, reducing the dietary cation anion difference (DCAD) in the transition period has been shown to affect a linear decrease in the incidence of milk fever (Mulligan and Doherty 2008) and hence can reduce the risk of slow calvings and compromised neonates.

Therefore rations for dry cows must contain sufficient energy to support maintenance and foetal growth. Providing excess nutrients, particularly energy to put condition on thin cows towards the end of the dry period might negatively affect survival by increasing the incidence of over-conditioning and periparturient disorders. Dystocia, or calving difficulty, is often associated with over-conditioned (fat) cows. Dystocia profoundly affects calf health and survival, as well as cow lactation and reproductive performance (Emer and Lewis, 2011).

2.3.7. Selenium levels in dairy calves

Research on selenium and its nutritional importance has changed markedly in the last 75 years (Alltech, 2003). The research interests lead to the focus on the fact that selenium deficiency causes white muscle disease in domestic animals, (Muth *et al*., 1958; Alltech, 2003).

Selenium levels in animals are dependent on the link; soil-plant-animal whereby intake is dependent on the plant and soil concentrations (Campbell *et al*., 1995; Kamada *et al*., 2007).

In animals, mineral elements constitute a relatively small amount of the diet even though they are vital to animal health, reproduction and productivity. Low concentrations of selenium are essential micronutrients but are toxic at high concentration with only a relatively small difference between these two levels. Selenium is an essential trace element for both animals and humans. In farm animals the recommended dietary selenium concentration is 0.3 mg/kg dry matter (National Research Council, 2001).

Supplementation of livestock diets with selenium may enhance the nutritional quality of livestock products. Selenium supplements are in two principal forms i.e., inorganic mineral salts and organic forms such as Selenium Yeast (Juniper *et al.*, 2006). Under normal dietary conditions, the majority of endogenous selenium is present in body tissues and fluids (Suzuki and Ogra, 2002). Selenium absorption occurs in the small intestine (Weiss, 2003) and after that; selenium is transported to the blood. Concentrations of selenium in serum and whole blood have been used as an index of selenium status because increased concentrations of selenium in serum or whole blood have been related to reduced milk somatic cell count, reduced mastitis and improved neutrophil function (Cebra *et al.*, 2003; Weiss and Hogan, 2005).

Selenium is essential for the development and motility of sperm, influence on immunity indicators that is improvement of bactericidal activity of neutrophils granulocytes, and increase in antibody production as well as an effect on fertility that is reduced cases of retained placenta (Underwood and Suttle 1999). Selenium is a natural antioxidant therefore protects lipid based organelles and cell membranes from oxidation by radicals (Baldi, 2005).

Deficiency of selenium is associated with impaired growth, fertility and health in farm livestock (Phipps *et al.*, 2008). Clinical examination of animals for manifestation of selenium deficiency signs such as locomotory disorders due to muscular dystrophy, heart activity disorders, and increased activity of muscle-specific enzymes in blood plasma and post-mortem macroscopic and microscopic lesions in muscle tissue can be useful in assessing the selenium status in animals (Van Saun, 1990; Fisher *et al.*, 1995). In humansô Phipps *et al.*, (2008) reported selenium deficiency to be a cause of severe cardiomyopathy and joint abnormalities. Therefore dietary selenium requirement is important for both livestock and human health, and has been associated with a reduction in somatic cell count and the disease incidence in cattle (Weiss, 2002). Selenium status analysis in tissues can be complimented by direct determination of selenium content in feeds, blood, and tissues. The determination of selenium levels requires use of whole blood, plasma or serum. Most studies on selenium status and the concentration in whole blood have reference 100εg per liter as the standard level (Van Saun, 1990; Fisher *et al.*, 1995). Selenium levels can also be determined by assessing the activity of glutathione peroxidase since this enzyme contains selenium as its structural component (Enjalbert *et al.*, 1999; Pavlata *et al.*, 2000). These two can however be assessed concurrently as reported by Ortman *et al.*, (1999) and Pehrson *et al.*, (1999) for a comparative basis. The criterion used mostly in the assessment of selenium metabolism in the dam-offspring system is the selenium concentrations in tissues (Van Saun *et al*., 1989). The tissues that can be used for this assay include foetal liver and kidney tissues (Abdelrahman and Kincaid 1993 and Orr and Blakley 1997). Zust *et al*. (1996) used blood plasma and liver tissue to assess the selenium status in calves. Muscular tissue can also be used for the assay of selenium status (Pavlata *et al*., 2001). The objective of this investigation was to assess the relations among selenium concentrations and growth and performance of dairy calves.

The positive effect of selenium supplementation on clinical disease is probably mediated via effects of selenium on neutrophils and other immune cells. The aim of the current study was to find out how blood concentration of selenium affects dairy calf growth and performance.

The function of selenium is essential in the production of glutathione peroxidase (Hatanaka *et al.*, 2000), which works in conjunction with vitamin E (Douill *et al.*, 1998) protect cell membranes from damage caused by free radicals produced by oxidative metabolism (Clausen *et al.,*1989).

Studies of selenium levels in tissues has taken center stage in the human physiology as a potential anticancer agent (Clark *et al.*, 1996 ; Combs and Clark 1999) by promoting formation of white blood cells which destroys the cancer cells and is an essential component of more than 10 selenoproteins with multiple biochemical functions. In humans selenium boosts the immune system (Girodon *et al.*, 1999) by increasing the activity and number of white blood cells and prevents premature aging, degenerative diseases, cardiovascular diseases, inflammatory diseases, stroke, cataracts, and rheumatoid arthritis. It is also necessary for normal thyroid functions (Dejneka *et al.*, 2007) and protection of heavy metal toxicity. Deficiency of the element can cause Keshan disease, characterized by an enlarged heart and poor heart function (Yang *et al.*,

1984) or to be a factor for essential hypertension (Babalola *et al*., 2007). This disorder is endemic in some of most selenium-poor soils in the world. High blood levels of selenium can result in selenosis, which is associated with gastrointestinal upsets, hair loss, white blotchy nails and mild nerve damage (Gasmi *et al.*, 1997).

The trace element concentrations in body fluids i.e. blood, serum, urine and tissue is used as the standard indicator of the trace elements levels of the body. The determination of metals *in vivo* in organs is not possible and it is done indirectly and as a result accurate and precise methods for trace metal determination in different biological fluids and tissue are essential. There are several methods available for selenium determination in different biological materials, the most common technique is atomic absorption spectrometry (AAS), both hydride generation AAS (HG-AAS) (Tiran *et al.*, 1993;Dong 1997) and electro-thermal AAS (ETAAS) (ķahin *et al*., 2005; Vale *et al.*, 2007; Da Silva *et al.*, 2010).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. Study area

The study was conducted in Mukurweini District of Nyeri County, Kenya in the period between May and August 2012. Nyeri County is located in Central Kenya and covers a total land area of about 3,266 sq km. The County is sub-divided into seven districts namely; Othaya, Mukurweini, Mathira, Kieni East, Kieni West, Municipality and Tetu, (Table 3.1) with 39 locations and 193 sub-locations. Mukurweini District measures 179.2 km2 and borders Kirinyaga West to the South-East, Mathira and Tetu Districts to the North, Nyeri South to the West and Murangôa East and West to the south. The District was previously divided into seven administrative locations: (Gakindu, Giathugu, Gikondi, Githi, Muhito, Rutune and Thanu) but has been reorganized into four divisions, fifteen locations and 29 sub locations. The earlier locations also constitute the electoral wards for the Nyeri County Council. The total human population is 87,447 with a density of 459 persons per sq km, Nyeri District Strategic plan (2005-2010). Dairy farming is an important enterprise in the County, with the farmers practicing zero-grazing methods, where pastures are cut and carried to the cattle (MOLD/DLPO Annual report, 2008).

Table 3. 1. Administrative units in Mukurweini District, Kenya and their respective sizes

LOCATION	TOTAL	Household	Area	Density
Gakindu	14,111	3723	22.7	622
Muhito	17,407	4447	28.3	615
Githi	11,679	2869	28.2	414
Giathugu	15,618	3841	30.8	507
Gikondi	19,234	4587	37.8	509
Rutune	9,398	2138	31.7	296
Mukurweini District	87,447	21,605	179.5	487

Kenya National Bureau Statistics, 2009

Figure 3. 1. Map of Mukurweini District, Nyeri County, Kenya showing the locations of Mukurweini District, 2003 (PACE Kenya Data Base, 2006).

3.2 Study design

An observational and completely randomized controlled trial (RCT) was conducted in Mukurweini District of Nyeri County Kenya between May and August 2012. Observational data from the smallholder dairy farms included: nutritional practices, animal demographics, and measurements of calf size and health. The randomized controlled trial was a 3×3 factorial feeding design to test nine feed interventions and their effects on calf growth and health on smallholder dairy farms in Mukurweini District Nyeri County Kenya. The smallholder dairy farms with Holstein-Friesian cattle were selected purposively based on Wakulima Dairy Limited records of artificial insemination that projected the farms that were likely to have a newborn calf (< 1 week old), and the farmersô willingness to participate in the study. Due to the repeated weekly measurements each calf was to contribute a total of 8 observations during the study period giving a total of 280 observations for the whole study period. These farms were allocated identification numbers between one and 36 (Table 3.2). Farm numbers 10 and 24 were excluded from the study since the calves died. Farm number three had two animals enrolled in the study giving a total of 37 animals however two animals were excluded from the study i.e. farm number 10 and 24 due to pre-mature mortality thus giving a total of 35 animals under study (Table 3.2).

On being born, and after evaluation, the study calves were randomly allocated to one of the nine feed intervention groups, i.e., an estimated four calves per feed intervention group. The nine feed groups were based on three possible groups of calf starter intake and three groups of milk intake hence the 3×3 factorial feeding design.

The nine feed interventions therefore outlined were; control calf starter + control milk intake (1), control calf starter + half milk intake (2), control calf starter + full milk intake (3); half calf starter; Half Calf Starter + Control Milk Intake (4), Half Calf Starter +Half Milk Intake (5), Half

Calf Starter +Full Milk Intake (6) and Full Calf Starter +Control Milk Intake (7), Full Calf Starter +Half Milk Intake (8), Full Calf Starter +Full Milk Intake (9). Full calf starter intake was defined as lead feeding to achieve up to 1 kg/day at weaning, half calf starter was to maximize intake at 0.5kg/day at weaning, while control calf starter intake was whatever calf starter intake the farmer normally offered (ranged from 0-0.2 Kg/day). Full milk intake was defined as 4 Liters/day; and half milk intake was 2 Liters/day, while control milk intake was whatever milk quantity the farmer normally offered (ranged from 2-5 liters/day). The period of data collection by calf examination and visual observation was from May 2012 to August 2012.

Table 3. 2. Summary of the nine feed intervention groups for the study calves

	Full calf starter (FCS)	**Half calf starter (HCS)**	**Control calf starter (CCS)**
Full milk intake (FMI)	Feed intervention Group 9; n=4 Calf id.:5,19,22,27	Feed intervention Group 6; n=4 Calf id.:1,13,25,31	Feed intervention Group 3; n=3 Calf id.:4,17,34
Half milk intake (HMI)	Feed intervention Group 8; n=4 Calf id.:8,11,18,30	Feed intervention Group 5; n=3 Calf id.:3,26,33	Feed intervention Group 2; n=4 Calf id.:6,15,20,35
Control milk intake (CMI)	Feed intervention Group 7; n=4 Calf id.:7,14,28,29	Feed intervention Group 4; n=4 Calf id.:2,16,23,32	Feed intervention Group 1; n=5 Calf id.:3,9,21,24,36
Total number of study calves	12	11	12

KEY:
CCS: control calf starter=range 0 ï 0.2Kgs calf starter   CMI: control milk intake =5.5 liters milk
HCS: half calf starter = 0.5Kgs calf starter   HMI: half milk intake = 2 liters milk
FCS: full calf starter =1 Kgs calf starter   FMI: full milk intake =4 liters milk
n= number of calves in each feed intervention group

3.2.1. Farm and calf sampling frame and sampling

The target population of the study consisted of smallholder dairy farmers in Mukurweini District, Nyeri County, Kenya. The study farms were selected purposively based on WDL (Wakulima Dairy Limited) records of artificial insemination (AI) that projected the farms that were likely to have a newborn calf (<1 week old) on the farm, and as well as based on the farmersô willingness to participate in the study. The other important factor of selection of the farms was that each of the homesteads had to have a maximum of 4 animals and belong to WDL (Wakulima Dairy Limited) in order to be enrolled. The coordinator of WDL (Wakulima Dairy Limited) provided a list of eligible active members to facilitate this process.

A total of 36 smallholder farms were then purposively selected from the list to represent a broad cross-section of the WDL (Wakulima Dairy Limited) members and each was assigned an identification number a figure between numeral one and 36.

The farmers were then requested to participate in the study and those who agreed were asked to sign a written consent. The consent outlined the purpose of the study and the number of visits to be made. Farmers notified the research team when their dams calved.

The 35 study calves were randomly allocated to the nine feed intervention groups, which included combinations of milk intake, calf starter and controls (which were the feeds that the farmer normally gave to their dairy calves).The study calves were recruited in May and June 2012.

3.2.2. Household interviews for house/farm demographics

The data collected during the study period included; observational data from the selected farms which included nutritional practices and animal demographics and measurements of calf size and health.

During the first visit, baseline information was collected by personal interview using a comprehensive questionnaire administered in English or Kikuyu to determine the general farm characteristics, calf management techniques including peri-parturient care, feeding and housing and previous history of calf diseases. The questionnaire was closed type for its major part and was administered to the head of the household or the person in charge of managing the cattle during the visit (Appendix I).

The questionnaire further obtained household data through questions on the gender, marital status, and education background of the responsible personnel for the calf, experience in dairy farming, size of the farm and household, and percentage income from dairy farming. There was information on calf management practices that is weaning age, type of housing, type of milk feeding (bucket or suckling), time to first colostrum ingestion, and amount of colostrum fed on first day.

3.2.3. Data on specific calf management during the trial

At the first farm visit, the study calf variables recorded included: date of birth, sex, dam parity, and breed. The questionnaire (Appendix I) was structured with closed form (categorical) questions to ease administration, minimize variation and improve precision. Data on the type of management practice i.e., housing criteria and hygiene ; housing was either individually in a pen or in a group, housing hygiene was dependent on the floor type, comfort and cleanliness this was verified by physical inspection of the farm at the time of the interview.

On each subsequent visit, which was every seven days, a follow-up calf survey form (Appendix 2) was completed. The main activity observed was the different calf management aspects like cleanness of the calf pen. This included making an assessment of the condition of the flooring in the calf house (presence of potholes, drainage, and accumulation of dung) and general hygiene of the calf. Housing condition was graded from 1 to 6; (1=poor; presence of potholes, absence of drainage, and excessive accumulation of dung, 2-4=average; minimal potholes, minimal drainage, and minimal accumulation of dung), 5 and 6=good (absence of potholes, adequate drainage, and no accumulation of dung).

The feeding practices were also assessed by asking the calf attendants questions on the quantity of milk or calf starter fed to a calf per day along with other feeds provided and drinking water availability. The feed available to the calves was recorded according to the type of forage. Different species of forage from the feed bundles in the calf manger were separated and identified. The supplements fed to the study calves were also identified and recorded. The occurrences of ill health cases between visits were also recorded and treatments of the calves in the study were administered when necessary.

3.2.4. Clinical examination of the study calves

Clinical examinations of the dairy calves were performed in a routine manner. All the calves received visual health appraisal every week that was recorded.

The main activities accomplished during the regular visits were clinical examination of calves for any health problem. This was assessed visually using subjective criteria i.e., appetite and manure consistency as well as through a physical exam of the cardiopulmonary system, gastrointestinal system, feet and skin condition or any other ailment.

Measurements were taken on the calves on a weekly basis for a period of eight weeks at ages ranging from 3 days old to 60 days old. The body height was measured from the withers to the ground at the heel, and weight was estimated by measuring the heart girth using a weight band tape while calves were in standing position. The heart girth obtained was then used to estimate the bodyweight using the following formula: Bodyweight [kg] = (Heart girth [cm] ï 67.07)/0.4 (Changôa et al., 2010).

3.2.5. Collection of blood samples for selenium analyses

On the first visit to the farm following the birth of a calf, whole blood was collected between 24 hours and seven days after birth through jugular venipuncture using bleeding needles directly into Vacutainer® tubes with clot activator. The tubes were allowed to stand for 10 minutes for the whole blood to clot and were stored on ice packs in plastic cool boxes for transportation to the laboratory. Serum was harvested from the clotted whole blood after centrifuging at 3000 rpm for 10 minutes, and then stored at ï20°C until analysis. In this study, the selenium status determinations were performed on serum that was collected from calves that were aged between 1 ï 3 days. Serum was selected as the medium to measure selenium because serum selenium is more accurate in measuring the short term changes in selenium status than whole blood selenium (Gerloff, 1992).

The serum selenium concentration was determined by atomic absorption spectrometry at the GMP Laboratories in Nairobi. In an atomic absorption analysis the element being analyzed must be reduced to the elemental state, vaporized, and imposed in the beam of radiation from the source (Skoog, 1997).

There are three basic principles of atomic absorption spectroscopy and these can be expressed by three simple statements i.e., all atoms absorb light, the wavelength at which light is absorbed is specific for a particular chemical element and the amount of light absorbed is proportional to the concentration of absorbing atoms. Essentially, quantitative analysis by atomic absorption spectroscopy is a matter of converting samples and standards into solutions, and then comparing the instrumental responses of standards and samples. These comparative responses are then used to establish accurate concentration values for the element of interest.

3.3. Data handling and analysis

The data were entered and stored in Microsoft office Excel 2010 (Microsoft Corporation, 2010) and analysed using SAS (Statistical Analytical System version 9.1.3 portable). Observed data lines/curves were plotted to help visualize the increases in mean weekly weights and heights for each feed group over the various time points. Data on weekly weight and height of the calves were converted to average daily gain (ADG) in weight for each week. ADG of weight were analyzed using analysis of variance (ANOVA) under the general linear model (GLM) procedure in SAS at pÒ0.05 to determine a feed group effect and interaction on calf performance. Post hoc Bonferroni test calculates a new pair wise alpha to keep the family wise alpha value at 0.05 (or another specified value). The formula for doing this is as follows: $\alpha_B = \frac{\alpha_{FWE}}{c}$ where Ŭ$_B$ is the new alpha based on the Bonferroni test that should be used to evaluate each comparison or significance test, Ŭ$_{FWE}$ (family wise error) is the family wise error rate as computed in the first formula, and *c* is the number of comparisons (statistical tests).

CHAPTER FOUR

4.0 RESULTS

4.1. Calf morbidity and mortality

There were two calf withdrawals as a result of a stillbirth and mortality two days after recruitment into the study. During the study period, 17.1 percent (6/35) of the calves got sick from diarrhea and pneumonia at 11.4 percent (4/35) and 5.7 percent (2/35) respectively. While during the study 5.7 percent (2/35) of the calves died (Table 4.1). Diarrhea was the most dominant at of the cases. The calves that got sick were from feed intervention groups control calf starter and control milk intake (1), control calf starter and half milk intake (2), half calf starter and control milk intake (4), half calf starter and half milk intake (5), half calf starter and full milk intake (6) and full calf starter and half milk intake (8) while those that died were also from different feed intervention groups i.e. full calf starter and full milk intake (9) and full calf starter and control milk intake (7) .

Table 4. 1. Summary of the morbidity and mortality among the 35 dairy calves enrolled in a randomized control survey in Mukurweini District, Kenya between May and August 2012

Calf status	Frequency	Proportion (percent)
Morbidity	6/35	17.1
Mortality	2/35	5.7

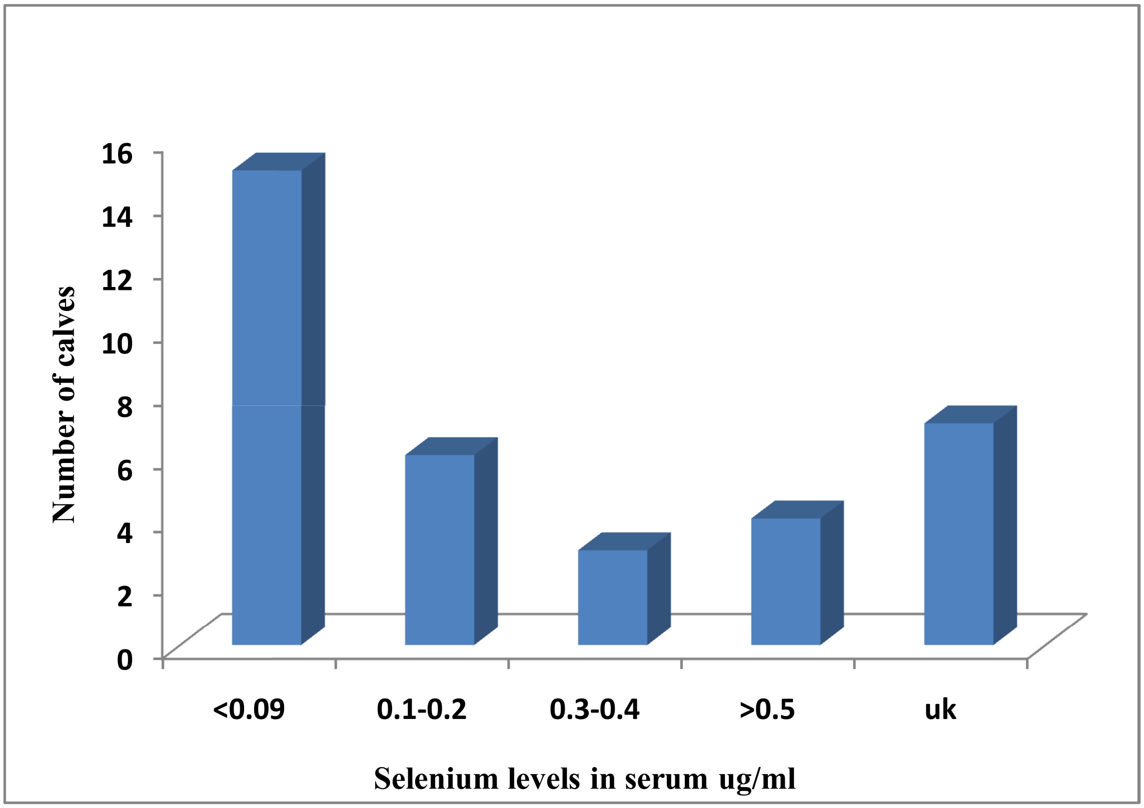
4.2. Serum selenium levels in the study calves and the associated morbidity and mortality during the study period

Selenium content was determined in 28 blood samples from the individual calves, the remaining seven were not determined due to storage faults and thus they were damaged. The results of this study showed a varied distribution in terms of the serum selenium levels. The levels ranged from <0.09 to > 0.5 µg per ml. The serum selenium mean concentration was 0.2023 εg of selenium per ml of blood with standard deviation of 0.2145 εg per ml and a range of between 0.0053 and 0.6745 εg per ml**.** The present study revealed an increase in incidence of disease with selenium concentration levels less than 0.1 εg/ml of serum of the study calves.

The highest number of calves at 42.8 percent (15/35) were in the category of <0.09 µg per ml while the lowest number of calves 8.5 percent (3/35) were in the category of between 0.3 and 0.4 µg per ml. There were some of the study calves whose serum selenium levels could not be determined at 20 percent (7/35) due to poor storage of the samples leading to spoilage (Figure 4.1).

According to the study findings, the calves that got sick, 83.3 percent (5/6) had serum selenium levels that were Ò0.1196 µg per ml while only one calf 16.7 percent (1/6) had serum selenium levels of 0.4110 µg per ml, (Figure 4.1).The results of the study also showed that out of the calves that died during the study period, one had serum selenium level of 0.3146 µg per ml while the other had an unknown selenium level as the samples were deemed futile (Figure 4.1 and Table 4.2).

Figure 4. 1. Serum selenium levels in serum of 35 dairy calves in smallholder dairy farms of Mukurweini district, Kenya



Key:

uk= unknown levels due to spoilage

<0.09= low serum selenium levels

Table 4. 2. Calf morbidity and mortality in relation to the serum selenium levels across the 35 dairy calves enrolled in a randomized control survey in Mukurweini District, Kenya between May and August 2012

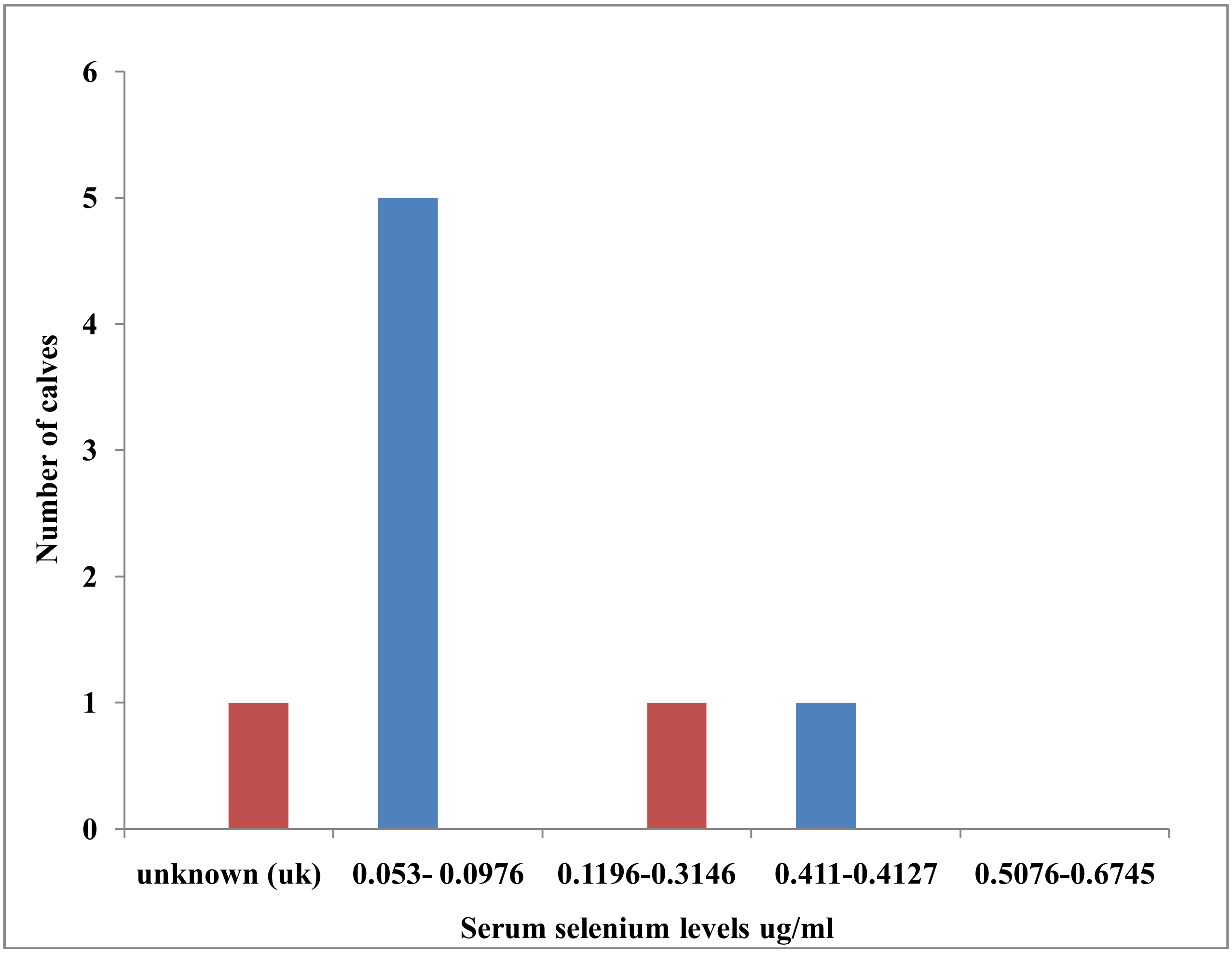
Selenium levels (µg/ml)	Morbidity	Mortality
unknown (uk)	0	1
0.053- 0.0976	5	0
0.1196-0.3146	0	1
0.411-0.4127	1	0
0.5076-0.6745	0	0
Totals	6	2

Key:

uk= unknown levels due to spoilage

<0.09= low serum selenium levels

Figure 4. 2. Serum selenium levels and the related study calf morbidities and mortalities in the 35 study calves in Mukurweini district Nyeri county Kenya



KEY:

Morbidity

Mortality

4.3. Farm demographics and management practices

Based on the questionnaire, it was found that male entrepreneurs managed the majority of the dairy farms 65.7 percent, however they assumed a supervisory role in most of the activities, and they were instrumental with regard to purchasing of farm inputs and selling activities. All the animals kept were dairy pedigree, Holstein Friesian and all the farmers practiced cut-and-carry zero-grazing production system for their animals in free-stall units. As indicated in Table 4.2, out of the 35 respondents, 65.7 percent (23/35) were males and 34.3 percent (12/35) were females, and part of the female headed households originated from widowhood. The study also indicated that 91.4 percent (32/35) of the respondents were married, 5.7 percent (2/35) of the respondents were widowed, while only 2.9 percent (1/35) was not married.

During the study, 54.3 percent (19/35), of the farmers had more than 10 years dairy farming experience while 34.3 percent (12/35) had 4-9 years and only 11.4 percent (4/35) had 1-3 years dairy farming experience (Table 4.3).

The household sizes ranged from less than 2 persons to more than 5 persons per household. Of the sampled population, the highest proportion of 57.1 percent (20/35) had household sizes that ranged between 3-5 persons while 28.6 percent (10/35) of the population had household sizes of equal to or less than 2 persons. Only a small proportion of 14.3 percent (5/35) had a household size of more than 5 persons (Table 4.3).

High literacy levels (97.1 percent) were found among the farmers interviewed, with only a small proportion of 2.9 percent (1/35) being illiterate. This is indicated by the fact that most of the farmers in the study had attained secondary school education and primary school education at

57.1 percent (20/35) and 37.1 percent (13/35), respectively; while a small proportion of 2.9 percent (1/35) had attained college education. A small proportion of 2.9 percent (1/35) had no formal education (Table 4.3).

The results showed a skewed distribution of land acreage. Over half of farms reported land ownership of less than 2 acres, while 31.4 percent (11/35) of the farmers had land equal to 2 acres, 14.3 percent (5/35) of the farmers indicated that they owned more than 2 acres in area, and a only a small proportion of 2.9 percent (1/35) had land that was of an unknown size, since they could not describe the size of their land (Table 4.3).

Of the 35 farmers interviewed, 48.6 percent (17/35) had other sources of income and only depended on dairy farming for less than 50percent of their income while 40 percent (14/35) indicated keeping of livestock as a source of 50-70 percent of their income. Only a small proportion of 11.4 percent (4/35) depended on dairy farming for more than 70 percent of their daily livelihoods (Table 4.3).

Table 4. 3. General description of the farmer socio-demographic characteristics in 35 dairy farms in a randomized control in Mukurweini District, Kenya between May and August 2012

Factor	category	Frequency	Proportion (percent)
Respondentôs gender	Male	23	65.7
	Female	12	34.3
Marital status	Married	32	91.4
	Widowed	2	5.7
	Single	1	2.9
Education level	Non-formal	1	2.9
	Primary	13	37.1
	Secondary	20	57.1
	College	1	2.9
Dairy farming experience	1-3 years	4	11.4
	4-9 years	12	34.3
	>10 years	19	54.3
Land sizes	<2 acres	18	51.4
	2 acres	11	31.4
	>2 acres	5	14.3
	unknown	1	2.9
Household sizes	<=2 persons	10	28.6
	3-5 persons	20	57.1
	>5 persons	5	14.3
Percentage income from dairying	<50 percent	17	48.6
	50-70 percent	14	40.0
	>70 percent	4	11.4

4.4. Calf management practices

As indicated in Table 4.2, of the 35 calves recruited into the study, 60 percent (21/35) were male while the rest, 40 percent (14/35), were female. Parity among their dams ranged from 1 to 9. Out of the 35 cows, 51.4 percent (18/35) were between the 3rd and the 6th parity, with 37.2 percent (13/35) being their 1st and the 2nd calving, while only a small proportion of 11.4 percent (4/35) had calved more than six times (Table 4.4).

The farmers indicated a high degree of intervention in managing newborn calves; 97.1 percent (34/35) of the owners indicated that feeding of first colostrum was done in less than six hours after birth, and only.9 percent (1/35) stated that calves were fed colostrum six to twelve hours after birth. About 97.1 percent (34/35) of the households practiced bucket calf-feeding technique, while 2.9 percent (1/35) allowed the calf to suckle the dam either before or after milking (Table 4.4).

The respondents fed their dairy calves on calf starter at different calf ages; 45.7 percent (16/35) at 3 months of age, and 37.1 percent (17/35) provided their dairy calves with calf starter earlier than 3 months, while 17.1 percent (6/35) of the respondents weaned their calves at more than 3 months of age (Table 4.4).

Regarding calf housing, 88.6percent (33/35) of farms visited had a separate calf unit, while 11.4percent (4/35) kept calves in the same shed as adult animals (Table 4.4).The height of Napier grass at harvesting was mostly less than 1 meter, at 68.58percent (24/35), while 31.4percent (11/35) harvested their Napier grass at more than 1 meter of height for the calves (Table 4.4).

Table 4. 4. General description of the calf characteristics and management factors in 35 dairy farms in a randomized control trial in Mukurweini district, Kenya between May and August 2012

Factor	Category	Frequency	Proportion (percent)
Sex of calves	Male	21	60.0
	Female	14	40.0
Dam parity	1-2 calving	18	51.4
	3-6 calving	13	37.2
	>6 calving	4	11.4
Weaning age	Never	13	37.1
	3 months	16	45.8
	>3 months	6	17.1
Age at first colostrum feeding	<6 hours	34	97.1
	6-12 hours	1	2.9
Separate housing	Yes	31	88.6
	No	4	11.4
Napier grass height at harvesting	<1 meter	24	68.6
	>1 meter	11	31.4

4. 5. Forage and nutritional management practices

As indicated in Table 4.4, the animals were primarily fed on forages such as Napier grass (*Pennisetum purpureum*) at 74.3 percent (24/35), while other grasses, which included *Desmodium spp*., Rhodes grass (*Chloris gayana*) and Kikuyu grass (*Pennisetum clandestum*), were fed at 77.1 percent (27/35) of farms (Table 4.4).The crop residues given included banana leaves at 74.3 percent (26/35) and sweet potato vines at 65.7 percent (23/35). A mineral salt lick was provided to calves at 20.0 percent (7/35) of farms (Table 4.5). Water was provided *ad libitum* on 77.1 percent of farms, while other farms did not give their calvesô access to water all the time.

Table 4. 5. General description of the forage characteristics and management factors in 35 dairy farms in a randomized control trial in Mukurweini district, Kenya between May and August 2012

Factor	**Category**	**Frequency**	**Proportion (percent)**
Napier grass provision	Yes	26	74.3
	No	9	25.7
Other grasses provision	Yes	27	77.1
	No	8	22.9
Banana leaves provision	Yes	9	25.7
	No	26	74.3
Sweet potatovines provision	Yes	23	65.7
	No	12	34.3
Minerals provision	Yes	7	20.0
	No	28	80.0
Water provision	Always	27	77.1
	Not- always	8	22.9

4.6. Weekly weight gain in the study dairy calves on smallholder dairy farms in Mukurweini District, Kenya

Table 4.6 shows the mean weekly weights at the end of the study period. The feed intervention groups Full calf starter +Control milk intake (7) and Half calf starter +Half milk intake (5) recorded the highest and lowest mean weights at 64.65 Kgs and 49.94 Kgs respectively for the whole study period (Table 4.6).

The feed intervention group: Half Calf Starter +Half Milk Intake (5) was significantly different $p < 0.05$ from feed intervention groups: Control calf starter + Control milk intake (1) Control calf starter + Half milk intake (2), Control calf starter + Full milk intake (3), , Half calf starter +Full milk intake (6), Full calf starter +Control milk intake (7), and Full calf starter + Half milk intake (8).

The weight of calves in the feed intervention group Full calf starter + Control milk intake (7) was significantly different $p < 0.05$ from those of feed intervention groups: Control calf starter + Control milk intake (1), Control calf starter + Half milk intake (2), Control calf starter + Full milk intake (3), Half Calf Starter +Control Milk Intake (4), Half Calf Starter +Half Milk Intake (5), Full calf starter + Half milk intake (8) ($p=0.0015$) and Full calf starter +Full milk intake (9).

The nine feed interventions had an overall positive significant group effect on the outcome weekly weight gain with F-value of 5.88 and ($p< 0.001$). i.e., there was progressive weight gain in the calves fed under the nine different regimes.

Table 4. 6. General description of the forage characteristics and management factors in 35 dairy farms in a randomized control trial in Mukurweini district, Kenya between May and August 2012

Feed intervention	Mean wkly weight	SEM	LL	UL	SD	COV
CCS+CMI	56.01	1.72	52.63	59.39	10.19	18.18
CCS+HMI	59.11	1.92	55.62	59.10	11.05	18.69
CCS+FMI	57.98	1.93	54.50	61.46	11.09	19.12
HCS+CMI	53.93	1.44	50.59	57.26	8.64	16.02
*HCS+HMI**	*49.94*	*1.54*	*46.09*	*53.79*	*8.02*	*16.06*
HCS+FMI	62.09	2.08	58.70	65.46	12.31	19.82
*FCS+CMI**	*64.65*	*2.17*	*60.73*	*68.57*	*11.07*	*17.11*
FCS+HMI	56.15	1.46	52.71	59.57	8.54	15.21
FCS+FMI	52.73	1.80	48.95	56.51	9.53	18.08

KEY;
SEM- standard error of mean
LL-lower limit
UL-upper limit
SD-standard deviation
COV-coefficient of variation

Feed intervention:
CCS: control calf starter=0-0.2 Kgs/day
HCS: half calf starter= 0.5 Kgs/day
FCS: full calf starter= 1 kg /day
CMI: control milk intake= 5.5 liters /day
HMI: half milk intake = 2 liters/day
FMI: full milk intake= 4 liters/day

4.7. Bonferroni test results for the mean weekly weight (Kg)

The post hoc Bonferroni test result showed that feed intervention groups Half calf starter + Half milk intake (5) and Full calf starter + Control milk intake (7) were significantly different $p<0.05$ from the rest of the feed intervention groups **(**Table 4.7).

Table 4. 7. Bonferroni test results of Dairy calf mean weekly weight (Kg) in relation to the feed intervention subjected to on smallholder dairy farms in Mukurweini District, Kenya.

Feed intervention group	Mean weekly weight
(Half calf starter + Half milk intake)5	49.94[a]
(Full calf starter + Full milk intake) 9	52.73[ab]
(Half calf starter +Control milk intake)4	53.93[ab]
(Control calf starter + Control milk intake)1	56.01[abc]
(Full calf starter + Half milk intake) 8	56.15[abcd]
(Control calf starter + Full milk intake)3	57.98[abcd]
(Control calf starter + Half milk intake)2	59.11[bcd]
(Half calf starter +Full milk intake)6	62.09[cd]
(full calf starter +control milk intake)7	64.65[d]

*The feed intervention group labeled [a] is significantly different from all the groups labeled [ab, abc, abcd, bcd, cd] and [d]. The feed intervention group labeled [d] is also significantly different from all the groups labeled [cd, bcd, abcd, abc, ab] and [a]. The feed intervention groups exclusive with the letter [a] and [d] while the rest have an interface between the letters [a, b, c] and [d.]

4.8. Calf and farm level factors associated with overall weight gain for calves in smallholder dairy farms of Mukurweini district of Kenya

A Univariate linear regression model was created using SAS to evaluate the effect of the calf and farm level factors on the mean weekly weight gains for the 35 dairy calves (Table 4.8). The findings showed that there was positive significant association $p<0.05$ across the nine feed intervention groups and the mean weekly weight gains at ($p <0.001$), (Table 4.8). The calf sex was also significantly associated with the mean weekly weight gains at ($p<0.05$).According to the findings of this study; the male calves had recorded a lower mean weekly weight gain as compared to their female counterparts. The housing conditions i.e., housed separately or not housed separately were also significantly associated with the mean weekly weight gains at ($p <0.05$), (Table 4.8).

Table 4. 8. Univariate linear regression models; effect of feed intervention group, calf sex and housing on the mean weight gain in 35 friesian calves in smallholder dairy farms of Mukurweini district of Kenya

Variable	Coefficient	F-value	P-value
Dairy experience	19.06	0.27	0.765
Household size	18.96	1.77	0.172
Dam parity	18.90	2.70	0.069
Colostrum provision time	19.03	0.50	0.480
feed intervention group [a]	6.86	6.41	<0.001*
Calf sex [b]	18.87	5.33	0.022*
Housing [c]	17.92	37.00	<0.001*

All the factors assessed are listed but those that were found significant are those marked with *.

[a] Feed intervention groups

[b] Calf sex (male versus female)

[c] Housing (separated versus grouped)

4.9. Study calf mean weekly height gain (cm)

As indicated in Table 4.8, the mean weekly heights were different across the nine feed intervention groups at the end of the trial. The feed intervention groups that contained Full calf starter + Control milk intake (7) and Half calf starter + Half milk intake (5) were significantly different from the other feed intervention groups with recorded means weekly heights of 84.2 cm and 75.6 cm respectively (Table 4.9). The feed intervention group Full calf starter + Control milk intake (7) had the highest mean weekly Height at 84.2 Cm for the whole study period while the other feed intervention with a significantly different mean i.e., Half calf starter +Half milk intake (5) had the lowest mean weekly weight gain of 75.6 Cm (Table 4.9). The nine feed interventions had an overall significant effect on the weekly height gains with F-value of 6.41 and ($p < 0.05$).

Table 4. 9. Study calf mean weekly height gain (cm) in relation to the nine feed interventions subjected to calves on smallholder dairy farms in Mukurweini District, Kenya

Feed intervention	Mean weekly Height	SEM	LL	UL	SD	COV
CCS+CMI	79.97	0.78	78.16	81.78	4.62	5.77
CCS+HMI	80.17	0.83	78.30	82.03	4.75	5.93
CCS+FMI	78.94	1.06	77.07	80.80	6.06	7.68
HCS+CMI	78.03	0.87	76.24	79.81	5.24	6.71
*HCS+HMI**	*75.59*	*0.97*	*73.53*	*77.65*	*5.06*	*6.70*
HCS+FMI	81.43	1.00	79.61	81.42	5.94	7.29
*FCS+CMI**	*84.17*	*1.13*	*82.07*	*86.27*	*5.75*	*6.83*
FCS+HMI	78.66	0.85	76.82	80.49	4.98	6.34
FCS+FMI	76.29	1.23	74.26	78.31	6.49	8.51

KEY;
SEM- standard error of mean
LL-lower limit
UL-upper limit
SD-standard deviation
COV-coefficient of variation

KEY; the feed interventions

CCS: control calf starter=0-0.2 Kgs/day

CMI: control milk intake= 5.5 liters /day

HCS: half calf starter= 0.5 Kgs/day

HMI: half milk intake = 2 liters/day

FCS: full calf starter= 1 kg /day

FMI: full milk intake= 4 liters/day

4.10. Bonferroni test results showing the study calf mean weekly Height (cm) in relation to the feed intervention subjected to on smallholder dairy farms in Mukurweini District, Kenya.

A post hoc Bonferroni was done to determine the effect of the nine feed intervention groups on the outcome: height gain (Cm). The study findings revealed significant difference $p<0.05$ across; feed intervention groups Half calf starter + Half milk intake (5) (75.59^{a}) and the rest of the feed intervention groups as well as across Full calf starter + Control milk intake (7) (84.17^{d}) and the rest of the feed intervention groups (Table 4.10).

The post hoc results revealed a significant difference $p<0.005$ across feed intervention group Half calf starter + Half milk intake (5) and Control calf starter + Control milk intake (1) ,Control calf starter + Half milk intake (2) ,Control calf starter + Full milk intake (3) , Half calf starter +Full milk intake (6) ,Full calf starter + Control milk intake (7) (, and Full calf starter + Half milk intake (8) .

There was also significant difference $p<0.05$ across feed intervention group: Full calf starter + Control milk intake (7) and Control calf starter + Control milk intake (1) , Control calf starter + Half milk intake (2) , Control calf starter + Full milk intake (3) , Half calf starter +Control milk intake (4), Half calf starter + Half milk intake (5), Full calf starter + Half milk intake (8) and Full calf starter + Full milk intake (9) .

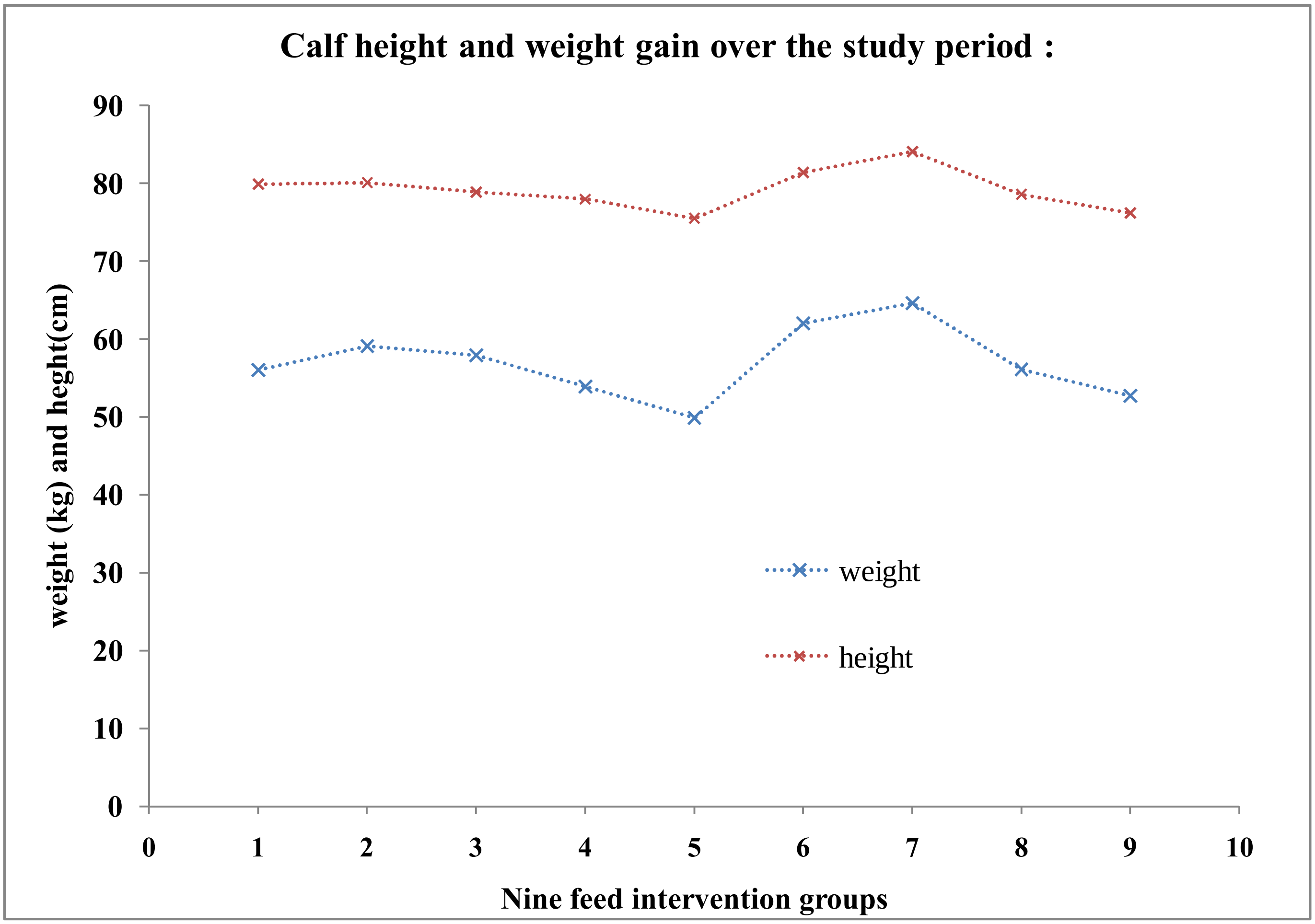
Table 4. 10. Bonferroni test results of Dairy calf mean weekly Height (cm) in relation to the feed intervention subjected to on smallholder dairy farms in Mukurweini District, Kenya.

Comparison-wise error rate = 0.0014

Feed intervention group	Mean weekly height
Half calf starter + Half milk intake (5)	*75.59*[a]
Full calf starter + Full milk intake (9)	76.29[ab]
Half calf starter +Control milk intake (4)	78.03[abc]
Control calf starter + Control milk intake (1)	78.66[abc]
Full calf starter + Half milk intake (8)	78.94[abc]
Control calf starter + Full milk intake(3)	79.97[abcd]
Control calf starter + Half milk intake (2)	80.17[bcd]
Half calf starter +Full milk intake (6)	81.43[cd]
Full calf starter + Control milk intake (7)	*84.17*[d]

*The feed intervention group labeled a is significantly different from all the groups labeled [ab, abc, abcd, bcd, cd] and [d]. The feed intervention group labeled d is also significantly different from all the groups labeled [cd, bcd, abcd, abc,ab] and [a].

Figure 4. 3. Graph demonstrating the differences in weight (kg) and height (cm) gain between calves in the nine feed intervention groups in smallholder dairy farms in Mukurweini District, Kenya.



KEY: Feed intervention groups;

1 = Control calf starter + Control milk intake, 2= Control calf starter + Half milk intake,

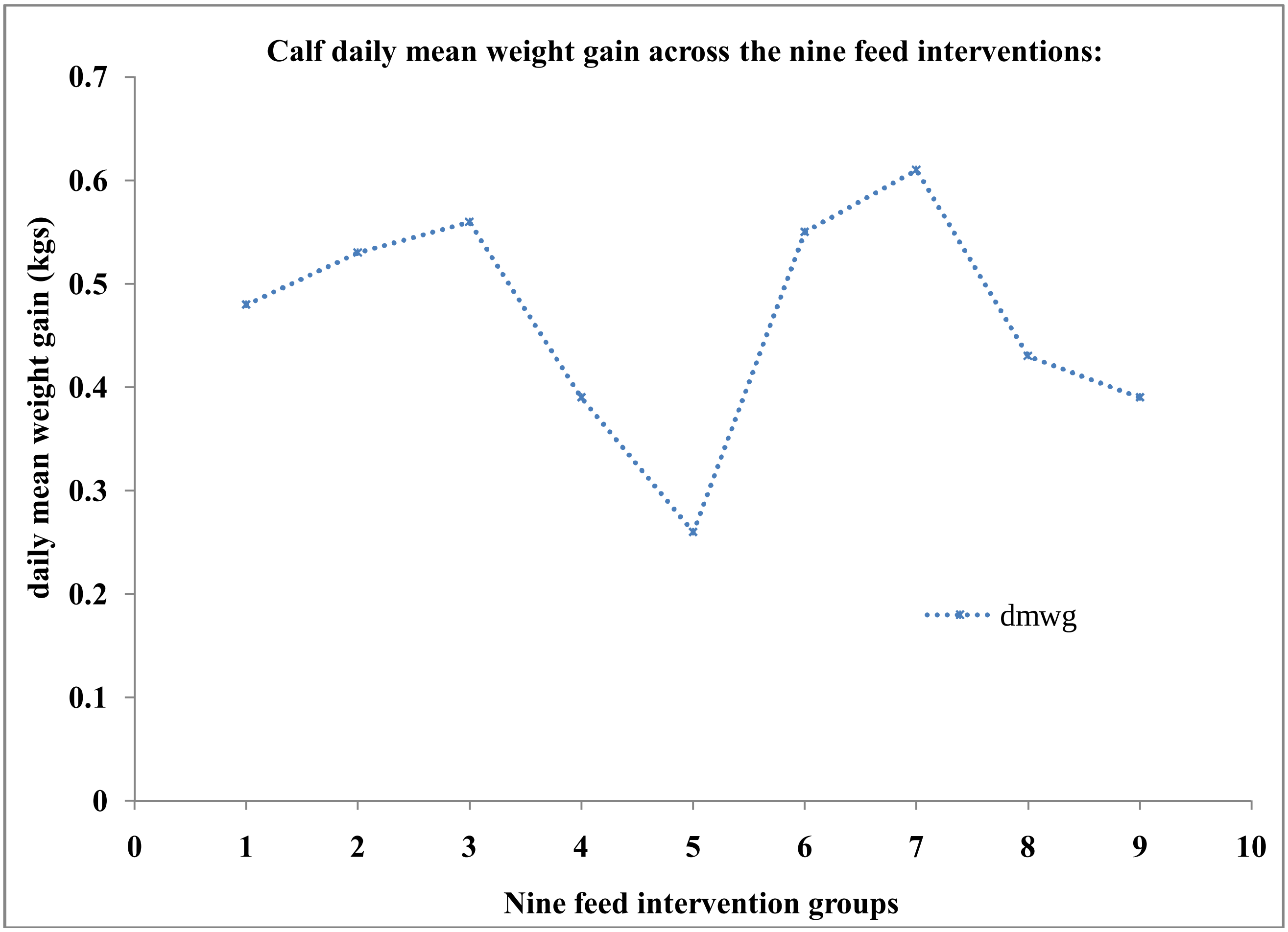
3= Control calf starter + Full milk intake, 4= Half calf starter +Control milk intake,

5= Half calf starter + Half milk intake, 6= Half calf starter +Full milk intake,

7= full calf starter +control milk intake, 8= Full calf starter + Half milk intake,

9= Full calf starter + Full milk intake

Figure 4. 4. Graph demonstrating the differences in height gain (Cm) between calves in the nine feed intervention groups in smallholder dairy farms in Mukurweini District, Kenya.



KEY:

dmwg= daily mean weight gain

Feed intervention groups;

1 = Control calf starter + Control milk intake, 2= Control calf starter + Half milk intake,

3= Control calf starter + Full milk intake, 4= Half calf starter +Control milk intake,

5= Half calf starter + Half milk intake, 6= Half calf starter +Full milk intake,

7= full calf starter +control milk intake, 8= Full calf starter + Half milk intake,

9= Full calf starter + Full milk intake

4.11. Regression model effect of calf and farm level factors on mean height gain

A Univariate linear regression analysis of the calf and farm level factors was done to assess their association with the overall mean weekly height gains for the dairy calves. This showed that there was a significant difference across the nine feed intervention groups in relation to the mean weekly height gains at a ($p<0.001$), (Table 4.11). The calves that were housed separately from other calves/animals had an overall higher mean weekly height gain as compared to the calves that were not housed individually at a ($p<0.001$), (Table 4.11).

Table 4. 11. Univariate linear regression models; effect of feed intervention group and housing of calves on mean height gain in 35 Friesian calves in Mukurweini district of Kenya.

Variable	coefficient	F-value	P-value
Dairy experience	7.38	0.38	0.6814
Household size	7.35	1.33	0.2653
Dam parity	7.36	0.99	0.3738
Colostrum provision time	7.37	0.45	0.5008
Calf sex	7.37	0.72	0.3953
[a]Feed intervention group	5.22	36.23	<0.0001*
[b]Housing	0.72	22.31	<0.0001*

The factors assessed are listed but those that were found significant are those marked with *.

[a]Feed intervention group (Groups 1-9)

[b]Housing (separated housing versus grouped housing)

4.12. Study calf mean daily weight gain (Kg)

The results of the study calf mean daily weight gain in relation to the feed intervention groups at the end of the trial are indicated in Table 4.13below. The feed intervention group with the highest daily mean weight gain was HCS+FMI (half calf starter and full milk intake) with a dmwg of 0.61 kg per day, while the feed intervention group with the lowest dmwg was HCS+ HMI combination (half calf starter and half milk intake) with a dmwg of 0.26 Kgs per day (Table 4.13). These two feed intervention groups were significantly different from the rest of the feed intervention groups .The remaining feed intervention groups reported a dmwg of >0.39 Kgs per day. The confidence limits indicate a significant difference between treatments HCS+CMI, HCS+HMI, HCS+FMI and FCS+HMI (Table 4.13). This is indicated by the fact that the confidence limits of these specific feed intervention groups do not overlap. The recorded outcome (daily mean weight gain) of these groups is significantly different across the various feed intervention groups (Table 4.13). These feed intervention groups have a calf starter component although it is in different proportions.

Table 4. 12. Study calf mean daily weight gain (Kg) in relation to the feed treatment in smallholder dairy farms in Mukurweini District, Kenya.

Feed intervention	dmwg	SEM	LL	UL	SD	COV
CCS+CMI	0.48	0.10	0.4803	0.6079	0.57	119.58
CCS+HMI	0.53	0.08	0.3989	0.5307	0.44	83.03
CCS+FMI	0.56	0.07	0.4277	0.5596	0.36	63.69
HCS+CMI	0.39	0.05	0.2644	0.3899	0.31	79.16
HCS+HMI	0.26	0.06	0.1154	0.2604	0.27	104.09
HCS+FMI	0.55	0.05	0.4799	0.6074	0.31	50.37
FCS+CMI	0.61	0.06	0.4008	0.5522	0.27	49.17
FCS+HMI	0.43	0.05	0.3052	0.4349	0.25	58.63
FCS+FMI	0.43	0.06	0.2432	0.3913	0.28	70.45

KEY;
SEM- standard error of mean
UL-upper limit
COV-coefficient of variation
LL-lower limit
SD-standard deviation

KEY;

CCS: control calf starter=0-0.2 Kgs/day
HCS: half calf starter= 0.5 Kgs/day
FCS: full calf starter= 1 kg /day
Dmwg = daily mean weight gain
CMI: control milk intake= 5.5 liters /day
HMI: half milk intake = 2 liters/day
FMI: full milk intake= 4 liters/day

Figure 4. 5. Graph shows the optimal mean body mass (kg) of 35 Frisian calves under nine feed intervention groups by age in weeks.

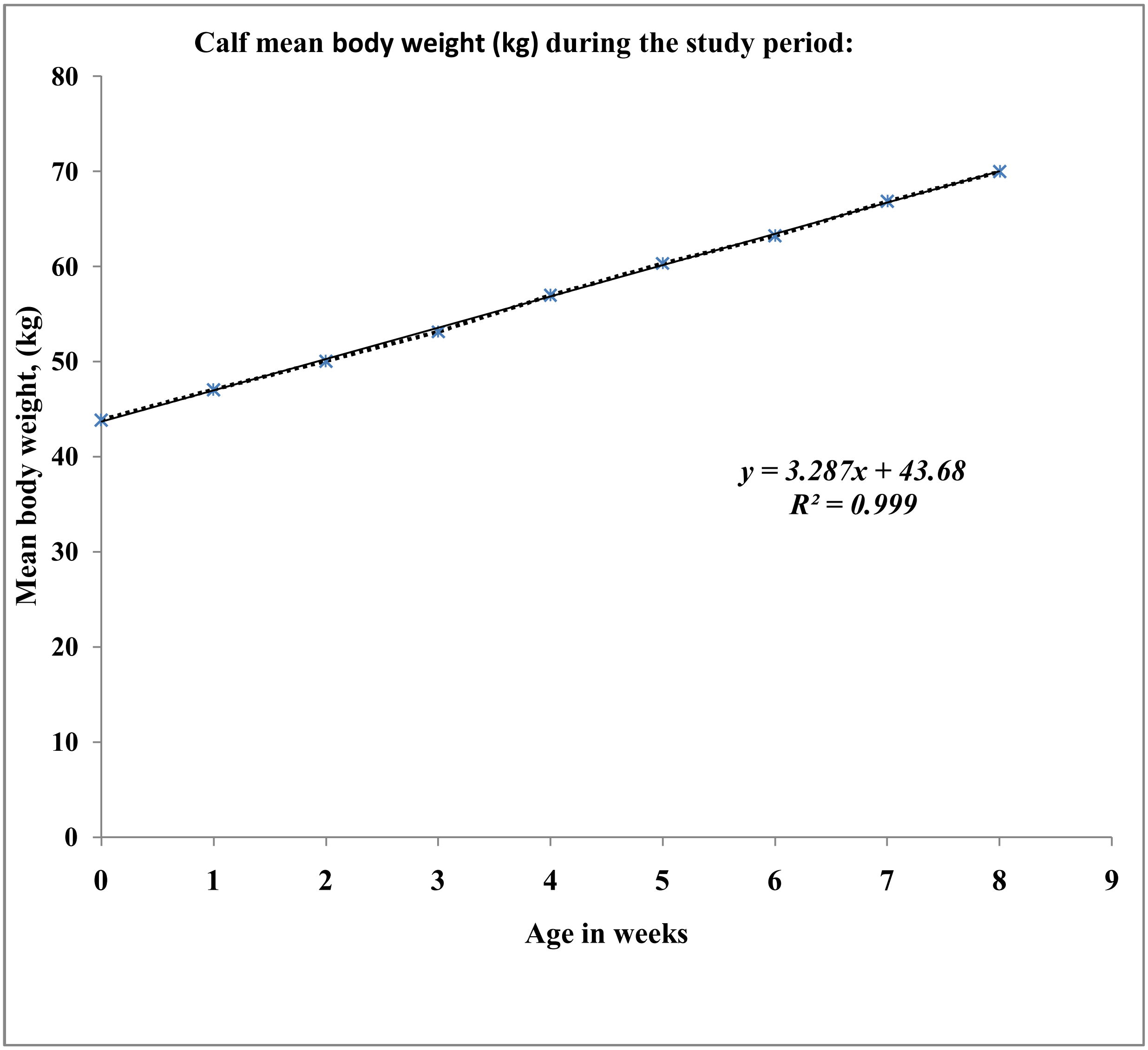
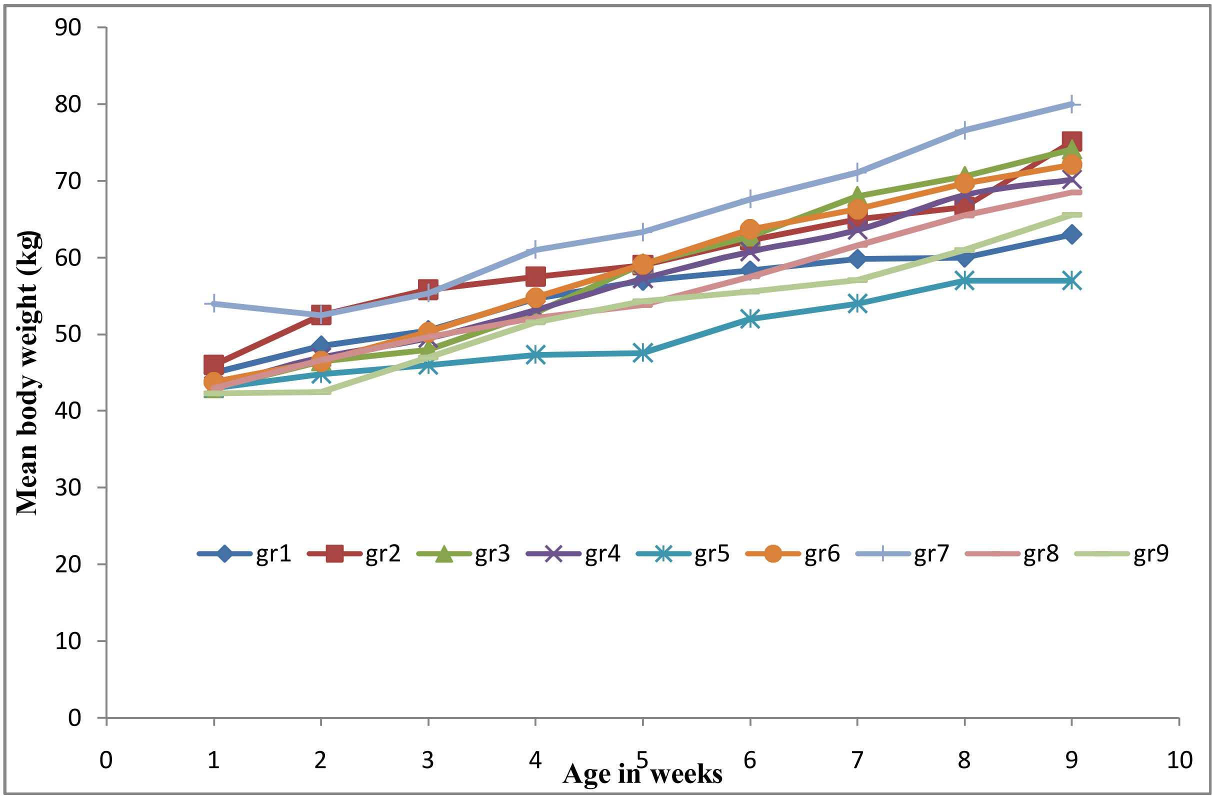


Figure 4. 6. Graph shows the differences in mean weight gain (kg) by age in weeks between the study calves across the nine feed intervention groups in smallholder dairy farms in Mukurweini District, Kenya.



KEY:

The significant feed intervention groups are italicized and marked by *.

**gr 1* recorded the highest weight gains while **gr 5* recorded the lowest weight gains during the study.

**gr 1 = Control Calf Starter + Control Milk Intake*

gr 2=Control Calf Starter+ Half Milk Intake

gr 3= Control Calf Starter + Full Milk Intake

gr4= Half Calf Starter + Control Milk Intake

**gr5= Half Calf Starter + Half Milk Intake*

gr6= Half Calf Starter + Full Milk Intake

gr7= Full Calf Starter + Control Milk Intake

gr8= Full Calf Starter + Half Milk Intake

gr9= Full Calf Starter+ Full Milk Intake

Figure 4. 7. Graph shows the Mean body height (cm) of 35 Frisian calves under nine feed intervention groups.

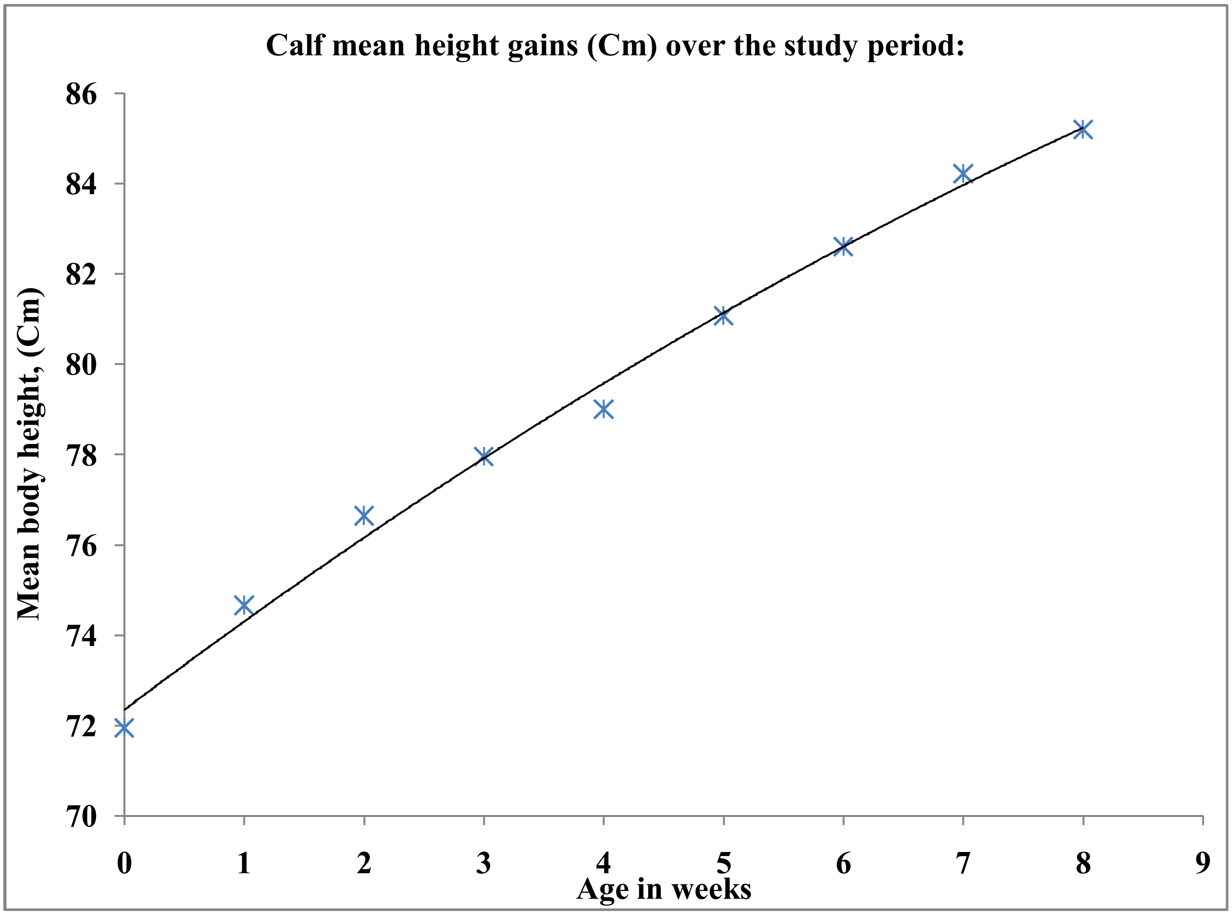
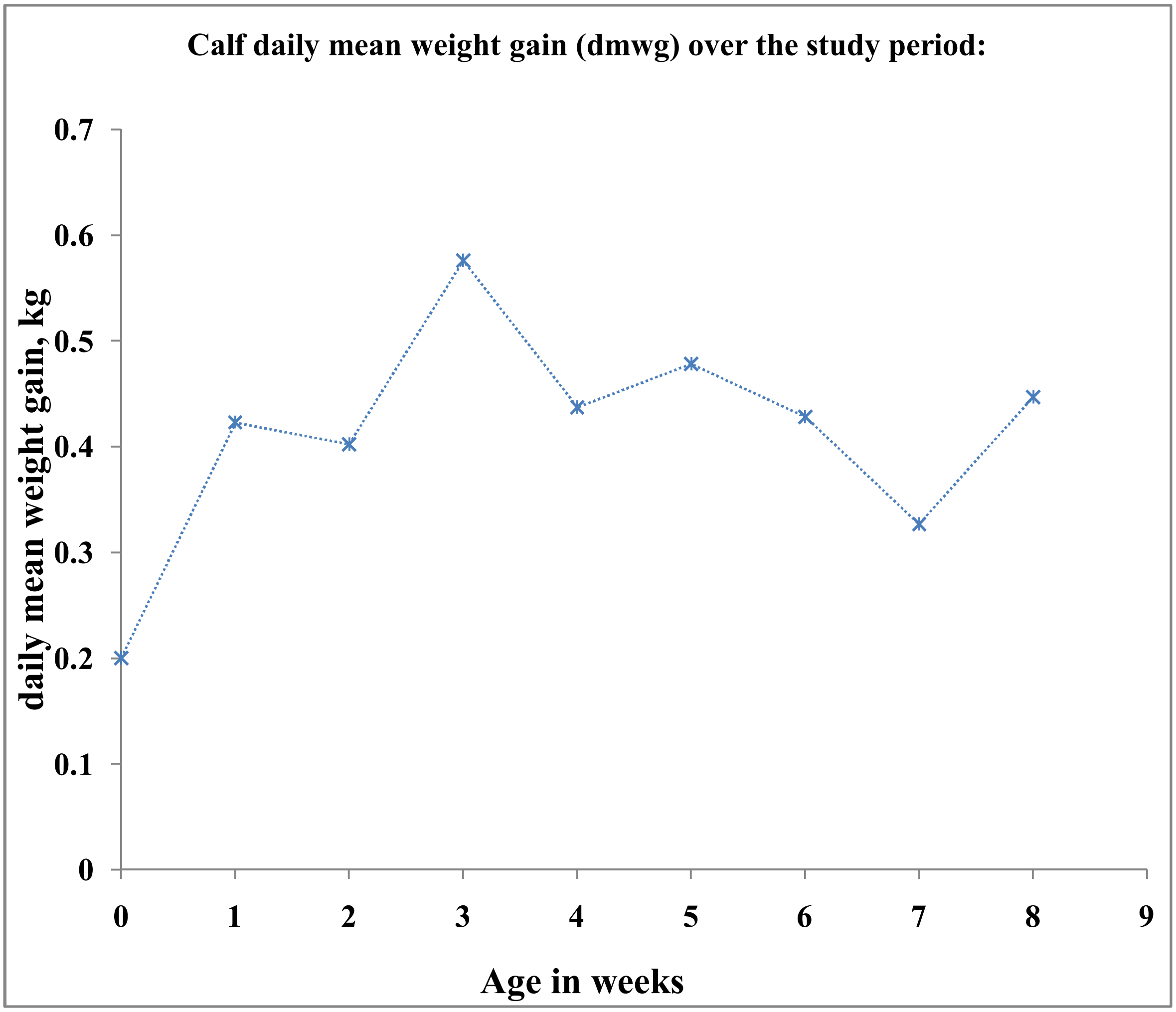


Figure 4. 8. Graph shows the daily mean weight gain (Kgs) of 35 Friesian calves in smallholder dairy farms of Mukurweini district, Kenya.



CHAPTER FIVE

5.0. DISCUSSION

The results of this study revealed that, male-headed households were more than the female headed households. These results agree with those of Gitau *et al*., (1992); Baltenweck and Staal (2000); Ndebele *et al.,* (2007); and Wambugu *et al*., (2011). This could be due to the fact that the womenôs contribution is more so toward the dairy labour i.e. cleaning of the pens, forage gathering and feeding the animals as opposed to menôs roles that include making key decisions in management and running of the dairy enterprise.

The study further revealed that at least 91.4 percent of the respondents were married, and only a small proportion of less than 10 percent of the respondents were not married, was and were either widowed or single.

The findings of this study also showed that the education level of the household heads varied with at least 97 percent having attained formal education and only a small proportion of about 2.9 percent had no formal education. The general high literacy levels were probably due to availability and accessibility to educational facilities in the region.

A proportion of slightly above 54 percent of the smallholder farmers who enrolled in the study had more than 10 years dairy farming experience, while 34.3 percent had 4-9 years dairy farming experience and only a small proportion of 11.4percent had 1-3 years dairy farming experience.

There was a skewed distribution of land acreage. Over half of the farms reported land ownership of less than two acres in area, while 31.4 percent of the farmers had two acres in area, 14.3 percent of the farmers indicated that they owned more than two acres in area, and a only a small proportion of 2.9 percent of land that was of an unknown size. The small land sizes are possibly due to the intensified farming systems that accommodate several livestock production systems and is further influenced by the increasing population pressure and building of permanent structures for housing.

The household size of 3-5 people had the highest proportion at 57.4 percent while that of > 5 persons was at 14.7 percent. These proportions were generally high in relation to the land space for settlement that ranged between less than or equal to two acres. Therefore there is a possibility that resource availability was limited because in such cases, land tends to be a limited as available land is used for buildings and settlement. This may result in difficulties in feed acquisition.

Smallholder dairy production in developing countries has a broad perspective to it since it may be practiced for family consumption or for commercial purposes (Udo and Cornelissen, 1998; Bebe *et al*., 2003).The results of this study showed that 48.6 percent (17/35) of the smallholder farmers did not fully depend on smallholder dairy farming for their livelihoods. This is probably because they had other sources of income or had formal employment hence the dairy farming was to supplement their income. A proportion 40.0 percent, (14/35) of these smallholder farmers indicated keeping of livestock as a source of 50-70 percent of their income. Only a small proportion of 11.4 percent (4/35) of the small holder farmers depended on dairy farming for more than 70 percent of their daily livelihoods. This is probably because they had no alternative means of income.

In this study, good management practices, including colostrum management and favourable housing conditions on the farm were likely responsible for the low incidence of important diseases such as diarrhoea and pneumonia at 11.4 percent (4/35) and 5.7 percent (2/35) respectively. In a study carried out by Gitau *et al*., 1994b the calf morbidity and mortality due to diarrhea were at 16.1 percent and 9.4percent respectively while the calf morbidity due to pneumonia was at 3.2 percent.

The smallholder farmers in Mukurweini primarily feed their dairy calves on forages such as napier grass (*Pennisetum purpureum*) and other grasses, which include; *Desmodium spp*., Rhodes grass (*Chloris gayana*) and kikuyu grass (*Pennisetum clandestum*) as well as on crop residues such as banana leaves and sweet potato vines to the dairy calves. This is a common scenario in tropical countries where the smallholder production systems relies on stall-fed cut-and-carry regimes of the locally available pasture nappier grass and other grasses, supplemented with purchased concentrate feed, to free grazing on unimproved natural pasture in the more marginal areas, (Wambugu *et al*., 2011).

The results of this study show that feed intervention, calf sex and housing had a significant effect on the outcome variable (mean weekly weight) with ($p= 0.00$)1and ($F= 5.88$) for feed intervention, ($p=0.022$) and ($F=5.33$) for calf sex and ($p< 0.001$) and ($F=37$) for housing.

The amounts of nutrients that are required for maintenance and growth of calves are not fixed but vary with body weight (**BW**) and average daily gain (**ADG**) when these two are high, the requirements will be high Drackley, 2008. The Full calf starter +Control milk intake had calf starter intake that aimed at having a daily consumption of up to one kg per day at the time of weaning, with a milk consumption that ranged between 2-5 liters per day depending on its availability. The milk intake may have been restricted to a once-a-day milk feeding system of low milk quantity, therefore prompting higher intakes of calf starter, and hence, greater gains in growth of these calves. This regimen would encourage earlier intake of starter feed, thus promoting rumen development therefore allowing for smoother weaning transition and earlier weaning (Davis and Drackley, 1998). In order to stimulate reticulo-rumen development, it is important to initiate intake of calf starter early in life, (Williams and Frost, 1992). Studies have repeatedly shown that calves receiving a diet of solely milk have reduced rumen development (Warner 1991; Drackley, 2002), and that solid feed is required for stimulation of the rumen microbial volatile fatty acid (VFA) production. It is the presence of these VFAs that initiates rumen epithelial development (Heinrichs and Lesmeister, 2005). Therefore, higher levels of milk intake offered may indirectly slow the development of the rumen by slowing down rumen papillae formation (Heinrichs and Lesmeister, 2005). This suggests that there is a fine balance between the levels of milk offered to maximize the growth potential of the calf in early life whilst at the same time ensuring an adequate intake of calf starter concentrate to initiate rumen development. The superiority of Full calf starter + Control milk intake group could have been primarily a result of the full calf starter component, as it is possible that the milk intake was somewhat restricted, since milk intake was whatever quantity the farmer wished to feed. If the farmer found it costly to feed more milk, it is possible that the farmer could reduce the milk component and focus on the full calf starter, especially since the calf starter was being provided free of charge as part of the study. The Half CS + Half MI recorded the lowest weights and heights even though the starter intake was at 0.5 kg and two liters of milk were provided per day. the low growth rates could be because the feed only supplied for calf maintenance requirements but could not meet the growth requirements, According to Hodgson, 1971; Huber *et al*., 1984; and Drackley (2002), lower starter intake results in a slow rate of rumen development, which may in turn contribute to calves being stunted when weaned from milk. Khan *et al*., 2007a reported that weaning of calves before their rumen develops enough for efficient digestion of starter and volatile fatty acid absorption would result in slumps in their growth. In order to capitalize on the rapid early growth potential of young calves, the calf starter should be offered to calves for *ad libitum* consumption from the first week of life (Hafez and Lineweaver, 1968; Drackley, 2002). *Ad libitum* intake of calf starter further stimulates intake of higher amounts of calf starter early in life i.e., as from first week of calf life (Hafez and Lineweaver, 1968; Drackley, 2002). The milk intake in calves on smallholder dairy farms in Kenya is usually restricted in most farm settings at about two to four liters per day, a quantity that typically only allows for maintenance requirements of the calf (Hafez and Lineweaver, 1968; Drackley, 2002), making ad lib calf starter feeding essential. Even though calf starter intake is reported to increase quickly when milk fed to calves is decreased, weaning of the calf before the rumen is developed enough to efficiently digest the starter and absorb the resulting VFA can result in pronounced slumps in growth, Drackley, 2008.In order to have a proportional increase in wither height and body weight that is reported to be highest during the first two months of life (Drackley, 2002), it is important to ensure a high consumption of calf starter during this phase of growth, to allow for high nutrient consumption and subsequent rapid growth in calves (Drackley, 2002). The efficiency of dietary protein use for body protein gain in growing calves is reported to be highest in young calves less than two months of age, and this growth potential decrease with increase in body size (Gerrits *et al*., 1996).The ideal and recommended growth rates in calves range between 0.5 and 0.73 Kgs per day for the dairy breeds (Lyimo 2006; Laswai *et a*l., 2007). The findings of this study indicated a daily mean average growth weight of 0.47 Kgs. This growth rate per day is higher than the reported growth rates of only 0.207 Kgs for up to five months of age in dairy calves raised in intensive systems in Kiambu County, Kenya (Gitau *et al.,* 1992; Gitau *et al.*, 1994a; 1994b). Growth rates of 0.24 Kgs per day were also reported in Kenya, and deemed to usually result in late age at first calving, averaging 41 months (Odima *et al.*, 1994). The Full CS + Control MI recorded the highest daily mean weight gain at 0.61 Kgs while Half CS + Half MI recorded the lowest daily mean weight gains at 0.26 Kgs. The higher growth rates recorded in this study are possibly due to the higher protein content especially in the calf starter, irrespective of the proportions of the calf starter. Akayenzu *et al.,* (1994) and Lyimo *et al.,* (2010) have reported higher growth rates in smallholder dairy calves due to the higher protein content in calf starter.

The sex of the study calves had an overall significant effect on the weight gain but no significant effect on the height gain of the smallholder dairy calves. The female calves recorded a higher weight gain even though the male calves were more in number than the female calves but it had no significant effect on the height gain of the smallholder dairy calves.

The results of this study also show that management factors such as housing contributed significantly (p=<0.001, F= 37) to the improved performance of the study calves, similar findings have been reported elsewhere to affect calf performance positively (Place *et al*., 1998).Several studies that have been done in the past on calf diseases illustrated a better calf health performance when calves were housed individually in single calf hutches (Heath, 1992, Anderson and Bates, 1994). This practice has been postulated to decrease the individual pathogen load for calves compared to calves that have been housed together in with other livestock irrespective of the species.

The findings of this study show that disease incidence was higher in calves with selenium levels between 0.0084 and 0.01196 εg of selenium per milliliter of blood as compared to study calves with selenium levels of >0.2 εg of selenium per milliliter of blood. According to Leslie (2011), serum selenium levels of 0.05 εg per milliliter of blood are reported to be adequate in healthy calves. The limit of adequacy for blood selenium concentration is reported by Smith *et al.*, (1988) and Weiss (1994) to be set at 0.20 εg/ml, while Van Saun (1990) and Gerloff(1992) reported concentrations greater than 0.10 εg/ml of blood as adequate levels. This discrepancy is partly based on different estimates of the relation between whole blood selenium concentration and plasma selenium concentrations, as all these authors agree that plasma selenium concentration levels above 0.07-0.075 εg/ml are adequate. In Norwegian cattle, Ropstad *et al.,* (1987) found that plasma Selenium concentration of 0.07 εg/ml corresponded on average to a serum selenium concentration of 0.13 εg of selenium per milliliter of blood. The main reason for using serum as the medium to measure the levels of selenium in this study was because serum selenium is reported to be more accurate in measuring the short term changes in selenium status than whole blood selenium (Gerloff, 1992).

CHAPTER SIX

6.0. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

From the results obtained, it can be concluded that;

- The feed intervention groups which contained calf starter and milk intake had an overall higher mean weight gain than the mean weights that have been recorded in studies on calf feeding in Kenya irrespective of the quantities. The study recorded overall average daily weight gain of 0.47 Kgs which is close to the recommended standards for animal welfare hence an improved performance of dairy calves on smallholder farms. From this study the daily mean weight gain formed the most critical component for determination of optimal calf performance in calves reared by smallholder farmers.
- Calves under calf starter irrespective of the quantities had a higher overall performance in terms of weight and height gain as indicated by the post hoc Bonferroni test as compared to those under exclusive milk intake or control regimes.
- The smallholder farmers in Mukurweini primarily feed their dairy calves on forages such as Napier grass (*Pennisetum purpureum*) and other grasses, which include; *Desmodium spp*., Rhodes grass (*Chloris gayana*) and kikuyu grass (*Pennisetum clandestum*). The farmers also provide crop residues such as banana leaves and sweet potato vines to the dairy calves. The nappier grass is cut at a height of less than one meter by most of the farmers. Mineral lick and water is also provided ad libitum by most of the farmers.
- The feed intervention group (7) FCS+CMI was superior to the rest of the groups as it recorded the highest weight, height and average daily weight gains while group (5) HCS+HMI was inferior to the rest and it recorded the lowest gains.

6.2. RECOMMENDATIONS

Based on the findings of this study, the following can be recommended;

- Smallholder farmers should capitalize on the rapid early growth potential of young calves, which allow for greater average daily weight gains by ensuring that, they pay serious attention to supplementation of calves through early weaning so as to improve their performance and increase survival rates of dairy calves as this is beneficial to the farmer.

- In order to reduce or control the bias that arises on the outcome parameters when both parties are aware of what feed interventions are being administered it is necessary to consider blind studying the farmers and the evaluators to the feed intervention groups to have accurate results by preventing under or over recording of the parameters of the study calves being assessed.

- In order to determine the true effects of calf starter and milk intake on growth and performance of the calves under study, it would be essential to use fewer numbers of feed intervention groups and a higher sample size with a completely randomized control trial which could give more significant finding.

6.3. FUTURE RESEARCH AREAS

- Further research is needed to assess the short and long term social economic implications of the suggested feeding system in relation to prices of feeds, milk and weight gain in calves.

- There is need for studies on how best the existing local forages could be selected and combined for optimal performance of calves.

REFERENCES

Abdelrahman, M. M., and **Kincaid, R. L. (1993)**: Deposition of copper, manganese, zinc, and selenium, in bovine fetal tissue at different stages of gestation. Journal of Dairy Science, **76**: 3588- 3593.

Aiumlamai, S. (1999): Dairy management and animal health. Small holder dairying in the tropics, **12**: 225.

Akayenzu, J. M., Linn, J. G., Otterby, D. E., Hansen, W. P. and **Jonson, D. J. (1994):** Evaluation of calf starter containing different amount of crude protein for growth of Holstein Friesian calves. Journal of Dairy Science, **77**: 1882-1889.

Aldridge, B., Garry, F. and **Adams, R. (1992):** Role of colostral transfer in neonatal calf management: failure of acquisition of passive immunity. Compendium Continuing Education for Practicing Veterinarian, **14**; 265-269

Amoki, O.T. (2001): Management of dairy calves in Holleta area, central highlands of Ethiopia Faculty of veterinary medicine, Addis Ababa University, Debre Zeit, Ethiopia, Msc thesis.

Anderson, J. F. and **Bates, D. W. (1994):** A systems approach to total animal health care for dairy herd replacements and dairy-beef steers. Proceeding 8th International Congress Animal Hygiene. St. Paul 1994: HP41-47.

Appleby, M. C., Weary, D. M., and **Chua, B. (2001)**: Performance and feeding behaviour of calves on ad libitum milk from artificial teats. Applied Animal Behaviour Science Journal, **74**:191-201.

Ayantunde, A. A., Fernández-Rivera, S. and **McCrabb, G. (2005):** Coping with feed scarcity in smallholder livestock systems in developing countries. Animal Sciences Group, University of Reading press publication. pp.306

Babalola, O. O., Anetor, J. I., and **Adeniyi, F. A. A., (2007)**: Low blood selenium: A probable factor in essential hypertension. African Journal of Biotechnology, **6**: 1697-1702.

Baldi, A. (2005): Vitamin E in dairy cows. Journal of Livestock Production Science, **98**: 117-122.

Baltenweck, I., Staal, S. J., Owango, M., Muriuki, H., Lukuyu, B., Gichungu, G., Kenyanjui, M., Njubi, D., Tanner, J. and **Thorpe, W. (1998)**: Intensification of dairying in the greater Nairobi milk-shed: spatial and household analysis. Collaborative Research Report, ILRI, Nairobi.

Baltenweck, I. and **Staal, S. J. (2000)**: Determinants of adoption of dairy cattle technology in the Kenyan highlands: a spatial and dynamic approach. Paper presented at the International Association of Agricultural Economics (IAAE) Meetings, Berlin.

Bar-Peled, U., Robinzon, B., Maltz, E., Tagari, H., Folman, Y., Bruckental, I., Voet, H., Gacitua, H. and **Lehrer, A. R. (1997)**: Increased weight gain and effects on production parameters of Holstein ï Friesian heifer calves that were allowed to suckle from birth to six weeks of age. Journal of Dairy Science **80**, 2523-2325

Barrington, G.M., and **Parish, S., M. (2001):** Bovine Neonatal Immunology. Veterinary Clinics of North America Food Animal Practice: **17(3):**463.

Bebe B. O., Udo, H. M. J., and **Thorpe, W. (2002)**: Development of smallholder dairy systems in the Kenya highlands. Outlook on Agriculture **31**:113-120.

Bebe, B. O., Udo, H. M. J., Rowlands, G. J., and **Thorpe, W. (2003a):** Smallholder dairy systems in the Kenya highlands: cattle population dynamics under increasing intensification. Livestock Production Science **82**: 211-221.

Bebe, B. O., Udo, H. M. J., Rowlands, G. J., and **Thorpe, W. (2003b):** Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices. Livestock Production Science **82**: 117-127.

Breier, B. H., Bass, J. J, Butler, J. H. and **Gluckman, P., D. (1986):** The somato-trophic axis in young steers: influence of nutritional status on pulsatile release of growth hormone and circulating concentrations of insulin like growth factors. Journal of Endocrinology, **111**: 209-215.

Bruning-Fann, C., and **Kaneene, J. B. (1992):** Environmental and managemental risk factors associated with morbidity and mortality in perinatal and pre-weaning calves: a review from an epidemiological perspective. Veterinary Bulletin, **62**:399-403.

Cadlow, G.L. (1988): Relationship of calf antibody status to disease and performance. Veterinary Record, **122**: 63-65.

Cebra, C.K. Heidel, J.R. Crisman, R.O. and **Stang, B.V. (2003):** The relationship between endogenous cortisol, blood micronutrients, and neutrophil function in post-parturient Holstein cows. Journal of Veterinary International Medicine, **17**: 902-907.

Chassagne, M., Barnouin, J. and **Chacornac, J.P. (1999)**: Risk factors for stillbirth in Holstein heifers under field conditions in France: a prospective survey**.** Theriogenology, **51:**1477-1488.

Clark, L.C., Combs, G.F. and **Turnbull, B., W. (1996)**: The nutritional prevention of cancer with selenium; 1983-1993: a randomized clinical trial. Journal of the American Medical Association, **276**: 1957-1963.

Clausen, J., Nielsen, S.A. and **Kristensen, M. (1989)**: Biochemical and clinical effects of an antioxidant supplementation of geriatric patients. Biological Trace Element Research, **20**: 135-151.

Combs, G.F, and **Clark, L., C. (1999)**: Selenium and cancer. Nutritional Oncology: Academic Press, San Diego.

Cunningham, J.G. (1992): Text Book of Veterinary Physiology. Sounders publication. Pp331.

Da Silva, M. C. S., Naozuka, J. and **Oliveira, P.V. (2010):** *In vivo* bioavailability of selenium in enriched *Pleurotuso streatus* mushrooms Metallo-mics, **2**: 162-166.

Dann, H. M., Litherland, N. B., Underwood, J.P., Bionaz, M., D'Angelo, A., McFadden, J.W. and **Drackley, J. K.** (**2006**): Diets during far-off and close-up dry periods affect periparturient metabolism and lactation in multi-parous cows. Journal of Dairy Science, **89**: 3563-3577.

Davis, C. L. and **Drackley, J. K.** (**1998**): The development, nutrition, and management of the young calf. Iowa State University Press publication.

De Jong, R. (1996): Dairy stock development and milk production with smallholders., Department of Animal Production Systems, Wageningen Agricultural University, PhD Thesis.

Dejneka, W., Sworczak, K., and **Obolończak, L. (2007)**: Classification of thyroid gland disease on the basis of selenium concentration in serum. Roczniki PaŒstwowego Zakladu Higieny, **58**: 563-567. (Abstract).

Desai, M. and **Hales, C.N. (1997)**: Role of fetal and infant growth in programming metabolism in later life, Biological Review Cambridge Philosophy of Sociology: **72**, 329-348.

Dewell, R.D., Hungerford, L.L., and **Keen, J.E. (2006):** Association of neonatal serum immunoglobulin G1 concentration with health and performance in beef calves. Journal of American Veterinary Medicine Association, **228:**914ï 921

Diaz, M. C,, Van Amburgh M. E., Smith, J.M., Kelsey, J. M. and **Hutten, E. L, (2001):**Composition of growth of Holstein calves fed milk replacer from birth to 105- kilogram body weight. Journal of Dairy Science **84**:830-842.

Dimitrov, M., Mitev, J., Gergovska, Z., Miteva, and **Vasilev, N. (2000):**Relationship between the duration of the parturition phases of dairy cows, body condition and the postpartum uterine inflammations. Bulgaria Journal of Agricultural Science **6**:455-462.

Douill, C., Bost, M. and **Accominotti, M. *(*1998)** : Effect of selenium and vitamin E supplementation on lipid abnormalities in plasma, aorta and adipose tissue of Zucker rats. Trace Elements Research, **65**: 221-236.

Drackley, J. K. and **M. E. Van Amburgh. (2005)**: Nutrient requirements of the calf: Birth to weaning. Proceeding Dairy Calves and Heifers Conference, pp. 86-95.

Drackley, J.K. (2000). Calf nutrition related to heifer growth and longevity. Proc. 61st Minnesota Nutrition Conference Minnesota Soybean Research and Promotion Council Technical Symposium, pp. 153-168, September 19-20, Bloomington, MN Minnesota Extension Service, St. Paul, MN.

Drackley, J.K. and **Bartlett, K.S. (2002)**, Impact of early nutrition in calves on health and lifetime productivity. University of Illinois, USA.

Drackley, J. K. (2005): Early growth effects on subsequent health and performance of dairy heifers. Calf and Heifer Rearing Chapter 12. Nottingham University Press,

Drackley, J. K. (2008): Calf nutrition from birth to breeding. Veterinarye Clininics North America Food Animal Practice, **24**:55-86.

Drackley, J. K., B. C. Pollard, H. M. Dann, and **J. A. Stamey. (2007):** First-lactation

Drackley, 2011

Emer Kennedy and **Eva Lewis (2011):** Rearing healthy calves: Management of cows pre-calving and calves post birth and rearing options. Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork

Enjalbert, F., P. Lebreton and **O. Salat. (1999):** Effects of copper, zinc and selenium status on performance and health in commercial dairy and beef herds: retrospective study E´ cole Nationale Ve´ te´ rinaire, Unite´ de Nutrition, Toulouse Cedex 3, France, and NBVC, Le Bois Dieu, Lissieu, France

Fallon, R. J. (**1983):** The effect of feeding and management factors on calf performance,

Fernández H. T., Busso C. A.1, , Laborde H. E., Torrea M. B., Fernández L. M., López G. H., Delucchi F. and **García B. N. (2012):**Growth, blood metabolites and hormones in calves fed diets with different amounts of energy and protein during the pre- or post weaning periods African Journal of Agricultural Research, **7(25)**: 3739-3746.

Fisher, D. D., Saxton, S. W., Elliott, R. D., Beatty, J. M. (1995): Effects of selenium sources on Selenium status of lactating cows. Veterinary Clinics Nutrition **2**: 68-73

Flower, F.C. and **Weary D.M**. (**2001)**: Effects of early separation on the dairy cow and calf: 2. Separation at 1 day and 2 weeks after birth Applied Animal Behaviour Science Journal 2001, **70**:275-284.

Fluharty, F. L., T., B. Turner, S. J. Moeller. and **G., D. Lowe. (1996)**: Effects of weaning and diet on growth of calves, Ohio State University Research and Reviews*:* Research Bulletin 156.

French, N.P., Tayler, J., and **Hirst, W., M. (2001):** Smallholder dairy farming in the Chickwaka communal land, Zimbabwe Birth, death and demographic trends: Preventive Veterinary Medicine, 48, 101-112.

Gachuiri, C. K., R. G. Wahome, P. N. Mbugua, M. M. Wanyoike, J. M. Z. Kamau and **S. J. M. Munyua. (1998):** Performance of dairy animals under two zero grazing systems in Kiambu and Nyandarua districts. The Kenya Veterinarian 23:180-182.

Garry, F., Aldeidge, B., F. and **Adams, R. (1993)**: Role of colostral transfer in neonatal calf management: current concepts in diagnosis: Compendium Continuing Education for Practicing Veterinarian **15**; 1167-1174.

Gasmi, A., Garnier, R., and **Galliot-Guilley, M. (1997):** Acute selenium poisoning: Veterinary and Human Toxicology, **39**: 304-308.

Gerloff, B.J. (1992): Effect if selenium supplementation on dairy cattle. Journal of Animal Science **70**:3934ï 3940.

Gerrits, W. J. J., G. H. Tolman, .J. W. Schrama, S. Tamminga, M. W. Bosch, and **M. W. Verstegen. (1996):** Effect of protein and protein free energy intake on protein and fat deposition rates in pre-ruminant calves of 80 to 240 kg live weight. Journal of animal science 74: 2129-2139**.**

Giorgetti, H. D, Busso, C. A., Montenegro, O. A., Rodríguez, H. D. and **Kugler, N. M. (2006):** Management techniques to improve cattle raising in central, semiarid rangelands of Argentina. Rangelands, **28**: 32-36.

Girodon, F., Galan, P., and **Mong. (1999)**: Impact of trace elements and vitamin supplementation on immunity and infections in institutionalized elderly patients: a randomized controlled trial. Archives of Internal Medicine, **159**: 748-754.

Gitau, G. K, McDermott, J. J., Adams, J. E., Lissemore, K. D., and **Waltner-Toews, D. (1994a):** Factors influencing calf growth and daily weight gain on smallholder dairy farms in Kiambu district, Kenya. Preventive Veterinary Medicine, **21**: 179-190.

Gitau, G.K., O'Callaghan, C.J., McDermott, J.J., Omore, A.O., Odima, P.A., Mulei, C.M., and **Kilungu J.K., (1994a)**: Health and productivity of cattle in smallholder dairy farms in Kiambu District, Kenya: *Prev. Vet. Med.*, 21: 155-166.

Gitau, G.K., McDermott, Waltner-Toews, D., Lissemore, K.D., Osumo, J.M. and **Muriuki, D., (1994b)**: Factors influencing calf morbidity and mortality in smallholder dairy farms in Kiambu District of Kenya. *Prev. Vet. Med.,* 21: 167-177.

Gitau, G.K. (1992): Health and productivity of calves in smallholder dairy farms in Kiambu District, Kenya Master of Science Thesis, University of Guelph, December 1992.

Gitau, G. K., Perry, B. D., and **McDermott, J. J. (1999):** The incidence, calf morbidity and mortality due to *Theileria parva* infections in smallholder dairy farms in Murangâ, Kenya. Preventive Veterinary medicine, **39:** 65-79

Gitonga, P.N., (2010): Postpartum reproductive performance of dairy cows in medium and large scale farms in Kiambu and Nakuru districts of Kenya. Faculty of veterinary medicine, the University of Nairobi, Kenya, MSc thesis.

Gleeson, D., O'Brien, B. and **Fallon, R. J. (2007)**: Feeding of cold whole milk once daily to calves in a group and its effect on calf performance, health, and labour input. International Journal of Applied Res. Veterinary Medicine, **5**:97-104.

Godden, S. M., Haines, D. M., Konkol, K. and **Peterson, J.** (**2009**):Improving passive transfer of immunoglobulins in calves: Interaction between feeding method and volume of colostrum fed. Journal of Dairy Science, **92**: 1758-1764.

Godden, S., (2008): Colostrum management for dairy calves. Veterinary Clinics of North America: Food Animal Practice, **24**:19-39.

Government of Kenya (2008): Sessional Paper of the National Livestock Policy.

Griebel, P.J., Qualtiere, L., Davis, W.C., Lawman, M.J., and **Babiuk, L.A. (1987):**.Bovine peripheral blood leukocyte subpopulation dynamics following a primary bovine herpesvirus-1 infection. Viral Immunology **1**(4):267ï 286.

Hafez. E. S and **J. A., Lineweaver, (1968):** Suckling Behaviour in natural and artificially fed neonate calves. Journal of Ethology 25(2) 187-198

Hatanaka, N., Nakaden, H. and **Yamamoto, Y. (2000)**: Selenium kinetics and changes in glutathione peroxidase activities in patients receiving long-thermo parenteral nutrition and effects of supplementation with selenite Journal of Nutrition, **16**: 22-26.

Heath, S.E., (1992). Neonatal diarrhoea in calves: Investigation of herd management practices. The Compendium, Food Animal, 14: 385-395.

Heinrichs, A., J. and **Radostits, O., M. (2001)**: Health and production management of dairy calves and replacement heifers Herd Health: Food Animal Production Medicine, Pp333 ï 395.

Hodgson, J., (1971): The development of solid food intake in calves: The relationship between liquid and solid food intake. Journal of Animal Production 13:593-597.

Hoffman, P.C. (2003a): Monitoring calf and heifer management systems affirmation or information, Proc. North Central Region Calf and Heifer Tour and Workshop, Hotel Winneshiek, Decorah, IA, pp. 121-135, Iowa State, Minnesota, and Wisconsin Extension and, Professional Dairy Heifer Growers Association, Stratford, IA.

Holemans, K.J. Verhaeghe, J., Dequeben, J. and **Mathieu, C.M. (1996)**. Insulin sensitivity in adult female rats subjected to malnutrition during the perinatal period. Journal of Gynecological Investigation, **3**: 71-77.

Hough, R. L., McCarthy, F. D., Kent, H. D., Eversole, D. E. and **Wahlberg, M. L.** (**1990**): Influence of nutritional restriction during late gestation on production measures and passive immunity in beef cattle; Journal of Animal Science, **68**: 2622-2627.

ILRI (1996): ILRI annual project report 1995, Addis Ababa: Ethiopia.Pp74 -75.

Jasper, J. and **Weary, D.M**. (**2002**): Effects of *ad libitum* milk intake on dairy calves. Journal of Dairy Science, **85**:3054-3058.

Juniper, D. T., Phipps, R. H., Jones. and **A. K. Bertin, G. (2006):** Selenium supplementation of lactating dairy cows: effect on selenium concentration in blood, milk, urine and feces. Journal of Dairy Sciences, **89**: 3544-3551

Kamada H., Nonaka, I., Ueda, Y., and Murai, M., (2007): Selenium addition to colostrum increases immunoglobulin G absorption by newborn calves. Journal of Dairy Sciences, **90** (12):5665-70

Karanja, H. M. (2003): The Dairy Industry in Kenya: The Post-Liberalization Agenda. Paper presented at a Dairy Industry Stakeholders Workshop held in Nairobi, Kenya.

Khan, M., A., Lee, H., J., Lee, W., S., Kim, H., S., Ki KS, Hur, T.. Y, Suh, G. H., Kang, S., J, and **Choi, Y., J. (2007):** Structural growth, rumen development, and metabolic and immune responses of Holstein male calves fed milk through step-down and conventional methods. Journal of Dairy Science, **90**:3376-3387.

Kifaro, G.C. and **Temba, E.A. (1991):** Calf mortality and culling rates in two dairy farms in Iringa region, Tanzania. Proceeding of the 17thscientific conference of the Tanzania society of animal production, Arusha.

Kiragu J W, Mitaru B N, Siamba D N, Irungu K R G and **Ngatia S K (2008):** Strategies for early weaning of dairy calves based on forages and solid feeds on growth and rumen function. Paper presented at the 11th Kenya Agricultural Research Institute (KARI) Biennial Scientific Conference, 10th ï 14th November 2008, Nairobi, Kenya. 17.

Kmicikewycz, A. D. (2011): Nutritional feeding and management strategies to optimize growth and health in dairy calves Faculty of the Graduate school of the University of Minnesota, MSc thesis

Kenya National Bureau of Statistics, (2009).

Kugler N, Giorgetti H.D., Rodríguez G.D., Cechi, G., Montenegro, O.A. and **Busso, C.A. (2008):** Cow performance in conventional and early weaning herds in north Patagonia, Argentina Rangelands, **30**: 12-16

Lanyasunya, T. P., W. H. Rong, S. A. Abdulrazak and E. A. Mukisira. (2006). Effect of supplementation on performance of calves on small holder dairy farms in Bahati Division of Nakuru District, Kenya Pakistan Journal of Nutrition **5**:141-146.

Lanyasunya, T. P., Wekesa, F. W., de Jong, R., Udo, H., Mukisira, E. A. and **Ole Sinkeet, N. S. (1999):** Effects of a calf rearing package introduced to smallholder dairy farms in Bahati division, Nakuru district, Kenya pp. 450- 457. In: Proceedings 6th Biennial KARI Scientific Conference Kenya.

Laswai, G. H., Lyimo, H. L. N., Mtenga, L. A., Kimambo, A. E., Mgheni, D. M., Hvelplund, T., Madsen, J. and **Weisbjerg, M. (2007):** Effects of local concentrate and weaning age on the performance of crossbred calves. Journal of Animal and Feed Sciences, **16:**419-423

Leslie, K. (2011): Associations between the incidence of *Cryptosporidium Parvum* and selenium status in neonatal dairy calves in Ontario. University of Guelph Project Report

Lukuyu, B., S. Franzel., P. M. Ongadi. and **A. J. Duncan. (2011):** Livestock feed resources: Current production and management practices in central and northern rift valley provinces of Kenya. Livestock Research for Rural Development.**23 (5)**

Lyimo, H. L. N. (2006): Development of dairy calf rearing strategy for smallholder farmers in Turiani division, Mvomero district Tanzania. Sokoine University, PhD. Thesis.

Lyimo, H. L. N., Laswai, G. H., Mtenga, L. A., Kimambo, A. E., Mgheni, D. M., Hvelplund, T., Weisbjerg, M. R. and **Madsen, J. (2011):**Performance of crossbred calves raised on different dietary treatments under smallholder dairy farm conditions. Livestock Research for Rural Development, **22** (3).

Lyimo, H. L. N., Mtenga, L. A., Kimambo, A. E., Hveplund, T., Laswai, G. H.and **Weisbjerg, M. R. (2004):** A survey on calf feeding systems, problems and improvement options available for the smallholder dairy farmers of Turiani in Tanzania. Livestock Research for Rural Development, **16(23)**

Lyimo, H. L.N., Laswai G. H., Mtenga, L. A., Kimambo, A. E., D. M.Mgheni., T.Hvelplund., M. R.Weisbjerg. and **J.Madsen (2010):**Performance of crossbred calves raised on different dietary treatments under smallholder dairy farm conditions Livestock Research for Rural Development, **22** (3)

Macdonald, K. A., J. W. Penno, A .M. Bryant, and **J. R. Roche. (2005)**: Effect of feeding level pre- and post puberty and body weight at first calving on growth, milk production, and fertility in grazing dairy cows. J. Dairy Sci. **88**:3363-3375.

McGee, M., Drennan, M. J. and **Caffrey, P. J. (2006)**:Effect of age and nutrient restriction pre-partum on beef suckler cow serum immunoglobulin concentrations, colostrum yield, composition and immunoglobulin concentration and immune status of their progeny**.** Irish Journal of Agricultural Food Resources, **45:**157-171.

Mee, J.F. (2008): Prevalence and risk factors for dystocia in dairy cattle: a review**.** Veterinary Journal, **176:** 930-9101.

Mee, J.F., Rogers, P.A., and**O'Farrell, K.J. (1995)**: Effect of feeding a mineral-vitamin supplement before calving on the calving performance of a trace element deficient dairy herd. Veterinary Record, **137:**508-512.

Ministry of Livestock and Fisheries Development (MOLFD) (2006): Towards a competitive and sustainable dairy industry for economic growth in the 21st century and beyond Dairy Policy.

Ministry of Livestock and Fisheries Development (MOLFD) DLPO (2008): Annual report.

Moran, J. B. (2009): Business management for tropical dairy farmers. Journal of Tropical dairy farming pp. 280.

Moran, J. and **D. McLean. (2001):** Heifer rearing: A guide to rearing dairy replacement heifers in Australia pp.135.

Moran, J. B. (2002): Calf rearing: A practical guide (2ndEdition). 210 pp. Land-Links.

Moran, J. B. (2005): Feeding management for small holder dairy farmers in the humid tropics Journal of Tropical dairy farming; pp. 290.

Moran, J. B. (2011): Rearing young stock on tropical dairy farms in Asia Journal of Animal Science, **24(9):**1318-1328.

Mukurweini Constituency Strategic Plan 2007-2012

Mulligan, F.J., and**Doherty, M.L. (2008).**Production diseases of the transition cow**:** Veterinary Journal, **176:3**-9.

Muriuki, H., Omore, A., Hooton, N., Waithaka, M., Ouma, R., Staal, S, J. and **Odhiambo, P. (2003).**A review of the policy environment in the Kenya dairy sub-sector; Smallholder Dairy Project Research and Development Report 2.

Muth, O. H., J. E. Oldfield, L. F. Remmert and **J. R. Schubert. (1958):** Effect of selenium and vitamin e on white muscle disease. Science **128**: 1090.

Myers, S. E., D.B. Faulkner, F.A., Ireland, L.L., Berger. and **D. F. Parrett. (1999):** Production systems comparing early-weaning to normal-weaning with or without creep feeding for beef steers: Journal of Animal Science, **77:**300.

National Research Council (NRC): (2001): Nutrient Requirements of Dairy Cattle Natl. Acad. Press, Washington DC: 244-248.

Ngigi, M.W. (2004): Successes in African Agriculture; The case of smallholder Dairying in Eastern Africa: Paper Presented at the NEPAD/IGAD Regional Conference in Nairobi, Kenya.

Nonnecke, B.J., Foote, M.R., Smith, J.M., Pesch, B.A., and **Van Amburgh, M. E. (2003):** Composition and functional capacity of blood mononuclear leukocyte populations from neonatal calves on standard and intensified milk replacer diets Journal of Dairy Science, **86:**3592-3604.

Odima, P.A., McDermott, J.J. and **Mutiga, E., R. (1994)**: Reproductive performance of dairy cows on smallholder dairy farms in Kiambu District, Kenya: Design, Methodology and Development constraints. Proceedings of the 7th ISVEE Symposium, The Kenya Veterinarian, **18** (2): 366.

Omore, A; McDermott, J. J. and **Gitau, G.K. (1996)**: Factors influencing production on dairy farms in central Kenya. KARI Fifth Scientific Conference, Nairobi. pp 370-380.

Orodho, A. B. (2006): The role and importance of Napier grass in the smallholder dairy industry in Kenya.

Orr, J. P., and **Blakley, B. R. (1997):** Investigation of the selenium status of aborted calves with cardiac failure and myocardial necrosis. Journal of Veterinary Diagnostics Investigations **9**: 172-179

Ortman, K., Andersson, R., and **Holst, H. (1999)**: The influence of supplements of selenite, selenate and selenium yeast on the selenium status of dairy heifers. Acta Vet. Scandinavica, **40**: 23-34

Osuji, P. O., Khalili, H., Umunna, N. N., Sibanda, S. and **Shenkoru, T. (1995):**Effect of level of milk feeding and type of housing on the performance of crossbred calves (*Bos taurus* x *Bos indicus*) and Zebu calves (*Bos indicus*). Journal of Tropical Agriculture, **72** (3): 1 - 8.

Owen, E., Kitalyi, A., Jayasuriya, N. and **Smith, T. (2005):** Livestock and Wealth creation: Improving the husbandry of animals kept by resource poor people in developing countries, Nottingham University Press.

PACE, (2006): Kenya Data Base.

Pavlata, L., Illek, J., Pechova, A. (2001): Blood and tissue selenium concentrations in calves treated with inorganic or organic selenium compounds ï a comparison. Acta Vet. Brno **70**: 19-26.

Peeler, E. J and **A. Omore, (1997):** Manual of livestock Production Systems in Kenya 2nd Edition KARI (Kenya Agricultural Research Institute), Nairobi, Kenya.

Peterson, G. A., T. B., Turner, K. M., Irvin, M. E., Davis, H. W., Newland, and **W. R., Harvey.** (**1987**): Cow and calf performance and economic considerations of early-weaning fall-born beef calves.Journal of Animal Science.**64**:15.

Phipps, R. H., Grandison, A. S., Jones, A. K., Juniper, D. T., Ramosmorales, E. and **Bertin, G. (2008):** Selenium supplementation of lactating dairy cows: effects on milk production and total selenium content and speciation in blood, milk and cheese. Journal of AnimalScience, **2**: 1610-1618.

Pollock, J.M., Rown, T.G., Dixon, J.B., Carter, S.D. Spiller, D. and **Warenius, H. (1993):** Alteration of cellular immune responses by nutrition and weaning in calves Research Veterinary Science, **55**: 298-306.

Quan, J. (2011): A future for small-scale farmers, Science Review: Foresight Projection Global Food and Farming Futures, University of Greenwich, London.

Quigley, III, J.D., and **Drewry, J.J. (1998)**: Symposium; Practical considerations of transition cow and calf management, Nutrient and Immunity Transfer from Cow to Calf Pre and Post-calving (*Bos indicus*): Journal of Agricultural Science **96**:309-612.

Ropstad, E., Overnes, G., Refsdal, A. O. (1987): Selenium concentrations in Norwegian dairy herds related to reproduction and health performance. Acta Agric. Scand. **37**, 397-405.

Radostits, O. M., K. E. Leslie and **Fetrow., J. (1994)**: Herd Health: Food animal production medicine 2nd edition, Saunders publication, pp.631

Şahin, F., Volkan, M. and **Ataman, O.Y. (2005):** Effect of nitric acid for equal stabilization and sensitivity of different selenium species in electro-thermal atomic absorption spectrometry Analytica. Chimica. Acta, (Aabstract) **547**: 126-131.

Salami, Adeleke., B. Kamara, Abdul. and **Brixiova, Zuzana. (2010)**: ñSmallholder Agriculture in East Africa: Trends, Constraints and Opportunitiesò, African Development Bank Group, Working Paper Series No. 105, April 2010.

Scientific Veterinary Committee, (1995): animal welfare report.

Sivula, N., J., Ames, T.R., Marsh, W.E., and **Werdin, R.E. (1996)**: Descriptive epidemiology of morbidity and mortality in Minnesota dairy heifers calves. Preventive Veterinary Medicine, **27**: 155 ï 171.

Skoog, D. A. (1997). Principles of Instrumental Analysis New York: Holt.

Smallholder Dairy Project, (SDP). (2005): The uncertainty of cattle numbers in Kenya: SDP Policy Brief No. 10 Smallholder Dairy (R&D) Project.

Sivula, N. J., Ames, T. R., Marsh, W. E., Werdin, E. (1996): Descriptive epidemiology of morbidity and mortality in Minnesota dairy heifer calves. Preventive Veterinary Medicine **27**:155-171.

Smith, K. L, Hogan, J. S., Conrad, H. R. (1988) Selenium in dairy cattle: Its role in disease resistance. Veterinary Medicine **83**: 72-78.

Staal S., Chege L., Kenyanjui M., Kimari A., Lukuyu B., Njubi D., Owango M., Tanner J., Thorpe W. and Wambugu M. (1998a): Characterization of dairy systems supplying the Nairobi milk market: A pilot survey in Kiambu District for the identification of target groups of producers: Smallholder Dairy Project. pp. 85.

Staal S., Owango M., Muriuki H., Lukuyu B., Musembi F., Bwana O., Muriuki K., Gichungu G., Omore A., Kenyanjui M., Njubi D., Baltenweck I. and Thorpe W. (1998b): Dairy systems characterization of the Nairobi milk shed: Application of spatial and household analysis. Smallholder Dairy Project, Kenya.

Staal, S. J., Kruska, R., Baltenweck, I., Kenyanjui, M., Wokabi, A., Njubi, D., Thornton, P. and **Thorpe, W. (1999):** Combined household and GIS analysis of smallholder production systems: an application to intensifying smallholder dairy systems in Central Kenya: Proceedings of the 3rd International Symposium on Systems Approaches for Agricultural Development, National Agrarian University La Molina, Lima, Peru.

Staal, S., C. Delgado and **C. Nicholson(1997)**: Smallholder Dairying under Transactions Costs in East Africa. World Development, **5**: 779-794.

Statistical Analytical System: version 9.1.3 portable

Thorpe, W., H. G. Muriuki., A. Omore., M. O. Owango and **S. Staal. (2000):** Development of smallholder dairying in Eastern Africa with particular reference to Kenya Paper Project Review Workshop, Harare, Zimbabwe.

Tizard, I. (1995): Veterinary Immunology, 4th edition: Saunders publication.

Tyler, J. W., Hancock, D.D., Wiksie, S. E., Holler, S. L., Gay, J. M., and **Gay, C. C. (1998):** Use of serum protein concentration to predict mortality in mixed-source dairy replacement heifers: Journal of Veterinary Internal Medicine, **12:**79ï 83.

Udo, H. and **Cornelissen, T., (1998)**: Livestock in resource-poor farming systems Outlook Agriculture, **27**:237ï 242.

Vaccaro, L. (1990): Survival of European dairy breeds and their crosses with Zebus in the tropics, Animal Breeding Abstracts, **58:**475-493

Vale, G., Pereira, S.and **Mota, A. (2007)**: Enzymatic probe sonication as a tool for solid-liquid extraction for total selenium determination by electro-thermal atomic absorption spectrometry Atlanta journal, **74**: 198-205

Valk, Y.S. (1990): Review report of DEAF survey during 1989: Ministry of Livestock Development, Nairobi, Kenya pp.69.

Van Amburgh, M., and **Drackley, J. (2005)**: Current perspectives on the energy and protein requirements of the pre-weaned calf. Calf and Heifer Rearing Chapter 5 Nottingham University Press.

Van Saun, R. J., Herdt, T. H., and **Stowe, H. D. (1989)**: Maternal and fetal selenium concentrations and their interrelationships in dairy cattle. Journal of Nutrition **119**: 1128-1137

Van Saun, R. J. (1990): Rational approach to selenium supplementation essential. Feedstuffs (Jan 15): 15-17

Vanleeuwen, J .A., Mellish, T., Walton, C., Kaniaru, A., Gitau, R, K., Mellish, K., Maina, B., and **Wichtel, J. (.2012)**: Management, productivity and livelihood effects on Kenyan smallholder dairy farms from interventions addressing animal health and nutrition and milk quality, Tropical Animal Health and Production, **44**:231-238.

Virtala, A. M., Grohn, Y. T. and **Erb, H. N. (1999)**:The effect of maternally derived IgG on the risk of respiratory disease in heifers during the first three months of life Preventive Veterinary Medicine, **39:** 25-37.

Wakhungu, J.W. (2001): Dairy cattle breeding policy for Kenyan smallholders; an evaluation based on a demographic stationery state productivity model. PhD Thesis, University of Nairobi.

Wambugu, S., Kirimi, L. and **Opiyo., J. (2011):.**Productivity trends and performance of dairy farming in Kenya: Tegemeo institute of agricultural policy and development WPS 43/2011.

Warner, R.G. (1991): Nutritional factors affecting the development of a functional ruminantð a historical perspective. Proceedings, 1991 Cornell Nutrition Conference for Feed Manufacturers, Rochester, NY, pp. 1-12.

Weaver, D.M., Tyler, J.W., VanMetre, D.C., Hostetler, D.E., Barrington, G.M. (2000): Passive transfer of colostral immunoglobulins in calves, Journal of Veterinary Internal Medicine, **14:**569ï 577.

Webester, J. (1984): Calf Husbandry, health and welfare: London: Granada publishing Ltd. PP 1-17.

Weder, C. E. (1996): A Review of Early-weaning ï Effects on Calf Performance, Digestive System Development, Sexual Development, Animal Behavior, Carcass Quality and Economics. MSc Thesis.

Weiss, W., P. and **Hogan, J., S. (2005):** Effect of selenium source on selenium status, neutrophil function, and response to intra-mammary endotoxin challenge of dairy cows: Journal of Dairy Sciences, **88**; 4366-4374.

Weiss, W.P. (2002): Relationship of mineral and vitamin supplementation with mastitis and milk quality. Proceeding Annual Meeting National Mastitis Council, pp.37-44.

Weiss, W.P. (2003): Selenium nutrition of dairy cows: comparing responses to organic and inorganic selenium forms: Proceeding 19thAlltech Annual Symposium; Nutritional Biotechnology in the Feed and Food Industries, pp.333-343.

Wells, S.J., Dargatz, D., A. and **Ott, S., L.(1996):** Factors associated with mortality to21 days of life in dairy heifers in the United States. Preventive Veterinary Medicine, **29:**9ï 19.

West, G. (1995). Blacks Veterinary Dictionary, 18thedition: London: Black publisher Ltd.

Wittum, T., E. and **Perrino, L., J. (1995):** Passive immune status 24hours post-partum and long-term health and performance of calves: American Journal of Veterinary Resources **56**:1149ï 1154.

Wudu, T. J., (2004): Calf morbidity and mortality in dairy farms in Debre zeit, Ethiopia and its environs, Faculty of veterinary medicine, Addis Ababa University, Debre Zeit, Ethiopia, Msc thesis.

Wudu, T. J., Kelay, B., Mekonnen, H., M. and **Tesfu, K. (2008):** Calf morbidity and mortality in smallholder dairy farms in Adaœ Liben district of Oroma, Ethiopia. Tropical Animal Health and Production, **40**; 369ï 376.

Yang, Q.G., Chen, J. and **Wen, Z. (1984)**: The role of selenium in *Keshan* disease Advances in Nutritional Research 203-231.

Zust, J., Hrovatin, B., and **Simundic, B. (1996)**: Assesment of selenium and vitamin E deficiencies in dairy herds and clinical disease in calves. Veterinary Record **139**: 391-394

APPENDIXES

Appendix I

Observational Study Survey for Cost-Benefit Nutritional Study of Smallholder Kenyan Dairy Farmers:

Farm ID: Date: _____________ Interviewer: __________________

I. Farm overview:

1. How many people live in this household > 5 days per week? _____

2. Marital status: ____ single ___ married ____ separated/divorced ____ widowed

3. Motherôs education completed: ____ primary ___ secondary ____ college/university

4. Fatherôs education completed: ____ primary ___ secondary ____ college/university

5. Motherôs age _____ years

6. Fatherôs age _____ years

7. Number of years since joining WDL ____ 1-3 yrs ____ 4-6 yrs ___ 7-9 yrs ____ > 10 yrs

8. Percent of total income coming from dairy production: ____< 50percent ____50-70 percent ____> 70percent

9. Area of land owned: _______________ acres _____________hectares

10. Area of land rented: _______________ acres _____________ hectares

II. Please indicate the brand (if applicable) and amounts (in kg or cups or spoons/day) of the feeds listed that were given to each calf yesterday. Indicate if always available free choice. Note if mineral block lick has Se or not, if a mineral block is available.

Type/Brand	Calf #1 ID_______
Milk	é é é LITERS
Calf pellets	Y/N
Calf pencils	Y/N
Napier grass	Y/N
Sweet potato vines	Y/N
Banana leaves	Y/N
Mineral block lick	Y/N
Water always out	Y/N
other	Y/N

III. How do your calves usually receive their first colostrum?

1) Free choice suckle 2) bucket 3) other. Specify:

2) How soon would most of your calves receive 4L of colostrum?

1(< 6 hours 2) 6 - 12 hours

3) What do you do if a calf is weak and unable to drink colostrum during the first day of life?

____

4). How long do you feed calf pellets, calf pencils or dairy ration to your calves?

______ never _____ to 3 months age _____ to 6 months age ____ to 9 months age ____ longer

5). At what height do you cut and feed your Napier grass for calves < 12 months old?

_____ most< 1.0 meter _____ most> 1.0 meters

<u>IV. Health and Productivity</u>: Examination of Study Calf

	Calf #1 ID_______
a. Age	
b. Normal appetite?	Y/N
c. Treatment of any disease for week?	Y/N
d. Weight	
e. Height	
f. Body condition score	
g. TPR Normal / **A**bnormal	N / A
h. Cardio/pulmonary system	N / A
i. Gastrointestinal system	N / A
j. Feet condition	N / A
k. Skin parasite/condition	N / A
l. Any other ailment	Y / N ____________
m. Manure consistency OK?	Y/N
n. Housed separate from others?	Y/N
o. Calf pen comfort / hygiene (/6)	

Appendix II

<u>Experimental Study Survey for Cost-Benefit Nutritional Study of Smallholder Kenyan Dairy Farmers:</u> for subsequent farm visits after the study calf is born

Farmer Name: ______________________ Farm Number: ______________.

Group: ____________ Visit Number: 1 2 3 4 5 6 7 8 9 Visit Date:

Interviewer Initials:

<u>Part A. Post-birth visit question (ask these only at the first visit after the birth)</u>

i. Was the birth observed (was someone around)? Y / N

ii. What time of day was the birth? ________________________

iii. Did you need to give assistance to deliver the calf? Y / N

iv. Sex of calf M / F

v. Was the calf weak during the first 6 hours? Y / N

vi. Were any treatments given to the calf? Y / N (specify) ____________________

<u>Part B. For every post-natal visit</u>

1. Please indicate the **brand/product** (if applicable) and **average amounts** (in kg or cups or spoons/day) of the feeds listed that were given to each calf **<u>daily during the last week</u>**. Indicate if always available free choice.

	Brand	Calf_____
Milk		
Calf pellets		
Calf pencils		
Napier grass	__	
Other grasses	__	
Other forage (sweet potato vines, banana leaves, other specify)	__	
Mineral block lick		
Water available always / not always	__	A / N
Any other feeds?		

2. How long is the chopped length of your Napier grass (and banana leaves/stems, if fed)?
____ Majority is < 1 inch ____ majority is 1-3 inches _____majority is > 3 inches

3a. At what height did you cut and feed your Napier grass for **calves** this week (answer only if different from above)?

_____ Most< 1.0 meter
_____ Most>1.0 meters

4. Did you make any **sudden / unusual** changes in feed (amount or type) to your cows or calves?
_____YES _____NO

II. Health and Productivity: Examination of Cattle Study **Calf**

	Calf #1 ID_______
a. Age	
b. Normal appetite?	Y/N
c. Treatment of any disease for week?	Y/N
d. Weight	
e. Height	
f. Body condition score	
g. TPR Normal / Abnormal	N / A
h. Cardio/pulmonary system	N / A
i. Gastrointestinal system	N / A
j. Feet condition	N / A
k. Skin parasite/condition	N / A
l. Any other ailment	Y / N ___________
m. Manure consistency OK??	Y/N
n. Housed separate from others?	Y/N
o. Calf pen comfort / hygiene (/6)	