EGERTON UNIVERSITY LIBRARY

# SMALLHOLDERS' USE OF ANIMAL INFORMATION AND TRAIT PREFERENCES IN INSEMINATION AND HERD REPLACEMENT PRACTICES IN DAIRY CATTLE IN WESTERN KENYA




BETT KIPKEMOI BENARD




A Thesis Submitted to the Graduate School in Fulfillment for the Requirements of the award of Master of Science Degree in Livestock Production Systems of Egerton University

EGERTON UNIVERSITY

MAY, 2016

2016109104

EGERTON UNIVERSITY LIBRARY

## DECLARATION AND RECOMMENDATION

### DECLARATION

I declare that this thesis is my original work and has not been presented in this or any University.

Signature: ..... Date: 23/05/16...

**Name of candidate: Bett Kipkemoi Benard**

**Registration No: KM11/3276/12**

### RECOMMENDATION

This thesis has been submitted with my approval as the University supervisor.

Signature: ..... Date: 23/05/16

**Bockline Omedo Bebe**

**Professor of Livestock Production Systems**

**Department of Animal Sciences, Egerton University**



EGERTON UNIVERSITY LIBRARY

## COPYRIGHT

**©2016, Bett, K.B**

All rights reserved. No part or whole of this thesis may be reproduced, stored in a retrieval system or transmitted in any form or means such as electronic, mechanical or photocopying without the prior written permission of Egerton University on behalf of the author.

## DEDICATION

I dedicate this work to my sister Rose Kemboi and my immediate former boss Faith Gitahi for their immeasurable support.

## ACKNOWLEDGEMENT

I wish to convey my deepest gratitude to my sister Rose Kemboi and my former immediate boss and a colleague Faith W. Gitahi for their unwavering support throughout my studies. I greatly acknowledge your financial and moral support throughout my studies. You played a key role in ensuring that I started my masters' programme and as I look back with sense of pride and fulfillment, I can't imagine how it could have been without your support. Special thanks go to my supervisor Prof. Bebe who went out of his way to ensure that I get every support I needed to complete my studies; without his mentorship and invaluable academic support, this thesis could not have been written. You have not only refined my professional skills but you have also positively influenced my world view and the way I generally perceive life issues. I appreciate the support of all the lecturers from the department of Animal Science for the exemplary work they are doing in producing expertise skills that match the emerging needs of our modern day's challenges. I also wish to acknowledge the support from my colleagues particularly Duncan Cheruiyot for sharing valuable ideas during my entire studies and research period. To sum it all, I'm grateful to God for His grace, strength and guidance throughout my study period.

## ABSTRACT

Smallholder farmers pursue the breeding objective of attaining more milk yield. However, they do not practice herd recording to inform their insemination and replacement practices when using own reared stock or purchased breeding stock. Under these circumstances, there is the likelihood that farmers do not make informed decisions when choosing breeding dams and sires and replacement stock to achieve the breeding objective of increased milk yield. This study was designed to (i) determine animal identification systems and type of animal recording by smallholders (ii) establish smallholders' sources of dairy breeding stock, (iii) examine source of dam and sire information and whether smallholders consider such information adequate for breeding decisions and (iv) determine traits of preference in breeding sires and dams. The study used multi-stage sampling procedure to select 245 small-scale dairy farmers in regions classified milk surplus (MSR) and milk deficit (MDR) counties of Nandi and Vihiga respectively. Data were analyzed using descriptive, non parametric test statistics and logistic regression modeling. From the study, animal identification was predominantly by name/colour and rarely by ear tagging and recording was predominantly about production and breeding. Breeding sires were more frequently sourced from fellow farmers or own reared bull but use of AI semen was less frequent. Breeding dams comprised cull cows and heifers and about 40% were externally sourced. Farmers sourced animal information for breeding mainly from fellow farmers and they sought more often about the breed followed by performance history and breeder in milk surplus region. In milk deficit region farmers sought information often about breeder farmer followed by breed and performance history. A dairy breeder farmer was considered the most useful information sourced in both milk surplus and milk deficit regions. Milk yield trait and fertility were the traits smallholders paid more attention to when selecting a dam and a sire for breeding in both regions. This information will guide breeding practices such as insemination, herd replacement and other interventions commonly practised by smallholder dairy farmers and extension officers who assist farmers in order to improve productivity in smallholder dairy production system.

## TABLE OF CONTENTS

**DECLARATION AND RECOMMENDATION** ..... II
**COPYRIGHT** ..... III
**DEDICATION** ..... IV
**ACKNOWLEDGEMENT** ..... V
**ABSTRACT** ..... VI
**TABLE OF CONTENTS** ..... VII
**LI ST OF TABLES** ..... IX
**LIST OF ABBREVIATIONS AND ACRONYMS** ..... X
**CHAPTER ONE** ..... 1
1.0 INTRODUCTION ..... 1
1.1. Background Information ..... 1
1.2. Statement of the Problem ..... 2
1.3. Research Objectives ..... 3
1.4. Research Questions ..... 3
1.5. Justification ..... 4
1.6. Scope and limitation of the study ..... 4
1.7. Definition of terms ..... 4
**CHAPTER TWO** ..... 6
2.0 LITERATURE REVIEW ..... 6
2.1. Dairy Breeding Objectives in Smallholder dairy Farms in Western Kenya ..... 6
2.2. Dairy Trait Preferences by Smallholder Farmers ..... 7
2.3. Animal Identification and Herd Recording by Smallholder Farmers ..... 10
2.4. Sire and Dam Information for Genetic Improvement ..... 13
2.5. Methodological Approaches in Studying Smallholder Dairy Breeding Improvement ..... 17
**CHAPTER THREE** ..... 19
3.0 METHODOLOGY ..... 19
3.1. Study site ..... 19
3.2. Sampling procedure ..... 21



EGERTON UNIVERSITY LIBRARY

3.3. Sample size.....23
3.4. Data collection.....23
3.5. Data analysis.....25
**CHAPTER FOUR** .....27
4.0 RESULTS AND DISCUSSION.....27
4.1. Animal identification and recording in smallholder dairy herds in Western Kenya.27
4.2. Sources of dams and sires in smallholder dairy herds in Western Kenya.....30
4.3. Sources and usefulness of sire and dam information to the smallholder dairy farmers in Western Kenya.....36
4.4. Determining traits preferences for sire and dam to mate by smallholder dairy farmers in Western Kenya.....41
**CHAPTER FIVE** .....44
5.0 CONCLUSIONS AND RECOMMENDATIONS.....44
5.1. Conclusions.....44
5.2. Recommendation.....44
5.3 Further Research.....45
**REFERENCES** .....46
**APPENDIX** .....57

## LI ST OF TABLES

Table 1: Traits of economic importance in dairy breeds of cattle and buffaloes.....8
Table 2: Summary of variables and measurements for each objective of the study.....24
Table 3: Odds ratio estimates for animal identification and performance recording practices in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya .....29
Table 4: Odds ratio estimates for sources of dams of heifers and cows in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya .....32
Table 5: Odds ratio estimates for sources of sires of heifers and cows in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya .....34
Table 6: Odds ratio estimates for reasons of mating with bull or Artificial Insemination semen in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya .....36
Table 7: Odds ratio estimates for animal breeding information and their sources accessed by smallholder dairy farmers in regions classified milk surplus or milk deficit.....38
Table 8: Odds ratios (and their 95% confidence intervals) for stated usefulness in the two milk production regions.....40
Table 9: Odds ratio estimates for trait preferences by smallholder farmers when selecting a bull for mating in dairy herds in regions classified milk surplus or milk deficit in Western Kenya .....42
Table 10: Odds ratio estimates for trait preferences by smallholder farmers when selecting a heifer or a cow for mating in dairy herds in regions classified milk surplus or milk deficit regions in Western Kenya.....43

## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ADHIS | Australian Herd Dairy Improvement Scheme |
| AFC | Age at First Calving |
| AI | Artificial Insemination |
| CI | Calving Interval |
| CIDP | County Integrated Development Plan |
| CDLP | County Director of Livestock Production |
| DFS | Days from calving to First Service |
| DMY | Daily Milk Yield |
| DRSK | Dairy Recording Services of Kenya |
| EADD | East Africa Dairy Development |
| EBV | Estimated Breeding Value |
| ESAP | Ethiopian Society of Animal Production |
| FAO | Food and Agriculture Organization |
| IAEA | International Atomic Energy Agency |
| ILRI | International Livestock Research Institute |
| LL | Lactation Length |
| LY | Lactation Yield |
| LSM | Least Square Means |
| MDR | Milk Deficit Region |
| MOL&FD | Ministry of Livestock and Fisheries Development |
| MSR | Milk Surplus Region |
| NBS | Nucleus Breeding Schemes |
| NGO | Non-Governmental Organizations |
| SAS | Statistical Analysis System |
| SDCP | Smallholder Dairy Commercialization Programme |
| SDP | Smallholder Dairy Programme |
| SPSS | Statistic Package for the Social Sciences |

# CHAPTER ONE

# 1.0 INTRODUCTION

## 1.1. Background Information

Smallholder dairy production in Kenya is characterized by integration with crops on small land holdings less than ten acres with herds often less than ten animals producing less than ten litres per cow per day (Bebe *et al.*, 2003; Chagunda *et al.*, 2006; Musalia *et al.*, 2007; Murage & Ilatsia, 2011). Reasons for keeping cattle in this system include milk for family food, incomes and manure with which smallholder sustains soil fertility while producing food and fodder crops (Bebe *et al.*, 2003; FAO, 2011). As described by McDermott *et al.* (1999), smallholders practice dairying with multiple objectives and functions but with less intensive knowledge application. The multiple production objectives for milk include more milk for family food, nutrition and income (Bebe *et al.*, 2003; Murage & Ilatsia, 2011) which is implemented through a breeding strategy that maximizes the proportion of potentially high milk yielding dairy genotypes in the herd (Bebe *et al.*, 2003; Murage & Ilatsia, 2011). An estimated over 800,000 dairy farmers implementing this breeding strategy account for more than 85% of the annual total domestic milk production and 80% of the total marketed milk annually in Kenya (Bebe *et al.*, 2002; SDP, 2004; GOK, 2010).

Smallholder dairy farmers are however facing challenges in realizing sustained increase in milk yield through this breeding strategy of maximizing the proportion of potentially high milk yielding dairy genotypes in their herds. They often purchase cull-cows then inseminate with bulls of unknown genetic merit because the supply of breeding stock is insufficient for the rising demand, herd performance recording is generally absent and uptake of Artificial Insemination (AI) remain very low (Bebe *et al.*, 2003; Murage & Ilatsia, 2011). This is particularly true for Western Kenya, a region classified milk deficit (Okeyo *et al.*, 2000; Njoroge *et al.*, 2004). Farmers in Western Kenya typically keep one to three cows (Wanjala *et al.*, 2014) which they often source from the neighbouring milk surplus Rift Valley region. This region has a comparatively improved supportive services and larger herds able to produce tradable surplus milk, breeding bulls and replacement stock (Mudavadi *et al.*, 2001; Njoroge *et al.*, 2004).



EGERTON UNIVERSITY LIBRARY

Despite the adoption of dairy recording scheme that is centralized in Kenya, record keeping among smallholder dairy farmers remains a major challenge (Kosgey *et al.*, 2011). Most smallholders have difficulties practicing herd record keeping (SDCP, 2010). This has been attributed to few and infrequent transactions which farmers are able to recall, but these are inaccurate for breeding decisions targeting a change in milk yields. There is, therefore, a likelihood of smallholders being unable to implement informed dairy breeding improvement decisions.

Informed breeding practice requires good record keeping that provides useful information for good management and more profitable dairying (Khan *et al.*, 2005; Chagunda et al., 2006) because animal recording system is crucial for the success of any breeding programme. Proper record keeping entails all the activities that involve the measurement of various indicators of animal performance, recording the information, processing and interpretation and being able to use the results in breeding practice. Keeping proper records for animal performance is also of enormous value for management decision-making by individual farmers and for the industry as a whole (Chagunda *et al.*, 2006).

Dairy cattle performance recording provides the basis for informed dairy breeding improvement through identifying and using superior sires and dams (Chagunda *et al.*, 2006). What informs breeding practiced by farmers depends on what kind of breeding information the farmer has. It is likely that information on sire and dam that is obtainable fails to adequately inform dairy breeding practices which would contribute to improved genetic merit for milk productivity. This is due to lack of proper recording of animal performance. There is, therefore, limited understanding of what informs smallholders' insemination and herd replacement practices.

### 1.2. Statement of the Problem

Smallholder dairy farmers are interested in obtaining more milk yield from their small herds but they do not practice herd recording to inform their insemination and replacement practices in breeding improvement when using own reared stock or purchasing breeding stock (Omondi *et al.*, 2009; Kosgei *et al.*, 2011). Under these breeding circumstances, there is the likelihood that farmers do not obtain useful information about breeding dams and sires to inform insemination and replacement practices for attaining their breeding objective. This raises several questions

including whether smallholders' breeding objectives are informed by animal identification systems and performance recording, sourcing of breeding stock and performance information, and trait preferences when choosing sire and dam for breeding. Answers to these questions are relevant for improving breeding practices and productivity in the smallholder dairy herds.

## 1.3. Research Objectives

### 1.3.1 Broad Objective

To contribute to improved dairy breeding practices in order to enhance productivity in smallholder dairy herds.

### 1.3.2 Specific Objectives

i. To determine animal identification systems and animal records kept related to breeding practices.
ii. To establish the sources of breeding sires and dams in smallholder dairy herds.
iii. To examine the sources of information on sires and dams and determine how useful these are to farmers for choice of sire and dam to mate.
iv. To determine traits of preference in sire and dam selection among smallholder dairy farmers.

## 1.4. Research Questions

To achieve the above objectives, the following research questions guided the study.

i. What are the frequently used animal identification systems and records in smallholder dairy herds?
ii. Where do the smallholders source sires and dams for insemination and herd replacement practices?
iii. Where do the smallholder dairy farmers source sire and dam information and how useful is the information obtained for insemination and herd replacement practices?
iv. Which are the traits of preference to farmers when sourcing breeding sires and dams for insemination and herd replacement?

### 1.5. Justification

Insemination and herd replacement practices in the absence of performance recording present a challenge to sustainable dairy breeding improvement. Therefore, knowledge of the best breeding practices in smallholder herds would inform interventions to improve breeding practices for farmers and extension service providers. The sourcing of breeding stock from farms in Rift Valley region by smallholders in Western Kenya region involves a breeding practice that has technical and economic implication. Information from this research will help to fill the gap in what informs smallholders' insemination and herd replacement practices and the necessary interventions for improving productivity in smallholder dairy herds.

### 1.6. Scope and limitation of the study

This study was carried out in Hamisi in Vihiga county and Aldai in Nandi county. The two counties represent milk deficit and milk surplus regions, respectively. They are situated in two neighbouring provinces: Western and Rift-Valley provinces, respectively, in Western parts of Kenya. In spite of the similar geography, previous studies have shown that Western Kenya has been milk deficit while its immediate Rift Valley neighbour is milk surplus. Only two divisions were selected in the two regions due to constrain in resources (funds) to cover the entire region. The study only focused on breeding practices in the two regions in Western parts of Kenya and how it could have possibly contributed to decline of dairy breeds genetics and by extension lower productivity of dairy cows. Other social-cultural and economic factors that could be affecting the choice of breeds and informed breeding decisions were not considered.

### 1.7. Definition of terms

**Breeding practices:** Refers to decisions dairy farmers make about insemination and replacement of their dairy herds.

**Smallholders:** These are dairy farmers keeping less than ten dairy animals in less than ten acres and produce less than ten litres per cow per day.

**Breeder farmer:** This is a farmer who produces improved surplus dairy breeding stock and sells to other farmers.

**Breeding information:** This refers to information e.g. breed, breeder farmer, progeny history and production performance which farmers seek when making replacement or insemination decisions.

**Social-economic factors:** These are factors that enhances or limits productivity in smallholder dairy production systems and includes level of education, land size, credit facilities and infrastructure.

**Breeding value:** Animal's individual value as genetic merit; Assessment of the future genetic potential of an animal.

**Sire:** A bull used for breeding purposes (Male parent of the calf).

**Dam:** Female (used for breeding purpose) parent of the calf.

**Artificial insemination:** Technique of collecting semen from a male and inserting it into the genital tract of a female.

**Heifer:** The younger female of cattle above age of six months to first calving.

**Cull cow:** A cow removed or disposed off from the farm because the owner has determined to be inferior.

**Performance recording:** Measurement of various indicators of animal performance and the use of that information in the decision making.

**Animal Recording:** Process by which data including parentage, characteristics, performance and relevant events are collected, recorded and safely stored and made appropriately accessible for use.

**Identification:** Giving an animal individually or collectively a unique identifier.

**Breeding objectives:** Traits targeted for improvement in the breeding programme based on their influence on economic returns and costs of production to the farmer.

# CHAPTER TWO

# 2.0 LITERATURE REVIEW

## 2.1. Dairy Breeding Objectives in Smallholder dairy Farms in Western Kenya

Dairy cow breeding objectives focus on increasing the genetic merit for high milk yield at an economic cost (Ombura *et al.*, 2007, Njubi *et al.*, 2011). This requires implementing a well-defined breeding objective (Wahinya *et al.*, 2015). Breeding objective encompass those traits targeted for improvement in the breeding programme based on their influence on economic returns and costs of production to the farmer (Duguma *et al.*, 2010). Dairy cattle improvement often targets traits of economic importance to improve profitability and sustainability of dairy cattle operations (Sarakul *et al.*, 2011; Wahinya *et al.*, 2015). Profitability of dairy cattle enterprises does not only depend on milk production but also on non-productive characteristics such as fertility and health traits (Toghiani, 2012). Consistent reproduction is of great importance for dairy cattle since daily yield is highest during early lactation and because longer dry periods (caused by failure to conceive quickly) leads to greater costs for maintenance without any income. Both late age at first calving (AFC) and long calving intervals are major constraints to profitability in dairy cattle farming. Other traits of interest are disease resistance, temperament, udder characteristics, milk let-down and body size and shape (Jain & Muladno, 2009). Defining the breeding objectives is first step in making informed breeding decisions. Kosgey (2004) emphasized that breeding objectives should include all relevant characteristics of an animal e.g. production, reproduction, fitness and health characteristics and each trait should be assigned an economic value. Besides, functional traits such as reproduction and health traits have recently received increased focus due to biological, economic, ethical reasons and animal welfare concerns (Toghiani, 2012).

Implementation of defined breeding objectives require use of animal performance records. This is a challenge since in smallholder herds performance records are hardly kept yet farmers pursue broad breeding objectives incorporating increased milk yield with adaptability to diseases and low quality feed resources with non marketed benefits including manure, insurance and financing roles of cattle (Bayer *et al.*, 2001; Bebe *et al.*, 2003; ESAP, 2004; Mattoni *et al.*, 2007; FAO, 2009). According to Bebe *et al.* (2003), smallholders rank milk production for generating

cash income and feeding the family as the major objective for keeping dairy cattle. Body weight is another production trait of major consideration by smallholders. This is important to smallholders when they sell surplus cows for slaughter or to other farmers for production and given that dairy cattle also serve as savings account (Bayer *et al.*, 2001; Bebe *et al.*, 2003).

Smallholders interested in generating income from milk sales strive to produce milk surplus that can be marketed. Their breeding decisions are, therefore, generally geared toward acquiring high yielding cows regardless of high nutritional and health care demands (Bebe *et al.*, 2003; Menjo *et al.*, 2009). Given the differences between breeds in terms of disease resistance, market value and appropriateness for different management systems (Ouma *et al.*, 2004), smallholders need performance records to inform their breeding decisions. Marius *et al.* (2010) emphasize that dairy breeds should be subjected to selection for specific production traits and consideration for adaptation is needed since milk production in the tropics is limited by the extreme climate. Other livestock values to smallholders in determining the breeding objectives include accumulation of fluid capital assets, insurance and cash needs (Njubi, *et al.*, 2011). This, therefore, implies that heavy body weight may be more preferred because it attracts high market value especially when selling cows either for slaughter or to other farmers for production. This is a common practice among smallholders (Udo & Cornelissen, 1998; Bebe *et al.*, 2003) and would seem to suggest that breeding objectives should be in line with the overall objectives of the smallholder farmers to meet their production goals. It has not been however highlighted how smallholders make informed breeding decisions in the absence of performance recording. Under smallholder production systems, conventional breeding methods are challenged by absence of records and small herd sizes among others (Kahi *et al.*, 2004; Ombura *et al.*, 2007). This however has not stopped smallholders from making deliberate efforts to produce improved dairy cows which are often sold as breeding stock and used as replacement stock. This study seeks to fill the knowledge gap on this aspect in smallholder dairy farms where some kind of unconventional breeding is practiced to address the problem of shortage and high cost of quality heifers.

### 2.2. Dairy Trait Preferences by Smallholder Farmers

When dairy farmers are selecting animals for breeding stock, they are usually more concerned with animal's genetic value rather than its phenotypic value of a particular trait (Kiplagat *et al.*, 2012). The challenge dairy breeders often encounter is, therefore, to determine which dams and

sires to mate in order to obtain progeny with traits of desired attributes. Through development of a clear index based on a well-defined breeding objectives, farmers can make informed decisions to achieve genetic progress in the health and production traits (Rhone *et al.*, 2008). The use of EBV based on an index for genetic selection is still not utilized by many smallholder dairy farmers in developing countries because pedigree records on the traits of economic importance are scanty to inform the process (Wasike *et al.*, 2007).

**Table 1: Traits of economic importance in dairy breeds of cattle and buffaloes**

| Trait category | Specific traits |
|---|---|
| Production | Milk yield |
| | Concentration of milk solids-fats and protein. |
| Reproduction | Days open |
| | Services per conception/conception rate |
| | Calving ease |
| | Fertility |
| | Age at first calving |
| | Calving interval |
| | Age at first collection of semen |
| Health | Disease resistance |
| Physical appearance | Body shape, size and dimensions |
| | Udder characteristics, structural traits |
| | Body conditions. |
| Management | Longevity |
| | Milk let-down |

Source: Jain & Muladno, (2009), selection criteria and breeding objectives in improvement of productivity of dairy cattle and buffaloes in Asia.

Reproductive wastage is of major economic importance to both dairy cattle and beef industries globally (Fortes *et al.*, 2013), therefore, reproductive traits are very important in dairy animals. Consistent reproduction in dairy cattle is important since daily yield is highest in early lactation

and because longer dry periods resulting from failure to conceive quickly results in greater costs of dry cow maintenance (Jain & Muladno, 2009).

Previous studies have shown that smallholders express greater need for dairy cattle genotypes with the potential for high milk yield (Bebe *at el.*, 2003; Menjo *et al.*, 2009; Njubi *et al.*, 2011). In Kenya, the superior germplasm is disseminated through natural bull services, artificial insemination (AI), and a combination of AI and bull services and to a very limited extent, multiple ovulation and embryo transfer (Murage & Ilatsia, 2011). However, information about the sires and dams for insemination and replacement decisions is needed as this influences genetic improvement. Though female reproductive performance is considered in culling by smallholders, it is more for economic reasons than for genetic improvement (Fortes *et al.* 2013). This could be better explained by lack of reliable and accurate information about the culled animal, implying that breeding decisions made by farmers are likely not informed by history of performance.

In the absence of performance records, farmers are likely to make breeding decisions on observed phenotypic characteristics and physical appearance only. For instance, health is likely to be of greater concern because sick animals may be a pointer to problematic animals which owners are culling. Body size is important when selling cows for slaughter or to other farmers for production because it has influence on market value (Bebe *et al.*, 2003). Udder traits may be associated with milk production, resistance to mastitis or ease of milking (Jain & Muladno, 2009). These, however, have limitations in selection, for instance, longevity is a pointer to adaptable animal that has survived diseases or culling, but the animal will be on declining fertility.

Murage & Ilatsia (2011) observed a rising demand for breeding animals among smallholders for high performing cows so as to meet the demand for dairy products. For on-farm dairy production, farmers seek set of animal attributes which best satisfy circumstances and objectives (Mugisha *et al.*, 2014). From a practical perspective, the traits of interests are best identified by farmers and therefore should be objectively assessed (Kosgey *et al.*, 2011). Among most smallholders, the sale or home consumption of milk and the sale of surplus animals for breeding and meat are of economic importance (Bebe *et al.*, 2008). The information available on trait preferences is not explicit on whether smallholders match their dairy breeding objectives and the

main reason for keeping dairy cattle with the selection of breeding sires and dams. Trait preferences in dam and sire selection will help to realize the breeding objective for high milk yield in smallholder farms and focus research on the traits of interest.

### 2.3. Animal Identification and Herd Recording by Smallholder Farmers

In dairy breeding, farmers should endeavour to milk better cows than the cows they currently have in their herds. Herd performance recording is important for achieving this goal. Animal recording organizations have demonstrated that animal recording systems are necessary in breeding decisions towards increased productivity (Trivedi, 1997; Ombura *et al.*, 2007). The smallholder dairy farmer is no different, as family income will also increase if more productive dairy cows are milked. Bester *et al.* (2001) observed that successful genetic progress depends on animal identification and the keeping of regular records, tasks that are not generally perceived as important by smallholders who often fail to either tag their animals or to take regular measurements. Identification of animals is important to modern commercial farming as it facilitates successful management (FAO/WHO, 2004). Group identification is generally done for ownership and management while individual animal identification is needed for recording individual animal performance (Whittier, 2011).

Countries like Botswana that have succeeded in animal identification started by initially making it compulsory for all livestock in the country to have a unique registered brand that could be traced to a particular farm, individual, family or community (Ekuam, 2008/2009). According to Oltjen *et al.* (2005), individual animal identification systems not only permit the depth of information needed for quality features authentication, but also provide the information needed for tracking an animals' performance from weaning to its productive age and selection of individuals with the most desirable genetic merit.

The aim of a livestock recording scheme is generally to provide farmers with information about individual animals for management and for breeding purposes i.e. to estimate total yield per animal, and use these estimates for genetic evaluation purposes. Kosgey *et al.* (2011) observed that little has been done to develop suitable recording procedures for smallholder production systems that can generate objective data for use in genetic improvement within the systems. Rhone *at el.* (2008) found out that farmers who kept records on individual animals had

significantly higher milk fat percentages and lower bacterial scores than farmers who did not. Proper record keeping is one of the factors that determine genetic improvement and keeping proper pedigree records will provide useful breeding information that will help to avoid inbreeding (Ombura *et al.*, 2007; Muasya *et al.*, 2013). Dairy cattle breeding programmes in developing countries are more vulnerable to the effects of inbreeding as they are often characterized by inconsistent pedigree and performance recording (Nilforooshan *et al.*, 2008, Mugisha *et al.*, 2014).

The objective of record keeping can also be designed to provide information about the livestock, their use, performance and development, by both farmers and national authorities (Katingi, 2011). This will ensure that information both at the national and farmer level is available for use in making critical breeding decisions for smallholder farmers.

In Kenya animal recording is undertaken by Dairy Recording Service of Kenya. This is a farmers' organisation dominated by large scale farmers. Studies have shown that few smallholders keep performance records (Bebe *et al.*, 2002). Omondi *et al.* (2009) reported that only 22.5% of the smallholder farmers kept records of their dairy enterprises. Small scale dairy production system farm owners have also been found to lack proper recording systems. In some cases farmers have been found to keep only AI recording card and milk sale receipts which they used to follow up productive and reproductive efficiency of their cows (Mureda *et al.*, 2008). Herd size in smallholder production systems has been found to affect adoption of record keeping (Bachman, 1998). Very small herd sizes on one hand and relatively large on the other hand, have been associated with low recording while medium herd sizes of between three and six cows have been associated with high recording participation (Chagunda *et al.*, 2006). In a case study of smallholder animal recording in Sri Lanka, Amarasekera, (1998) indicated that smallholders having one or two cows very rarely kept individual production records. This was attributed to the argument that, in small herds, transactions are few and less frequent such that farmers are familiar with their herds and might account these to memory. Khan *et al.* (2005) in his study reported that when asked about daily milk yield (DMY), lactation length (LL), lactation yield (LY), age at first calving (AFC) and calving interval (CI) of cattle and buffaloes, farmers only gave averages and ranges of the productive and reproductive traits and did not have any written records. Without written records, farmers have to depend on their memory when making

decisions affecting their farm practices. Memory, however, can become unreliable, particularly after a few days, months or years (SDCP, 2010).

Animal recording is an activity that involves the measurement of various indicators of animal performance and the use of that information in the decision making (ADHIS, 2015). Nilforooshan *et al.* (2008) emphasized that genetic evaluation of an animal depends on the number of available records on the animal itself and its relatives. In modern dairy farming, successful management relies on good record keeping and on information that can be derived from it. Farm records are normally utilized routinely for daily management decisions. Jelan & Dahan, (1998) observed that quantitative knowledge about a farm provides the basis for understanding where dairy has been, where it is today and where it is going.

The major recording activities that provide useful information to smallholders when sourcing for breeding stock comprise of breeding records and milk production records (Risstrom, 2014). The main emphasis for dairy farmers is to sell as much milk as possible with maximum efficiency, both financially and in terms of animal welfare (Ombura *et al.*, 2007). Substantial improvements in milk production can be achieved through establishment of simple, accurate, understandable and easy to keep recording systems (Kosgei *et al.*, 2011). Furthermore recording of animal performance is of enormous value for management decision making for both individual farmer and for the industry or country as a whole (Jelan & Dahan, 1998). Keeping track of what is happening on the dairy farm requires some records. Good dairy management practice requires having a good useful set of farm records. Farm records are ideal for smallholders who often engaged in mixed farming since they will be able to evaluate dairy enterprise (SDCP, 2010).

Long term benefits that the farmers get from record keeping include better prices for animals with documented information, improved access to both national and international markets for their animal products due to their traceability (Oltjen *et al.*, 2005). Dairy farmers further benefit from improved services due to better use of communal bargaining power, strong collaboration between farmers for their regional development and better livelihoods for the livestock keepers (Katingi, 2011, SDCP, 2010). For a herd recording service to be of benefit to the tropical dairy farmer, it needs to focus on the production traits that are important in a particular country. In Australia, for example, herd recording programmes focus on kilograms of protein and milk fat produced as these are the basis of payment (Australian Dairy Industry, 2014). In Thailand, dairy

farmers are paid for litres of milk with a bonus for milk with a fat test percentage above a set standard, and a penalty if it is below that standard (Risstrom, 2014). Therefore, for a herd recording programme in Thailand to be relevant to farmers, it needs to focus on litres of milk and fat test percentage. It is important that the herd recording service provider, whether government institution, extension service provider, or a farmer-owned and controlled co-operative or association, focuses on the relevant economic needs of the dairy farmers they are servicing. The breeding programme can be strengthened by enhancing pedigree recording to enable long-term management of genetic variability and genetic improvement (Muasya *et al.*, 2013). Smallholders play a role in genetic improvement of their dairy herds through proper selection of sires and dams to mate.

To enhance more participation of performance recording by smallholders, central recording scheme in Kenya (DRSK) needs to constantly provide information to enable farmers to compare their animal performance and therefore stimulate competition that will enhance production (Bebe *et al.*, 2003). It is also necessary to develop simple and standardized recording systems for smallholders (Mureda *et al.*, 2008). The accuracy of genetic evaluation depends on the recording system and the method of evaluation (Nilforooshan *et al.*, 2008). These should be tested and validated by extension in collaboration with relevant researchers (Kosgey *et al.*, 2011). There is need to understand specific types of records related to breeding and production kept by smallholders in order to determine whether there are deliberate efforts to improve genetic potential through upgrading.

### 2.4. Sire and Dam Information for Genetic Improvement

Selection of superior individuals as parents within breeds and choice of breeds or composite lines to be used in crossbreeding systems are the general tools that are available to smallholders to bring about genetic improvement in their dairy herds (Van der Lee *et al.*, 2014). Genetic change and improvement takes place when the parents of the next generation of animals are chosen (Ombura *et al.*, 2007). Groen, (1999) observed that genetic improvement focuses on directional improvement in genetics of animals in coming generations such that they will produce the desired products more efficiently under the expected future economic, social, and ecological production environment. For a dairy herd, that means choosing the sires and dams of potential heifer replacements and doing so on the basis of their expected genetic merit (Kahi & Rewe,

2008). Staal *et al.* (2001) reported that smallholder farmers use AI services or rely on communal bulls where AI services cannot be accessed easily. Given that there is a shortage of own-produced replacements due to low calf survival and heifer and cow mortalities, many farmers have been obtaining replacement stock from large-scale dairy farms (Staal *et al.*, 2001). This however may no longer be the case given that most large scale dairy farms have collapsed or have been subdivided for resettlement of smallholders, particularly in the highland areas where dairying is concentrated (Bebe *et al* 2002). This dynamic raises the question about smallholders' current source of breeding stock to meet the high demand.

The challenge of the dairy cattle breeder is to determine which cows and bulls to breed in order to obtain progeny with high quality milk production traits, as well as any other desirable attributes (Kiplagat *et al.*, 2012). Due to the wide variety of information available for dairy farmers, a number of different methods of selection of sires and dams may need to be used by smallholder dairy farmers (Jain & Muladno, 2009). Possible sources of information used by smallholder dairy farmers when carrying out selection include government extension officers, NGOs, Private Service providers, farmers owning the bull, other farmers, media, and farm labourers and reading information (Minjauw *et al.*, 2002; Schreiber, 2002; Zander *et al.*, 2013).

Farmers are interested in information on performance traits which are either production or reproductive traits. The selection objective in dairy breeding has been milk production (Ombura *et al.*, 2007). Toghiani, (2012) emphasized that milk, fat and protein yields and fat and protein percentages are the main economic traits for selection in dairy cattle. This information should be obtained from farm records but given that most smallholders who are one of the possible sources of breeding stock to other smallholders do not keep records, proper information is not often available. Smallholder dairy farmers therefore face some technical problems when making breeding decisions due to low level of farm recording which has been a major handicap in the testing of AI bulls. The use of bulls of unknown pedigree records has led to little or no gain and in some cases considerable harm due to the use of inferior bulls (Muasya *et al.*, 2014). The identification of superior breeding stock may be based on phenotype of individual animal or on that of its close relatives, especially if accurate records are available (Ombura *et al.*, 2007).

### 2.4.1. Sire Selection

The choice of bulls used in the herd today determines what kind of cows will be in production in future. Farmers require and make use of breeding males they perceive to be superior (Kosgey *et al.*, 2004). The sire pathway of selection offers more opportunity for increasing intensity of selection. However, smallholder dairy farmers often have little or no choice when selecting males for breeding (Ndebele *et al.*, 2007). In some cases, only a single bull is available for a community (Bayer *et al.*, 2001). Farmers that use genetic information (EBV) provided by records and phenotypes when selecting sires have been found to have significantly higher milk fat percentage than farms that used only phenotypes and personal opinion (Rhone *et al.*, 2008). Farmers who kept individual animal records have been found to used EBV (Rhone *et al.*, 2008) when selecting sires. Regarding AI, the selection of semen from the AI centres run by government agencies and private owners is often very limited and inseminators may not offer much choice or will make selection on their own (Baltenweck *et al.*, 2004). When selection of stud bull is possible, farmers normally do so mainly by phenotypic selection on bull performance (Baltenweck *et al.*, 2004; Herath & Mohammad, 2009).

In situations where all the pedigree information is available, the bull's dam is given more consideration than its sire (Herath & Mohammad, 2009; Mugisha *et al.*, 2013). However, from the farmers' perspective, the convenience in the availability of the bull or AI service is usually more important than the genetic make-up of the animal (Staal *et al.*, 2001; Herath & Mohammad, 2009). In circumstances of low sire variety, factors other than the genetic potential of the bull must take precedence. One factor is genetic relationship of the bull to the cow and the desire to avoid inbreeding. Farmers have been found to select bulls basing on their pedigree performance, its breed characteristics and structural and health conditions (Jain & Muladno, 2009).

At the national or breeding company level progeny testing of bulls is critical as, through artificial insemination, this is the fastest means of making genetic change (Chagunda *et al.*, 2006; Ombura *et al.*, 2007; Quddus, 2012). Proving bulls is undertaken by selecting bulls expected to produce high performing offspring and recording the milk production, reproductive and other performance of female offspring across as many herds as possible.

Use of quality genetics from performance tested bulls, whose records are kept, will allow the farmer to select the right bull for their cow or the bull that meets their breeding goals. From a pool of world class genetics, farmers can choose for example, calving ease bulls to avoid the problems of dystocia in their herds (Chatikobo, 2009). Proven bulls are also ranked on type traits such as udder attachment, fitness traits such as leg conformation and production traits (Chatikobo, 2009).

### 2.4.2. Dam Selection

The low reproductive rate of cattle compared to other livestock species limits opportunities for genetic selection of females by dairy farmers (Brotherstone & Goddard, 2005). The opportunities for selection are further decreased by high AFC and long calving interval found among smallholders (Jain & Muladno, 2009). Most selection done especially within a farmer's own herd, will be effectively culling of unwanted animals, rather than selection of the best animals (Fortes *et al.*, 2013). Herath & Mohammad (2009) observed that the replacement females for cattle in smallholder dairy production systems are usually from the heifers bred within the same herd whereas large farms may specialize and direct their attention to milking adult cows hence may sell off young female calves to be raised by others. This, however, contradicts earlier findings from Staal *et al.*, 2001 that many farmers obtain replacement stock from large-scale farms due to low calf survival and heifer and cow mortalities.

Jain & Muladno (2009) recommended that, when selecting among females, smallholder farmers should select females on the basis of expected milk producing ability, reproduction, health and structural traits while considering the conditions under which the animal will be raised. Management approach needs to match the environment in which the animal is reared. When getting breeding information about sires and dams, several selection methods are normally used by smallholders key among them being individual performance, pedigree selection ,selection on the basis of collateral relatives and progeny testing (Andrabi & Moran, 2007; Philipson *et al.*, 2011). Available literature on Sire and dam information for genetic improvement among smallholders exposes knowledge gaps that need to be bridged. This will ensure proper interventions are carried out to improve productivity in smallholder dairy production system.

## 2.5. Methodological Approaches in Studying Smallholder Dairy Breeding Improvement

In a bid to understand smallholder's dairy breeding improvement, several approaches have been applied. Sarakul *et al.*, 2011 noted that characterization of factors that affect genetic improvement, selection, and mating strategies in a population is essential to evaluate genetic improvement programs and determine areas that need to be improved. Implementation of appropriate dairy technologies related to genetic improvement may be affected by differences among farmers e.g. record keeping, experience, education background and decision making (Rhone *et al.*, 2008; Sarakul et al., 2009; Yeamkong et al., 2010a). This includes looking at various types and sources of information smallholders' access in order to inform their breeding decisions. Understanding the sourcing and animal information available to smallholders will help to assess whether the smallholder farmers are making improvement in the quality of dairy animals on their farms.

Replacement females are usually purchased from other smallholders and in some cases obtained from heifers bred within the farm (Herath & Mohammad, 2009). Bebe *et al.* (2003) attributed the sourcing of heifers by smallholders from fellow smallholders within their local farming systems and less frequently from large-scale farms or outside their farming systems to high pricing and fear of adaptability. Examining insemination and replacement practices will help to determine whether smallholders are making genetic improvement or not in their herds (Andrabi & Moran, 2007). Given that most smallholders don't keep farm records, there is a likelihood that they inseminate their animals using bulls of unknown pedigree and obtain replacement stocks mostly cull cows whose performance cannot be fully ascertained due to absence of systematic performance records. Chagunda *et al.* (2006) observed that use of pedigree recording is important when breeding technologies such as AI are used to enhance widespread use of selected parents across many herds and several production environments. Knowing pedigrees will also help to avoid breeding of closely related animals (Nilforooshan *et al.*, 2008).

Examining performance of the animals will help in accessing smallholder's dairy breeding improvement (Musalia *et al.*, 2010; Sarakul *et al.*, 2011; Wassie, *et al.*, 2014). Characterization of factors that affect genetic improvement, selection and mating strategies in a population is essential to evaluate genetic improvement programmes and determine areas that need to be improved (Sarakul *et al.*, 2011).

The level of genetic improvement of milk production in dairy cattle populations can be measured within a certain period of time. The increase in the amount of milk can be used as an indicator of genetic change for milk production (Yeamkong *et al.*, 2010). This will indicate whether selection and mating strategies used by smallholders have resulted in any breeding improvement. Higher or lower milk production levels in individual herds could be an indicator of genetic trend.

Decision making on sire and dam selection is crucial in assessing smallholders dairy breeding improvement. Whether smallholders make decisions on sire selection by themselves or with the input from other people can be compared with the genetic trend. Sarakul *et al.* (2011) in his study on smallholder dairy farmers in Thailand reported that farmers in most farms (64%) with negative and no genetic trends made decisions on sire selection on their own without any input from other people. In contrast, farmers in farms with positive genetic trends made decisions on sire selection primarily based on outside input (75%).The different approaches in sire selection could be related to farmers' experience. Farmers with longer farm experience may have been more confident in their knowledge of animal breeding, thus they did not consult with other people, and they had less updated information on genetic selection of animals.

Routinely monitoring test results on smallholders' cows for milk production, composition and quality and for mastitis will help among others in breeding genetically improved stock (Philipsson *et al.*, 2011; Moran, 2013). Performance records and breeding records therefore play a very crucial role in studying smallholder dairy breeding improvements. Accumulated 305-day milk yield and pedigree information of first lactation cows could be used for genetic prediction (Sarakul et al., 2011). Virtually every aspect of dairy cattle performance is controlled by genetics; milk, fat and protein yield, reproduction, feed efficiency, length of life in the herd, calving ability, and ability to resist diseases such as mastitis as well as all the dairy cattle conformation traits such as udder, feet and legs and stature. Since every aspect of dairy cattle performance is under some degree of genetic control, this can be taken advantage of to achieve breeding improvement for smallholders (Quddus, 2012; Wahinya *et al.*, 2015). The challenge, however, is that smallholders' breeding practices have not been described adequately in the literature. There is need to understand what inform smallholders' replacement and insemination practices in order to design interventions that can improve their productivity.

# CHAPTER THREE

# 3.0 METHODOLOGY

## 3.1. Study site

Two regions bordering each other were selected for this study with one representing a region classified milk surplus (Nandi County) and the other classified milk deficit (Vihiga county) and have a thriving trade in milk and breeding stock (Mudavadi *et al.*, 2001; Muriuki *et al.*, 2003) (Figure 1). Several studies conducted in the past have consistently reveal that Western Kenya region has been perpetually a milk deficit region (Waithaka *et al.*, 2002; Wambugu, 2011; Wanjala *et al.*, 2014). This has been attributed to several factors including shortage of replacement heifers, feed related factors, Socio economic factors e.g. lack of credit, genetic and animal breeding factors and low number of lactating cows (Mudavadi *et al*, 2001; Wanjala *et al.*, 2014).

The CIDP, 2013-17 for Vihiga County and annual livestock production reports estimated milk production at approximately 24,110,112 million litres for the year 2012. With a population estimate of 572,577 people (CIDP, 2013-17; CDLP, 2012), using FAO recommendations for milk consumption of 0.25 litres/person per day, the demand for milk in the region is about 52,247,651 litres per annum against a production of 24,110,112 million litres/annum. Therefore, the County's milk deficit stood at 28,137,539 million litres per annum. On the other hand, the Nandi County SDCP annual report for 2012 estimated annual milk production for 2012 at 139,644,379 litres. Going by the estimated human population of 818,787 and the FAO's recommendation of 0.25 litres/person per day, the demand for milk in the county was about 74,714,314 million litres per annum. This gave a surplus of 64,930,165 litres per annum. This agrees with the earlier studies that Nandi County is a milk Surplus County (Mudavadi *et al.*, 2001; SDP, 2005).

Nandi County is in North Rift of Kenya, occupying an area of 2,884.4 $Km^2$. The County is bordered by Kakamega County to the west, Uasin Gishu County to the North East, Kericho County to the South East corner, Kisumu County to the South and Vihiga County to the South West. It receives a bimodal rainfall, ranging between 1,500 -2,000mm per annum and lies on an

altitude of about 1300m-2500m above sea level. Geographically, the unique jug-shaped structure of Nandi County is bound by the Equator to the south and extends northwards to latitude $0^0$34'N. The Western boundary extends to Longitude $34^0$45'E, while the Eastern boundary reaches Longitude $35^0$25'E. The arable area is 234,000 Ha shared by livestock production mainly dairy & crop production (Nandi County Development plan, 2013).

Vihiga County borders Kakamega County to the North, Nandi County to the East, Kisumu County to the South, and Siaya County to the West. The total area occupied by the county is 530.9 $Km^2$ and lies between longitudes $34^0$ 30' and $35^0$ 0' East and between latitude $0^0$ and $0^0$ 15' North and altitude of 1,300-1,800M above the sea level (Ongadi *et al.*, 2007). The county has equatorial climate with fairly well distributed rainfall throughout the year with an average annual precipitation of 1900mm (CIDP, 2013-2017). Temperatures range between 14°c -32°c, with a mean of 23°c. Agriculture is the main economic activity with dairy being one of the key economic activities (CIDP, 2013-2017).

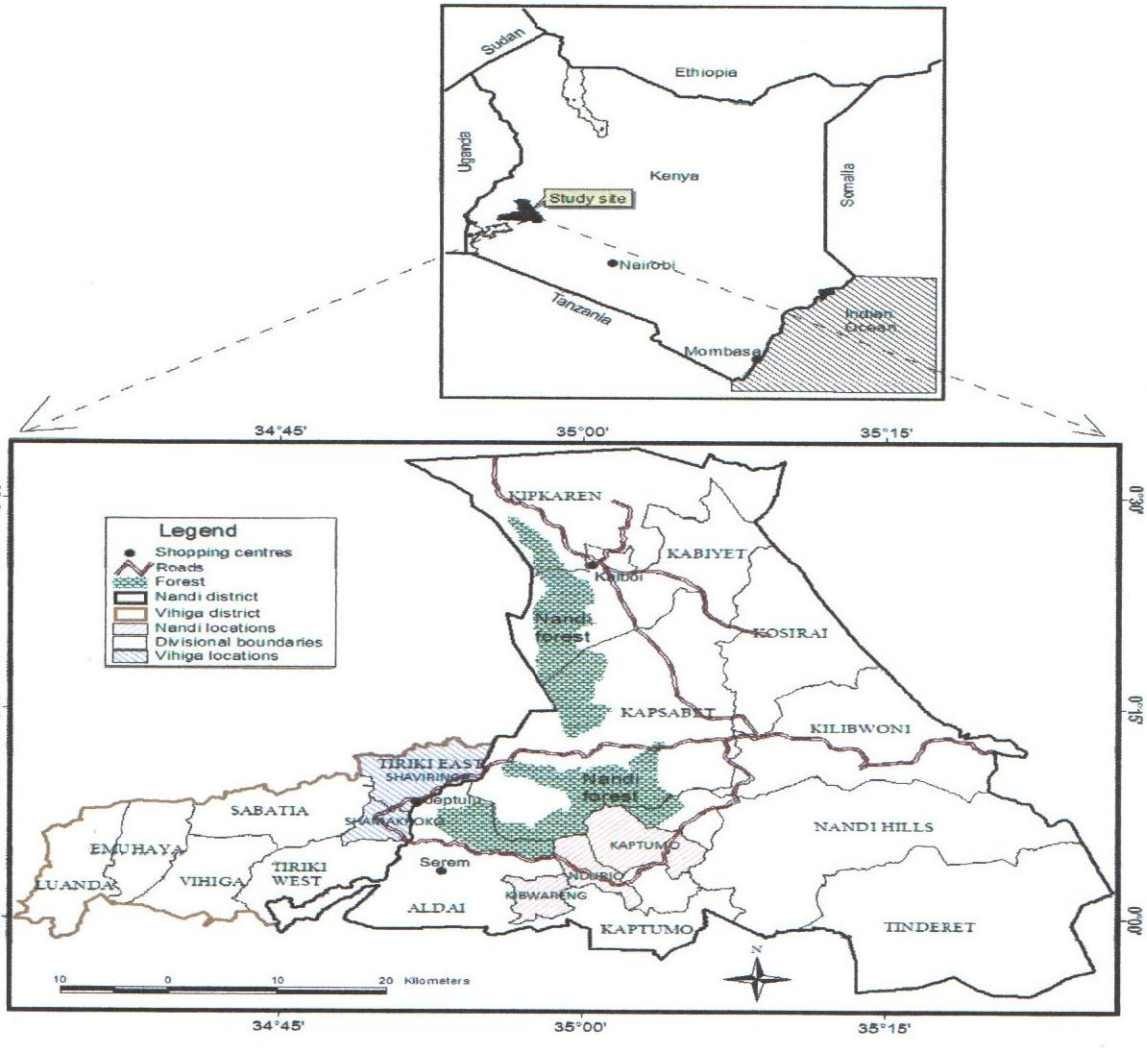



**Figure 1:** A Map of Kenya showing Nandi and Vihiga Counties.
Adopted from Muthui *et al.* (2012)

### 3.2. Sampling procedure

The target population for the study was smallholder dairy farmers in the two regions classified as milk surplus and milk deficit. Multistage sampling was used in this study. First the two regions were stratified based on milk production circumstances. Second, The two divisions (Aldai in Nandi County and Hamisi in Vihiga County) were purposively sampled because they fall within the milk production circumstances (milk surplus and milk deficit respectively) and have a long

history of trading in milk and breeding stock (Mudavadi *et al.*, 2001; SDP, 2005). Third, two locations in Aldai division and three locations in Hamisi division were purposively selected. In each location, two sub-locations prominent in dairy production were randomly selected then transect lines drawn to join pairs of major landmarks (such as schools and shopping centres) along which every fifth household to the right and then to the left was sampled to provide the needed data.

According to The Kenya National Bureau of Statistics (2009) population estimates, Hamisi division has population estimate of 148,259 people and average density of 780.3 persons per $Km^2$ living in 32,096 households of which 60% live below the poverty line. The division has two agro-ecological zones (Upper Midland zone and Lower Midland zone). Maize (usually inter-cropped with beans) and dairy are the two major enterprises. Farm holdings are small, limiting on-farm fodder production (Ongadi *et al.*, 2007), therefore, farmers complement by grazing or tethering cattle but mostly under zero grazing of cut - and - carry stall feeding (Waithaka *et al.*, 2002) in which Napier grass and crop residues are the main feeds, concentrate supplementation is generally restricted to milking cows.

Aldai division in Nandi South as per 2009 Kenya National Bureau of Statistic's population estimates, has a population of 156,967 and average density of 300.63 persons per square kilometer living in 30,768 households. The division has a long history of dairy production that can be traced to colonial era which contributed to developing supportive infrastructure for dairy production including milk processing plants and a number of dairy cooperatives. Herds are also larger hence surplus production of breeding stock for sale. Predominant production system practiced by farmers in this area is extensive system where most animals are grazed both on natural or planted pastures and legumes. Paddocking of pastures is practiced and there is a notable aspect of fodder production. Natural pastures were dominant in the division and coupled with relatively large land sizes per household, explains why extensive dairy farming is practiced (Waithaka *et al.*, 2002). Improved pastures comprising Rhodes grass and Nandi Setaria also supplement natural pastures for grazing.

### 3.3. Sample size

The sample size was derived from the formula based on Cochran's (1977) sample size formula for both continuous and categorical data in which the desired sample size (n), the 95% confidence interval (z) set at 1.96, the coefficient of variation (c) set to 1.13 and the expected difference (d) in dairy herd size between the milk surplus and deficit regions set at 20% were applied in the formula:

$$n = 2\left[\frac{zc}{d}\right]^2$$

The value of c and d were obtained from earlier dairy characterization studies in Western Kenya by Waithaka *et al.* (2002), Musalia *et al.* (2010) and KNBS (2009) and this gave an estimated sample size of 245 households. This sample was distributed equally to ten sub-locations in the two divisions.

### 3.4. Data collection

Primary data was collected through interview method using a pre-tested, structured questionnaire administered to 245 households visited. Pretesting of questionnaires was done to determine its validity and reliability. The questionnaire guided data collection on identification systems, record keeping and the sources of breeding stock and how information about breeding stock was obtained. Further, farmers were asked about how they perceived usefulness of animal information availed to them by fellow farmers or brokers selling the animals and the preferences for specific traits on sires and dams.

Each farmer visited was asked to state two identification types they frequently use from the list of name/colour, tag number, branding/notching, or none. Animal information included breed, breeder (where to buy and reputation of the farm), production history (individual production performance and lifetime production performance) and progeny history (progeny performance, pedigree records and breeding value estimates). A summary of variables and measurements in the study is presented in Table 2.

**Table 2: Summary of variables and measurements for each objective of the study**

| Variables | Description of variables | Response measured |
|---|---|---|
| 1.1. Animal identification | • Name/Colour<br>• Tag number<br>• Branding/notching<br>• None | Two mostly used identification types |
| 1.2. Animal recording | • Breeding records<br>• Production records<br>• Veterinary (treatment) records<br>• Sales and purchases<br>• Inventory records (Deaths and births | Three mostly kept records |
| 2.1. Sources of female stock | • Born on the farm<br>• Bought from;<br>• Fellow smallholder farms<br>• Commercial large scale farms<br>• Market<br>• Unknown | Source of each female present in the farm. |
| 2.2. Source of sire | • Own bull<br>• Other farmers' bull<br>• Private AI<br>• Government AI/bull<br>• Unknown | Source of sire of female cattle on the farm |
| 2.3. Source of dam | • Own reared heifer/cow<br>• Purchased cow<br>• Purchased heifer | Source of dam of each female present in the farm. |
| 3.1. Sire and dam information | • Breeder<br>• Breed<br>• Production history<br>• Progeny history | Information is very, somewhat or not useful |
| 3.2. Source of sire and dam information | • Extension officer<br>• Fellow farmers<br>• NGO advisor<br>• Private service provider | Three most frequent sources |
| 4.1.Trait preferences in sires and dams | • Milk yield<br>• Fertility<br>• Body size and conformation<br>• Udder conformation<br>• Temperament | Rank in order of importance, three traits of importance |

### 3.5. Data analysis

This study used Primary data collection. Analysis used SPSS version 22 and SAS 9.2 software (IBM SPSS Statistic, 2013; SAS Inst. Inc., 2011, Cary, NC). Frequencies for each variable was determine using SPSS. Chi-square was used to test independence and model fitting was done using logistic regression to compute odds ration estimates using SAS.

#### 3.5.1. Determining types of animal identification and animal recording in use

The objective was analyzed using the descriptive statistics and logistic regression. This involved the use of Percentages and tables. The milk production status (surplus and deficit) was cross tabulated with animal identification system and animal recording types (Table 2) to determine the most used identification types and records in each milk producing region from Chi square test statistics and odds ratios from logistic regression.

#### 3.5.2. Establishing the sources of sires and dams of the female animals present in the herd

In each of the milk producing region, the source of breeding stock was determined from cross tabulation of sources by region using Chi-square test statistic and odds ratios from logistic regression.

#### 3.5.3. Examining where farmers source sire and dam information and usefulness in choice of sire and dam to mate

Data on three stated frequent sources of sire and dam information were cross tabulated with milk producing regions for Chi-square test statistics to examine where smallholders frequently source information about sires and dams to mate (Table 2). For information sourced, analysis was performed to determine which of the sources and specific information was considered by farmers as most useful for insemination and replacement decision from logistic regression model in which usefulness of information was explained by the parental information (sire and dam) and the source of information (Table 2).

### 3.5.4. Determining smallholders' most preferred traits of sire and dam to mate

The traits of sire and dam that the smallholders attach high preference to were determined from logistic regression to explain preference ranking of the traits. The model was ran separately for each milk producing region (surplus or deficit region).

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

### 4.1. Animal identification and recording in smallholder dairy herds in Western Kenya

The survey obtained a sample of 116 herds with a population of 351 heifers and cows in the MSR region and another 121 herds with a population of 218 heifers and cows in the MDR region. Table 3 presents frequency and corresponding odds ratio estimates for animal identification and performance recording for the animals in the sample herds. The herds were in milk deficit and surplus regions of western Kenya. Animal identification by name is 153.9 times more frequent than by ear tagging and the practice though predominant in both regions, it is more frequent in MSR (93%) than ($P<0.001$) in MDR (72%) and rarely by ear tagging (0.9 to 6%). Ear tagging aids in recording animal pedigree and performance, and therefore in absence of ear tagging of animals, breeding decisions are not reliably and objectively informed. This problem is seemingly greater in the milk deficit ($p<0.001$) than in milk surplus region, because a larger proportion of the animals were not identified (22% vs 6%).

Recording of animal performance information is practiced in not more than a third of the herds with animal breeding information (using simple booklets, cards, files or individual sheets) recorded in more herds (36.7%) than ($p <0.001$) is recording animal information on production (26.7%) or health (13.3% herds). Relative to inventory records, breeding records were 1.5 times more frequent in the milk surplus region and 1.87 times more frequent in the milk deficit region while production records were 1.63 times more frequent in milk surplus region (Table 3). In contrast, health records were 0.54 to 0.59 times less frequently kept relative to inventory records in both regions. It may be that smallholders pay more attention to breeding, production and inventory records than to health in their dairy herd management strategies. The fact that breeding and production records were the most frequently kept animal records, may reflect deliberate efforts to upgrade for more milk production.

However, absence of effective animal identification and performance recording is a challenge for implementing breeding strategies targeted to increasing milk yield, which has been observed by several authors (Bester *et al.*, 2001; Mugisha *et al.* 2014; Risstrom, 2014). Ear tagging is a cheaper effective animal identification for good herd performance recording practice. The low

uptake of ear tagging by smallholder farmers is probably because they are unable to afford ear tags or they find it easy to memorise information about the few individual animals in the herd, often about one to three cows. But it is important that extension services and dairy development intervention emphasize to farmers that animal records are even more useful long after the exit of the animal from the herd in informing breeding decisions (Neary *et al.*, 2010; Whittier, 2011) in addition to increasing the market value of an animal as observed by Oltjen *et al.* (2005). Dairy regulating authorities may need to consider applying a policy requiring keeping basic animal records when delivering milk to processors and the processors to keep such database or transmit the same to centralised animal recording services, which Kenya already has a mandated institution (Livestock Recording Centre).

Whittier (2011) emphasized the importance of visual animal identification systems in maintaining records for genetic and management decisions. Identification facilitates breeding and selection management for recording progress in production and reproduction traits (FAO/WHO, 2004, Neary *et al.*, 2010) as well for traceability.

**Table 3: Odds ratio estimates for animal identification and performance recording practices in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya**

| Factor | Variable | Frequency (%) | Odds ratio | (95%CI) | P-value |
|---|---|---|---|---|---|
| | | Animal identification | | | |
| *Identification* (n=569 animals) | | | | | <0.001 |
| | No-identity | 12.2 | 3.37 | (3.24, 4.43) | <0.001 |
| | Name | 85.0 | 153.90 | (132.30, 179.02) | <0.001 |
| | Eartag | 2.8 | Reference | | |
| *Region* | | | | | <0.001 |
| Milk surplus | No-identity | 6.1 | 7.38 | (3.80, 14.33) | <0.001 |
| (n=351 animals) | Name | 93.0 | Not estimatable | | <0.001 |
| | Eartag | 0.9 | Reference | | |
| Milk deficit | No-identity | 22,0 | 4.45 | (3.78, 5.23) | <0.001 |
| (n=218 animals) | Name | 72.0 | 40.57 | (34.67, 47.48) | <0.001 |
| | Eartag | 6.0 | Reference | | |
| | | Performance information recording | | | |
| *Performance recording* | | | | | <0.001 |
| (n=237 herds) | Breeding | 36.7 | 1.55 | (1.23, 1.97) | <0.001 |
| | Health | 13.3 | 0.55 | (0.37, 0.81) | <0.001 |
| | Production | 26.7 | 1.74 | (1.36, 2.22) | <0.001 |
| | Inventory | 23.3 | Reference | | |
| *Region* | | | | | 0.003 |
| Surplus milk | Breeding | 31.7 | 1.50 | (1.14, 1.98) | <0.001 |
| (n=116 herds) | Health | 12.2 | 0.54 | (1.14, 1.98) | <0.001 |
| | Production | 34.2 | 1.63 | (1.24, 2.14) | <0.001 |
| | Inventory | 21.9 | Reference | | |
| Deficit milk | Breeding | 47.4 | 1.87 | (1.18, 2.96) | <0.001 |
| (n=121 herds) | Health | 15.8 | 0.59 | (0.27, 1.28) | 0.273 |
| | Production | 10.5 | 0.39 | (0.13, 1.13) | 0.062 |
| | Inventory | 26.3 | Reference | | |

Source: Cross sectional survey data

Oltjen *et al.* (2005) noted that farmers who have adopted identification systems are more likely to have their cattle qualify for more lucrative marketing opportunities.

Only 25% of farmers in both milk deficit region and milk surplus region kept records and this confirms earlier observation by Omondi *et al.* (2009) that only 22.5% of smallholders keep records in central highland of Kenya. During data collection, it was observed that breeding records were in several simple forms ranging from simple booklets to card files and individual sheets. Bebe *et al*, (2003) and Khan *et al.* (2005) observed that record keeping of production performance on daily milk yield, lactation yield, lactation length and age at first calving was infrequent among smallholders. Without animal identification and record keeping, smallholder dairy farmers are not able to make meaningful genetic progress (Bester *et al.*, 2001; Kahi *et al.*, 2004; Mugisha *et al.*, 2014). Probably, they rely on trust, reputation and branding of the breeders to inform their breeding decisions. Lack of systematic animal registration and performance recording is a major constrain in evaluation of livestock performance particularly in smallholder production systems (SDCP, 2010). The problem could further lead to underestimation of inbreeding levels of a population especially where pedigree information is incomplete (Muasya *et al.*, 2013).

### 4.2. Sources of dams and sires in smallholder dairy herds in Western Kenya

Results in Table 4 show where smallholder dairy farmers frequently sourced their heifers and cows and their dams for herd replacement or expansion. Of all the females (calves, heifers and cows) in the herds at the time of survey, about a half (53.2%) were born and reared on the farms while the remainder (46.8%) were externally sourced with majority (79%) sourced from fellow smallholder farmers (Table 4). Selection of female animals in large scale dairy herds for increased milk yield is objectively informed by herd performance recording. However, female animals in smallholder herds sourced within own herds, from fellow smallholder herds or from markets were respectively 38.38, 18.99 and 2.57 times more ($p<0.001$) than those sourced from large scale dairy herds where herd recording is better (Table 4). Farmers in both MSR and MDR exhibit similar patterns in sourcing of female animals predominantly from within own herds (55.7%-49.1%) and from fellow smallholder herds (36.6%-37.2%) but rarely from the markets (7%) or large scale dairy herds (3 %).

Compared to female stock sourced from large scale farms, those reared within the herd were 47 times more in surplus milk region and 25 times more in the milk deficit regions. The odds of female stock being sourced from small-scale farms were 21.81 times more in milk surplus region

and 15.50 times more in milk deficit region compared to sourcing from large scale farms. This findings contrasts with the Staal *et al.*, (2001) who reported that smallholders obtained their breeding stock from large scale dairy farms. This breeding practice can be associated with sourcing dams from on-farm, i.e. 14.54 times more frequently in milk surplus region and 2.86 times more frequently in the milk deficit region compared to purchasing heifers. This can be explained by high demand for dairy heifers in the Kenyan dairy sector (Murage & Ilatsia, 2011) which makes quality in-calf heifers more costly for smallholders (Musalia *et al.*, 2010).

Smallholders make effort to improve genetic potential for their dairy herds through selection of sires and dams to mate and when acquiring heifers and cows for replacement. This, however, has been limited by absence of records, small herd sizes and low adoption of breeding technologies such as AI (Kahi *et al.*, 2004; Ombura *et al.*, 2007). To address the problem of quality breeding stock in developing countries, Kahi *et al.*, 2004 recommended nucleus breeding programmes (NBS) for genetic improvement in dairy cattle. Muasya *et al.*, 2013 observed that NBS are easier and cheaper to implement since recording is carried out in the nucleus. Genetic gains realized in the nucleus herds are usually passed onto the commercial tier through semen and replacement stock (Muasya *et al.*, 2013). The commercial tiers have been private large scale dairy farms and some government institutions which have been serving as a source of improved genetic pool for dairy farmers (Bebe, 2008). The challenge, however, stems from the fact that such commercial farms have been too expensive for smallholder dairy farmers. This has been compounded by diminishing role of the majority of government institutions whose mandate was to among others offer affordable breeding stock to dairy farmers (Bebe, 2002).

Table 4 also show that the dams reared within the herd and externally sourced was in the ratio of 5.6 to 4.4 in the total sample, indicating that smallholders source about 40% of their female herd outside their own herds. Bebe *et al.*, 2003a observed that smallholders in the Kenya highlands practicing semi-zero- and zero-grazing systems were unable or unwilling to produce the heifers needed to maintain their herd size due to diminishing land sizes (Bebe *et al.*, 2002). Considering the large number of smallholder dairy herds with one to three cows, this presents a huge market for trading dairy heifers in Kenyan dairy sector.

**Table 4: Odds ratio estimates for sources of dams of heifers and cows in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya**

| Factor | Variables | Frequency (%) | Odds ratio | (95% CI) | P-value |
|---|---|---|---|---|---|
| ---------- | *Sources of heifers and cows*---------- | | | | ---------- |
| Sources of females (n=569 animals) | | | | | <0.001 |
| | Born on-farm | 53.2 | 38.38 | (32.52, 45.30) | <0.001 |
| | Bought from market | 7.0 | 2.57 | (2.15, 3.08) | <0.001 |
| | Bought from smallholder farms | 36.8 | 18.99 | (16.09, 22.42) | <0.001 |
| | Bought from large scale farms | 3.0 | Reference | | |
| Region | | | | | <0.001 |
| Milk surplus ($n$=351 animals) | Born on-farm | 55.7 | 47.49 | (38.07, 59.24) | <0.001 |
| | Bought from market | 5.1 | 2.05 | (1.60, 2.63) | <0.001 |
| | Bought from smallholder farms | 36.6 | 21.81 | (17.48, 27.21) | <0.001 |
| | Bought from large farms | 2.6 | Reference | | |
| Milk deficit ($n$=218 animals) | Born on-farm | 49.1 | 25.30 | (19.69, 32.52) | <0.001 |
| | Bought from market | 10.1 | 2.95 | (2.56, 3.85) | <0.001 |
| | Bought from smallholder farms | 37.2 | 15.50 | (12.07, 19.96) | <0.001 |
| | Bought from large scale farms | 3.7 | Reference | | |
| ---------- | *Sources of dams of heifers and cow* -------- | ----- | ---------- | | |
| Sources of dams (n=569 animals) | | | | | <0.001 |
| | Own reared heifer/cow | 56.4 | 4.74 | (4.59, 4.90) | <0.001 |
| | Purchased cow | 26.8 | 1.37 | (1.32, 1.42) | <0.001 |
| | Purchased heifer | 16.8 | Reference | | |
| Region | | | | | <0.001 |
| Milk surplus region ($n$=359 animals) | Own reared heifer/cow | 61.0 | 14.54 | (13.53, 15.62) | <0.001 |
| | Purchased cow | 30.1 | 4.30 | (3.99,4.63) | <0.001 |
| | Purchased heifer | 8.9 | Reference | | |
| Milk deficit region ($n$=218 animals) | Own reared heifer/cow | 50.0 | 2.86 | (2.74, 2.30) | <0.001 |
| | Purchased cow | 22.5 | 0.76 | (0.72, 0.80) | <0.001 |
| | Purchased heifer | 27.5 | Reference | | |

Source: Cross sectional survey data



University Library

The female animals traced to their dams reveal that 56% have been reared within the present herds while the remainder were purchased cull-cows (26.8%) or purchased heifers (16.8%) and herd replacement by cull cows is 1.37 times more frequent than by heifers. While herd replacement by cull cows is 4.3 times more frequent in the MSR, it is 0.76 times less frequent in the MDR relative to herd replacement with heifers (Table 4).

Use of cull cows for breeding is common in smallholder herds and can be explained by high cost of breeding heifers because of shortage and high demand which surpasses generation of heifers. Shortage of quality breeding stock is a feature in other developing countries including Thailand where Sarakul *et al.* (2011) has reported shortage of breeding stocks and that the few on sale are not affordable to smallholders. In western Kenya, the majority of the cull cows are from fellow smallholder herds where performance is unrecorded and parentage is unknown, in most cases. This breeding practice has adverse implications on productivity changes in the national herd, considering that smallholders own over 80% of the dairy herd in Kenya (Bebe *et al.*, 2003; SDP, 2004).

Table 5 presents the odds ratio estimates for sources of sires of heifers and cows present in the herds at the time of survey for heifers and cows whose sire histories were traced. Estimates show that less than one in ten (12%) have been sired through AI semen and these AI sired females are four times fewer in the MDR than in the MSR (4.6% vs 16.5%). Mating is predominantly by bulls (61%) and farmers claim that they own or source the bulls from fellow farmers who keep such bulls to charge a fee for service. For more than a quarter of the female animals in the herds, sires cannot be traced, or are unknown. Relative to those of AI sired, females born with unknown sires is 2.09 times more in the total sample, but is 12.28 times more in the MDR and 1.33 times more in the MSR.

In both surplus and deficit milk regions, insemination with own bulls or with bulls from other farmers was 1.82 to 16.06 times more frequent than with AI services. These provide evidence that insemination with bulls still predominate over AI semen in smallholder herds. Previous studies have identified the reasons for limited use of AI to include perceived high cost of the service, the non-availability of the service, the notion that AI purported to produce more bull calves than females, lack of money to pay for AI at the time when animals are on heat, AI services being quite far from farmers, lack of sensitization about the benefits of AI and very high

expectations of AI service which are rarely met (Baltenweck *et al.*, 2004; Mugisha *et al.*, 2014; Musalia *et al.*, 2010). Despite the long history of AI use in Kenya, its use is still low among smallholders. The results conflict with the perception that, the barriers are no longer the lack of supportive infrastructure or high cost of AI services. The argument has been further based on the assumption that, the private AI technicians are more readily available in dairy producing areas providing a wide range of choices on service charges depending on source of semen, local or imported semen (Murage & Ilatsia, 2011, Baltenweck *et al.*, 2004). The observations that there was a sharp contrast between preference for AI by farmers and the actual use was noted by Mugisha *et al.*, (2014) and Baltenweck *et al.*, (2004). This could be attributed to reasons given above regarding the low number of farmers using AI compared to those using bull service.

**Table 5: Odds ratio estimates for sources of sires of heifers and cows in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya**

| Factor | Variables | Frequency (%) | Odds ratio | (95% CI) | P-value |
|---|---|---|---|---|---|
| Sire sources | | | | | <0.001 |
| (n=569 animals) | Own bull | 21.8 | *1.78* | (1.70, 1.85) | <0.001 |
| | Other farmers bull | 39.2 | *3.48* | (3.34, 3.62) | <0.001 |
| | Unknown | 27.0 | *2.09* | (2.00, 2.18) | <0.001 |
| | AI service | 12.0 | Reference | | |
| Region | | | | | <0.001 |
| Milk surplus | Own bull | 26.4 | 1.82 | (1.74, 1.90) | <0.001 |
| (*n*=351 animals) | Other farmers bull | 36.4 | 2.90 | (2.78, 3.02) | <0.001 |
| | Unknown | 20.7 | 1.33 | (1.26, 1.39) | <0.001 |
| | AI service | 16.5 | Reference | | |
| Milk deficit | Own bull | 14.3 | 3.44 | (2.79, 4.26) | <0.001 |
| (*n*=218 animals) | Other farmers bull | 43.8 | 16.06 | (13.11, 19.65) | <0.001 |
| | Unknown | 37.3 | 12.28 | (10.03, 15.05) | <0.001 |
| | AI service | 4.6 | Reference | | |

Source: Cross sectional survey data

Another challenge for smallholder dairy breeding improvement is high use of unknown sires (20.7 to 37.3% of the replacement stock), which their use was 1.33 times more frequent in milk surplus region and 12.28 times more frequent in milk deficit region compared to inseminating with AI semen (Table 5). This breeding practice is associated with absence of animal identification and recording already observed in results presented in Table 3.

The reasons that farmers stated for choosing to mate with bull or AI semen summarised in Table 6 reveal that motives for mating with AI semen differ from those of mating with bulls and there are significant differences between MSR and MDR regions ($P< 0.001$). Mating with AI is the choice when upgrading (upgrading, maintaining purebred). Any other reason (avoid diseases, lack of choice) is 0.005 times less likely relative to upgrading. In contrast, mating with a bull is due to other many reasons than upgrading and these other reasons are 1.247 times more important than to upgrade when mating with a bull.

Use of AI service is low in smallholder herds though the technology would accelerate change in productivity and quality of milk production. But the alternative use of bull in mating is challenged in that the bulls are those without known genetic merit and therefore potential genetic progress is unknown. Reversing the low uptake of AI will require innovating in service delivery, and the starting entry point should be the farmer groups such as dairy hubs and cooperative movement, which have support and regaining confidence in the country (Van der Lee, *et al.*, 2014). Improved capacity building and sensitization of farmers to change the wrong perceptions about AI should be intensified.

**Table 6: Odds ratio estimates for reasons of mating with bull or Artificial Insemination semen in smallholder dairy herds in regions classified milk surplus or milk deficit in Western Kenya**

| Farmers' stated reasons | Reasons for mating with a bull | | | Reasons for mating with AI semen | | |
|---|---|---|---|---|---|---|
| | % | Odds ratio | P value | % | Odds ratio | P value |
| *Total sample (n=237)* | | | | | | |
| Upgrading | 47.3 | Reference | | 93.7 | Reference | |
| Others | 52.7 | 1.247 | <0.001 | 6.3 | 0.005 | <0.001 |
| *Milk surplus region (n=116)* | | | | | | |
| Upgrading | 49.1 | Reference | | 93.1 | Reference | |
| Others | 50.9 | 1.070 | <0.001 | 6.9 | 0.005 | <0.001 |
| *Milk deficit region (n=121)* | | | | | | |
| Upgrade | 45.4 | Reference | | 94.2 | Reference | |
| Others | 54.6 | 1.441 | <0.001 | 5.8 | 0.004 | <0.001 |

Source: Cross sectional survey data

Because pedigree and performance records are rarely kept in smallholder dairy herds, breeding with sires reared on the farm has limited potential to give genetic gains (Kahi *et al.*, 2004). Their pedigree and breeding values are unknown and they are not progeny tested. Breeding stock sourced from large scale farms where pedigree and performance recording is better, would be a better strategy of making genetic progress in smallholder herds.

### 4.3. Sources and usefulness of sire and dam information to the smallholder dairy farmers in Western Kenya

Table 7 presents the odds ratio estimates for animal breeding information and their sources accessed by farmers to inform implementation of breeding practices to improve milk productivity in the herd. Farmers source several specific information about animals when acquiring for mating which in order of importance are animal breed (28.7%), breeder (26.6%),

production history (24.1%) and progeny history (20.7%) in the total sample. Relative to progeny history which was set as the reference trait, breed was 1.66 times more frequently sourced in milk surplus region while breeder was 1.56 more frequently sourced in the milk deficit region, where demand for breeding stock is higher and therefore low priority may be placed on a breed of dairy cow (Musalia *et al.*, 2010, Mudavadi *et al.*, 2001). However, about a third (31.2%) of the farmers do not source any animal information to inform their mating practices. In this logistic regression, information sourcing from the extension service was made the reference base. Compared to farmers sourcing animal information from extension service, those not sourcing any animal information to make mating decisions are 0.65 times fewer in MSR region but 1.24 times more in the MDR region. In contrast, those sourcing animal information from fellow farmers to make mating decisions are 1.74 times more in the MSR but 0.73 times fewer in the MDR. These results corroborate those observed in Table 5 that private AI services is less frequent than bull services and the bulls are more frequently those of fellow farmers. This has implications on genetic gain that can be made in smallholder dairy herds. A study on smallholder's decision making on sire selection in Thailand indicated that farmers in most farms with negative (64%) and no genetic trends (62%) made decisions on sire selection without seeking information while those who sourced information (75%) had positive genetic trends (Sarakul *et al.*, 20011). This demonstrates the benefits of selection based on animal information.

**Table 7: Odds ratio estimates for animal breeding information and their sources accessed by smallholder dairy farmers in regions classified milk surplus or milk deficit**

| Factor | variables | Frequency (%) | Odds ratio | (95% CI) | P-value |
|---|---|---|---|---|---|
| ---------- | ---------- Animal breeding information | | | | ---------- |
| *Animal information* (n=237 farmers) | | | | | <0.001 |
| | Breed | 28.7 | 1.55 | (1.43, 1.68) | <0.001 |
| | Breeder | 26.6 | 1.41 | (1.30, 1.53) | <0.001 |
| | Production history | 24.1 | 1.22 | (1.12, 1.32) | 0.051 |
| | Progeny history | 20.7 | Reference | | |
| *Region* | | | | | <0.001 |
| Milk surplus (n=116) | Breed | 30.2 | 1.66 | (1.408 1.86) | <0.001 |
| | Breeder | 24.1 | 1.22 | (1.08, 1.38) | 0.277 |
| | Production history | 25.0 | 1.28 | (1.13, 1.44) | 0.818 |
| | Progeny history | 20.7 | Reference | | |
| Milk deficit (n=121) | Breed | 27.3 | 1.44 | (1.29, 1.61) | <0.001 |
| | Breeder | 28.9 | 1.56 | (1.40, 1.75) | <0.001 |
| | Production history | 23.1 | 1.16 | (1.03, 1.30) | 0.007 |
| | Progeny history | 20.7 | Reference | | |
| ---------- | Source of animal breeding information | | | | ---------- |
| *Source of animal information* (n=237 farmers) | | | | | <0.001 |
| | Not sourced | 31.2 | 1.02 | (0.96, 1.08) | <0.001 |
| | From fellow farmers | 35.9 | 1.24 | (1.17, 1.31) | <0.001 |
| | From extension service | 32.9 | Reference | | |
| *Region* | | | | | <0.001 |
| Milk surplus (n=116 farmers) | Not sourced | 23.3 | 0.65 | (0.58, 0.72) | <0.001 |
| | From fellow farmers | 44.8 | 1.74 | (1.60, 1.88) | <0.001 |
| | From extension service | 31.9 | Reference | | |
| Milk deficit (n=121 farmers) | Not sourced | 38.8 | 1.24 | (1.15, 1.34) | <0.001 |
| | From fellow farmers | 27.3 | 0.73 | (0.67, 0.80) | <0.001 |
| | From extension service | 33.9 | Reference | | |

Source: Cross sectional survey data

Smallholders more frequently sourced animal information from fellow farmers and to a lesser extent from public extension officers when inseminating or replacing a cow in the herd. This breeding practice has implications on genetic gain that can be made in smallholder dairy herds because only a few animals have some basic breeding information. A large proportion of bulls used in mating are either without records or unknown.

From the study, it is instructive to note that farmers in both regions may not have been able to access pedigree information, breeding value estimates and progeny performance, which is critical for breeding decision. This could be attributed to low record keeping in smallholder herds as discussed above.

For information sourced, further analysis was performed to determine those that the farmer considered most useful for making insemination and replacement decision. Results are presented in Table 8 and they show that progeny history was less frequently considered useful, which was consistent with its low preference as it was less frequently sourced information about an animal for breeding (Table 7). An exception is breed information in the milk deficit region, where it has already been observed that farmers may have placed low importance to breed (Table 7) due to high demand for breeding stock. Breeder farmer was considered the most useful type of breeding information in both milk surplus region (28%) and milk deficit region (31%) although breed was the most sought information for breeding and replacement practices in milk surplus region. This was consistent with the most frequently sourced type of breeding in in milk deficit region.

**Table 8: Odds ratios (and their 95% confidence intervals) for stated usefulness in the two milk production regions**

| Region | Information type | Frequency (%) | Odds ratio | 95% CI | | P-Value |
|---|---|---|---|---|---|---|
| Milk surplus Region (n=94) | Breed | 26 | 1.01 | 0.95 | 1.07 | 0.0001 |
| | Breeder | 28 | 1.23 | 1.16 | 1.31 | 0.0013 |
| | Production history | 25 | 1.05 | 1.99 | 1.12 | |
| | Progeny history | 21 | Ref. | | | |
| Milk deficit region (n=90) | Breed | 20 | 0.48 | 0.45 | 0.52 | 0.0001 |
| | Breeder | 31 | 2.61 | 2.00 | 2.31 | 0.0001 |
| | Production history | 27 | 2.15 | 1.41 | 2.82 | 0.0001 |
| | Progeny history | 22 | Ref | | | |

Source: Cross sectional survey data

It is notable that farmers had conflicting perspectives on the usefulness of breeding information they obtain from fellow farmers and extension service depending on the source and the type of information. For instance, breeder was considered the most useful breeding information in MSR, though breed was the most frequently sourced breeding information. An exception was observed in MDR where breeder was the most sought information and the most useful breeding information. The fact that breed was the least useful breeding information in MDR could be attributed to the shortage of breeding stock (Musalia *et al.*, 2010; Mudavadi *et al* 2001) hence farmers placed low importance to breed due to high demand and did not find the information useful.

Traditionally, public extension has been perceived as the major source of information for farmers (Waithaka *et al.*, 2002; Zander *et al.*, 2013) but the findings reveal that farmer to farmer extension has gained popularity among farmers. This could be attributed to declining role of public sector in provision of extension services due to reduced funding and inability of the private sector to fully fill the gap. This conforms to Schreiber's, (2002) observation that dairy farmers can serve as part of the knowledge base of other farmers or as communication channels to them. On the other hand public and private extension represent the professional bodies that have the capacity to deal with proper identification systems and record keeping and emerging issues like climate change and necessary technologies that will improve productivity among smallholders. Moris, (1991) observed that if African governments continue to support public

extension, it should be by means of a professional type of service delivery which enables highly trained staff to be in direct contact with farmers. Zander *et al.*, 2013 recommended that extension need to be integrated with education and other support services for farmers if they are to be able to choose technologies that suit them best. Farmers need to significantly improve their capacity to make their own decisions through information sourcing. The public sector together with the private sector should improve their role in fostering farmer education and ensuring that the information available to farmers is useful.

### 4.4. Determining traits preferences for sire and dam to mate by smallholder dairy farmers in Western Kenya

Results in Table 9 summarize odds ratio estimated for the stated trait preferences when selecting a bull for mating in milk surplus and milk deficit regions of western Kenya. Focus was given to the bull because majority of the farmers mate with bulls. Estimates show that preference is higher for milk yield than for fertility and conformation traits (57.6%, 19.9% and 17.4% respectively in the total sample). Farmers expressing preference for temperament, conformation and fertility traits are 0.04 to 0.19 times fewer compared to those expressing preference for milk yield.

Relatively, a higher proportion of farmers express preference for body conformation in the MDR region than those in the MSR region (25.8 vs 8.6%). The expressed preferences reflect that smallholders would want to complement pedigree and performance records with physical evaluation of a bull and this can be explained by their frequent use of bulls when inseminating cows.

**Table 9: Odds ratio estimates for trait preferences by smallholder farmers when selecting a bull for mating in dairy herds in regions classified milk surplus or milk deficit in Western Kenya**

| Factor | Trait variables | Frequency (%) | Odds ratio | (95% CI) | P value |
|---|---|---|---|---|---|
| *Traits preference* (n=237 farmers) | | | | | <0.001 |
| | Temperament | 9.0 | 0.04 | (0.03, 0.05) | <0.001 |
| | Body Conformation | 17.4 | 0.19 | (0.18,0.21) | 0.626 |
| | Fertility | 19.9 | 0.17 | (0.16,0.19) | 0.028 |
| | Milk yield | 57.6 | Reference | | |
| *Region* | | | | | <0.001 |
| Milk surplus | Temperament | 4.3 | 0.02 | (0.01, 0.03) | <0.001 |
| (*n* =116 farmers) | Body Conformation | 8.6 | 0.05 | (0.04, 0.06) | <0.001 |
| | Fertility | 19.8 | 0.12 | (0.11, 0.13) | 0.044 |
| | Milk yield | 67.2 | Reference | | |
| Milk deficit | Temperament | 5.8 | 0.07 | (0.05,0.09) | <0.001 |
| (*n* =121 farmers) | Body Conformation | 25.8 | 0.37 | (0.34,0.41) | <0.001 |
| | Fertility | 20.0 | 0.27 | (0.24,0.30) | 0.226 |
| | Milk yield | 48.3 | Reference | | |

Source: Cross sectional survey data

The trait preferences stated by farmers when selecting a cull cow or a heifer is reported in Table 10. Results show that more farmers express preference for milk yield (51.4% i.e. 41.5% for heifer and 61.3 for cull cow) and fertility (17.8% i.e. 25% for heifer and 10.5% for cull cow) traits. However, fewer farmers in the MDR express preference for fertility when selecting cull cows than when selecting heifers (5 vs 33%). Very few farmers pay attention to udder of a heifer (5.5%) or a cull cow (6.3%) in their selection of breeding females. Both the traits and the region were significant ($p<0.001$).

The results further show that when selecting heifers for breeding, more farmers in MSR express preference for milk yield (55%) while more farmers in MDR express preference for fertility trait (33%). When selecting cull cow for mating, milk yield was given preference by more farmers in both regions i.e. 62.4% in MSR and 60.3% in MDR. It is further worth noting that farmers in both regions ranked second body conformation when selecting cull cow for mating (18% in MSR and 14% in MDR). This indicates that smallholders would want to complement pedigree and

performance records with physical evaluation of a cull cow and this can be explained by their frequent use of purchased cows as a source of dams of heifers or cows present in the farm.

High preference for milk yield in selection of heifers and cull cows for breeding and replacement is in line with smallholders breeding objective of more milk yield (Njubi *et al.*, 2011; Ombura *et al.*, 2007). Proper record keeping as one of the key factors that contribute to genetic improvement should be enhanced. The preference for breeder in checking animal information obtained may be showing that smallholders rely on trust, reputation and branding of the breeders to inform their breeding decisions.

**Table 10: Odds ratio estimates for trait preferences by smallholder farmers when selecting a heifer or a cow for mating in dairy herds in regions classified milk surplus or milk deficit regions in Western Kenya**

| Traits | Selecting heifer for mating | | | Selecting cull cow for mating | | |
|---|---|---|---|---|---|---|
| | % | Odds ratio | P value | % | Odds ratio | P value |
| *Total sample (n=237)* | | | | | | |
| Temperament | 10.2 | 0.18 | <0.001 | 5.5 | 0.08 | <0.001 |
| Body conformation | 17.8 | 0.31 | 0.425 | 16.0 | 0.12 | <0.001 |
| Fertility | 25.0 | 0.46 | <0.001 | 10.5 | 0.10 | <0.001 |
| Udder | 5.5 | 0.10 | <0.001 | 6.3 | 0.06 | <0.001 |
| Milk yield | 41.5 | Reference | | 61.3 | Reference | |
| *Milk surplus region (n=116)* | | | | | | |
| Temperament | 15.7 | 0.15 | 0.138 | 0 | - | - |
| Body conformation | 10.4 | 0.09 | 0.017 | 18.0 | 0.13 | 0.756 |
| Fertility | 16.5 | 0.16 | 0.039 | 16.2 | 0.12 | 0.064 |
| Udder | 2.0 | 0.01 | <0.001 | 3.4 | 0.02 | <0.001 |
| Milk yield | 55.4 | Reference | | 62.4 | Reference | |
| *Milk deficit region (n=121)* | | | | | | |
| Temperament | 5.0 | 013 | <0.001 | 10.7 | 0.08 | <0.001 |
| Body conformation | 24.8 | 0.84 | <0.001 | 14.0 | 0.11 | 0.238 |
| Fertility | 33.0 | 1.26 | <0.001 | 5.0 | 0.03 | <0.001 |
| Udder | 9.1 | 0.26 | <0.001 | 9.9 | 0.07 | <0.001 |
| Milk yield | 28.1 | Reference | | 60.3 | Reference | |

Source: Cross sectional survey data

# CHAPTER FIVE

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

i. In smallholder dairy herds, animal identification is predominantly by name/colour and rarely by ear tagging and recording is predominantly about production and breeding.

ii. Breeding sires are more frequently sourced from other fellow farmers or own reared bull while use of AI semen was less frequent and targeted to upgrading the herd. A large proportion of breeding dams are externally sourced (about 40%) and comprised cull cows and heifers.

iii. Farmers sourced animal information for breeding mainly from fellow farmers and they sought more often about the breed followed by performance history and breeder in milk surplus region. In milk deficit region farmers sought information often about breeder farmer then breed and performance history. A dairy breeder farmer was considered the most useful information in both milk surplus and milk deficit region.

iv. Milk yield trait and fertility were the traits attracting the highest preference when selecting a dam and a sire for breeding purpose in both regions.

## 5.2. Recommendations

i. This study recommends targeted interventions in the milk deficit region to animal identification and record keeping. Farmers and other innovative entrepreneurs should be encouraged to tap into the huge potential that exist in unmet demand for heifers. This could be translated into business opportunities in AI service delivery and production of heifers. This is the only way to address the problem of shortage of breeding stock since public funding is not likely to increase to support breeding services. Smallholders should be encouraged to fully embrace breeding of heifers as this will also provide sustainable way of improving productivity.

ii. With farmer to farmer extension gaining popularity among farmers, more interventions should target strengthening this extension approach. Such interventions should target

investing in accessible model farms and exchange farmer tours/farm visits. It is recommended that public extension which is tasked with dissemination of extension information and new technologies should be strengthened to enhance contact with the identified model farms where demonstrations on new technologies and field days can be conducted to rich out to many farmers. The targeted interventions will also help to improve information usefulness especially targeting production performance history and progeny history which appeared to be a major impediment to farmers through proper animal identification and record keeping.

iii. Holistic approach should be employed in order to match the farmers' interest for milk yield with results. This will address breeding challenges, feeding and appropriate management approaches that will merge the needs of the improved breeds for increased productivity

### 5.3 Further Research

i. Studies should be conducted on the influence of the current production systems and social-economic and cultural issues on smallholder productivity in Western Kenya. The concern about low adoption of improved breeds and other recommended technologies such as Artificial Insemination should be investigated.

ii. The impact of collapsed large scale farms that used to provide breeding stock should be assessed. The prospects of strengthening institutional linkages to provide the necessary support services to smallholder dairy farmers in the region need to be exploited.

iii. There is need to establish the effect of privatization and reduced Government involvement in Animal breeding (recording, identification, semen distribution and herd books, etc.) and Artificial insemination services; input and veterinary drugs supplies; Animal health care and dipping services on smallholder dairy farmers.

## REFERENCES


Amarasekera, S. K. R. (1998). Animal recording in smallholder farming systems: The Sri Lankan experiences. Ministry of Livestock Development and Infrastructure. In K. R. Trivedi (ed), *International Workshop on Animal Recording for Smallholders in Developing Countries* (pp. 69-77). ICAR Tech. Series No. 1.

Andrabi, S.M.H. & Moran, C. (2007). Selection of Dairy Cow Bulls for Artificial Insemination. *International Journal of Agriculture & Biology*, 1, 175–178. http://www.fspublishers.org. Retrieved on 18 March 2016.

Australian Dairy Industry In Focus 2014. http://www.dairyaustralia.com.au/Industry-information/About-Dairy. Retrieved on December 16th, 2014.

Bachman, F. (1998). Animal recording for livestock development experiences of the Swiss Agency for Development and Co-Operation and of Interco-Operation in India. In K. R. Trivedi (ed), *International Workshop on Animal Recording for Smallholders in Developing Countries* (pp. 59-68). ICAR Tech. Series No. 1.

Baltenweck, I., Ouma, R., Anunda, F., Mwai, O., & Romney, D. (2004). Artificial or natural insemination: The demand for breeding services by smallholders. *http://www.smallholderdairy.org/publications/Conference/KARI2004*. Retrieved on March 12th, 2015.

Bayer, W., Lossau, V.A. & Feldmann, A. (2001). *Smallholders and Community-Based Management of Farm Animal Genetic Resources.* Proceedings of the workshop held in Mbabane, Swaziland, 7–11 May.

Bebe, B.O. (2008). Assessing potential for producing dairy replacements under increasing intensification of smallholder dairy systems in the Kenya highlands. *Livestock Research for Rural Development*, 20 (2) 2008.




EGERTON UNIVERSITY LIBRARY

Bebe, B. O., Udo, H. M. J. & Thorpe, W. (2002). Development of smallholder dairy systems in the Kenya highlands. *Outlook on agriculture,* 31(2), 113-120.

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

Bebe, B.O. (2003). *Herd Dynamics of Smallholder Dairy in the Kenyan Highlands*, PhD Thesis, Wageningen University, The Netherlands). pp 27, 53-66.

Bester, J., Matjuda, L. E., Rust, J. M. & Fourie, H. J. (2001). *The Nguni: A Case Study.* In: Proceedings of the workshop, Mbabane, Swaziland, pp 45-53.

Brotherstone, S. & Goddard, M. (2005). Artificial selection and maintenance of genetic variance in the global dairy cow population. Phil. Trans. R. Soc. B (2005) 360, 1479–1488 doi:10.1098/rstb.2005.1668

Chagunda, M. G. G., Msiska, A. C. M., Wollny, C. B. A., Tchale, H., & Banda, J. W. (2006). An analysis of smallholder farmers' willingness to adopt dairy performance recording in Malawi. *Livestock Research for Rural Development*, 18(5), *Article #66.* Retrieved December 3, 2014, from http://www.lrrd.org/lrrd18/5/chag18066.htm

Chatikobo, P. (2009). Artificial Insemination in Rwanda: Exploring Opportunities, Overcoming Challenges. Retrieved on 15 October 2013 from *http://www.slideshare.net/eadairy/dairy-news-vol-3.*

Cochran, W. G. (1977). Sampling techniques, 3rd edition. John Wiley & Sons, New York, USA.

Duguma, G., Mirkena, T., Haile, A., Iñiguez, L., Okeyo, M. M, Tibbo, A. B, Rischkowsky, J. S. & Wurzinger, M. (2010). Participatory approaches to investigate breeding objectives of livestock keepers. *Livestock Research for Rural Development, 22* (4). Retrieved on December 13, 2014, from http://www.lrrd.org/lrrd22/4/dugu22064.htm

Ethiopian Society of Animal Production (ESAP) (2004). *Farm Animal Biodiversity in Ethiopia:*

*Status and Prospects*. Asfaw Yimegnuhal and Tamrat Degefa (Eds). Proceedings of the 11th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 28-30, 2003. ESAP, Addis Ababa. 441pp.

Ekuam, E.D. (2008/2009). Livestock Identification, Traceability and Tracking: Its Role in Enhancing Human Security, Disease Control and Livestock Marketing in IGAD Region. *http://www.fao.org/fileadmin/user_upload/drought/docs/livestock%20ID.pdf.* Retrieved on 2nd January 2015.

Food and Agriculture Organization. (2011). *Dairy Development in Kenya*, by H.G. Muriuki. Rome.

Food and Agriculture Organization (FAO)/World Health Organization (WHO), 2004: Animal Identification Practices. Retrieved on 11 October 2014 from http://www.fao.org/3/a-y5454e/y5454e03.pdf.

Food & Agriculture organization (FAO) (2009). Livestock keepers – guardians of biodiversity. Animal Production and Health Paper. No. 167. Rome.

Fortes, R. S., Kasey, L. D., Sigrid, A. L., Brian, M. B., Antonio, R., Rachel, J. H., Gry, B., Stephen, S. M., & Milton G. T. (2013). Genomic regions associated with fertility traits in male and female cattle: Advances from microsatellites to high-density chips and beyond. *Animal Reproduction Science,* 141, 1–19.

Government of Kenya. (2010). Kenya National Dairy Master Plan. Ministry of Livestock Development, Nairobi.

Groen, A. F. (1999). *Breeding goal definition.* In: Workshop on Developing Breeding Strategies For Lower Input Animal Production Environments, Bella, Italy (pp. 22-25). *ICAR Technical Series - No 3.*

Herath, H. M. S. P., & Mohammad, S. (2009). *The current status of cattle breeding programmes in Asia.* In: Selection and Breeding of Cattle in Asia: Strategies and Criteria for Improved Breeding, IAEA, Austria.

IBM SPSS Statistics version 22, (2013).

Jain, A. K. & Muladno, M. (2009). *Selection criteria and breeding objectives in improvement of productivity of cattle and buffaloes.* In selection and breeding of cattle in Asia: Strategies and criteria for improved breeding, IAEA, Austria.

Jelan, Z. A., & Dahan, M. M. (1998). Monitoring Livestock Productivity in Malaysia. In K. R. Trivedi (ed*), International Workshop on Animal Recording for Smallholders in Developing Countries* (pp. 79-88). *ICAR Technical Series No.1.*

Kahi, A. K. & Rewe, T. O. (2008). Biotechnology in livestock production: Overview of possibilities for Africa. *African Journal of Biotechnology* 7 (25), 4984-4991. http://www.academicjournals.org/AJB. Retrieved on 18th December 2014

Kahi, A.K., Nitter, G. & Gall, C.F. (2004). Developing breeding schemes for pasture based dairy production systems in Kenya. II. Evaluation of alternative objectives and schemes using a two-tier open nucleus and young bull system. *Livestock Production Science*, 88, 179–192.

Katingi, E. (2011). Sustainable *breeding strategies for ruminants in Eastern and Southern Africa.* Farmer workshop, FARAJA institute in Isinya town, Kenya.

Kenya National Bureau of Statistics (KNBS) (2009). Ministry of Planning, National Development and Vision 2030. *KEN-KNBS-PHC-2009-v0.1.* Retrieved on 16 December 2013 from http://www.knbs.or.ke/index.

Khan, R.N. & Usmani, R. H. (2005). Characteristics of rural subsistence small holder livestock production system in mountainous areas of NWFP, Pakistan. *Pakistan Veterinary Journal 25*(3), 115-120.

Kiplagat, K. S., Limo, M. K. & Kosgey, S. I. (2012). Genetic improvement of livestock for milk production. INTEC-Open science/Open mind. http://dx.doi.org/10.5772/50761. Retrieved on 16 December 2014.

Kosgey, I. S., Mbuku, S. M., Okeyo, A. M., Amimo, J., Philipsson, J. & Ojango, J. M. (2011).

Institutional and organizational frameworks for dairy and beef cattle recording in Kenya: a review and opportunities for improvement. *Animal Genetic Resources, 48*, 1–11. Doi: 10.1017/S2078633610001220.

Kosgey, I.S. (2004). *Breeding Objectives and breeding strategies for small ruminants in the tropics.* (PhD). Thesis. Animal Breeding and genetics group, Wageningen University).

Marius, L., Imbayawro-Chikosi, E. V., Hanyani-Mlambo, B. T. & Mutisi, C. (2010). Breed preference, selection criteria and production performance of dairy cattle in the selected smallholder dairy farms in Zimbabwe. *Second RUFORUM Biennial Meeting, Entebbe, Uganda.*

Mattoni, M., Bergero, D. & Schiavone, A. (2007). Assessment of Structural Traits and Management Related to Dairy Herds in the Peri-urban Area of Bobo Dioulasso (South West of Burkina Faso). *Journal of Agriculture and Rural Development in the Tropics and Subtropics Volume,* 108(1), 41–50.

Matete, G. O., Gathuma, J. M., Muchemi, G. Ogara, W., Maingi, N., Maritim., W. & Moenga., B. (2010). Institutional and organizational requirements for implementing the Livestock Identification and Traceability System in Kenya. *Livestock Research for Rural Development, 22 (10) Article #182.* Retrieved December 11, 2014, from http://www.lrrd.org/lrrd22/10/mate22182.htm.

McDermott, J., Randolph, T. F. & Staal, S. J. (1999). The economics of optimal health and productivity in smallholder livestock systems in developing countries. *Scientific and Technical Review of the Office International des Epizooties, 18* (2), 399-424.

Menjo, D. K., Bebe, B. O., Okeyo, A. M. & Ojango, J. M. K. (2009). Survival of Holstein-Friesian heifers on commercial dairy farms in Kenya. *Applied Animal Husbandry & Rural Development*, 2, 14-17.

Minjauw, B., Muriuki, H.G. & Romney, D. (2002). Development of farm field school methodology for smallholder dairy farmers in Kenya. Presented at the International Learning Workshop on Farmer Field Schools (FFS): Emerging Issues and Challenges,

Yogyakarta, Indonesia 21-25 October 2002. Nairobi: ILRI.

Moran, J. B. (2013). Addressing the key constraints to increasing milk production from smallholder dairy farmers in tropical Asia. *International Journal of Biological Sciences, 2*(3), 90-98.

Moris, J. (1991) Extension alternatives in tropical Africa. Published by the Overseas Development Institute, Regent's College, Inner Circle, and Regent's Park London NW1 4NS. 184pp.

Muasya, T. K., Peters, K. J. & Kahi A. K. (2013). Breeding structure and genetic variability of the Holstein Friesian dairy cattle. *Animal Genetic Resources, 52*, 127–137.

Mudavadi, P. O, Otieno, K, Wanambacha, J. W, Odenya, J. O, Odendo, M. and. Njaro O. K. (2001). Smallholder Dairy production and marketing in western Kenya. British Department for International Development (DFID), SD (R&D) Project.

Mugisha, A., Kayiizi, V., Owiny, D., & Mburu, J. (2014). Breeding services and the factors influencing their use on smallholder dairy Farms in Central Uganda. *Veterinary Medicine International*, (2014), 6. http://dx.doi.org/10.1155/2014/169380.

Muthui, N. J., Mshenga, P. M. & Bebe, O. B. (2012). *A comparative analysis of breeding information sourcing and net margin estimates of inseminations and replacement decisions of smallholder dairy farmers.* Third RUFORUM Biennial Meeting 24 - 28 September 2012, Entebbe, Uganda.

Murage, A. W. & Ilatsia, E. D. (2011). Factors that determine use of breeding services by smallholder dairy farmers in Central Kenya. *Tropical Animal Health Production,* 43, 199-207.

Mureda, E., & Zeleke, M. Z. (2008). *Characteristics and constraints of crossbred dairy cattle production in Lowland areas of Eastern Ethiopia.* Agricultural College, ATVET, Holleta, Ethiopia.

Muriuki, H., Omore, A., Hooton, N., Waithaka, M., Ouma, R., Staal, S.J. & Odhiambo, P.

(2003). The policy environment in the Kenya dairy sub-sector: a review. SDP Research and Development Report 2. Nairobi (Kenya): Smallholder Dairy (R&D) Project.

Musalia, M. L., Wangia, M .M.S., Shivairo, S.R. & Violet Vugutsa, V. (2010). Effects of policy change on the dairy production support services within the smallholder dairy farmers in Butere/Mumias and Kakamega districts of Western Kenya. *African Journal of Agricultural Research*, 5(8), 661-667. doi: 10.5897/ajar09.583.

Musalia LM, Wangia SMM, Shivairo RS, Okutu P, Vugutsa V (2007). Dairy production practices among smallholder dairy farmers in Butere/Mumias and Kakamega districts in Western Kenya. *Tropical. Animal. Health Production.* 39: 199-205.

Nandi County Integrated Development plan. (2013)

Ndebele, J.J., Muchenje, V., Mapiye, C., Chimonyo, M., Musemwa, L. & Ndlovu, T. (2007). Cattle breeding management practices in the Gwayi smallholder farming area of South-Western Zimbabwe. *Livestock Research for Rural Development*, 19 (12).

Neary, M., & Yager A. "Purdue Agriculture-Department." *Methods of Livestock Identification. Purdue University, Dec 2002.Web 4 Aug.2014.*

Nilforooshan, A. M., Amir, K. & Mohammad, A. E. (2008). Effects of missing pedigree information on dairy cattle genetic evaluations. Dummerstorf, 5(2), 99-110.

Njoroge, L. I., Baltenweck, R., Ouma, S., Staal, D. & Romney R. (2004). *Breeding services in Kenya: An examination of trends and factors predisposing adoption of artificial insemination technology*. East African Regional Animal Production Society Conference, KARI Headquarters, Nairobi.

Njubi, D. M., Wakhungu, J. W. & Badamana, M. S. (2011). Prediction of Second Parity Milk Yield of Kenyan Holstein-Friesian Dairy Cows on First Parity Information Using Neural Network System and Multiple Linear Regression Methods. *Livestock Research for Rural Development. Volume 23, Article #64.* Retrieved April 5, 2016, from http://www.lrrd.org/lrrd23/3/njub23064.htm.

Oltjen, J., Drake, D., & Forero, L. (2005). Value of Individual Record Keeping to Commercial Livestock Operators. *Livestock Identification #4 in a series for producers*. Retrieved on 23 January 2015 from http://animalscience.ucdavis.edu/animalID/.

Okeyo, A. M., Kajume, J. K., Mosi, R. O., Okila, E. V. A., Gathuma, J. M., Kiere, S. M. N., Agumbah, G., Kuria, J. N., & Chema, S. (2000). *Artificial Insemination a bio-technological tool for genetic improvement of Kenyan dairy cattle herds: Historical perspective, Current status, Challenges and Way forward in the next Millennium. A Kenya Country Paper.* "Symposium on Dairy Cattle Breeding in East Africa: Sustainable Artificial Insemination Service", Kenya Agricultural Research Institute (KARI), Headquarters, Kiplagat Road, Nairobi.

Ombura, J., Wakhungu, J. W., Mosi R. O., & Amimo, J. O. (2007). An assessment of the efficiency of the dairy bull dam selection methodology in Kenya. *Livestock Research for Rural Development 19*(1), Article #10.

Omondi, S. P. W. & Meinderts, J. (2009). The status of good dairy farming practices on small-scale farms in central highlands of Kenya. http://www.kari.org/conference/*on Agriculture*; 27,237–242;

Ongadi, P. M., Wakhungu, J.W., Wahome, R.G. & Okitoi, L.O. (2007). Characterization of grade dairy cattle owning households in mixed small scale farming systems of Vihiga, Kenya. *Livestock Research for Rural Development. Volume 19, Article #43.* Retrieved April 30, 2016, from http://www.lrrd.org/lrrd19/3/onga19043.htm

Ouma, E., Abdulai[1], A., Drucker[3], A. & Obare[4], G. (2004). Assessment of Farmer Preferences for Cattle Traits in Smallholder Cattle Production Systems of Kenya and Ethiopia. In Conference on International Agricultural Research for Development, Deutscher Tropentag, Berlin, October 5-7.

Philipsson, J., Rege, J. E. O., Zonabend, E. & Okeyo A. M. (2011). Sustainable breeding programmes for tropical farming systems *In*: J. M. Ojango, B. Malmfors, and A.M. Okeyo

(Eds), *Animal Genetics Training Resource*. International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences Uppsala, Sweden.

Quddus, M.A. (2012). Adoption of dairy farming technologies by small farm holders: practices and constraints. *Bangladesh Journal of Animal Science*, 41 (2), 124-135.

Rhone, J. A., Koonawootrittriron S. & Elzo M. A. (2008). Record keeping, genetic selection, educational experience and farm management effects on average milk yield per cow, milk fat percentage, bacteria score and bulk tank somatic cell count of dairy farms in the central region of Thailand. *Tropical Animal Health,* 40, 627-636.

Risstrom, I. (2014). Herd recording. Retrieved on 30 June 2014 from http://www.ilri.org/InfoServ/Webpub/fulldocs/SmHDairy/chap14.html.

Sarakul, M., Koonawootrittriron, S., Elizo, M. A. & Suwanasopee, T. (2011). Factors influencing genetic change for milk yield within farms in Central Thailand. *Asian-Australian Journal of Animal Science, 24(8)*, 1031-1040.

Sarakul, M., Koonawootrittriron, S., Suwanasopee, T., Hirunwong, A. & Thongprapi, T. (2009). Situation of production and attitude for sire selection of dairy farmers in Thailand. In: Proceeding of the 47nd Kasetsart University Annual Conference, March 17-21. Bangkok, Thailand. pp. 174-181.

SAS Institute Inc. (2011) SAS Institute Inc. 2011. SAS/STAT® 9.3 User's Guide.

Schreiber, C. (2002.). Sources of innovation in dairy production in Kenya. *International Service for National Agricultural Research.* Briefing Paper No 58.

Smallholder Dairy Commercialization Programme (SDCP) (2010). Ministry of Livestock Development. Smallholder farmers' guide to dairy farming as a business.

Smallholder Dairy Project (SDP) (2004). Competitiveness of the smallholder dairy enterprise in Kenya. SDP Policy Brief 3. Nairobi, Kenya: Smallholder Dairy Project.

Smallholder Dairy Project (SDP) (2005). The uncertainty of cattle numbers in Kenya. SDP

Policy Brief No. 10.Smallholder Dairy (R&D) Project.

Staal, S. J., Owango, M., Muriuki, H., Kenyanjui, M., Lukuyu, B., Njoroge, L., Njubi, D., Baltenweck, I., Musembi, F., Bwana, O., Muriuki, K., Gichungu, G., Omore, A., & Thorpe, W. (2001). Dairy Systems Characterisation of the Greater Nairobi Milk Shed. SDP Research Report.

Toghiani, S. (2012). Genetic relationships between production traits and reproductive performance in Holstein dairy cows. *Archives Animal Breeding, 55(5)*, 458-468.

Trivedi, K. R. (1997*). International Workshop On Animal Recording For Smallholders In Developing countries.* India.

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

Van der Lee, J., Zijlstra, J.; Wouters, A.P. & Van Vugt, S.M. (2014). *Milking to Potential: Strategic Framework for Dairy Sector Development in Emerging Economies.* Discussion paper. Centre for Development Innovation and Livestock Research, Wageningen UR (University & Research Centre), Wageningen.

Vihiga County First County Integrated Development Plan. (2013-2017)

Wahinya, P. K., Okeno T. O., Kosgey I. S. and Kahi A. K. (2015). Economic and Biological Values for Pasture-Based Dairy Cattle Production Systems and their Application in Genetic Improvement in the Tropics. *Journal of Animal Production Advances* 2015, 5(5): 664-675. Retrieved on 21 March 2015 from DOI: 10.5455/japa.20150517032130

Waithaka, M.M., Nyangaga, J.N., Staal, S.J., Wokabi, A.W., Njubi, D., Muriuki, K.G., Njoroge, L.N. & Wanjohi, P.N. (2002). Characterization of dairy systems in the western Kenya region. Smallholder Dairy (R&D) Project Report of Dairy and Crop Characterization Activities in Western Kenya. http://hdl.handle.net/10568/1859.

Wambugu, S., Karimi, L. & Opiyo, J. (2011). Productivity trends and performance of dairy

farming in Kenya. Tegemeo Institute of Agricultural Policy & Development., Egerton University.

Wanjala, S.P.O, Njehia, B. & Ngichabe C (2014). Assessment of the Structure and Performance of the Milk market in Western Kenya. *International Journal of Current Research,* 6(3): 5652-5656.

Wasike, C. B., Indetie, D., Pitchford, W. S., Ojango, J. M. K. & Kahi A. K. (2007). Genetic evaluation of growth of Kenya Boran cattle using random regression models. *Tropical Animal Health Production,* 39: 493–505. DOI 10.1007/s11250-007-9014-4.

Wassie, T., Mekuriaw, G. & Mekuriaw, Z. (2014). Milk production performances of Holstein Friesian x Arsi and Holstein Friesian x Boran cross-bred cattle at Agarfa Agricultural Technical Vocational and Educational Training (ATVET) College, Oromia, Ethiopia. *Livestock Research for Rural Development*, 26 (8) 2014.

Whittier, C. J. (2011) .Basic principles of identifying cattle. *http:// www. Progressive cattle. com/ focus topics/identification/3642.*

Yeamkong, S., Koonawootrittriron, S., Elzo, M. A. & Suwanasopee, T. (2010). Effect of Experience, Education, Record Keeping, Labor and Decision Making on Monthly Milk Yield and Revenue of Dairy Farms Supported by a Private Organization in Central Thailand. *Asian-Australian Journal of Animal Sciences,* 23(6), 814-824.

Zander, K.K., Mwacharo, J.M., Drucker, A.G. & Garnett, S.T. (2013). Constraints to adopting livestock improvement technologies in Kenya: the case of Narok and Nakuru districts. *Journal of Arid Environments,* 96, 9-18.

## 7.0. APPENDIX

### Appendix A: Questionnaire to collect data on the use of animal information and trait preferences in insemination and herd replacement practices by smallholders.

**Introduction**

I am a student from Egerton University conducting a research on the Use of Animal information and Trait Preferences in Insemination and Herd Replacement practices by Smallholders in Western Kenya.

- I am collecting information on insemination using bull and Al service, and purchase of heifer and cull-cow for breeding purposes, sources and type of breeding information, identification systems used and types of records kept.
- The results will be used to improve breeding decisions by farmers, extension service providers and other dairy stakeholders for informed dairy breeding improvement.
- Results will be shared with the stakeholders in a feedback workshop to be planned at a later stage
- All information will be treated confidential.
- I am kindly asking for your consent to be part of the study.
- **Household consent obtained [Yes] [No]. Thank you.**

**General Information**

| | | | |
|---|---|---|---|
| **Questionnaire number** | [ _ _ _ _ _ _ _ _ ] | **Date dd/mm/yy** | [ _ _ _ _ _ _ _ _ ] |
| **Name of household head** | | | |
| **Name of main respondent** | | | |
| **3. Relationship of respondent to household head?** *00*=Head of hhd; 01=Spouse;02=Child; 03=Farm labourer; 04=Others (specify) | | | [– –] |
| **4. Gender of the head of the household** 01=Male, 02=Female | | | [– –] |
| **5. Age of head of the household in years** | | | [_ _] |
| **6. Highest level of education of household head** 00= no formal education; 01= Primary; 02 = Secondary; 03=Certificate level training; 04=Diploma level training; 05=Graduate level training | | | [_ _] |
| 7. **Primary occupation or source of livelihood** 01 Dairying; 02=Cash and food crops; 03=Salaried employment; 04=Business , 05=Remittances: 06=0thers (specify) | | | [_ _] |
| **8. Dairy farm category** | 1=Supplier farm (Rift valley); 2= Buyer farm in Western province. | | [_ _] |
| **9. Dairy farming experience** | Years in dairy farming | | [_ _] |
| | | | |

| | | | | |
|---|---|---|---|---|
| **10. Land allocation to dairy** | Fodder | [_ _] | Crops | [_ _] |

## Section A: Information on bull and AI for insemination services

**A/1:** In the table below, indicate the different type(s) and source(s) of information you receive or would like to receive when **acquiring/selecting a bull for insemination services**

| | **Which are your sources of the information?** | **How useful has the information been to you for decision making?** |
|---|---|---|
| **Type of information** | List up to three from *code A/1.1* | 00=Not at all<br>01=Somewhat<br>02= Very |
| Individual production performance | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Progeny performance | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Pedigree records | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Breeding value estimates | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Life time performance records of that animal | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Specific traits | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Breed of the bull | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Reputation of the farmer who reared that animal | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| The price | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Where to buy/obtain | [_ _]<br>[_ _]<br>[_ _] | [_ _] |

### Code A/1.1

| | | | | | |
|---|---|---|---|---|---|
| 00= Never source for information | 01=Extension officer | 03= Farmer owning the bull | 04 =NGO advisor | 05=Other farmers | 06=Private service provider |

| | | | |
|---|---|---|---|
| 07=Farm labourer | 08=Reading information magazine | 09=Media channels | 10=Other (specify) |

A/2: In the table below, indicate the different type(s) and source(s) of information you receive or would like to receive when **acquiring/selecting AI semen for insemination services**

| | **Which are your sources of the information?** | **How useful has the information been to you for decision making?** |
|---|---|---|
| **Type of information** | List up to three from **code A/2.1** | 00=Not at all<br>01=Somewhat<br>02= Very |
| Individual production performance | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Progeny performance | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Pedigree records | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Breeding value estimates | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Life time performance records of that animal | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Specific traits | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Breed of the bull | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Reputation of the farmer who reared that animal | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| The price | [_ _]<br>[_ _]<br>[_ _] | [_ _] |
| Where to buy/obtain | [_ _]<br>[_ _]<br>[_ _] | [_ _] |

Code A/1.1

| | | | | | |
|---|---|---|---|---|---|
| 00=Never source for information | 01= Extension officer | 03=Farmer owning the bull | 04=NGO advisor | 05=0ther farmers | 06=Private service provider |
| 07=Farm labourer | 08=Reading information magazine | | Media channels | Other(specify) | |

**Code: A/1.3 (see next page for questions)**

| | | | | |
|---|---|---|---|---|
| 00= Milk yield | 01= Fertility | 02=Body conformation | 03= Temperament | 04 = Body size |

**A/3:** In the table below, indicate three specific traits in order of importance for which you receive or would like to receive information on when **you have to decide on a bull or Al semen for insemination service. (Code A/1.3 above)**

| Service | First | Second | Third |
|---|---|---|---|
| **Bull** | [ _ _ ] | [ _ _ ] | [ _ _ ] |
| **Al semen** | [ _ _ ] | [ _ _ ] | [ _ _ ] |

## Section B: Information on heifer and cull-cow for breeding purposes

**B/1**: n the table below, indicate the different type(s) and source(s) of information you receive or would like to receive when **acquiring/selecting a heifer for breeding purposes.**

| | **Which are your sources of the information?** | **How useful has the information been to you for decision making?** |
|---|---|---|
| **Type of information** | List up to three from *code B/1.1* | 00=Not at all<br>01=Somewhat<br>02= Very, |
| Individual production performance | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Progeny performance | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Pedigree records | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Breeding value estimates | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Life time performance records of that animal | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Specific traits | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Breed of the Heifer | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Reputation of the farmer who reared that animal | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| The price | [ _ _ ]<br>[ _ _ ] | [ _ _ ] |

| | | |
|---|---|---|
| | [ _ _ ] | |
| Where to buy/obtain | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |

**Code B/1.1**

| | | | | | |
|---|---|---|---|---|---|
| 00=Never source for information | 01= Extension officer | 03=Farmer owning the heifer/cow | 04=NGO advisor | 05=0ther farmers | 06=Private service provider |
| 07=Farm labourer | 08=Reading information magazine | | Media channels | Other(specify) | |

B2: In the table below, indicate the different type(s) of information you receive or would like to receive when **acquiring /selecting a cull cow for breeding purposes.**

| | **Which are your sources of the information?** | **How useful has the information been to you for decision making?** |
|---|---|---|
| **Type of information** | List up to **from code B/1.1above page** | 00=Not at all<br>01=Somewhat<br>02= Very, |
| Individual production performance | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Progeny performance | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Pedigree records | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Breeding value estimates | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Life time performance records of that animal | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Specific traits | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Breed of the Cow | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| Reputation of the farmer who reared that animal | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |
| The price | [ _ _ ]<br>[ _ _ ] | [ _ _ ] |

| | | |
|---|---|---|
| | [ _ _ ] | |
| Where to buy/obtain | [ _ _ ]<br>[ _ _ ]<br>[ _ _ ] | [ _ _ ] |

**B/3:** In the table below, indicate three specific traits in order of importance for which you receive or would like to receive information on when **you have to decide on a heifer or cull-cow for breeding purposes**

| **Service** | **First** | **Second** | **third** |
|---|---|---|---|
| **Heifer** | [ _ _ ] | [ _ _ ] | [ _ _ ] |
| **Cull-cow** | [ _ _ ] | [ _ _ ] | [ _ _ ] |

**Code: B/1.3 for question A/3 and question A/4**

| | | | | |
|---|---|---|---|---|
| 00= Milk yield | 01=Fertility | 02=Body conformation | 03= Temperament | 04 = Body size |
| | 05= Udder conformation | | | |

Section H: Production and Reproductive Performance of Daughter- Progenies by Insemination and Breeding cow sources

H/1: Provide details of each female cattle in the herd

| **Female cattle** | | | | | |
|---|---|---|---|---|---|
| NO. | Breed | Source of the animal | Where animal was obtained | Sire of the animal | Dam of the animal |
| 1. | | [___] | [___] | [___] | [___] |
| 2. | | [___] | [___] | [___] | [___] |
| 3. | | [___] | [___] | [___] | [___] |
| 4. | | [___] | [___] | [___] | [___] |
| 5. | | [___] | [___] | [___] | [___] |
| 6. | | [___] | [___] | [___] | [___] |
| 7. | | [___] | [___] | [___] | [___] |
| 8. | | [___] | [___] | [___] | [___] |
| 9. | | [___] | [___] | [___] | [___] |
| 10. | | [___] | [___] | [___] | [___] |
| 11 | | [___] | [___] | [___] | [___] |
| 12 | | [___] | [___] | [___] | [___] |
| 13 | | [___] | [___] | [___] | [___] |
| 14 | | [___] | [___] | [___] | [___] |
| 15 | | [___] | [___] | [___] | [___] |
| 16. | | [___] | [___] | [___] | [___] |
| 17. | | [___] | [___] | [___] | [___] |
| 18. | | [___] | [___] | [___] | [___] |
| 19 | | [___] | [___] | [___] | [___] |
| 20 | | [___] | [___] | [___] | [___] |

**Codes for H1**

**Breed**

01=Holstein-Friesian
02=Ayrshire
03= Jersey
04= Guernsey
05= Dairy x dairy cross
06= Dairy x zebu cross
07= Zebu
08= Others -specify

**Source of the animal**

01 =Born on the farm
02= Bought from other farms
03= Bought from commercial large scale dairy farm
4 = Bought from market
5 = Bought from Government farm
06= Obtained from a development project
07 = Gift/Dowry payment
08= Unknown

**From where obtained**

00=Rift valley
01= Western
02=Nyanza
03=unknown

**Sired through**

01= Own bull
02= Other farmers' bull
03= Private AI
04= Government AI
05 = Cooperative / Self Help Group AI
06= Project AI
07= Project bull
08=Unknown

**Dam**

00=own reared heifer /cow
01=Purchased cow
02=Purchased heifer

**SECTION I. Herd Management**

**I/1** Do you keep **written records** for you dairy enterprises? [_ _ _] 1 = Yes, 2 = No

If yes, which one(s) 1st [_ _ _] 2nd [_ _ _] 3rd [_ _ _]

**I/2** What **kind of animal identification system** for cattle do you use in your farm? 1st [_ _] 2nd [_ _]

| **1/1** Kinds Of Written Records | **I**/2 Identification Systems |
|---|---|
| 01= Breeding records<br>02 = Production records<br>03 = Veterinary (treatment) records<br>04 = Sales and purchases<br>05 = Deaths and births<br>06 = All<br>07 = Other (specify) | 01 = none<br>02 = name<br>03 = tag number<br>04 = branding/notching<br>05 = colour<br>06 = other (specify)_____ |

**Thank you for your cooperation**

FARMER'S NUMBER /_ _/ ENUMERATOR CODE /_ _/ DATE (DD/MM /YY) /_ _/ _ _/ **2014**



EGERTON UNIVERSITY LIBRARY