

**EVALUATION OF FUNCTIONAL TRAITS IN HOLSTEIN-FRIESIAN CATTLE ON  
LARGE-SCALE FARMS IN NAKURU DISTRICT OF KENYA**

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A thesis submitted to the Graduate School in partial fulfilment for the requirements of the Master of Science Degree in Animal Production (Animal Breeding option) of Egerton University.

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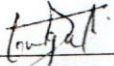


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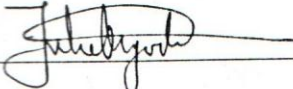
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## **DEDICATION**

**This work is dedicated to**

**Mr. Sosten Kibore Menjo (Late)**

Who through his strict upbringing was able stimulate my thirst for knowledge

And to My Family

**Mrs Rosaline Menjo, Mrs Milca Bore, Chumba, Peter, Chelimo, Maritim and  
My Siblings**

Who supported and encouraged me through out my studies

Who were patient with me on many occasions during my studies

Who dared me to hope for the best and

Whose unconditional love lifted me.

Thank you



## ABSTRACT

The use of imported semen within the Holstein-Friesian population in Kenya has contributed to increases in milk production per cow. However, information on how this impact on functional traits, particularly early life survival and reproductive traits of dairy cattle is lacking. This study evaluated age at first calving (AFC), survival to age at first calving (SAFC), and survival to four years of age (S1460) in the Holstein-Friesian cattle populations of four medium to large-scale dairy farms in Nakuru district of Kenya. The records used were for the period 1990 to 2003. Environmental factors were evaluated for all the three traits, and genetic parameter estimates obtained for AFC. The average AFC was  $1058 \pm 159$  days with a heritability estimate of  $0.15 \pm 0.06$ . On average, daughters of dams with sires originating from New Zealand and Australia had an earlier AFC (907 days) relative to those with sires from Europe (1031 days). To evaluate SAFC and S1460, a survival analysis was carried out using the survival kit. On average, 25% of all the animals born on the four farms were culled prior to attaining a first calving. While the highest proportion of losses was due to unspecified reasons, the relative risk of being culled was highest when an animal had a specific disease. The first 60 days of life were the most critical for early survival. The herd, year-season of birth and sire region of origin significantly ( $p < 0.001$ ) affected mortality and culling rates. Daughters of sires from South-Africa and Israel tended to have better survival rates than those with sires originating in other regions. From the analyses, it was evident that some unfavourable selection was practiced towards animals sired by Kenyan-born bulls. To facilitate accurate assessment of causes of mortality and culling, record keeping on health management is important. The use of sires from heterogeneous sources without a clearly defined breeding objective other than increased milk production potential is negatively impacting on early survival of Holsteins on large-scale dairy farms in Kenya. Economic implications of losses before attaining a productive age need to be evaluated in order to formulate intervention strategies for livestock producers to make informed decisions on choice of sires for breeding.



## **TABLE OF CONTENTS**

|                                                                  |     |
|------------------------------------------------------------------|-----|
| COPYRIGHT                                                        | iii |
| ACKNOWLEDGEMENTS                                                 | iv  |
| DEDICATION                                                       | v   |
| ABSTRACT                                                         | vi  |
| TABLE OF CONTENTS                                                | vii |
| LIST OF FIGURES                                                  | x   |
| LIST OF TABLES                                                   | xi  |
| LIST OF ABBREVIATIONS                                            | xii |
| CHAPTER ONE                                                      | 1   |
| INTRODUCTION                                                     | 1   |
| 1.1. Background Information                                      | 1   |
| 1.2. Objectives of the study                                     | 3   |
| 1.3. Hypotheses                                                  | 3   |
| CHAPTER TWO                                                      | 4   |
| LITERATURE REVIEW                                                | 4   |
| 2.1. Dairy cattle production in Kenya                            | 4   |
| 2.1.1. Breeds and breeding policy                                | 4   |
| 2.1.2. Marketing of milk                                         | 5   |
| 2.1.3. Constraints to improved dairy productivity in Kenya       | 6   |
| 2.2. Dairy cattle breeding programs in developing countries      | 6   |
| 2.3. Genetic and phenotypic parameters in breeding programmes    | 7   |
| 2.3.1. Heritability                                              | 7   |
| 2.3.2. Repeatability                                             | 8   |
| 2.3.3. Phenotypic and genetic correlations                       | 9   |
| 2.3.4. Genotype x environmental interaction                      | 9   |
| 2.4. Traits of economic importance for dairy breeding programmes | 10  |
| 2.4.1. Production traits                                         | 11  |
| 2.4.2. Functional traits                                         | 12  |
| 2.5. Culling and mortality in dairy production systems           | 14  |
| 2.5.1. Voluntary culling                                         | 15  |



|                                                                     |    |
|---------------------------------------------------------------------|----|
| 2.5.2. Involuntary culling                                          | 16 |
| 2.5.3. Economic impact of culling                                   | 16 |
| 2.5.4. Analysis of culling and mortality                            | 17 |
| CHAPTER THREE                                                       | 18 |
| MATERIALS AND METHODS                                               | 18 |
| 3.1. Data source                                                    | 18 |
| 3.2. Herd management                                                | 20 |
| 3.2.1. Feeding management                                           | 20 |
| 3.2.2. Breeding management                                          | 21 |
| 3.2.3. Health management                                            | 21 |
| 3.2.4. Culling policy                                               | 21 |
| 3.3. Data                                                           | 22 |
| 3.3.1. Data editing                                                 | 22 |
| 3.3.2. Definition of traits                                         | 22 |
| 3.3.2. Definition of fixed effects                                  | 23 |
| 3.4. Statistical analyses                                           | 25 |
| 3.4.1. Analysis of AFC                                              | 25 |
| 3.4.2. Survival analyses                                            | 26 |
| CHAPTER FOUR                                                        | 29 |
| RESULTS                                                             | 29 |
| 4.1. Descriptive statistics and genetic parameter estimates for AFC | 29 |
| 4.2. Culling and mortality in various LSF                           | 30 |
| 4.2.1. Descriptive statistics for culling and mortality             | 30 |
| 4.2.2. Environmental factors influencing differential culling       | 31 |
| 4.2.3. Causes of mortality and culling                              | 33 |
| 4.3. Survival analysis of mortality prior to four years of age      | 34 |
| 4.3.1. Effects of systematic environmental factors                  | 34 |
| 4.3.2. Effects of the sire's region of origin on culling            | 37 |
| 4.3.3. Trend in SAFC and S1460                                      | 40 |
| CHAPTER FIVE                                                        | 41 |
| DISCUSSION AND CONCLUSIONS                                          | 41 |
| 5.1. Age at first calving                                           | 41 |
| 5.2. Culling and mortality on various LSF                           | 42 |
| 5.3. Causes of mortality and culling                                | 43 |
| 5.4. Survival to AFC and to 1460 days                               | 44 |



|                                                             |    |
|-------------------------------------------------------------|----|
| 5.5. Influence of sire's region of origin on SAFC and S1460 | 45 |
| 5.6. Conclusion                                             | 46 |
| REFERENCES                                                  | 47 |



## LIST OF FIGURES

|                                                                                                                                                                                                                                                         |    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1: Location of the four farms where data for the study were obtained and their ecological zones .....                                                                                                                                            | 18 |
| Figure 2: Rainfall patterns in the study areas for the period 1990 to 2003 .....                                                                                                                                                                        | 19 |
| Figure 3: Graphical test of the assumption that the baseline hazard function for mortality in the different LSF were proportional .....                                                                                                                 | 28 |
| Figure 4: Phenotypic and genetic trends in age a first calving .....                                                                                                                                                                                    | 30 |
| Figure 5: Percentage of animals culled based on their sire area of origin .....                                                                                                                                                                         | 31 |
| Figure 6: The Proportions of animals culled for different age groups.....                                                                                                                                                                               | 32 |
| Figure 7: Proportion of animals culled for different reasons of disposal before four years of age .....                                                                                                                                                 | 33 |
| Figure 8: Proportion of animals culled prior to first calving for various reasons of disposal .....                                                                                                                                                     | 34 |
| Figure 9: Kaplan-Meir survivor curves for survival to age at first calving (SAFC) and survival to 1460 days (S1460) for the various large-scale farms (LSF) .....                                                                                       | 36 |
| Figure 10: The relative risk of animals being culled depending on the age at first calving class (class 1= animals that calved earliest on the farm, to class 5= animals that calved closer to 1460 days) on the various large scale farms (LSF). ..... | 37 |
| Figure 11: Baseline survivor curves for animals sired by bulls from various regions for survival to attaining an age at first calving.....                                                                                                              | 38 |
| Figure 12: Baseline survivor curves for animals sired by bulls from various regions for survival to 1460 days of age .....                                                                                                                              | 39 |
| Figure 13: Annual trends in proportion of animals culled prior to attaining a first calving (SAFC), and those culled prior to attaining four years of age (S1460) .....                                                                                 | 40 |



## LIST OF TABLES

|                                                                                                                                                                                                                                                                                        |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Table 1: Repeatability estimates of economically important traits in dairy cattle.....                                                                                                                                                                                                 | 9  |
| Table 2: Lactation milk yields of HF cattle from various countries .....                                                                                                                                                                                                               | 11 |
| Table 3: Characteristics of Large Scale farms from which data was collected .....                                                                                                                                                                                                      | 19 |
| Table 4: Data structure for survival to age at first calving (SAFC) and survival to 1460 days<br>(S1460) .....                                                                                                                                                                         | 23 |
| Table 5: Number of animals per sire region of origin for various large scale farms .....                                                                                                                                                                                               | 24 |
| Table 6: Grouping of reasons for culling on large scale farms in Kenya .....                                                                                                                                                                                                           | 24 |
| Table 7: Data structure for evaluation of age at first calving .....                                                                                                                                                                                                                   | 26 |
| Table 8: Summary statistics on factors affecting age at first calving and the least square (LS)<br>means for different effects on the Large Scale farms .....                                                                                                                          | 29 |
| Table 9: Statistics on culling of all female animals born and culled on the various Large scale<br>farms from 1993-2003 .....                                                                                                                                                          | 30 |
| Table 10: Percentage of animals culled within each season of the year.....                                                                                                                                                                                                             | 32 |
| Table 11: Summary statistics for mean age at failure (days) and proportion culled at various level<br>of fixed effects influencing survival to first calving (SAFC) and survival to four years of<br>age(S1460) in Holstein Friesian cattle raised on large scale farms in Kenya ..... | 35 |



## **LIST OF ABBREVIATIONS**

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|        |                                                 |
|--------|-------------------------------------------------|
| ABS    | American Breeders Service                       |
| ACZ    | Agro-Climatic Zones                             |
| ADC    | Agriculture Development Cooperation             |
| AFC    | Age at first calving                            |
| AI     | Artificial Insemination                         |
| CAIS   | Central Artificial Insemination Station         |
| CI     | Calving interval                                |
| DFREML | Derivative Free Restricted Maximum Likelihood   |
| DM     | Dry matter                                      |
| DRSK   | Dairy Recording Services of Kenya               |
| GDP    | Gross Domestic Product                          |
| GxE    | Genotype by environment interaction             |
| HF     | Holstein-Friesian                               |
| HYS    | Herd-year season                                |
| KSB    | Kenya Stud Book                                 |
| KCC    | Kenya Cooperative Creameries                    |
| LSF    | Large-scale farm                                |
| MOLFD  | Ministry of Livestock and Fisheries Development |
| MSF    | Medium-scale farm                               |
| S1460  | Survival to four years of age                   |
| SAFC   | Survival to age at first calving                |
| SCC    | Somatic Cell Count                              |
| SDP    | Smallholder Dairy Project                       |
| SSF    | Small-scale farm                                |
| TBD    | Tick-Borne Diseases                             |
| TMR    | Total Mixed Rations                             |
| USA    | United States of America                        |
| WWS    | World Wide Sires                                |

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## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1. Background Information**

The dairy industry in Kenya is a very important sector of the economy and currently accounts for 3.5 % of the total national gross domestic product (GDP) and about 14 % of the agricultural GDP (Smallholder Dairy Project, 2004). The industry forms a significant part of the rural economy in Kenya with over 0.8 million households deriving living through dairying and related activities (Omore *et al.*, 1996). Apart from milk, dairy animals also provide manure, other marketed products such as calves, culled animals for beef, as well as intangible benefits such as insurance and financing roles (Bebe *et al.*, 2002).

Dairy farms are categorised into large scale (LSF) for those over 50 hectares with herd sizes of over 50 head, medium scale (MSF) for holdings of 20-50 hectares with herd sizes of 20 to 50 head, and small scale (SSF) where holdings are less than 10 hectares with a herd sizes of less than 10 head. Medium and large-scale farms account for about 24% of the exotic dairy cattle, and are a major source of high quality breeding stock and processed milk in the domestic market (Bebe *et al.*, 2002; Muriuki *et al.*, 2003). The national dairy population is estimated at 6.7 million (Smallholder Dairy Project, 2005), comprising of Holstein-Friesian (HF), Ayrshire, Guernsey, Jersey, Brown Swiss breeds and their crosses with each other, and with the indigenous cattle. The HF comprises the largest population of any exotic dairy breed in the country (Ojango and Pollott, 2001; Bebe *et al.*, 2002).

Lactation milk yield of the HF in the country is currently twice as high in medium and large-scale herds (4540kg) as in smallholder herds (2151kg) (Ojango *et al.*, 2004). This is attributed to improved management in MSF and LSF in which Total Mixed Rations (TMR) are provided to meet the physiological and production requirements of the animals, implementation of a consistent animal health programme, and use of imported semen from bulls with high genetic merit for milk production (Ojango and Pollott, 2001; Bebe *et al.*, 2002; Muriuki *et al.*, 2003). In SSF, farmers lack adequate access to production resources of land, capital, skilled labour and managerial skills necessary for realising positive genetic progress in milk yields (Batz



*et al.*, 1999; Bebe *et al.*, 2003). In addition, their dairy herds experience high levels of reproductive wastage, consequently limiting the scope for selection of replacement heifers.

While increasing milk production per animal in tropical dairy production systems is desirable, it is important to accompany such improvements with improved performance in functional traits which tends to deteriorate with increased selection pressure for milk yield (Hoekstra *et al.*, 1994; Meuwissen *et al.*, 1995; Vollema, 1998). Functional traits are those traits that are not directly related to yield but rather to specific physiological functions of an animal that decrease cost of inputs (Groen *et al.*, 1997). These include traits related to health status and disease resistance, reproduction, locomotion and survival. Depression in functional traits would result in fragile animals with increased susceptibility to disease, poor survival rate and poor reproductive performance (Cunningham and Syrstad, 1987). Consequently, farmers are faced with high veterinary costs, increased costs of replacement and reduced opportunity for voluntary culling, leading to decreased genetic gain (Waltrick and Koops, 2001).

Problems of herd health and adaptability are of concern in dairy herds in the tropics because of persistent exposure to multiple stresses of low quality and quantity feed, heat stress, high disease and parasitic incidences, poor husbandry and breeding practices (Ansell, 1985; Ombura *et al.*, 2007). The combined effect of mortality and culling is estimated to cause losses of 40 to 60% of female dairy cattle conceived or born in the tropics (Vaccaro, 1990). Involuntary losses of animals at any stage of their lifetime within a production system affects the overall cost of production and reduces the efficiency of output, leading to reduced profitability. Since any positive changes in functional traits will lead to more profitable dairy production in all farming systems, information on the influence of different environmental factors affecting functional traits will enable producers to make rational management decisions for increased profitability.

In evaluating lifetime productivity, the lifespan of a female farm animal can be partitioned into two time periods; a raising period from birth to first parturition, and the subsequent reproductive period until disposal. Within the first period, the AFC represents a truncation point when an animal's status changes from an input-based resource, to a productive



asset for a producer. Producers can, to some extent manipulate the AFC through management. However, it will remain variable due to differential reproductive efficiency (Ettema and Santos, 2004).

The use of imported semen within the HF population in Kenya has contributed to increases in milk production per cow, but, genotype by environment interactions (GxE) have been shown to have a significant impact on productivity (Ojango *et al.*, 2002). Information is limited on causes of involuntary culling and differences in survival rates during the early life of cattle in tropical production systems.

### **1.2. Objectives of the study**

The overall objective of this study was to quantify and evaluate factors influencing AFC and survival to first calving in HF cattle raised on LSF in Kenya. The specific objectives were to:

1. Determine the effects of systematic environmental factors on AFC, mortality and culling prior to AFC (SAFC) and prior to four years of age (S1460) in HF cattle raised on LSF.
2. Quantify causes of mortality and culling prior to first calving (SAFC) and prior to four years of age (S1460) in HF cattle raised on LSF
3. Evaluate differential adaptation for SAFC and S1460 in heifers sired by bulls from different regions of the world from which Kenya imports semen for breeding.

### **1.3. Hypotheses**

- Ho<sub>1</sub>: Systematic environmental factors have no significant effect on AFC, SAFC and S1460 in HF cattle raised on LSF in Kenya.
- Ho<sub>2</sub>: There is negligible mortality and culling prior to age at first calving (SAFC) and prior to four years of age (S1460) in HF cattle raised on LSF.
- Ho<sub>3</sub>: The origin of a sire has no significant influence on progeny survival to AFC and to 1460 days in HF on LSF in Kenya



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Dairy cattle production in Kenya**

Kenya has one of the most rapidly expanding dairy industries in sub-Saharan Africa. It constitutes 85% of dairy cattle in East and Central, Africa and 70% of those found in eastern and southern Africa (Thorpe *et al.*, 2000). The average annual consumption of milk per person in the country is four times the average (25kg/yr) for sub-Saharan Africa (Smallholder Dairy Project, 2004). The dairy industry supports over 0.8 million households, generating an estimated 365,000 waged jobs in addition to the family labor (Omore *et al.*, 1996).

Dairying is mainly concentrated in agro-ecological zones 2 to 4, highland areas, where temperature is moderated by altitude. The areas also receive reliable rainfall and have fertile volcanic soils (Jaetzold and Schinudt, 1983). The Central Province of the country has the highest concentration of dairy cattle (106 cattle /km<sup>2</sup>) while Rift Valley Province has the largest number of animals. An estimate by the SDP (Smallholder Dairy Project, 2005) puts the national dairy herd population at 6.7 million

##### **2.1.1. Breeds and breeding policy**

There are an estimated 2.7 million pure-bred exotic dairy cattle in Kenya, comprising of HF, Ayrshire, Guernsey, Jersey, Brown Swiss, and 4 million crosses (Smallholder Dairy Project, 2005). Larger breeds (HF and Ayrshire) tend to produce more milk. However they have a higher nutritional demand, and hence their adaptability and production efficiency vary with the production system they are maintained in (Rege, 1998; Kahi *et al.*, 2000; Wakhungu, 2000). Under Large-scale intensive dairy conditions, HF have been shown to yield up to 6,259 kg in a 305-day lactation (Ojango, 2000) and Ayrshire 4,085 kg (Ombura *et al.*, 2007)

The breeding policy pursued in the country has been one of upgrading the *Bos indicus* cattle towards pure-bred *Bos taurus* types using imported semen from animals with high genetic merit for milk production (Philipsson *et al.*, 1988). An open nucleus type of breeding scheme has been practised, where genetic improvement is mainly carried out by LSF and government



multiplication farms, with replacement heifers being sold to other producers (Conelly, 1998). However, this practice has been pursued without any properly defined breeding programme, and often in disregard of the ecological and socio-economic characteristics of the production systems (Bebe *et al.*, 2003). Okeyo *et al* (2000) recommended the development of a dairy breeding policy that would take into consideration the different strata of dairy farmers, underlying agro-ecological potential of the general area, milk market demand, genetic potential of the dairy cattle breeds in relation to production systems, the level of development of the infrastructure and the available reproductive biotechnologies.

### **2.1.2. Marketing of milk**

Milk is marketed through both formal and informal markets. The formal market refers to processed milk that is marketed through various processors, co-operatives and licensed milk traders, while the informal market refers to unprocessed milk that is directly sold to consumers. It is estimated that raw milk accounts for 86% of the fresh milk market while processed milk accounts for 14% (Smallholder Dairy Project, 2005). Out of the total milk production from the farms, 36% is consumed at the farm level by the household and calves, and 64% is marketed (Thorpe *et al.*, 2000).

Until 1992 the country had only one milk processor, the Kenya Cooperative Creameries (KCC). However due to liberalisation in the industry and changes in the economic framework, the new KCC 2000 currently accounts for less than 15% of the total market share of all the processed milk while the remaining 85% is handled by over 45 processors. Owango *et al.* (1998) demonstrated that real milk prices in the formal sector increased dramatically between 1992 and 1995, with farm-gate prices ranging from Ksh 11 to 35/ kg, depending on the infrastructure and access to markets.



### **2.1.3. Constraints to improved dairy productivity in Kenya**

In Kenya, there are no effective genetic improvement programmes for any cattle breed, owing to various constraints. These include lack of proper national breeding policy, small herd sizes, lack of systematic identification, inadequate animal performance and pedigree recording, organizational shortcomings, lack of funds, expertise and structure required for operating an efficient genetic improvement programme based on artificial insemination (AI) and field recording in the whole population (Kahi *et al.*, 2004). This has resulted in little genetic progress being achieved in terms of milk production across the different production systems.

The most important environmental constraint to improved dairy productivity is under nutrition. Under-nutrition resulting from poor and low quality of available feeds and inadequate mineral supplementation contributes to low milk yield of between 5 and 8kg/day, and long calving intervals (CI) that are sometimes prolonged to 600 days in smallholder farms in the country (Omore *et al.*, 1999). In addition, health stressors, decrease in land size due to land fragmentation by government settlement programmes and traditional family inheritance and lack of dairy policy are major hindrances to improved dairy productivity.

## **2.2. Dairy cattle breeding programs in developing countries**

In developing countries, the main goal in raising dairy cattle is increased milk yield per cow at an economic cost (Chagunda *et al.*, 2004; Ombura *et al.*, 2007). This could be achieved through selection within existing populations, importation of superior breeding stock, crossbreeding and upgrading of the indigenous cattle using the exotic animals (Cunningham and Syrstad, 1987; Kahi *et al.*, 2004). Most of the developing countries, however, lack proper breeding policies that would help guide breeding programmes to achieve the goals targeted (FAO, 2006). Breeding programmes in many developing countries also lack necessary infrastructure, leading to inefficient recording systems and poor data processing procedures (Cunningham and Syrstad, 1987; Philipsson *et al.*, 1988). Livestock producers therefore import genetic material from several countries that have programmes in place for their own populations and own production circumstances.



The use of imported semen has resulted in increased milk yield per cow in several cases (Ojango, 2000; Vargas and van Arendonk, 2004). Nevertheless, effects of genotype by environment interaction (G X E) lower productivity relative to their country of origin (Bondoc *et al.*, 1989; Ojango *et al.*, 2002). The productivity of most exotic dairy breeds in tropical and subtropical environment is lower than their contemporaries raised in temperate environments by 30 to 40% (Bondoc *et al.*, 1989; Ojango *et al.*, 2002). This could be due to problems of adaptability as a result of stress from low quality feeds, disease incidences, parasites and heat load (Chilliard, 1989). Other constraints identified include poor breeding services, ineffective disease control resulting in high mortality and culling, and poor access to output markets which contribute to low incentive to increased production (Vaccaro, 1990; Muriuki *et al.*, 2003).

Strategies for breed improvement other than having their own breeding programmes have been evaluated in a number of studies (Kahi *et al.*, 2004; Vargas and van Arendonk, 2004). The economic benefit of a separate breeding programme for each country is a function of the cost of the breeding programme and the expected change in genetic gains achievable over that obtained with the importation of genetic material from other environments (Dillon *et al.*, 2006). To be sustainable, the breeding strategy adopted by developing countries needs to ensure most of the improvement is determined from within the population under the prevailing environmental conditions (Philipsson and Okeyo, 2006).

### **2.3. Genetic and phenotypic parameters in breeding programmes**

Effective breeding programmes depend on accuracy of genetic and phenotypic parameter estimates, which include heritability, repeatability and correlations between traits (Burrow, 2001). These parameters are ratios of (co)variance components, and vary according to the environment, the breed and the model of analysis (Falconer and Mackay, 1996; Burrow, 2001; Hearnshaw *et al.*, 2002).

#### **2.3.1. Heritability**

Heritability is defined as the proportion of phenotypic variance that is due to heredity. It expresses the proportion of total variance that arises from the differences in breeding value, and



therefore what determines resemblance between relatives (Falconer and Mackay, 1996). The most important function of heritability in a genetic study is its predictive role of expressing the reliability of the phenotypic value as a guide to the breeding value. Heritability values range from zero to one, in which the higher it is, the greater the genetic control on the trait and the more the expected response to selection for the trait. Its magnitude varies between populations and environments and differs depending on the method of estimation used. The heritability estimates of production traits have been reported to be in the range of 0.25-0.35 (Vargas and van Arendonk, 2004).

There are numerous estimates of genetic parameters for milk production traits in various populations. Maijala *et al* (1974) reviewed estimates up to 1974, whereas (Pearson *et al.*, 1990) presented parameter estimates obtained from studies since 1979 to 1990. Average heritability estimates presented were 0.31 and 0.29 for milk and fat yield, respectively. The range for the estimates was from 0.17 to 0.38 for milk yield and, from 0.15 to 0.40 for fat yield indicating a high level of genetic influence and, therefore, allowing for improvement of these traits through selection. However, functional traits tend to have low heritability. Values for reproductive traits range from 0.01 to 0.15 (Grosshans *et al.*, 1997) and those for survival traits range from 0.002 to 0.20, depending on the type of model used for analysis (Dematawewa and Berger, 1998; Roxstrom and Strandberg, 2002; Sewalem *et al.*, 2003).

### **2.3.2. Repeatability**

Repeatability expresses the proportion of variance of single measurement that is due to permanent differences, both genetic and environmental between individuals. Repeatability differs according to the nature of the character, the genetic properties of the population and the environmental condition under which individuals are kept. Repeatability is useful as a measure to indicate gain in accuracy expected from multiple measurements (Falconer and Mackay, 1996). Estimates of repeatability for some economically important traits in dairy cattle are presented in Table 1.



Table 1: Repeatability estimates of economically important traits in dairy cattle

| Trait              | Repeatability estimate | Author        |
|--------------------|------------------------|---------------|
| Milk yield         | 0.42                   | Pereira(2005) |
| Fat yield          | 0.23                   |               |
| Fat percentage     | 0.75                   | Wilcox(2003)  |
| Protein yield      | 0.41                   |               |
| Protein percentage | 0.60                   | Wilcox(2003)  |
| Persistence        | 0.60                   | Wilcox(2003)  |
| Calving Interval   | 0.12,-0.13,            | Pereira(2005) |

### 2.3.3. Phenotypic and genetic correlations

Correlations are measures of strength of relationship between two variables. It is important to know how improvement in one character will cause simultaneous changes in other characters (Henderson and Quaas, 1976; Falconer and Mackay, 1996). The Correlation between breeding values for two traits indicates the extent to which the two traits are influenced by the same genes. Correlations generally range from  $-1$  to  $+1$ . The larger the magnitude, the greater the relationship between the traits. Genetic correlations between milk yield and fertility traits have been estimated at  $-0.2$  to  $-0.6$  in the Kenyan environment (Ojango and Pollott, 2001). Antagonism between productive and reproductive traits has been reported in other environments (Hoekstra *et al.*, 1994; Grosshans *et al.*, 1997; Lopez-Gatius, 2003).

### 2.3.4. Genotype x environmental interaction

Animal productive and reproductive potentials are expressed only as much as their environmental conditions allow. Therefore, it is possible that the best genotype in one environment may not be best in another environment (Cero'n-Mun~ oz *et al.*, 2004). This phenomenon is known GxE. The GxE may involve either a change in the relative magnitude of variances across different environments, or genetic correlations between the "same trait" in different environments being significantly less than unity (Stanton *et al.*, 1991).

The existence of GxE may result in reduced genetic progress in breeding programmes, particularly in developing countries (Ojango *et al.*, 2002). Globalization of the dairy cattle industry has resulted in increased use of North-American HF semen in several environments



(Philipsson and B. Lindhe, 2003; Dillon *et al.*, 2006). Despite the evidence that global selection can increase rates of genetic progress in dairy cattle by up to 17% compared to within country selection (Dillon *et al.*, 2006), doubts have been raised relating to GxE due to diverse environments.

Several studies have been carried out in different countries to assess the impact of GxE affecting performance of HF in tropical environments. Powell *et al* (1990) obtained a correlation of 0.42 between HF bulls and cows evaluated in Ecuador compared with animals in the United States of America. Costa *et al.* (1998) also obtained a correlation of less than unity between Brazilian and USA HF. That study showed that GxE influenced milk production within Brazil. Kolver *et al* (2002) reported significant GXE for milk traits and fertility traits when the performance of imported and New Zealand HF dairy cows was compared on all pasture or TMR diets. Cero'n-Munoz (2004) reported that in countries with differing environments, progeny of HF sires may calve at relatively younger or older ages compared with contemporary herd mates in one environment versus another. Therefore, care should be taken in choosing sires when comparing progeny in different dairy production systems in the tropics because of the possibility of GXE for relative rankings (Cero'n-Munoz *et al.*, 2004).

#### **2.4. Traits of economic importance for dairy breeding programmes**

Traits of importance to dairy production include production traits (milk yield, butter fat and protein content), reproductive traits (AFC, CI days open, number of services per conception), type traits (udder conformation, pelvic cavity angle) and survival traits (pre-weaning survival, survival to first calving, survival in breeding cows). Somatic cell count (SCC), as a measure of susceptibility to mastitis is also included in selection criteria in temperate countries (Emanuelson, 1988; Schutz, 2005). These differ between breeds, and within a breed, and with the system under which the animals are raised. Production traits like lactation milk yield and butterfat yield constitute the marketable output while fertility, survival and conformation traits are the functional traits.



### 2.4.1. Production traits

Selection and genetic improvement in dairy production has concentrated on increase in milk yield per cow per lactation, resulting in genetic progress of 1 to 2% per annum in high input production systems (Allaire and Gibson, 1992). Consequently, lactation milk yield has almost doubled across all dairy breeds and production systems in the temperate countries (Dillon *et al.*, 2006). Average lactation milk yields tend to vary between countries due to agricultural pricing policies. Yields reported by various countries are presented in Table 2.

Table 2: Lactation milk yields of HF cattle from various countries

| Country      | Average Lactation<br>Milk Yield | Average Butter<br>Fat % | Average Protein<br>% | Source                          |
|--------------|---------------------------------|-------------------------|----------------------|---------------------------------|
| USA          | 10300                           | 4.31                    | 3.1                  | (Kuczaj, 2002)                  |
| Canada       | 7567                            | 3.75                    | 3.3                  | Zwald(2001)                     |
| Italy        | 7246                            | 3.53                    | 3.2                  | Pirlo(1999)                     |
| Netherlands  | 8668                            | 4.30                    | 3.3                  | DAD-IS-FAO-(2007)               |
| Sweden       | 9082                            | —                       | —                    | Philipsson and Lindhe<br>(2003) |
| Australia    | 6065                            | 3.94                    | 3.2                  | Hayes(2003)                     |
| New Zealand  | 6788                            | —                       | —                    | Lopez-Gatius(2003)              |
| South Africa | 8388                            | 3.48                    | 3.2                  | ARC(2002)                       |
| Israel       | 10281                           | 3.23                    | 3.0                  | Weller(2004)                    |
| Kenya        | 4540                            | —                       | —                    | Ojango <i>et al</i> (2004)      |

The increase in lactation milk yield per cow has extended to exotic dairy breeds performing in developing countries through use of imported semen from temperate countries (Ojango *et al.*, 2002). The continued increase in genetic merit for milk production in developed countries has however resulted in dairy cows that are under increasing nutritional stress, especially in early lactation. With selection on milk yield only, the correlated increase in feed intake is not large enough to cover the increased energy requirements (Dillon *et al.*, 2006). These constraints to high levels of production tend to be more pronounced in low-input smallholder systems than in the relatively well managed high-input medium and large-scale production systems found in developing countries (Omore *et al.*, 1996; Staal and Omore, 1998; Ojango and Pollott, 2004).



#### 2.4.2. Functional traits

The term functional trait is used to define those characters of an animal, which increase efficiency not by increased output, but by decreased cost of input (Groen *et al.*, 1997). Major groups of breeding goal traits belonging to this category are health, fertility, calving ease, udder disorders and conformation traits. These traits determine the productive herd life of dairy cattle, defined as the time from the first calving to the time of departure from the herd. These traits are of economic importance because beyond some point, high yielding cows tend to be more susceptible to diseases, have poor survival rate and poor reproductive performance resulting in increased involuntary culling (Cunningham and Syrstad, 1987). Research has shown a negative correlation between milk production and functional traits, where increased milk yield per cow tends to be accompanied by a reduction in performance in functional traits and hence, increased risk of being culled (Hoekstra *et al.*, 1994; Meuwissen *et al.*, 1995; Vollema, 1998).

#### *Reproductive traits*

Reproductive performance affects the amount of milk produced per cow per day of herd life, breeding costs, rate of voluntary and involuntary culling, and the rate of genetic progress for traits of economic performance (Plaizier *et al.*, 1998). Measures of reproductive performance include conception rate, CI, age at first service, non-return rates, number of insemination per conception, and number of days open. These reproductive traits tend to have low heritabilities, However the amount of variation is large enough for selection (Rege, 1991; Thaller and Aumann, 1996; Grosshans *et al.*, 1997). Reduced herd fertility results in additional inseminations, increased veterinary costs, a decrease in milk production per day of herd life, an increase in involuntary culling and decrease in selection intensity in the herd.

Fertility traits tend to vary greatly with the environment the animals are raised in. Farm management practices including sensitivity and specificity of oestrous detection and insemination procedures, all modify reproductive performance in dairy cattle (Westwood *et al.*, 2002). Dairy cows with very high milk yields tend to have long calving intervals due to long days open and increased number of services per conception, resulting in reduced profitability in dairy enterprise (Esslemont *et al.*, 2001; Olori *et al.*, 2002). Trends in milk production,



reproductive performance and survival in Irish HF cattle indicate that increasing genetic merit for milk yield reduces fertility and survival (Evans *et al.*, 2004).

Among the fertility traits, AFC represents the end of a period in which replacement heifers are not generating income. Its a, rearing period requires considerable capital expenditures including feed, housing, and veterinary expenses (Tozer and Heinrichs, 2001). It has been estimated that the cost of rearing animals up to AFC constitutes 15 - 20% of the total expenses related to milk production in temperate production systems (Heinrichs, 1993). The average AFC has been reported to be 22 - 24 months of age in the USA (Crowley *et al.*, 1991); Willard, 1997 #142}, 29-36 months in Italy (Pirlo *et al.*, 1999) and 30.3 months in Malawi (Chagunda *et al.*, 2004). In Kenya the AFC has been reported to range from 28 to 34 months (Okeyo and Mosi, 1999; Lobo *et al.*, 2000; Ojango, 2000). The heritability of AFC is generally low (0.05 - 0.2), making selection for the trait difficult (Rege, 1991; Njubi *et al.*, 1992; Lucy, 2001; Biffani *et al.*, 2003; Amimo *et al.*, 2006). Negative genetic correlations between yield and AFC have been reported by Pirlo *et al* (1999) and Hansen *et al* (2004). Grosshans *et al* (1997), however reported positive genetic and phenotypic correlations between AFC and milk production traits for dairy cows in New Zealand. Hodel *et al* (1995) noted that animals with an AFC of more than 32 months had poorer fertility than those that calved at an earlier age.

### *Survival traits*

Survival traits are the measures of success of the animal to avoid both voluntary and involuntary culling. These traits include losses at the pre-weaning stage, before first calving and in adult animals. Vaccaro (1990) estimated that combined voluntary and involuntary culling cause a loss of 40 - 60% of the exotic female dairy cattle in the tropics. Of these losses, 21% occur at the embryonic stage, 38% during calf stage, and 11% at one year of age, with the remainder occurring after one year of age. The ability of an animal to survive varies with the age of the animal and the environmental conditions under which they are raised (French *et al.*, 2000; Evans *et al.*, 2004).



The risk of an animal dying is at its highest within the first two month of life (Tarrès *et al.*, 2005). Calf mortality and culling has been reported to range from 10 - 35% in the first 6 months of life (Gitau *et al.*, 1994; De Jong, 1996; Lanyasunya *et al.*, 1999; French *et al.*, 2000). Losses in the period between one year and first calving have been reported at 13.8% (Menzies *et al.*, 1995). Once an animal becomes productive, mortality rates tend to decrease to a range of 1 to 4.3% in the temperate countries (Harris *et al.*, 1992; Faye and Perochon, 1995; Menzies *et al.*, 1995; Esslemont and Kossaibati, 1997; Stevenson and Lean, 1998).

A long herd life substantially decreases the replacement costs per lactation and enables a cow to achieve her maximum capacity of performance when attaining full maturity (Allaire and Gibson, 1992; Vanraden and Klaaskatei, 1993; Sewalem *et al.*, 2005). In addition, the potential for a long herd life with good health and fertility reduces treatment costs and the incidence of involuntary culling, which increases the scope for voluntary culling (Dillon *et al.*, 2006).

## **2.5. Culling and mortality in dairy production systems**

Culling of dairy cows is a complex decision involving several factors, and is generally classified into two major categories, involuntary and voluntary. Cows leaving the herd voluntarily are culled either due to low production, poor type or poor dairy characteristics, whereas those culled involuntarily have health problems, reproductive disorders, mastitis, or die due to severe diseases and accidents (Oltenacu *et al.*, 1984). The level of involuntary culling in a dairy herd is an important indicator of health and adaptability, whereas voluntary culling is indicative of management strategies and objectives of the producer. The frequency of culling differs in various herds over the years, and depends on many environmental factors. The percentage of cows culled annually has influence on the economic performance of a dairy enterprise. Marrow(1981) suggested that involuntary or forced culling should be kept below 10% to bring about a longer productive life, to permit herd expansion and to create opportunities for more intense selective culling. Annual total culling rates should be kept at close to 18% to maximize the benefit of age and genetic improvement (Esslemont and Peeler, 1993; Peters and Ball, 1994).



Mortality is a measure of the number of deaths (in general, or due to a specific cause) in a cattle population. Mortality rate is typically expressed in units of deaths per 100 animals and can be expressed as pre-natal mortality, pre-weaning mortality and adult cow. High mortality rates result in insufficient generation of heifer replacement, reduction in the productive life span, reduced lifetime productivity, reduced overall profitability through a reduction in the proportion of cows producing at mature levels (Gardner *et al.*, 1990; Harris *et al.*, 1992; Menzies *et al.*, 1995; Stevenson and Lean, 1998; Thomsen *et al.*, 2004). In the USA, mortality and culling has been estimated at between 30 and 35% with an average of 25.5% of the cows lost each year (Fischer, 2005). Both genetic and non-genetic factors influence mortality and culling at all stages of life (Vaccaro, 1990; Bebe *et al.*, 2003).

### **2.5.1. Voluntary culling**

Low milk production is the most frequent cause of voluntary culling of cows where the farmer culls the cows with the lowest production regardless of their health condition (Durr *et al.*, 1997; Sewalem *et al.*, 2005). In HF herds in Kenya, Ojango *et al* (2002) noted that animals with low yield were most likely to be culled at an early age compared to high yielding cows. Smallholder herds, however, cull less for low production, resulting in voluntary culling accounting for 10% of cow exits and 5% of heifer exits (Bebe *et al.*, 2003).

Sale of dairy cows and heifers as breeding animals for other producers, or as a strategy to reduce the extra animals in the herd, has also been identified as one main reason for voluntary culling of dairy cows (Harris *et al.*, 1992). Surplus heifers are common in farms which are not expanding yet have a low involuntary culling rate. Some farms are centres for genetic improvement for certain breeds and offer in-calf heifers for sale. In some systems, culling policies fix the age at which a healthy and productive animal is culled to avoid reduced productive and reproductive efficiency that occurs as animals age (Harris *et al.*, 1992; Rajala-Schultz and Grohn., 2001). The productive lifespan of high yielding cows has been estimated to range from 3.40 to 3.55 years in temperate countries (Rita *et al.*, 2002). However, when kept under intensive dairy production systems most dairy cows live to be five or six years before their annual milk production decrease to the point where it is no longer profitable for a farmer to keep



them (Waltrick and Koops, 2001). Cows kept under more extensive grazing conditions tend to be kept up to 12 years of age (Berger *et al.*, 1981).

### **2.5.2. Involuntary culling**

Regardless of variations in production systems, 50% of culling has been shown to be mainly as a result of health disorders (Sol *et al.*, 1984; Rogers *et al.*, 1988; Esslemont and Kossaibati, 1997; Seegers *et al.*, 1998). Diseases can affect culling decisions indirectly through decreased performance in milk yield, reduced growth rate, abortions, lameness and organ dysfunction, for example, loss of teat or udder (Erb *et al.*, 1985; Grohn *et al.*, 1998). Reproductive failure is another factor leading to involuntary culling (Rajala-Schultz and Grohn., 2001). Reproductive disorders include conditions such as abortion, stillbirth, cystic ovaries, difficult breeders, dystocia and anoestrus (Rajala-Schultz and Grohn, 1999). Death among dairy cows constitutes a major reason of involuntary culling and is a problem both in terms of financial losses (value of dead cows, decreased production and extra labor) and compromised animal welfare (Thomsen *et al.*, 2004).

### **2.5.3. Economic impact of culling**

Culling influences profitability of dairy production by affecting herd life, replacement rates, and milk yield (Weigel *et al.*, 2003). A high culling rate results in insufficient generation of heifer replacements to maintain and expand the dairy herd. This may lead to increased replacement costs resulting from the purchasing of replacements from the market (MoA, 1998; Bebe *et al.*, 2001). In French dairy herds, Seegers *et al* (1994) estimated that a 5% increase in the culling rate induced a 20% increase in replacement cost per litre of milk produced in the affected herd. Studies have shown that approximately 5 - 25.5% of dairy cows leave their herds after first calving (Schutz, 2005; Garry, 2006). High culling rates also contribute to reduced profitability of dairy herd by reducing the percentage of cows producing at mature levels. Losses due to premature culling include loss of future income and losses related to idle production factors (Beaudeau and Seegers, 2000).



#### **2.5.4. Analysis of culling and mortality**

Survival analysis offers an alternative way to study culling wherein the response variable studied is the precise age at culling while accounting for possible truncated records. Records on animals still alive at the time of the study are treated as censored. The procedure therefore makes use of all the information available at a given time without restricting observations to a single, arbitrarily defined point (Ducrocq, 1997). The approach is based on the concept of hazard rate, i.e. probability (risk) of being culled at certain time  $t$ , given that the cow has been alive prior to  $t$  (Ducrocq, 1997). The hazard rate is usually modeled as a product of a baseline hazard function, representing the natural aging process, and an exponential function of effects that influence the culling process, such as herd-year-season, milk production level, AFC or genetic effects such as a sire effect (Ducrocq, 1997). In evaluating survival data, the use of proportional hazard models provide a better fit to the data due to their ability to properly account for animals that are still alive at the time of the analysis (censored), their ability to account for the skewed distribution of survival times, and their ability to model key environmental factors as time dependent variables (Ducrocq, 1997; Weigel *et al.*, 2003). Survival analysis is useful because it provides a continual assessment of how dairy cattle genotypes are adapting to the prevailing herd management conditions without the necessity of detailed measurements on many traits (Allaire and Gibson, 1992; Ducrocq, 1994).

Survival analysis relies on the likelihood principles for the estimation of parameters that describe the data in some parametric or non-parametric way. Maximum likelihood techniques are used following the same procedures and lead to the same properties as in classical statistical problems (Ducrocq, 1994). Survival analysis techniques have been used for analyzing longevity traits in several dairy cattle populations (Ducrocq, 1994; Vukasinovic *et al.*, 1997; Vollema, 1998; Ojango and Pollott, 2004), and many countries currently use them in routine genetic evaluations for longevity (Interbull, 2003).



## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1. Data source

Data was obtained from four medium to large- scale dairy farms in Nakuru district of the Rift valley province of Kenya. The farms were selected on the basis of being HF breeders in Kenya that were registering their animals with the Kenya Stud Book (KSB), recording their herd performance with the Dairy Recording Services of Kenya (DRSK), and having complete pedigree records for the period starting 1990 to the year 2003. The geographical location of the farms (within Njoro, Naivasha and Bahati divisions of Nakuru district) is presented in Figure 1.

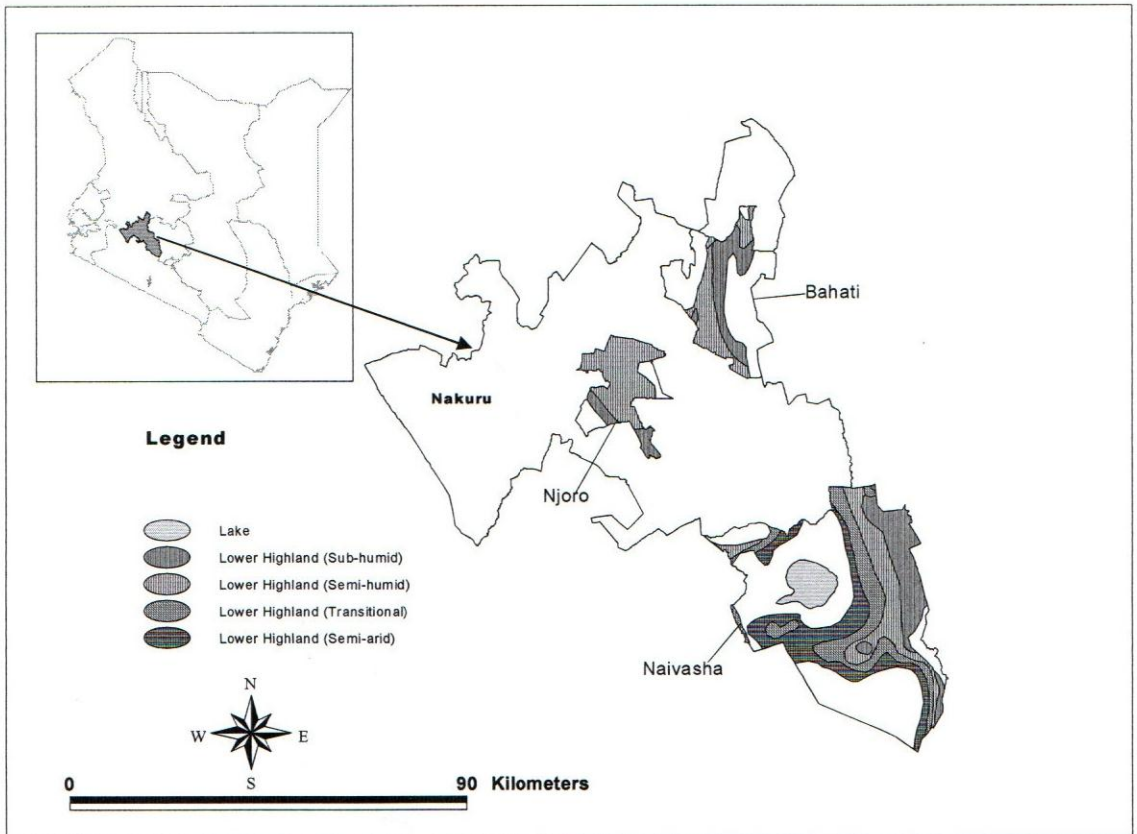


Figure 1: Location of the four farms where data for the study were obtained and their ecological zones



All the farms were located within agro-ecological zones II, III and IV (Jaetzold and Schinudt, 1983) with natural vegetation consisting of Kikuyu grass (*Pennisetum clandestinum*), star grass (*Cynodon plectostachyum*) and scattered acacia trees, shrubs and forest trees. Characteristics of each farm are presented in Table 3.

Table 3: Characteristics of Large Scale farms from which data was collected

| Farm identity | Farm location | Farm size (ha) | Herd size (n) | Altitude (m) | Mean annual Rainfall (mm) | Agro-Ecological zone |
|---------------|---------------|----------------|---------------|--------------|---------------------------|----------------------|
| LSF-1         | Bahati        | 323.7          | 505           | 1906         | 1125                      | II                   |
| LSF-2         | Njoro         | 363.8          | 953           | 2194         | 900                       | III                  |
| LSF-3         | Naivasha      | 971.2          | 1701          | 1885         | 593                       | IV                   |
| LSF-4         | Njoro         | 80.9           | 953           | 2194         | 706                       | II                   |

The annual rainfall pattern for all the areas is presented in Figure 2 from which three seasons were defined based on the average monthly precipitation as January to March (1), April to September (2) and October to December (3).

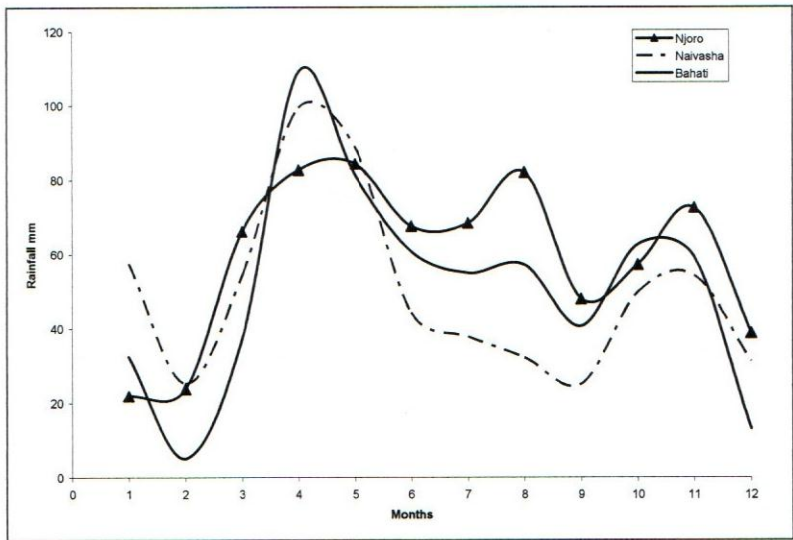


Figure 2: Rainfall patterns in the study areas for the period 1990 to 2003



## **3.2. Herd management**

### **3.2.1. Feeding management**

On all the farms, animals were managed in age groups of calves, weaners and breeding stock. Once born, calves were left with their dams to naturally suckle colostrum for five days. At the end of this period, they would be separated from their dams and artificially fed on either fresh or fermented milk at the rate of 4 - 6 liters per day up to weaning at 6 months of age. Other feeds available for this age group included calf pellets, mineral salts, Lucerne hay and plenty of water.

Weaners were mainly grazed on good quality pastures and supplemented with commercial weaner pellets and mineral salt. At weaning male animals on LSF-3 and LSF-1 were reared separately from the females and those not earmarked for breeding or sale as breeding bulls were castrated and raised as steers later to be slaughtered for beef. However, bull calves in LSF-2 and LSF-4 were sold or killed within the first week of birth. On all the farms, all female calves were retained and reared either as potential replacement animals or for future sale as in-calf heifers.

Three of the farms LSF-2, LSF-3 and LSF-4, provided a mixture of cereal grains, oil seed crops and grasses of different qualities in such a way as to meet the nutrient requirements for the adult animals. On these farms, the milking herds were grouped based on their level of production into; high producers yielding over 30 liters of milk per day, medium producers yielding 18-30 kg/day and low producers yielding less than 18 kg per day. Within a specific lactation feeding would be varied depending on the number of days an animal was in milk. The quantity of energy in the feeds would be gradually reduced from the time an animal had been in milk for six months, as the cow would most likely be in-calf and require to be prepared for drying off. On LSF-1, animals were grazed on good quality pasture and provided with silage and cereal based concentrates at milking times.



### **3.2.2. Breeding management**

On all the four farms, insemination was aimed at realizing a calf per cow per year. From the age of fourteen months, heifers that had attained a weight of 280 kg were served as they came into heat, with the aim of having all heifers served by eighteen months of age. Adult animals that came on heat 45 to 60 days post-partum down were inseminated. Pregnancy diagnosis was carried out on animals three months after the last service and “empty” animals would be induced to come on heat using hormones.

Semen for insemination was obtained through the Central Artificial Insemination Station (CAIS) at Kabete, or imported semen suppliers such as American Breeders Service (ABS), World Wide Sires (WWS) and Semex. Sometimes semen from farm bred sires was used.

### **3.2.3. Health management**

Routine health management practices were strictly adhered to in order to minimize loss of animals. These included monthly deworming, weekly spraying with acaricide and routine vaccination against prevalent cattle diseases such as foot and mouth disease, rinderpest, anthrax and lumpy skin disease. In addition, heifers were vaccinated against brucellosis before joining bulling heifers. Occurrence of mastitis was regularly monitored in all the herds through weekly mastitis tests and any identified case was treated expediently.

### **3.2.4. Culling policy**

Culling practices differed on the farms. On LSF-3 and LSF-2, in-calf heifers were sold as breeding stock to other dairy farmers with few being retained as replacement stock. LSF-4 and LSF-1 retained most of the female calves to expand their herds. On all the farms animals with more than six parities and those producing less than 3,000 kg of milk in any lactation after the first lactation were sold. Other criteria for culling included poor physical condition, disease status and accidental injury.

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### **3.3. Data**

Records available for the period 1990 to 2003 were collected. On all the farms, individual animal cards were maintained from birth to the time of disposal. Farms LSF-2 and LSF-3 maintained electronic records of animals from 1997. A total of 3,678 animal records were obtained from all the farms. The information obtained on each animal were pedigree information, date of birth, dates of first service, date of calving, milk yields, lactation lengths, dates of disposal and reasons for disposal.

#### **3.3.1. Data editing**

All the records were entered into an MS-Access database then checked and accredited for consistency. Pedigree records for individual animals were verified against records maintained by the KSB which issues certificates of registration giving the dates of birth, sire, dam and grand parents of an animal.

For an animal's record to be used in the final analysis, it had to have a date of birth, and if it had calved, an AFC not less than 606 days. The final dataset comprised of 3,508 cows from 4 herds, sired by 323 bulls. The average number of daughters per sire were 11, ranging from 1 to 110.

#### **3.3.2. Definition of traits**

Three traits of interest were AFC, SAFC, and S1460. Environmental factors affecting all these traits were evaluated, and genetic parameter estimates obtained for AFC.

In evaluating SAFC, records on all animals with an AFC were censored at the age of first calving (however, for some animals due to AFC being very advanced, an upper limit for AFC was set to 4 years of age (1,460 days). Also censored were animals that were sold prior to attaining a first calving since the farmers' policy, was where possible, to sell in-calf heifers to other producers for profit. For animals that died prior to attaining their first calving, their age at disposal (within 1460 days) was taken as their lifespan. If an animal had not attained an AFC by 1460 days of age, its record was censored.



In the S1460, records on all animals were considered until 1460 days of age irrespective of whether or not the animal had calved for the first time prior to attaining this age. Any animal's record that went beyond 1,460 days of age was censored at 1460 days. Other censoring criteria were as in SAFC. Evaluating survival to four years of age in two categories (SAFC and S1460), would enable a critical evaluation of survival in early life in a herd. A summary of the data structure and proportion of records censored is presented in Table 4.

Table 4: Data structure for survival to age at first calving (SAFC) and survival to 1460 days (S1460)

|                                  | SAFC | S1460 |
|----------------------------------|------|-------|
| Total number of observation      | 3508 | 3508  |
| Number of animals with AFC       | 1525 | 1525  |
| Average failure time (days)      | 458  | 651   |
| Number of right censored records | 2628 | 2302  |
| Percent censoring                | 74.9 | 65.62 |

### 3.3.2. Definition of fixed effects

The fixed effects included in the models where applicable were: herd-year-season (HYS), reason for culling (R), and sire region of origin (SR). Grouping of sires by region of origin rather than by country was preferred in order to obtain reasonable estimates of differences in progeny performance on the LSF. Five regions were defined and the number of offspring for each SR group across the four farms is illustrated in Table 5.



Table 5: Number of animals per sire region of origin for various large scale farms

| Sire region of origin | Number of animals per herd |       |       |       |       |
|-----------------------|----------------------------|-------|-------|-------|-------|
|                       | Total number               | LSF-1 | LSF-2 | LSF-3 | LSF-4 |
| Kenya                 | 1338                       | 192   | 477   | 524   | 145   |
| USA & Canada          | 1124                       | 102   | 272   | 629   | 121   |
| Europe                | 413                        | 130   | 179   | 72    | 32    |
| Israel & South        | 232                        | 26    | 3     | 201   | 5     |
| Australia             | 241                        | 18    | 2     | 221   | -     |
| Unknown               | 157                        | 37    | 20    | 54    | 46    |

The various farms did not regularly record reasons for culling and in several instances clear distinctions between defined causes were not indicated. Reasons for culling were therefore grouped into five categories as presented in Table 6.

Table 6: Grouping of reasons for culling on large scale farms in Kenya

| Disposal Category | Disposal reasons recorded on Farms                                                                                                                                                                |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dead              | Low production, old age, others, slaughtered, accident, missing , stolen, blind, Fracture, Poisoning, Lameness, Died                                                                              |
| Disease           | Cancer, kidney/liver failure, scour, septicemia, tick borne disease pneumonia, leptospirosis, coccidiosis, foot and mouth disease, hardware disease, milk fever, bloat, mastitis, missing quarter |
| Early Loss        | Dead within one week of age                                                                                                                                                                       |
| Fertility         | Abortion, difficult breeder, dystocia, stillbirth<br>cystic ovary, metritis, free martins, premature twins,                                                                                       |
| Sold              | Sold                                                                                                                                                                                              |



### 3.4. Statistical analyses

#### 3.4.1. Analysis of AFC

Analyses of variance were conducted for AFC in order to assess the environmental effects on the trait using the GLM procedures of GENSTAT (GENSTAT, 2007) Step-down procedures were used to determine the most appropriate model based on the R-square value and the levels of significance for various effects and their interactions. The final model used was:

$$y_{ijk} = \mu + h_i + sr_j + e_{ijk} \quad \text{Model 1}$$

where  $y_{ijk}$  is the AFC record of the  $k^{\text{th}}$  animal,  $\mu$  is the underlying mean for the trait,  $h_i$  is the fixed effect of the  $i^{\text{th}}$  herd-year-season ( $i = 1$  to 104),  $sr_j$  is the fixed effect of the  $j^{\text{th}}$  sire region of origin ( $j = 1$  to 6) and  $e_{ijk}$  is the random residual, assumed to be normally distributed with mean zero and variance  $\sigma_e^2$ .

A univariate Derivative Free Restricted Maximum Likelihood (DFREML), (Meyer, 1998) procedure was used to estimate variance components for AFC, where in addition to the fixed effects included in model 1, a random effect due to the animal was included. To estimate the heritability of AFC, a numerator relationship matrix was constructed based on a pedigree file containing all animals on the LSF, with all known relationships going back for two generations. Details on relationships were obtained from pedigree records at the KSB register. The programme "Pedigree Viewer" Kinghorn(1998) was used to re-code and re-order the pedigree file so that animals were numbered in chronological order. The structure of the data used is presented in Table 7.



Table 7: Data structure for evaluation of age at first calving

| Item                            | Number |
|---------------------------------|--------|
| Records                         | 3508   |
| Sires with progeny              | 323    |
| Average Sire progeny group      | 11     |
| Years of Records                | 13     |
| HYS-classes                     | 104    |
| Sire region of origin (Table 5) | 6      |
| Average AFC (Days)              | 1058   |

Best linear unbiased predictions of estimated breeding values were obtained by back-solution using the DFREML programme for all animals in the pedigree file. Genetic trends were estimated by regression of the average predicted breeding values in the particular trait on the year of birth. The phenotypic trends were obtained from the annual variations in LS means.

### 3.4.2. Survival analyses

The Survival Kit version 3.12 (Ducrocq and Solkner, 1998) was used to analyze SAFC and S1460. The distribution of lengths of life (SAFC and S1460) was described by the Kaplan-Meier estimate of the survival function (Kaplan and Meier, 1958). Initial analyses were carried out to investigate the influence of various factors on the risk of culling. Only those factors that significantly influenced culling were then used in further analyses. A semi-parametric proportional hazards model was assumed (Cox, 1972). No assumption was made on the baseline hazard function ( $\lambda(t)$ ) which characterizes how the whole population was ageing.

The model used in the analysis was:

$$\lambda(t) = \lambda_0(t) \exp\{y_i(t') + h_j + s_k\} \quad \text{Model 2}$$



where,  $\lambda_0(t)$  is a completely arbitrary baseline hazard function, representing the aging process;  $y_i(t')$  is the effect of the  $i^{\text{th}}$  year-season, assumed to be a piece-wise constant with jumps chosen to occur at date  $t' =$  the beginning of a different season each year. Changes occurred on January 1, April 1 and October 1 of each year,  $h_j$  is the effect of the  $j^{\text{th}}$  herd ( $j = \text{LSF-1 to LSF- 4}$ ) and  $s_k$  is the effect of the  $k^{\text{th}}$  sire area of origin ( $k=1$  to 6, Table 3)

In a second analysis, management practices and culling policies which are controlled by the dairy manager of each herd, and influenced by the herd environment, were accounted for by defining each herd as a separate stratum with a different baseline. The model for analysis was:

$$\lambda(t) = \lambda_{0j}(t) \exp\{y_i(t') + s_k(t)\} \quad \text{Model 3}$$

Where,  $\lambda_{0j}(t)$  is an arbitrary baseline hazard function representing the aging process; stratified by herd  $j$ ,  $y_i(t')$  the effect of the  $i^{\text{th}}$  year-season, assumed to be a piece-wise constant with jumps chosen to occur at date  $t' =$  the beginning of a different season each year and  $s_k$  is the effect of the  $k^{\text{th}}$  sire area of origin.

The assumption of proportional hazard across herds was checked as described by (Ducrocq *et al.*, 1988), by plotting the regression of  $\log[-\log \hat{S}_{0,j}(t)]$  on  $\log t$  for each herd  $k$ , where  $\hat{S}_{0,j}(t)$  is the estimated baseline survival function specific to the  $k^{\text{th}}$  herd (Figure 3).



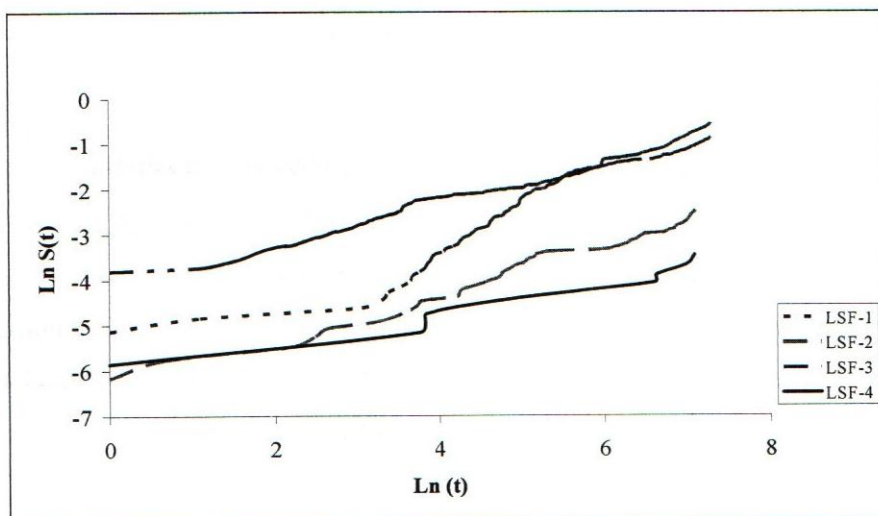


Figure 3: Graphical test of the assumption that the baseline hazard function for mortality in the different LSF were proportional

The regression lines obtained were quite diverse, indicating different baseline survivor functions across herds. The best model would thus be a Cox model.

To further assess the differential use of sires from various regions of the world, a model similar to Model 3 was used, except stratification was by sire's region of origin, and the fixed effect of HYS was included.

In the analyses of S1460, in order to determine the effect of AFC on culling prior to attaining four years of age (4 years = the highest AFC in the analysis), the AFC was included as a time dependent effect whose value changed when an animal calved for the first time.



## CHAPTER FOUR

### RESULTS

#### 4.1. Descriptive statistics and genetic parameter estimates for AFC

The average AFC was  $1058.25 \pm 159.25$  with a coefficient of variation of 13%. Animals on LSF2 had the earliest AFC (31 months), and LSF-1 the most delayed (46 months) with the largest variation (22%). On LSF-1, AFC ranged from 606 to 3,471 days of age. Summary statistics for factors affecting AFC with the least squares mean AFC estimates at various levels of the factors studied are presented in Table 8.

Table 8: Summary statistics on factors affecting age at first calving and the least square (LS) means for different effects on the Large Scale farms

| Fixed Effects           | df | Significance level | LS Means       |
|-------------------------|----|--------------------|----------------|
| Herd                    | 3  | ***                |                |
| LSF-1                   |    |                    | 1361 $\pm$ 296 |
| LSF-2                   |    |                    | 931 $\pm$ 86   |
| LSF-3                   |    |                    | 972 $\pm$ 135  |
| LSF-4                   |    |                    | 954 $\pm$ 120  |
| Sire region origin      | 5  | ***                |                |
| Europe                  |    |                    | 1031 $\pm$ 235 |
| Kenya                   |    |                    | 1018 $\pm$ 213 |
| Israeli & South Africa  |    |                    | 978 $\pm$ 166  |
| Australia & New Zealand |    |                    | 907 $\pm$ 191  |
| Unknown                 |    |                    | 1249 $\pm$ 284 |
| USA and Canada          |    |                    | 987 $\pm$ 153  |
| Year-season of birth    | 27 | ***                |                |

\*\*\*  $P < 0.001$

Environmental effects of herd, year-season of birth and sires' region of origin significantly affected AFC ( $p < 0.001$ ) (Table 8). Daughters of sires from New Zealand and Australia had the earliest AFC of 907 days (30 months) while those of sires from Europe had the most delayed AFC (1,031 days or 34 months).

A heritability estimate of  $0.15 \pm 0.0589$  was obtained for AFC. Genetic and phenotypic trends in AFC from 1990 to 2003 are presented in Figure 4.



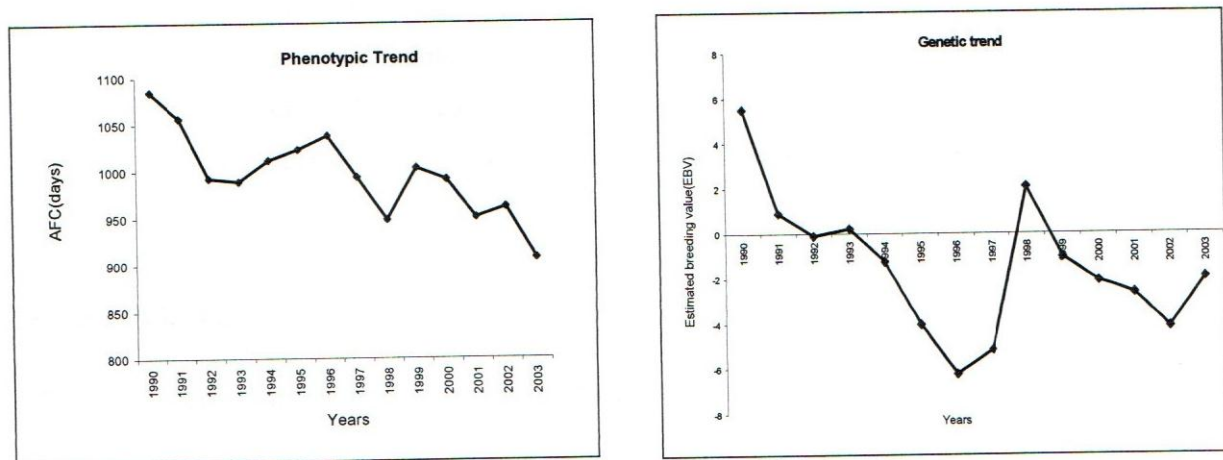


Figure 4: Phenotypic and genetic trends in age a first calving

There was a general improvement (decline) in both phenotypic and additive genetic value for AFC over the years. The average AFC decreased between 1990 and 2003, from 1085 days (36 months) to 906 days (30 months).

## 4.2. Culling and mortality in various LSF

### 4.2.1. Descriptive statistics for culling and mortality

The number of animals and proportion culled prior to first calving and numbers culled before attaining sixth parity are presented in Table 9.

Table 9: Statistics on culling of all female animals born and culled on the various Large scale farms from 1993-2003

| Farm  | Total number of animals | Total number culled 1993-2003 | % culled | Average age at culling | Number culled prior to first calving | % culled prior to first calving |
|-------|-------------------------|-------------------------------|----------|------------------------|--------------------------------------|---------------------------------|
| LSF-1 | 505                     | 332                           | 65.7     | 1503                   | 164                                  | 32.4                            |
| LSF-2 | 953                     | 578                           | 60.6     | 1562                   | 56                                   | 5.8                             |
| LSF-3 | 1701                    | 1080                          | 63.4     | 1236                   | 651                                  | 38.2                            |
| LSF-4 | 349                     | 46                            | 13.1     | 1783                   | 9                                    | 2.6                             |
| Total | 3508                    | 2036                          | 58.0     | 1521                   | 880                                  | 25.0                            |



Over the period covered by the study, 58% of all the animals born in the four farms were culled (Table 9). The LSF-1 had the highest proportion of animals culled (66%) and LSF-4 the least (13%). The average age at culling was 1,521 days with animals from LSF-3 being lost earlier (1,236 days) than those from other farms. Farm LSF-4 culled their animals at a much older age (1,783 days). On average, 25% of the animals born on the four farms were culled prior to first calving. The highest culling prior to first calving was observed in LSF-3 (38%) and was lowest in LSF-4 (3%).

**4.2.2. Environmental factors influencing differential culling**

*Effects of region of origin of the sire*

The proportion of all animals culled depending on the origin of the sire are presented in Figure 5.

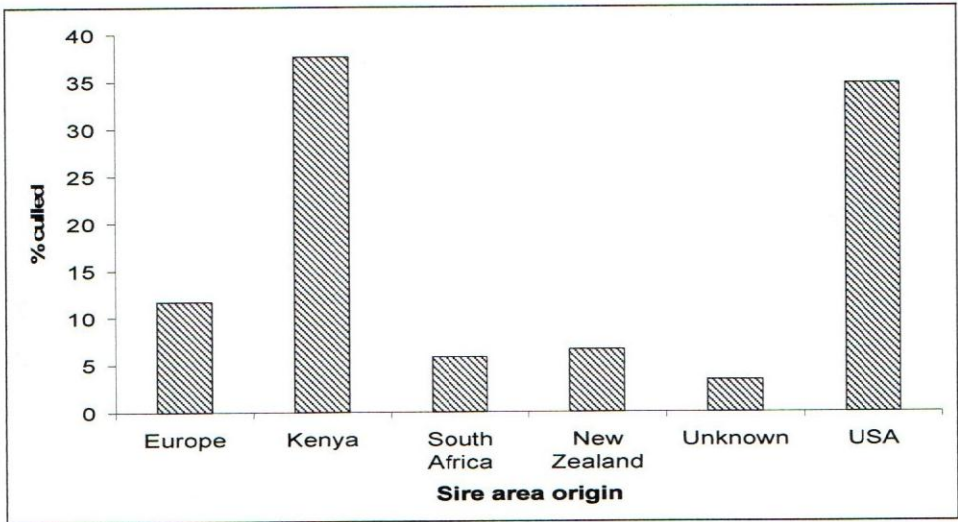


Figure 5: Percentage of animals culled based on their sire area of origin

From the raw statistics, large differences were observed in the rate of culling depending on the sire area of origin (Figure 5). The highest percentage culled were daughters of Kenyan born bulls (37.6%) followed by those born of bulls from the USA and Canada (34.7%). Daughters of South African and New Zealand sires had the lowest culling rate (5.8 to 6.6%).

*Seasonal effects*

The relative proportion of animals culled within each season is presented in Table 10.



Table 10: Percentage of animals culled within each season of the year

| Season | Number of animals born | Number of animals culled | % culled |
|--------|------------------------|--------------------------|----------|
| 1      | 819                    | 459                      | 56       |
| 2      | 1571                   | 941                      | 60       |
| 3      | 1118                   | 636                      | 57       |
| Total  | 3508                   | 2036                     | 58       |

Within each year, independent of the farms, there were differences in culling depending on the season (Table 10), with a greater proportion (60%) of culling taking place in the wet season (season 2) than during the drier periods of the year (season 1 and 3).

*Culling within different age groups*

The proportions of animals culled within different age groups are presented in Figure 6. Culling was highest after seven years of age (22%) and within the first six months of life (16%).

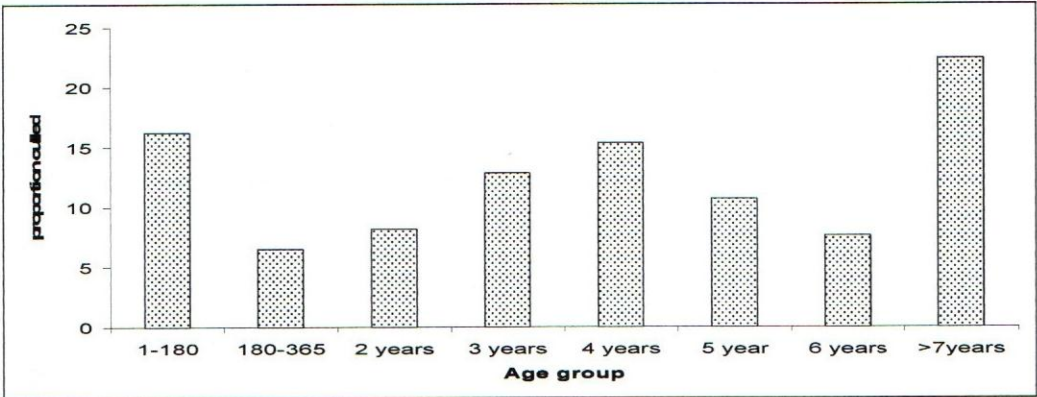


Figure 6: The Proportions of animals culled for different age groups



4.2.3. Causes of mortality and culling

The proportionate culling due to various reasons of disposal for all animals prior to attaining four years of age is presented in Figure 7.

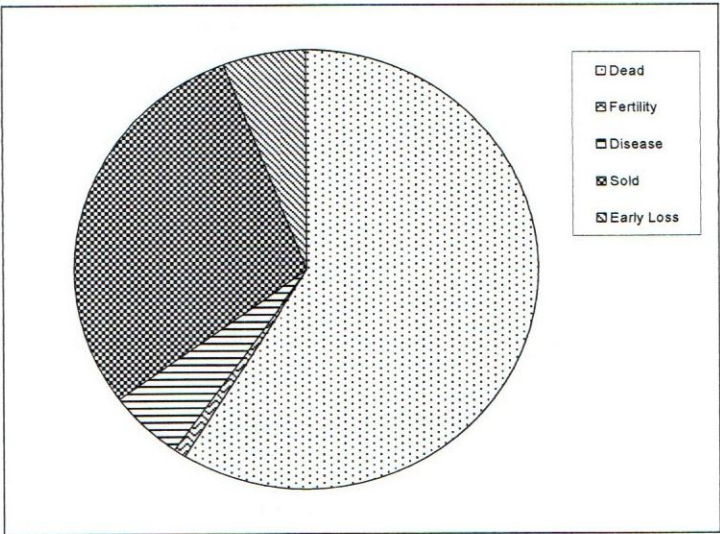


Figure 7: Proportion of animals culled for different reasons of disposal before four years of age

Over half of the culled animals prior to four years of age died without the reason of death being clearly indicated. Other animals were lost mainly through sale either to other farmers or for slaughter (29%), disease (5%) or fertility problems (1%). The proportionate culling due to various reasons of disposal for all animals prior to first calving is presented in Figure 8. The main cause of loss prior to first calving was death due to unspecified reason (68.4%).



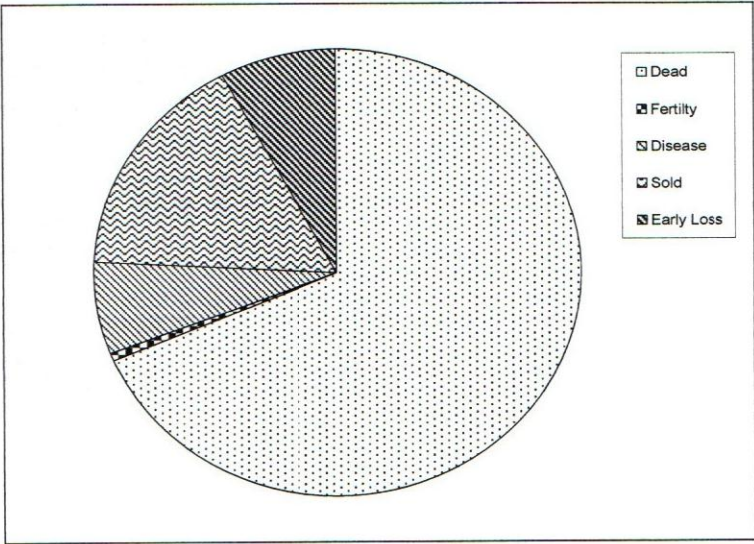


Figure 8: Proportion of animals culled prior to first calving for various reasons of disposal

**4.3. Survival analysis of mortality prior to four years of age**

**4.3.1. Effects of systematic environmental factors**

Statistics on factors that significantly influenced both SAFC and S1460, and the relative risk of being culled at each level of an effect based on analytical Model 2 (Chapter 3) are presented in Table 11.



Table 11: Summary statistics for mean age at failure (days) and proportion culled at various level of fixed effects influencing survival to first calving (SAFC) and survival to four years of age(S1460) in Holstein Friesian cattle raised on large scale farms in Kenya

| Fixed Effects             | SAFC          |            |                       |                   |                            | S1460      |                |                       |                   |                            |
|---------------------------|---------------|------------|-----------------------|-------------------|----------------------------|------------|----------------|-----------------------|-------------------|----------------------------|
|                           | No of Animals | Sign Level | Age at failure (days) | % of Total culled | Relative Risk <sup>a</sup> | Sign Level | No. of Animals | Age at failure (days) | % of Total culled | Relative Risk <sup>a</sup> |
| Herd                      |               | ***        |                       |                   |                            | ***        |                |                       |                   |                            |
| LSF1                      | 505           |            | 469.97                | 32.4              | 1.37                       |            | 505            | 529.40                | 35.2              | 0.72                       |
| LSF2                      | 953           |            | 360.59                | 5.8               | 0.23                       |            | 953            | 1024.32               | 33.7              | 1.00 <sup>b</sup>          |
| LSF3                      | 1701          |            | 463.56                | 38.2              | 1.00 <sup>b</sup>          |            | 1701           | 508.00                | 40.5              | 0.72                       |
| LSF4                      | 349           |            | 477.33                | 2.5               | 0.65                       |            | 349            | 734.50                | 4.0               | 1.12                       |
| Sire region of origin     |               | ***        |                       |                   |                            | ***        |                |                       |                   |                            |
| Europe                    | 344           |            | 288.49                | 22.9              | 1.09                       |            | 344            | 625.89                | 35.7              | 0.72                       |
| Kenya                     | 1338          |            | 495.15                | 21.6              | 1.00 <sup>b</sup>          |            | 1338           | 752.12                | 35.5              | 1.00 <sup>b</sup>          |
| S Africa/Israel           | 235           |            | 529.71                | 10.2              | 0.84                       |            | 235            | 873.21                | 18.3              | 0.72                       |
| New Zealand and Australia | 241           |            | 554.51                | 26.1              | 1.41                       |            | 241            | 628.99                | 30.7              | 1.12                       |
| Unknown                   | 157           |            | 585.95                | 24.8              | 0.88                       |            | 157            | 675.02                | 29.9              | 0.85                       |
| USA and Canada            | 1193          |            | 440.82                | 32.3              | 1.09                       |            | 1193           | 530.63                | 37.1              | 0.85                       |
| Year-season of birth      | 28 classes    | ***        |                       |                   |                            | ***        |                |                       |                   |                            |

\*\*\* P<0.001

<sup>a</sup> Computed as the exponential of the regression parameters solutions of the proportional hazards model

<sup>b</sup> Reference value



The fixed effects of herd sire region of origin and year-season of birth all significantly ( $p < 0.001$ ) influenced survival to SAFC and to S1460. On average, the number of animals culled and the average age at failure was lower for SAFC than for S1460. The risk of an animal being culled prior to SAFC differed between the farms and between the regions of origin of the sire. The interaction between herd and sire region of origin was not significant ( $p > 0.05$ ), and hence was excluded from the analyses. The second analysis involved stratification by herd. From this analysis, the Kaplan–Meier survivor curves for the two traits studied (SAFC and S1460) are presented in Figure 9.

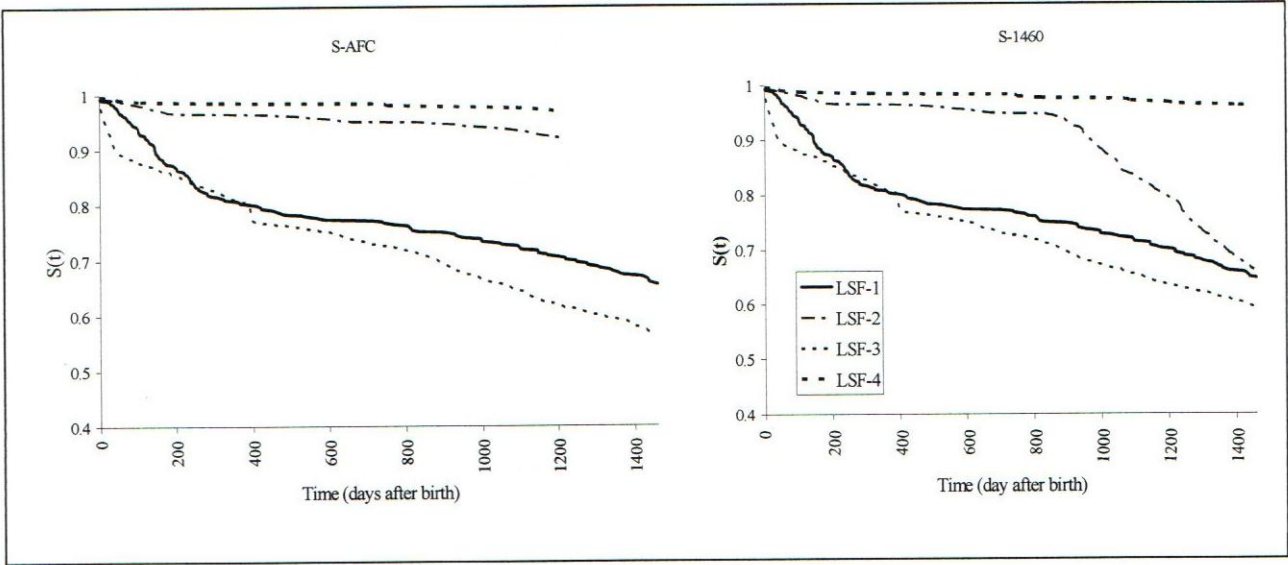


Figure 9: Kaplan-Meier survivor curves for survival to age at first calving (SAFC) and survival to 1460 days (S1460) for the various large-scale farms (LSF)

Prior to first calving, animals on LSF-4 and LSF-2 had the highest survival rate, with more than 90% of the animals being retained to an age of 1200 days (Figure 9, SAFC). The opportunity to survive on LSF-1 and LSF-3 reduced drastically in the first three hundred days of life, after which the rate of loss declined. An animal’s chance of survival on most farms did not change after it had calved (Figure 9, S1460). However, on LSF-2, a change in survival after calving for the first time was evident with a rapid decline in the chances for survival after 1200 days (Figure 9, S1460).

To better explore the nature of culling depending on first calving, AFC was divided into five classes, each with 20% of the animals (Class 1= lowest 20% AFC, and Class 5= highest



20% AFC). This effect was included to obtain raw statistics in the analysis of S1460 only. The animals relative risk of being culled depending on the age at which they calved for the first time on the different farms are presented in Figure 10.

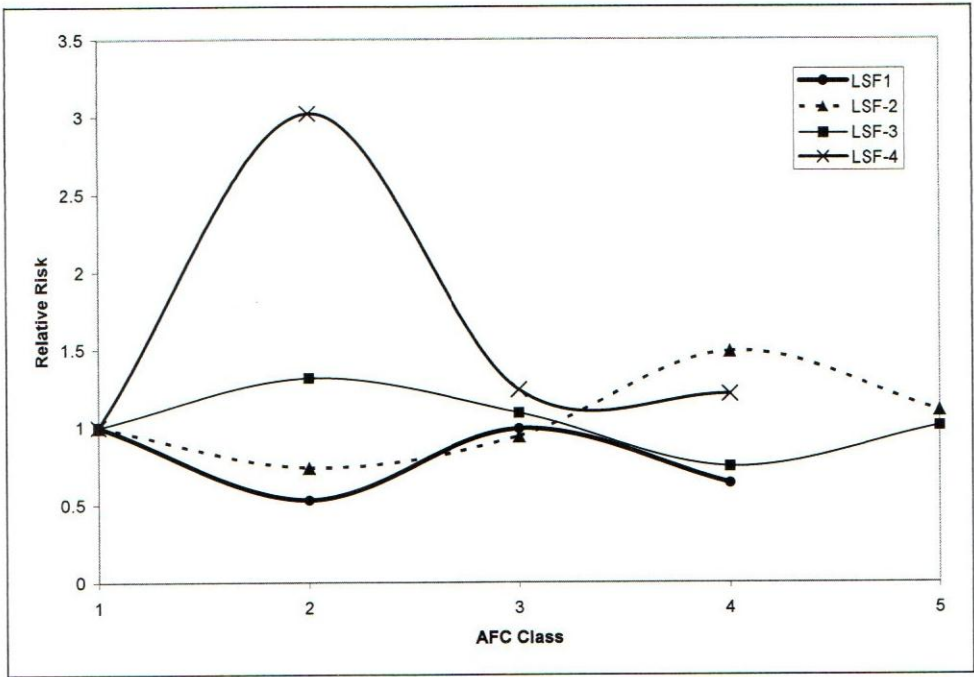


Figure 10: The relative risk of animals being culled depending on the age at first calving class (class 1= animals that calved earliest on the farm, to class 5= animals that calved closer to 1460 days) on the various large scale farms (LSF).

The greatest difference in the relative risk of being culled after first calving was observed on LSF-4, where animals within the second 20% age bracket had the highest risk of being culled. On LSF-2, the relative risk of being culled increased for animals after the third 20% AFC bracket, indicating that some degree of selection for a lower AFC was being practiced on this farm.

**4.3.2. Effects of the sire's region of origin on culling**

In both SAFC and S1460, the highest proportion of animals culled were those sired by bulls from the USA and Canada. However, the relative risk of being culled for both SAFC and S1460 was highest for animals sired by bulls from New-Zealand and Australia (Table 11). Animals sired by European bulls had the lowest risk of being culled prior to four years of age



(S1460) and had the lowest average age at failure, both in SAFC and S1460. Animals sired by South African and Israel bulls had a low risk of being culled in both SAFC and S1460.

The baseline survivor curves stratified by region of origin of sire for SAFC and S1460 are presented in Figure 11 and 12 respectively.

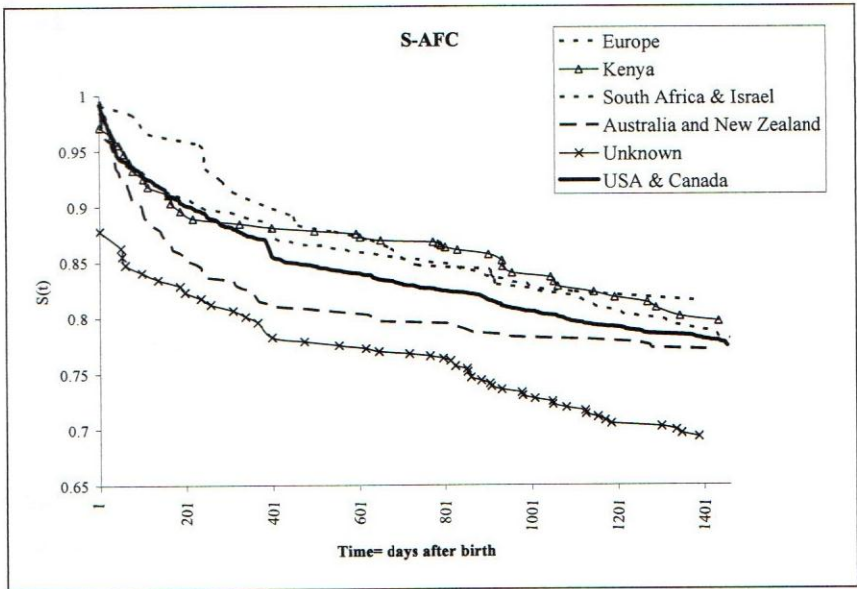


Figure 11: Baseline survivor curves for animals sired by bulls from various regions for survival to attaining an age at first calving



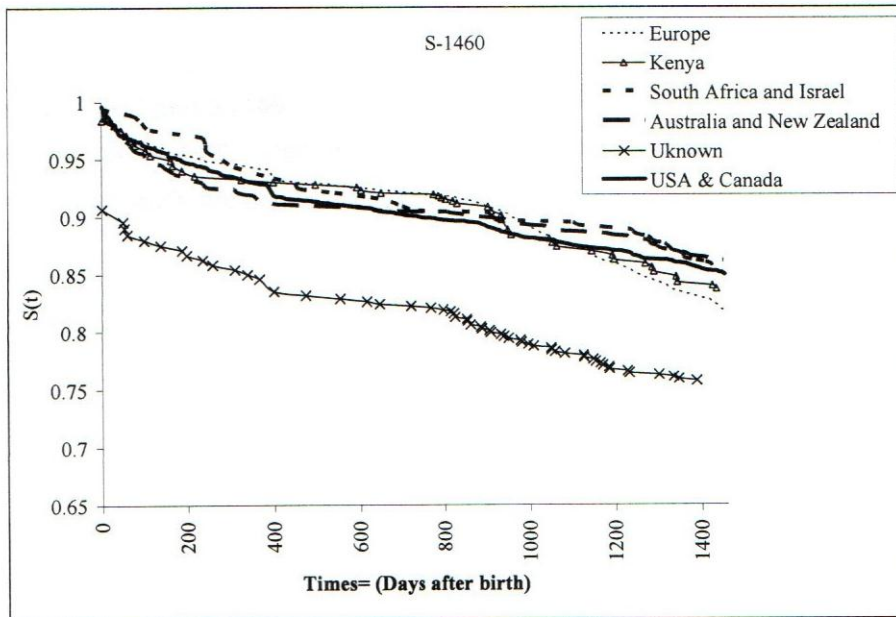


Figure 12: Baseline survivor curves for animals sired by bulls from various regions for survival to 1460 days of age

For both SAFC and S1460 (Figures 11 and 12), a high rate of mortality, irrespective of the origin of the sire, was evident within the first 200 days of life, after which the survival rate levelled off. Within this initial time period, daughters of sires from South-Africa and Israel tended to have better survival rates than those with sires originating in other regions. When the origin of the sire was not clear, the survival rate was much lower, with less than 70% of the animals attaining a first calving within 1,460 days (Figure 11). Some selection against animals sired by Kenyan born bulls was evident after first calving as the survival of these animals became lower than that of animals sired by bulls originating in the USA and Canada after 1,000 days of life (Figure 12).



4.3.3. Trend in SAFC and S1460

The trends in the percentage of animals being culled for both SAFC and S1460 over the years covered by the study are presented in Figure 13.

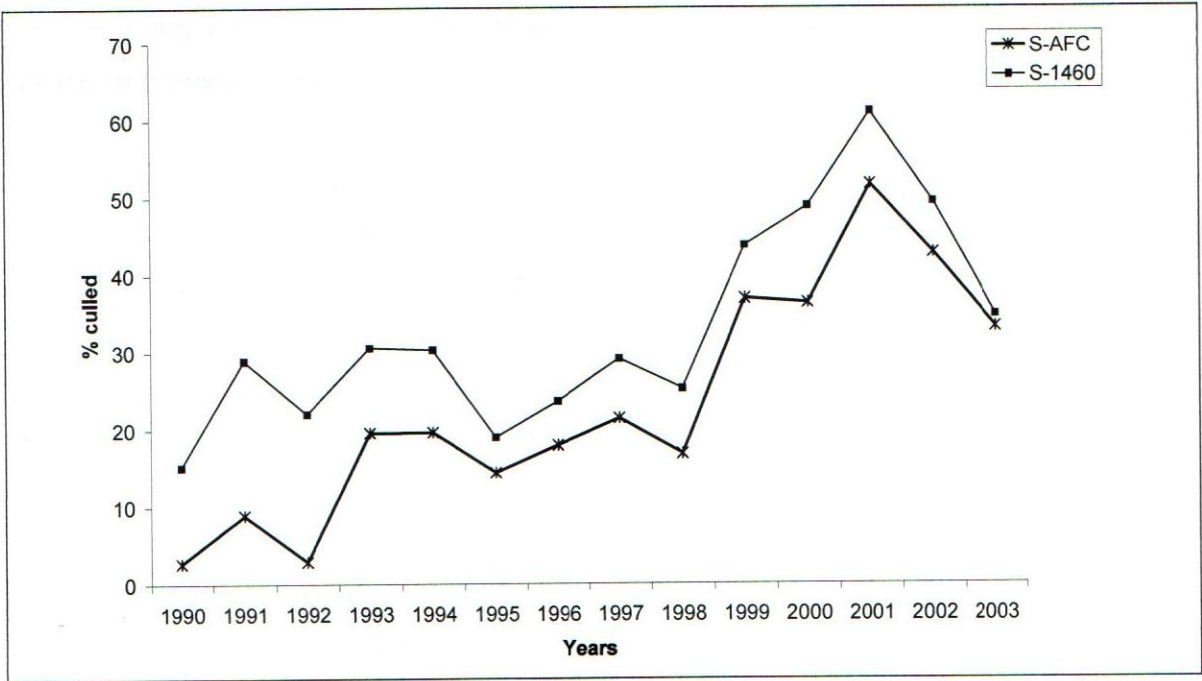


Figure 13: Annual trends in proportion of animals culled prior to attaining a first calving (SAFC), and those culled prior to attaining four years of age (S1460)

The lowest proportion of culling for both SAFC and S1460 occurred in 1990 (Figure 13). The rate of culling however increased to the highest level in 2001 (61% for S1460), then dropped to 35% for both SAFC and S1460. Censoring of the data when an animal achieved a first calving in SAFC is evident in the differential magnitude of culling over the years for SAFC and S1460 in Figure 13.



## CHAPTER FIVE

### DISCUSSION AND CONCLUSIONS

#### 5.1. Age at first calving

When raising dairy cattle, the objective of dairy breeders is to ensure that all heifer calves live until they are first in-calf, after which they are either sold to other farmers at premium prices, or retained for milk production. Any involuntary culling prior to attaining a first calving is thus an increased cost of producing one healthy in-calf heifer. The AFC was used as an indicator trait in the evaluation of early mortality of HF cattle on LSF. It was important for the AFC of the population under study to be evaluated, and the magnitude of various factors affecting it estimated prior to using it in the survival analysis. The characteristic of AFC in this study was such that animals calved for the first time within four years of age (1,460 days), with an average of  $1,058 \pm 159$  days. This was similar to the range reported in other studies carried out in similar environmental conditions (Okeyo and Mosi, 1999; Lobo *et al.*, 2000; Ojango, 2000).

The variation observed in AFC for the different herds clearly reflected differences in management practices across farms. The HF breed in Kenya is said to be a heterogeneous mixture because the sires originated from several different countries (Rege, 1991). This heterogeneity was evident through significant differences in AFC, depending on the origin of an animal's sire. On average, daughters of animals with sires originating from Australia and New Zealand tended to have an earlier AFC, while those with sires from Europe had later AFC, signifying some GXE phenomena. GXE have been shown to greatly affect productivity within the Kenyan environment (Ojango *et al.*, 2002).

The heritability estimate of  $0.15 \pm 0.06$  obtained for the AFC is within the range reported in other studies (Moore *et al.*, 1991; Ojango and Pollott, 2001; Amimo *et al.*, 2006). The environmental variance tends to be very large relative to the additive genetic variance in fertility traits. Improving management techniques such as feeding, heat detection, insemination services and use of high quality semen, should lead to considerable improvement in the AFC.



There was a general decline in both phenotypic and additive genetic value for AFC over the years (Figure 4), indicating an overall improvement in AFC. This is a positive result for the production system under study, However, having an average AFC that is too low is undesirable as it could lead to reduced length of productive life. A very low, AFC resulting from a high pre-pubertal growth rate has been shown to lead to a reduction in milk yields that could be associated with reduced development of mammary secretory tissue (Van Amburgh and Galton, 1998; Ettema and Santos, 2004).

## **5.2. Culling and mortality on various LSF**

Fifty eight percent of all the animals born in the four farms in the current study were culled within the ten years of the study, with an average annual culling rate of 29%. Studies on mortality indicate that the risk of death in dairy cattle is highest in the first two months of life, and then after the sixth parity (Tarrês *et al.*, 2005). Preliminary analyses of the data used in this study indicated a similar pattern in mortality, with the highest percentages of culled animals being those less than 180 days old, and those greater than seven years (Figure 6). Total annual culling rates of between 18% and 30% are reported to enable producers maximize on the benefits of age and genetic improvement (Esslemont and Peeler, 1993; Peters and Ball, 1994; Fischer, 2005). Vaccaro(1990) reported combined mortality and culling of 40 - 60% in female dairy cattle raised in a tropical environment. The exact age at which the culling occurs would need to be critically evaluated. Caution is required, as very early losses can erode genetic progress in a population. In this study, 25% of the animals born on the four farms were culled involuntarily prior to attaining a first calving. This rate is quite high for producers who raise their own replacement animals, and would invariably contribute to the high price of in-calf heifers on the market.

Herd effects reflected differences in management in terms of culling policies and animal health practices. The LSF-2 operated a strict culling policy aimed at replacing half the milking herd each year, while the LSF-3 tended to sell young animals, as the demand for in-calf heifers in the country has been high. From the survival analysis, it was evident that some selection for an early AFC was being practiced on the LSF-2 (Figures 9 and 10). The replacement strategy on



the LSF-2 was also evident from the drastic change in the survival function for animals that had calved for the first time (Figure 9, S1460).

Preliminary information from the various farms indicated that the LSF-1 and the LSF-4 did not apply any strictly defined culling policy since their aim was to build up the herd. However, on the LSF-1, the opportunity for animals to survive drastically reduced within the first 300-days of life, and less than 70% of the animals born lived to 1460 days (Figure 9). The LSF-4, on the other hand was able to retain a high proportion of animals born to 1,460 days (Figure 9). Trends in both voluntary and involuntary culling greatly affect the income to dairy enterprises. Producers would need to be advised on the short-comings in their current culling, and trade-offs that would ensure the most optimal strategy depending on their breeding goals.

### **5.3. Causes of mortality and culling**

A large proportion of animals in this study were lost due to involuntary culling prior to first calving (Figure 8) and prior to attaining four years of age (Figure 7). Of those lost within these periods, unspecified death resulted in the highest proportion of loss (Figures 7 and 8). Identification of early predictors of length of productive life is potentially of great interest in formulating breeding strategies to improve longevity of dairy cows. In most developing countries, however, systematic recording of health events is not carried out. Consequently, the impact of health disorders on culling is not easy to capture. In addition, within these environments, selection pressure tends to be greatly limited by the number of animals available. Beaudeau and Seegers (2000) noted that in several advanced dairy production systems, the impact of health disorders on culling in dairy cows was weak compared to that of low milk yield potential and poor reproductive performance.

In studies on length of productive life, reproductive disorders tend to be the most frequently stated reason for culling (Beaudeau and Seegers, 2000). Among the reproductive traits studied, still-birth rate can be used as an indicator of early mortality. In a study on still-birth in the Holstein population of the USA, Meyer and Berger (2001) showed that there has been an increase in the occurrence of stillbirths from 1985 to 1996 by 3.7% in primiparous cows and by 1.6% in multiparous cows. Studies from other populations where North American Holstein sires have been used have also reported an increase in the occurrence of still-births



(Steinbock and Na'sholm, 2003; Hansen *et al.*, 2004). Results from studies such as these need to be critically considered by countries with no clearly defined breeding strategies, as the choice of sires for breeding could negatively impact on adaptability and productivity.

#### **5.4. Survival to AFC and to 1460 days**

When rearing exotic cattle in Kenya, producers tend to overlook the losses incurred early in the life of an animal, and focus mainly on milk yield obtained in an animal's lifetime as the profitability of the enterprise. However, survival to AFC, and the effect of AFC on survival beyond first calving are very important traits for the dairy enterprise since they represent a period in which replacement heifers are not generating income, and instead require considerable capital expenditure (Tozer and Heinrichs, 2001). It has been estimated that the cost of rearing animals up to AFC constitute 15 to 20% of the total expenses related to milk production (Heinrichs, 1993).

The current study evaluated both survival of HF heifers in Kenya prior to attaining a first calving (SAFC), and the effect of AFC on culling prior S1460. Environmental factors of, H-ys of birth and sire area of origin significantly ( $p<001$ ) affected the mortality and culling rate for both SAFC and S1460. The AFC significantly influenced the survival of animals to four years of age on all the farms. However the magnitude of the effect differed greatly between farm to farm (Figure 10). Only on the LSF-2 was there evidence of some selection for an early AFC (Figures 9 and 10,; S1460).

The overall average rate of culling early in the life of the animals increased drastically from 1998 to 2003 (Figure 13). This is a highly undesirable trend as the consequence is a reduced availability of replacement heifers. The increase in culling could be an indication of reduced adaptability to the Kenyan environment by animals sourced from different environments. Cost implications of this trend need to be evaluated.



(Steinbock and Na'sholm, 2003; Hansen *et al.*, 2004). Results from studies such as these need to be critically considered by countries with no clearly defined breeding strategies, as the choice of sires for breeding could negatively impact on adaptability and productivity.

#### **5.4. Survival to AFC and to 1460 days**

When rearing exotic cattle in Kenya, producers tend to overlook the losses incurred early in the life of an animal, and focus mainly on milk yield obtained in an animal's lifetime as the profitability of the enterprise. However, survival to AFC, and the effect of AFC on survival beyond first calving are very important traits for the dairy enterprise since they represent a period in which replacement heifers are not generating income, and instead require considerable capital expenditure (Tozer and Heinrichs, 2001). It has been estimated that the cost of rearing animals up to AFC constitute 15 to 20% of the total expenses related to milk production (Heinrichs, 1993).

The current study evaluated both survival of HF heifers in Kenya prior to attaining a first calving (SAFC), and the effect of AFC on culling prior S1460. Environmental factors of, H-ys of birth and sire area of origin significantly ( $p<0.01$ ) affected the mortality and culling rate for both SAFC and S1460. The AFC significantly influenced the survival of animals to four years of age on all the farms. However the magnitude of the effect differed greatly between farm to farm (Figure 10). Only on the LSF-2 was there evidence of some selection for an early AFC (Figures 9 and 10,; S1460).

The overall average rate of culling early in the life of the animals increased drastically from 1998 to 2003 (Figure 13). This is a highly undesirable trend as the consequence is a reduced availability of replacement heifers. The increase in culling could be an indication of reduced adaptability to the Kenyan environment by animals sourced from different environments. Cost implications of this trend need to be evaluated.



### 5.5. Influence of sire's region of origin on SAFC and S1460

Liberalization of the AI industry in Kenya in 1992 resulted in an increased use of imported semen from various countries (Okeyo *et al.*, 2000). The choice of semen is, however, greatly influenced by individual farmer preference, and the aggressiveness of those marketing semen from various sources. The use of sires of diverse origin has been shown to differentially influence the length of productive life of HF within Kenya (Ojango *et al.*, 2004). Information on the influence of the origin of the sire on early survival of Holsteins is however scarce yet it is of great significance to the adaptation of the animals to the Kenyan environment.

Survivor curves stratified by sire region of origin (Figures 11 and 12) show that daughters of sires from Australia and New Zealand, the USA, Canada and Australia had lower survival chances than those sired by bulls from Kenya, Europe, South Africa and Israel. The first 60 days of an animal's life were the most critical for early survival irrespective of the origin of the sire. This concurs with the findings from other studies eg., (Tarrès *et al.*, 2005), and emphasizes the need to increase attention in health care in the age prior to first calving. Animals without clear records, especially on origin of sire, had a higher likelihood of being culled, with less than 70% of the animals in this category attaining a first calving (Figure 11). All these animals are, however, not discarded by the farmers since it is known that they were most likely sired by bulls of good potential for milk production raised on the farms.

Selection against animals sired by Kenyan born bulls was evident through a higher relative risk of being culled prior to attaining four years of age (S1460, Table 11). This type of selection tends to be practiced by the farmers because no information on breeding values is available for sires within Kenya as the national recording systems in place do not carry out any genetic evaluation. Selection against Kenyan bred sires was also reported by Ojango *et al.* (2002). This trend is of concern as these animals are expected to be better adapted in some ways to the environment and may ultimately be the better producers if given similar opportunities as daughters of foreign bred sires.



## **5.6. Conclusion**

A large proportion (25%) of HF cattle born on the Kenyan LSF was lost before reaching a productive age, suggesting limitations in the animals' adaptability to the prevailing environmental conditions. Proper record keeping, especially on health management, is important to facilitate accurate assessment on causes of mortality and culling. The use of sires from heterogeneous sources, without any clear strategy other than increased milk production potential is negatively impacting on early survival of HF on large-scale dairy farms in Kenya. The economic implications of the high losses before attaining a productive age need to be evaluated in order to formulate intervention strategies for livestock producers to make informed decisions on choice of sires for breeding.



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