HERD STRUCTURE, PRODUCTION TRAITS, CATTLE TRANSACTIONS AND AN ECONOMIC ANALYSIS OF ALTERNATIVE PRODUCTION SYSTEMS OF ZEBU CATTLE IN N. TANZANIA

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PETER K. NGATEGIZE

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ABSTRACT

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Livestock production in developing countries has begun getting much attention from governments, donor agents and researchers. In many countries cash crops constituted the major source of foreign exchange earnings and thus got much more attention than livestock production. However, the 1970's were generally a period of falling prices for most of the major cash crops (coffee, cocoa, cotton, sisal, etc.). The critical need for turning to other foreign exchange earning commodities, the need to reduce the importation of manufactured foodstuffs and the growing demand for animal proteins plus the pressure to improve the living conditions of the usually less privileged pastoral and agri-pastoral communities requires full understanding of the production potentials and constraints in their respective production systems.

The study set out to bring together the current literature on herd structure, production traits and cattle transactions of zebu herds in tropical Africa. Specifically

the study examines the herd characteristics and productivity of W'Arusha zebu herds in N. Tanzania.

The first chapter includes the problem statement, objectives and limitations of the study. In the second chapter, an introduction to Tanzania is made covering geographic, economic and social characteristics. The geographical, historical, and production conditions of the W'Arusha and the data collection methodology are presented.

The most important parts of the study are contained in chapter 3, 4 and 5. In chapter 3, literature, covering a wide range of production systems and management conditions is reviewed. Chapter 4 reports the results of the study from the W'Arusha sample herd. Chapter 5 presents the results of the regression analysis and herd growth simulations. Chapter 6 presents the conclusion from the study based on the literature and the findings from the sample herd. Some recommendations for further research, especially, covering the economics of production in livestock system are presented.

DEDICATION

To my parents, Sabina Babikinamu and Bonefance Kikafunda, whose wisdom, understanding and inspiration have been the foundation of my personal development.

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CHAPTER I

PROBLEM STATEMENT AND OBJECTIVES

1.1 Introduction

The rising demand for food in most African countries resulting from population growth and declining food output increases the need for research in all aspects of improving the food situation in the region. Because of calorie and protein shortages, millions of children die and/or suffer from retarded growth and development whilst many have their mental development, ability to learn and general behavior impaired. In most of these countries, animal protein shortages are part of the general hunger problem (French, 1970).

In many of the major livestock areas of Africa, for example Mauritania, Mali, Niger, Ethiopia, Sudan, Kenya, Botswana and Tanzania, production systems are similar with communal grazing of livestock and the structure of the industry being mainly of subsistence type. The herds operate at low levels of productivity, high mortality and low commercial offtake (Sullivan & Farris, 1976).

However, the livestock sector has, in most of this region, the potential to supply not only the national requirements of livestock products but also surplus for export to meat deficit areas in the region and abroad. The need for an improved livestock sector in any country goes beyond the provision of more and better quality food to the nations. Other goals include reducing imports, increasing exports, exports, more employment, increased incomes of rural people and the enhancement of equity goals.

The development of livestock implies the development of grassland farming since grass is the cheapest food for the ruminant animal. Fortunately, the grassland potential of the tropics is enormous despite the fact that the plain of nutrition of livestock is low (McIlroy 1964). Most government development plans have geared livestock improvement through subsidized programs like veterinary services, range management, dips and water facilities. The assumption behind these subsidized programs has been that producers would readily adopt the improved practices, become better managers and more market oriented (Sullivan, Farris, Yetley and Njukia, 1978).

A number of constraints have persistently impeded the livestock programs. They can generally be enumerated as:

(1) The traditional system of communal grazing and traditional attituds toward cattle.

(2) The prevalence of diseases.

(3) Environmental constraints of rainfall patterns and their influence on pasture availability.

(4) Inadequacies of the marketing system.

(5) The limited number of technical personnel.

(6) The depressed regulated prices and the deficiency in the financial resources available to governments.

The extent to which any of these problems influence development efforts in any of the countries is not covered in this paper. Suffice it to say that they still remain prevalent in much of tropical Africa. However, due to the pervasiveness of the communal grazing practice and the attention given to it in literature, it is highlighted in the next section.

1.2 Traditional Communal Grazing in Theory

In most livestock production systems in Africa, grazing is done on communally owned land. The herds graze the same pastures without restrictions on herd size or any attempt to control the grazing. The herds may graze together or separately. The practice is also characterized by virtually lack of any attempt, individually or collectively, to provide some form of pasture management.

The practice has some general advantages:

(1) There are little or no costs incurred in terms of pasture management. Animals are moved from place to place. The pastures are left to reseed and regrow during the rains especially after burning and with the help of animal manure in the range.

(2) Labor saving is common especially where families take turns in taking animals to pastures. No close attention is often necessary except in areas with wild animals and/or cattle rustlers or densely cultivated land.

Communal grazing, however, has been persistently criticized for the subsequent overstocking and overgrazing which cause heavy damage to pastures leading to soil erosion and desertification. Associated with the practice is the high mortality and low animal productivity due to long distances animals travel in search of pastures and poor management practices. There is a more likelihood of uncontrolled breeding that could result into inbreeding, poor quality calves from poor bulls and constraints in using artificial insemination. Attempts to improve the range would have to face the free-rider problem and the associated high costs of exclusion.

In the rational use of resources, economic theory says that resources are used up to the level at which the additional value of an input is equal to the additional cost of producing the additional output (MC = VMP). Thus a herdsman would add animals to a given pasture until the returns per animal are equal to the costs of getting these returns. However, in the communal grazing system, the same range is used by several individuals. The herds may graze together or separately but on the same area of land.

Thus as a rational being, each herdsman will seek to maximize his net gain. The benefits of adding one or more animals to his herd and the costs associated are evaluated. The benefits are a function of the increment of one animal. This increment may be measured in terms of additional milk, meat, manure, prestige, or wealth. Any farmer is better off grazing as many animals as he can acquire because if his cattle are not grazing on pasture land, someone else's will.

The costs are a function of the additional overstocking. However, these costs go to society; they are shared by all the herdsmen and society at large. Thus each herdsman shares only a fraction of the total costs. Therefore, as long as the returns (to the individual) are more than the costs (the portion going to the individual), the herdsman is acting rationally to add another animal until his personal additional costs equal to the additional returns. The process, however, will subsequently lead to overstocking. The good pastures will be grazed leaving less nutritive plants. Soil will in most cases be left bare and this will facilitate wash off by water and wind. Thus the "tragedy of the commons." (Hardin G., 1968).

The criticisms often offered in condemning communal grazing have received much attack in recent periods. Mackenzie (1973) asserts that overgrazing is often not due to overstocking but rather lack of pasture management. While Meadows (1981) believes that the problem of overgrazing has been exaggerated, Stanford (1978) warns that the tragedy-of-the-commons argument should cease to be used as a policy guideline.

1.3 Problem Statement and Purpose

Much of the literature available on livestock systems has been done by sociologists on pastoral communities in developing countries of Africa. Most of the studies have concentrated their research on the tribal rites in which cattle play a major role. Research work by animal scientists has been restricted to diseases, breeding, nutrition and other technical aspects of animal production based on western production systems. As a result, not only are the demographic characteristics of the herds little known, the condition of smallholder production, its opportunities and goals are often misunderstood (Dahl and Hjort, 1976).

Recent studies show that management practices substantially influence herd structure and production traits of herds in specific farming environments. The age-sex composition of a herd is a major determinant of animal sales, milk production, herd growth and resistance to drought (Shapiro, 1979). Therefore, any policies aiming at increasing offtake rates, herd growth and productivity require knowledge of these herd characteristics and how they are influenced by management practices. Such knowledge will not only be of value to policy makers but also to researchers and donor agents because such knowledge will reduce the potential for project failure. The smallholders will also be provided with technical and economic advice tailored to their needs rather than production packages based on western production systems. The inherent need for improving the productivity of livestock on small farms and efficiency in formulating projects through better knowledge of small holder herd structure and productivity, leads the study to the following objectives.

1.4 Objectives of the study

(1) To review the literature on herd structure, productivity and herd dynamics of pastoral and agri-pastoral production systems in Tropical Africa.

(2) To provide information on herd structure, productivity and cattle transactions for zebu herds of an agri-pastoral graoup in a selected study area.

(3) To determine the potential for increasing (improving) productivity of zebu herds without drastically changing the current production system.

(4) To analyze the management variables affecting the level of milk production under the current production system.

(5) To make recommendations on how improvements could be made in view of the findings of the study.

The study will focus particularly on the following questions:

(1) What is known about herd structure, production traits (coefficients) and transactions of livestock systems in Tropical Africa and what factors have a major influence on the variables?

(2) What herd characteristics are prevalent among the zebu herds of the W'Arusha of Northern Tanzania and what are the management practices that are important in influencing their

characteristics?

(3) What are the general implications of the present production traits herd structure and transactions on the development of the livestock sector among the W'Arusha?

CHAPTER II

AREA OF STUDY, DATA COLLECTION AND METHODOLOGY

2.1 The Geography and Economy of Tanzania

The Republic of Tanzania is the largest country in East Africa with an area of 945,000 square kilometers. It has a diversity of climatic regions and geographical features. Rainfall is highest in the northwest and southwest with two rainy seasons. The average annual precipitation is 760-1270 mm. Large areas in the center of Tanzania lie within the 250-500 mm isohyets. In this area, largely in the west and central zones, conditions are in varying degrees, unfavourable for the production of crops, except in limited areas where irrigation is feasible. A considerable part of this area is, however, suitable for livestock production, provided that tsetse fly infestation is controlled and water supplies are provided. About 25 percent of the country, mainly comprising of fertile areas along the borders with neighbouring countries and the Indian Ocean, are intensively settled and farmed.

The 17.4 million people belong to over 130 ethnic groups. The average population density is about 19 people per square kilometer. Over 90 percent of the population live in rural areas where subsistence agriculture is the major way of live. Agriculture contributes 45 percent of the Gross National Product, industry 16 percent and services 39 percent (U.S.D.S., 1979). The leading exports are coffee, cotton, sisal and spices. The stable foods include maize, cassava, millet and sorghum.

Tanzania is listed in the low income category by the World Bank with a Gross National Product per capital per year of less than $300 U.S. A 1969 national survey of households reported that the lowest 40 percent of the population shared 7.8 percent of the income, the middle 40 percent shared 28.9 percent and the top 20 percent shared 63.3 percent of the national income. Since 1967, Tanzania has chosen a socialist path with ambitious equity goals within Ujamaa framework; the philosophy stressing self reliance and African socialism.

2.2 The Livestock Sub-Sector

The cattle population was estimated at 11 million heads in 1973 (Mackenzie). Tanzania has a great potential for livestock production in spite of tsetse fly infestation in many areas that is responsible for cattle losses through the transmission of a disease known as trypanosomiasis, and lack of water in many parts of the country. However, the sector has generally remained unstructured, unspecialised and unimproved. There is little integration of crop and livestock enterprises except in a few areas like Kilimanjaro and Arusha regions. Cattle numbers are highest in the more densely settled areas. In 1967, 77 percent of cattle were reported to be located in the higher rainfall areas near

Lake Victoria, the central zone and the Arusha-Kilimanjaro regions.

Almost half of the cattle in Tanzania are held by people who cultivate the land. Their cattle are herded away from homestead areas on communal grazing. About 2 million are owned and herded by pastoralists in extensive grazing areas in the low rainfall zones, while some 1.5 million are owned by agricultural cultivators in densely settled areas and grazxed in association with the cultivated land. The residual 3 million, not readily classified in the above categories, are found in less densely populated areas (FAO/IBRD, 1969). In 1969, there were only 12,000 dairy-type animals in Tanzania and only half were held by small holders. In 1968-69, livestock contributed an estimated 15.6 percent of total agricultural output. In spite of this relatively low contribution to the overall national economy, livestock presents the only productive, visible and interest earning asset owned by most rural families.

2.3 Communal Grazing in Tanzania

The degree of overstocking in the country varies in different regions. Some areas outside of the main livestock producing areas are understocked (mainly due to tsetse infestation). In the producing areas the stocking rate is estimated to be over 25 percent too high for the available forage in average years (Sullivan and Farris, 1976). Proper grazing and stocking of these lands would provide an estimated 20 percent increase in forage growth and a 10 percent increase in meat production. Theoretically, destocking and/or range improvement and management would provide better nutrition for cows, increase calving rate, reduce calf mortality rates and produce marketable cattle in shorter period.

The village and Ujamaa Village Act of 1975 provides broad enabling powers to individual villages to control range development and grazing practices. In some areas, bush cleaning and establishing improved pastures would increase output without destocking but stocking rates would need to be controlled to achieve the most benefit from the improvement. Fencing to control grazing and enable rotational grazing is a possibility in some situations. However, this requires regular tick control, ample water and watering facilities, some supplemental feeding of salt and minerals, and an animal health program. This means, increased costs of production and higher risks to the farmer.

In general most of the programs directed at improved range and pasture management have not been successful or effective and more specific programs and procedures are called for in implementation (Sullivan and Farris, 1976).

2.4 The Georgraphical and Socio-Economic Characteristics of the W'Arusha

GEOGRAPHICAL LOCATION:

The W'Arusha inhabit the area comprising the southwestern slopes of Mt. Meru and the immediate peripheral area. Mt. Meru is an extinct volcano, 4,993 meters in altitude and about eighty kilometers west-south-west of Mt. Kilimanjaro. To the north and west are the pastoral Masai who extend across the border into southern Kenya. To the east are the Meru. The town of Arusha, which accommodates the district and regional headquarters is located in the study area.

In contrast to the surrounding steppe, the southern and eastern mountain slopes are well watered, cool and because of volcanic soils, notably fertile. The average annual rainfall ranges between 1100-1800 millimeters, according to altitude. On the western slopes, where the W'Arusha dominate and below 1,300 meters, rainfall diminishes rapidly to about 510 millimeters a year and the volcanic soils give away to comparatively infertile soils. On the southern mountain slopes, the population density approaches 390 people per square kilometer but falls gradually toward the western slopes and the lower lying plains where 8 people per square kilometer is common.

HISTORICAL PERSPECTIVE

The W'Arusha are believed to have migrated into the area although their exact origin is not clearly understood. They have had a close relationship with the pastoral Masai and at the time of the first European travellers, were classified as Masai based on fairly superficial observation. However, in contrast to the Masai, they are principally agriculturalists with a strong interest, economically and socially, in livestock. They were also said to be more oriented toward the modern sector (Gulliver, 1963).

AGRICULTURE:

The traditional economy of the W'Arusha was based on a number of staples, namely, maize, bananas, beans and finger millet. To a lesser extent was the cultivation of tobacco, gourds, squash and honey gathering in the forest. During the last two decades, deliberate cash crop cultivation has begun. These include coffee, beans, peas, onions, wheat and pyrethrum.

The farm sizes range between 1-4 hectares. A number of cows are also kept to meet family needs of meat, milk, manure and social livestock obligations, and sale for cash. The average herd size for family is four cows, two goats, and three sheep. The management of cattle vary from farm to farm. Some families keep grade cattle under improved management practices like stall feeding, use of concentrates and disease control. The area is not only heavily populated but it also has a ratio of cattle to people of about 1 to 1 which is relatively high. It is reported that producers manage their cattle more economically because of the demand for dairy products and scarcity of land for enlarging herds (Sullivan and Farris, 1976). Land ownership is mainly private rather than communal. In some drier north-west parts, however, cattle graze the communal pastures which are mainly the uncultivated waste land. Grass shortage due to lack of rains and overgrazing is prevalent. However, it is possibly true that the major problems of livestock are primarily lack of water and poor range management rather than actual overgrazing due to numbers of livestock (Mackenzie, 1973).

2.5 Data Collection and Sampling Methodology*

The study drew its data from a cross-sectional survey of cattle producers in Arusha region of N. Tanzania. The survey was carried out between November 1973 and June 1974.

A two stage probability sampling procedure was employed for the study. The 1967 census enumeration areas served as first stage sample units, being systematically selected with a probability proportional to their 1967 household populations. From each selected first stage unit, an independent, constant size subsample of individual households was drawn systematically. Practically, the systematic sampling procedure yields a representative random sample to which conventional two stage estimation procedures apply. The systematic sampling procedure used for selecting first stage sample units took account of the continuous variation in rainfall and attitude in the survey area.

The farm survey consisted of a single visit to the sampled households. Enumerators gathered data on household cattle management practices, and detailed individual cattle records. The interviews lasted 30-40 minutes for households having no cattle and 1-1½ hours for households with cattle.

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*Tom Zalla, Unpublished Ph.D. Thesis, 1981.

Information was provided almost all on a recall basis with the recall period varying from 1-2 days for milk data to as long as several years for cattle records. (Appendix I).

Often the person answering the questions was not the same person that worked closely with the herd. Inconsistencies and discrepancies occurred in numbers of animals reported, calving and breeding months. A good deal of discrepancy occurred in milk production data on the day preceding the survey and at key points during the lactation period (1, 3, 6 months and end of lactation). There was considerable evidence that many farmers were not being honest in reporting milk yields. Another source of data inconsistency was the individual enumerator idiosyncracy.

2.6 Methodology

The study highlights the important findings of existing literature on small livestock farms and pastoral communities. These are looked at in relation to the area of study and livestock production in developing countries in particular. The conditions obtaining in the study area as regards the environment, historical, political and socio-economic factors are identified. Computation of sample herd structure using sample totals and production traits using means, averages, variance and standard deviations are employed. Further analysis included regression analysis and simulation (Chapter 5).

2.7 Definitions

The following terms are used throughout the paper.

(1) Calving Rate or Calving Percentage: This is the proportion (percentage) of breeding cows which bear calves during the year:

$$\frac{\text{Cows that gave birth during the year}}{\text{Total number of breeding cows in the herd for the year}} \times 100$$

(2) Offtake Rate: This is defined to include the proportion of all the animals that leave the herd during the year.

(i) Crude Offtake Rate =

$$\frac{\text{net outflows+deaths+slaughters}}{\text{average herd size for the year}}$$

(ii) Commercial Offtake =

$$\frac{\text{Net outflows+slaughters}}{\text{Average herd size for the years}}$$

(3) Mortality Rate: This is the ratio of the number of animals that die in the year over the total number of animals in the herd for the year.

$$\text{Calf* mortality} = \frac{\text{Calf deaths in a year}}{\text{Calves born in the year}}$$

(4) Production Traits: This is also used in the same context as production coefficients or characteristics to include mortality rate, calving rate, age at calving, offtake rate, lactation yield, calving interval and other factors that affect the productivity and growth of a herd.

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*A calf is defined as cattle under one year of age.

2.8 Limitations of the Study

The following were the limitations of the study:

(1) The study was very much handicapped by the author's general lack of field experience in the area of study

(2) there was limited literature available on the socio-economic aspects of the area and on livestock production in the area, in particular

(3) since the data had been collected to meet different objectives, some information valuable to the study was either not collected or was in a form less useful to this study. For example (a) there was no information on communal grazing and problems relating to land adjudication, cattle and beef marketing in the area, (b) in reporting the information on cattle transactions, there was no distinction made between commercial sales or buying or gifts that relate to social functions, (c) calf management practices and the significance of milk production and use in the area would have been given more coverage so as to be more beneficial to the study

(4) the study does not capture the dynamics in the livestock subsector and therefore it could not include the prescriptive dimension based on the data that was collected. Therefore some of the recommendations were basically made by drawing more from literature than the survey data.

CHAPTER III

HERD STRUCTURE, PRODUCTION TRAITS AND CATTLE TRANSACTIONS OF SELECTED LIVESTOCK PRODUCTION SYSTEMS

3.1 Herd Structure

Information on herd structure of small farmers in tropical Africa has received increased interest in recent times. This has been due to the fact that they throw some light on the objectives of the various production systems and explain the management practices that go along with the different herd structures.

SEX STRUCTURE:

The ratio between newborn males and females in a herd is approximately one to one (Dahl and Hjort, 1976). However, among the mature animals, the ratio is generally much biased in favour of females. In Kalamoja, the proportion was found to be in the range of 49 percent to 85 percent (Dyson Hydson, 1970). Jacobs (1963) reported a female percentage of 51-61 percent for Masai herds of Kenya and Tanzania.

Meadows and White (1979) reported three reasons for high male calf mortality in the Kenyan district of Kajiado. It was determined that male calves are slaughtered at an early age:

(1) To save milk for human consumption

(2) To reduce stress on the dam by a suckling calf. This is especially true during the dry season.

(3) To have meat available in manageable quantities for the family.

For similar reasons, the Kalamajong are known to slaughter all young bulls unless they meet certain selection criteria (Dahl and Hjort, 1976). Selection criteria may be based on the performance of parents, the individual animal's conformation and the purpose of the animal. The male calves are selected for breeding, as steers and for traction. In some societies, they are also used for rituals. In a study focusing on management of small East African Zebu in relation to milk yield, calf growth and mortality, Stobbs (1966) observed that "lactation length was significantly longer when a calf was present at milking but the calving interval was longer" (p. 255). In some cases, calving interval could be as long as two years or more. Based on this finding, it can be argued that the farmer could sell or slaughter male calves in order to reduce calving interval in anticipation of getting a female calf the next calving. This could be the case especially where herd growth is a major objective of the family. However, this would mean reduced milk supply to the owner since indigenous cattle tend not to let down milk in the absence of their calf and thus shortening the lactation period (Barrett and Larkin, 1974). Similarly, calves, especially the males, may be deprived of much of their dams' milk as to cause distress and tender them more vulnerable to disease (Brown 1971). This practice could account for the high mortality observed in males even after the weaning period.

In Uganda, Ferguson and Poleman (1971) report that in central and western regions, the number of female calves exceed male calves in the herds. Herds are oriented towards supplying milk for sale or family consumption with more than 60 percent of the population recorded as heifers and cows. In the Eastern region, however, where ox-cultivation is practised, the economic value of bullocks is greater. The male calves are retained in the herds as potential plowing cattle. In the region, the ratio of male calves to female calves is 1:1 as opposed to 1:2 in most other regions. In the North Ethiopian Rift Valley, because of lack of market opportunities, almost all males are culled at an early age; hence females constitute approximately 95% of herd numbers (Galaty et al, 1981).

Horowitz (1979) reports a management practice in Mali, West Africa where the stockmen tend to keep up the proportion of steers to females high. Steers, because of their docility, are important in maintaining the stability, unity and tranquility of the herd and thereby, increasing milk production and reducing labor demands. Therefore the sex-structure of a herd has a strong relationship to the goals and objectives of the owners.

AGE STRUCTURE

The composition of the herds by age also is influenced by a number of factors. A common criticism of the small farm system has been that animals are kept on the farm for a time long beyond their optimal age. This is illustrated by the fact that animals of over 4-5 years of age constitute a large percentage of most herds. Doran, Kemp and Low (1979) report that over 60 percent of the animals in the Swazi herd were over 3 years. They suggest that the age composition is related to the fact that animals are kept for prestige, status or as a form of wealth. Alternatively, it may be a failure to understand the ecological environment; biological characteristics of the herd and the objectives of the stockman.

The age structure of the female herd is mainly a product of biological restrictions since milk production may be the main interest of the household and a general strategy becomes one of keeping enough cows to ensure an adequate year round milk supply. Secondly, given the high calf mortality, low growth rate, long calving intervals and poor breeding practices, it becomes reasonable to keep a cow in the herd to advanced age just to replace the present population and to allow for growth in cattle numbers. In economic terms, the stockman's objective will be to maximize returns by equating marginal returns with marginal costs. In this case, the marginal returns are measured not in terms of additional beef produced but also the additional calf and milk that the animal could produce in the next year.

The marginal costs are generally low given the communal grazing system.

It is also common for a stockman to keep an originally productive cow on the farm until its death, in gratitude or appreciation for its productivity. This may involve one or two animals in a herd but is an important indication of a strong relationship that a farmer has with his animals. The survival of a particular animal to an age of ten or more years is an indication of its good qualities. In most cases it will have been able to survive the prevalent diseases, drought periods and to stand up to the rigours of long journeys in search for pastures. In addition it may have other qualities like short calving interval and high milk production. Where cattle are herded in open pastures, an old productive animal may serve as a herd leader, thus maintaining tranquility in the herd.

The structure of male cattle is more subject to other factors like their value as a source of draft power, its performance as a breeding animal plus cultural differences like ritual and symbolic values ascribed to bulls. Meat consumption patterns and the degree of involvement in the cash economy are also important (Dahl and Hjort, 1976). In a number of areas where feed lots may be located, the male population in pastoral herds may be reduced substantially due to sales to feed lots. In Kenya, livestock development projects have been indered by shortage of bulls partly as a result of early slaughtering of male calves by most pastoral groups (White, 1980).

Lack of alternative avenues for investment and the anticipation of inflationary trends may increase the retention period of animals in the herd. Horowitz (1979) put it in the following way:

> "Where alternative avenues of investment are unattractive or unavailable, the conversion of animals to cash whose value is eroded by inflation is hardly a sound strategy." (pg. 57).

Lastly another biological constraint that may lead to the retention of relatively old animals on the farm is the fact that in most cases, due to lack of transport facilities, animals may have to trek long distances to marketing centers. Given the low growth rates, this may dictate that animals are not marketed until they are 4 to 5 years of age, otherwise they may not be able to survive the long distances (Mackenzie, 1973, Jarvis, 1980).

3.2 Production Traits

MILK PRODUCTION:

In many agripastoral communities, milk production rather than meat production is the primary goal of livestock husbandry. However, Mahadeven's (1966) assessment of dairy breeding research in East Africa concluded that selective breeding for milk production within indigenous cattle of East Africa has failed to give worthwhile results and that there was little reason to suppose on genetic grounds that it was likely to be successful in the future.

Schillhorn Van Veen (1981) contends that selection from these indigenous cattle is something that should be done. It takes time and patience but avoids losses and costs associated with the importation of exotic breeds (e.g., Holstein, Jersey, etc.). In Kilimanjaro region, zebu cattle account for over half of milk production, supplying more households with milk than grade cattle (Zalla, 1981).

The differences in milk yield between indigenous and exotic cattle are generally high. A study by Sacker and Trail (1966) of indigenous cattle in Uganda reported milk yield of between 590-910 kgs lactation for the zebu as compared with 2100-2700 kgs for the exotic breeds in the same environment but under a different management system (Maples and Trail, 1967).

Production traits also vary within the indigenous cattle breeds. Sacker and Trail (1966) reported that lactation milk yield and mean daily milk yield in the Ankole (longhorn) zebu cattle of western Uganda was significantly higher than in the shorthorn zebu cattle. For the Ankole breed, age at first calving was 51.3 months, lactation length 239 days, length of dry period 97 days, calving interval 342 days, and lactation milk yield 860 kgs. Corresponding figures for the shorthorn herd were 51.7 months, 230 days, 106 days, 347 days and 660 kgs. Age at first calving is reported as 49 months for Kilimanjaro region, 3½ to 5 years for Nigeria by Zalla (1981) and Pullan (1979) respectively. Wilson and Clarke (1976) reported that 29% of cows in the sedentary herds and 65% of cows in the migratory herds in Sudan were in calf before they were four years.

Calving interval is reported as 27 to 29 months by Zalla (1981), 27 months by Pullan (1979), 18 months for migratory herds (where owner moves with herd) and 30 for sedentary herds (owner has a permanent settlement thus limiting herd mobility) (Wilson and Clarke, 1976). Williamson and Payne (1978) give a lower figure of 11-14 months as typical of the East African zebu in general.

A number of studies have also been carried out to assess the performance of cattle under different farming systems. An intensive study of a number of herds in migratory and sedentary sectors of the livestock economy of Southern Sudan showed that in almost every production parameter, the performance of the former was superior to that of the latter (Wilson and Clarke, 1976). Sedentary herds tend to suffer more from parasites and disease build up in their limited environment, as well as from pasture and water shortages during drought periods and high incidences of inbreeding.

A study of beef cattle productivity with sedentary herds under traditional and improved management in Botswana was done in 1976 by Rennie, et al. A comparison of productivity over a 4-year period under the two production systems, the traditional system on unenclosed communal grazing (cattle post) and ranching within fenced paddocks was made. Calving percentage, 7-month old calf weight, calf mortality and post weaning growth to 18 months of age under cattle post conditions were 46.4 percent, 122.5 kg, 10.2 percent and 88.5 kg respectively. Corresponding figures for cattle on the fenced ranches were 74.0 percent, 177.4 kg, 8.5 percent and 105.8 kg. The study illustrated the potential for increased productivity even before more sophisticated techniques in range management, animal nutrition and animal breeding are employed. However, the study does not show whether the stocking rate and/or carrying capacity of the pastures were the same since this could be an important factor contributing to low productivity in the traditional system.

MORTALITY:

In most tropical herds, mortality in the first year is very high to the order of 20 to 40 percent (Mackenzie, 1973, Wilson and Clarke, 1973, Shapiro, 1979). There is also a high rate of death in old cows especially in the dry season. The principle cause of death appears to be a syndrome of chronic malnutrition and internal and external parasitic infestations, and old age. The average life span is around 10-13 years (Dahl and Hjort, 1976). Most of the deaths in young calves are due to disease and starvation because owners use most of the milk for family consumption and thus leaving very little for the calf.

Table 3.1 COMPARATIVE COEFFICIENTS OF ALTERNATIVE LIVESTOCK PRODUCTION SYSTEMS OF ZEBU CATTLE (TANZANIA, 1976)

PRODUCTION TRAIT	COEFFICIENT	
	TRADITIONAL SYSTEM	IMPROVED SYSTEM
1. Females over 3 years of age which calve	45%	60%
2. Deaths of calves before one year of age	30%	15%
3. Deaths of cattle over one year of age	10%	5%
4. Selling age of males	7 years	4 years
5. Sale of surplus and cull females	2.8%	18%
6. Market offtake	4.5%	12.7%

Source: D. E. Farris Consultants Report; Tanzanian Livestock-Meat Subsector. 1976, Vol. I.

Table 3.2 PRODUCTION CHARACTERISTICS AMONG THE DIFFERENT LIVESTOCK PRODUCTION SYSTEMS IN KENYA

PRODUCTION CHARACTERISTICS	COEFFICIENT			
	Pastoral system	Range subsistence cultivators	High potential small holders	Large-scale farmers
1. Zebu (indegenous cattle herd %	100	96	83	-
2. Milking cows in the herd %	65	-	-	-
3. Mature cows in the herd %	43	43	-	-
4. Calf losses %	36	38	31	-
5. Calving rate %	65	63	68	70
6. Adult losses %	10	-	-	2
7. Mature males in the herd %	5	-	-	-
8. Offtake rate %	8	10	12-15	15-20
9. Average lactation yield per cow	150 kg	1301t	1501t	1,050 kg

Source: Kivunja C. The Economics of Cattle and Beef Marketing in Kenya, 1976.

3.3 Cattle Transactions

The traditional herd is a multipurpose herd kept for milk, meat, cash, dowry investment for financial security and insurance. Animal manure may be sold or used on the farm. In some societies transactions between members require cattle as a medium of exchange. Dowry may be paid in no other form other than cattle (Farris, 1975). Cattle are given to neighbors or relatives for herding. The reasons are

(1) to allow those without cattle to have access to milk, meat or manure;

(2) to minimize risks from stealing or diseases if cattle are kept in one kraal or boma;

(3) to provide available grazing for cattle;

(4) and to reduce the size of the herd to a managable number.

As a result of such arrangements, cattle ownership becomes dispersed among the members of the community. Hedlund (1971) estimated that 30-40 percent of cattle that belong to a Masai (of Kenya and Tanzania) may be dispersed among his friends. Among the Chagga, about 15 percent of all zebu cattle are not owned by the household which cares for them (Zalla, 1981). In the same area, most farmers acquire cattle at birth (60 percent) or inheritance (11 percent). Among the Boran of Kenya, when a boy is born, he is given a heifer. A hair-cutting and naming ceremony occurs when he is four years and he is given another heifer. At the age of fifteen, when he is circumcised, he is given yet another heifer. At the age of marriage, he has acquired enough cattle to support the family (Dahl and Hjort 1976).

The growth of an individual herd is a result of not only reproduction within the herd but also of the distribution of cattle between households. Cattle purchases and borrowing are also common. Among the Chagga, Zalla (1981) reported that there was a tendency to borrow and purchase young breeding stock and to sell or slaughter older cows and males. Whereas most of the purchased and borrowed animals were for raising, the sales were mainly for slaughter.

COMMERCIAL OFFTAKE RATE:

The number of animals slaughtered plus the net transfers (cattle removed from the herd by sales, transfers, gift, etc. less cattle added to the herd by purchases, gifts, etc.) each year as a percentage of total herd size is a measure of herd productivity and an indicator of the scope for increasing productivity. The often cited offtake rate for tropical Africa is between 9-13 percent (Shapiro, 1979; Jarvis, 1979; Mackenzie, 1973). This offtake rate has been regarded to be too low compared to offtake rates on modern commercial farms. FAO (1976) reports 30.4 for Australia, and 15.6 for Latin America. This has stimulated interest into the search for the reasons for this observed low offtake rate. Meadows and White (1979), working in Kajiado district of Kenya, identified four determinants of offtake rates, (1) rainfall, (2) availability of animals for sale, (3) disease outbreaks, (4) the need for cash by the family.

Based on herd structure and a regression analysis of slaughter against price and rainfall, Doran, Low and Kemp

(1979) conclude that cattle among the Swazi are kept as a store of wealth and are only sold to meet specific cash needs. Jarvis (1980) repudiated, rejecting the conclusions arrived at from this study and asserting that communal grazing is the major factor influencing the practices. White (1981) asserted that studies of commercial beef cattle areas of North America show similar results. However, they are given a different interpretation. A rise in prices leads initially to a fall in beef supplied to the market. Fewer heifers are culled than before but are added to the breeding herd in order to increase long-term beef supplies. Some steers are also held to heavier weights than previously; both actions are in response to the desire to maximise total income over a period of time at the expense of current income. Thus, in the short run, a negative price response is not inconsistent with price maximisation behaviour. A similar study done in Sudan gave a positive price response in the regression analysis, leading to the conclusion that farmers were responsive to economic incentives (Khalifa and Sympson, 1972). The controversial results and interpretations have led to the following conclusion by Low (1980);

> "Although lack of adequate data will often limit the univocity of the results obtained, a clearer understanding of traditional herder's supply response to price should contribute to less contradictory interpretations of available data. However, even where unambiguous results are obtained, price response information alone cannot be used to determine the extent to which cattle owner's behavior is based on objectives rather than income maximization," (pg. 2).

It is now generally accepted that small farmers will respond to price although in some systems, a family has to have a basic minimum number of animals to provide for family needs. The requirement is usually about 3 standard stock units each of 500 kg live weight per head but varies from 2.5 to 4.5 according to ecological conditions, made up of various classes of stock that are kept for meat or milk (Brown 1971). On offtake rates, White (1981) reported, (in the future of pastoral peoples by Galaty, et al 1981):

> "We agree that cow rates of take off can't be explained by subsistence needs, but we think basically that the store-of-value argument is now out of date. The major factors influencing cattle sales and off-take rates are herd structure, market demand and rates of return." (pg. 220).

In general, the low offtake rates reflect the low growth rates of the animals, high calf mortality, an emphasis on milk rather than beef production, the importance of animal traction, the need for herd growth and the retention of cattle for social and security reasons.

CHAPTER IV

HERD STRUCTURE, PRODUCTION TRAITS AND CATTLE TRANSACTIONS OF THE WARUSHA SAMPLE HERD

4.1 Introduction

The previous chapter laid the background to this chapter. The herd structure and production traits of various livestock production systems were reviewed. Reasons for the differences in the traits were given whenever information was available. The emphasis was on the point that these differences between herds in a given geographical region or social organization are more than a function of biological processes and the adaptation to the environment. They also reflect the family goals and objectives in a given socio-economic environment.

The age-sex composition of a herd is a major determinant of animal sales, milk production, herd growth and resistance to drought. In response to historical, economic, political and environmental constraints each group has evolved complex cultural and herd management practices to ensure a stable and secure supply of livestock products to the family and the society at large.

The W'Arusha people of Northern Tanzania have made adaptations of their own. The herd structure and production traits of zebu herds among the W'Arusha are reported in this chapter. Attempts are made to offer explanations of any differences in the traits. Specifically, the chapter will cover the sex and age structure, calving age, calving internal, lactation period, weaning age, milk yield and transactions.

4.2 Herd Structure

SEX: The sample herd showed a male: female structure that was biased towards females. Of the 199 cattle in the sample, 65 (33%) were male and 134 (67%) were female (Table 4.1). A break down by sexual maturity is given in the table below.

TABLE 4.1. SEXUAL MATURITY, NUMBER AND PERCENTAGE FOR THE SAMPLE HERD

SEXUAL MATURITY	NO OF ANIMALS	PERCENTAGE
1. Heifer	65	33
2. Cow	69	35
3. Steer	11	5
4. Immature bull	36	18
5. Mature breeding bull	15	8
6. Mature bull but not used for breeding	3	1
TOTAL	199	100

Further evidence of bias in favour of females is shown by the sex of calvings that had been produced in the herd in the recent past. The data showed that the 69 calves of the cows' previous calving, 42 (61%) had been female and 27 (39%) had been males. Although it is generally believed that most male calves die or are slaughtered at an earlier age and are possibly not remembered when reporting such data, even the transactions data show that less male calves died in total than female calves (heifers). It is unlikely that there are genetic or environmental influences on sex before birth but more likely that male calves are killed early and hence are not usually recalled as having been born and died later.

AGE: The age of the animals in the herd ranged from less than one year to 18 years. A break down of the age into categories showed that 29 percent of the animals whose age was known were less than two years old and 25 percent were between 2 and 4 years of age. The age of 48 animals in the sample herd were not reported and therefore a breakdown by sexual maturity gave another picture of the age structure of the sample herd (Table 4.2).

From the table, the breakdown by sexual maturity gives a rough estimate of the ages of the animals involved. The animals that were ten years and more in age were 17 (8%) and were mainly female except for one steer. This is an indication that the importance of these animals kept to a relatively old age is more than prestige otherwise males could also have been found in the sample at that age category. This therefore leads to the conclusion that at least part of the differences in sex are attributed to management practices which are a function of the farmers' values,

TABLE 4.2. ANIMAL AGE BY SEXUAL MATURITY FOR THE ZEBU SAMPLE HERD

SEXUAL MATURITY	AGE CATEGORY IN YEARS									
	1	1-2	2-4	4-6	6-8	8-10	10-20	DON'T KNOW	TOTAL	%
HEIFER	18	8	23	6	1	0	0	9	65	33
COW	0	0	0	7	15	13	16	18	69	35
STEER	0	0	0	3	0	0	1	7	11	5
MALE CALF	13	5	12	1	0	0	0	5	36	18
MATURE BULL	0	0	1	5	2	0	0	7	15	8
NON-USED BULL	0	0	1	0	0	0	0	2	3	1
TOTAL	31	13	37	22	18	13	17	48	199	100
%	16	6.5	19	11	9	6.5	8	24	100	

objectives and goals.

4.3 Zebu Cattle Production Traits

This section presents the results from the study relating to the following production traits:

(1) Calving age

(2) Calving interval

(3) Lactation period

(4) Weaning age

(5) Milk yield

CALVING AGE:

Information was available for 43 cows. The age at first calving ranged between 1.5 to 8 years (Table 4.3). Twenty six (61%) had their first calving at the age of between 2 and 4 years. Thirty seven percent of the cows had their calving interval at 3 years of age. The mean calving age was calculated as 3.6 years. On the average, it is comparable to the calving age cited earlier in the literature, but tends to be on the lower side.

The relatively higher calving age can be attributed to a number of factors. The distribution of the herd by sexual maturity shows that there were only 15 breeding bulls in the whole sample. Assuming that these bulls were owned by different households, then the other 40 households had no breeding bulls. Given that the use of artificial insemination or grade bulls was very low, it is very likely that the age at which breeding was done could be an important factor.

Although the communal grazing system could facilitate the use of the few breeding bulls (theoretically one bull can be sufficient for more than 25 cows) there is no guarantee that different household herds graze together and if so, there is a possibility that proper timing of the heat period could be difficult.

The use of grade bulls especially through artificial insemination has been a general policy in Tanzania to improve the genetic base of the local cattle. However a number of factors still limit the wide use of this improved technique. These include:

(1) Failure to control breeding by local bulls especially in communally grazed herds.

(2) Failure to detect "heat" accurately due to the grazing of animals in open ranges most of the time.

(3) Insufficient technical personnel and the artificial insemination services.

(4) Poor infrastructure and the ability to get immediate service as soon as heat is detected.

(5) Farmers reluctance to upgrade their animals due to the increased risks and costs in the management of grade cattle.

CALVING INTERVAL:

Calving interval is the period between two calvings for a cow. It measures the ability of the cow to ensure an adequate replacement stock and is an important measure of the ability of a herd to grow and multiply. A calf born to the household means more than another valuable asset. It also means more milk to the household for consumption or sale.

Information was available for 21 cows for which the period between the last and previous birth was reported. The calving interval ranged from a low of 13 months to a high of 51 months. Fifty five percent of the cows had a calving interval of between 13 to 24 months. The mean calving interval was calculated as 26.3 months (±2.3).

Another indication or measure of calving interval was the period since the cow last gave birth. The average for this should generally given an estimate of half the calving interval for the herd. This was reported as 13.4 months which is roughly half the mean calving interval.

For the 69 cows in the sample herd, 46 (45%) had given birth in the previous twelve months. This gives a calving percentage of 67 (46/69 X 100) percent for the sample herd. The reasons for the long calving intervals are many and of varied nature. They include:

(1) Lack of breeding bulls and failure to detect heat accurately.

(2) Lack and/or failure to use artificial insemination.

(3) Weaning age and/or death or survival of the calf. The length of lactation is directly related to the weaning age but inversely related to calving interval for zebu cattle (see next section).

WEANING AGE AND LACTATION PERIOD:

Calves get most of their nutrition by suckling their mothers. This management practice has a number of advantages:

(1) The lactation period is generally prolonged.

(2) Milk let down by the dam is facilitated by the suckling calf (Barnett and Larkin, 1974).

(3) The calf has a more generally reliable (quality and quantity) and sufficiently nutritious source of food, at least in the earlier months of its life.

However, a suckling calf competes for the milk with the household members. It is estimated that it consumes over 90 liters from birth to the time it is able to digest grass (Stobbs, 1966). On the other hand, if a cow happens to loose the calf, it is known that it is most likely to get on heat faster thus shortening the calving interval. However, zebu cows will normally stop giving milk as soon as the calf is removed or dead.

For the 59 animals on which information was available, the weaning age ranged between 2 to 24 months. Ninety five percent had a weaning age of less than one year. The mean was calculated as 10.8 (±.6) months. The weaning age is synonomous to the age at which suckling stopped.

Assuming that successful insemination was achieved immediately after weaning, the calving interval would be reduced substantially to less than 2 years (20 months) (assuming 10.8 months lactation and 9 months gestation). Although a cow will ideally get in calf at between 2½ and 3 months after calving, zebu cattle tend to get in calf after weaning or will stop lactating as soon as they are pregnant (Barret and Larkin, 1974).

TABLE 4.3

PRODUCTION COEFFICIENTS FOR THE ZEBU HERD

MEASURE	NO OF COWS	MEAN	MIN	MAX
1. LACTATION LENGTH (MONTHS)	53	10.3	2.0	24.0
2. WEANING AGE (MONTHS)	59	10.8	2.0	24.0
3. END OF MILK FEEDING (MONTHS)	59	10.8	2.0	24.0
4. CALVING INTERVAL (MONTHS)	21	26.3	13.0	51.0
5. PERIOD BETWEEN PARTURITION (MONTHS) AND FIRST INSEMINATION	15	15.7	29.0	35.0
6. MONTHS SINCE BIRTH (MONTHS)	102	13.4	1.0	37.0
7. CALVING AGE (YEARS)	43	3.6	1.5	8.0

4.4 Cattle Transactions

INTRODUCTION

Cattle transactions include all forms of cattle movement or transfers into and/or from the sample herd. These may take a number of forms, namely, death, slaughter purchase, gifts received or given, sales, or payment of debts. Cattle transactions involve all the aspects that may lead to the decrease or increase of the herd size excluding births within the herd. The significance of looking at cattle transactions on small farms in developing economies relates to the fact that cattle serve roles beyond the commercial one. Livestock economists need to understand the farmers goals, objectives, and potentials when doing economic analysis at the farm level. Studies of farmers responsiveness to price or economic incentives and encouragement to adopt new technology have produced inconsistent results (Doran, Kemp and Low, 1979; Kharifa and Sympson,1972; Low, 1980). An attempt is made to answer the following questions from the data:

(1) What type of transactions occur among the sample households?

(2) How are the animals utilized?

(3) What animals, in terms of sex, age or sexual maturity, are involved under different types of utilization?

(4) What are the values of the animals involved?

Out of the 55 households, 35 households had had transactions in the previous twelve months. There were 89 transactions in all giving an average of 2.5 animals transacted per household per year for the households having transactions. However, for the total sample of 55 households the average was 1.6 per year. It is important to note, however, that some transactions could not be recalled from memory by the farmers. Therefore there is ahigh probability that the transactions are under-reported.

TYPE OF CATTLE AND TYPE OF TRANSACTION AND VALUE:

The majority of the cattle transactions were with female animals, comprising 56 percent of the total. There were, however, more heifers than cows transacted. Whereas most of the heifers were sold or given away for raising, a higher percentage of the cows had been slaughtered (Table 4.4).

The transactions involved animals of a wide range of ages. For the males, a higher percentage included steers and breeding bulls. About half of the breeding bulls and male calves were reported as deaths.

For all the 89 transactions, 25 (28%) were deaths, 21 (24%) had been sold or taken away from the household herd, 17 (19%) had been slaughtered and the rest were purchases, gifts or cattle brought from one farmer or taken to another farmer. Table 4.5 shows the distribution of the animals by type of transaction and final disposal of the animals. For the 25 animals that had died, 14 (56%) were used at home for meat while 11 (44%) had their meat discarded. Twelve (92%) of the 13 animals that were purchased or received by the households were for raising purposes. The remaining one was used for slaughter. Of the animals that were sold or given away, sixteen (76%) were for raising, three were for slaughter and two were used for some unknown purpose which could include one of the above. This was an important observation in that the households do not play the usually assumed role of beef production. The keeping of cattle for beef production is not the final goal of the household livestock enterprise. They also, and quite significantly, serve as calf operators. Similarly, all the animals that were brought home from some other farm or taken to another were for raising. Death and distress slaughter accounted

TABLE 4.5. SEXUAL MATURITY BY TYPE OF TRANSACTIONS FOR THE ZEBU SAMPLE HERD

TRANSACTIONS	SEXUAL MATURITY								
	HEIFER	COW	STEER	MALE CALF	BREEDING BULL	NON BREEDING BULL	DON'T KNOW	TOTAL	%
Purchase or Receipt	5	2	3	2	1	0	0	13	15
Died	8	5	1	5	6	0	0	25	28
Slaughtered	4	8	3	1	1	0	0	17	19
Sold or given away	10	3	2	2	2	1	1	21	24
Brought home from elsewhere	3	0	4	0	3	0	0	10	11
Taken elsewhere	0	2	0	1	0	0	0	3	3
TOTAL	30	20	13	11	13	1	1	89	
%	34	22	15	12	15	1	1		100

for 38 (43%) of all the animals transacted, raising 41 (46%), and slaughtering 7 (8%). Three (3%) had their type of transactions not reported (Table 4.5).

The value of the animals ranged between 50 to 700 Tanzania shillings (T. shs). Most of the animals (65 per cent) were valued between 200 to 400 T. shs. Eight of the eleven male calves were valued between 50 to 99 T. shs. This was not surprising as one would expect male calves to be valued less and also the fact that most of these were reported as having died in which case they would not have been valuable anyway. For the animals whose age was known, the data tends to show that the older the animal, the more valuable it was. However, as one would expect, most cattle which were disposed in the form of distress slaughter were less valuable.

TABLE 4.5. TYPE OF TRANSACTIONS AND DISPOSITION OF ANIMAL

DISPOSITION OF	TYPE OF TRANSACTIONS						
	PURCHASE OR RECIPT	DIED	SLAUGHTERED	SOLD OR GIVEN AWAY	BROUGHT HOME	TAKEN AWAY	TOTAL	%
Used meat at home	0	14	3	0	0	0	17	19
Distress slaughter	0	0	13	0	0	0	13	15
To be slaughtered	1	0	0	0	0	0	1	1
To slaughter	0	0	0	3	0	0	3	3
To be raised	12	0	0	0	10	0	22	25
To be raised	0	0	0	16	0	3	19	21
Discard meat	0	11	0	0	0	0	11	12
Don't know	0	0	1	2	0	0	3	3
TOTAL	13	25	17	21	10	3	89	100
%	15	28	19	24	11	3	100	

TABLE 4.6. SUMMARY OF TRANSACTIONS DATA

		Total
INFLOWS	Purchase or receipt	13
	Brought home	10
	Total inflow	23
OUTFLOWS	Sale or gifts	21
	Taken elsewhere	3
	Total outflow	24
NET OUTFLOW		1
SLAUGHTER		17
DEATHS		25
TOTAL CATTLE TRANSACTIONS (Outflows, inflows, deaths and slaughter)		89

MILK YIELD:

The results for 22 cows showed an average milk yield of 1.4 liters per day. On the average, the cows yield 1.9 liters at first month of their lactation, 1.8 liters in the third month, 1.2 liters during the sixth month and about 0.5 liters in the latter months of the lactation.

The average milk yield per lactation was calculated to be 411.5 liters (Table 4.7). This is low relative to the yields reported in the literature. One explanation could be the inaccuracy in reporting the yield due to measurement error or wrong memory recall. There are a number of factors that could explain the variation in milk production. These will be reviewed in Chapter 5.

TABLE 4.7

MILK YIELD AT DIFFERENT PERIODS OF THE LACTATION

PERIOD	YIELD IN LITERS			
	NO. OF ANIMALS	MEAN	MIN.	MAX.
1. YESTERDAY	22	1.357	0.285	2.850
2. ONE MONTH	65	1.914	0.285	4.200
3. THREE MONTH	63	1.797	0.285	4.200
4. SIX MONTH	56	1.210	0.171	4.200
5. END OF LACTATION	55	0.465	0.150	1.710
6. SIX MONTH PRODUCT	61	298.2	38.5	756.0
7. LACT. PRODUCT	51	411.5	38.5	1154.3

CHAPTER V

SIMULATION AND REGRESSION ANALYSIS

5.1 Introduction

Livestock production on small farmers in developing economies has received the attention of economists only in recent times. For some time, research on livestock has been done by anthropologists. Technical studies were also done but with direct contributions to national livestock projects like ranches. Even where agricultural research has been directly developed to meet the needs of the small mixed farmer as with Farming Systems Research (FSR), often the livestock component has been excluded (Boer and Welsch, 1977).

The livestock component on small farms seems to have been understood as one "where the animal is a scavenger and is there because it can utilize the local plant residues and homestead wastes" (Deans 1981, p. 2). There is more agreement that livestock perform a number of social, virtual, and economic functions although the relative ranking of these functions vary widely. The importance of the economic role of livestock on small farms, however, is getting more attention at present than ever before. The research needs in this direction are great and are expressed by Eicher and Baker (1982) thus:

> We are convinced that there is a need for
> a quantum increase in research on

> livestock by technical scientists and by economists in the 1980s in order to catch up with the impressive knowledge base that has been put into place by anthropologists over the past 40 years. (p. 177)

In this chapter the technical coefficients reported in the previous chapter are used along with some of the economic tools of analysis and decision making. A number of models using different assumptions are used to run a series of simulations of the herd over a number of years. Simulation, the dynamic representation of a system achieved by a model and moving it through time (LaDue and Vincent, 1974) is used due to its robustness. A modified markovian type of analysis for steady states (Anderson, Sweeney and Williams, 1982) is used in making an economic comparison of two steady states developed from the simulation. The last part of the chapter presents the results of a regression analysis of the determinants of milk yield on total milk yield per lactation.

The extent to which the models represent the real situation is debatable. However, Blackie and Dent (1979) have this to say on the adequacy of models:

> Fortunately, in practice, we are rarely concerned with absolute truth nor in perfect representation with our models. If we accept that a functional model is an abstraction of reality and an approximation to the functioning of the real system, then the problem is not to establish the truth of the model in any absolute sense but to determine whether the model we have constructed is an adequate representation for our purposes. (p. 94)

5.2 Background to the Simulations

The general conclusion from the literature review is that in most respects, the productivity of a herd is in part a function of the management practices by the farmers. The management practices are also a function of the farmers' goals and objectives in a given social, economic, political and physical environment.

In Tanzania, the Ujamaa philosophy requires the masses to participate in communal activities like farming, management of pastures and provision of services. This implies that the Government has taken what could be called a "Transformation Approach" to development. Although the successes of this policy have not been well documented and some question whether it will have a positive impact on productivity, this research paper assumes that this policy will continue into the foreseeable future.

The productivity of zebu cattle has been shown to be generally low in relation to desired national goals. Literature tends to emphasize that four major reasons could account for this (many others have been argued against in the literature).

(1) A poor marketing system and government regulated prices.

(2) Lack of other investment opportunities which limit incentives to sell because livestock remain the main store of wealth for many.

(3) Poor environmental conditions that influence the availability of stock for sale.

(4) The need for a minimum number of animals per household to meet social and economic needs of the family and reducing risk from periodic diseases and other uncertainties.

The research will attempt to test for the potential of increasing the offtake rate in the sample herd, currently estimated at 5% to 13% (Sullivan and Farris, 1976) without drastically reducing the number of animals and without use of borrowed capital.

A second analysis will be made to observe the growth of the herd assuming improvements of some productivity traits, namely, calf mortality and calving percentage. However, it will be assumed that outside intervention will be needed to provide the marketing services necessary for the higher offtake rates. This could include increased government facilities and services.

Therefore the following analyses will be made:

(1) A simulation of herd growth over a 15 year period using the current estimated production coefficients (Base analysis).

(2) A simulation of herd growth over a 15 year period using the desired offtake of 13% with other coefficients unchanged.

(3) A simulation of herd growth over a 15 year period with changes in selected production coefficients.

(4) Determining the steady states for the herd structure and offtakes under the present production system and also under the assumptions made

in 3.

(5) Carry out a cost-benefit analysis of the proposed innovations.

ASSUMPTIONS OF ANALYSES:

The simulations are made based on the assumptions that:

(1) No animal leaves the sample herd other than by way of death until it is equal to or over 4 years. Then the animal could die a natural death or be sold (market offtake).

(2) Any transactions below 4 years occur within the sample herd (55 households) and so does not reduce the sample herd size.

(3) The number of male and female calves born each year are equal (i.e., 50% each).

(4) The mortality rates for each age category are constant over the duration of the simulation analysis.

(5) The animals that die in each age category die at the end of that period. Thus the reduction in their number is observed in the next age category.

(6) The animals that die in the last category are mainly the old.

(7) The initial number of animals (by sex) in each age category is fixed and based upon actual number observed in the sample herd.

(8) The number of animals in the first age category (0-1 years) in the next year is given by the following formula:

$$N_I = \frac{N_5 P}{2} - (\frac{N_5 D_1}{2}).$$

Where N_I = No. of animals in the 1st category by sex (female or male).

P = Calving percentage (67 percent for the herd)

D_1 = Death rate or mortality rate for the category (different for the two sexes).

N_5 = No. of cows of 4 years and over.

(9) The number of animals in the intermediate categories is calculated as follows:

$$N_J = N_J-1 - D_{J-1}N_{J-1}.$$

Where N_J = No. of animals in the Jth age category.

N_J-1 = The previous age category.

D_J-1 = Death rate (different for each group--male or female of the last category).

Number of animals in the last category:

$$N=N_4-D_4N_4+N_5-ON_5-D_5N_5$$

Where N_5 = No. of animals in the 5th category for the female sex group.

N_4 = No. of animals in the previous category (4th).

D_4 = Death rate (4th age category)

D_5 = Death rate (5th age category).

O = Offtake rate.

However, in subtracting the offtake, a modification was made in the model so that the male to female ratio remains much the same as in the original structure.

The basic assumptions used in the base analysis is shown in Table 5.2. Adjustments are made from these numbers in subsequent simulations.

TABLE 5.1. HERD STRUCTURE AND SIZE OF THE SAMPLE HERD

AGE CATEGORY (YEARS)	NUMBER OF ANIMALS MALES	FEMALES
0-1	15	21
1-2	6	9
2-3	8	14
3-4	11	13
4	25	77
TOTAL	65	134
OVERALL TOTAL	199	

Source: Sample herd data

TABLE 5.2. ANIMAL MORTALITY RATES BY AGE AND SEX (MODEL 1)

AGE CATEGORY	MORTALITY RATE MALE	FEMALE
0-1	27	15
1-2	23	12
2-3	20	12
3-4	8	5
4	8	5

Source: Zalla, Unpublished Ph.D. Thesis

MODEL 1.

This was the base model. A simulation of the herd growth over a 15 year period was done using the coefficients presented in Table 5.1 and 5.2. The objective was to emulate the age-sex structure and herd size over the period. In the first simulation under model 1, a 5 percent offtake rate was used over the 15 year period (Appendix 2).

The results show a 89.95 percent (from an initial size of 199 animals to 378) growth in the herd over the 15 year period. The average annual increase was 4.37 percent. This was an indication of the potential for a higher offtake than the currently estimated national average of 59 percent. However, the annual growth rate compares well with the rates cited for similar areas in Eastern Africa.

Dahl and Hort (1976) have reported annual herd growths of 8 percent for Zambia, 5.6 percent for Nothern Kenya and 10 percent for Sahelian Cattle. The average annual offtake for the herd is 11 animals with about equal numbers for each sex.

In the second simulation, the same coefficients are followed as in simulation one. The only difference is that an offtake rate of 13 percent is used rather than 5 percent.

The results of the simulation clearly show a continued decline of the herd (Appendix 3). Over the 15 year period, the size of the herd declines by 52.76 percent. However, the annual commercial offtake is considerably higher with an average of 25 animals per year.

The conclusion arising from the two simulations is that in the present circumstances and/or assumptions, an annual commercial offtake of 13 percent is unattainable if the current herd size has to be maintained. However, simulation one shows that the commercial offtake could be increased above the current national estimate of 5 percent.

Therefore, the next step was to determine the optimal offtake rate under the current production system (Model 1). Optimal in a sense that it does not lead to a substantial decline or growth of the herd. The optimal offtake rate was found to be approximately 7.5 percent (Appendix 4). The sample herd attains a steady state in the 12th year of the simulation. That is, a situation whereby there was no or little change in the age-sex structure of the sample herd nor the annual commercial offtake.

MODEL II

The belief that the productivity of the herd could be improved through reduced mortality and increased calving percentage was the reason for the formulation of Model II.

In this analysis a number of assumptions are changed. Since the herd offtake rate can be increased substantially, it was assumed that if this increase was implemented, then the earning collected could contribute to the improvement of the herd through reduced mortality rates especially for the younger animals and increased calving percentage. These improvements do not necessarily need high levels of technology and capital. It is assumed that moderate improvements like providing housing for young calves and especially increased calving percentage could be attained by giving more attention to heat detection for the cows, borrowing a bull from a neighbour, and other simple husbandry practices. The ability to hire labor, which is not practiced with the livestock enterprises could possibly allow for more feed--like the grass and bananas that have to be gathered--to be given to the animals. This practice would contribute to better nutrition, high growth rates, earlier sell age for bulls and lower ages at calving for cows. Similarly calves, especially those in a transition from housed management to grazing would be more able to stand the outside environment and be more resistant to diseases. Also the period following the first year is also crucial to the growth of the herd because cattle at this age have a high mortality rate. The high adoption rate of improved technology in the area is reported by Sullivan and Farris (1976).

The assumptions of the model were:

(1) That mortality rates for the first three age categories could be reduced by five percent with minimal husbandry practices (Table 5.3), and

(2) that the calving percentage could also be increased by the same percentage from 67 to 72 percent.

Thus in most respects, the model is similar to the original version. Similarly, the first two simulations were done at 5 and 13 percent (Appendices 5 and 6 respectively). A search was also made for the offtake under the new coefficients that would give a steady state for the herd in relation to age-sex structure and offtake as in the previous model (Appendix 7). The model attained a steady state in the 13th year of the simulation with an offtake of 9.3 percent (Appendix 7).

Table 5.3 shows the age-sex structure of the herd in the stable state and the offtake. In the next section, the two steady states from Model I and Model II (henceforth referred to as steady states one and two respectively) are analyzed using the fifteenth year coefficients.

TABLE 5.3. ANIMAL MORTALITY BY AGE AND SEX (Model II)

AGE CATEGORY	MORTALITY RATE MALE	FEMALE
0-1	22	10
1-2	18	7
2-3	15	7
3-4	8	5
4	8	5

RESULTS

The simulation using the current production coefficients attained a stable/steady state in the 12th year at a 7.5 percent offtake. For the improved state (under the project), a stable/steady state was attained in the 13th year at an offtake of 9.3 percent.

TABLE 5.4. HERD STRUCTURE AND SIZE UNDER THE STEADY STATES FOR THE TWO MODELS

	MODEL I		MODEL II	
AGE CATEGORY (YEARS)	MALE	FEMALE	MALE	FEMALE
0-1	18	21	20	24
1-2	14	18	16	21
2-3	11	16	14	20
3-4	10	15	13	19
4	25	73	25	73
TOTAL (by sex)	78	143	88	157
TOTAL	221		242	
Offtake (by sex)	7	10	10	13
Total Offtake	17		23	

5.3 Economic Analysis of the Two Steady States

In this section, economic issues related to the two steady states are analyzed; the issues explored are as follows:

(1) What is the value of the animal sales on an annual basis for each state?

(2) What is the value of milk sales in state two over and above the value of milk in state one?

(3) What is the value of the herd structure for the two states?

(4) What are the costs that a developer would incur in order to attain state two?

THE ANNUAL INCOME FROM ANIMAL SALES:

The steady state one has a commercial offtake of 17 animals per year while state two has a commercial offtake of 22 animals per year. In order to calculate the monetary value of the sales, a distinction has to be made in the sexes since males have different values from females of the same age structure (Table 5.5).

STEADY STATE I.

SEX OF ANIMAL	NUMBER OF ANIMALS	VALUE PER ANIMAL (T. Shs)	TOTAL VALUE (T. Shs)
Male	7	385	2695
Female	10	365	3650
			6345

STEADY STATE II.

SEX OF ANIMAL	NUMBER OF ANIMALS	VALUE PER ANIMAL (T. Shs)	TOTAL VALUE (T. Shs)
Male	10	385	3850
Female	13	365	4745
			8595

The steady state one will have an annual income of 6,345 T. Shs. while state two earns 8,595 T. Shs. per annum. Therefore the incremental benefit from sales would be 8,595-6,345 = 2,250 T. Shs.

MILK SALES

In addition to the higher offtake rate, state two is achieved at a higher calving percentage (state one is at 67

Table 5.5. COMMERCIAL VALUE FOR THE ANIMALS BY SEX AND AGE (Tanzania Shillings)

AGE CATEGORY	ANIMAL VALUE	
	MALE	FEMALE
0-1	70	140
1-2	80	185
2-3	240	205
3-4	250	250
4	385	365

Source: Computed from the Sample Herd Data.

percent while state two is at 72 percent.) Therefore with an equal number of animals in the 5th category, state two has a higher number of animals in lactation than state one. At 67 percent, there are 67/100 X 73 = 49 animals compared to 72/100 X 73 = 53 animal in milk. This difference of 4 animals has the potential of yielding 411.5 litres of milk per lactation per cow. At a price of 2.00 T. Shs. a litre, this represents an incremental income of 411.5 X 4 X 2 = 3,292 T. Shs. per year.

HERD VALUE:

Apart from the incremental earnings from animal and milk sales, there is a substantial change in the structure of the herd contributing to a significant difference in the

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*$1 U.S. = 7.14 T. Shs (1970).

value of the two herds in the stable states (Tables 5.6 and 5.7). The calculations shown in the tables give a difference of 2,260 T. Shs. (61,850 - 59,590) in the value of the two herds. However, this is a one time adjustment and the value of the increase is captured indirectly in milk and offtake changes.

Therefore a government project aimed at improving the productivity of the herd would weigh the costs of the project against the annual returns estimated at 5,542 T. Shs. (2,250 + 3,292).

Literature tends to emphasize the fact that the commercial value more or less estimates the net returns to the farmer. This being so because fixed and variable costs to producers are minimal due to such factors as public ownership of land, labor for herding being provided by the family children not in school and government subsidized improved technology; for example, dips and veterinarian services (Sullivan and Farris, 1976). The next section incorporates the costs into the analysis over a fifteen year period.

TABLE 5.6. THE COMMERCIAL VALUE OF THE HERD UNDER STEADY STATE I

	AGE CATEGORY	SEX M	SEX F	ANIMAL VALUES M	ANIMAL VALUES F	TOTAL VALUE
1.	0-1	18	21	70	140	4200
2.	1-2	14	18	80	185	4450
3.	2-3	11	16	240	205	5920
4.	3-4	10	15	250	250	8750
5.	4	25	73	385	365	36270
						59,590

Discounted percent value = 49490 x .1401 = 8348.56

TABLE 5.7. THE COMMERCIAL VALUE OF THE HERD UNDER STEADY STATE II

	AGE CATEGORY	SEX M	SEX F	VALUE M	VALUE F	TOTAL VALUE
1.	0-1	20	24	70	140	4760
2.	1-2	16	22	80	185	5350
3.	2-3	14	20	240	205	7460
4.	3-4	13	19	250	250	8010
5.	4	25	73	385	365	36270
						61,850

Discounted present value: 61850 X .1401 = 8,665.18

Difference in value: 8665.18 - 8348.56 = 316.62 T. Shs.

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*A discount rate of 14 percent estimates the average used in LDC's (Eicher and Baker 1982).

5.4 A Cost-benefit Analysis of the Proposed Program

BENEFITS ARISING FROM THE PROGRAM:

The benefits accruing from the program include increased offtake and milk production. These are evaluated over the fifteen year period over which the simulations were run (Tables 5.9 and 5.10). The net difference in value for the herds (in the initial state and under the program) was computed in Tables 5.6 and 5.7, respectively.

COSTS INCURRED BY THE PROGRAM:

The costs under the program are generally more difficult to evaluate since the package of activities necessary to attain the improvements can't be exhaustively listed. A survey of literature on the area indicate that extension services (veterinary, animal husbandry and farm management) are being offered by government institutions (Walton I C, 1980). However, the efficiency and effectiveness of these programs leaves much to be desired.

The proposed program, therefore, would be directed at increasing the effectiveness of the existing programs and increasing the knowhow of the farmers in utilizing the innovations through the extension service. Thus a focus could be made on:

1. Farmer Training
2. A dipping program
3. Vaccination

The training program would cover the following aspects of livestock production:

(1) General farm economics and livestock marketing.

(2) Management of pregnant cows including nutrition and care at calving. This would increase the chances of having healthy calves at birth.

(3) Calf management practices. These would include nutrition, disease control, housing, dehorning and castration. These practices would enhance the reduction of calf mortality and increase the growth rate of the calves.

(4) General herd management including breeding bull selection, heat detection and culling. These techniques would ensure the retention of production animals in the herd and also improve the breeding program thus reducing calving intervals.

(5) Range management and animal nutrition with emphasis to locally available pastures and feeds like food crop residues and wastes. This would also contribute to the efficient use of resources and attainment of faster growth rates thus leading to early marketing of calving ages.

Under the proposed program, courses would be run for a week (5 days) in a year for the initial five years after which the existing institutions would continue to be operational. Five knowledgeable extension personnel could be invited to give the lectures at a fee of 50 T. Shs. a day. This would mean that an expenditure of 2,500 would be incurred per year.

The dipping program could be improved by ensuring that correct acaricide concentration levels are maintained at every dipping. This could be achieved by hiring the services of a veterinarian who would check the levels of the acaricides at each dipping. Assuming that dipping is done weekly, and a fee of 30 T. Shs is paid per visit, a total amount of 1,560 would be incurred annually.

In addition, the vaccination program could be reinforced by expending 1,000 per annum. This vaccination program would be directed against diseases like anthrax, foot and mouth, brucellosis and hemorhagic septaceamia.

Although this health control package may not be comprehensive enough, it is assumed that it will result in the reductions in mortality rates and the increase in calving percentage as was assumed in Model II.

TABLE 5.8. COSTS UNDER THE PROGRAM (INITIAL FIVE YEARS)*

ITEM	COST
1. Training	2,500
2. Dipping	1,560
3. Vaccination	1,000
	5,060

*After the initial five years, the training program would be phased off. Thus the annual costs thereafter would be 5,060 - 2,500 = 2,560.

TABLE 5.9 . RETURNS FROM INCREASED MILK PRODUCTION (T. SHS)

	1 No. of Mature Cows		2 No. of Lactating Cows		3	4	5
Year	State I	State II	State I	State II	Net Difference	Net Milk Yield*	Total Value
0	77	77	52	55	3	1,234.5	2,469
1	74	77	50	55	5	2,057.5	4,115
2	68	74	46	53	7	2,880.5	5,761
3	59	68	40	49	9	3,703.5	7,407
4	58	68	39	49	10	4,115.0	8,230
5	63	71	42	51	9	3,702.5	7,407
6	67	73	45	52	7	2,880.5	5,761
7	70	74	47	53	6	2,469.0	4,938
8	70	73	47	52	5	2,057.5	4,115
9	68	72	46	52	6	2,469.0	4,938
10	68	72	46	52	6	2,469.0	4,938
11	70	73	47	53	6	2,469.0	4,938
12	72	73	48	53	5	2,057.5	4,115
13	73	73	49	53	4	1,646.0	3,292
14	73	73	49	53	4	1,646.0	3,292
15	73	73	49	53	4	1,646.0	3,292

*Computed at 411.5 liters per cow per lactation.

TABLE 5.10. RETURNS ARISING FROM THE INCREASED OFFTAKE

Year	1 Offtake State I		2 Offtake State II		3 Net Offtake		4 Value per Animal (T. Shs.)		5 Total Value (T. Shs)
	M	F	M	F	M	F	M	F	
0	4	11	5	14	1	3	385	365	1,480
1	7	8	8	11	1	3	385	365	1,480
2	5	11	6	14	1	3	385	365	1,480
3	6	10	6	14	0	4	385	365	1,460
4	5	11	6	15	1	4	385	365	1,845
5	7	9	9	11	2	2	385	365	1,500
6	7	9	9	11	2	2	385	365	1,500
7	7	9	9	11	2	2	385	365	1,500
8	6	10	9	12	3	2	385	365	1,885
9	6	10	7	14	1	4	385	365	1,845
10	6	10	9	13	3	3	385	365	2,250
11	7	9	10	12	3	3	385	365	2,250
12	7	10	9	13	2	3	385	365	1,865
13	7	10	9	13	2	3	385	365	1,865
14	7	10	10	13	3	3	385	365	2,250
15	7	10	10	13	3	3	385	365	2,250

TABLE 5.11. DISCOUNTED NET RETURNS FROM THE PROPOSED PROGRAM (T. SHS)

Year	1 Gross Returns* (5 + 10)	2 Costs	3 Net Returns	4 Discount Rate (14%)	5 Discounted Returns
0	3,949	5,060	-1,115	1.0	-1,115
1	5,595	5,060	535	.8772	469.30
2	7,241	5,060	2,181	.7695	1,678.28
3	8,867	5,060	3,807	.6750	2,569.72
4	10,075	5,060	5,015	.5921	2,969.38
5	8,907	5,060	3,847	.5194	1,998.13
6	7,261	2,500	4,761	.4556	2,169.11
7	6,438	2,500	3,938	.3996	1,573.62
8	6,000	2,500	3,500	.3506	1,227.10
9	6,783	2,500	4,283	.3075	1,317.02
10	7,188	2,500	4,688	.2697	1,264.35
11	7,188	2,500	4,688	.2366	1,109.18
12	5,980	2,500	3,480	.2076	722.45
13	5,157	2,500	2,657	.1821	483.84
14	5,542	2,500	3,042	.1597	485.81
15	5,542	2,500	3,042	.1401	426.18
					19,348.47

*Summation of corresponding values in column 5 of Tables 5.9 and 5.10

RESULTS

Tables 5.8 through 5.11 show the computation of the discounted present value (DPV) of the returns over the fifteen years. Under the assumptions made, a net income of 19,348.47 is realized. In order to reflect the expected annual returns over the years, this value is amortized using a rate of 14 percent to give an annuity of 3,149.93 T. Shs (19,348.47 X .1628). Therefore, a proposed program with the objectives of increasing calving percentage and reducing calf mortality would be economical under the assumptions made. In addition the herd would have a higher value of 316.62 T. Shs under the project (Tables 5.6 and 5.7).

5.5 Determinants of Milk Yield Production

REGRESSION ANALYSIS:

Regression analysis is a statistical tool which utilizes the relationship between two or more quantitative variables so that one variable can be predicted from the other or others (Neter and Wasserman, 1974, p. 21). When a single predictor or independent variable is involved, then the regression procedure is termed simple regression. When more than one independent variable is included, the procedure is called multiple regression.

Multiple regression may be viewed either as a descriptive tool by which the linear dependence of one variable on others is summarized and decomposed, or as an inferential tool by which the relationships in the population are evaluated from the examination of sample data. The most important uses of the technique as a descriptive tool are:

(1) To determine the best linear prediction equation and evaluate its prediction accuracy.

(2) To control for other confounding factors in order to evaluate the contribution of a specific variable or set of variables.

(3) To find structural relations and provide explanations for seemingly complex multivariate relationships, such as done in path analysis.

The study will use regression analysis to evaluate the contribution of a number of variables in milk production. The general form of a multiple regression is as follows:

$$Y^1 = A + B_1X_1 + B_2X_2 + \ldots B_kX_k$$

where Y^1 = the estimated value of Y, the dependent variable.

A = the intercept of Y

X_1 to X_k = the independent variables

$B_{i's}$ = are the regression coefficients for X_1 to X_k.

The partial regression coefficients, the $B_{i's}$ in the equation stand for the expected change in Y with a change of one unit in the corresponding independent variable when all the other variables are held constant or otherwise controlled. The relative magnitude of the partial regression coefficient of an independent variable can be quite different from its multivariate regression coefficient with the dependent variable since the multivariate coefficient is confounded with the effects of other correlated independent variables.

The overall accuracy of the prediction equation is reflected by R^2, the proportion of variation explained by the variables included in the regression equation. Since the presence of an additional variable has some contribution to the overall R^2, a better statistical measure for the variation explained by the variables is $\bar{R}^2$. (Coefficient of multiple determinations).

Since independent variables are measured in different units (e.g., number of births the cow had previously, etc.), it is difficult to determine the relative importance of each independent variable on the basis of the B values alone. Since the relative contribution of each variable was of interest, the standardized regression coefficients were reported.

T-statistics test the significance of the B-coefficients at some stipulated level for a given sample size. Another statistical tool for testing whether the regression equation could be regarded as a satisfactory predictor is the F-ratio. Usually the F-ratio should be four times the reading for the selected percentage point in the F-table (Draper and Smith, 1966, p. 64).

COMPUTATION OF LACTATION MILK PRODUCTION:

Data on milk yield was collected in parts at one month, 3 months, 6 months and end of lactation. Thus the lactation yield had to be computed. The formula used to estimate milk yields per lactation was:

$$Q_L = 90\left(\frac{Q_1+Q_3}{2}\right) + 90\left(\frac{Q_3+Q_6}{2}\right) + 30(M_L-6)\left(\frac{Q_6+Q_E}{2}\right).$$

where Q_L = Lactation milk production

Q_1 = daily milk production at one month after parturition

Q_3 = daily milk production at 3 months after parturition

Q_6 = daily milk production at six months after parturition

Q_E = daily milk production at the end of lactation.

M_L = length of lactation in months.

If M_L (length of lactation in months) was less than three or more than six, their appropriate adjustments in the first two terms were made for cows which had not yet completed their most recent lactation. The missing production and lactation length figures were taken from the previous lactation. Since cows generally produce less milk in their first one or two lactations and given that a high proportion of cows had calved only once or twice, this procedure exerts obvious downward bias on estimated lactation milk production. Again figures reported by different enumerators were significantly different suggesting enumerator bias or reporting errors.

The analysis of the sample herd milk yields show that there is a very big variation in milk production net of calf consumption. The mean milk production was 411.5 liters with a minimum of 38.5 liters and a maximum yield of 1154.3 liters.

The review of literature showed that in some production systems, different calf management practices used do affect the amount of milk available to the household. In this regard, it was argued that a male calf may be starved because the farmer used most of the milk from the cow leaving little for the calf. It is also argued that in most cases, the lactation will stop soon after the calf is dead or weaned. Although some management practices have been developed to prolong the milk production of a cow in the absence of the calf, they seem not to be very successful and are demanding with regard to time and convenience. Since little was known about the production system and limited information was available on the theoretically known determinants of milk production, the study used some of the determinants for which data were available and have been cited as important determinants of milk production.

The following are some of the variables used in the analysis:

(1) Age of calf at weaning.

(2) Age of the animal.

(3) Number of days animal is fed bananas per week.

(4) Number of times animal has given birth.

(5) Dummy variable for sex of calf 1; female; 0; male.

(6) Frequency of water supply.

(7) Salt feeding frequency.

OTHER FACTORS THAT AFFECT MILK YIELD VARIABILITY:

A number of factors which are known to affect the milk yield in cattle could not be used in the analysis because they were not reported. They include:

(1) The nutrition level of the animal especially regarding more important nutrients during the lactation.

(2) The milking environment and milking techniques. This is especially important since milk release during milking is controlled by hormones.

(3) Number of times animal is milked per day.

(4) Amount of milk animal is left to consume. This is a function of how much is left milked for the calf to consume and/or length of time the calf is allowed with the dam.

(5) Presence or absence of calf during milking.

(6) Physiological condition of the animal. This could be a function of disease, pregnancy and other factors other than the feeding level.

Therefore the study could not analyze all factors affecting the variation in milk production nor the reasons for the low average yield per lactation for the herd.

EXPECTED SIGNS FOR SOME OF THE VARIABLES:

Some of the variables used were expected to have the signs for the B-coefficients known apriori.

(1) The milk yield per animal is expected to be positively related to the weaning period. The longer the animal is kept with a suckling calf, the more milk the animal is expected to give. It is a known characteristic of the zebu cattle

that on loss of her calf, the cow will stop milking since release is controlled by hormonal action stimulated by the presence of the calf.

(2) Age is expected to have a curvilinear relationship with milk yield. Thus one would expect to have a positive sign for the age variable and a negative sign for the age squared variable.

(3) The number of days the animal is fed banana leaves is a proxy for the feeding level. Thus it is assumed that the animals which have access to banana leaves, in addition to the general grazing, have a higher level of nutrition than the others and hence produce more milk. Thus a positive coefficient is expected. Similarly one would expect a positive coefficient for the number of days animal is fed shamba grass, salt and water.

(4) The coefficient for the dummy variable is expected to take any sign since no specific management practice was known in this particular area to favor one sex or the other.

The analysis is made with the general awareness that the data was inaccurate due to reporting errors by the people interviewed and enumerators (Zalla 1981). In addition much of what was recorded were estimates and in a number of cases, average milk yields were arrived at by estimating the previous lactation's for the cow concerned.

Plots of the dependent variable against independent variables did not indicate any significant relationships.

Therefore, the regression analysis was done with the awareness that there could be insignificant relationships.

ANALYSIS:

The procedure for the analysis was to use all the variables considered relevant into the equation and then reducing them systematically from the equation using the statistical criteria like the t-statistic of the coefficients and caution against multicollinearity. The independent variable was the milk yield per lactation net of calf consumption. A number of equations were run using the linear and quadratic forms of regression analysis.

The final equation was selected based on following criteria:

(1) The number of variables in the model. Too many variables tend to cause bias in the coefficients due to correlation between variables. It is also more difficult to avoid multicollinearity. With 35 observations, five variables were regarded appropriate.

(2) The equation with the highest R^2 or preferably $\overline{R}^2$ is often regarded the best since it explains a bigger proportion of the variation in the dependent variable given the variables included in the equation.

(3) Variables used in the equation must be important in influencing the dependent variable. Although the importance of a variable is usually supported

by the t-statistic or the statistical significance of the variable, it is common practice to keep a variable in an equation because of prior knowledge that it is important in influencing the dependent variable.

(4) The signs of the coefficients should also meet the expectations or prior knowledge of how the variable relates to the dependent variable.

After considering the above factors, the best equation to explain the variation in milk yield production and to convey the relative importance of the variables in the equation was selected. It is present as follows:

$$\underset{}{Y = -103} + \underset{\substack{(.78)\\ XX^*}}{.11X_1} + \underset{\substack{(5.0)\\ X^*}}{.72X_2} + \underset{\substack{(.36)\\ XXXX}}{.01X_3} + \underset{\substack{(.10)\\ XXXXX}}{.01D_1} + \underset{\substack{(.97)\\ XXX^*}}{.85X_4} - \underset{\substack{(-1.4)\\ XX^*}}{1.11X_5}$$

where $R^2 = .56$

$\bar{R}^2 = .46$

T-Statistics in parenthesis

$F = 5.9$

X_1 = Number of times animal is fed banana leaves per week

X_2 = Age of calf at weaning (months)

X_3 = Number of times animal has given birth.

X_4 = Age of the animal (years)

X_5 = Age of the animal (squared)

D_1 = Dummy variable; 1=female; 0=male

X = Significant at the .00001 level

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* = one-tail test used.

XX = Significant at the .1 level

XXX = Significant at the .2 level

XXXX = Significant at the .8 level

XXXXX = Significant at the .9 level

The equation explains half the variation in milk yield. This is relatively a good percentage in view of the fact that data used was not complete in that a number of variables that could have been incorporated in the model were missing.

The signs of the regression coefficients met the expectations or could be logically explained. The number of times animal is fed bananas has a positive contribution to milk yield. Similarly the number of times animal has given birth and the age of calf at weaning. The age of animal has a negative contribution to milk yield. This is possibly due to the higher calving age for the herd and poor physiological performance with age. Otherwise one would expect an increase in milk yield with time over the first few calvings and a decline in latter calvings. Thus it is easier to explain the positive sign for the number of times animal has given birth since most animals had had one or two calves only. This is partly due to mammary gland development in subsequent births and the fact that with subsequent births the animal is more at ease during milking thus facilitating milk let-down.

The positive sign for the dummy variable is an important contribution to the theories cited throughout this paper. Although it was argued that more milk would be available after milking the male calf or subsequent to starving it, the sign indicates that it is rather the presence of a female calf that is positively associated with milk yield in this system. This could be due to the fact that the animal and calf would be better fed and managed so that milk production is facilitated. In addition the presence of a female calf could mean a longer lactation period and thus a higher total yield for the lactation.

The magnitude of the B-coefficients given an indication of the relative importance of the variable in the regression equation. This is so because it is the standardized regression coefficients that were reported. Consequently, the order of importance for the variables is: weaning age of calf, age of cow, number of times animal has given birth, number of days animal is fed banana leaves per week and sex of the calf.

The equation is regarded as a mere attempt to explain the variation of milk yield in the sample herd and the variables that influence it. It does not exhaust all the variables that are known to be important nor does it use all possible models in arriving at the final result.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

The age-sex composition of a herd in a given production system is a major determinant of animal sales, milk production, herd growth, resistance to drought and general herd productivity (Shapiro, 1979). Although it is common to observe a higher female to male ratio in most livestock production systems, little information has been available to explain the changes that occur in sex ratios and ages of the animals in the herd. The paper brings together the literature from different production systems in Africa. Production traits, including calving age, calving interval, milk yield, mortality and offtake rates are reported. An attempt has also been made to give reasons for the differences in each production system cited.

The study particularly focuses on the W'Arusha of Northern Tanzania. Fifty five households were used in the study. The average herd size per household was 4 animals with the biggest herd being composed of 9 animals and the smallest with one animal.

The sample herd structure was found to be 67 percent female and 33 percent male. Fifty four of the animals whose age was known were four years or less. Only 11 percent of the animals were ten years or more and only one of these was a steer, the rest being females. The mean calving age was found to be 3.6 years, calving interval, 26.3 months, weaning age, 10.8 months, lactation length, 10.3 months, lactation production, 411.5 liters and the period between parturition and first insemination was 15.7 months.

On the average, each household carried out some form of transaction for the year. Animals of both sexes were involved, females (55%) and males (45%). About half of the animals were below three years or age and the rest were between 3 to 9 years of age. However, it is important to note that the transactions involved death or distress slaughter (43%), raising (46%) and slaughter (8%). There was a strong indication that all these transactions more or less took place within the sample herd. Therefore little of the transactions could be regarded as commercial offtake.

Attempts to explain the variation in milk yield were made with a lot of caution. Only 46 percent of the variation could be explained and a number of reasons are raised to explain the shortcomings of the model used.

The age of calf at weaning variable was statistically significant emphasizing the importance of the presence of the calf in facilitating milk release by the dam. The positive coefficient associated with dummy variable (sex of calf) is a further indication that female calves tend to be cared for more and are not slaughtered early (at least before the end of the lactating period). By being with the dam at milking they contribute to longer lactation periods thus higher total milk production. The feeding of banana leaves also has a positive contribution to milk production. This could be an indication of not only the nutrition value of the banana leaves but also their role in providing water to the animals. The simulations made for the herd growth showed that indeed offtake rate could be increased with little risk of reducing the herd size at the current level and still allowing for some growth in the total herd size. However, under the assumptions built in the model, an offtake rate of 13 percent was not feasible. The analysis over a fifteen year period shows that an intensive health program would result in increased returns to the tune of 19,348.47 T.shs. over the period. It is therefore recommendable that village planning efforts be directed towards attaining this goal of improving the productivity of the herd. The analysis of family herds as one big herd inevitably biases the results and has important implications in relation to what the herd structure and resource requirements would be under the two systems.

Any attempts to recommend changes arising from the conclusions of the analyses need more first-hand knowledge of the production system than was available to the author. Therefore more micro-level studies, specifically attempting to focus on the production system need to be carried out in order to come out with more practical results. The relationship between livestock and crop enterprises need be evaluated with close attention to returns, and competition for resources on the farm. The marketing constraints raised in the paper need to be analyzed in relation to how they influence the livestock sector.

There is still much that could be known and done before there is hope to improve the small holder livestock production systems to levels that would meet both the farmers' goals and objectives and those of the nation.

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APPENDIX I

SUMMARY OF
DATA COLLECTED ON CATTLE

1. Sex.
2. Age.
3. Sexual maturity.
4. Breed.
5. Where animal was acquired.
6. Price paid for the animal.
7. Feeding: (1) Type of grass or feeds.
   (2) Feeding regime
   (3) Frequency of feeding salt or water supply to animal.
   (4) Amount of feed fed to animal.
8. Number of times animal has given birth.
9. Months since first given birth.
10. Sex of last calf.
11. Disposition of last calf.
12. Months between last and previous birth.
13. Milk yield.
14. Lactation length.
15. Age of calf at weaning in month.
16. Age at first breeding for heifers.
17. Months between parturition and first insemination.
18. Type of semen used for insemination.

APPENDIX 2

A SIMULATION OF HERD AT FIVE PERCENT OFFTAKE (MODEL I)

YEAR= 0 TOTAL OFFTAKE =10											
FEMALES	1	21	2	9	3	14	4	13	5	77	OFF= 8
MALES	1	15	2	6	3	8	4	11	5	25	OFF= 2
YEAR= 1 TOTAL OFFTAKE =10											
FEMALES	1	22	2	18	3	8	4	13	5	79	OFF= 6
MALES	1	19	2	12	3	5	4	7	5	29	OFF= 4
YEAR= 2 TOTAL OFFTAKE =11											
FEMALES	1	22	2	19	3	16	4	8	5	81	OFF= 6
MALES	1	19	2	15	3	10	4	5	5	28	OFF= 5
YEAR= 3 TOTAL OFFTAKE =11											
FEMALES	1	23	2	19	3	17	4	15	5	79	OFF= 6
MALES	1	20	2	15	3	12	4	9	5	26	OFF= 5
YEAR= 4 TOTAL OFFTAKE =12											
FEMALES	1	22	2	20	3	17	4	16	5	82	OFF= 7
MALES	1	19	2	15	3	12	4	11	5	27	OFF= 5
YEAR= 5 TOTAL OFFTAKE =12											
FEMALES	1	23	2	19	3	18	4	16	5	87	OFF= 6
MALES	1	20	2	15	3	12	4	11	5	29	OFF= 6
YEAR= 6 TOTAL OFFTAKE =13											
FEMALES	1	25	2	20	3	17	4	17	5	91	OFF= 7
MALES	1	21	2	15	3	12	4	11	5	31	OFF= 6
YEAR= 7 TOTAL OFFTAKE =13											
FEMALES	1	26	2	22	3	18	4	16	5	95	OFF= 7
MALES	1	22	2	16	3	12	4	11	5	33	OFF= 6
YEAR= 8 TOTAL OFFTAKE =14											
FEMALES	1	27	2	23	3	19	4	17	5	98	OFF= 7
MALES	1	23	2	17	3	13	4	11	5	33	OFF= 7
YEAR= 9 TOTAL OFFTAKE =14											
FEMALES	1	28	2	24	3	20	4	18	5	101	OFF= 8
MALES	1	24	2	18	3	14	4	12	5	34	OFF= 6
YEAR= 10 TOTAL OFFTAKE =15											
FEMALES	1	29	2	25	3	21	4	19	5	105	OFF= 8
MALES	1	25	2	18	3	14	4	13	5	35	OFF= 7
YEAR= 11 TOTAL OFFTAKE =15											
FEMALES	1	30	2	26	3	22	4	20	5	110	OFF= 8
MALES	1	26	2	19	3	14	4	13	5	37	OFF= 7
YEAR= 12 TOTAL OFFTAKE =16											
FEMALES	1	31	2	26	3	23	4	21	5	116	OFF= 8
MALES	1	27	2	20	3	15	4	13	5	38	OFF= 8
YEAR= 13 TOTAL OFFTAKE =17											
FEMALES	1	33	2	27	3	23	4	22	5	120	OFF=10
MALES	1	28	2	21	3	16	4	14	5	40	OFF= 7
YEAR= 14 TOTAL OFFTAKE =17											
FEMALES	1	34	2	29	3	24	4	22	5	126	OFF= 9
MALES	1	29	2	22	3	17	4	15	5	42	OFF= 8
YEAR= 15 TOTAL OFFTAKE =18											
FEMALES	1	36	2	30	3	26	4	23	5	132	OFF= 9
MALES	1	31	2	22	3	18	4	16	5	44	OFF= 9

APPENDIX 3

A SIMULATION OF HERD GROWTH AT THIRTEEN PERCENT OFFTAKE (MODEL I)

YEAR= 0 TOTAL OFFTAKE =26						
FEMALES	1 21	2 9	3 14	4 13	5 77	OFF=20
MALES	1 15	2 6	3 8	4 11	5 25	OFF= 6
YEAR= 1 TOTAL OFFTAKE =26						
FEMALES	1 22	2 18	3 8	4 13	5 69	OFF=16
MALES	1 19	2 12	3 5	4 7	5 23	OFF=10
YEAR= 2 TOTAL OFFTAKE =25						
FEMALES	1 20	2 19	3 16	4 8	5 60	OFF=18
MALES	1 17	2 15	3 10	4 5	5 20	OFF= 7
YEAR= 3 TOTAL OFFTAKE =25						
FEMALES	1 17	2 18	3 17	4 15	5 47	OFF=18
MALES	1 15	2 13	3 12	4 9	5 16	OFF= 7
YEAR= 4 TOTAL OFFTAKE =23						
FEMALES	1 13	2 15	3 16	4 16	5 44	OFF=15
MALES	1 11	2 12	3 10	4 11	5 15	OFF= 8
YEAR= 5 TOTAL OFFTAKE =21						
FEMALES	1 13	2 11	3 13	4 15	5 45	OFF=12
MALES	1 11	2 8	3 10	4 9	5 15	OFF= 9
YEAR= 6 TOTAL OFFTAKE =19						
FEMALES	1 13	2 11	3 10	4 12	5 45	OFF=12
MALES	1 11	2 8	3 6	4 9	5 15	OFF= 7
YEAR= 7 TOTAL OFFTAKE =18						
FEMALES	1 13	2 11	3 10	4 10	5 43	OFF=11
MALES	1 11	2 8	3 6	4 6	5 15	OFF= 7
YEAR= 8 TOTAL OFFTAKE =17						
FEMALES	1 12	2 11	3 10	4 10	5 40	OFF=11
MALES	1 11	2 8	3 6	4 6	5 14	OFF= 6
YEAR= 9 TOTAL OFFTAKE =17						
FEMALES	1 11	2 11	3 10	4 10	5 37	OFF=11
MALES	1 10	2 8	3 6	4 6	5 13	OFF= 6
YEAR= 10 TOTAL OFFTAKE =16						
FEMALES	1 11	2 10	3 10	4 10	5 35	OFF=10
MALES	1 9	2 8	3 6	4 6	5 12	OFF= 6
YEAR= 11 TOTAL OFFTAKE =15						
FEMALES	1 10	2 10	3 9	4 10	5 34	OFF= 9
MALES	1 9	2 7	3 6	4 6	5 11	OFF= 6
YEAR= 12 TOTAL OFFTAKE =15						
FEMALES	1 10	2 9	3 9	4 9	5 32	OFF=10
MALES	1 8	2 7	3 6	4 6	5 11	OFF= 5
YEAR= 13 TOTAL OFFTAKE =14						
FEMALES	1 9	2 9	3 8	4 9	5 31	OFF= 8
MALES	1 8	2 6	3 6	4 6	5 10	OFF= 6
YEAR= 14 TOTAL OFFTAKE =13						
FEMALES	1 9	2 8	3 8	4 8	5 30	OFF= 8
MALES	1 8	2 6	3 5	4 6	5 10	OFF= 5
YEAR= 15 TOTAL OFFTAKE =13						
FEMALES	1 9	2 8	3 7	4 9	5 29	OFF= 8
MALES	1 7	2 6	3 5	4 5	5 10	OFF= 5

APPENDIX 4

SIMULATION OF HERD GROWTH AT 7.5 PERCENT OFFTAKE (MODEL I)

YEAR= 0 TOTAL OFFTAKE =15											
FEMALES	1	21	2	9	3	14	4	13	5	77	OFF=11
MALES	1	15	2	6	3	8	4	11	5	25	OFF= 4
YEAR= 1 TOTAL OFFTAKE =15											
FEMALES	1	22	2	18	3	8	4	13	5	77	OFF= 8
MALES	1	19	2	12	3	5	4	7	5	26	OFF= 7
YEAR= 2 TOTAL OFFTAKE =16											
FEMALES	1	22	2	19	3	16	4	8	5	74	OFF=11
MALES	1	19	2	15	3	10	4	5	5	25	OFF= 5
YEAR= 3 TOTAL OFFTAKE =16											
FEMALES	1	21	2	19	3	17	4	15	5	68	OFF=10
MALES	1	18	2	15	3	12	4	9	5	22	OFF= 6
YEAR= 4 TOTAL OFFTAKE =16											
FEMALES	1	19	2	18	3	17	4	16	5	68	OFF=11
MALES	1	17	2	14	3	12	4	11	5	23	OFF= 5
YEAR= 5 TOTAL OFFTAKE =16											
FEMALES	1	19	2	17	3	16	4	16	5	71	OFF= 9
MALES	1	17	2	13	3	11	4	11	5	24	OFF= 7
YEAR= 6 TOTAL OFFTAKE =16											
FEMALES	1	20	2	17	3	15	4	15	5	73	OFF= 9
MALES	1	17	2	13	3	10	4	10	5	25	OFF= 7
YEAR= 7 TOTAL OFFTAKE =16											
FEMALES	1	21	2	18	3	15	4	14	5	74	OFF= 9
MALES	1	18	2	13	3	10	4	9	5	25	OFF= 7
YEAR= 8 TOTAL OFFTAKE =16											
FEMALES	1	21	2	18	3	16	4	14	5	73	OFF=10
MALES	1	18	2	14	3	10	4	9	5	25	OFF= 6
YEAR= 9 TOTAL OFFTAKE =16											
FEMALES	1	21	2	18	3	16	4	15	5	72	OFF=10
MALES	1	18	2	14	3	11	4	9	5	25	OFF= 6
YEAR= 10 TOTAL OFFTAKE =16											
FEMALES	1	21	2	18	3	16	4	15	5	72	OFF=10
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 6
YEAR= 11 TOTAL OFFTAKE =16											
FEMALES	1	21	2	18	3	16	4	15	5	73	OFF= 9
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 7
YEAR= 12 TOTAL OFFTAKE =17											
FEMALES	1	21	2	18	3	16	4	15	5	73	OFF=10
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 7
YEAR= 13 TOTAL OFFTAKE =17											
FEMALES	1	21	2	18	3	16	4	15	5	73	OFF=10
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 7
YEAR= 14 TOTAL OFFTAKE =17											
FEMALES	1	21	2	18	3	16	4	15	5	73	OFF=10
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 7
YEAR= 15 TOTAL OFFTAKE =17											
FEMALES	1	21	2	18	3	16	4	15	5	73	OFF=10
MALES	1	18	2	14	3	11	4	10	5	25	OFF= 7

APPENDIX 5

A SIMULATION OF HERD GROWTH AT FIVE PERCENT OFFTAKE (MODEL II)

YEAR= 0 TOTAL OFFTAKE =10											
FEMALES	1	21	2	9	3	14	4	13	5	77	OFF= 8
MALES	1	15	2	6	3	8	4	11	5	25	OFF= 2
YEAR= 1 TOTAL OFFTAKE =10											
FEMALES	1	25	2	20	3	8	4	13	5	79	OFF= 6
MALES	1	22	2	12	3	5	4	7	5	29	OFF= 4
YEAR= 2 TOTAL OFFTAKE =11											
FEMALES	1	26	2	23	3	19	4	8	5	81	OFF= 6
MALES	1	22	2	18	3	10	4	5	5	28	OFF= 5
YEAR= 3 TOTAL OFFTAKE =12											
FEMALES	1	26	2	24	3	21	4	18	5	78	OFF= 7
MALES	1	23	2	18	3	15	4	9	5	26	OFF= 5
YEAR= 4 TOTAL OFFTAKE =13											
FEMALES	1	25	2	24	3	22	4	20	5	83	OFF= 8
MALES	1	22	2	19	3	15	4	14	5	27	OFF= 5
YEAR= 5 TOTAL OFFTAKE =14											
FEMALES	1	27	2	23	3	22	4	21	5	90	OFF= 8
MALES	1	23	2	18	3	16	4	14	5	32	OFF= 6
YEAR= 6 TOTAL OFFTAKE =14											
FEMALES	1	29	2	25	3	21	4	21	5	100	OFF= 6
MALES	1	25	2	19	3	15	4	15	5	34	OFF= 8
YEAR= 7 TOTAL OFFTAKE =15											
FEMALES	1	32	2	27	3	23	4	20	5	108	OFF= 7
MALES	1	28	2	21	3	16	4	14	5	37	OFF= 8
YEAR= 8 TOTAL OFFTAKE =16											
FEMALES	1	35	2	30	3	25	4	22	5	114	OFF= 8
MALES	1	30	2	23	3	18	4	15	5	39	OFF= 8
YEAR= 9 TOTAL OFFTAKE =18											
FEMALES	1	37	2	33	3	28	4	24	5	120	OFF= 9
MALES	1	32	2	25	3	20	4	17	5	41	OFF= 9
YEAR= 10 TOTAL OFFTAKE =19											
FEMALES	1	39	2	34	3	31	4	27	5	128	OFF= 9
MALES	1	34	2	26	3	21	4	18	5	44	OFF=10
YEAR= 11 TOTAL OFFTAKE =20											
FEMALES	1	41	2	36	3	32	4	29	5	138	OFF=10
MALES	1	36	2	28	3	22	4	19	5	47	OFF=10
YEAR= 12 TOTAL OFFTAKE =21											
FEMALES	1	45	2	38	3	33	4	30	5	148	OFF=11
MALES	1	39	2	30	3	24	4	20	5	50	OFF=10
YEAR= 13 TOTAL OFFTAKE =23											
FEMALES	1	48	2	42	3	35	4	31	5	158	OFF=12
MALES	1	42	2	32	3	26	4	22	5	53	OFF=11
YEAR= 14 TOTAL OFFTAKE =24											
FEMALES	1	51	2	45	3	39	4	33	5	167	OFF=12
MALES	1	44	2	34	3	27	4	24	5	57	OFF=12
YEAR= 15 TOTAL OFFTAKE =26											
FEMALES	1	54	2	47	3	42	4	37	5	178	OFF=12
MALES	1	47	2	26	3	29	4	25	5	60	OFF=14

APPENDIX 6

A SIMULATION OF HERD GROWTH AT THIRTEEN PERCENT OFFTAKE (MODEL II)

YEAR= 0 TOTAL OFFTAKE =26											
FEMALES	1	21	2	9	3	14	4	13	5	77	OFF=20
MALES	1	15	2	6	3	8	4	11	5	25	OFF= 6
YEAR= 1 TOTAL OFFTAKE =26											
FEMALES	1	25	2	20	3	8	4	13	5	69	OFF=16
MALES	1	22	2	12	3	5	4	7	5	23	OFF=10
YEAR= 2 TOTAL OFFTAKE =27											
FEMALES	1	22	2	23	3	19	4	8	5	58	OFF=20
MALES	1	19	2	18	3	10	4	5	5	20	OFF= 7
YEAR= 3 TOTAL OFFTAKE =26											
FEMALES	1	19	2	20	3	21	4	18	5	45	OFF=18
MALES	1	16	2	16	3	15	4	9	5	15	OFF= 8
YEAR= 4 TOTAL OFFTAKE =25											
FEMALES	1	15	2	18	3	19	4	20	5	43	OFF=17
MALES	1	13	2	13	3	14	4	14	5	14	OFF= 8
YEAR= 5 TOTAL OFFTAKE =24											
FEMALES	1	14	2	14	3	17	4	18	5	46	OFF=14
MALES	1	12	2	11	3	11	4	13	5	16	OFF=10
YEAR= 6 TOTAL OFFTAKE =22											
FEMALES	1	15	2	13	3	13	4	16	5	49	OFF=12
MALES	1	13	2	10	3	9	4	10	5	17	OFF=10
YEAR= 7 TOTAL OFFTAKE =21											
FEMALES	1	16	2	14	3	12	4	12	5	49	OFF=13
MALES	1	14	2	11	3	9	4	8	5	17	OFF= 8
YEAR= 8 TOTAL OFFTAKE =21											
FEMALES	1	16	2	15	3	13	4	11	5	44	OFF=14
MALES	1	14	2	11	3	9	4	8	5	16	OFF= 7
YEAR= 9 TOTAL OFFTAKE =20											
FEMALES	1	14	2	15	3	14	4	12	5	40	OFF=12
MALES	1	12	2	11	3	9	4	8	5	14	OFF= 8
YEAR= 10 TOTAL OFFTAKE =19											
FEMALES	1	13	2	13	3	14	4	13	5	37	OFF=12
MALES	1	11	2	10	3	9	4	8	5	13	OFF= 7
YEAR= 11 TOTAL OFFTAKE =18											
FEMALES	1	12	2	12	3	12	4	13	5	36	OFF=11
MALES	1	10	2	9	3	9	4	8	5	12	OFF= 7
YEAR= 12 TOTAL OFFTAKE =17											
FEMALES	1	12	2	11	3	11	4	11	5	35	OFF=11
MALES	1	10	2	8	3	8	4	8	5	12	OFF= 6
YEAR= 13 TOTAL OFFTAKE =16											
FEMALES	1	11	2	11	3	10	4	10	5	33	OFF=10
MALES	1	10	2	8	3	7	4	7	5	12	OFF= 6
YEAR= 14 TOTAL OFFTAKE =15											
FEMALES	1	11	2	10	3	10	4	10	5	32	OFF= 9
MALES	1	9	2	8	3	7	4	6	5	11	OFF= 6
YEAR= 15 TOTAL OFFTAKE =15											
FEMALES	1	10	2	10	3	9	4	10	5	31	OFF= 9
MALES	1	9	2	7	3	7	4	6	5	10	OFF= 6

APPENDIX 7

A SIMULATION OF HERD GROWTH AT 9.3 PERCENT OFFTAKE (MODEL II)

```
YEAR=  0 TOTAL OFFTAKE =19
 FEMALES  1  21    2   9    3  14    4  13    5  77    OFF=14
   MALES  1  15    2   6    3   8    4  11    5  25    OFF= 5

YEAR=  1 TOTAL OFFTAKE =19
 FEMALES  1  25    2  20    3   8    4  13    5  74    OFF=11
   MALES  1  22    2  12    3   5    4   7    5  25    OFF= 8

YEAR=  2 TOTAL OFFTAKE =20
 FEMALES  1  24    2  23    3  19    4   8    5  68    OFF=14
   MALES  1  21    2  18    3  10    4   5    5  23    OFF= 6

YEAR=  3 TOTAL OFFTAKE =20
 FEMALES  1  22    2  22    3  21    4  18    5  59    OFF=14
   MALES  1  19    2  17    3  15    4   9    5  20    OFF= 6

YEAR=  4 TOTAL OFFTAKE =21
 FEMALES  1  19    2  20    3  20    4  20    5  58    OFF=15
   MALES  1  17    2  16    3  14    4  14    5  20    OFF= 6

YEAR=  5 TOTAL OFFTAKE =20
 FEMALES  1  19    2  18    3  19    4  19    5  63    OFF=11
   MALES  1  16    2  14    3  14    4  13    5  22    OFF= 9

YEAR=  6 TOTAL OFFTAKE =20
 FEMALES  1  20    2  18    3  17    4  18    5  67    OFF=11
   MALES  1  18    2  13    3  12    4  13    5  23    OFF= 9

YEAR=  7 TOTAL OFFTAKE =20
 FEMALES  1  22    2  19    3  17    4  16    5  70    OFF=11
   MALES  1  19    2  15    3  11    4  11    5  24    OFF= 9

YEAR=  8 TOTAL OFFTAKE =21
 FEMALES  1  23    2  20    3  18    4  16    5  70    OFF=12
   MALES  1  20    2  16    3  13    4  10    5  23    OFF= 9

YEAR=  9 TOTAL OFFTAKE =21
 FEMALES  1  23    2  21    3  19    4  17    5  68    OFF=14
   MALES  1  20    2  16    3  14    4  12    5  23    OFF= 7

YEAR= 10 TOTAL OFFTAKE =22
 FEMALES  1  22    2  21    3  20    4  18    5  68    OFF=13
   MALES  1  19    2  16    3  14    4  13    5  23    OFF= 9

YEAR= 11 TOTAL OFFTAKE =22
 FEMALES  1  22    2  20    3  20    4  19    5  70    OFF=12
   MALES  1  19    2  16    3  14    4  13    5  23    OFF=10

YEAR= 12 TOTAL OFFTAKE =22
 FEMALES  1  23    2  20    3  19    4  19    5  72    OFF=13
   MALES  1  20    2  16    3  14    4  13    5  24    OFF= 9

YEAR= 13 TOTAL OFFTAKE =22
 FEMALES  1  23    2  21    3  19    4  18    5  73    OFF=13
   MALES  1  20    2  16    3  14    4  13    5  25    OFF= 9

YEAR= 14 TOTAL OFFTAKE =23
 FEMALES  1  24    2  21    3  20    4  18    5  73    OFF=13
   MALES  1  20    2  16    3  14    4  13    5  25    OFF=10

YEAR= 15 TOTAL OFFTAKE =23
 FEMALES  1  24    2  22    3  20    4  19    5  73    OFF=13
   MALES  1  20    2  16    3  14    4  13    5  25    OFF=10
```

APPENDIX 8

HERD GROWTH SIMULATION MODEL I

```
$LIST CATTLEMODELA
          DIMENSION DM(5),DF(5),KVIM(5),KVIF(5),KZF(4),KZM(4)
          DATA DM/.27,.23,.20,.08,.08/
          DATA DF/.15,.12,.12,.05,.05/
          DATA KVIM/15,6,8,11,25/
          DATA KVIF/21,9,14,13,77/
          DATA CPCT/.67/
          PRINT 900
      900 FORMAT(1X,'ENTER % OFFTAKE RATE')
          READ 910,COFF
      910 FORMAT(F5.2)
          X=KVIM(5)
          Y=KVIF(5)
          FMRAT=X/Y
          IYR=-1
          DO 100 I=1,16,1
          TNUM=0.
          DO 160 K=1,5,1
      160 TNUM=TNUM+KVIF(K)+KVIM(K)
          IOFF=(TNUM*COFF)+.5
          XOFF=IOFF
          X=KVIF(5)
          Y=KVIM(5)
          Z=Y+X
          IOFFM=(XOFF*(Y/Z))+.5
          IOFFF=IOFF-IOFFM
          IOFF=IOFFF+IOFFM
          IYR=IYR+1
          IF(IYR .EQ. 0)GO TO 200
          X=KVIF(5)
          Y=KVIM(5)
          DO 110 K=1,4,1
          KZF(K)=(KVIF(K)*(1.-DF(K+1)))+.5
      110 KZM(K)=(KVIM(K)*(1.-DM(K+1)))+.5
          DO 116 K=1,4,1
          KVIF(K+1)=KZF(K)
      116 KVIM(K+1)=KZM(K)
          KVIF(5)=KVIF(5)-IOFFF+(X*(1.-DF(5))+.5)
          KVIF(1)=((X*CPCT*.5)*(1.-DF(1)))+.5
          KVIM(5)=KVIM(5)-IOFFM+(Y*(1.-DM(5))+.5)
          KVIM(1)=((X*CPCT*.5)*(1.-DM(1)))+.5
          X=KVIF(5)
          MINM=(X*FMRAT)+.5
          X=KVIM(5)-MINM
          KOFFM=X*(1.-FMRAT)
          K=IOFFM-KOFFM
          IF(K .LT. 0)KOFFM=IOFFM
          KVIM(5)=KVIM(5)-KOFFM
          KVIF(5)=KVIF(5)+KOFFM
          IOFFM=IOFFM+KOFFM
          IOFFF=IOFFF-KOFFM
      200 PRINT 810,IYR,IOFF
      810 FORMAT(1X,//,1X,'YEAR= ',I2,' TOTAL OFFTAKE =',I2)
          PRINT 800,(J,KVIF(J),J=1,5,1),IOFFF
      800 FORMAT(1X,' FEMALES ',5(I2,1X,I3,4X),' OFF=',I2)
          PRINT 820,(J,KVIM(J),J=1,5,1),IOFFM
      820 FORMAT(1X,'   MALES ',5(I2,1X,I3,4X),' OFF=',I2)
      100 CONTINUE
          STOP
          END
#END OF FILE
#
```

APPENDIX 9

HERD GROWTH SIMULATION MODEL II

```
$LIST CATTLEMODEL2
>              DIMENSION DM(5),DF(5),KVIM(5),KVIF(5),KZF(4),KZM(4)
>              DATA DM/.22,.18,.15,.08,.08/
>              DATA DF/.10,.07,.07,.05,.05/
>              DATA KVIM/15,6,8,11,25/
>              DATA KVIF/21,9,14,13,77/
>              DATA CPCT/.72/
>              PRINT 900
>          900 FORMAT(1X,'ENTER % OFFTAKE RATE')
>              READ 910,COFF
>          910 FORMAT(F5.2)
>              X=KVIM(5)
>              Y=KVIF(5)
>              FMRAT=X/Y
>              IYR=-1
>              DO 100 I=1,16,1
>              TNUM=0.
>              DO 160 K=1,5,1
>          160 TNUM=TNUM+KVIF(K)+KVIM(K)
>              IOFF=(TNUM*COFF)+.5
>              XOFF=IOFF
>              X=KVIF(5)
>              Y=KVIM(5)
>              Z=Y+X
>              IOFFM=(XOFF*(Y/Z))+.5
>              IOFFF=IOFF-IOFFM
>              IOFF=IOFFF+IOFFM
>              IYR=IYR+1
>              IF(IYR .EQ. 0)GO TO 200
>              X=KVIF(5)
>              Y=KVIM(5)
>              DO 110 K=1,4,1
>              KZF(K)=(KVIF(K)*(1.-DF(K+1)))+.5
>          110 KZM(K)=(KVIM(K)*(1.-DM(K+1)))+.5
>              DO 116 K=1,4,1
>              KVIF(K+1)=KZF(K)
>          116 KVIM(K+1)=KZM(K)
>              KVIF(5)=KVIF(5)-IOFFF+(X*(1.-DF(5))+.5)
>              KVIF(1)=((X*CPCT*.5)*(1.-DF(1)))+.5
>              KVIM(5)=KVIM(5)-IOFFM+(Y*(1.-DM(5))+.5)
>              KVIM(1)=((X*CPCT*.5)*(1.-DM(1)))+.5
>              X=KVIF(5)
>              MINM=(X*FMRAT)+.5
>              X=KVIM(5)-MINM
>              KOFFM=X*(1.-FMRAT)
>              K=IOFFM-KOFFM
>              IF(K .LT. 0)KOFFM=IOFFM
>              KVIM(5)=KVIM(5)-KOFFM
>              KVIF(5)=KVIF(5)+KOFFM
>              IOFFM=IOFFM+KOFFM
>              IOFFF=IOFFF-KOFFM
>          200 PRINT 810,IYR,IOFF
>          810 FORMAT(1X,//,1X,'YEAR= ',I2,' TOTAL OFFTAKE =',I2)
>              PRINT 800,(J,KVIF(J),J=1,5,1),IOFFF
>          800 FORMAT(1X,' FEMALES ',5(I2,1X,I3,4X),' OFF=',I2)
>              PRINT 820,(J,KVIM(J),J=1,5,1),IOFFM
>          820 FORMAT(1X,'   MALES ',5(I2,1X,I3,4X),' OFF=',I2)
>          100 CONTINUE
>              STOP
>              END
#END OF FILE
#
```