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COMPUTER - BASED PEDIGREE CHARTING AND INBREEDING EFFECTS ON PERFORMANCE TRAITS OF N'DAMA CATTLE IN FASHOLA, OYO STATE, NIGERIA.

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ABSTRACT

The limited number of information usually available on farm animals in the developing countries and the need for the animal breeder to know the pedigree of individual animals in order to determine their level of inbreeding and relationship has been a most challenging task. A computer-based pedigree charting and inbreeding coefficient calculation program was developed. It was written with Nantucket Clipper (R) 5.01 and Nantucket Tools II (R) for Clipper 5.01 to take care of animals with minimal parental information peculiar to most developing countries. The program finds and saves to the disk the pedigree information to the seventh generation on all individual animal whose immediate parental information is available. The new database file is then used to calculate the inbreeding coefficient of that individual animal using Wright's formula. The speed and capacity of the computer program is basically determined by the available computer resources.

Records of 4184 N'Dama calves born between 1947 and 1984 at Fashola Stock Farm, Oyo State, Nigeria was used to test the efficiency and efficacy of the computer program and to determine the effects of inbreeding on some

performance traits. These traits include age at first calving (AFC), average calving interval (CALINT), birth weight (CALBWT), 120-day adjusted weight (AD120D), average daily gain to 120 days (120DG), 205-day adjusted weight (AD205D), average daily gain to 205 days (205DG), 365-day adjusted weight (AD365D) and average daily gain to 365 days (365DG).

Only 273 of the 4184 calves (6.53%) were inbred with an average inbreeding coefficient (INCOEF) of 9.71%, while five out of 293 sires (1.71%) with INCOEF of 9.25% and 43 out of 1849 dams (2.33%) with INCOEF of 9.95% were inbred. The INCOEF for the entire population was 0.63%; for males the mean was 0.70% and 0.58% for females.

The mean CALBWT (n=4162) was 18.86 ± 0.05kg. The effects of sex, year, season, parity, age of dam, dam's AFC and dam's INCOEF was highly significant. A percentage increase in the dam's inbreeding coefficient resulted in 65.2g decrease in calf birth weight.

The mean AD120D and 120DG (n=54) was 99.73 ± 1.95kg and 0.670 ± 0.0015kg respectively. The mean AD205D and 205DG (n=652) was 105.54 ± 0.74kg and 0.427 ± 0.0004kg respectively. The mean AD365D and 365DG (n=779) was 133.90 ± 0.88kg and 0.315 ± 0.002kg respectively. Neither the inbreeding coefficient of the calf nor that of its dam had any important influence on these traits, however, these traits were affected by sex, season and parity (P<0.05).

The mean AFC (n=1756) was 40.43 ± 0.18 months and the mean CALINT was 445.34 ± 2.68 days. The AFC of heifers was significantly affected by the heifer's level of inbreeding and a percentage rise in inbreeding level of heifers resulted in about 10 days decrease in AFC.

The study shows that inbreeding was low in the N'Dama population at Fashola and that it affected only the calf's birth weight and heifer's age at first calving in N'Dama cattle.

The major implications of the conclusions drawn from this study is that although the number of inbred animals in the population is relatively low, however the inbreeding level of these animals is high. This is a result of the fact that breeding policy on the farm was not strictly adhered to and the lack of proper and adequate registration system and inconsistent animal identification on the farm may be responsible for the inbreeding observed in the N'Dama population at Fashola Stock Farm.

DEDICATION

This work is dedicated to the doyen of personal computing:

William H. Gates (Jnr.)

Chairman / Chief Executive Officer

Microsoft Corporations (the largest independent maker of personal computer software).

Bill Gates, your foresight, ingenuity and determination in the field of personal computing is the secret behind the success of this project.

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'Tunji Abanikannda

CERTIFICATION

I certify that this research work was carried out by **Olatunji Tajudeen Fazazi ABANIKANNDA** in the Department of Animal Science, University of Ibadan, Nigeria, under my supervision.

[signature]	25-10-95
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CHAPTER ONE

1.0 INTRODUCTION

The increasing demand for meat as a source of animal protein in Nigeria has led to the undertaking of various measures aimed at ensuring constant and adequate supply of beef for the ever growing population. Some of these are achieved by identifying, examining and investigating various factors (genetic and environmental) that may affect the productivity of the stock indigenous to Nigeria and how the knowledge can be gainfully employed to improve the status of the livestock industry.

In order to achieve this goal, various methods such as crossbreeding the local breeds with imported stock and replacing the indigenous stock have been tried over the years aimed at improving both the genic composition of the indigenous cattle and increasing overall productivity of the industry. However, each method has its own associated merits and demerits. But the adoption of any particular method is dependent on the trait of interest and the economic justification of adopting such method.

Crossbreeding has been extensively used in the dairy and beef cattle industry in developed countries of the world. It is usually employed in improving traits with very low heritability (Syrstad, 1986). However the decreasing ability of the offspring (with increasing level of exotic genes) to withstand the extremes of adverse environmental condition in developing countries of the world and the accompanying high cost of procuring and maintaining the exotic breeds has led some countries to focus attention on how the local animals with comparatively good genetic constitution can be selected and retained within the population.

The genotype of an animal is the animal's constitution as regards the factors composing its germ plasm; the hereditary factors which it may transmit to its offspring (Falconer, 1993). It is more than the sum of all its genes because it also describes the particular combination and arrangements of these genes. A particular gene will have different effects in different genic combinations. This is the reason for the observed differences in the traits exhibited by different animals, breeds or species.

Performance traits of beef cattle are essentially traits of economic importance and are quantitative in characters. They are determined by several genes in differing genic combinations (Falconer, 1993). The extent to which these traits can be improved is basically determined by the innate ability of the individual animal. Thus long range approach aimed at improving the animal's performance must be directed through improving the animal's genetic constitution.

Crossbreeding has been extensively but haphazardly used in most developing countries of Africa to improve the performance of the local stock. Although crossbreeding promotes the pairing of unlike genes by the mating of animals that belong to different families, breeds or species, this must be carried out systematically and in a sustainable manner. Crossbreeding as a tool to be used for genetic improvement in Africa can only be achieved through a consistent approach and the application of genetics and planned animal breeding programs.

The main advantage of crossbreeding is the resultant heterosis or hybrid vigour observed in offspring of such mating. Crossbreeding is most useful when there are wide differences between breeds and the inferior ones are the most numerous. This is the case in Africa and in particular in Nigeria. Heterosis, the superiority of the offspring over their mid-parental average, is expressed as improvement in performance and fitness traits. In the case of developing livestock industry, the exotic breeds contribute improved performance while the local breeds, the fitness traits.

Inbreeding, the mating together of individuals that are related to each other by ancestry, is another method of improving livestock productivity. It is the mating of animals that are more closely related than the average of the population from which they come (Falconer, 1993). Usually, the aim of deliberate inbreeding is not to study the effects of the breeding method per se, but rather to try to produce superior inbred stock by ensuring the concentration of the genes of interest within the herd (Falconer, 1993).

The traits exhibited by individual animal is not dependent on their genotype alone but influenced to a large extent by the prevailing environmental conditions. The environment of the animal includes all the non-genetic factors which may influence the performance of the animal either in the positive or negative direction. It is the sum total of all these external factors affecting individual animal such as feeding, housing, management practices, pests and diseases and the prevailing climatic conditions that determine the ultimate performance of the animals. And in a developing country like Nigeria, many components of this environment are deleterious to high productivity.

The inability of the breeds of cattle found here in Nigeria to produce as much as the temperate breeds is therefore not only due to differences in genic composition but also differences in the environment. The Nigerian environment is essentially a stressful one and it is mostly inimical to the maximum expression of the animal's genetic potential. This environment is characterized by factors such as excessive heat stress, incidence of infectious and parasitic diseases, adverse climatic conditions, poor management practices, unavailable and poor quality feed resources and the inability to fashion out a sustainable breeding and improvement program.

The observed characteristics of an animal, (i.e. the phenotype) is the sum total of the performance of the animal as affected by its genotype and all prevailing environmental conditions. Although, it is not possible to directly evaluate the performance of the animal as affected by its genotype in practice but this can be estimated. The closer the phenotypic value can be obtained by making corrections for many identifiable environmental factors, the faster progress can be made genetically. It therefore becomes imperative that as many environmental factors as possible should be identified and corrected for. It will then be possible to identify animals with the best genetic constitution in the prevailing environmental circumstances in the developing countries of the world and indeed Africa.

1.1 JUSTIFICATION OF THE STUDY

Productive traits in beef cattle are quantitative in nature, it is worthy of note that the environment under which the animals are reared be considered while evaluating such traits. Most quantitative traits are greatly affected by environmental factors in Tropical developing countries and the knowledge of these effects can be exploited to provide the animal its basic requirements for the best performance. However, to what extent the performance of the animals can be improved is primarily determined by their innate capacity. And it is this genotype x environmental interaction that makes breed substitution a costly venture.

The N'Dama breed is the breed of choice for the humid tsetse fly infested tropics because of the fact that the animal has shown great potential as a beef breed and is above all trypanotolerant (ILCA, 1979). The humid tropics is characterized by high ambient temperatures, high humidity and high solar radiation. The ability of N'Dama to be adapted to this region of West and Central Africa has been well documented by FAO (1980).

Besides the climatic hazards of the humid region, the tsetse fly challenge is of paramount importance. This vector (Glossina sp) is responsible for the transmission of a deadly disease that affects livestock in this region. The disease transmitted, Trypanosomiasis, and its severity is dependent on previous exposure and the ability to contain the attendant parasiteamia by this indigenous breed of West and Central Africa. For most exotic and non-trypanotolerant indigenous breed, death is usually the result without expensive chemotherapy.

Various symptoms observed during the attack and the post-mortem examination of dead animals reveals that death usually occurs as a result of acute congestive heart failure due to a combination of anaemia, circulatory disturbances associated with increased vascular permeability and myocardial damage (Murray et al, 1983). The ability of the trypanotolerant breeds to contain these attacks make them valuable animal genetic resource for the future. The two most notable breeds that are trypanotolerant are the N'Dama and West African Shorthorn, and the basis of this trypanotolerance has been found to be genetic (Murray et al, 1983). An international effort is currently going on in several countries of West and Central Africa to improve the productivity of the N'Dama breed (ILCA, 1980).

The Fashola Stock Farm is one of the project sites for the study of the N'Dama cattle. The farm was essentially set up as a breeding and improvement centre since 1947. Consequently the volume of records available can readily give an insight into the various environmental and genetic factors involved in the present level of productivity, albeit scanty and incomplete. Several breeding methods had been adopted on the farm at various times in the past.

This available records is large enough to provide sufficient information on highlighting the merit and demerits of past efforts if sufficient tools (technical and statistical) are available to take care of all the peculiarities of the data available.

1.2 OBJECTIVES OF THE STUDY

The limited number of information usually available on farm animals in the developing countries and the need for the animal breeder to know the pedigree of individual animal in order to determine the relationship and inbreeding coefficients has been a most challenging task. Usually, scanty information on the immediate parents of animals are often available in animal population spread over many years in developing countries. Fashola Stock Farm established in 1947 is one of such farms where data on N'Dama cattle has accumulated. Due to the fact that the farm was not originally set up for inbreeding purposes and that importation of fresh genetic stock had been stopped for a relatively long time on the farm, it can be expected that some inbreeding may have occurred due to the management system adopted on the farm.

The objectives of this study are as follows:

1. To develop a computer program that can trace and retrieve all the pedigree information on all animals born on any farm whose immediate parents (sire and dam) are known;

2. To make the program chart the pedigree of any animal up to the fifth generation and to calculate the inbreeding coefficient of any such animal that may be inbred using Wright's formula;

3. To use the inbreeding coefficient as a covariate in any statistical analysis for determining (among other) factors that affect the performance traits of animals;

4. To package the computer program to handle productivity data for animal production and breeding;

5. To apply the developed computer program in the determination of effect of inbreeding on some growth and reproductive performance traits of the N'Dama cattle at Fashola Stock Farm, in the Humid Tropics of Nigeria.

CHAPTER TWO

2.0 REVIEW OF LITERATURE

2.1 INBREEDING

Falconer (1993) defined inbreeding as the mating together of individuals that are related to each other by ancestry. It is the mating of animals more closely related than the average of the population from which they come. The major aim of inbreeding is to increase the probability that two alleles at a particular locus in an individual are identical by descent. This will result in an increase in the proportion of homozygous loci in the inbred individual.

The undesirable consequence of this increased homozygosity is a decline in performance in traits associated with general vigour such as reproduction, survival and growth rates (Brinks and Knapp, 1975; Sachdeva et al, 1983; Guba and Wolf, 1984 and Mac Neil et al, 1989). Inbreeding increases uniformity for simply inherited and highly heritable traits but it also leads to increased variability for economically important quantitative traits (Hohenboken, 1985).

Despite the decreased performance associated with inbreeding, efforts are still being made to deliberately mate animals that are closely related as a method in animal breeding. This is based on the fact that when an inbred line is formed from an elite stock, it can contain no genes however inferior it may appear which were not present in its admired progenitors, nor can it hand any others on to its descendants (Fisher, 1965).

The aim of deliberate inbreeding is not to study the effects of the breeding method per se, but to produce superior inbred stock by ensuring the concentration of genes of interest within a herd (Falconer, 1993). This breeding method has been extensively used in obtaining high producing animals and maintaining elite stocks (Sharafutdinov, 1984).

The measure of the degree of inbreeding is termed the coefficient of inbreeding and was derived by Wright (1921) as the correlation between uniting gametes. He developed a system of estimating the inbreeding coefficient;

$$F_x = (\tfrac{1}{2})^{n+n'+1}(1 + F_a)$$

where F_x = the inbreeding coefficient of individual **x**

n = the number of generations through the sire

n' = the number of generations through the dam

F_a = the inbreeding coefficient of a common ancestor "**a**"

Various researches on inbreeding indicated that inbreeding has not always had the same effect on productivity, but in most instances productivity has declined with increasing levels of inbreeding (Noland et al, 1964).

In order to circumvent the undesirable effects of inbreeding, some suggestions have been proffered to avoid inbreeding and improve livestock productivity. It was suggested that in a situation where animal populations are small, there should be a rapid turnover of sires to minimise inbreeding (McDowell, 1983). Crossing of full-sib families having a common parent should be avoided and modified full-sib selection could be used alternately with half-sib selection or typical full-sib selection may be carried out once after several cycles of modified full-sib selection (Dhillon and Khehra, 1984).

2.2 ESTIMATING INBREEDING COEFFICIENT

Inbreeding coefficient is a measure of the degree of inbreeding and it is the correlation between uniting gametes. The first attempt at estimating inbreeding coefficient was made by Wright (1921). Wright's classical path coefficient analysis of inbreeding systems provides an expression for the degree of homozygosity that occurs as a result of mating related animals. Wright's (1922) coefficient of inbreeding provide the quantitative basis for estimating consequences from any sort of inbreeding based on pedigree relationships, ignoring possible effects of selection and assortive mating.

This coefficient of inbreeding usually designated F estimates the proportion by which numbers of heterozygous loci are expected to decline, compared with the base population, because of correlation between genotypes of the parents i.e. relationship of the parents (Wright, 1922). Malécot (1969) also described the coefficient of inbreeding (F) as the correlation between the genic content of gametes which unite to produce the individual or the probability of the gametes being identical in origin, by descent from a common ancestor.

Wright (1922) gave the formula for estimating inbreeding coefficient as

$$F_x = (½)^{n+n'+1} (1 + F_a)$$

where F_x = the inbreeding coefficient of individual x

n = the number of generations through the sire

n' = the number of generations through the dam

F_a = the inbreeding coefficient of a common ancestor "a"

The F_x is the sum total of all possible paths of the ancestors common to both the sire and dam. And this can be computed with the knowledge of the pedigree of the individual **x**. This inbreeding coefficient of an individual is one half the numerator of the relationship coefficient between its sire and dam.

Wright and McPhee (1925) described the coefficient of inbreeding as correlation between the egg and sperm which unite to produce the offspring in question. It was shown that the coefficient measures the percentage reduction from the average degree of heterozygosis in the foundation stock. They pointed out that coefficient of inbreeding is not an absolute but rather a relative measure of quality of an animal. It measures the probable similarity of the germ cells which unite to produce the offspring relative to the similarity of random germ cells from the foundation stock.

As a result of considerable overlapping of generations especially in females in the herd at any particular time, no regular system of inbreeding is possible with cattle. Furthermore the length of generation for males is usually less than females. This makes the computation of inbreeding coefficient by pedigree analysis increasingly complex in succeeding generations. This has led to the development of several methods of estimating inbreeding coefficient to facilitate application of the Wright's principle.

The first attempt at facilitating the estimation of inbreeding coefficient was made by Wright and McPhee (1925) where they proposed an approximate method of calculating coefficients of inbreeding and relationship from livestock pedigrees. Although this method is singularly lacking in computational instructions designed to relieve the tedium of path tracing and to ensure the accuracy of the computed values.

Cruden (1949) proposed a method for the computation of inbreeding coefficients in a closed population. His method permits the accumulation of data, so that the inbreeding coefficients for any generation may be directly determined from those obtained for preceeding ones and thus eliminates the preparation and examination of long pedigree charts. This method requires the computation of inbreeding coefficient of all possible mating and some hypothetical mating for a base generation early in the history of the line. The coefficients for later generations are then constructed as simple functions of the coefficients of the base generation. This method outlined a time saving procedure for predetermining coefficients in closed populations that maintained accuracy in computations. Cruden's method did not however take into consideration the inbreeding coefficient of a particular common ancestor.

Emik and Terrill (1949) outlined a systematic procedure for calculating inbreeding coefficient. Their method is based on the simplification of inbreeding coefficient by using methods of combining the numerator relationship to avoid tracing out each line of descent on each pedigree. It involves the determination of the numerator relationships which are arranged in a table with the appropriate derivatives in columns designating the number of generations that the common ancestor may be removed from the dam. These derivatives are then added for each ancestor in the dam's pedigree and the sum divided by 2 to give the F_x of the offspring.

Hoen and Grandage (1960) used the above method with an IBM - 650 computer. With the computer, the effects of possible inbred crosses by using parent-offspring numerator relationships can be calculated.

Hazel and Lush (1950) in their work on computing inbreeding and relationship coefficients from punched cards first made an attempt at using the computer. Their method entails using punched cards in a sorting and tabulating procedure. They did not however use a computer for the calculation of the coefficient.

2.3 COMPUTER CALCULATION OF INBREEDING COEFFICIENT

The development of computer programs for the calculation of inbreeding coefficients was first announced by Mange (1964). His programs compute coefficients based on path values found in a seven-generation pedigree. The program was written in Fortran language. The limitation of the program is that it does not retrieve the coefficient of the common ancestor for use in the formula. Due to the fact that data are stored in the computer memory, all functions are completed in a relatively short time. However this method of data storage determines and limits the size of the population that can be examined and the computer used for this problem has a relatively modest storage capacity.

Rehfeld et al (1967) developed a program for computer calculation of inbreeding coefficient. It was written in Fortran for a general purpose digital computer (General Electric 225) with an 8192 word (about 20kb) memory capacity and four magnetic tape drives. The program is tested with data from a seven-generation line and the amount of data it can handle depends on the memory size of the computer.

Two computer programs were listed in the booklet of the Symposium on use of Computer in Animal Science Teaching, Research and Extension (ASAS, 1978). The programs are described as follows:

a. Canada Agriculture Inbreeding Coefficient program version II-B. It was written in Fortran and available on cards. It is ran on an IBM 360/65 machine and written by Alan Emsley. This program computes inbreeding coefficients for up to 3000 individuals per generation and can include up to 800 individuals per generation in a coefficient of parentage matrix if they have progeny in the next generation. It can handle overlapping generations. The limitation of this program is that it is only available on cards and it runs on complex computer architecture.

b. Wright, another computer program is written in Fortran and available on cards. The author is John W. Hardiman. It ran on an IBM 360/50. It is used for research and separates breeders from non-breeders and calculates Wright's coefficient of inbreeding by the variance-covariance for all breeders for variable numbers of lines and generations. The limitation of this program is that it is only available on cards and it runs on complex computer architecture.

Orihashi and Fushimi (1982) made comparison of some methods of calculating inbreeding coefficients on a computer. The methods of the various programs were compared from the viewpoint of computational complexity. They concluded that the fastest method of computing inbreeding coefficient was that of using recurrence formulae.

Boyce (1983) reviewed methods of computing inbreeding and kinship coefficients from pedigree information. Comparison of the two main approaches to the problem of computing inbreeding coefficients for several thousands of individuals in pedigrees of more than 10 generations are made. He concluded that the method of iterative algorithm using recurrence formulae for coefficients of parentage is faster than the modification of a path searching algorithm.

Tai et al (1984) developed a software for storing parentage information and constructing pedigree trees. The system also enables the measurement of the inbreeding coefficient of a parent and the kinship relationship between two parents. The limitation of this computer program is that it was intended for use in plant breeding and it did not take into consideration problems peculiar to animal population.

Yoshida (1985) using a modification of PISP (a computer program for pedigree data management) computed the inbreeding coefficients of sweet potato cultivars.

The most recent effort documented in literature is Golden et al (1991) performance programmed method for computing inbreeding coefficients from large data sets for use in mixed model analyses. The program was written in C and an algorithm is given for the computation of inbreeding coefficients for large data sets even on small computing architectures. This work was carried out by the authors because the computation of exact coefficients of inbreeding from very large data sets was believed to be too expensive or too difficult a task to perform. However, approximate methods have been used instead and the work was intended to demonstrate the effects of using approximation methods for inbred data.

The aim of this project is to develop a computer program that can handle data peculiar to developing countries of the world and to optimize what had already been done and make such program require minimal computer resources.

2.4 EFFECTS OF INBREEDING ON SOME PRODUCTIVITY OF LIVESTOCK

The effects of inbreeding on the productivity of different classes of livestock have been extensively reported in literature. Inbreeding effects on productivity of livestock are discussed below:

2.4.1 CHICKEN

Due to the relatively lower generation interval and fecundity of this class of livestock, several researches have been carried out on inbreeding effects on their productivity.

Some of the productivity traits affected by inbreeding are mating behaviour, age at first egg, egg weight, egg fertility, egg hatchability, Chick mortality, body weight and dressing percentage.

2.4.1.1 Mating Behaviour: The mating behaviour of both male and female birds is very important in hatchery operation as this will determine the percentage of fertile eggs that will be produced by the females.

Cheng et al (1985) reported that inbred males approached females significantly less frequently and showed courtship waltzing, treading and tail bending less frequently than the randombred males. The inbred females showed significantly lower frequencies of crouching, being treaded by a male, tail bending and successful mounts than randombred females.

2.4.1.2 Age at First Egg: Inbreeding of chicken has been reported to affect the age at first egg by Hagger (1985). However, Chaitanyam and Singh (1985) reported the contrary on age at sexual maturity.

2.4.1.3 Embryonic Mortality: The mortality of embryos is reflected by the number or percentage of live chicks produced on incubation of such fertile eggs. Hagger (1986) reported that the inbreeding of the embryo to a large extent affect the viability of the embryo. Also the egg weight is negatively affected by the level of inbreeding.

2.4.1.4 Egg Production: The number of eggs produced by the bird is a reflection of the profit that will accrue from commercial poultry operation.

Chaitanyam and Singh (1985) showed that the regression of egg production on inbreeding percentage was of importance. Hagger (1985; 1986) concluded that inbreeding resulted in large differences in egg production with the inbred having fewer eggs than the randombreds or crossbreds.

2.4.1.5 Egg Weight: There is a minimum weight that must be attained before an egg can be considered suitable for incubation. Likewise, the weight of a table egg determines its grade, price and eventual acceptability to the consumer.

Hagger (1986) found that inbreeding greatly affected the weight of eggs laid by inbred hens but the report of Chaitanyam and Singh (1985) was contrary to this.

2.4.1.6 Egg Fertility: Cheng et al (1985) showed that fertility percentage decreases with increasing inbreeding of the male and or female birds. But Chaitanyam and Singh (1985) working with White Leghorns stated that the regression of egg fertility on inbreeding percentage was not important.

2.4.1.7 Egg Hatchability: Level of inbreeding of the male and female birds have been proved to affect the hatchability of such eggs.

Cheng et al (1985) found that hatchability was greater for eggs from crossbred hens than from randombred or inbred hens.

2.4.1.8 Body weight: Hagger (1985) reported that inbreeding significantly affected the body weight of hens at 40 weeks. Also Chaitanyam and Singh (1985) found that the regression of body weight at sexual maturity on inbreeding percentage was significant.

2.4.2 PIGS

Inbreeding depression was expressed in pigs in reduced litter size, high incidence of gonadal hypoplasia and reduced or absent libido (Hradecky et al, 1985). Some of the traits reported in literature are reviewed below.

2.4.2.1 Age at first farrowing:

This is the age at which the female animal first produced an offspring. In pig it is an indication of the expected number of farrowings by the animal throughout its productive life.

Inbreeding was reported to considerably decrease this reproductive trait. Gerasch (1986) stated that inbreeding affects the age at first farrowing but Pavlova et al (1986) observed that inbreeding had no adverse effect on the trait.

2.4.2.2 Piglet weight:

Timofeev et al (1986) reported large differences in piglet weight due to increasing inbreeding of the sow and / or the boars.

Hradecky et al (1985) also reported that inbreeding depression affect piglet weight. However, Ter'maeva (1984) reported that there was no difference in the piglet weight of inbred and outbred litters.

The weight of piglets at birth is positively correlated with the rate of gain and piglet survival.

2.4.2.3 Piglet mortality: Stillbirth, an undesirable occurrence at farrowing, is associated with inbreeding depression.

Hradecky et al (1985) reported that stillbirth increases with increasing inbreeding level of piglets. Gerasch (1986) also stated that there was a trend for a greater incidence of stillbirth in inbred litters.

2.4.2.4 Litter size: Gerasch (1986) reported that inbreeding affects the number of litters produced per sow. He also found that litter size at 21 days was significantly smaller for inbred litters.

Timofeev et al (1986) also confirmed that litter size at birth and 21 days are affected by the level of inbreeding of the sows and / or boars.

Ter'maeva (1984) and Hradecky et al (1985) also reported that litter size decreased as the inbreeding coefficient of the litter increased.

However, Pavlova et al (1986) reported that comparison of litter size of sows inbred, topcrossed and outbred did not differ.

The prolificacy and fecundity of pigs is expressed as the number of live piglets produced per farrowing. This is the litter size. Inbreeding is adversely associated with the reduced number of live piglets farrowed by sows and it is directly related to litter size.

2.4.2.5 Litter weight: Pavlova et al (1986) reported that litter weight at weaning was affected by the level of inbreeding of the sows.

Timofeev et al (1986) and Hradecky et al (1985) both confirmed that level of inbreeding affect litter weight at birth and at weaning.

2.4.2.6 Milk yield: Pavlova et al (1986) observed that milk yield of sows is not adversely affected by the level of inbreeding of the sows.

2.4.2.7 Carcass quality: The quality of pork is assessed by the weight of the cuts and ratio of the lean to fat. It is an undesirable trait to have a pig with relatively high backfat thickness because this will eventually affect the lean:fat ratio of its cuts.

Dobao et al (1985) who worked on the weight of bone, backfat, ham to shoulder and internal fat of slaughtered pigs reported that there was significant correlation of bone weight with weights of lean and backfat, of weight of lean with fat weight, of backfat weight with weight of ham and shoulder and of weight of internal fat with weight of backfat. The differences in the inbreeding coefficient in the 3 strains of pigs studied was adduced to the differences in these carcass qualities.

2.4.3 SHEEP

Studies of the effects of inbreeding on some reproductive and growth traits of sheep have been reported in the literature. Some of the traits studied include: ewe fertility, lamb mortality, birth weight, preweaning growth rate, weaning weight, body weight at slaughter and carcass quality.

Lamberson and Thomas (1984) in their review of inbreeding in sheep concluded that regression of individual performance on level of inbreeding generally indicated detrimental effects of inbreeding on performance. They stated that intentional use of inbreeding for genetic improvement of sheep population has limited merit.

2.4.3.1 Ewe fertility: Lamberson and Thomas (1984) reported that of the traits investigated, ewe fertility showed the greatest decrease as the level of inbreeding increased. For each percentage increase in inbreeding, ewe fertility decreased by 0.014.

2.4.3.2 Lamb mortality: Afifi et al (1984) stated that although the level of inbreeding of lambs was not responsible for the observed increase in mortality of the lambs up to any of the ages studied but the degree of inbreeding of dams was responsible and the greater the degree of inbreeding the higher the mortality.

Lamberson and Thomas (1984) reported that lamb survival defined as lambs weaned / lambs born decreased as the level of individual inbreeding increased. They concluded that a percentage increase in lamb's inbreeding decreased their survival by 0.028.

Wooliams et al (1983) in their study of factors affecting lamb mortality reported that mortality from several of causes studied was increased by inbreeding but decreased by crossing inbred lines. Maternal inbreeding was significant for underdeveloped lambs which eventually fail to survive.

Inbreeding levels of both the dam and lamb has been shown as important in the survival of the lamb as indicated above.

2.4.3.3 Birth weight: Davis and Kinghorn (1985) and Pieta et al (1983) reported that level of dam's and / or lamb's inbreeding affects birth weight of lambs.

2.4.3.4 Pre-weaning growth rate: Davis and Kinghorn (1985) regressing preweaning growth rate on dam's inbreeding found significant effect of inbreeding.

Vanli et al (1985) concluded in their research that inbreeding of the lamb significantly affected the average daily gain in the Australian Merino lambs.

2.4.3.5 Weaning weight: The effect of inbreeding on the weaning weight of lambs had been well documented by Pieta et al (1983), Davis and Kinghorn (1985) and Vanli et al (1985) and all reported adverse effect of inbreeding on weaning weight of lambs. They also found the effect of inbreeding on the body weight of lambs at slaughter.

2.4.3.6 Carcass quality: Pieta et al (1983) found effect of different degrees of inbreeding on the meat production of lambs such as dressing percentage, weight of cuts and percentages of cuts, content of protein in the lean and content of intra-muscular fat.

2.4.4 CATTLE

The effect of inbreeding has been extensively investigated on cattle. Although the fact that these animals are uniparous with a relatively longer generation interval had been an impediment to the study of inbreeding effects on reproductive performance, however appreciable data has been collected on most of the productive traits of cattle.

Some deleterious diseases of cattle had been linked with inbreeding (Baird et al, 1986; Havrankova et al, 1984) such as dilated cardiomyopathy and achondroplasia in the progeny of some bulls.

Sorensen and Kennedy (1984) reported that in random mating populations of finite size, with an additive genetic model, the additive genetic variance declines with levels of inbreeding. Russell et al (1984) also reported that genetic variances change with increasing level of inbreeding.

Specific effects of inbreeding as reported in the literature are stated below.

2.4.4.1 DAIRY PERFORMANCE

The effect of inbreeding on the milk yield of cows have been reported by Nurzhanov (1986) who stated that milk yield and fat percentage of milk at various stages of lactation are dependent on the level of inbreeding. Kravchenko et al (1985a), Chenykh et al (1982), Sharafutdinov (1983), Sharafutdinov (1982), Sachdeva et al (1983), Ernst et al (1983), Hudson et al (1984), Hudson (1983) and Srinivas and Gurnani (1981) also confirmed that milk yield and fat content are influenced by degree of inbreeding. They reported similar effects of inbreeding on milk yield at every stage of lactation from the first to the peak lactation of the cow. They also reported inbreeding effect on lactation length, milk stayability and the protein content.

2.4.4.2 REPRODUCTIVE PERFORMANCE

Inbreeding has been reported to be one of many factors affecting various reproductive indices.

Levels of inbreeding of the animals affect their reproductive ability either directly or indirectly. For example, the cystic ovarian disease of cows have been reported to be hereditary (Cole et al, 1986) and the incidence of the disease increases with increasing level of inbreeding.

Flade and Zeller (1986) reported that levels of inbreeding of bulls affect their age at first semen collection, semen production, sperm concentration, mass motility and forward motility. They reported that out of bulls that were 12.5% and 6.25% inbred, 50.2% and 39.8% respectively did not produce viable semen. These low performances resulting from inbreeding depression were significant when compared with their contemporaries that were non-inbred.

Maksimova and Brovko (1985) also reported that level of inbreeding of cows affected the number of inseminations per conception.

However, Kravchenko et at (1985b) reported in their study that moderate inbreeding involving a single high producing ancestor did not have adverse effect on reproductive traits of cows.

2.4.4.2.1 Age at first calving: The age at which the animal had its first calf is very important in the cattle industry. This is because the earlier the animal calve, the quicker the rate of return on investment and the more the number of calves produced by the cow throughout its productive life.

Nurzhanov (1986) reported that age at first calving differs between outbred, closely, moderately and remotely inbred cows. Shcheglachev (1983) and Hudson et al (1984b) both reported that age at first calving increased with increasing level of inbreeding. Srinivas and Gurnani (1981) however reported that inbreeding did not affect the age at first calving.

2.4.4.2.2 <u>Calving Interval</u>: The shorter the interval between two successive calvings the better the reproductive ability of the cow. Inbreeding like several other factors has been reported to affect the calving interval of cattle.

Maksimova and Brovko (1985) reported that the degree of inbreeding of cows significantly affect their average calving intervals. Hudson <u>et al</u> (1984b) also reported that calving interval steadily increased with increasing level of inbreeding of cows. Srinivas and Gurnani (1981) however reported that calving interval was not affected by inbreeding.

2.4.4.2.3 <u>Number of Calvings Per Productive Life</u>: This is the number of live calves produced by the cow throughout the length of its productive life. This is affected by several factors such as age at first calving, calving interval and inbreeding level of the cow.

Nurzhanov (1986) confirmed that the lifetime number of calving of a cow is affected by the degree of inbreeding of that cow. Shcheglachev (1983) also reported that the length of breeding life of cattle decreased with increasing level of inbreeding.

2.4.4.2.4 Abortion, Stillbirth and Calf Mortality: The fewer the incidence of abortion and stillbirth the better the reproductive performance indices of the cow. Several factors have been identified as responsible for the occurrence of these phenomena and that inbreeding of both the foetus and or its parents have been reported to exert significant effect on reproductive parameter. While most researchers (Maksimova and Brovko, 1985; Hudson et al, 1984) reported inbreeding effect on abortion and stillbirth rates of cows, only Nurzhanov (1986) reported that inbreeding did not affect these reproductive parameters.

Calf survival is as important as abortion and stillbirth. This is because a live calf produced by the cow should survive up to weaning. Inbreeding significantly affect the survival of calf to weaning. Maksimova and Brovko (1985) reported that inbreeding affects the survival of calves to six months of age. Hudson et al (1984) and Hudson et al (1984b) confirmed that inbreeding affected the survival of calves to 48 months of age. Srinivas and Gurnani (1981) also found correlation between inbreeding coefficient and calf survival in the Sahiwal cattle.

2.4.4.3 GROWTH TRAITS

Factors affecting the growth traits of cattle have been investigated in both the dairy and beef cattle enterprises.

The growth traits of cattle are essentially useful in assessing the performance of the animals and are observed at various stages of development of the animal. Some of the growth traits include birth weight, weaning weight, pre and post weaning growth rates, body conformation, body / linear measurements, growth curves, mature weight and carcass quality. They are affected by various levels of inbreeding.

2.4.4.3.1 Birthweight: The birth weight of an animal is the weight of the animal recorded within the first 48 hours of its birth. This is the first information available on an individual animal and it is very useful in predicting the future performances of such animal. Inbreeding depression resulting from increasing level of inbreeding have been established as a major factor affecting the birth weight of calves (Maksimova and Brovko, 1985).

Butts et al (1984) stated that inbreeding of progeny negatively affected birth weight of the calves. Also Sachdeva et al (1983) found that the level of inbreeding of the dam and or calf significantly affect the birth weight of the calf.

2.4.4.3.2 Weaning Weight: Some genetic and non-genetic factors have been identified as affecting the weaning weight of calves. One of such genetic factors is inbreeding which exerted negative influences on weaning weights of calves. Antal and Bulla (1986) stated that inbreeding of calf affects the weight a calf attained at weaning. This is also confirmed by Irgang et al (1985) and Sachdeva et al (1983). Maksimova and Brovko (1985) also reported that varying degrees of inbreeding affect calf's weight at weaning.

2.4.4.3.3 Pre / Post weaning gain: This parameter is expressed as calf's daily gain prior to weaning and after weaning respectively.

Antal and Bulla (1986), Inoue (1986) and Sachdeva et al (1983) all found the effects of varying levels of inbreeding on the pre and post weaning rate of gain of calves. They concluded that inbreeding depression significantly lowered the daily gain of calves at both stages of growth of calves.

2.4.4.3.4 Mature weight: The final weight of an animal is the most important trait in beef cattle industry. It is also useful as an index of the cattle's growth rate, and inbreeding of the animal has been reported to affect mature weight. Maksimova and Brovko (1985), Antal and Bulla (1986) and Butts et al (1984) reported that the mature weight and maturing rate of cattle decrease with increases in the level of inbreeding.

McCurley et al (1984) reported that the regression of estimated growth curve parameters on levels of inbreeding of the individual and of their dams showed that inbreeding of individual was negatively related ($P < 0.01$) to the estimated mature body weights of the three breeds studied. They found that each percentage increase in the individual's level of inbreeding resulted in about 2kg decrease in estimated mature body weight. But they reported that the level of inbreeding of the dam was positively related to estimates of mature body weight of calves in the three breeds.

2.4.4.3.5 Carcass Quality: The ratio of lean to fat, meat to bone and dressing percentage of the animal after evisceration are all good indicators of the expected returns on investment in the beef cattle industry. And these parameters of meat quality have been investigated with respect to levels of inbreeding.

Antal and Bulla (1986) found significant effects in the carcass quality of outbred and inbred bulls as expressed in their carcass daily gain, dressing percentage, internal fat weight, percentage of lean and the percentage of moisture in the lean.

Inoue (1986) also reported that inbreeding affects the dressing percentage, marbling score and rib eye area of the beef cattle while Guba and Wolf (1984) found that regression of inbreeding coefficient on carcass traits ranged from -0.002 to 0.36.

2.4.4.3.6 <u>Linear Measurement</u>: Various indices of linear measurement in beef cattle enterprise has been found as indicators of productivity of the animal. Los' (1984) reported that the level of inbreeding of cattle affects height at withers, heart girth and body length of Russian Brown cows.

Guba and Wolf (1984) also found that the correlation of the inbreeding coefficient with body measurements ranged from -0.07 for chest depth at 12 months of age to -0.22 for heart girth at 6 months of age. Sachdeva et al (1983) and De Nise (1983) both reported the negative effect of level of inbreeding on body measurements.

2.5 N'DAMA CATTLE

2.5.1 ORIGIN AND HISTORY IN NIGERIA.

N'Dama cattle breed of West Africa is believed to be of the Hamitic Longhorn cattle ancestry which migrated from Morocco in North Africa along the Coast and preserved around the Gulf of Guinea (Olutogun, 1976). This breed of cattle is more ancient than other West African cattle breeds like the Zebu and the West African Dwarf Shorthorn.

The ability of the breed to tolerate high level of tsetse fly challenge made them adaptable to the Forest Zone and were concentrated in the Fouta Djallon

Highlands centuries ago. The ancestral route of the breed is described by Olutogun (1976) who confirmed that the Fouta Djallon Highlands is the main centre of dispersion of the breed.

The first batch of N'Dama cattle imported into Nigeria in the early 1940's were kept at the Ilorin farm for adaptability studies. In 1942, the N'Dama cattle breed was introduced to the Ilora farm. This farm was to train ex-servicemen discharged from the military service. In 1947 another herd of the N'Dama was imported from French Guinea around Mawou and Dabela districts. After the initial losses of the animals to trypanosomiasis, the animals soon became adapted to this Sub-humid and Humid environment. Further importation were made in 1952 and 1979. The performance of the imported and Fashola-bred stock were compared. Since then, the breed has been used on the farm either as purebreds or are crossed with some other local and exotic breeds of cattle (Olutogun, 1976).

2.5.2 PERFORMANCE TRAITS OF N'DAMA CATTLE.

2.5.2.1 GROWTH CHARACTERISTICS

The N'Dama cattle is a naturally small animal with a low weight at birth when compared with Zebu breeds of Nigeria. However, there is a slight variation in the birth weight of the breed across different regions of West Africa. In Kolda, Senegal (ILCA, 1982) the birth weight of the breed was reported as 17.70kg while at Teko Livestock Station in Sierra Leone it was 14.90kg (Carew et al, 1986). In the Accra plains of Ghana, the birth weight of N'Dama was 14.68kg (Ngere and Cameron, 1972). At Yudum, the Gambia, the birth weight was 20.40kg (ILCA, 1980). The mean birth weight of N'Dama calves born at Fashola Stock Farm between 1960 and 1963 was 19.96kg (Abanikannda, 1989). Tizikara (1988) reported 18.50kg for those born between 1947 and 1984.

However, despite this relatively low birth weights, the N'Dama cattle is superior in weight gains and mature weight than other trypanotolerant breeds of West Africa (Olutogun, 1976).

Olutogun (1976) reported the weaning weight of N'Dama breed at the Upper Ogun cattle ranch from 1952 to 1974 as 109.10kg and this is close to the 109.09kg reported by Ngere and Cameron (1972) in Ghana. Abanikannda (1989) gave the weaning weight of N'Dama at the Fashola Stock Farm from 1960 to 1963 as 100.14kg while Tizikara (1988) reported 112.50kg.

The differences observed both in the birth and weaning weights of N'Dama have been attributed to several factors. These factors include; season of birth, year of birth, sex of calf, sire effect, dam effect, age of dam, inbreeding, crossbreeding, parity, gestation length e.t.c. (Abanikannda, 1989; Tizikara, 1988; Ehiobu and Ngere, 1986; Adeyanju et al, 1976 and Olutogun, 1976).

The adaptability of the N'Dama breed to the tsetse infested region of West and Central Africa has been of tremendous importance in livestock productivity of this zones.

2.5.2.2 TRYPANOTOLERANCE

The tsetse fly challenge predominant in the humid region of West Africa has been a major obstacle to the cattle industry in these regions. The fly is a vector of the much dreaded Trypanosoma spp which transmits Trypanosomiasis in cattle and man. The clinical disease in cattle varies considerably in severity and duration. The disease syndrome may either be acute or chronic and various strains of Trypanosoma have been identified (Murray and Trail, 1983). Those that are of economic importance to animals are T. vivax, T. congolense, T. theileri (ILCA, 1983). The major feature of the disease in cattle is anaemia and it is observed as the pallor of the mucous membrane. Infected animals occasionally show loss of appetite associated with pyrexia, although they usually continue to eat throughout the course of the disease.

In infected herd, the severely affected ones are usually trailing at the rear of the herd (ILCA, 1983) and such animals are wasted and lethargic. In the terminal stages of the disease, the affected animals often become extremely weak and are unable to rise. Death occurs as a result of congestive heart failure arising from a combination of anaemia and myocardial damage (ILCA, 1983).

Some West African breeds of cattle are able to survive this infection without the use of drugs in areas of medium to high tsetse fly challenge. This phenomenon is termed *Trypanotolerance*. The exploitation of genetic resistance to this disease is becoming increasingly important for livestock development programmes in the developing countries of West and Central Africa. Trypanotolerance is generally attributed to the taurine breeds of cattle in West and Central Africa (ILCA, 1983) and the N'Dama and West African Shorthorn are the most trypanotolerant.

Despite the fact that trypanotolerance will have to be a major component of livestock production in some areas of Africa, cattle breeds with this trait constitute less than 5 percent of the total cattle population in Africa (ILCA, 1983). Particular attention has been focussed on the N'Dama breed because of its relatively fixed phenotype, its trypanotolerance which can be enhanced through improved nutrition and selection for high productivity.

It was initially suggested that trypanotolerance results from adaptation of the breed to trypanosomiasis but studies (Murray and Trail, 1983) has confirmed that trypanotolerance has a genetic basis. Several workers are already documenting the mode of action of trypanosomiasis and the Trypanotolerance of N'Dama (ILCA, 1983).

2.5.2.3 PRODUCTIVITY AND VIABILITY

With the prevalent tsetse fly environment under which the N'Dama cattle is bred and decrease in tsetse fly challenge as more land is cleared for farming the N'Dama cattle will become of relative importance. However, a survey of the status of trypanotolerant livestock in West and Central Africa showed that the productivity of trypanotolerant cattle is comparable or higher than other non-trypanotolerant breeds under the same moderate to high tsetse fly challenge (ILCA, 1983).

Productivity indices were basically determined by the level of tsetse fly challenge and the management system adopted on the farm and it was found that values for herds kept on stations were more productive than those on ranches (Table 1). Herds kept under tsetse free environment also have a better performance than those kept under tsetse challenge (ILCA, 1979; Tizikara, 1988 and Fall et al, 1982).

Aside from tsetse challenge, Fall et al (1982) reported that year of calving and month of calving significantly affect ($P < 0.01$) the cow productivity indices obtained at Kolda, Senegal.

Table 2.1: Productivity estimates for N'Dama cattle in Nigeria

Traits	Management level Ranch	Station
Tsetse challenge	Medium	Nil
Cow viability (%)	100.0	100.0
Calving percentage	58.0	100.0
Calf viability <= 1 yr	85.8	97.0
Yearling weight (kg)	156.0	131.0
Mature Cow weight (kg)	212.0	266.0
Index / Cow / Year (kg)	86.4	127.8
Index / 100kg Cow / year (kg)	33.2	48.1

Source: Olutogun (1976) and ILCA (1979).

2.5.2.4 REPRODUCTIVE PERFORMANCE

Reproductive performance is the most essential trait in livestock enterprise. If there is no calf, there is no economic return (Carew et al, 1986).

Best cows in the herd are those that have low age at first calving, minimum calving intervals and live a long time. Therefore, the most important measure of reproductive performance in the females are age at first calving, calving interval and length of the productive life of the cow.

2.5.2.4.1 AGE AT FIRST CALVING

Several factors have been identified to affect the N'Dama cow's age at first calving and this include season of birth, year of birth and management practices (Tizikara, 1988; Carew et al, 1986; Fall et al, 1982 and Olutogun, 1976).

Carew et al (1986) gave the mean age at first calving of N'Dama at the Teko station, Sierra Leone as 46.50 ± 0.70 months while Olutogun (1976) gave the age at first calving at Upper Ogun N'Dama under a ranching condition as 47.60 ± 0.38 months. However, Fall et al (1982) gave the age at first calving as 39.80 ± 0.80 months at the Kolda station, Senegal. This shows that management greatly influences age at first calving in N'Dama females.

2.5.2.4.2 CALVING INTERVAL

The period of time between two successive parturition in the cattle is known as the calving interval. The shorter the calving interval the more the number of calvings of the cow during its productive years.

Factors reported to affect the calving intervals of N'Dama are age of cow, parity, year and season of calving and age at first calving (Olutogun, 1976; Tizikara, 1988; Fall et al, 1982 and Carew et al, 1986).

The mean calving interval of 515 ± 11 days was reported at Teko, Sierra Leone (Carew et al, 1986) while Olutogun (1976) reported 631 ± 11 days. Fall et al (1982) gave the mean calving interval as 495 ± 16 days in Kolda, Senegal. It would therefore appear that management is a key factor in calving interval in N'Dama.

2.5.2.4.3 LENGTH OF PRODUCTIVE LIFE

The length of the productive life of cows is an important consideration in reproductive performance. Fall et al (1982) gave the average length of the cow's productive life as 10.8 years while Carew et al (1986) gave the average productive life as 11.3 years. Olutogun (1976) reported the average of 12 years with some N'Dama cows staying on the ranch until 15 years old. Perhaps long productive life is a breed characteristic for N'Dama cattle.

2.5.2.5 MILK PRODUCTION

Although N'Dama cattle is not well suited for commercial dairy production, its potential for milk production has been exploited in The Gambia, Senegal and Sierra Leone. Some of the reasons for poor dairy performance may be attributed to its small udder, bad temperament and small body size.

Milk yield of N'Dama cows has been influenced by improving management practices, supplementary feeding, milking procedure and length of the lactation length.

Milk yield of N'Dama has been reported as 280kg in 209 days or 125kg in 189 days at the Fashola Stock Farm, Nigeria (Tizikara, 1988).

2.5.2.6 DRAUGHT POWER

N'Dama oxen are stronger relative to their body size and can sustain an average traction of up to 14% of their body weight (Starkey, 1982). Oxen grazing local pasture can work for 3 to 5 hours a day, five days a week without any additional supplementary feeding. They can achieve a ploughing rate of 0.04ha /hr on open land and 0.03ha/hr in rice swamps (Starkey, 1984). Harrowing and leveling rates of 0.065 - 0.099 and 0.052 - 1.100 ha /hr respectively have been reported by Starkey (1984). N'Dama cattle is therefore useful to farmers in all the developing countries of West and Central Africa.

In summary, N'Dama cattle is useful not only for its trypanotolerance but for its good quality meat, milk with higher butter fat content, and as a powerful draught animal for land preparation for the peasant farmers of West and Central Africa.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 THE FASHOLA STOCK FARM

3.1.1 History and Objectives

The Fashola Stock Farm was established in 1947 by the then British Colonial Government in the Oyo province of Western Nigeria. Details of how the site was identified and chosen was described by Tizikara (1988).

The farm is currently owned by the Oyo State Government under the direct supervision of the Ministry of Agriculture and Natural Resources.

The foundation stock included the initial importation of 93 heads of N'Dama from the French Guinea (now Guinea Republic) and those of Ilorin and Ilora farms.

The stated objectives of the farm are:

(a) To multiply N'Dama cattle for distribution to local farmers;

(b) To produce a type of beef cattle that can thrive under a low level of management in heavy tsetse fly challenge areas of Southern Nigeria;

(c) To produce a strain of cattle that would grow economically under a good level of management with little or no tsetse fly challenge;

(d) To serve as an experimental research farm and to transfer research results to local farmers, for the improvement of their herds;

(e) To serve as a multiplication centre for other local breeds especially Keteku and Muturu cattle.

(f) To serve as a training ground for students and aspiring cattle farmers.

3.1.2 GEOGRAPHICAL LOCATION

The farm is situated in a low to medium tsetse fly risk zone in the Derived Guinea Savannah belt of Nigeria. The farm is infested with Trypanosome vivax as the most prevalent species of Trypanosome (FAO, 1980).

It is situated at an altitude of 228.6m above sea level on latitude 7° 54'N and longitude 3° 43'E of the Equator.

It is bounded on the north by the Oyo-Iseyin road, on the south by Awon river, on the west by the Alapata river and on the east by the Ologede river (Figure 3.1).

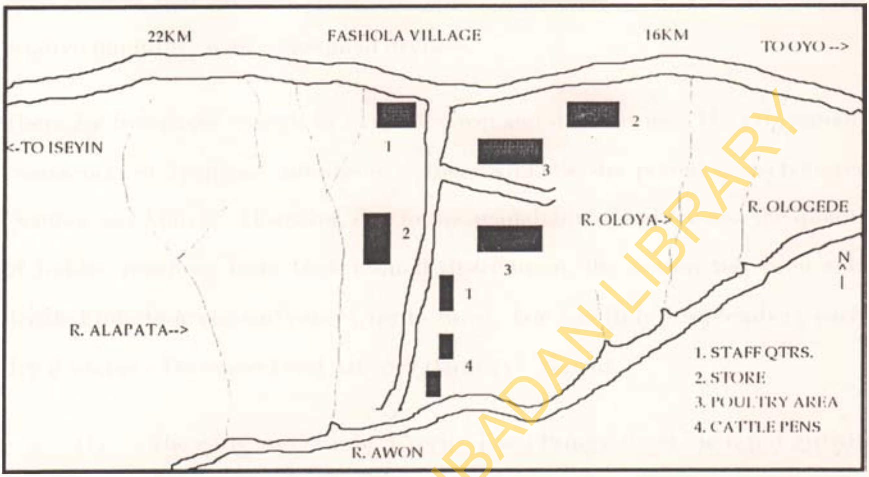

Figure 3.1: Sketch of Fashola Stock Farm as at 31st March, 1947.

The Federal Government of Nigeria has now acquired more land adjacent to the farm for its Livestock Development Projects.

3.1.3 CLIMATE, VEGETATION AND SOIL

The climatic condition of Fashola Stock Farm is more of the tropical rain forest than the Derived savannah. The annual rainfall pattern is influenced by two opposing winds; the south west monsoon wind and the north east trade wind. The former is responsible for the periods of high relative humidity as a result of high rainfall that prevails while the latter is characterized by a drop in the relative humidity, with consequent dryness.

There are two major seasons in a year, the wet and dry seasons. The rain usually commences in April and subsides in October while the dry period spans between October and March. However, due to the availability of fodder and the quality of fodder resulting from such rainfall distribution, the season has been sub-divided into four viz; early wet (April - June), late wet (July - September), early dry (October - December) and late dry (January - March).

(1) The early wet season (April - June) brings about the rapid growth of succulent nutritious grasses and fodder for livestock production and this stimulates "compensatory growth" rates in ruminants.

(2) The late wet season (July - September) brings fodder and grasses to maturity, lignification peaks and consequently there is a drop in the nutritional value of the grasses and fodders. This period consequently brings about slight decrease in daily gain if the animals depend solely on grasses.

(3) The early dry season (October - December) brings flowering and podding to maturity but new growth (second seasonal growth) in some grasses and forage is encountered. The nutritional status of the vegetation is slightly boosted as a result of this secondary regrowth.

(4) The late dry (January - March) is the hungry season for ruminant livestock and they are solely dependent on dry standing hay. The rivers are drying up and consequently there is also shortage of water leading to starvation during the season.

The mean annual precipitation, mean monthly precipitation and mean seasonal precipitation are shown on Figures 3.2, 3.3 and 3.4 respectively.

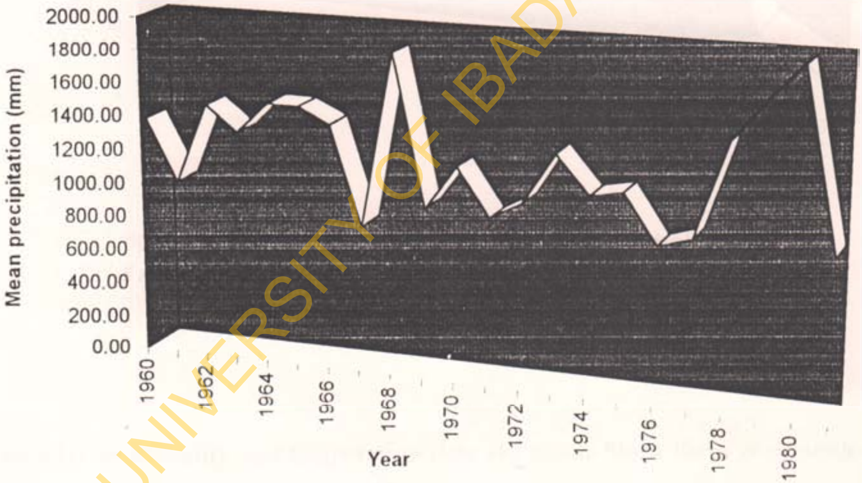

Figure 3.2: Annual precipitation at Fashola Stock Farm (1960 - 1981)

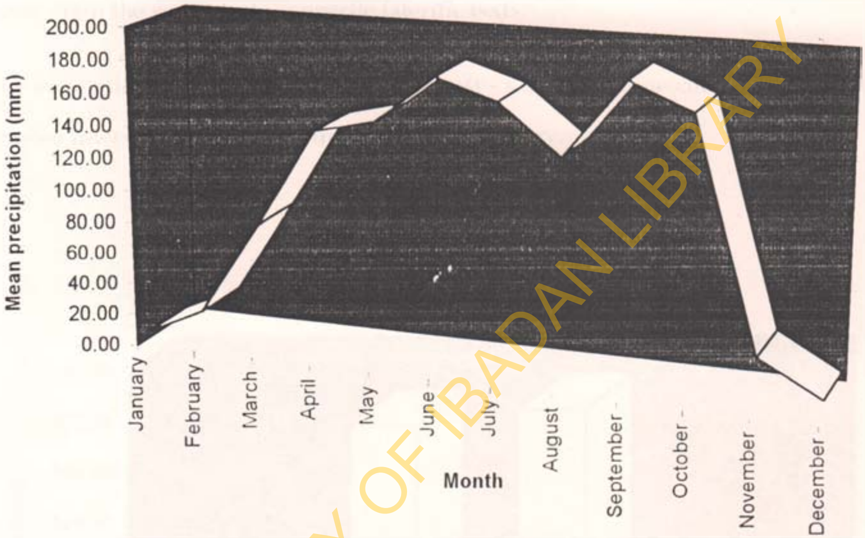

Figure 3.3: Mean monthly precipitation at Fashola Stock Farm (1960 - 1981)

The relative humidity and temperature data at Fashola Stock Farm is presented in Table 5. The annual minimum temperature is about 21°C while the maximum is 33°C. Relative humidity varies between 52% and 78% depending on the period of the year.

Tizikara (1988) described the soil of Fashola as of low to moderate fertility and more often the soil structure overlie lateritic beds.

The vegetation of the farm is typical of forest - savannah zone comprising of tall grasses interspersed between trees and forest gallery.

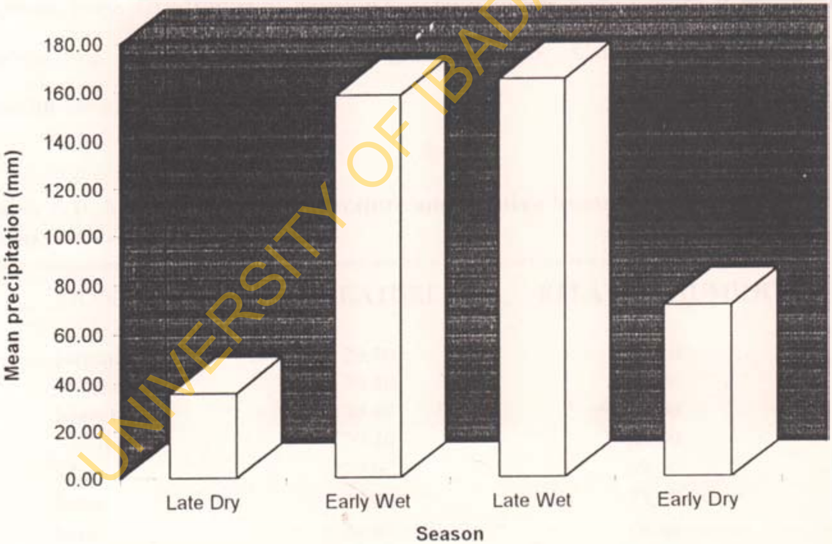

Figure 3.4: Mean seasonal precipitation at Fashola Stock Farm (1960 - 1981)

3.1.4 MANAGEMENT PRACTICES

3.1.4.1 Pasture Management

The 340 hectares of land on the farm was divided into 107 paddocks of about 2 hectares each and established with grass - legume mixtures.

The species of grasses were Elephant grass (Pennisetum purpureum), Guinea grass (Panicum maximum), Giant Star grass (Cynodon plectostachium) and Gamba grass (Andropogon gayanus). The legumes were Centro (Centrosima pubescens), Stylo (Stylosanthes gracilis) and Calopo (Calopogonium mucunoides).

Table 3.1: Mean monthly temperature and relative humidity of Fashola Stock Farm (1960 - 1981)

MONTH	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)
January	29.10	52.10
February	30.40	58.20
March	30.40	59.50
April	29.40	64.80
May	29.00	69.20
June	27.20	73.60
July	26.00	78.60
August	25.40	78.30
September	26.00	78.60
October	27.40	74.50
November	28.50	65.80
December	29.70	59.90

Maintenance of the pasture included slashing, mowing and occasionally pastures invaded by weeds are burnt in the dry season and ploughed back into the soil. N.P.K. fertilizer was sometimes applied for the replenishment of the soil nutrients but it was later discontinued.

3.1.4.2 Herd Management

The system of animal husbandry on the farm is semi - intensive. The animals were grouped into paddocks according to their sex, age and physiological status. Usually there were six major divisions viz: Nursing 1, Nursing 2, Nursing 3, Old Cows, Weaners and Sick Animals. Each of these was under the supervision of two herdsmen.

Routine management operations included castration, spraying, deworming and vaccination. Animals were dewormed quarterly except calves. Dipping or spraying of animals against ectoparasites was carried out once a month during the dry seasons and fortnightly during the wet seasons. Vaccination against notifiable diseases included heamorrhagic septicaemia, contagious bovine pleuro - pneumonia, black quarter disease, anthrax and brucellosis.

A veterinary unit attached to the farm carried out all necessary disease control measures and emergencies. Sick animals were kept in a sick bay where they were diagnosed and treated. Post mortem examinations were performed on dead animals to identify the probable cause of death.

Animals were identified soon after birth by any of these methods; tatooing, neck - tag, ear - notching or branding. Other management practices are described by Tizikara (1988) and Abanikannda (1989).

3.1.4.3 Breeds and Breeding

The foundation stock was imported to Fashola Stock Farm in 1947 and included 20 bulls and 73 heifers of the N'Dama breed. Later some other N'Dama males and females were brought from Ilorin farms. More importation of N'Dama were made from Upper Ogun Cattle Ranch and from Zaire, Guinea and Sierra Leone. Muturu, Keteku and a few heads of White Fulani were later introduced to the farm.

In 1964, crossbreeding programme was initiated through the USAID. Santa Gertrudis, Brahman, Jersey, Angus, Hereford semen were imported from the USA for this programme. Two live bulls of Brahman breed were also imported.

Except for the crossbreeding attempt pasture mating was adopted where a breeding bull was allowed access to the breeding cows throughout the year in each fenced paddock. Bull to Cow ratio for pasture mating fluctuates between 1:20 and 1:30. Heifers were first introduced to bulls between the ages of two and three years and nursing cows were introduced into the breeding paddocks at 45 - 60 days post partum.

3.1.5 DATA COLLECTION, PREPARATION AND ANALYSIS

3.1.5.1 Data Collection

The data used in this study were extracted from the Fashola Stock Farm record books. These records were kept in a series of field books and have been collected since the farm was established in 1947 up till 1984. The major records kept on the farm are those of calvings, weight and mortality.

Database records extracted from the information available are:

(a) Calf identification number

(b) Calf breed or genotype

(c) Date of birth of calf

(d) Sex of calf

(e) Sire identification number

(f) Sire breed or genotype

(g) Dam identification number

(h) Dam breed or genotype

(i) Birth weight of calf

(j) Weaning weight of calf

(k) Age of calf at weaning

3.1.5.2 Data Preparation

The data extracted from the field books were coded using a pre-defined code for each and all of the variables (Appendix I).

The coded data were then written into the computer diskettes using Dbase IV (1990). The database file was then used for preliminary statistical analyses to verify and validate the coded values using SPSS/PC+ (1991). Obvious mistakes arising from the entering of the data on computer were identified and corrected. Comprehensive verification and validation of the database file was done using the Statistical Package for the Social Sciences (SPSS/PC+, 1991) to prepare the frequency distribution and cross-tabulations of each of the variables and the correction of mistakes. This was followed by the construction of logical subclasses to the various probable sources of effects on the traits studied.

Some variables not originally available in the field books were then computed and added to the list of variables originally present.

The season of birth was assigned values from 1 - 4 to signify the four sub-divisions of the seasons within a year. Calves born between January and March was assigned 1, April - June 2, July - September 3 and October - December 4.

The age of dam was computed for all dams that were born on the farm and whose birth records can be traced and retrieved. However, imported heifers (foundation stock) were given a default date of birth. A small computer program was written to retrieve the date of birth of all dams that were born on the farm and default the imported heifers with a date 2 years less than their date of importation. The program further deducted their date of calving from their date of birth and the difference returned as the age of dam in days. This was divided by 30 (on assumption that a month is averagely 30 days) and the result gave the age of dam in months.

The parity, age at first calving and calving interval were computed using a small computer program. The logic of the program is to identify all dams that had calves and sort them in chronological order (based on their identification number and date of calvings) for contiguous records. Starting with the first calving of a particular dam, the computer returns 1 as the parity and a unit increment for each subsequent calvings of the same dam.

The age of the dam at parity 1 (one) is automatically returned as the age at first calving of that dam. The computer further calculates the calving interval by deducting the succeeding calving date from the immediate preceding date of calving of that same dam and the difference is returned in days in the calving interval field.

The average daily gain (ADG) and adjusted weaning (WNWT) / yearling weight (YLWT) were computed from the values obtained using the formula (BIF, 1990).

$$ADG = (WNWT - BTHWT) / WNAGE$$

where ADG = Average daily gain

WNWT = Weaning weight

BTHWT = Birth weight

WNAGE = Age at weaning

The ADG gave the pre-weaning daily gain of any particular calf at the specified weaning age.

The adjusted weaning weight was computed to standardize the ages of the calves in order to compare the differences in their weaning weight since the calves were not weaned at the same age. The formula for the adjusted weight (BIF, 1990) was:

$$ADWT = ((WNWT - BTHWT) / WNAGE) \times AGE$$

where ADWT = Adjusted weight (weaning / yearling)

WNWT = Weaning weight

BTHWT = Birth weight

WNAGE = Age at weaning

AGE = Standardized age e.g. 205 for weaning and 365 days for yearling weight

The criteria for selecting any specific standardized age is determined basically by the range of the actual age at weaning of the calf. For example, calves weaned at 170 to 240 days fits into the 205 day adjusted weaning weight while those weaned between 280 to 450 days fits with the 365 day adjusted yearling weight. This assumption will minimize either over-estimating or under-estimating the weight at standardized age.

The database file was then re-evaluated and re-verified to identify records with impossible values. Such records were then deleted from the file and not used in subsequent analyses. Records that were deleted were those with extremely low or high ADG, adjusted weight, calving interval, age at first calving. About four percent of the total number of records finally used for the analyses were deleted. The criteria for this deletion and selection of records is as described by Olutogun (1976), Tizikara (1988) and Abanikannda (1989).

3.1.6 THE DEVELOPMENT OF A PEDIGREE CHARTING AND INBREEDING COEFFICIENT COMPUTER PROGRAM

3.1.6.1 Introduction

The fact that there is considerable overlapping of generations, especially in females in the herd at any particular time, no regular system of inbreeding coefficient determination is possible with cattle. Also the generation interval for males is usually less than for females, this makes the computation of inbreeding coefficient by pedigree analysis increasingly complex in succeeding generations Cruden (1949).

The limited number of information usually available on farm animals in the developing countries and the need for the animal breeder to know the pedigree of individual animals to determine relationship and inbreeding coefficients has been a most challenging task.

To circumvent this problem several computer programs to chart the pedigree structure of individual animal and to calculate their inbreeding coefficient based on pedigree analysis had been developed in the past (Mange, 1964; Rehfeld et al, 1967; ASAS, 1978; Orihashi and Fushimi, 1982; Boyce, 1983; Tai et al, 1984; Yoshida, 1985 and Golden et al, 1991). However, each of these programs had its limitations as discussed in the literature review and the unavailability and inability to adapt these programs to livestock productivity data peculiar to developing countries had been a major handicap to the use of these programs.

Usually productivity data kept on Fashola Stock Farm consisted only the information on the immediate parents of the animal (sire and dam) and no information whatsoever on their pedigree. One of the objectives of this study is to develop a computer program that requires minimal computer resources and yet be capable of charting the pedigree structure and calculating the inbreeding coefficient of individual animal as accurate as possible.

This led to the development of a computer program that can trace and chart the pedigree of any particular animal born on the farm and whose immediate parents (sire and dam) are known. The foundation animals were considered as the base generation and the animals were assumed to be unrelated by ancestry.

The program known as Pedigree Chart Master System (PCMS) was conceived to specially handle problems associated with animal breeding database management system. It was written using the Nantucket Clipper and Nantucket Tools II for Clipper version 5.01. It is an interactive interface for some stand alone computer programs which can be invoked by highlighting and selecting a choice from the menu. It requires minimal computer knowledge because the whole system is activated via a pop - up menu driven system that is easy to operate.

This program will trace, find, chart and write to the disk the pedigree information on any animal whose immediate parental information (sire and dam identification) is available. It will iteratively do the search on this particular animal up to the fifth generation. This can be expanded further to the n^{th} generation depending on the available computer resources. All the retrieved information will then be written to the disk permanently. A new database file will then be created and used for the calculation of inbreeding coefficient of every individual in the population by the application of Wright's formula.

3.1.6.2 Program Development

The target users for this program are expected to be those involved in animal breeding research. This is because the program is developed and designed exclusively for use in animal breeding teaching, research and extension services.

Apart from the conventional facilities to **'Create, Use, Save, Modify** and **Save**' a database file available in this program, other modules are targeted at the case study. However with slight modification to the source code of the program, it can be adapted for use with any other standard / conventional database files.

The essence of this program is to handle existing database files without the rigor of re-entering the data. Data manipulation is effectively done with minimal inconvenience. Some of the modules meant specifically for the case study are discussed as below:

3.1.6.2.1 Convert (Id. No.) Identification Number

This program is intended to handle the problem peculiar to Fashola Stock Farm. During the verification of the data, it was observed that different record keeping systems were adopted on the farm depending on the orientation of the Farm Management. This resulted in conflicting identification numbers. For example, there were instances when two different animals were given the same identification number irrespective of sex and other animals had two different identification numbers.

These problems were solved by devising a registration system whereby a particular animal will have an identification number that is absolutely unique to that animal alone. The logic of this program is to sort all the calving records on the farm in chronological order by year, month and day of calving. The registration system ascribes the first 2 digits to the year of birth, the next 2 digits to the month of birth and the last 2 digits the number of that particular calving within the month. As such, no two animals were given the same identification number and this facilitated the search of the pedigree in Fashola Stock farm. This module now reassigns the new identification for all the males that were used as sires and females that were used as dams in the database file.

3.1.6.2.2 Change (Struct.) Structure

This module is to append additional fields to the already existing database file to make room for the storage of information to be retrieved during pedigree charting .

It appends all the fields necessary after searching if the database file does not already contain such new fields to avoid field duplication.

3.1.6.2.3 Chart

This is the module that searches, retrieves and writes the pedigree information of the requested animal to its corresponding field.

It retrieves all the pedigree information available on an individual up to the fifth generation. This can be expanded to handle higher generation by modifying the source codes for this routine. It was limited to the fifth generation because the records at Fashola Stock Farm did not exceed the fifth generation.

3.1.6.2.4 Inb. Coefficient

This module computes the inbreeding coefficient of any particular animal based on its pedigree analysis.

The calculated values are saved to the disk in the field meant for inbreeding coefficient.

The inbreeding coefficient for any individual was calculated using the Wright's (1921) formula:

$$F_x = (½)^{n+n'+1} (1 + F_a)$$

where F_x = the inbreeding coefficient of individual **x**

n = the number of generations through the sire

n' = the number of generations through the dam

F_a = the inbreeding coefficient of a common ancestor "**a**"

The calculated inbreeding coefficient was obtained from path searching of identical parent/s along the sire and dam pedigree.

3.1.6.2.5 Display By

This module helps to display the pedigree structure of animals and the inbreeding coefficient of that animal.

There is an option of either displaying the animals within a specified range (based on record numbers on the database file) or specifying the actual identification number of the requested animal. And the pedigree of the individual is displayed as in Figure 3.5.

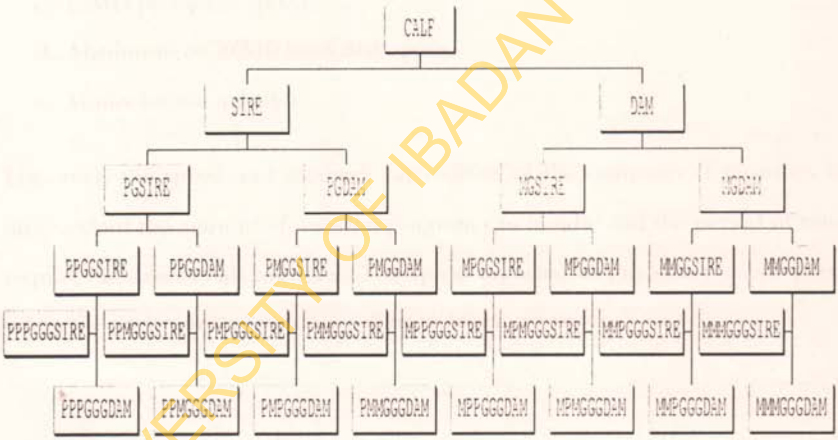

Figure 3.5: Schematic diagram of a pedigree chart

Kernel of the source codes for some of these modules are given in Appendix II.

3.1.6.3 Program requirements and limitations

This program requires minimal computer resources and it will run perfectly well on computer with the following minimal configuration:

a. 512 kb on board RAM (Random Access Memory)
b. DOS 3.3 and above
c. 12MH processor speed
d. Minimum of 20 MB hard disk space
e. Monochrome monitor.

However, the speed and memory capabilities of the computer determines to a large extent the amount of data the program can handle and the period of time it requires to execute all routines. The speed reported in this study was recorded when the program was used on a 386 (16 Mhz) computer.

3.1.7 Statistical Analyses

Olutogun and Dettmers (1977) remarked that since most animal breeding data have disproportionate subclass numbers, the accuracy of computed parameters and the validity of conclusions drawn from each analysis are highly dependent on how accurately the selected mathematical model best describe the biology involved. To this end, efforts were made to ensure that computations and calculations in this study do not only make statistical sense but also are biologically meaningful and interpretable. Several models were tested and the best adopted.

The validated data was first analysed using the General Lineal Model (GLM) of SAS (1990) and finally with the least squares procedures of Harvey (1989). The latter is a least squares maximum likelihood mixed model computer program specifically designed for statistical analysis in animal breeding. The versatility of the program to handle data with unequal observation in the subclasses made it a good tool in animal production research.

The conventional analysis of variance (ANOVA) cannot be used for this analysis due to the irregular distribution of variables amongst the various subclasses.

Analysis of variance was carried out by least squares procedure of Harvey (1989) and the statistical model describing each of the traits studied are given as follows:

The general model describing the age at first calving of N'Dama heifers was:

$$Y_{ijk} = \mu + R_i + S_j + Cb_I + Db_I + e_{ijk}$$

where Y_{ijk} = Individual heifer's age at first calving

μ = Population mean

R_i = Year of birth effect (i = 1,.....29)

S_j = Season of birth effect (j = 1,....4)

Cb_I = Regression of inbreeding coefficient of calf

Db_I = Regression of inbreeding coefficient of heifer

e_{ijk} = Residual random error

The general model describing the average calving interval of N'Dama cows was:

$$Y_{ijklmn} = \mu + R_i + S_j + P_k + D_l + A_m + Db_l + e_{ijklmn}$$

where Y_{ijklmn} = Individual cow's average calving interval

μ = Population mean

R_i = Year of birth effect (i = 1,.........31)

S_j = Season of birth effect (j = 1,....4)

P_k = Parity effect (k = 1,........8)

D_l = Regression of age of dam

A_m = Regression of dam's age at first calving

Db_l = Regression of inbreeding coefficient of dam

e_{ijklmn} = Residual random error

The general model describing birth weight of the calves was:

$$Y_{ijklmno} = \mu + X_i + R_j + S_k + P_l + D_m + A_n + Cb_l + Db_l + e_{ijklmno}$$

where $Y_{ijklmno}$ = Individual calf's birth weight

μ = Population mean

X_i = Sex effect (i = 1,2)

R_j = Year of birth effect (j = 1,.........38)

S_k = Season of birth effect (k = 1,....4)

P_l = Parity effect (l = 1,........12)

D_m = Regression of age of dam

A_n = Regression of dam's age at first calving

Cb_I = Regression of inbreeding coefficient of calf

Db_I = Regression of inbreeding coefficient of dam

$e_{ijklmno}$ = Residual random error

The general model describing 120-day adjusted weight (AD120D) and daily gain from birth to 120 day (120DG) of the calves was:

$$Y_{ijklmno} = \mu + X_i + S_j + P_k + C_l + D_m + A_n + Cb_I + Db_I + e_{ijklmno}$$

where $Y_{ijklmno}$ = Individual calf's AD120D and 120DG

μ = Population mean

X_i = Sex effect (i = 1,2)

S_j = Season of birth effect (j = 1,....3)

P_k = Parity effect (k = 1,........6)

C_l = Regression of calf's birth weight

D_m = Regression of age of dam

A_n = Regression of dam's age at first calving

Cb_I = Regression of inbreeding coefficient of calf

$e_{ijklmno}$ = Residual random error

The general model describing 205-day adjusted weight (AD205D) and daily gain from birth to 205 day (205DG) of the calves was:

$$Y_{ijklmnop} = \mu + X_i + R_j + S_k + P_l + C_m + D_n + A_o + Cb_I + Db_I + e_{ijklmnop}$$

where $Y_{ijklmnop}$ = Individual calf's AD205D and 205DG

μ = Population mean

X_i = Sex effect (i = 1,2)

R_j = Year of birth effect (j = 1,.........18)

S_k = Season of birth effect (k = 1,....4)

P_l = Parity effect (l = 1,........11)

C_m = Regression of calf's birth weight

D_n = Regression of age of dam

A_o = Regression of dam's age at first calving

Cb_I = Regression of inbreeding coefficient of calf

Db_I = Regression of inbreeding coefficient of dam

$e_{ijklmnop}$ = Residual random error

The general model describing 365-day adjusted weight (AD365D) and daily gain from birth to 365 day (365DG) of the calves was:

$$Y_{ijklmnop} = \mu + X_i + R_j + S_k + P_l + C_m + D_n + A_o + Cb_I + Db_I + e_{ijklmnop}$$

where $Y_{ijklmnop}$ = Individual calf's AD365D and 365DG

μ = Population mean

X_i = Sex effect (i = 1,2)

R_j = Year of birth effect (j = 1,.........18)

S_k = Season of birth effect (k = 1,....4)

P_l = Parity effect (l = 1,........12)

C_m = Regression of calf's birth weight

D_n = Regression of age of dam

A_o = Regression of dam's age at first calving

Cb_I = Regression of inbreeding coefficient of calf

Db_I = Regression of inbreeding coefficient of dam

$e_{ijklmnop}$ = Residual random error

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 PART A: PROGRAM DEVELOPMENT AND UTILIZATION

4.1.0 Overview

The program is written in Clipper(R) and it requires a minimum of 512Kb of memory with at least a double density floppy disk drive and a hard disk capacity of at least 20Mb. It operates on DOS 3.3 and above and supports both VGA and Monochrome cards.

The package consist of some useful stand-alone programs for use in animal breeding research. These programs can be accessed through a user-friendly pop-up menu environment that requires only highlighting of prompts and selection of desired routines. It requires minimal computer experience to use most of the programs available in the package.

The program is intended for use exclusively for research and it has been optimized for both speed and program size. However, areas that may require adjustments or contain bugs shall be rectified as soon as it is discovered.

It shall be greatly appreciated if the user could please note down error messages that may be obtained during the course of the use of the programs and the key sequence or operations being carried out when such errors occur. This is a very useful information as it allows us to simulate the condition in order to generate similar error message which will in turn aid in further enhancement and optimization of the package.

Such information should be sent to the Programmers:

O.T.F. Abanikannda or Dr. Olusanya Olutogun,

Department of Animal Science,

University of Ibadan,

Nigeria.

4.1.1 Installing and Accessing the Package

The computer package is in a 3.5" floppy diskette for installation on the hard disk. You first make a directory for the package on the hard disk.

C:\>md pedchart

This makes a sub-directory (pedchart) on the hard disk. You now change to the Pedchart sub-directory as follows:

C:\>cd\pedchart

You now insert the diskette in your (A) drive and type as follows:

C:\PEDCHART>copy a:*.*

The package is now installed on the hard disk. After installation, you type PEDCHART at the prompt as follows:

C:\PEDCHART>pedchart

An initial screen with the name of the software on the top bar, details of address of where it was developed in a box in the center of the screen and the patent registration of the package at the bottom row will be displayed.

A dialog box then appears prompting for the user's access name and password. Typing in the correct name and password gives access to the running of the package, however, if after three (3) consecutive trials with wrong name and or password, the program quits the package back to the operating system.

After typing the correct name and password, it prompts you for the current date which you may type in or accept the date displayed (if it is the current date) by pressing the return key. It then prompts for the current time and you type it in or press return to accept the one displayed.

The package can now access the main program displaying five (5) menus on the top row of the program. These menus are: **File, Edit, Toggles, Utility** and **Help** menus. These menus can be activated by either pressing the F10 function key (usually at the topmost row of the computer keyboard) and using the left or right arrow keys (<- or ->) to highlight the menu you may wish to open. Press the return key to select the highlighted menu. This open up the menu and you can then highlight and select whatever option you may wish to invoke on the menu.

Alternatively, you may activate the menu system by holding down the **Alt** key (usually at the bottom row of the keyboard) and simultaneously press the **highlighted character** of the menu i.e. **Alt + F** will open the file menu while **Alt + T** will open the Toggles menu.

An option preceeded with an arrowhead indicates that such option opens to a sub-menu and is achieved by highlighting the option and pressing the return key. Movement and selection in the sub-menu is as described for the menu system e.g. highlighting the Save As menu option and selecting it will open the sub-menu of Normal Text (TXT) and Dbase Format (Dbf).

4.1.2 <u>WORKING WITH MENUS</u>

4.1.2.1 <u>File Menu</u>:- After activating the File Menu, five (5) options are listed on the menu viz: **Create, Use, Modify, Save As** and **Exit**. You can highlight any of these options using the up or down arrow keys to move to the desired option.

4.1.2.1.1 <u>CREATE</u>:- This option allows you to create a database file of your choice and it is activated and selected by pressing Alt + F and then C or through the use of the arrow keys. After selecting Create, it prompts you for the name of the database file you want to create. Type in the name of the file to create and press the return key. It prompts you for the number of fields the file will contain and you respond by typing the number of fields to create.

The program now gives you the options of typing in the field name, type, length and decimal places (if it is a numeric field) for all the fields you want to create. It returns you to the bar as soon as all the fields are correctly created.

The field name is a name to identify the field and it must be unique i.e. no two fields can have the same name. It takes up to ten (10) characters as the field name.

The field type is only a character and it describes the type of information to be stored in the field. It could be character (C), Numeric (N), Date (D) or Memo (M). A field declared as character takes any character (be it letters, numbers or special characters) while a numeric field takes only numbers. A date field takes only dates and a memo field takes notes or any string.

The field length specifies the upper limit of the maximum characters the field can accommodate e.g. a character field (Surname) to contain **ABANIKANNDA** must be at least **11 characters** long. Note that spaces and decimal points are counted as a character, thus provision must be made for them. The field length for date is default to eight (8) while memo is ten (10). The decimal place signifies the number of decimal places a numeric field will have e.g. a numeric field (Weight) with length of 6 and Decimal place 2 will be represented as 999.99 (Note that the decimal point is counted as the sixth character).

4.1.2.1.2 USE:- This allows you to specify the name of the database file you want to open and make current. Every other initially opened database files are closed and the one in USE remains the only opened database file. This is essential before you can perform any task on the database file e.g. you cannot BROWSE if there is no file in USE.

4.1.2.1.3 MODIFY:- Highlighting and selecting this option allows you to modify the structure of the database file. You may add additional fields to the database file. After selecting it, you are prompted for the name of the Database file to modify and number of additional fields to add. Correctly typing the name of the file and the number of fields to create will give you the prompts as in CREATE whereby you enter the field name, type, length and decimal place.

4.1.2.1.4 SAVE AS:- This option enables you to save the current database file either as a text file (.txt) or a database file format (.dbf). After selecting the SAVE AS option, it opens a sub-menu to specify the format in which such file will be saved. Saving as normal text will allow only the characters that can be read to be processed and the special characters associated with database files eliminated when such files are viewed with DOS TYPE or EDIT command. It is also useful to save as a text file, which is the standard data format for use in statistical analyses using other packages. Some statistical package cannot read the database files as '.dbf' e.g. LSMLMW (Harvey, 1989) while others have facility to read the .dbf files e.g. SPSS/PC+ and SAS.

4.1.2.1.5 EXIT:- This is the only normal way of getting out of the package. Selecting this option take you out of package and return you to the DOS prompt. It can be invoked by special key sequence if the menu bar is not activated. And this is done by pressing the **Alt + X**. This is the shortcut or quick key for quitting the package. Before the program quits, all opened database files with their associated index and form files will be closed and the initial screen of the monitor before loading the PEDCHART will be restored on quitting.

4.1.2.2. <u>EDIT</u>:- This is the menu that handles the editing of database files that may be in USE. It consist of only one option i.e. **BROWSE**.

4.1.2.2.1 <u>BROWSE</u>:- This is selected by pressing the **Alt + E** and **B**. On selection, a small box is displayed in the centre of the screen and the most recently opened (USED) database file is displayed within the box for browsing and necessary editing. While in the BROWSE mode, pressing the arrow keys will move the cursor about in the database file and the PgUp, PgDn, Home and End keys can also be used for cursor movement. Pressing the ESC key (usually at the top left corner of the keyboard) will get you out of the Browse menu.

4.1.2.3 <u>TOGGLES</u>:- This option is responsible for the setting of some parameters that controls the operation of the program. It is a session control for the package and it is active throughout the use of the package. Three options are available on this menu viz: **BELL, WRAP** and **CONFIRM**. The toggles operates like a switch i.e. On / Off and a check (x) mark is placed beside the option that is set On.

4.1.2.3.1 <u>BELL</u>:- Selecting this will put a check mark (x) against the Bell on the menu. Selecting again will de-select the option. If the BELL option is selected, it will enable the computer to beep warning sounds on errors while operating the package.

4.1.2.3.2 <u>WRAP</u>:- This is a useful toggle when you want to have complete freedom for the use of the arrow keys. Selecting WRAP enables you to continuously flip through the menu by pressing either of the Up or Down arrow keys. E.g. with WRAP on, pressing the Up arrow key while Bell is highlighted will move the highlight to Confirm or pressing the left arrow key while on File menu will open up the Help menu and vice versa.

4.1.2.3.3 <u>CONFIRM</u>:- Selecting the CONFIRM allows you to press a return (or Enter) key after typing. For example, if you want to type in a name i.e. MOSOPE in a Six column field, Setting the CONFIRM On will allow you to press the return key for the program to accept your entry otherwise the program accepts the entry as soon as the sixth character (in this case E) is typed.

4.1.2.4 UTILITY:- This is the core of this package and it is the basis on which the program is developed. It consists of five (5) major options which are actually stand alone (can be operated on itself) programs. The options available in the menu are **ConVert Id. No., Change Struct., Chart, Inb. Coeff.** and **Display By**. Each of these options is targeted to the case study (Fashola Stock Farm Records) but with little modifications to the source code of the program at compilation time, it can be adapted for use with other similar database files.

4.1.2.4.1 ConVert Id. No:- This option is specifically intended for the case study in which the animal registration number is neither unique nor consistent. This program is developed to give the animals new identification numbers and changing all occurrences of such old numbers with the new identification numbers. The option opens a sub-menu and it comprises of the following three options viz: New Identification No., Convert Male Animals and Convert Female Animals.

The Algorithm is based on the fact that the birth recorded on the Fashola Stock Farm for any particular month between 1947 and 1984 is not up to one hundred (100) and the registration method adopted for most part of the period is based on sex, e.g. we may have animal with registration number 310150 as a Bull and Heifer (i.e. two animals share the same number). Based on the fact that the identification number of the animals must be unique in order to have a reliable and accurate pedigree information, efforts are made to make the identification number unique. This is achieved by sorting the animals on their date of birth, the sorted database file is now modified to include three (3) new fields for the new identification numbers (calves, sires and dams).

4.1.2.4.1.1 New Identification No.:- This gives new identification number to all the calves born on the farm and available on the database. The new number given to the animals is a 6-digit number comprising of the first 2 digits being the year of birth, the next 2 digits being the month of birth and the last 2 digits being the number of the birth in that month irrespective of sex or breed. For example, the third animal born in June of 1957 is registered as 570603 where 57 is the year of birth, 06 the month and 03 the birth number of the animal.

The identification starts with the first animal and ends on the last animal in the database. It takes approximately 1 minute, 30 seconds for 4500 records.

4.1.2.4.1.2 Convert Male Animals:- This gives new identification to the male animals that were born on the farm and used as sires on the farm. The search is for locating the first male animal born on the farm and locating where it was used as sire and changing the old sire number with the new one for all the occurrences of that particular animal as sire.

This procedure takes approximately 2 minutes for the 4500 records. All sires in the database that were born on the farm or whose ancestry can be traced will be given the new number.

4.1.2.4.1.3 <u>Convert Female Animals</u>:- This gives new identification to the female animals that were born on the farm and used as dams on the farm. The search is for locating the first female animal born on the farm and locating where it was used as dam and changing the old dam number with the new one for all the occurrences of that particular animal as dam.

This procedure takes approximately 2 minutes for the 4500 records. All dams in the database that were born on the farm or whose ancestry can be traced will be given the new number.

4.1.2.4.2 <u>Change Struct</u>.:- Selecting this option will automatically modify the database structure of the file whose pedigree we want to chart.

This is done in preparation for the charting of the pedigree and calculation of inbreeding coefficients. It adds additional twenty-nine fields to store the pedigree information and inbreeding coefficient of the animals. Four of the fields are used to store identification No. of the grand-parents, eight to store the great grand-parents, sixteen to store the great great grand-parents and the remaining one is to store the inbreeding coefficient.

This procedure takes about five (5) minutes to modify the test data.

4.1.2.4.3 Chart:- Selecting this will transform the data and trace, retrieve and write to the disk pedigree information of animals except the base generation. The pedigree chart is based on the algorithm that every animal born on the farm and whose immediate parents are known can be used to draw the pedigree chart. A search on a sire that was born on the farm will give us the two parents of such sire which represents 2 of the grand-parents of the calf we started the search with. The other 2 grand parents are retrieved by tracing the parents of its dam. This search is iterative and continues to the fifth generation starting with the calf as the first generation.

The retrieved pedigree information are stored in the new fields created with the Change Struc. option. The pedigree information is permanently stored on the disk and each calf born on the farm has its associated pedigree chart. This pedigree information is what will be used via the path tracing method to calculate the inbreeding coefficient of the animals using the Wright's formula.

It takes approximately four (4) minutes for the 4500 records.

4.1.2.4.4. Inb. Coeff.:- This option calculates the individual inbreeding coefficient of all the animals born on the farm and listed in the records using the Wright's (1922) formula:

$$F_x = (½)^{n+n'+1} (1 + F_a)$$

where F_x = Inbreeding coefficient of calf (x)

F_a = Inbreeding coefficient of the common ancestor "a"

n = Number of generations away through the sire

n' = Number of generations away through the dam

The algorithm of the program is to pick on an animal through the sire (included) and search for recurrence of such animal on the dam side of the chart. The sum of all such occurrences gives the F_x (Inbreeding coefficient of calf). Some useful conditional statements are built into the program to prevent over estimating or under estimating the inbreeding coefficient. For example, the inclusion of the inbreeding coefficient of an inbred ancestor (F_a) in the calculation of the F_x (Inbreeding coefficient of calf) involving such ancestor.

The program is sequentially operated as it starts with calculation from the first generation to the fifth. It is pretty fast and very accurate. It takes about 2 minutes, 30 seconds for 4500 records. The calculated values are stored in the field meant for inbreeding coefficient and it can be retrieved afterwards without going through the process all over again.

4.1.2.4.5 Display By:- This option allows you to display the pedigree chart via two options on the sub-menu i.e. Record Number and Identification No. The requested information is displayed as in Figure 4.1.

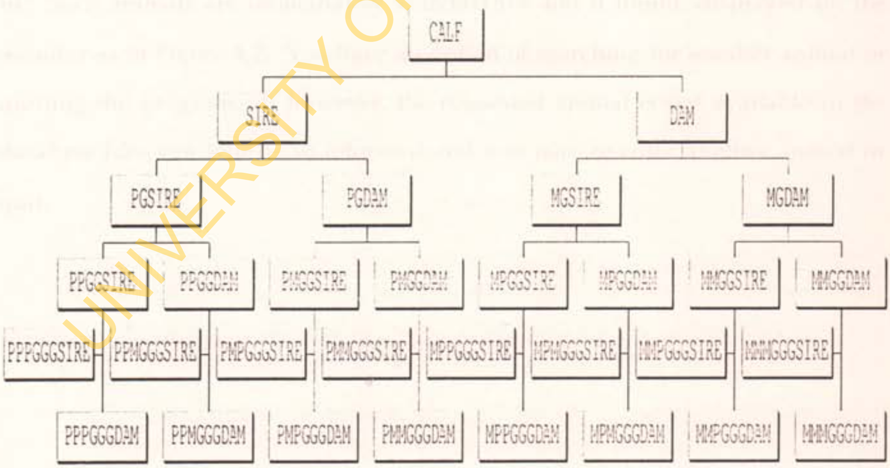

Figure 4.1: Schematic diagram of a pedigree chart

4.1.2.4.5.1 Record Number:- This sub-menu prompts you for the record number you want to start the display with and the record number you wish to stop. All the selected records will be displayed, showing their pedigree chart and inbreeding coefficient. Pressing any key but F10 will move to the next record to display while the F10 key will abort the procedure. The program runs until an F10 key is pressed or the upper limit record is reached.

4.1.2.4.5.2 Identification No.:- This option specifically request for the particular animal whose pedigree and inbreeding coefficient you are interested in. Such animals are immediately searched for and if found, displayed on the monitor as in Figure 4.2. You have an option of searching for another animal or quitting the program. If however, the requested animal is not available in the database file, you will be so informed and you may re-enter another animal or quit.

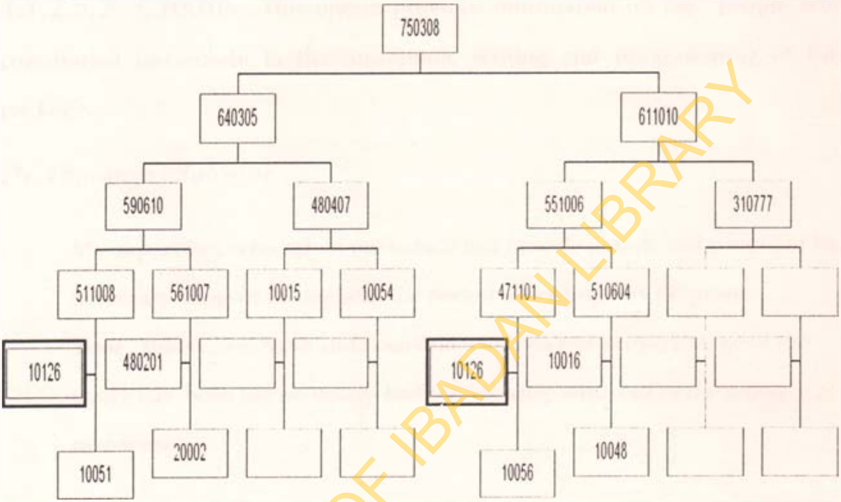

Figure 4.2: Pedigree chart of calf # 750308

NOTE: The common ancestors are boxed.

4.1.2.5 Help

4.1.2.5.1 Help:- This option on the Help menu when selected will take you to this program that provide useful information on each of the menu options. This program you are currently working on is the Help program.

4.1.2.5.2 <u>Credit</u>:- This option provides information on the people who contributed immensely to the conception, writing and programming of this package.

Dr. Olusanya Olutogun

My supervisor who sat on me to face this herculean task and provided the necessary support throughout the period of writing this program.
Your timely, relevant and constructive criticism at every stage of the study has been the necessary tool for "making sense out of the whole non-sense".

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Misses 'Korede Osibeluwo, 'Bisi Idowu and 'Lolape Falade

All (1992/93) graduates of the Department of Computer Science, University of Ibadan. I thank you all for the challenging tasks, brain storming questions and useful criticism at every stage of the program development.

4.2 PART B: PROGRAM APPLICATION ON FASHOLA STOCK FARM

4.2.1 POPULATION STRUCTURE AND LEVEL OF INBREEDING AT FASHOLA STOCK FARM.

4.2.1.1 POPULATION STRUCTURE

Apart from the pedigree chart obtainable from the Pedigree Chart Master Systems (PCMS), basic statistics of population were also obtained in a sub-routine of the program. Table 4.1 describes the population structure of the farm and lists the frequency distribution of all calves by year of birth.

Table 4.1: Annual rate of Inbreeding of calves at the Fashola Stock Farm between 1947 and 1984.

Year of Calving	N	Calves		Sires	Inbreeding Coefficient(%)		
		Male	Female		Overall	Male	Female
1947	9	4	5	5	0.00	0.00	0.00
1948	59	28	31	15	0.00	0.00	0.00
1949	64	34	30	13	0.00	0.00	0.00
1950	56	28	28	9	0.00	0.00	0.00
1951	56	23	33	5	0.00	0.00	0.00
1952	56	30	26	9	0.00	0.00	0.00
1953	71	35	36	10	0.53	0.36	0.69
1954	105	54	51	12	0.48	0.93	0.00
1955	133	68	65	15	0.56	0.74	0.39
1956	145	77	68	16	1.47	1.62	1.29
1957	240	135	105	22	1.12	1.34	0.83
1958	233	118	115	20	1.17	1.38	2.17
1959	102	57	45	12	1.78	1.54	2.08
1960	175	83	92	14	1.46	1.73	1.22
1961	202	103	99	16	1.45	1.61	1.29
1962	176	95	81	17	0.59	0.49	0.69
1963	136	68	68	10	0.62	0.37	0.87
1964	186	93	93	11	0.12	0.13	0.10
1965	166	94	72	20	0.30	0.13	0.52
1966	80	27	53*	16	0.43	1.22	0.03
1967	105	1	104*	23	0.27	0.00	0.27
1968	82	3	79*	17	0.46	0.00	0.48
1969	3	1	2	3	0.00	0.00	0.00
1970	17	3	14*	11	0.74	0.00	0.89
1971	26	12	14	9	0.00	0.00	0.00
1972	91	12	79*	17	0.50	0.00	0.57
1973	76	21	55*	13	0.41	0.00	0.57
1974	157	76	81	19	0.12	0.21	0.04
1975	256	142	114	30	0.66	0.85	0.43
1976	171	82	89	27	0.07	0.10	0.05
1977	151	73	78	18	0.02	0.00	0.03
1978	157	77	80	54	0.72	0.85	0.59
1979	147	84	63	47	0.21	0.33	0.05
1980	120	63	57	43	0.47	0.30	0.66
1981	63	27	36	33	0.00	0.00	0.00
1982	66	24	42+	30	0.19	0.52	0.00
1983	37	19	18	15	0.00	0.00	0.00
1984	9	1	8+	8	0.00	0.00	0.00
1947 - 1984	4184	1975	2209 *	293	0.63	0.70	0.58

*=P <0.01   +=P<0.05

4.2.1.1.1 Calving distribution

The number of calves dropped between 1947 and 1953 was relatively stable before the introduction of some heifers from Ilora in 1953. There was a consistent increase in the number of calves dropped on the farm from 1954 to 1958. There was a sharp drop in number of calves born in 1959 and this may be attributed to the gradual withdrawal of the Colonial administrators on the farm prior to independence. The number of calves dropped between 1960 and 1965 was relatively stable and this may be due to the fact that proper documentation of calving on the farm had commenced. However, the inconsistent distribution observed between 1966 and 1973 may be attributed to several factors. These includes the political crisis within the Western region in 1966 up to the civil war era of 1967 until 1970 when the war was over and the post war period of 1970 to 1973.

Another factor that may be responsible for this inconsistent pattern of distribution may be explained by the fact that this project only takes into consideration the Purebred N'Dama population and all those Crossbred calves produced between 1964 and 1968 were not included in these analyses.

The calving distribution increases from 1974 to 1975 when it sharply declined in 1976 up to 1984. This marked decline in number of calves dropped in 1976 was a result of the fractionalization of the herd due to asset sharing among the three new states created from the old Western region in 1975. Also the return to civil rule in 1979 with its associated fiscal and managerial indiscipline may be adduced for the lower calves produced in the early 1980's.

For ease of comparison on the calving distribution, the years can be grouped into various management period to give a clearer picture of how these periods affect the number of calves dropped. This difference can only be attributed to political rather than natural causes (Figure 4.3).

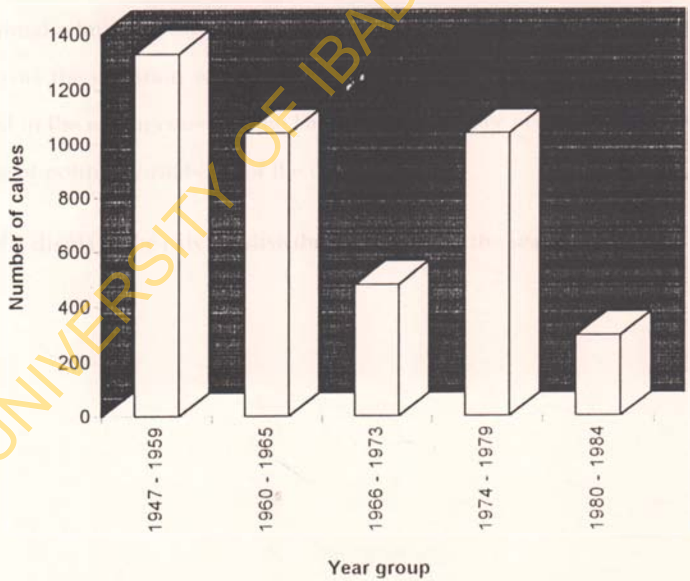

Figure 4.3: Calving distribution of N'Dama by year group at Fashola Stock Farm (1947 - 1984)

It was observed from Figure 4.3 that incessant state creation by the various Military regimes that ever ruled the country leads to the fractionalization of the herd. Assets were shared politically and animals removed to the new states. This perhaps led to the fluctuations both in the herd structure and in the level of inbreeding. Record keeping systems are often disrupted by the incessant changes in management even at the best of times on the farm. The most stable periods for consistent and reliable record keeping systems were between 1947 and 1960 and from 1963 till 1966. The first period coincided with the presence of the Colonial administrators in Nigeria prior to independence. The second stable period was the duration when the USAID Livestock Advisor was present and involved in the management of the Fashola herd. Other periods are littered with one type of political instability of the other.

Figure 4.4 displays the calving distribution based on the season of birth of calves.

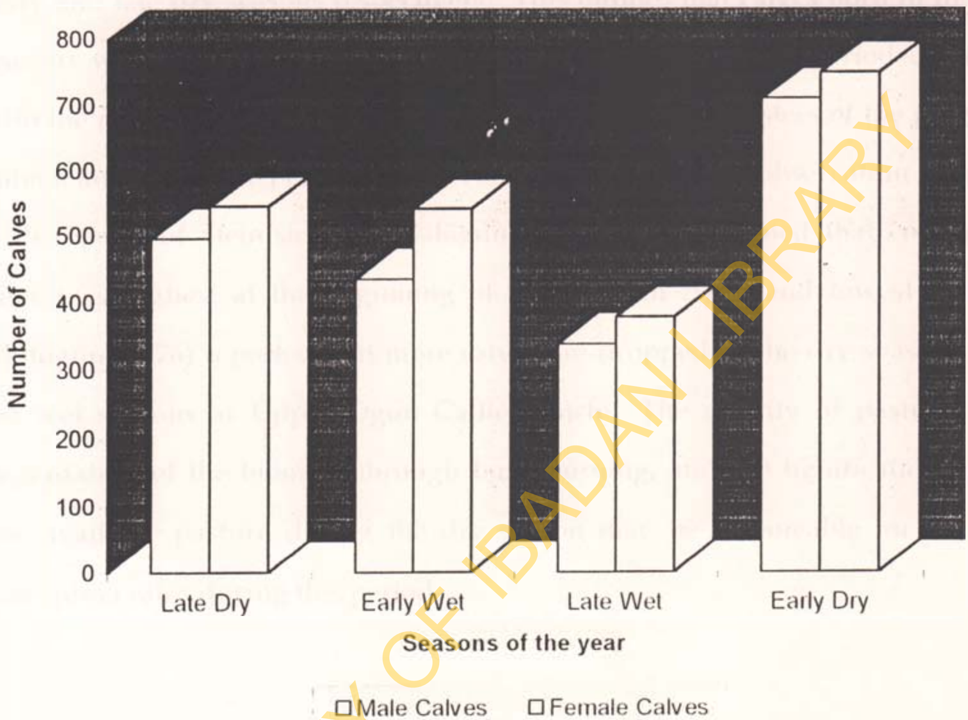

Figure 4.4: Frequency distribution of calving by season of birth and sex of calf at Fashola Stock Farm (1947 - 1984)

Based on this classification, the lowest calf crop was recorded in the late wet season (17.10 percent of the total calf population) while the largest calf crop was in the early dry season (34.80 percent of total calf crop). Thus close to 60 percent of the total calf crop were dropped in the dry season (October - March). It is pertinent to note that gestation length in cattle is averagely 280 days and that animals that conceive during the early and late wet season will calve during the early and late dry seasons respectively. This implies that calves born in the dry seasons were actually conceived in the wet seasons and this period coincides with the period of fresh lush pastures for the first two trimesters of the pregnant animal and this is the period of high conception rates. This observation is in line with reports of Steinbach and Balogun (1971) who explained that conception rates was highest at the beginning of the rains in April and lowest in July. Olutogun (1976) reported that more calves are dropped in the dry seasons than the wet seasons at Upper Ogun Cattle Ranch. The scarcity of pastures and degradation of the biomass through bush burning, and the lignification of the few available pasture during the dry season may be responsible for the low conception rates during this period.

4.2.1.1.2 Sex ratio

The probability of having a male or female calf in any cattle (beef or dairy) enterprise is 50 percent. Table 4.1 describes the frequency distribution of calves by sex and year of birth.

Out of the 4184 N'Dama calves recorded on the Fashola Stock Farm between 1947 and 1984, only 1975 were male calves and 2209 were female calves. This 47:53 ratio significantly ($P<0.01$) deviated from the 50:50 ratio expected on the farm ($X^2=13.09$, 1df). However, of the 38 years covered in this study only the sex ratio of six years (1966, 1967, 1968, 1970, 1972 and 1973) were highly significantly

(P<0.01) different from the expected ratio and two years (1982 and 1984) significantly (P<0.05) deviated from the expected 50:50 sex ratio.

It is observed that these two periods coincided with the period of the civil strife and the civilian rule in Nigeria. These are the duration of worst management practices on the farm and some of the calvings in that period may not have been properly documented. This lack of information on male calves for these years was so high that it affected the sex ratio of the entire population.

4.2.1.2 LEVEL OF INBREEDING ON THE FARM

The results obtained from the module of the program that calculates inbreeding coefficient of calves born on the Fashola Stock Farm revealed that inbreeding took place on the farm between 1953 and 1984.

Out of 4184 N'Dama calves born within these periods, only 273 (6.53 percent) were inbred to varying degrees. Figure 4.5 outline the frequency distribution of inbred calves by their level of inbreeding.

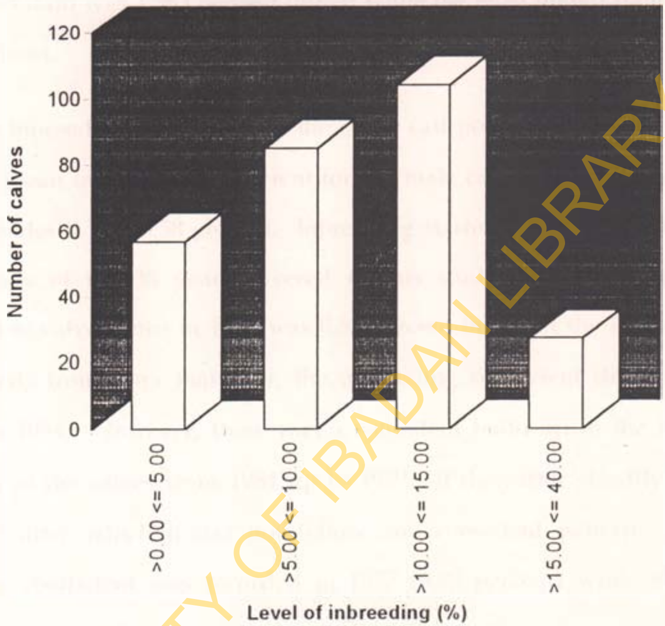

Figure 4.5: Frequency distribution of inbred calves by level of inbreeding at Fashola Stock Farm (1947 - 1984)

Only five out of 293 sires (1.71 percent) used on the farm were inbred and only 43 of the 1849 dams (2.33 percent) were inbred. The least inbred calf had an inbreeding coefficient of 0.781 percent while the most inbred had 37.50 percent inbreeding coefficient. The least inbred sire used for breeding on the farm was 3.125 percent inbred and the most inbred sire was 25.00 percent inbred. The least inbred dam was 1.563 percent inbred while the most inbred dam was 25.00 percent inbred.

The mean inbreeding coefficient for the entire calf population was 0.63 percent, while the mean inbreeding coefficient for the male calves was 0.70 percent and for the females it was 0.58 percent. Inbreeding started on the farm in 1953 and for 28 years of the 38 years covered in this study Table 4.1. Inbreeding coefficient of calves born in 1953 was 0.53 percent but with the introduction of new animals from Ilora that year, the inbreeding coefficient dropped to 0.48 percent in 1954. However, there was a consistent build-up in the inbreeding coefficient of the calves from 1954 up to 1959. It thereafter steadily decreases until 1963 after which it did not follow any consistent pattern. The least inbreeding coefficient was recorded in 1977 (0.02 percent) while the highest inbreeding coefficient was recorded in 1959 (1.78 percent).

With the introduction of 93 (20 bulls and 73 in-calf heifers) heads of cattle to the Fashola Stock Farm in 1947, breeding practices were normal. The initial heads of cattle introduced to the farm was regarded as the base generation and were assumed unrelated by descent or ancestry for the purpose of this study. This assumption is backed-up by historical events of the importation from Guinea. Other later importation were from Sierra Leone, Belgian Congo (Zaire and recently The Gambia (1980 - 1981).

The pattern of inbreeding observed in this study can best be explained in the context of the management history of the farm. The period when the herd was relatively few and closed to new importation recorded higher levels of inbreeding, new importation to the farm diluted the genes and thus inbreeding declined. The history of initial and subsequent importation is described by Olutogun (1976) and Tizikara (1988). Usually the pedigree information of the newly imported animals were not available and the animals were assumed not to be related to the ones already on the farm. This assumption appears reasonable since importation were from different countries.

Another major factor that may be responsible for this irregular pattern of inbreeding levels was political. There was no deliberate adoption of inbreeding as a breeding policy on the farm. Every time there was a state of political instability in the country, there was no consistent and conscientious record keeping system.

The period of civil war (1967 - 1970) in this country also ushered in yet another period when record keeping system was at its worst on the farm. This is because calving were not properly documented and when recorded, little or no information was available on the parentage. The reason why it was difficult to obtain this information was perhaps due to the unsettled political climate and the intermittent war and rumours of war.

Also the inconsistent method of registration of animals due to the changes in management staff makes it impossible to trace the pedigree of many calves. In fact the computer program developed was specifically initiated to address this anomaly but it must be admitted that some animals which were removed from the records when they failed the tests of authenticity may underestimate the inbreeding coefficient of N'Dama cattle on this farm. That is the reason why these analyses were limited to only those animals whose genealogy could be traced by the computer.

The non-availability of information on male calves during the civil war era also made the tracing of pedigrees thereafter more difficult. That was why the level of inbreeding and the number of inbred calves born immediately after that period was very low relative to those years preceeding the civil war.

4.2.2 INBREEDING EFFECTS ON REPRODUCTIVE TRAITS OF N'DAMA CATTLE.

4.2.2.1 AGE AT FIRST CALVING

The age at which an animal had its first calf is the most important single variable for predicting differences in efficiency of production (Kress et al, 1969).

The mean age at first calving (AFC) for 1756 N'Dama heifers used in this analysis was 40.43 ± 0.18 months with a coefficient of variation of 18.95 percent.

Table 4.2: Least squares analysis of variance for age at first calving of N'Dama heifers at the Fashola Stock Farm (1949 - 1977).

Source	df	Mean Square
Year of birth	28	1003.29**
Season of birth	3	130.69*
Regressions		
Calf's Inb. Coeff.	1	5.74
Dam's Inb. Coeff.	1	549.67**
Error	1722	42.64

**=P<0.01, *=P<0.05

The analysis of variance shown in Table 4.2 indicated that year of birth of dam and dam's inbreeding coefficient (DAMINB) significantly ($P<0.01$) affected the age at first calving of such dams. The season of birth of dam exerted important influence ($P<0.05$) on the AFC of such dams. However the inbreeding of the dams' calf (CALFINB) does not affect the AFC of the dam as expected.

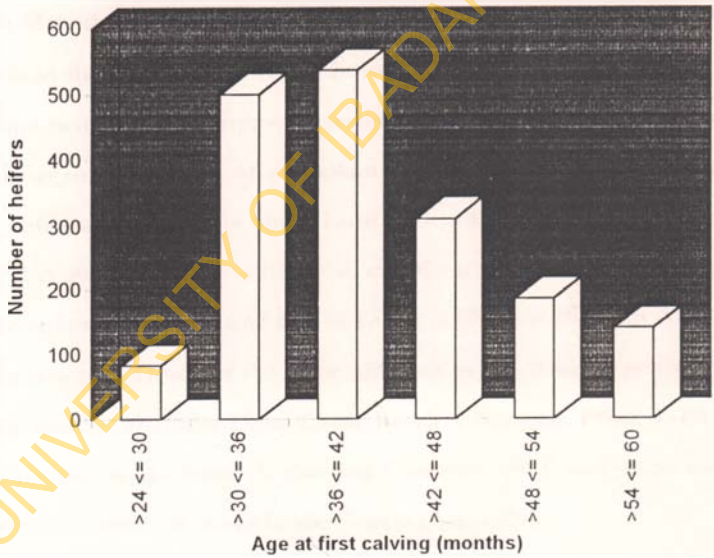

Figure 4.6: Frequency distribution of N'Dama heifers by age at first calving at Fashola Stock Farm (1947 - 1984)

Figure 4.6 showed the frequency distribution of heifers by their age at first calving. Only 4.74 percent of the 1756 heifers calved before 30 months of age, 28.47 percent calved between 30 and 36 months, while 30.52 percent of these N'Dama heifers calved between 36 and 42 months. 17.71 percent calved between 42 and 48 months, 10.59 percent first calved between 48 and 56 months while only 7.97 percent calved after 54 months.

Although Mahadevan (1966) reported an age at first calving of 3½ - 4 years for zebu cattle in the tropics, FAO (1980) however stated a range of 26 - 36 months for N'Dama heifers under improved management. The mean AFC obtained in this study agrees with that of Akinokun (1970) who worked on a subset of N'Dama cattle at the Fashola Stock Farm and obtained a mean AFC of 40.60 months. It is also very close to the 39.40 months reported by Touchberry (1967) on the Sierra Leone N'Dama and that of Fall et al (1986) with mean AFC of 39.80 months in Senegal. However the value obtained in this study is relatively lower than 47.60 months at Upper Ogun Cattle Ranch (Olutogun, 1976); 45.60 months at the Accra plains of Ghana (Ngere and Cameron, 1972) and 46.50 months at Teko Livestock Station in Sierra Leone (Carew et al, 1986).

Several factors have been advanced for the differences in these values. For example, the Upper Ogun Cattle Ranch was purely commercial while others were in similar management set-up as that of Fashola Stock Farm. Basically age at first calving is affected by both environmental and genetic factors.

Oyedipe et al (1982) reported that heat stress imposed on the animals as a result of increased ambient temperature suppressed feed intake and growth rate of such animals which consequently delay puberty and age at first calving. Tucker (1982) also noted that an ambient temperature above 27°C lengthens the oestrus cycle, decreases duration and intensity of oestrus, reduces fertility and increases embryonic mortality and consequently increases the age at first calving.

Fashola environment is essentially tropical and may exert the same inimical effects on maximum expression of the genetic worth of these animals in their reproductivity (Abanikannda, 1989). This may be the reason why animals in the humid tropics especially calve at a relatively older age when compared with the temperate breeds. Over-heating affects reproduction, creates unfavourable endocrine balance and reduced feed intake. These assertions substantiate the report of Tuah and Danso (1985) who recounted that high ambient temperature and relative humidity reduces feed intake and reproductive performance in N'Dama cattle in Ghana.

4.2.2.1.1 Year of birth effect on age at first calving

The year of birth of heifers exerted significant ($P<0.01$) influence on heifer's AFC. Table 4.3 describes the year of birth effect on age at first calving.

Table 4.3: Effect of year of birth of heifers on age at first calving (AFC) at the Fashola Stock Farm (1949 - 1977).

Year of birth	N	L.S.Means (Months)	S.E.
1949	92	43.65^{bcdefg}	0.69
1950	110	40.39^{fgh}	0.63
1951	140	44.48^{abcdef}	0.56
1952	117	39.91^{fgh}	0.61
1953	110	40.24^{fgh}	0.63
1954	135	40.41^{efgh}	0.57
1955	152	35.51^{h}	0.54
1956	102	37.97^{fgh}	0.65
1957	154	36.27^{gh}	0.54
1958	169	36.62^{gh}	0.51
1959	95	37.02^{fgh}	0.68
1960	31	49.71^{abc}	1.18
1961	32	49.96^{ab}	1.16
1962	26	42.51^{cdefgh}	1.28
1963	2	39.33^{fgh}	4.62
1964	4	39.56^{fgh}	3.28
1965	7	51.22^{a}	2.47
1966	2	35.89^{h}	4.63
1967	2	39.94^{fgh}	4.62
1968	5	51.54^{a}	2.94
1969	2	48.88^{abcd}	4.62
1970	8	48.43^{abcd}	2.32
1971	80	47.32^{abcde}	0.76
1972	36	40.37^{fgh}	1.09
1973	41	42.60^{cdefgh}	1.02
1974	40	44.28^{abcdef}	1.05
1975	45	47.32^{abcde}	0.98
1976	12	39.67^{fgh}	1.89
1977	5	42.28^{defgh}	2.92

Means with different superscripts differ significantly ($P<0.05$)

The heifers covered in this analysis are those born between 1949 and 1977. The foundation heifers whose actual age could not be ascertained were excluded from this analysis.

The least squares mean of age at first calving in this study was 42.53 ± 0.41 months. Heifers born in 1955 had the least AFC (16.51 percent less than mean AFC) while heifers born in 1965 recorded the highest age at first calving (21.18 percent greater than mean AFC).

The distribution of heifers by year of birth follow the same pattern as that of the calving distribution. The pre-independence era recorded more heifers than the post-independence era. Heifers born between 1949 and 1959 (11 years) accounted for 78.36 percent of the total heifers used in this analysis while those born between 1960 and 1977 (18 years) accounted for only 21.64 percent of the total heifers investigated in this analysis. The reasons for this difference can be attributed to the same causes as in the calving distribution discussed earlier since all the heifers were calves born on the farm.

Based on the values obtained in this study, it will be observed that the least square means of AFC of N'Dama heifers follow the same trend when grouped into management period. Least squares mean of AFC between 1949 and 1954 was relatively higher than the values obtained between 1955 and 1959. Although AFC for the years 1960 and 1962 were higher than the preceeding year group but the intermittent lower values obtained in 1963-1964 and 1966-1967 does not give any specific or consistent pattern. It is observed that values obtained between 1949 and 1959 were relatively consistent when compared to values obtained after 1960. This may be due to several factors but the most notable ones being a reflection of changing farm management, the irregular and lower frequency distribution of heifers peculiar to the post-independence era and the varying environmental conditions over the years.

Ehiobu and Ngere (1986) reported the significant effect of year of birth of White Fulani heifers on their AFC at Ibadan. Also Olutogun (1976); Tizikara (1988) and Ojo (1991) all reported that year of birth of N'Dama heifers significantly affected their age at first calving.

4.2.2.1.2 Season of birth effect on age at first calving

The season of birth of heifers notably influence their AFC. Figure 4.7 describes the seasonal effect on age at first calving.

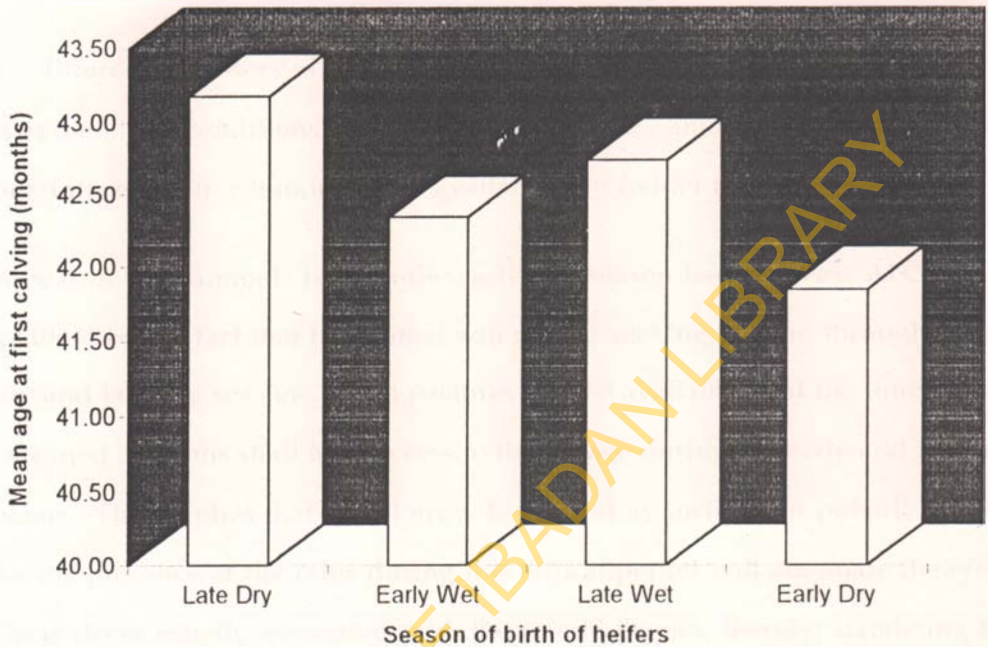

Figure 4.7: Season of birth effect on age at first calving at Fashola Stock Farm (1949 - 1977)

The frequency distribution of heifers across the seasons is relatively steady. The early dry season had about 29.44 percent of the 1756 heifers examined while the late dry had 22.67 percent; early wet had 28.70 percent and late wet had 19.19 percent.

The early dry season recorded the least AFC and it was 1.60 percent less than the mean AFC while the late dry season had the highest AFC and it was 1.53 percent greater than the mean AFC. The values obtained between the early wet and late wet seasons are not significantly different.

The differences observed across the seasons was a reflection of changing environmental conditions as expressed in the amount of precipitation, temperature, relative humidity and availability of fodder for the animals.

The reason why animals born in the early dry season had the least AFC can be explained by the fact that the animal will still be sucking its dam throughout the early and late dry seasons. Lush pastures will be available as at the time it shall be weaned and thus shall have access to this forage during the early and late wet seasons. This implies that it will grow faster and as such attain puberty earlier. Also the presence of the rains during this critical period will attenuate the effect of heat stress usually associated with the humid tropics, thereby stabilizing the hormonal balance in the animal and ensuring longer duration of oestrus.

The results obtained in this study agrees with reports of Ojo (1991); Tizikara (1988); Oyedipe et al (1982) and Olutogun (1976).

4.2.2.1.3 Effect of inbreeding on age at first calving

The level of inbreeding of the calf (CALFINB) born by the heifer did not exert any significant impact on the AFC of heifers. However, the level of inbreeding of the heifer (DAMINB) had an important influence on the heifer's age at first calving.

The mean CALFINB of this analysis was 1.18 percent while mean DAMINB was 0.29 percent. The correlation between CALFINB and DAMINB was 0.06, while the correlation between AFC and CALFINB was -0.01 and between AFC and DAMINB it was -0.09. The regression of DAMINB on AFC was -0.3315 ± 0.089 months. This implies that a percentage increase in heifer's inbreeding coefficient will result in (0.3315 months) about 10 days decrease in the AFC of the heifers ($P<0.01$). The intercept of the regression line was 40.53 months and the regression equation is defined by;

$$Y = 40.53 + (-0.3315 \times DAMINB)$$

where Y = Estimated age at first calving

40.53 = The intercept (**a**)

-0.3315 = The slope of the regression line (**b**)

DAMINB = The heifer's inbreeding coefficient (**X**)

However, the regression of CALFINB on AFC was -0.0077 ± 0.473 months (about 0.231 days) and this was not an important factor on AFC. The very high standard errors obtained for this estimate may be the reason why CALFINB was not significant on AFC.

It can be concluded that inbreeding affects the AFC of N'Dama heifers at Fashola Stock Farm. This result agrees with the work of Nurzhanov (1986); Hudson <u>et al</u> (1984b) and Scheglachev (1983) who reported similar effect on heifers in their study. The consensus in literature is that inbreeding depresses AFC and other reproductive traits associated with level of inbreeding (McCurley et al, 1984; Dinkel et al, 1972; Flower et al, 1963; Alexander and Bogart, 1961 and Swiger et al, 1961).

4.2.2.2 CALVING INTERVALS

The number of days a cow takes to conceive after the immediate last parturition is one of the most important criteria for determining reproductive ability of that cow. This is influenced by a lot of factors which includes reproductive diseases, management practices, embryonic mortality, neonatal deaths and the presence of active fertile bulls (Olutogun, 1976).

The mean calving interval (CALINT) of 1270 cows used in this study was 445.34 ± 2.68 days with a coefficient of variation of 21.41 percent. This is equivalent to an average calving rate of 81.96 percent. Table 4.4 describes the least squares analysis of variance for average calving interval of N'Dama cows at the Fashola Stock Farm.

Table 4.4: Least squares analysis of variance for average calving interval of N'Dama cows at the Fashola Stock Farm (1947 - 1977).

Source	df	Mean Square
Year of birth	30	29279.21**
Season of birth	3	1746.97
Parity	7	190297.06**
<u>Regressions</u>		
Age of Dam	1	1255225.54**
Age at first calving	1	907069.52**
Dam's Inb. Coeff.	1	2686.73
Error	1226	7501.67

**=P<0.01, *=P<0.05

The year of birth of cows, parity of dam, age of dam and its age at first calving meaningfully influenced its average calving interval. However, season of birth and dam's inbreeding coefficient did not exert any significant impact on calving interval.

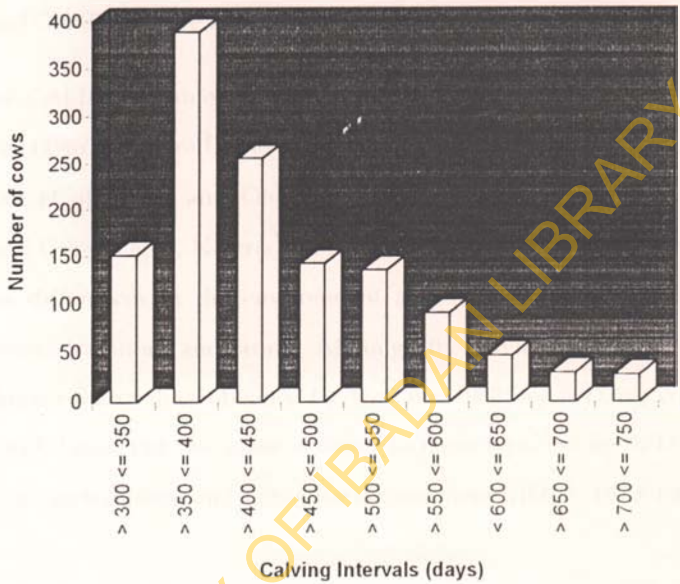

Figure 4.8: Frequency distribution of N'Dama cows by average calving intervals at Fashola Stock Farm (1947 - 1977).

Figure 4.8 outline the frequency distribution of cows by their average calving interval. Only 12 percent of the cows in this analysis had an average CALINT less or equal to 350 days, 30.6 percent had CALINT between 350 and 400 days, 20.2 percent had CALINT between 400 and 450 days, 11.2 percent had CALINT between 450 and 500 days, 10.7 percent had CALINT between 500 and 550 days, 7.2 percent had CALINT between 550 and 600 days, 3.7 percent had CALINT 600 and 650 days, 2.3 percent had CALINT between 650 and 700 days while only 2.1 percent had CALINT above 700 days.

The mean CALINT obtained in this study is close to 467 days reported by Touchberry (1967) in Sierra Leone but lower than values obtained by Carew et al (1986), Fall et al (1982) and Olutogun (1976) in Teko, Sierra Leone, Kolda, Senegal and Upper Ogun, Nigeria respectively. These observed differences may be due to differences in the environment and management practices of the various research stations and farms. Although the calving rate obtained in this study is higher than values obtained by Tizikara (1988) for N'Dama cows at the Fashola Stock Farm, but this value is closer to those reported for N'Dama cows raised on research stations and tsetse free environments (ILCA, 1979; 1986).

4.2.2.2.1 Effect of year of birth of cows on average calving interval

The year of birth of cows exerted significant influence on their average calving intervals (CALINT). Table 4.5 shows the effect of year of birth on average calving interval.

Table 4.5: Effect of year of birth of N'Dama cows on average calving interval (days) at the Fashola Stock Farm (1947 - 1977).

Year of birth	N	L.S.Means (Days)	S.E.
1947	382	388.94^{bc}	9.61
1948	11	355.89^{bcde}	31.09
1949	63	354.40^{bcde}	12.96
1950	81	357.62^{bcde}	11.55
1951	82	384.12^{bc}	11.86
1952	67	362.72^{bcd}	13.21
1953	56	381.73^{bc}	13.68
1954	66	355.46^{bcde}	12.94
1955	69	339.17^{bcde}	12.02
1956	63	361.18^{bcd}	12.51
1957	76	379.03^{bc}	12.26
1958	79	374.17^{bcd}	12.35
1959	47	380.34^{bc}	14.77
1960	15	277.67^{cde}	25.52
1961	7	352.34^{bcde}	37.10
1962	3	325.76^{bcde}	51.70
1963	7	331.86^{bcde}	35.14
1964	11	307.57^{cde}	29.10
1965	4	361.54^{bcd}	45.18
1966	4	358.63^{bcde}	44.76
1967	8	368.47^{bcd}	32.56
1968	4	337.59^{bcde}	43.83
1969	1	336.74^{bcde}	87.34
1970	2	251.09^{de}	62.07
1971	22	438.04^{b}	20.56
1972	13	398.42^{bc}	25.05
1973	6	385.86^{bc}	36.26
1974	10	351.24^{bcde}	28.61
1975	8	371.65^{bcd}	31.83
1976	1	235.31^{e}	87.09
1977	2	830.24^{a}	65.12

Means with different superscripts differ significantly ($P<0.05$)

The cows covered in this analysis are those born between 1947 and 1977. The least squares mean of average calving interval in this study was 367.57 ± 9.85 days. The longest CALINT was recorded for cows born in 1977 (125.87 percent greater than the mean) while 1976 recorded the shortest CALINT (35.98 percent less than the mean).

The frequency distribution of the cows used in this analysis follows the same pattern as in the calving distribution discussed earlier. The pre-independence era had more cows than the post-independence era. Cows born between 1947 and 1959 (13 years) accounted for 89.92 percent of the total cows used in this analysis while those born between 1960 and 1977 (18 years) accounted for only 10.08 percent of the total cows used. This may be adduced to the very high standard errors obtained for CALINT in the post-independent era.

The average calving interval obtained in the pre-independence era are relatively more consistent and reliable than those of the post-independence era and also the values obtained are not significantly different throughout this period (1947 - 1959).

This observation can only be explained in terms of the frequency distribution across the years and the associated changing management policies of the farm. Thus calving interval is more affected by environmental rather than genetic factors. This observation is in consonance with reports of Akinokun (1970); Olutogun (1976); Mrode (1984); Wilson (1986); Tizikara (1988) and Ojo (1991).

4.2.2.2.2 Season of birth effect on average calving interval

Season of birth did not exert any notable effect on CALINT of N'Dama cows studied. Table 4.6 shows the least squares mean of calving interval by season of birth of cows.

Table 4.6: Seasonal effects on average calving interval (Days) of N'Dama cows at the Fashola Stock Farm (1947 - 1977).

Season	N	Average calving interval (days) L.S.Means	S.E.
Late dry (Jan-Mar)	582	370.73	11.12
Early wet (Apr-Jun)	238	368.08	11.20
Late wet (Jul-Sep)	187	363.18	11.65
Early dry (Oct-Dec)	263	368.31	10.86

The large differences observed in the frequency distribution of the cows by the season of birth may be adduced for the insignificance of season on CALINT. 45.83 percent of the cows were born in the late dry season, while 18.74 percent were born in the early wet season, 14.72 percent in the late wet season and 20.71 percent in the early dry season. This distribution is not as uniform as would be expected since the late dry season accounted for almost half of the total cows studied. Although Tizikara (1988) reported significant effect of season on calving interval but the results obtained in this study is contrary.

4.2.2.2.3 Parity of dam effect on average calving interval

The parity of dam exerted significant influence on CALINT of N'Dama cows. Table 4.7 depicts the parity effect on average calving interval of N'Dama cows.

Table 4.7: Effect of parity on average calving interval of N'Dama cows at the Fashola Stock Farm (1947 - 1977).

		Average calving interval (days)	
Parity	N	L.S.Means	S.E.
2	436	528.34^{a}	10.19
3	276	452.85^{b}	9.02
4	195	402.19^{c}	9.66
5	142	370.98^{d}	11.24
6	95	360.38^{e}	13.73
7	71	313.80^{f}	16.83
8	37	275.11^{g}	21.23
9	18	236.95^{h}	27.04

Means with different superscripts differ significantly (P<0.05)

The frequency distribution of cows consistently decreases with increasing parity number. Cows with only two parities accounted for 34.33 percent of the total cows used in this analysis, while cows with nine parities accounted for only 1.42

percent of the total cows studied. This constant decrease in frequency as a result of increasing parity number is expected and confirms the observation of Tizikara (1988) and Olutogun (1976).

First calving interval of cows (parity two) is 43.70 percent longer than the mean calving interval of the cows. Second calving interval (parity three) is 23.20 percent longer, while third calving interval (parity four) is 9.42 percent longer than the mean calving interval. The ninth parity (eight calving interval) recorded the shortest interval (35.54 percent shorter than the mean calving interval). The calving intervals are meaningfully different from one another.

The implication of this observation is that primiparous animals take more time to conceive after parturition and this is a result of the delay in the oestrus of the cow. The hormonal changes occurring in the animal at parturition needs some time to restore the animal back to its initial physiological state and thus this lapse of time decreases with increasing parities. This means that the higher the parities the shorter the lapse of time for restoring hormonal balance and therefore the shorter the calving interval (Tizikara, 1988; Olutogun, 1976 and Akinokun, 1970).

4.2.2.2.4 Age of dam effect on average calving interval

Increasing parity of dam indirectly means increasing age of dam. It is then anticipated that age of dam should exert similar influence on CALINT.

The age of dam significantly ($P<0.01$) affected the CALINT of N'Dama cows. The average age of dam (DAMAGE) used in this analysis was 82.69 ± 1.02 months. The age at which the cow first calved also exerts significant ($P<0.01$) influence on the CALINT of cows. The average age at first calving (AFC) of the cows used in this analysis was 40.84 ± 0.84 months.

The correlation between DAMAGE and AFC was 0.59, while the correlation between DAMAGE and CALINT was 0.10 and correlation between AFC and CALINT was -0.0093. The regression of DAMAGE on CALINT was 0.423 ± 0.091 days and AFC on CALINT was -0.334 ± 0.110 days. This implies that a month increase in DAMAGE will lead to a corresponding 0.423 days increase in CALINT while a unit increase in AFC will lead to a 0.334 days decrease in CALINT. This means that the older the animal at first calving the shorter its calving intervals but the older an animal grows the longer its calving interval. Although the correlation between these traits is very low, yet the regressions are statistically significant ($P<0.01$).

4.2.2.2.5 Effect of Inbreeding on average calving interval

The level of inbreeding of cows did not exert significant effect on the calving intervals of cows studied.

The mean inbreeding coefficient of cows (DAMINB) used in this analysis was 0.098 percent, and the correlation between DAMINB and CALINT was -0.0219. The regression of DAMINB on CALINT was -1.096 ± 2.11 days. The relatively high standard error of DAMINB may be due to the very low number of inbred cows included in this analysis and the consequently low mean DAMINB for the analysis. This may probably be the reason for the insignificance of the regression of DAMINB on CALINT. Although this observation agrees with Srinivas and Gurnani (1981) but most workers reported that inbreeding of dam had important influence on their calving intervals (Maksimova and Brovko, 1985; Hudson et al, 1984b; McCurley et al, 1984; Dinkel et al, 1972; Flower et al, 1963; Alexander and Bogart, 1961 and Swiger et al, 1961).

4.2.3 INBREEDING EFFECTS ON GROWTH TRAITS OF N'DAMA CATTLE

4.2.3.1 BIRTH WEIGHT

The weight of an animal recorded within the first 48 hours after parturition is referred to as its birth weight. This trait is of economic importance in both beef and dairy enterprise because of its correlated response with some vital parameters in both enterprises (Abanikannda, 1989 and Rahnefeld et al, 1980).

The mean birth weight of 4162 N'Dama calves CALBWT included in this study was 18.86 ± 0.05kg with a coefficient of variation of 15.34 percent. The calves included in this analysis are those born between 1947 and 1984.

The least squares analysis of variance shown in Table 4.8 revealed that sex of calf, year of birth, season of birth, parity of dam, age of dam, dam's AFC and dam's inbreeding coefficient (DAMINB) all exerted important influence on the weight of calves at birth. However, the inbreeding coefficient of the calf (CALFINB) is not an important factor on the birth weight of N'Dama calves used in this analysis as is to be expected.

Table 4.8: Least squares analysis of variance for birth weight (kg) of N'Dama calves at the Fashola Stock Farm (1947-1984).

Source	df	Mean Square
Sex of calf	1	833.57**
Year of birth	37	157.65**
Season of birth	3	38.66**
Parity	11	37.37**
<u>Regressions</u>		
Age of Dam	1	88.97**
AFC of dam	1	231.50**
Calf's Inb. Coeff.	1	2.32
Dam's Inb. Coeff.	1	71.95**
Error	4105	6.64

**=P<0.01, *=P<0.05

The birth weight of calves studied range between 10.43kg and 39.01kg. Figure 4.9 describes the frequency distribution of calves by their birth weight at the Fashola Stock Farm.

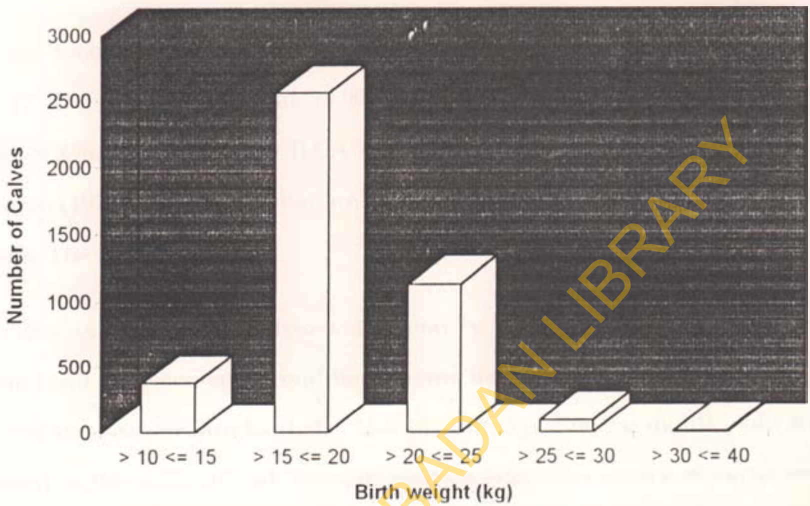

Figure 4.9: Frequency distribution of N'Dama calves by birth weight at Fashola Stock Farm (1947 - 1984)

About 8.99 percent of the total calf studied weighed below 15kg at birth. Majority of the calves (61.46 percent) had birth weight ranging between 15kg and 20kg, while 27.13 percent had birth weight of 20 - 25 kg. Only 2.16 percent had birth weight of between 25 and 30kg while only 0.26 percent were above 30kg.

The mean birth weight of N'Dama calves obtained in this study is very close to 18.50kg reported by Tizikara (1988) on N'Dama calves born within the same period as this study (1947 - 1984). Although the value obtained is lower than 19.96kg of Abanikannda (1989) who worked on a subset of N'Dama calves born between 1960 and 1963 at the Fashola Stock Farm, however the value is higher than 17.70kg at Kolda, Senegal, 14.90kg at Teko, Sierra Leone, 14.68kg at Accra plains of Ghana reported by ILCA (1982); Carew et al (1986) and Ngere and Cameron (1972) respectively, but lower than 20.40kg reported by ILCA (1980) at Yudum, The Gambia.

The differences observed in these values may be due to the differing managerial systems and environmental conditions across the regions in which these farms and research stations are located. Also the difference in the number of calves included in this analysis and the years studied is another source of variation in the observed values.

4.2.3.1.1 Sex of calf effect on birth weight

The sex of calf exerted a significant ($P<0.01$) influence on the birth weight of N'Dama calves born on the farm. Table 4.9 reflects the effect of sex on the birth weight of calves.

Table 4.9: Effect of sex on birth weight (kg) of N'Dama calves at the Fashola Stock Farm (1947 - 1984).

Variable	N	Birth weight (kg) L.S.Means	S.E.
Overall mean	4162	19.34	0.21
Sex of calf			
Male	1964	19.81[a]	0.21
Female	2198	18.88[b]	0.21

Means with different superscripts differ significantly ($P<0.05$)

The least squares mean of birth weight for all calves on the farm is 19.34 ± 0.21kg. Male calves were 2.43 percent above the mean while the female calves were 2.38 percent below the mean. The male calves were about 1kg heavier than female calves. The 4.93 percent advantage of male calves over female calves is close to the 4.1 percent, 4.2 percent and 4.5 percent reported by Johnson and Gambo (1975); Shin et at (1975) and Adeyanju et al (1976) respectively in cattle.

This difference in birth weight of calves has been attributed to the longer gestation length for males (Reynolds et al, 1980). Several other researchers have reported the significant effect of sex on birth weight of N'Dama calves (Abanikannda, 1989; Tizikara, 1988; Carew et al, 1986; Fall et al, 1982 and ILCA, 1980).

4.2.3.1.2 Year of birth effect on birth weight

The year of birth of calves is an important (P<0.01) factor on the birth weight of calves. Table 4.10 shows the effect of year of birth on the birth weight of N'Dama calves.

Table 4.10: Effect of year of birth on birth weight of N'Dama calves at the Fashola Stock Farm (1947 - 1984).

Year of birth	N	Birth weight (kg) L.S.Means	S.E.
1947	9	17.91^{klmnopq}	0.87
1948	59	19.04^{ghijklm}	0.40
1949	64	18.51^{hijklmnop}	0.38
1950	54	17.62^{nopq}	0.41
1951	55	17.30^{pq}	0.41
1952	56	16.83^{q}	0.40
1953	71	17.60^{opq}	0.37
1954	104	17.73^{mnopq}	0.32
1955	131	18.29^{ijklmnop}	0.30
1956	144	17.76^{lmnopq}	0.29
1957	238	18.63^{hijklmnop}	0.26
1958	227	19.17^{fghijkl}	0.26
1959	99	19.25^{fghijk}	0.32
1960	175	19.36^{fghij}	0.27
1961	202	18.92^{ghijklmno}	0.26
1962	174	20.28^{bcdefg}	0.28
1963	136	19.79^{cdefgh}	0.29
1964	185	18.67^{hijklmnop}	0.27
1965	166	20.73^{bcde}	0.28
1966	80	21.51^{b}	0.35
1967	105	20.50^{bcdef}	0.32

Table 4.10: (Continued)

Year of birth	N	Birth weight (kg) L.S.Means	S.E.
1968	82	20.18^{bcdefg}	0.35
1969	3	23.75^{a}	1.50
1970	17	20.87^{bcd}	0.66
1971	26	20.96^{bc}	0.54
1972	90	19.50^{efghij}	0.34
1973	76	18.58^{hijklmnop}	0.36
1974	157	19.02^{ghijklmn}	0.29
1975	256	18.11^{jklmnopq}	0.26
1976	171	17.39^{pq}	0.27
1977	151	17.70^{mnopq}	0.29
1978	157	17.87^{klmnopq}	0.29
1979	147	17.38^{pq}	0.30
1980	120	19.57^{defghi}	0.31
1981	63	20.98^{bc}	0.38
1982	66	21.05^{bc}	0.37
1983	37	23.13^{a}	0.47
1984	9	24.19^{a}	0.89

Means with different superscripts differ significantly ($P<0.05$)

The frequency distribution of calves by year of birth is a reflection of the calving distribution on the farm and the reason for this distribution has been discussed earlier. The heaviest calves were born in 1984 (25.08 percent greater than the mean) while the lightest calves were born in 1952 (12.98 percent less than the mean birth weight).

Although there was no consistent pattern in the birth weight of calves across the years, however there was a consistent pattern within the same year group. The birth weight was relatively steady between 1947 and 1957, it increased between 1958 and 1964, it further increased between 1965 and 1971, it thereafter declined between 1972 and 1979 and finally increased between 1980 and 1984. This difference across year group has been explained in terms of varying environmental conditions which to a large extent determines the availability of pastures for the animal and the changing management policies on the farm. This observation agrees with reports of Mrode (1984) and Adeneye et al (1977).

4.2.3.1.3 Season of birth effect on birth weight

Season of birth of calves exerted important influence (P<0.01) on the birth weight of such calves. Figure 4.10 shows the effect of season of birth on the birth weight of N'Dama calves at the Fashola Stock Farm.

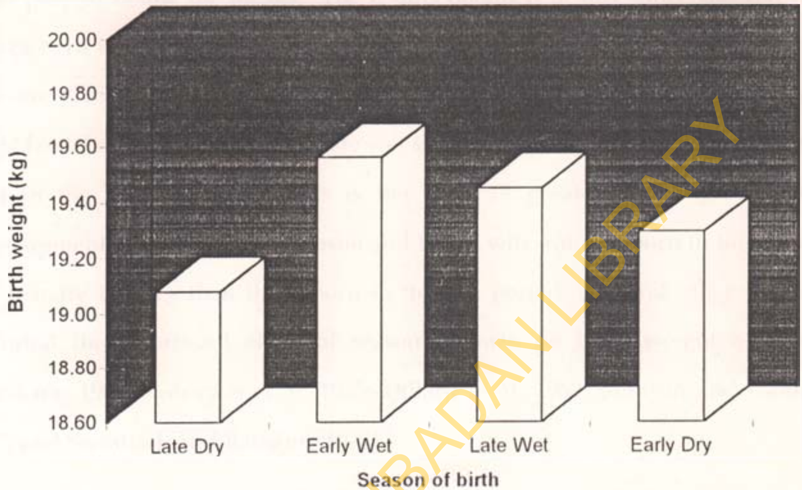

Figure 4.10: Effect of season of birth on birth weight of N'Dama calves at Fashola Stock Farm (1947 - 1984)

24.80 percent of the calves were dropped in the late dry season (Jan - Mar), 23.31 percent were dropped in the early wet season (Apr - Jun), 17.01 percent in the late wet season (Jul - Sep) and 34.89 percent in the early dry season (Oct - Dec). The reason for this distribution has been explained earlier on and it is a reflection of the changing climatic conditions expressed in the quantity and quality of pastures available to the animals during pregnancy.

Calves born in the early wet season were heaviest at birth (1.14 percent above the mean birth weight) and calves born in the late dry season were lightest at birth

(1.34 percent below the mean). The results obtained in this study showed that calves born in the two wet seasons were heavier than those born in the two dry seasons. This may be due to the fact that animals born in the early wet season must have been conceived in the late wet season and this implies that the animal was in the third trimester (this is the stage of greatest foetal growth and development) at the early wet season and this is why animals born in this period are usually heavier than those born in the dry period. Several other workers reported the significant effect of season of birth on birth weight of calves (Tizikara, 1988; Roberson et al, 1985; Dillard et al, 1980; Johnson and Gambo, 1975 and Steinbach and Balogun, 1971).

4.2.3.1.4 Parity of dam effect on birth weight

The parity of dam is an important factor on the weight of calves at birth. Table 4.11 outlines the effect of parity on birth weight.

Table 4.11: Effect of parity of dam on birth weight of N'Dama calves at the Fashola Stock Farm (1947 - 1984).

Parity of dam	N	Birth weight (kg) L.S.Means	S.E.
1	1837	18.91[a]	0.09
2	859	19.49[a]	0.11
3	513	19.74[a]	0.13
4	334	19.93[a]	0.16
5	222	19.81[a]	0.19
6	155	19.63[a]	0.23
7	111	19.43[a]	0.27
8	68	19.40[a]	0.33
9	38	19.41[a]	0.43
10	16	19.75[a]	0.66
11	7	18.89[a]	0.98
12	2	17.75[b]	1.84

Means with different superscripts differ significantly ($P<0.05$)

As expected, the number of calves produced by the dams according to the parity of the dam consistently decreases with increasing parity of the dam. This means that the higher the parity of the dam, the lower the frequency of calving.

Almost 44.14 percent of the calves included in this study were from primiparous dams and only 3.15 percent of the calves were from dams with parities of eight or more.

The lightest calves are those from dams with parity 12 and they are 8.22 percent lighter than the mean birth weight, while the heaviest calves are from parity 4

(3.05 percent heavier than the mean birth weight). Although there seems to be no significant difference in the birth weight of calves due to parity, except parity 12 which differs distinctly from the rest, yet the birth weight of calves follows a consistent and steady pattern but for the upsurge at parity 10. Although the birth weight of calves steadily increases from the first parity to the fourth, it declined slightly till the ninth parity but increased to the tenth parity and continued declining to the twelfth parity.

This observation agrees with Lopez (1985) and Tizikara (1988) who reported that birth weight of calves steadily increases with the parity of the dam up to a point and then stabilizes before declining after a certain stage in the life history of the dam. This observation is due to the fact that in cattle, the animal does not complete its physiological development till about the fourth calving and this implies that the foetus and the dam will both be competing for the inadequate nutritional resources available to the dam, thereby limiting the growth and development of the foetus and consequently the birth weight of the calf.

4.2.3.1.5 Effects of the regression variables on birth weight

With the exception of calf's inbreeding coefficient (CALFINB) which did not exert an important influence on the birth weight of calves, other regressions viz; Age of dam (DAMAGE), Age at first calving of dam (AFC) and dam's inbreeding coefficient (DAMINB) all had significant ($P<0.01$) influence on birth weight.

Table 4.12 shows the correlation between these factors and the calf's birth weight.

Table 4.12: Correlation between the regression variables and birth weight.

	DAMAGE	AFC	CALFINB	DAMINB	CALBWT
DAMAGE	1.0000	0.6332	0.0247	0.0012	0.0749
AFC		1.0000	0.0037	0.0026	0.0840
CALFINB			1.0000	0.0710	-0.0040
DAMINB				1.0000	-0.0329

The mean DAMAGE obtained in this analysis was 70.58 ± 0.82 months. The regression of DAMAGE on CALBWT was 0.0020 ± 0.0001kg. The positive association between DAMAGE and CALBWT implies that CALBWT increases with increasing DAMAGE, and a month increase in DAMAGE will lead to a 2g increase in CALBWT. This observation agrees with the findings of Lopez (1985) and Tizikara (1988). The reason for this may be attributed to the same cause as that of increasing parity which invariably means increasing age of dam.

The age at first calving (AFC) of dam exerted similar influence on CALBWT. This may be due to the relatively high correlation (0.6332) between AFC and DAMAGE. The unadjusted mean age at first calving of dams studied was 48.48 ± 0.65 months. The regression of AFC on CALBWT was 0.0042 ± 0.001kg and this means that a month increase in AFC resulted in 4.23 grams increase in CALBWT. This implies that the longer it takes a dam to produce the first calf, the heavier the birth weight of its subsequent calves.

The mean calf's inbreeding coefficient (CALFINB) in this analysis was 0.634 ± 0.0001 percent. The regression of CALFINB on CALBWT was -0.0029 ± 0.015kg. There is a negative correlation between CALFINB and CALBWT and this means that a percentage increase in CALFINB will result in 2.9 grams decrease in CALBWT, however this regression was not significant. Although Butts et al (1984) and Sachdeva et al (1983) reported that level of inbreeding of calf had significant effect on the birth weight of calves, the results obtained in this study is contrary. However this may be due to the low number of inbred calves (6.56 percent) and the very low mean CALFINB obtained in this analysis.

The mean dam's inbreeding coefficient (DAMINB) was 0.151 ± 0.00001 percent. The regression of DAMINB on CALBWT was -0.0652 ± 0.031kg. The negative correlation between DAMINB and CALBWT implies that a percentage increase in DAMINB resulted in 65.2 gram decrease in CALBWT.

The relatively high correlation and regression of DAMINB on CALBWT may be responsible for the significance of DAMINB on CALBWT. This observation is a result of inbreeding depression associated with increasing homozygosity of the dam as explained by Falconer (1993). This is in agreement with reports of

MacNeil et al (1989); Maksimova and Brovko (1985); McCurley et al (1984); Sachdeva et al (1983) and Dinkel et al (1968).

4.2.3.2 CONSTANT AGE ADJUSTMENT OF WEIGHTS

Because calves were not born on the same day but throughout the year and whereas weaning was carried out at specific times within the year, it became necessary to adjust weights to constant ages as recommended by BIF (1990). To this end three constant ages were analysed in this study and these are 120-day, 205-day and 365-day adjusted weights.

4.2.3.2.1 120-day adjusted weight and daily gain from birth to 120-day

Animals included in this analysis are those with weaning ages between 100 and 150 days. There are 54 calves within this weaning age range and their distribution is depicted in Figure 4.11.

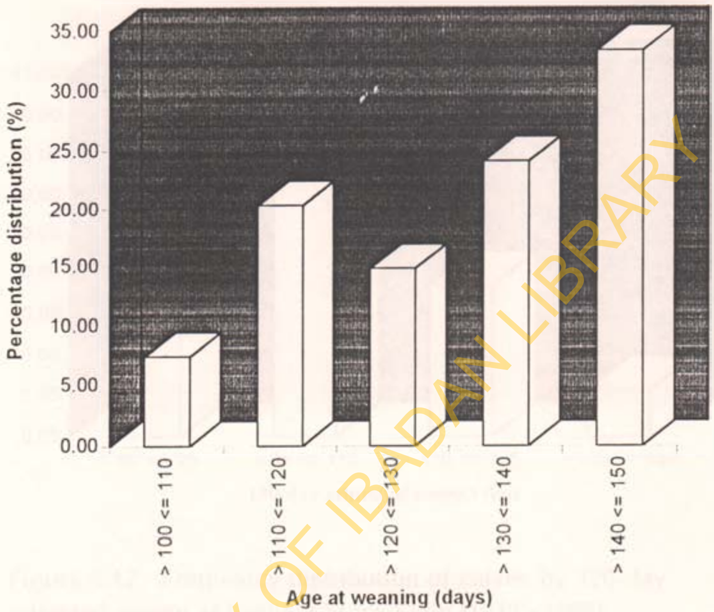

Figure 4.11: Frequency distribution of N'Dama calves by age at weaning at Fashola Stock Farm (1949 - 1966)

The mean 120-day adjusted weight (AD120D) for the 54 calves was 99.73 ± 1.95kg, while the mean average daily gain from birth to 120-day (120DG) was 670.27 ± 15.03g with coefficients of variation of 14.37 and 16.48 percent respectively. Figure 4.12 illustrates the frequency distribution of calves by their AD120D.

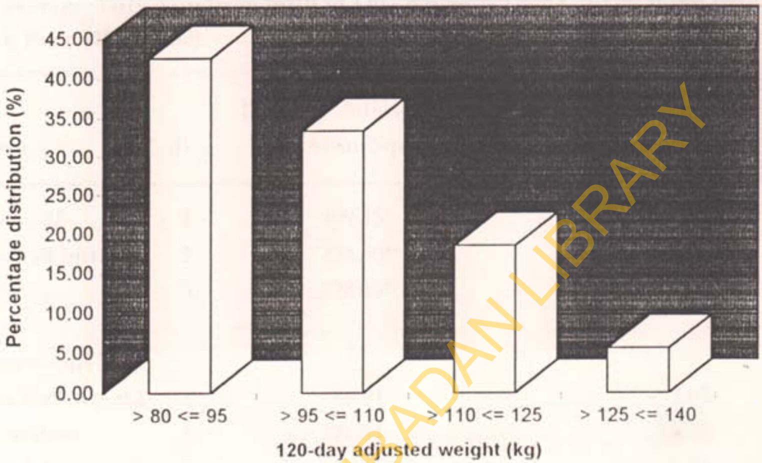

Figure 4.12: Frequency distribution of calves by 120-day adjusted weight at Fashola Stock Farm (1949 - 1966)

Most of the calves (75.92 percent) had AD120D between 80kg and 110kg and the frequency consistently decreases with increasing AD120D. Table 4.13 presents the least squares analysis of variance for both AD120D and 120DG.

Table 4.13: Least squares analysis of variance for 120 - day adjusted weight and average daily gain from birth to 120 - day of N'Dama calves at the Fashola Stock Farm (1962-1983).

Source	df	120 - day Adjusted weight Mean Squares	Daily gain to 120d Mean Squares
Sex of calf	1	499.45*	34.69*
Season of birth	2	724.50**	50.32**
Parity	5	328.45**	22.81**
Regressions			
Calf's Birthweight	1	86.94	3.65
Age of dam	1	221.54	15.38
AFC of dam	1	89.50	6.22
Calf's Inb. Coeff.	1	77.39	5.38
Error	41	86.73	6.02

**= P<0.01, *=P<0.05

Sex of calf was a significant (P<0.05) factor on both AD120D and 120DG, whereas season of birth and parity of dam exerted more influence (P<0.01) on both traits. However none of the regression variables included in the analysis was important on both traits.

The identical effects of these factors on both AD120D and 120DG is a result of the high correlation between both traits which means that there is a correlated response in one as the other is being influenced and this is due to the fact that both traits are controlled by the same sets of gene pairs.

4.2.3.2.1.1 Sex of calf effect on AD120D and 120DG

The sex of calf was an important influence on both traits. Table 4.14 gives the least squares means on the population, sex of calf, season of birth and parity of dam.

Table 4.14: Least squares mean of 120 - day adjusted weight and average daily gain from birth to 120 - day of N'Dama calves at the Fashola Stock Farm (1962 - 1983).

Variable	N	120 - day Adjusted weight (kg) L.S.Means	S.E.	Daily gain (g) L.S.Means	S.E.
Overall mean	54	102.13	2.05	690.24	17.08
Sex of calf					
Male	38	106.23[a]	1.92	724.43[a]	15.96
Female	16	98.03[b]	3.25	656.06[b]	27.09
Season of birth					
Late dry (Jan-Mar)	27	94.30[b]	2.26	624.99[b]	18.80
Early wet (Apr-Jun)	14	105.61[a]	2.83	719.23[a]	23.60
Early dry (Oct-Dec)	13	106.48[a]	3.64	726.51[a]	30.33
Parity					
1	20	92.20[b]	2.56	607.45[b]	21.34
2	10	106.13[a]	3.12	723.57[a]	26.03
3	9	99.83[ab]	3.56	671.04[ab]	29.70
4	8	109.48[a]	3.69	751.49[a]	30.76
5	3	98.55[ab]	6.17	660.43[ab]	51.38
6	4	106.60[a]	5.78	727.47[a]	48.16

Means with different superscripts differ significantly ($P<0.05$)

The least squares means of AD120D and 120DG in this study was 102.13 ± 2.05kg and 690.24 ± 17.08g respectively. Male calves were 8.2kg (8.37 percent) heavier and gain 68.37g (10.42 percent) per day than the female calves. This observed advantage of male calves over the female calves is explained by the fact that male calves were heavier at birth and are more aggressive while feeding than female calves. This observation agrees with reports of Cartwright and Carpenter (1961) and Ferreira et al (1982).

4.2.3.2.1.2 Season of birth effect on AD120D and 120DG

The season of birth of calves exerted significant influence on both AD120D and 120DG. The smallest AD120D and 120DG were recorded in the late dry season, while the highest were recorded in the early dry season (Table 4.14). Calves born in the late dry season were 7.67 percent and 9.45 percent less than the mean AD120D and 120DG respectively, whereas calves born in the early dry season were 4.26 percent and 5.26 percent higher than the mean AD120D and 120DG respectively. Only three seasons were used in this analysis because no calf was dropped in the late wet season in this subset.

The reason why the lightest calves were recorded in the late dry season is due to the fact that at that period of the year, the dams hardly have enough to eat to sustain their various nutritional and physiological requirements, not to talk of having extra to produce sufficient milk for their calves. Unfortunately, supplemental feeding policy was not strictly and consistently adhered to at the Fashola Stock Farm to augment this lack of nutrient supply in the dry season. At the early wet season, the grasses are just growing and the animals require more to compensate for the losses incurred in the preceeding season. However, dams that calve in the early dry season had more feed at the last stages of pregnancy and the remnants of grasses and fodders are still available to supply necessary nutrients for their metabolic activities.

4.2.3.2.1.3 Parity of dam effect on AD120D and 120DG

Parity of dam has a significant effect on both AD120D and 120DG. Although the trend in both AD120D and 120DG did not follow any consistent pattern from parity to parity (Table 4.14), however the lightest AD120D and 120DG were obtained at parity 1 (9.72 percent and 11.99 percent below the mean AD120D and 120DG respectively), while the heaviest AD120D and 120DG were obtained at parity 4 (7.20 percent and 8.87 percent above the mean AD120D and 120DG respectively) when it reached its peak.

This observation is due to the fact that the dam does not complete its physiological development until the fourth parity and therefore nutrients made available to the dam are competed for by both the dam and its suckling calf at the lower parity (Lopez, 1985 and Tizikara, 1988). Also the mothering ability of the dam increases with increasing parities (Preston and Willis, 1974), thus calves from dams with higher parities are expected to be heavier than calves from dams with lower parities.

4.2.3.2.1.4 Effects of the regression variables on AD120D and 120DG

None of the four factors studied exerted significant effect on both AD120D and 120DG. The correlations between these factors and both traits are given in Table 4.15.

Table 4.15: Correlation between the regression variables and AD120D and 120DG.

	CALBWT	DAMAGE	AFC	CALFINB	AD120D	120DG
CALBWT	1.0000	-0.0069	-0.1107	-0.1023	0.4692	0.2956
DAMAGE		1.0000	0.6920	0.0969	-0.0589	-0.0622
AFC			1.0000	0.0015	-0.1633	-0.1532
CALFINB				1.0000	0.0390	0.0639

The mean birth weight (CALBWT) of the 54 calves studied was 19.30 ± 0.38kg. The regression of CALBWT on both AD120D and 120DG was 2.37 ± 0.65kg and 11.38 ± 5.39g respectively. Although there is a moderately high positive correlation between CALBWT and both traits the regression was not an important factor on both traits. The regression coefficient obtained in this study is close to the 2.67 ± 0.20kg reported by Rahnefeld et al (1980).

The mean age of dam (DAMAGE) used in this analysis was 74.69 ± 7.37 months. The regression of DAMAGE on AD120D and 120DG was 0.007 ± 0.04kg and 0.059 ± 0.40g respectively. This regression was not significant due to the very low estimates obtained and the high standard errors of the estimates and it may be attributed to the small number of animals involved in this analysis.

The mean age at first calving of dam (AFC) obtained in this analysis was 49.85 ± 5.45 months and the regression of AFC on both AD120D and 120DG was -0.047 ± 0.063kg and -0.39 ± 0.52g respectively. This follows the same pattern as the DAMAGE and it was due to the very high correlation between the dam's AFC and DAMAGE. The very high standard error of estimates may be responsible for this non-significance. Also the very low correlation between AFC and both traits may be adduced for the non-significance of AFC on both traits.

The mean inbreeding coefficient of the calves (CALFINB) studied was 0.579 ± 0.30 percent and the regression of CALFINB on both AD120D and 120DG was 0.55 ± 0.83kg and 4.58 ± 6.88g respectively. There was a very low positive correlation between CALFINB and both traits. The very high standard errors obtained was due to small number of calves and wide variability in traits which may be responsible for the non-significance of CALFINB on both traits.

4.2.3.2.2 205-day adjusted weaning weight and daily gain from birth to 205 day

Calves that were included in this analysis were those that had weaning age ranging from 150 to 260 days. There were 652 calves studied and their frequency distribution by weaning age is graphically presented in Figure 4.13.

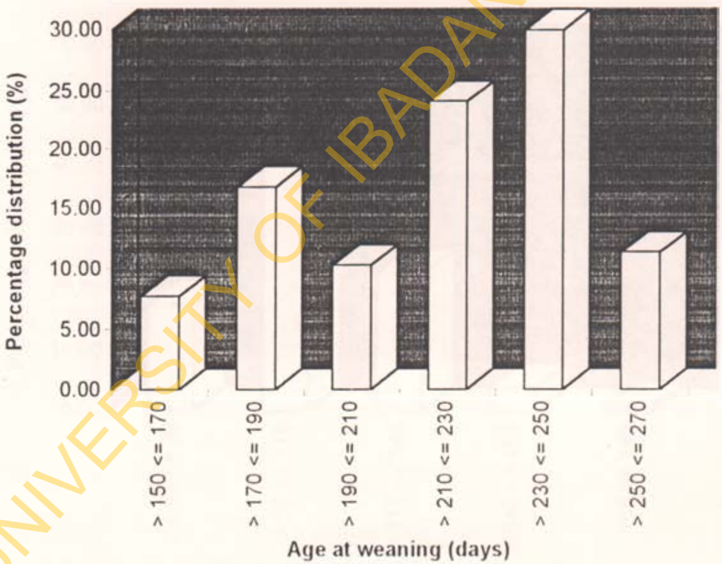

Figure 4.13: Frequency distribution of N'Dama calves by age at weaning at Fashola Stock Farm (1960 - 1983)

The mean 205-day adjusted weaning weight (AD205D) for the 652 calves born between 1960 and 1983 was 106.54 ± 0.74kg, while the mean daily gain from birth to 205 day (205DG) was 426.64 ± 3.57g with coefficient of variation of 17.67 percent and 21.36 percent respectively. Figure 4.14 gives a pictorial presentation of frequency distribution of calves and their AD205D.

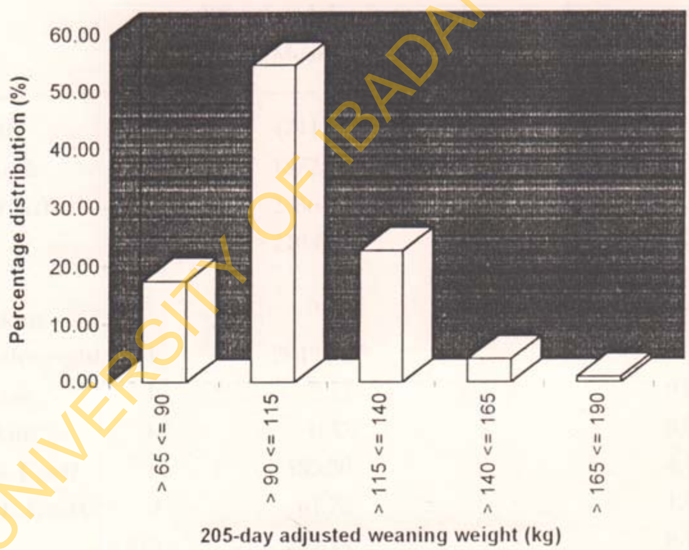

Figure 4.14: Frequency distribution of calves by 205-day adjusted weight at Fashola Stock Farm (1960 - 1983)

Most of the calves (77.45 percent) studied had AD205D between 90kg and 140kg. and the frequency constantly decreases with increasing AD205D. Table 4.16 describes the least squares analysis of variance for both AD205D and 205DG.

Table 4.16: Least squares analysis of variance for 205 - day adjusted weaning weight and daily gain from birth to 205 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1983).

Source	df	205 - day Adjusted weight Mean Squares	Daily gain to 205d Mean Squares
Sex of calf	1	4744.28**	112.88**
Year of birth	17	1872.09**	44.55**
Season of birth	3	2956.14**	70.34**
Parity	10	218.61	5.20
Regressions			
Calf's Birthweight	1	2949.94**	1.22
Age of dam	1	2.12	0.05
AFC of dam	1	0.32	0.01
Calf's Inb. Coeff.	1	185.50	4.42
Dam's Inb. Coeff.	1	61.72	1.47
Error	615	282.14	6.71

**=P<0.01, *=P<0.05

Sex of calf, year of birth and season of birth exerted important influences (P<0.01) on both traits, however calf's birth weight (CALBWT) was significant on AD205D only. Other factors examined did not significantly influence both traits. The two traits are controlled by the same pairs of genes and are such influenced to a large extent by the same factors (Abanikannda, 1989).

4.2.3.2.2.1 Sex of calf effect on AD205D and 205DG

Sex of calf was an important factor on both AD205D and 205DG. Table 4.17 describes the effect of sex of calf on its AD205D and 205DG.

Table 4.17: Effect of sex on 205 - day adjusted weaning weight and average daily gain from birth to 205 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1983).

Variable	N	205 - day Adjusted weight (kg) L.S.Means	S.E.	Daily gain (g) L.S.Means	S.E.
Overall mean	652	103.31	2.78	410.87	13.55
Sex of calf					
Male	340	106.22[a]	2.88	425.05	14.03
Female	312	100.40[b]	2.86	396.70	13.92

Means with different superscripts differ significantly (P<0.05)

Male calves were 5.82kg (5.80 percent) heavier and gain 28.35g (7.15 percent) per day more than the female calves. This difference may be due to the relatively higher birth weight of male calves and the domineering nature of male calves while feeding (Abanikannda, 1989). This advantage of male over female calves was also reported by Fall et al (1982); Mrode (1984) and Tizikara (1988).

4.2.3.2.2.2 Year of birth effect on AD205D and 205DG

The year of birth of calves exerted significant (P<0.01) influence on both traits. Table 4.18 shows the effect of year of birth on both AD205D and 205DG.

Table 4.18: Effect of year of birth on 205 - day adjusted weaning weight and average daily gain from birth to 205 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1983).

		205 - day Adjusted weight (kg)		Daily gain (g)	
Year of birth	N	L.S.Means	S.E.	L.S.Means	S.E.
1960	66	106.37^{abcd}	3.07	425.80^{abcd}	14.97
1961	63	107.58^{abc}	3.00	431.79^{abc}	14.65
1962	55	109.02^{abc}	3.23	438.72^{abc}	15.75
1963	74	103.42^{bcd}	3.09	411.43^{bcd}	15.07
1964	71	107.17^{abcd}	3.02	429.69^{abcd}	14.71
1965	43	101.17^{bcde}	3.36	400.46^{bcde}	16.38
1966	18	90.50^{cde}	4.85	348.39^{cde}	23.64
1967	16	103.74^{bcd}	4.90	412.97^{bcd}	23.92
1968	3	82.88^{e}	10.35	311.21^{e}	50.50
1974	27	94.56^{cde}	4.46	368.18^{cde}	21.77
1975	68	116.48^{ab}	3.39	475.10^{ab}	16.54
1976	13	87.22^{de}	5.45	332.38^{de}	26.57
1977	18	93.38^{cde}	4.75	362.44^{cde}	23.19
1978	68	109.19^{abc}	3.45	439.56^{abc}	16.81
1979	31	107.14^{abcd}	4.09	429.57^{abcd}	19.96
1980	15	126.33^{a}	5.14	523.17^{a}	25.09
1981	2	126.17^{a}	12.21	522.40a	59.55
1983	1	87.23^{de}	17.08	332.46^{de}	83.31

Means with different superscripts differ significantly ($P<0.05$)

Although the 18 years studied were not contiguous, it was observed that the years were consecutive in two distinct year group viz: 1960 - 1968 and 1974 - 1983. About 62.73 percent of the calves studied were born between 1960 and 1968 while only 37.27 percent were born between 1974 and 1983. The frequency distribution of calves within the two year groups is fairly consistent except for 1968, 1981 and 1983.

The heaviest calves were those born in 1980 (22.28 percent greater than the mean AD205D) and the lightest calves were those born in 1968 (19.78 percent less than the mean AD205D). As expected, the 205DG follows the same trend. The variation in both climatic conditions and management practices over the years may be responsible for the significant differences observed in this study. The significant effect due to year of birth on both AD205 and 205DG had been reported earlier by Brown et al (1970); Alim and Taher (1979); Mrode (1984); Carew et al (1986); Tizikara (1988) and Abanikannda (1989).

4.2.3.2.2.3 Season of birth effect on AD205D and 205DG

The season of birth exerted a significant effect on AD205D and 205DG. Figure 4.15 pictorially demonstrates the effect of season of birth on both AD205D and 205DG.

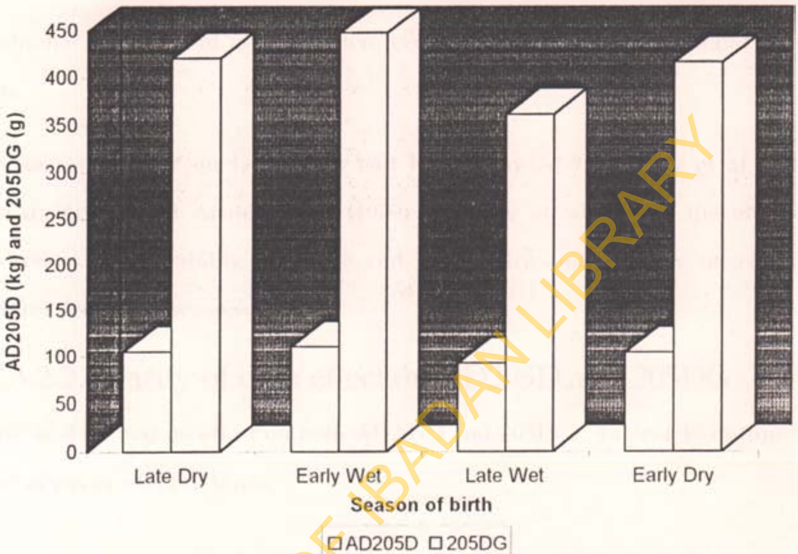

Figure 4.15: Effect of season of birth on AD205D and 205DG at Fashola Stock Farm (1960 - 1983)

The late wet season exerted the smallest effect on both AD205D and 205DG (10.03 percent and 12.30 percent below the mean AD205D and 205DG respectively) and this steadily increases through the early and late dry seasons to reach a peak in the early wet season (7.29 percent and 8.94 percent above the mean AD205D and 205DG respectively). Calves born in the late wet season had the least AD205D and 205DG because the animals grew up in the dry seasons and as such both dam and calf will not have sufficient forage to meet their nutritional requirement moreso when feed supplement is rarely offered on the farm.

This seasonal effect on both traits had been reported by Carew et al (1986); Tizikara (1988) and Abanikannda (1989) and they all attributed the observed differences to availability of forage and the quality and quantity of available pastures across the seasons.

4.2.3.2.2.4 Parity of dam effect on AD205D and 205DG

Parity of dam had no effect on both AD205D and 205DG. Table 4.19 outline the effect of parity on both traits.

Table 4.19: Effect of Parity of dam on 205 - day adjusted weaning weight and average daily gain from birth to 205 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1983).

		205 - day Adjusted weight (kg)		Daily gain (g)	
Parity of dam	N	L.S.Means	S.E.	L.S.Means	S.E.
1	267	102.18	2.10	405.34	10.23
2	146	102.98	2.34	409.26	11.40
3	81	105.08	2.73	419.48	13.30
4	50	107.33	3.22	430.47	15.69
5	34	108.04	3.55	433.95	17.28
6	30	104.27	3.74	415.55	18.23
7	21	108.10	4.29	434.22	20.91
8	13	99.56	5.33	392.60	26.00
9	4	102.53	8.80	407.07	42.94
10	5	107.61	8.02	431.86	39.13
11	1	88.74	17.11	339.82	83.47

AD205D and 205DG steadily increases from the first parity to the fifth parity, thereafter there was no uniformity up to the eleventh parity. Although both traits steadily increase with increasing parity, the effect is not large enough to be of any significance. The AD205D and 205DG reaches a peak at the fifth parity before it starts to decline.

Most researchers reported significant effect of parity on AD205D and 205DG (Preston and Willis, 1974 and Tizikara, 1988) but the contrary was obtained in this study. This discrepancy may be due to the fact that most of the calves (88.65 percent) were from dams with parities one to five and the irregular and low frequency distribution of calves from parities six to eleven.

4.2.3.2.2.5 <u>Effects of the regression variables on AD205D and 205DG</u>

With the exception of effect of CALBWT on AD205D, none of the other regression variables had important influence on both traits. The correlation between these factors and both traits is presented in Table 4.20.

Table 4.20: Correlation between the regression variables and AD205D and 205DG.

	CALBWT	DAMAGE	AFC	CALFINB	DAMINB	AD205D	205DG
CALBWT	1.0000	-0.0109	-0.0813	-0.0154	-0.0141	0.1259	-0.0205
DAMAGE		1.0000	0.6640	0.0729	-0.0013	-0.0515	-0.0503
AFC			1.0000	0.0275	-0.0065	-0.0352	-0.0235
CALFINB				1.0000	0.0778	0.0182	0.0206
DAMINB					1.0000	-0.0112	-0.0092

The mean CALBWT of the 652 calves included in this analysis was 19.08 ± 0.11kg. The regression of CALBWT on AD205D and 205DG was 0.866 ± 0.267kg and -0.652 ± 0.306g respectively. The correlation between CALBWT and AD205D was positive but very low while the correlation between CALBWT and 205DG was negative and low. Although it will be expected that birth weight will affect both traits in the same way due to the very high correlation between AD205D and 205DG but results obtained in this study confirm that the effect of CALBWT was significant only on AD205D. The significance of birth weight on weaning weight had been reported by Jeffery et al (1971); Jeffery and Berg (1972); Rahnefeld et al (1980); Ferreira et al (1982); Tizikara (1988) and Abanikannda (1989).

The mean age of dam (DAMAGE) obtained in this analysis was 81.69 ± 2.15 months. The regression of DAMAGE on AD205D and 205DG was -0.0214 ± 0.018kg and -0.105 ± 0.088g respectively. The fact that parity of dam had no significant effect on both traits may be responsible for this observation because increasing parity is indirectly increasing the age of dam. Also the very low correlation and regression coefficients obtained in this study may be responsible for this non-significance. This observation is different from reports of most researchers who worked on weaning weight (Preston and Willis, 1974 and Tizikara, 1988).

The age at first calving of dam (AFC) is not an important factor on both AD205D and 205DG. The mean AFC of this analysis was 58.02 ± 1.70 months. The regression of AFC on both traits was 0.0069 ± 0.022kg and 0.0336 ± 0.111g respectively. The very high standard error of these estimates may be responsible for the non-significance of AFC on both traits. Also the very high correlation between AFC and DAMAGE tend to explain the similarity in the manner the two factors affect both traits.

Neither the inbreeding of the calf (CALFINB) nor that of its dam (DAMINB) exerted any significant influence on both AD205D and 205DG. The mean CALFINB and DAMINB was 0.725 ± 0.11 percent and 0.247 ± 0.07 percent respectively. The regression of CALFINB on both traits was 0.172 ± 0.267kg and 0.837 ± 1.307g respectively while the regression of DAMINB on both traits was -0.122 ± 0.419kg and -0.596 ± 2.046g respectively. The very low number of inbred calves and dams included in this study may be responsible for the very high standard errors obtained due to very high variability in the estimated parameters. This in turn is responsible for the non-significance of inbreeding of both the calf and its dam on the AD205D and 205DG.

Although most researchers (Irgang et al, 1985; Antal and Bulla, 1986; Inoue, 1986; Maksimova and Brovko, 1985 and Sachdeva et al, 1983) reported that inbreeding of calf and / or dam affect the weaning weight of calves, but the fewer number of inbred calves and dams peculiar to this study may be attributed for the contrary results obtained in this study.

4.2.3.2.3 365-day adjusted yearling weight and daily gain from birth to 365 day

779 N'Dama calves with yearling age ranging from 260 to 460 days were studied in this analysis. Figure 4.16 presents the frequency distribution of calves by their yearling age.

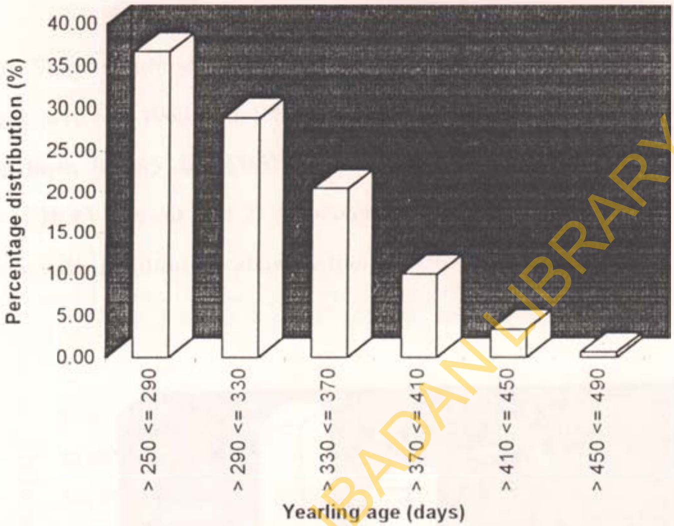

Figure 4.16: Frequency distribution of N'Dama calves by yearling age at Fashola Stock Farm (1960 - 1982)

The results obtained in this analysis is similar to that obtained in the 205-day adjusted weaning weight analysis. The same number of factors were studied in both analyses and the results obtained were identical in both cases. The high genetic, phenotypic and environmental correlation between 205-day weaning weight and 365-day yearling weight (Alenda and Martin, 1987 and Knights et al, 1984) may be responsible for the similarity observed in these two analyses. Thus the explanation for the factors that were discussed earlier still holds for this analysis too.

The mean 365-day adjusted yearling weight (AD365D) for the 779 N'Dama calves born between 1960 and 1982 was 133.90 ± 088kg, while the mean daily gain from birth to 365 day (365DG) was 314.77 ± 2.40g with a coefficient of variation of 18.43 percent and 21.24 percent respectively. Figure 4.17 illustrates the frequency distribution of calves by their AD365D.

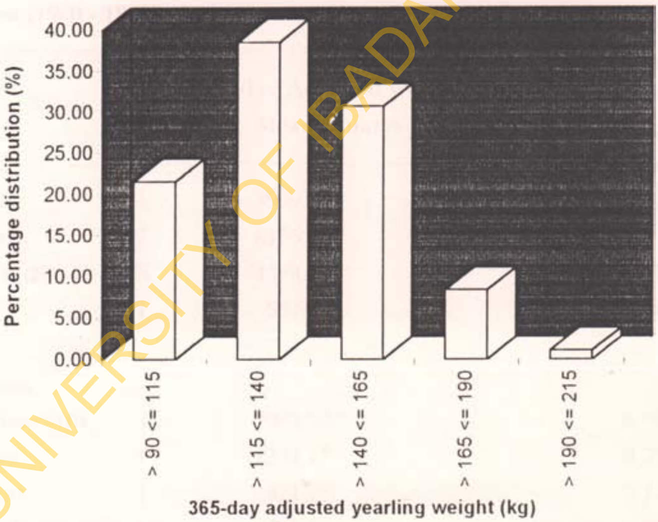

Figure 4.17: Frequency distribution of calves by 365-day adjusted yearling weight at Fashola Stock Farm (1960 - 1982)

Most of the calves (69.19 percent) had AD365D between 115kg and 165kg and the frequency constantly declines with increasing AD365D.

Several factors were investigated and Table 4.21 describes the least squares analysis of variance for both AD365D and 365DG.

Table 4.21: Least squares analysis of variance for 365 - day adjusted yearling weight and daily gain from birth to 365 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1982).

Source	df	365 - day Adjusted weight Mean Squares	Daily gain to 365d Mean Squares
Sex of calf	1	3959.78**	29.72**
Year of birth	17	6155.94**	46.21**
Season of birth	3	4378.17**	32.87**
Parity	11	551.78	4.14
Regressions			
Calf's Birthweight	1	9092.52**	6.95
Age of dam	1	1294.17	9.72
AFC of dam	1	821.22	6.17
Calf's Inb. Coeff.	1	848.75	6.37
Dam's Inb. Coeff.	1	135.25	1.02
Error	741	392.28	2.95

**=P<0.01, *P<0.05

Sex of calf, year of birth and season of birth of calves exerted significant influences on both traits, however calf's birth weight (CALBWT) was significant only on AD365D. Other factors examined did not significantly influence both traits.

4.2.3.2.3.1 Sex of calf effect on AD365D and 365DG

Sex of calf was an important factor on both AD365D and 365DG. Table 4.22 gives the effect of sex on calves' AD365D and365DG.

Table 4.22: Effect of sex of calf on 365 - day adjusted yearling weight and average daily gain from birth to 365 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1982).

Variable	N	365 - day Adjusted weight (kg) L.S.Means	S.E.	Daily gain (g) L.S.Means	S.E.
Overall mean	779	128.73	3.00	300.58	8.21
Sex of calf					
Male	369	131.27^{a}	3.10	307.55^{a}	8.50
Female	410	126.18^{b}	3.11	293.62^{b}	8.51

Means with different superscripts differ significantly (P<0.05)

Male calves were 5.09kg (4.03 percent) heavier and gain 133.93g (4.74 percent) per day more than the female calves. This may be due to the higher birth weight of male calves which has been positively correlated to the final weight of the calves. This finding confirms the earlier reports of Brown et al (1970); Anderson and Wilham (1978); Fall et al (1982) and Ferreira et al (1982).

4.2.3.2.3.2 Year of birth effect on AD365D and 365DG

The year of birth of calves exerted significant effect on both AD365D and 365DG. Table 4.23 outlines the effect of year of birth on both traits.

Table 4.23 Effect of year of birth on 365 - day adjusted yearling weight and average daily gain from birth to 365 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1982).

Year of birth	N	365 - day Adjusted weight (kg) L.S.Means	S.E.	Daily gain (g) L.S.Means	S.E.
1960	78	152.59[a]	3.49	365.97[a]	9.55
1961	102	148.66[ab]	3.27	355.18[ab]	8.95
1962	77	136.83[abc]	3.48	322.79[abc]	9.53
1963	57	140.46[ab]	3.73	332.72[ab]	10.21
1964	96	148.43[ab]	3.24	354.57[ab]	8.87
1965	71	127.97[bcd]	3.51	298.51[bcd]	9.60
1966	6	103.06[e]	8.73	230.25[e]	23.92
1967	41	116.32[de]	4.28	266.60[de]	11.72
1968	52	138.10[ab]	4.03	326.27[ab]	11.03
1971	1	100.00[e]	20.16	221.89[e]	55.23
1974	59	145.13[ab]	4.13	345.52[ab]	11.32
1975	66	138.92[ab]	3.76	328.50[ab]	10.30
1976	17	108.38[e]	5.32	244.83[e]	14.57
1977	21	118.26[cde]	5.26	271.91[cde]	14.41
1978	8	139.59[ab]	7.75	330.35[ab]	21.24
1979	8	142.59[ab]	7.68	338.55[ab]	21.04
1980	10	113.01[de]	6.86	257.52[de]	18.80
1982	9	98.80[e]	7.16	218.59[e]	19.60

Means with different superscripts differ significantly ($P<0.05$)

Like in the 205-day adjusted weaning weight, the years covered in this analysis were not contiguous, however it can be classified into two distinct groups viz: 1960 - 1968 and 1971 - 1982. Also the frequency distribution of calves is more consistent in the former than the latter and the 1960 - 1968 year group had 74.45 percent of the total calf used in this analysis.

The calves born in 1960 had the highest AD365D and 365DG (18.54 percent and 21.76 percent above the mean AD365D and 365DG respectively) while those born in 1982 had the least AD365D and 365DG (23.25 percent and 27.28 percent below the mean AD365D and 365DG respectively). The very large disparity in the frequency distribution of calves across the years and the changing management policy adopted on the farm discussed earlier may be attributed for the inconsistent pattern of both AD365D and 365DG by year of birth. This further confirms the reports of Fall et al (1982) and Carew et al (1986) who worked on N'Dama calves at Senegal and Sierra Leone respectively.

4.2.3.2.3.3 Season of birth effect on AD365D and 365DG

The season of calving has an important effect on both traits. Figure 4.18 illustrates the effect of season of birth on both AD365D and 365DG.

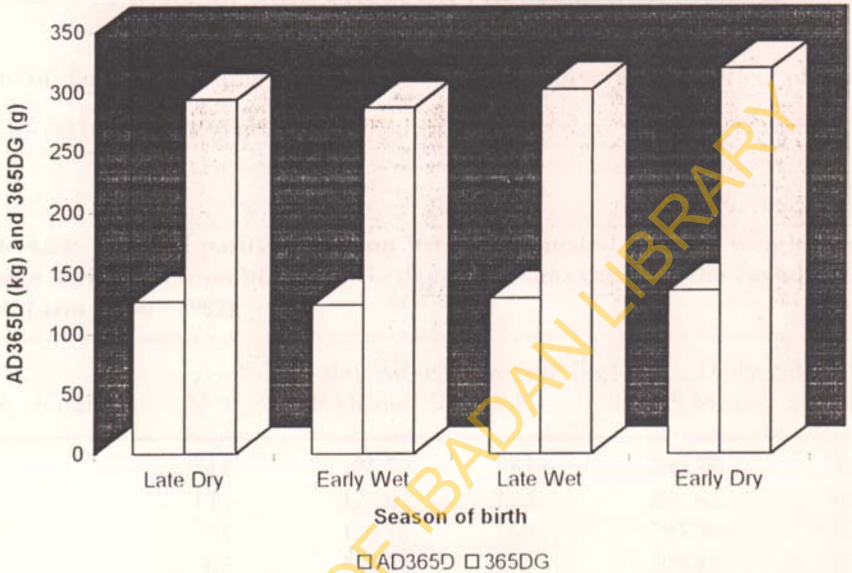

Figure 4.18: Effect of season of birth on AD365D and 365DG of N'Dama calves at Fashola Stock Farm (1960 - 1982)

The early wet season showed the least effect on AD365D and 365DG but this constantly increases and peaked at early dry season before it started declining again. This seasonal variation is explained in terms of availability of pastures and fodders for the growth and development of the calves. Seasonal effect on AD365D and 365DG of N'Dama calves had been well documented by Fall et al (1982) and Carew et al (1986).

4.2.3.2.3.4 Parity of dam effect on AD365D and 365DG

Parity of dam did not affect both traits. Table 4.24 describes the effect of parity on both AD365D and 365DG.

Table 4.24: Effect of parity of dam on 365 - day adjusted yearling weight and average daily gain from birth to 365 - day of N'Dama calves at the Fashola Stock Farm (1960 - 1982).

Parity of dam	N	365 - day Adjusted weight (kg) L.S.Means	S.E.	Daily gain (g) L.S.Means	S.E.
1	344	121.50	1.81	280.78	4.97
2	146	123.63	2.23	286.62	6.10
3	91	126.16	2.66	293.56	7.29
4	67	131.58	3.03	308.41	8.30
5	43	124.98	3.55	290.30	9.72
6	28	129.73	4.15	303.32	11.36
7	29	129.31	4.19	302.19	11.47
8	16	126.89	5.41	295.55	14.83
9	9	129.85	7.01	303.65	19.21
10	2	136.92	14.30	323.02	39.18
11	3	120.81	11.80	278.89	32.32
12	1	143.38	20.77	340.73	56.90

Despite the non-significance of parity on both traits, the trend is consistent for both traits. There was a slight steady increase in both AD365D and 365DG from parity one to parity four after which a decline sets in at parity five but thereafter there was no consistency up to the twelfth parity.

The reason why parity had no effect may be due to the fact that 83.18 percent of the calves used in this analysis were from parity one to parity four. The inconsistency observed after parity eight may be due to the very low frequency distribution (1.93 percent) of calves. This may be the reason why results obtained in this analysis contradicted earlier reports of Preston and Willis (1974) and Alenda and Martin (1987).

4.2.3.2.3.5 Effects of regression variables on AD365D and 365DG

With the exception of CALBWT on AD365D, none of the regression variables included in this analysis had significant impact on both traits. Table 4.25 gives the correlation between these factors and both traits.

Table 4.25: Correlation between the regression variables and AD365D and 365DG.

	CALBWT	DAMAGE	AFC	CALFINB	DAMINB	AD365D	365DG
CALBWT	1.0000	0.0774	0.0266	-0.0019	-0.0350	0.1589	0.0518
DAMAGE		1.0000	0.6620	-0.0076	-0.0263	-0.0987	-0.1082
AFC			1.0000	-0.0244	-0.0255	-0.0298	-0.0330
CALFINB				1.0000	0.0326	0.0889	0.0901
DAMINB					1.0000	0.0015	0.0054

The mean CALBWT was 19.01 ± 0.10kg. The regression of CALBWT on AD365D and 365DG was 1.575 ± 0.327kg and 1.574 ± 0.896g respectively. There was a low positive correlation between CALBWT and both traits. The relatively lower correlation between CALBWT and 365DG may be responsible for the non-significance of CALBWT on 365DG. The positive correlation between birth weight of calves and its final weight had been documented (Rahnefeld et al, 1980; Ferreira et al, 1982 and Knights et al, 1984).

The mean age of dam (DAMAGE) for this analysis was 80.04 ± 2.15 months. The regression of DAMAGE on AD365D and 365DG was -0.066 ± 0.019kg and -0.180 ± 0.053g respectively. The low negative correlation and regression coefficients obtained may be responsible for the non-significance of DAMAGE on both traits. This further substantiates the earlier observation that parity of dam did not exert important influence on both traits.

The AFC did not influence both traits significantly. The mean AFC was 55.48 ± 1.72 months. The regression of AFC on both traits was 0.038 ± 0.024kg and 0.110 ± 0.066g respectively. The high positive correlation between DAMAGE and AFC may be the reason why AFC also affected both traits in similar manner as DAMAGE. Also the relatively low regression coefficient may be responsible for this effect.

Neither the calf's nor dam's inbreeding level had any important influence on both AD365D and 365DG. The mean CALFINB and DAMINB in this analysis was 0.659 ± 0.09 percent and 0.307 ± 0.07 percent respectively. The regression of CALFINB on both traits was 0.906 ± 0.355kg and 2.481 ± 0.971g respectively while the regression of DAMINB on both traits was 0.029 ± 0.463kg and 0.081 ± 1.27g respectively. The low mean inbreeding coefficient of both the calf and its dam is negligible to impact any important influence on these traits. This is a result of the low number of inbred calf and or dams included in this analysis. Although most workers (Maksimova and Brovko, 1985; Irgang et al, 1985; Sachdeva et al, 1983 and Inoue, 1986) reported significant effect of inbreeding on final weight of calves, the relatively small number of inbred animals in this study may be attributed to the deviation observed in this study.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The computer program charts pedigree up to the seventh generation, but the data of animals born on the farm contains pedigrees up to the fifth generation only. The test data for the computer program was the calving records kept at the Fashola Stock Farm between 1947 and 1984. The pedigree information retrieved was then used to estimate individual inbreeding coefficient by the computer program. This inbreeding coefficient was then used along with other factors to investigate their effects on some growth and reproductive traits.

Only 273 of the 4184 calves (6.53%) used in this study were inbred and their level of inbreeding ranges between 0.781 and 37.50%. Of the 293 bulls used as sires in this study, only 5 (1.71%) were inbred with inbreeding coefficient ranging from 3.125 to 25.00%, while only 43 of the 1849 dams (2.33%) were inbred with inbreeding coefficient ranging between 1.563 and 25.00%.

The mean inbreeding coefficient of the entire calf population was 0.63%. For the male calves, mean inbreeding coefficient was 0.70% and 0.58% for the female calves.

The mean inbreeding coefficient of the 273 inbred calves was 9.71 percent, while the mean inbreeding coefficient for the 135 male inbred calves was 10.20 percent and 9.23 percent for the 138 female inbred calves.

The mean age at first calving of the 1756 N'Dama heifers used in this analysis was 40.43 ± 0.81 months. About 33.21 percent of the heifers calved first between 2 and 3 years. The inbreeding coefficient of the heifers exerted significant impact ($P<0.01$) on their age at first calving. A percentage increase in the level of inbreeding of heifer resulted in about 10 days decrease in their age at first calving. Year of birth and season of birth also exerted significant influences on the age at first calving of N'Dama heifers.

The average calving interval of the 1270 cows in this analysis was 445.34 ± 2.68 days. Although the effect of inbreeding level of cow (DAMINB) was not important in this analysis, however the correlation between DAMINB and CALINT was -0.0219 and the regression of DAMINB on CALINT was -1.096 days. The effects of year of birth, parity of dam, age of dam and dam's age at first calving were significant on the average calving interval of the N'Dama cows.

The mean birth weight of the 4162 N'Dama calves used in this analysis was 18.86 ± 0.05kg. The least squares mean birth weight of male calves was 19.81 ± 0.21kg while that of the female calves was 18.88 ± 0.21kg. Inbreeding of the dam has significant ($P<0.01$) influence on the birth weight of calves. A percentage increase in the dam's inbreeding level resulted in 65.2g decrease in the birth of its calf. Although a percentage increase in the inbreeding of calf resulted in 2.89g decrease in calf's birth weight, however inbreeding of the calf was not an important factor on the birth weight of calves. Sex of calf, year of birth, season of birth, parity of dam, age of dam and dam's age at first calving exerted significant (P<0.01) influence on the birth weight of N'Dama calves born on the farm.

The mean 120-day adjusted weight, 205-day adjusted weight, 365-day adjusted weight obtained in this study was 99.73 ± 1.95kg, 106.54 ± 0.74kg and 133.90 ± 0.88kg respectively while the mean daily gain from birth to 120 day, birth to 205 day and birth to 365 day was 670.27 ± 15.03g, 426.64 ± 3.57g and 314.77 ± 2.40g respectively. Neither the inbreeding of the calf nor that of its dam had any important effect on all the traits. The correlation between these traits and inbreeding of both the calf and its dam is low and the regression are not statistically significant. The effects of sex of calf, season of birth and year of birth were significant on all traits studied. However, parity of dam was significant only on the 120-day adjusted weight and calf's birth weight was significant only on the 205-day adjusted weight and 365-day adjusted weight.

5.2 CONCLUSIONS

The following conclusions are drawn from the study.

1. Inbreeding actually took place on the farm between the years 1953 and 1982. This occurred due to the management practice adopted on the farm with regard to breeding. This is because pasture mating was practised in most part of the farm's history and proper documentation of breeding animals was lacking.

2. The number of inbred animals on the farm may actually be greater than detected and reported in this study. This is because most animals transferred or imported to the farm are not usually accompanied with the necessary pedigree information. Thus such animals are considered as being non-inbred and not related to the animals already on the farm. The registration system adopted for animal identification on the farm is very confusing and greatly misleading. The unavailability of proper records during the political crisis period coupled with the intermittent fragmentation of the herd as a result of incessant state creation may also be responsible for the low number of inbred animals observed in this study.

3. The reproductive traits are more significantly affected by inbreeding than the growth traits. Both the growth and reproductive traits are significantly affected by most of the environmental factors identified and investigated in this study.

4. The number of bulls (293) used as sires on the farm is more than the recommended 1:20 bull:cow ratio. This implies that selection was hardly practised on the farm since the bull:cow ratio is less than 1:7. Also the cows were used for too long on the farm.

5. The number of dams (1849) used on the farm within the period covered in this study was so high that the average number of calves produced per cow was 2.26. This is an indication that selection with regard to breeding animals was hardly implemented (if at all adopted) on the farm.

6. The breeding policy of the farm was not strictly adhered to as dictated in the mandate setting up the farm. Lack of proper records for all activities on the farm and the inadequate information contained in the few record books give room for some doubt about the efficiency of the management.

5.3 RECOMMENDATIONS

Due to the fact that one of the fundamental objectives of this study was to develop a computer program to chart pedigree and calculate inbreeding coefficient of individual animal born on the farm, recommendations to be made will be addressed at the specific problems encountered in the course of this study.

Since the availability of accurate and reliable data on the performances of an animal is essential to the overall appraisal of the genetic worth of that individual animal, it is therefore necessary that adequate provision be made at the Fashola Stock Farm for the recording of the animal's individual performance. There should be a data bank to contain information on all animals that ever existed on the farm. Information on the pedigrees and progenies of all breedable animals should be available.

At the national level, there should be a central animal registry whereby census of all classes of livestock in the country shall be kept. There should be a unique registration system where each individual animal is given a unique identification number. Every transaction concerning such animals should be well documented with reference to the identification of the animal. Information on the animal e.g. sex, breed, date of birth, identification number of pedigree or progenies (if available), health records and several other productivity indices that may be computed on that individual animal should be maintained in a database. This will assist in the retrieval of necessary information about an animal before such animal can be sold, bought or transferred for breeding on other farms. Enforcement of this registration on every livestock farmer is the first step to assessing the genetic potential and productivity of animals in this region of the world. The central animal registry should work hand in hand with several other livestock and allied research stations (local and international) and ensure that information flow to and from these research organizations is with minimal inconvenience on the part of the researchers and the end users. There should be a standard (nationally acceptable) format for the recording of animal's productivity so that comparisons across regions / breeds can easily be made.

Most of the factors affecting productivity of N'Dama cattle at the Fashola Stock Farm are essentially environmental in nature rather than genetic. This implies that although the animals have innate capabilities to produce, the environment is inimical to the maximum realization of this potential.

Productivity traits are quantitative in nature and as such are greatly influenced by environmental factors. Any effort aimed at improving the performances of animals at the Fashola Stock Farm must initially be directed at improving the prevailing environmental constraints.

Based on the climatic nature of this part of the world, it is observed that the animals are sustained on fodder and pastures whose availability is solely seasonal, with surplus and scarcity of feed according to the dictate of the seasons. In order to have even growth and development across the seasons efforts must be made to supplement the feed resources of the animals especially during the period of scarcity. Routine operations on the farm should be strictly adhered to and provision should be made for the supply of necessary inputs to achieve the set goal.

Records kept on the farm must be up to date and information therein must be as accurate and reliable as possible. Information obtained from the animal breeder should be used to assess the productivity of the animals.

In conclusion, it must always be ensured that information contained in the record books are not guestimates but rather actual estimates and must neither be **contaminated, compromised** nor **corrupted**.

REFERENCES

Abanikannda, O.T.F. (1989). Genetic parameter estimates for preweaning traits of N'Dama cattle in a stressful environment of the humid tropics of Nigeria. M.Sc. Dissertation, Dept. of Animal Science, University of Ibadan, Nigeria. Pp 69.

Adeneye, J.A., Bamiduro, T.A., Adebanjo, A.K. and Akinyemi, A.A. (1977). Factors affecting birth weight of Holstein - Friesian calves in Western Nigeria. J. Agric. Sci., U.K. 88(1): 111 - 117.

Adeyanju, S.A., Akinokun, O. and Ariyibi, O.O. (1976). Preweaning performances of N'Dama cattle. Nig. J. Anim. Prod. 3 (2): 117 - 123.

Afifi, E.A., Galal, E.S.E. and El-Kimary, I.S. (1984). Lamb livability in two closed flocks of local Rahmani and Barki sheep. Zeitschrift fur Tierzuchtung und Zuchtungsbiologie. 101 (4): 312 - 316.

Akinokun, O. (1970). A preliminary study of age at first calving and calving intervals of a herd of N'Dama cattle. Nig. Agr. J. 7: 148 - 151.

Alenda, R and Martin, T.G. (1987). Genetic parameters and consequences of selection of growth traits in a beef herd selected for yearling weight. J. Anim. Sci. 64(2): 366 - 372.

Alexander, G.I. and Bogart, R. (1961). Effect of inbreeding and selection on performance characteristics of beef cattle. J. Anim. Sci. 20(4): 702 - 707.

Alim, K.A. and Taher, A. (1979). The performance of Friesian and Buffalo calves. World review of Anim. prod. Vol. 15, No 1: 71.

Anderson, J.H. and Wilham, R.L. (1978). Weaning weight correction factors from Angus field data. J. Anim. Sci. 47: 124 - 130.

Antal, J. and Bulla, J. (1986). The effect of inbreeding on meat production in cattle. Pol'nohospodarstvo. 32: 4, 360 - 368.

ASAS (1978). Symposium on use of computer in animal science teaching, research and extension. Published by American Society of Animal Science, Illinois, U.S.A. Pp 64.

Baird, J.D., Maxie, M.G., Kennedy, B.W. and Harris, D.J. (1986). Dilated (congestive) cardiomyopathy in Holstein cattle in Canada; genetic analysis of 25 cases. Proceedings of the 14th World Congress on Diseases of Cattle, Dublin. 1, 89 - 94.

BIF (1990). Beef Improvement Federation. Guidelines for uniform Beef Improvement programs. Oklahoma State University, Still Water, OK 74078. Sixth edition.

Brown, C.J., Ray, M.L., Smith, F. and Smith, R.M. (1970). Factors affecting weaning traits of beef calves in Eastern Arkansas. Ark. Agric. Exp. Sta. Bull. 750 Pp 18.

Boyce, A.J. (1983). Computation of inbreeding and kinship coefficients on extended pedigrees. Journal of Heredity. 74: 6, 400 - 404.

Brinks, J.S. and Knapp, B.W. (1975). Effects of inbreeding on performance traits of beef cattle in the Western region. Colorado state university Tech. Bull. 123: 1 - 36.

Butts, W.T., McCurley, J.R. and Bovard, K.P. (1984). Growth patterns of Angus, Hereford and Shorthorn cattle. II. Relationship of growth patterns of dams with progeny performance. J. Anim. Sci. 59: 5, 1205 - 1212.

Carew, S.F., Sanford, J., Wissocq, Y.J., Durkin, J. and Trail, J.C.M. (1986). N'Dama cattle productivity at Teko livestock station, Sierra Leone and initial results from crossbreeding with Sahiwal. ILCA Bulletin No. 23: P 2 - 11.

Cartwright, T.C. and Carpenter, J.A. (1961). Effects of nursing habits on calf weights. J. Anim. Sci. 20: 904 (Abs).

Chaitanyam, K. and Singh, B.P. (1985). The effects of inbreeding on economic characters in White Leghorns. Indian Journal of Poultry Science 20: 1, 54 - 57.

Cheng, K.M., Burns, J.T. and Shoffner, R.N. (1985). Mating behaviour and fertility in domestic chickens. I. Inbreeding. Applied Animal Behaviour Science. 13: 4, 371 - 381.

Chernykh, A.I., Tsys', V.I. and Kochetkova, N.P. (1982). The formation of selection herds of brown cattle. Doklady Vsesoyuznoi Akademii Sel' skokhozyaistvennykh Nauk. 2, 30 - 32.

Cole, W.J., Bierschwal, C.J., Youngquist, R.S. and Braun, W.F. (1986). Cystic ovarian disease in a herd of Holstein cows: a hereditary correlation. Theriogenology 25: 6, 813 - 820.

Cruden, D. (1949). The computation of inbreeding coefficients for closed populations. J. Her. 40: 248 - 251.

Davis, G.P. and Kinghorn, B.P. (1985). Inbreeding effects on pre-weaning growth traits in sheep. Proceedings of the Fifth Conference, Australian Association of Animal Breeding and Genetics, University of New South Wales, Sydney, New South Wales, Australia, 26 - 28 August, 1985. 230 - 231.

Dbase IV (1990). Database Management system. (Version 4.0). Ashton Tate Corp. U.S.A.

DeNise, R.S.K. (1983). Relationships among the growth curve parameters and productivity traits in beef cows. Dissertation Abstracts International, B. Sciences and Engineering. 43: 11, 3422.

Dhillon, B.S. and Khehra, A.S. (1984). Suggestions to overcome the limitation of inbreeding in modified full - sib selection. Cereal Research Communications. 12: 1/2, 105 - 106.

Dillard, E.U., Rodriguez, O. and Robison, O.W. (1980). Estimation of additive and non-additive direct and maternal genetic effects from cross breeding beef cattle. J. Anim. Sci. 50(4): 653 - 663.

Dinkel, C.A., Anderson, L.M., Parker, W.R. and Trevillyan, W.R. (1972). Effects of inbreeding on fertility and livability in beef cattle. J. Anim Sci. 35 (4): 725 - 729.

Dobao, M.T., Poza, M.L., Rodriganez, J. and Silio, L. (1985). Differences in carcass composition in three strains of Iberian pigs. Anales del Instituto Nacional de Investigaciones Agrarias, Ganadera. 22: 1, 99 - 112.

Ehiobu, N.G. and Ngere, L.O. (1986). Effect of inbreeding on birth weight of White Fulani cattle. Trop. Vet. 4: 133 - 138.

Emik, L.O. and Terrill, C.E. (1949). Systematic procedures for calculating inbreeding coefficients. J. Her. 40: 51 - 55.

Ensminger, M.E. (1968). Beef cattle science (4th Edition). The interstate printers and publishers inc., Danville, Illinois. P 178.

Ernst, L.K., Grigor'ev, Yu. N. and Kharitonov, S.N. (1983). Relationship between productivity and degree of inbreeding in Black Pied cows. Byulleten' Nauchnykh Rabot. Vsesoyuznyi Nauchno Issledovatel'skii Institut Zhivotnovodstva. 69, 23 - 25.

Falconer, D.S. (1993). Introduction to quantitative genetics. Oliver and Boyd, Edinburgh. (4th Edition).

Fall, A., Diop, M., Sanford, J., Wissocq, Y.J., Durkin, J. and Trail, J.C.M. (1982). Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal. ILCA Research Report No. 3. Pp 70.

FAO (1980). Trypanotolerant livestock in West and Central Africa. Vol. 2. - Country studies. Rome, Animal production and health paper No. 20 (In collaboration with ILCA and UNEP).

Ferreira, P.R.C., Sampaio, I.B.M. and Oliverira, J.A.L. (1982). Factors affecting variation in the 205-day weight of Nellore calves. Anim. Breeding Abst. (Art. 5973).

Fisher, R.A. (1965). The theory of inbreeding. Oliver and Boyd, Edinburgh (2nd Edition) Pp 150.

Flade, D. and Zeller, K. (1986). Effect of moderate inbreeding on inbreeding rate, culling rate, reasons for culling, body weight gain and semen production and quality of young bulls. Wissenchaftliche Zeitschrift der Humboldt Universitat zu Berlin, Mathematisch Naturwissenchaftliche Reihe. 35: 4, 327 - 334.

Flower, A.E., Brinks, J.S., Urick, J.J. and Willson, F.S. (1963). Comparisons of inbred lines and linecrosses for performance traits in Hereford range cattle. J. Anim. Sci. 22(4): 914 - 918.

Gerasch, G. (1986). Reproductive and rearing performance of an inbred German Yorkshire population. Wissenchaftliche Zeitschrift der Humboldt Universitat zu Berlin, Mathematisch Naturwissenchaftliche Reihe. 35: 4, 364 - 371.

Golden, B.L., Brinks, J.S. and Bourdon, R.M. (1991). A performance programmed method for computing inbreeding coefficients from large data sets for use in mixed analyses. J. Anim. Sci. 69: 3564 - 3573.

Guba, S. and Wolf, G. (1984). Changes in some standard characteristics of cattle in response to various extents of inbreeding. Acta Agronomica Academiae Scientiarum Hungaricae. 33: 1-2, 67 - 95.

Hagger, C. (1985). Line and crossing effects in a diallel mating system with highly inbred lines of White Leghorn chickens. Theoretical and Applied Genetics 70: 5, 555 - 560.

Hagger, C. (1986). Genetic effects of heterosis in F1 and backcrosses of inbred lines of White Leghorns. Zeitschrift fur Tierzuchtung und Zuchtungsbiologie. 103: 1, 26 - 32.

Harvey, W.R. (1989). User's Guide for LSMLMW PC-1 version. Mixed model least squares and maximum likelihood computer program. Dept. of Dairy Sc., Ohio State University, U.S.A. Pp 59.

Havrankova, J., Slavickova, M., Cerny, M. and Slapnicka, J. (1984). Achondroplasia in the progeny of bulls from one line - a cytogenetic examination of sires. Veterinarstvi. 34: 3, 128 - 130.

Hazel, L.N. and Lush, J.L. (1950). Computing inbreeding and relationship coefficients from punched cards. J. Her. 41: 301 - 306.

Hoen, K. and Grandage, A.H.E. (1960). Calculation of inbreeding in family selection studies on the IBM-650 data processing machine. Biometrics 16: 292 - 296.

Hohenboken, W.D. (1985). The manipulation of variation in quantitative traits: a review of possible genetic strategies. J. Anim. Sci. 60: 1, 105 - 110.

Hradecky, J., Hruban, V., Hojny, J., Pazdera, J. and Stanek, R. (1985). Development of a semi - inbred line of Landrace pigs. I. Breeding performance and immunogenetic characteristics. Laboratory Animals. 19: 4, 279 - 283.

Hudson, G.F.S. (1983). Inbreeding in dairy cattle. Dissertation Abstracts International, B. Sciences and Engineering. 43: 12, 3781 - 3782 124pp.

Hudson, G.F.S., Vleck, L.D. van and Van-Vleck, L.D. (1984a). Inbreeding of artificially bred dairy cattle in the Northeastern United States. Journal of Dairy Science. 67: 1, 161 - 170.

Hudson, G.F.S., Vleck, L.D. van and Van-Vleck, L.D. (1984b). Effects of inbreeding on milk and fat production, stayability and calving interval of registered Ayshire cattle in the Northeastern United States. Journal of Dairy Science. 67: 1, 171 - 179.

ILCA (1979). Trypanotolerant livestock in West and Central Africa. Vol. 1. General study, Addis Ababa, ILCA Monograph No. 1/2 Pp 148.

ILCA (1980). Trypanotolerant livestock in West and Central Africa. Vol. 2. Country studies, Addis Ababa, ILCA Monograph No. 2/2. Pp 303.

ILCA (1982). Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal. ILCA Research Report No. 3. Pp 70.

ILCA (1983). Livestock productivity and Trypanotolerance. Network Training Manual. Pp 198.

ILCA (1986). Trypanotolerance network situation report, December 1985. ILCA Livestock Productivity and Trypanotolerance Group. Working Document 222, 98p.

Inoue, R. (1986). Effects of pedigree structure on carcass traits of beef cattle of the Okayama strain if Japanese Blacks. Japanese Journal of Zootechnical Science. 57: 1, 29 - 35.

Irgang, R., Dillard, E.U., Tess, M.W. and Robison, O.W. (1985). Selection for weaning weight and postweaning gain in Hereford cattle. I. Population structure and selection applied. J. Anim. Sci. 60: 5, 1133 - 1141.

Jeffery, H.B. and Berg, R.T. (1972). Influence of cow size and other factors on weight gain of beef calves to 365 days of age. Can. J. Anim. Sci. 52: 11 - 21.

Jeffery, H.B., Berg, R.T and Hardin, R.T. (1971). Factors affecting preweaning performance in beef cattle. Can. J. Anim. Sci. 51: 561 - 577.

Johnson, A.O. and Gambo, A. (1975). Growth performance of dairy crossbred calves at Shika. Samaru Agric. Newsletter 17(2): 41 - 45.

Knights, S.A., Baker, R.L., Gianola, D. and Gibb, J.B. (1984). Estimates of heritability and of genetic and phenotypic correlations among growth and reproductive traits in yearling Angus bulls. J. Anim. Sci. 58(4): 887 - 893.

Kravchenko, N.A., Vinnichuk, D.T., Gavrilenko, V.P. and Pavlovskii, G.A. (1985a). The effect of inbreeding on the milk yield, reproductive ability and exterior of high-yielding Simmental cows. Molochnoe i Myasnoe Skotovodstvo, Kiev. 66, 13 - 17.

Kravchenko, N.A., Vinnichuk, D.T., Gavrilenko, V.P. and Pavlovskii, G.A. (1985b). Selection and genetic parameters in record-yielding inbred or outbred Simmental cows. Molochno Myasnoe Skotovodstvo, Kiev. 67, 35 - 37.

Kress, D.D., Hauser, E.R. and Chapman, A.B. (1969). Efficiency of production and cow size in beef cattle. J. Anim Sci. 29: 373.

Lamberson, W.R. and Thomas, D.L. (1984). Effects of inbreeding in sheep: a review. Animal Breeding Abstracts. 52: 5, 287-297.

Lopez, D. (1985). Productive characteristics of bovine cattle in the tropics. I. Growth traits. Cuban J. of Agric. Sci. 19: 125 - 136.

Los', N.F. (1984). The effect of inbreeding on dairy performance of Russian Browncows. Selektsiya Molochnogo Skota. 181 - 186.

MacNeil, M.D., Dearborn, D.D., Cundiff, L.V., Dinkel, C.A. and Gregory, K.E. (1989). Effects of inbreeding and heterosis in Hereford females on fertility, calf survival and preweaning growth. J. Anim. Sci. 67: 895 - 901.

Mahadevan, P. (1966). Breeding for milk production in tropical cattle. Farnham Royal, CAB, Technical communication No. 17, 154p

Maksimova, T.M. and Brovko, N.V. (1985). Type of breeding and reproductive performance of cows. Sbornik Trudov. Belorusskii Hauchno Issledovatel'skii Institut Zhivotnovodstva. 26, 57 - 61.

Malécot, G. (1969). The mathematics of heredity. W.H. Freeman and Co., San Francisco. Pp 88.

Mange, A.P. (1964). Fortran programs for computing Wright's coefficient of inbreeding in human and non human pedigrees. Am. J. Human Genetics 16: 484.

McCurley, J.R., Butts, W.T. and Bovard, K.P. (1984). Growth patterns of Angus, Hereford and Shorthorn cattle. I. Comparison of inbred and non-inbred lines, changes in patterns over time and effects of level of inbreeding and reproductive performance. J. Anim. Sci. 59: 5, 1194 - 1204.

McDowell, R.E. (1983). Strategy for improving beef and dairy cattle in the tropics. Cornell International Agriculture Mimeograph No. 100, 34pp.

Mrode, R.A. (1984). A study of body weight and reproductive performance in White Fulani cattle. M. Phil. thesis, Dept. of Anim. Sci. University of Ife, Nigeria. 126p.

Murray, M., Morrison, W.I., Murray, P.K., Clifford, D.J. and Trail, J.C.M. (1983). Trypanotolerance - A review, Livestock productivity and Trypanotolerance. ILCA Network Training Manual. P 165 - 175.

Murray, M. and Trail, J.C.M. (1983). Trypanotolerance: Genetics, Environmental influences and mechanisms. ILCA Network Training Manual. P 177 - 190.

Neuman, A.L. (1977). Beef cattle (7th Edition) John Wiley and Sons Inc. London Pp 234.

Ngere, L.O. and Cameron, C.W. (1972). Crossbreeding for increased beef production. I Performance of crosses between local breeds and either Santa Gertrudis or Red Poll. Ghana Journal of Agricultural science, Accra, 5: 43 - 49.

Noland, P.R., Gifford, W. and Brown, C.J. (1964). Effects of inbreeding in a Poland China line of Swine on certain productivity traits. Arkansas Agr. Expt. Sta. Tech. Bull. Pp 23.

Nurzhanov, E.K. (1986). The effect of inbreeding on the milk yield and reproductive ability of cows. Zhivotnovodstvo 7, 22 - 23.

Ojo, F. O. (1991). Correlations between heifers weight and age at first calving of N'Dama cattle at Fashola Stock Farm. B.Sc. Project. Dept. of Anim. Sci. University of Ibadan, Nigeria. 49p.

Olutogun, O. (1976). Reproductive performance and growth of N'Dama and Keteku cattle under ranching conditions in the Guinea savannah of Nigeria. Ph.D. Thesis. University of Ibadan, Nigeria. Pp 292.

Olutogun, O. and Dettmers, A. (1977). Heritability estimates of live weights from an extensively managed beef cattle population in the southern Guinea Savannah of Nigeria. Nig. J. Gen. 1: 62 -68.

Orihashi, Y. and Fushimi, M. (1982). Comparison of some methods of calculating inbreeding coefficients on a computer. Biometrics. 38: 4, 1102.

Oyedipe, E. O., Osori, D.K., Akerejola, O. and Sarror, D. (1982). Effect of level of nutrition on onset of puberty and conception rates of zebu heifers. Theriogenology and Int. J. of Anim. Reproduction 18 (5): 225.

Pavlova, E.A., Pavlov, G.L. and Kartysheva, T.A. (1986). Creation of a high-yielding herd of pigs. Zhivotnovodstvo. 2, 36 - 37.

Pieta, M., Lipecka, C., Efner, T. and Gruszecki, T. (1983). Meat production of ram lambs inbred to different degrees. Annales Universitatis Mariae Curie Sklodowska, EE Zootechnica. 1, 283 - 288.

Preston, T.R. and Willis, M.B. (1974). Intensive Beef Production. (2nd Edition) Pergamon Press. Oxford England. Pp 567.

Ralph, B. (1959). Improvement of livestock (1st Edition). The Macmillan Co., New York. P 185 - 186.

Rahnefeld, G.W., Parker, R.J., Yodserance, S. and Stringham, W.E. (1980). Influence of body weight and changes in body weight of the cow on preweaning traits of calf. Can. J. Anim. Sci. 60: 599 - 607.

Rehfeld, C.E., Bacus, J.W., Pagels, J.A. and Dipert, M.H. (1967). Computer calculation of Wright's inbreeding coefficient. J. Her. 58: 81 - 84.

Reynolds, W.L., De Rouen, T.M., Moin, S. and Koonce, K.L. (1980). Factors influencing gestation length, birth weight and calf survival of Angus, Zebu and Zebu cross beef. J. Anim. Sci. 51(4): 860 - 867.

Roberson, R.L., Sanders, J.O. and Cartwright, T.C. (1985). Direct and maternal genetic effects on preweaning characters of Brahman, Hereford and Brahman-Hereford crossbred cattle. J. Anim. Sci. 63(2): 438 - 446.

Russell, W.C., Brinks, J.S. and Richardson, G.V. (1984). Changes in genetic variances with increased inbreeding of beef cattle. Journal of Heredity. 75: 1, 8 - 10.

SAS (1990). SAS Users guide: Statistics, Statistical analysis systems inc. Cary, North Carolina, U.S.A. Pp 584.

Sachdeva, G.K., Tomar, S.S. and Sharma, A. (1983). Effects of inbreeding on various economic traits of dairy cattle - a review. Agricultural Reviews 4: 2, 136 - 142.

Sharafutdinov, G. (1982). The effect of inbreeding on milk yield of Kholmogor cows. Molochnoe i Myasnoe Skotovodstvo. 5, 21.

Sharafutdinov, G. (1983). Genetic quality of bulls obtained by different selection methods. Molochnoe i Myasnoe Skotovodstvo. 10, 44 - 45.

Sharafutdinov, G.S. (1984). Methods of obtaining high - producing animals. Zhivotnovodstvo. 11, 42 - 43.

Shcheglachev, N.D. (1983). Inbreeding and its use in the improvement of Black Pied cattle. Puti soversh. plem. i produkt. kachestv krup. rogat. skota. 102 - 105.

Shin, W.J., Kang, T.L., Paik, Y.K., Chee, S.H. and Park, Y.I. (1975). The effect of various genetic and environmental factors on birth and weaning weights in Korean cattle. Korean J. Anim. Sci. 17(3): 223 - 227.

Sorensen, D.A. and Kennedy, B.W. (1984). Estimation of genetic variances from unselected and selected populations. J. Anim. Sci. 59: 5, 1213 - 1223.

SPSS/PC+ (1991) Statistical package for the social sciences PC- version. SPSS inc. 444, N. Michigan avenue, Chicago, Illinois, U.S.A.

Srinivas, B. and Gurnani, M. (1981). Incidence of inbreeding and its effect on some traits of Sahiwal cattle. Indian Journal of Dairy Science. 34: 1, 8 - 15.

Starkey, P.H. (1982). N'Dama cattle as draught animals in Sierra Leone. World Animal Review, Rome 42: 19 - 26.

Starkey, P.H. (1984). N'Dama cattle: A productive trypanotolerant breed. World Animal Review, Rome, 50: 2 - 15.

Steinbach, J. and Balogun, A.A. (1971). Seasonal variation in the conception rate of beef cattle in the seasonal - equitorial climate of southern Nigeria. Int. J. Biometeor 15 (1): 71.

Swiger, L.A., Gregory, K.F., Koch, R.M. and Arthaud, V.A. (1961). Effect of inbreeding on performance traits of beef cattle. J. Anim. Sci. 20(3): 626 - 630.

Tai, G.C.C., Tarn, T.R. and DeJong, H. (1984). A software for storing parentage information and constructing pedigree trees for potato cultivars and parents. American Potato Journal 61: 8, II, 538 - 539.

Ter'maeva, L.K. (1984). The use of inbreeding during selection of pigs for finishing performance. Genet. selekts. issled. na Urale. Inf. materialy. 457 - 458.

Timofeev, L.V., Mikeenkov, V.E., Feduleev, I.A. and Kalyabina, L.I. (1986). Reproductive characters of sows mated to unrelated inbred boars. Zhivotnovodstvo. 3, 30 - 31.

Tizikara, C. (1988). Estimation of genetic parameters of some growth and reproductive traits in N'Dama cattle and their crosses. Ph.D. Thesis, Dept. of Animal Science, Obafemi Awolowo University, Ile - Ife, Nigeria. Pp 160.

Touchberry, R.W. (1967). A study of N'Dama cattle in the Musaia animal husbandry station in Sierra Leone. Univ. of Illinois Agr. Exp. Sta. Bull. No. 724, 40p.

Tuah, A.K. and Danso, N. (1985). Preliminary studies in the performance and productivity of N'Dama and West African Shorthorn cattle in Ghana. Trop. Anim. Health production 17(2): 114.

Tucker, A.N. (1982). Seasonality in cattle. Theriogenology and Int. J. of Anim. Reproduction 17: 1, 73 - 78.

Vanli, Y., James, J.W., McGuirk, B.J. and Atkins, K.D. (1985). The effects of some environmental factors and inbreeding on weanling characteristics of Australian Merino lambs. Doga Bilim Dergisi, D1 Veterinelik ve Hayvancilik. 9: 3, 274-281.

Wilson, R.T. (1986). Livestock production in central Mali: Long term studies on cattle and small ruminants in the agropastoral system. ILCA research report No. 14, 111p.

Woolliams, C., Wiener, G. and Macleod, N.S.M. (1983). The effects of breed, breeding system and other factors on lamb mortality. 3. Factors influencing the incidence of weakly lambs as a cause of death. Journal of Agricultural Science, U.K. 100: 3, 563 - 570.

Wright, S. (1921). Systems of mating. I - V. Genetics 6: 111 - 178.

Wright, S. (1922). Coefficients of inbreeding and relationship. Am. Nat. 56: 330 - 339.

Wright, S. and McPhee, H. (1925). An approximate method of calculating coefficients of inbreeding and relationship from livestock pedigrees. J. Agr. Res. 31: (4) 377 - 383.

Yoshida, T. (1985). Inbreeding coefficients of breeding lines in sweet potato. Japanese Journal of Breeding. 35: 4, 464 - 468.

APPENDIX I

CODES FOR SEX, SEASON AND GENOTYPE/TAG

PARAMETERS		CODE
a. Sex		
Male		1
Female		2
b. Season		
Late Dry (January - March)		1
Early Wet (April - June)		2
Late Wet (July - September)		3
Early Dry (October - December)		4
c. Genotype/Tag		
Ex - Ilorin	IL	01
Purebred N'Dama	N	02
Purebred Muturu	M	03
Ex - Congo Upper Ogun	CU	04
Fashola born N'Dama		05
Brahman x Keteku	BK	06
Muturu x N'Dama	MN	07
Brahman x N'Dama	BN	08
Keteku x N'Dama	KN	10
Brahman x Muturu	BM	11
Ex - Upper Ogun Estate	UOE	12
N'Dama crosses	NX	13
Holstein x N'Dama	HN	27
German Brown x N'Dama	GBN	28
Purebred German Brown	GB	29
Jersey - Brahman x N'Dama	JBN	30
Purebred White Fulani	WF	31
Purebred Keteku	K	32

APPENDIX II

KERNEL OF SOURCE CODES OF SOME OF THE COMPUTER PROGRAMS

```
*----------------------------------------------------------
* It is meant to interlink other existing program in the pack-
* age.
* Design : O. T. F. Abanikannda
* Programmer : O. T. F. Abanikannda
* Date July, 1994
* Blk 516, Flat 6, Low Cost Housing Estate, Isolo, Lagos
*----------------------------------------------------------
*  Note: Create with RMAKE RET.RMK

#include "Omenu.ch"
#include "Inkey.ch"
#include "Mybox.ch"  //Make use of ASC 176 to draw background
#include "Achoice.ch"

/* Definitions for all of the menus and menu prompts */

// Menu definitions
#define F_CREATE 10
#define F_USE    11
#define F_MODIFY 12
#define F_SAVE   13
#define F_EXIT   14

// Prompt definitions
#define S_DBF  131
#define S_TXT  132

#define E_BROWSE 20

#define U_MODISTR 34
```

```
#define U_CHART   30
#define U_DISPLAY 31
#define U_CONVERT 32
#define U_INBRED  33

#define D_BYREC   311
#define D_BYID    312

#define C_NEWID   323
#define C_MALE    321
#define C_FEMALE  322

#define T_BELL    40
#define T_WRAP    41
#define T_CONFIRM 42

#define H_HELP    50
#define H_CREDIT  51

#define BACK_GROUND (REPL(CHR(176), 9))

STATIC hBar, hFileMenu, hEditMenu, hUtilMenu, hHelpMenu, hTogMenu,
hSaveSubMenu, hDispSub, hConvSub

FUNCTION Main() //This is the startup function for the entire program
LOCAL nChoice, cScr
 SET CURSOR OFF
 SET TALK  OFF
 SET BELL  OFF
 SET DATE  BRITISH
 SET SCOREBOARD OFF
 SET ESCAPE OFF

  cScr:= SAVESCREEN(0, 0, 24, 79)
  CLS
  Startup()   //This Would Contain the startup code with background display
  Accept_Passwd()
  CreateBar()
```

```
DISPBOX(0,0,24,79, BACK_GROUND, cBackGround)
@ 24,0 CLEAR TO 24, 79
@ 24, ( 80 - LEN ( cMessg )) /2 SAY cMessg
CompanyBox(.F.) //Display Company Information
SHOWTIME(0,71,.F.,"W/R+",.T.,.T.)
BarDisplay(hBar)
//BarActivate( hBar, nKey )  // nKey added
SHOWTIME(0,71,.F.,"W/R+",.T.,.T.)
*-------- KEYBOARD CHR(K_ALT_F) //Go straight to the file menu

// Initially give bar complete control
BarActivate( hBar )
  nChoice := BarMenuChoice( hBar )

DO WHILE nChoice != F_EXIT
  DO CASE
  CASE nChoice == F_CREATE
       DO Createdatabase
  CASE nChoice == F_USE
       DO Usedatabase
  CASE nChoice == F_MODIFY
       DO Modifydatabase
  CASE nChoice == S_DBF
       DO Savedatabase
  CASE nChoice == S_TXT
       DO Savetextfile
  CASE nChoice == E_BROWSE
       DO Browsedatabase
  CASE nChoice == U_MODISTR
       DO Modifyer
  CASE nChoice == U_CHART
       DO Chartmaster
  CASE nChoice == U_INBRED
       DO Inbreeder
  CASE nChoice == D_BYREC
       DO Chartbyrec
  CASE nChoice == D_BYID
       DO Chartbyid
```

```
    CASE nChoice == C_NEWID
        DO Converter
    CASE nChoice == C_MALE
        DO Convertmale
    CASE nChoice == C_FEMALE
        DO Convertfemale
    CASE nChoice == H_HELP
        DO Help
    CASE nChoice == H_CREDIT
        DO Credit
    OTHERWISE
        BarActivate( hBar )
    ENDCASE
        nChoice := BarMenuChoice( hBar )

        DISPBOX(0,0,24,79, BACK_GROUND, cBackGround)
        @ 24,0 CLEAR TO 24, 79
        @ 24, ( 80 - LEN ( cMessg )) /2 SAY cMessg

        CompanyBox(.F.)
        BarActivate( hBar )
        SHOWTIME(0,71,.F.,"W/R+",.T.,.T.)

        nChoice := BarMenuChoice( hBar )

  ENDDO
  CLOSE ALL
  ERASE CALF.NTX
  SET PATH TO
  SHOWTIME()
  RESTSCREEN(0,0,24,79, cScr)
  RETURN NIL

//Program to chart the pedigree information of animals up to the fifth level

#include "INKEY.CH"

FUNCTION chartmaster
```

```
LOCAL REC, TEMPX, TEMP1, TEMP2, TEMP3, TEMP4, TEMP5, TEMP6,
TEMP7, TEMP8, TEMP9, TEMP10, TEMP11, TEMP12, TEMP13, TEMP14,
TEMP15, TEMP16, TEMP17, TEMP18, TEMP19, TEMP20, TEMP21, TEMP22,
TEMP23, TEMP24, TEMP25, TEMP26, TEMP27, TEMP28, TEMP29, TEMP30
SET ESCAPE OFF
SET CURSOR OFF
@1,0 CLEAR TO 21,79
USE FASHOL NEW
        @12,05 SAY "PLEASE WAIT WHILE PROGRAM IS
TRANSFORMING                FILES FOR PEDIGREE CHARTING"
INDEX ON CALFID TO "CALFID.NTX"
CLOSE DATABASES

USE FASHOL NEW EXCLUSIVE ALIAS MASTER
USE FASHOL INDEX CALFID NEW ALIAS SORT1
USE FASHOL INDEX CALFID NEW ALIAS SORT2
USE FASHOL INDEX CALFID NEW ALIAS SORT3

SELECT MASTER
GO TOP

DO WHILE .NOT. EOF()
@1,0 CLEAR TO 21,79
TEMPX := TEMP1 := TEMP2 := TEMP3 := TEMP4 := TEMP5 := TEMP6 := TEMP7
:= TEMP8 :=  TEMP9 := TEMP10 := TEMP11 := TEMP12 := TEMP13 := TEMP14
:= TEMP15 := TEMP16 :=  TEMP17 := TEMP18 := TEMP19 := TEMP20 := TEMP21
:= TEMP22 := TEMP23 := TEMP24 :=  TEMP25 := TEMP26 := TEMP27 := TEMP28
:= TEMP29 := TEMP30 := 0

  @18,20 SAY "PEDIGREE CHARTING IN PROGRESS..........."
  @20,20 SAY "WORKING ON RECORD"
  @20,38 SAY RECNO()
  @20,49 SAY "OF"
  @20,52 SAY LASTREC()

     SET SOFTSEEK ON

     // Parents are found
```

```
        LOCATE FOR MASTER->CALFID <> 0 WHILE (!EOF())
        IF FOUND() .AND. !(DELETED())
              REC = RECNO()
              TEMPX:=MASTER->CALFID
              TEMP1:=MASTER->SIREID
              TEMP2:=MASTER->DAMID
        ENDIF
        .
        .
        .
        .
        ENDDO
RETURN NIL
```

*/ This program converts the Identification Number of the animals to the new format

```
FUNCTION Converter
LOCAL YEAR, MONTH, REC, COUNTS, cScr
cScr := SAVESCREEN(0,0,24,79)
SET ESCAPE OFF
SET CURSOR OFF
    @ 5,5 CLEAR TO 20,75
USE FASHOL NEW ALIAS MASTER
YEAR := MONTH := REC := COUNTS := 0
GO TOP
DO WHILE !(EOF())

@ 5,5 CLEAR TO 20,75

@ 10,20 SAY "LOCATING CALVES AND BEING GIVEN NEW
IDENTIFICATION"


    YEAR = MASTER->CALBYY

    DO WHILE YEAR == MASTER->CALBYY .AND. !(EOF())
```

```
        MONTH = MASTER->CALBMM
        COUNTS = 1

         DO WHILE MONTH == MASTER->CALBMM .AND. !(EOF())
            @12,20 SAY "IDENTIFICATION CHANGE IN PROGRESS........"
            @18,20 SAY "WORKING ON RECORD"
            @18,38 SAY RECNO()
            @18,49 SAY "OF"
            @18,52 SAY LASTREC()

         .
         .
         .
         .
         ENDDO

      ENDDO

RETURN NIL
```

*/ This program converts the Identification Number of the animals (male)

```
FUNCTION Convertmale
LOCAL TEMP1,TEMP2,REC, cScr
cScr := SAVESCREEN(0,0,24,79)
SET ESCAPE OFF
SET CURSOR OFF
@ 5,5 CLEAR TO 20,75

USE FASHOL NEW

@12,15 SAY "PLEASE WAIT WHILE PROGRAM IS TRANSFORMING
DATABASE FILE"

INDEX ON SIRENO TO SIRE
```

```
CLOSE DATABASES

@ 5,5 CLEAR TO 20,75
USE FASHOL NEW ALIAS SORT1
USE FASHOL INDEX SIRE NEW ALIAS SORT2

SELECT SORT1
DO WHILE(!EOF())

@ 10,20 SAY "LOCATING SIRES AND BEING GIVEN NEW IDENTIFICATION"

   @12,20 SAY "IDENTIFICATION CHANGE IN PROGRESS........."
   @18,20 SAY "WORKING ON RECORD"
   @18,38 SAY RECNO()
   @18,49 SAY "OF"
   @18,52 SAY LASTREC()

LOCATE FOR SORT1->CALFSEX=1 WHILE(!EOF())
.
.
.
.
ENDDO
RETURN NIL


*/ This program converts the Identification Number of the animals (female)

FUNCTION Convertfemale
LOCAL TEMP1,TEMP2,REC, cScr
cScr := SAVESCREEN(0,0,24,79)
SET ESCAPE OFF
SET CURSOR OFF
@ 5,5 CLEAR TO 20,75

USE FASHOL NEW
```

```
@12,15 SAY "PLEASE WAIT WHILE PROGRAM IS TRANSFORMING
DATABASE FILE"

INDEX ON DAMNO TO DAM
CLOSE DATABASES

@ 5,5 CLEAR TO 20,75
USE FASHOL NEW ALIAS SORT1
USE FASHOL INDEX DAM NEW ALIAS SORT2

SELECT SORT1
DO WHILE(!EOF())

@ 10,20 SAY "LOCATING DAMS AND BEING GIVEN NEW
IDENTIFICATION"

   @12,20 SAY "IDENTIFICATION CHANGE IN PROGRESS........."
   @18,20 SAY "WORKING ON RECORD"
   @18,38 SAY RECNO()
   @18,49 SAY "OF"
   @18,52 SAY LASTREC()

LOCATE FOR SORT1->CALFSEX=2 WHILE(!EOF())
.
.
.
.
RETURN NIL

// This program draws the pedigree chart of individual animals by record
number


#include "INKEY.CH"

FUNCTION chartbyrec
LOCAL cScr, mANS := " ", mRec := mGET := 0  // These are local variables for
answer and calfid
```

```
SET ESCAPE OFF
SET CURSOR ON
@5,5 CLEAR TO 20,70
USE FASHOL NEW READONLY     // The Fashol.dbf is in use in the read only
mode
 mRec := 0
 mGET := 0
@ 14,23 SAY "Start From What Record : " GET mRec PICTURE "999999"
@ 16,25 SAY "Stop At What Record : " GET mGET PICTURE "999999"
 READ
 @1,0 CLEAR TO 23,79
 DO WHILE mRec > mGET
  .
  .
  .
  .
  .

  ENDDO
  CLEAR GETS
  CLOSE DATABASES
RETURN NIL
```

// This program draws the pedigree chart of individual animal by Calf Id.

```
FUNCTION chartbyid
LOCAL cScr, mANS := " ", mGET := 0  // These are local variables for answer
and calfid
SET ESCAPE OFF
SET CURSOR OFF
 DO WHILE !FILE("CALF.NTX")     // Check if the index file already exist.
 USE FASHOL NEW READONLY       // The Fashol.dbf is in use in the read
only mode
  @5,5 CLEAR TO 20,70
      @12,20 SAY "PLEASE WAIT WHILE DATA IS BEING TRANSFORMED"
      INDEX ON CALFID TO CALF
```

```
CLOSE DATABASES
ENDDO

USE FASHOL INDEX CALF NEW READONLY      // The Fashol.dbf is in use
in the read only mode
@5,5 CLEAR TO 20,70
GO TOP
DO WHILE LASTKEY() != K_F10
.
.
.
ENDDO
RETURN NIL
```