EVALUATION OF THE DAIRY POTENTIAL OF BUNAJI AND BOKOLOJI BREEDS

BY

ADEMOLA OLATUNDE JOHNSON
B.Sc. (Eons) Agric.A.B.U. 1969
M.Sc. Agric. A.B.U. 1974

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of reference.

A. O. Johnson

ADEMOLA O. JOHNSON

4th January 1988

DATE

DEDICATION

This thesis is dedicated to my capable wife Josephone Oyenike JOHNSON for her persistent support, unrelenting endurance and loving inspiration in our married life.

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ABSTRACT

The Study herein reported involves the evaluation of the dairy potential of Bunaji, Bokoloji (Sokoto Gudali) breeds on dairy productive traits in which a total of 3105 records of 761 cows over a period of 24 years were used. The records on birth weight were 3647 for the two breeds. The investigation also included the study on the environmental factors influencing dairy traits and the genetic estimates of the dairy traits.

Results showed that for both breeds, the Chi-squares comparison showed significant differences for both first and all calvings between year and ($P<.0.05$).

The recorded age at first calving were 45.7 months and 46.7 months for Bunaji and Sokoto Gudali breeds. The Calving interval recorded for bunaji and Sokoto Gudali breeds were 13.46 months and 13.45 months.

For the 305-day milk yield results showed that whereas the effects of breed was not significant ($P>0.05$), the effects of year or month of calving as well as parity were all significant ($P<0.001$). The average milk yield for all lactations were 1039 kg and 1055 kg for Bunaji and Sokoto Gudali breeds.

Regarding lactation length, results showed non-significance ($P>0.05$) for effects of breed, but the effects of year and parity were very highly significant ($P<0.001$). and the effects of month of calving was also highly significant ($P<0.003$). The lactation length recorded was 239.2 days and 236.2 days for Bunaji ana sokoto Gudali breeds respectively.

The heritability estimates for age at first calving, calving interval, lactation length, milk yield per day dry period, all lactation milk yield and birth weight varied from 12 to 0.40 and 0.12 to 0.31 respectivly for Bunaji and Sokoto Gudali breeds.

The estimates of genetic progress revealed that the genetic improvement of 0.9% and 0.*5%* per year were obtained respectively for Bunaji and Sokoto Gudali breeds.

Selection for improvement in milk yield indirectly through selection for lactation length showed the least loss in accuracy when selection is made for the top 5% as compared with the top *25%* of the cow population.

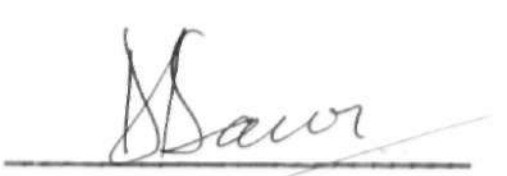
THESIS APPROVAL

We certify that this thesis by Ademola O. JOHNSON meets the regulations governing the award of Doctor of Philosophy of the Ahmadu Bello University, and the conditions of the relevant ordinance and regulations have been fulfilled.

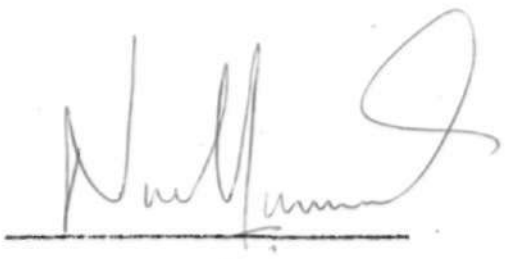
Internal Examiners



DR. N.I. DIM
Department of Animal Science
Ahmadu Bello University
Zaria.



PROFESSOR D.I. SARROR
Dean Postgraduate School
Ahmadu Bello University
Zaria.



PROFESSOR N.N. UMUNNA
Department of Animal Science
Ahmadu Bello University
Zaria.

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INTRODUCTION

The production of milk and milk products in the tropics are grossly inadequate and this has resulted in huge financial investment in importation from temperate countries to sustain the demand for these products. For Nigeria, an overall and sustained improvement of the productivity per animal unit as well as the animal industry in terms of beef and milk has been suggested as a pre-requisite to enhance an attempt to meet both present and future demand for livestock products (F.A.O. 1966). This should involve improvement in the techniques of production, provision of conducive animal environment and the complementary economics of production.

The tropical environment and the genotypes found therein have been faulted for the prevailing apparent poor animal performance. However, where detailed studies have been done on dairy production traits using tropical genotypes, heritability estimates for milk yield have been recorded that parallel or even exceed values reported for temperate genotypes within temperate zone (Galukande, Mahadevan and Black 1962; Robertson, 1950). This situation has been ascribed to either a lack of selection being applied or inconsistent selection pressure being used among the tropical genotypes (Roache, Wellington and Mahadevan, 1970). However, the amount of milk given by the tropical genotypes is apparently low relative to the temperate genotypes and even then the lactation length is also short comparatively.

It would thus appear that the genotypes of tropical environment are slow in achieving improved milk production, given their native environment. As a result, crossbreeding with temperate genotypes has been advocated so as to obtain a higher level of milk production (Foster, 1960). However, an appropriate evaluation of the milk production potential of tropical genotypes should be made, so that optimal improvement in dairy production can be realised from a crossbreeding exercise with exotic genotypes.

The objectives of this study are:

1. Evaluation of the dairy potential of Bunaji and Sokoto Gudali breeds in terms of dairy productive traits.
2. Investigation of the environmental factors influencing the dairy traits.
3. Investigation of the genetic control of the dairy traits by estimation of heritabilities and genetic correlations among the dairy traits.

The merit of an initial evaluation of the inherent dairy potential of tropical genotypes would result in choosing and applying positive co-ordinated, breeding and animal management measures that would accrue in a continuous progress in achieving the desired goal, of increased milk production in the industry.

For any desired improvement in dairy production to be meaningful, a national breeding policy should be evolved based on the knowledge of initial evaluation of potential of dairy genotypes. The adopted breeding techniques measures as well as the suggested improved animal management process

must also be adhered to and co-ordinated nationally and should not be changed erratically or abandoned as this would destroy the dairy industry ultimately.

CHAPTER TWO

LITERATURE REVIEW

2.1. Dairy Production in the tropics

Dairying in the tropics which involves the use of indigenous breeds of cattle is characterised by low milk yield. Even where temperate genotypes have been introduced, the milk productivity has only improved slightly. Constraints to remarkable increase in milk production in the tropics have been attributed to poor genetic base of the indigenous stock, inadequate nutrition, prevailing diseases and the hot humid climate per se. However tropical indigenous cattle have been noted to increase to some extent in body size and performance, i.e. rate of body growth and relatively in milk production when good feeding was employed in addition to minimising the disease challenge in the animal environment. Consequently, significant improvement in dairy productivity in the tropics could be achieved provided the genotype is improved along with improvements in nutrition and supported by disease control measures. On the other hand, a sustained intensive selection within the indigenous stock of cattle that is given a regular good feeding in an environment where the disease situation is considerably reduced could also result in substantial increase in dairy performance productivity.

In appraising dairy produc[illegible] the tropics, it is very vital to examine closely [illegible] found in tropical environment by investigating their adaptability to the environment especially, the prevailing disease condition and their potential for economic milk production as well as the constraints to overall profitable milk productivity.

2.2. Indigenous breeds of cattle in the tropics

The indigenous breeds of cattle in the tropics, especially in the African continent which includes, the west, east, south and North Africa can broadly be classified as humped or zebu cattle and humpless cattle. Each group can further be divided into the long-horned and short-horned breeds respectively (Shaw and Colville, 1950). A cross between dwarf shorthorn and zebu has been classified as Sanga breed and it is into this breed that Mason and Maule (1960) classified the Africander and Nguni cattle found in South Africa. A schematic diagram of the classification of indigenous breeds of cattle found in the tropics of Africa is given in Fig. 1. In body size, these breeds of cattle ranged from the small framed Ndama, Muturu, the small zebu of somaliland and the small East African zebu and also the Nguni of South Africa to the relatively large framed Bunaji, Gudali, Wadara, the Boran and Ankole of East Africa and the Africander of South Africa.

2.2.1. Adaptability to climate and diseases

The breeds of cattle indigenous to the tropics are heat-tolerant, but the climatic stress which is caused by air temperature, solar radiation and humidity could partly be responsible for the low productivity of these animals. [illegible] temperature above which cattle begin to have [illegible] normal body temperature is known as [illegible] temperatures. The normal body temperature of a cow is reported to be between 37.8° and 38.9°C, while the confort [illegible] for respiratory rate is between 20 and 50 per minute [illegible]

(Ittner et al., 1954). The critical temperature for temperate cattle ranges from 23.9° to 26.7°C, while that for Brahman cattle is between 32.2°C and 35°C (Regan and Richardson, 1938; Ragsdale et al., 1948; and Kibler and Brody, 1950). Humidity has been reported not to have a harmful effect on dairy cattle by Seath and Miller (1945), and work done at Puerto Rico by Arrilaga et al. (1952) also supported this view, although the authors pointed out that humidity affected beef breeds; however, Kibler and Brody (1953) indicated that changes in humidity at temperature below 23.9°C have little effect on the dairy cattle, and that at higher temperatures changes in humidity raised body temperature and respiration rates. Thus the climatic stress to which indigenous breeds of tropical cattle are tolerant may be responsible for the comparative reduction of food consumption and the inevitable resultant decrease in beef and milk production. The adaptation of the indigenous breeds of cattle in the tropics is clearly due to their having a higher heat-tolerance than the temperate cattle breeds, and body temperature is one way of checking heat tolerance (Rhoad, 1944). Work done in the tropical environment of South Africa (Bonsma and Pretorius, 1943) have shown that shorthorned cattle have a lower body temperature and [illegible] coloured cattle reflect more solar heat than those with dark hair.

INDIGENOUS BREEDS OF CATTLE
IN TROPICS OF AFRICA

HUMPED OR ZEBU CATTLE

1. Boran
2. North Sudan Zebu
3. Madagascar Zebu
4. Small Zebu of Somaliland
5. Small ;ast African Zebu

LONGHORNED BREEDS	SHORTHORNED BREEDS	INTERMEDIATE
1. Rahaji (Red Fulani)	1. Gudali	(Humped x Humpless)
2. Bunaji (White Fulani)	2. Wadara	1. Ngenda spp.
		2. Arado
		3. Dwarf Shorthorn x Zebu-SANGA
		a. Ankole
		b. Tswana
		c. Africander
		d. Angolan
		e. Nguni

HUMPLESS CAT E

LONGHORED BREEDS
1. Kuri or Chad

S ORTHORNED BREEDS
1 Muturu or Dwarf Shorthorned.
2 dama
teku

Source: Cates (1952)
Mason and Maule (1960)

Fig. 1: Indigenous breeds of cattle in tropics of Africa.

As such heat dissipation could be difficult unless animals in the tropics, especially the humid parts, possess a large skin area per unit weight. These features are found in the small Nguni breed of South Africa (Ittner et al., 1958). Undoubtedly these characteristics are possessed by most breeds of indigenous tropical cattle to some extent by virtue of their adaptation to the tropical environment, although this adaptation may be at the expense of their milk and beef productivity. The adverse effects of a hot environment on livestock are more pronounced than those of a cold environment. Various studies have shown the depressive effects of heat on livestock, with the dairy cattle at Missouri, U.S.A. (Ragsdale et al., 1948) and at California, (Regan and Richardson, 1938) and with beef cattle at EL Centro which is in the desert valley region of California (Ittner and Kelly, 1951). However, McIntyre (1967) reported that under the Australian conditions, milk yield was neither affected by temperature nor by humidity. On the other hand, Brown et al (1960) had earlier noted that monthly milk yield differences was inversely related to temperature. Negative correlations between daily milk yield and average daily temperature above 15.6°C have also been recorded by Sims and Porter (1966) and similarly by Calvano (1967). The results of Conrad et al (1964) showed that growth and especially milk yield tended to be reduced under heat stress. This finding is supported by the reports of Dodd (1957) and Kleiber (1961) which associated reduced productivity to depression in feed intake as a result of

increased heat load on the animals. It is apparent therefore that temperature and humidity have depressing effects on animal productivity, especially milk yield.

Indigenous breeds of cattle are also tolerant to diseases, internal and external parasites and vectors. The prevailing high temperatures and high relative humidity favour the development of both internal and external parasites as well as vectors. Whereas internal parasites are mainly a problem of wet tropical regions, they constitute less problems in the dry tropical zones. However, external parasites are an important factor in the health of farm animals in both wet and dry tropical regions (Min. Agric. Holland, 1972). Flies and ticks in particular cause irritation to the animals while also some of these flies and ticks transmit infectious diseases. Where sufficient rainfall supports dense undergrowth and forests, the presence of disease-bearing organism is perpetuated by the presence especially of tse-tse fly (Glossina spp) which can render cattle production less economic. The tropical breeds of cattle however, are moderately tolerant to this prevailing disease and parasitic environment. Even then some of the humpless breeds of cattle such as Ndama, Muturu and Keteku are more tolerant to trypanosomiasis and piroplasmosis, exhibiting thriftiness in the dry season as well as ability to endure high parasitic build up during the wet season as compared with other humped breeds of tropical cattle (Touchberry, 1967). Foster (1960) reported that the incidence of disease in the Shika herd had considerable effect on

decreasing the herd number and thus upsetting the genetic virtues. Calf mortality was reported to cause losses of many calves, while rinderpest outbreak resulted in losses in calves in poor condition. Contagious abortion in the Shika herd, helminthiases and trypanosomiasis caused appreciable reduction in animal numbers (Nigeria, Agric. Dept. 1948a, 1953, Government Printer, Lagos, Cited by Foster, 1960). The general condition of the cattle in the tropics are depressed by these diseases and parasites, but their adaptation to the prevailing conditions although accompanied by relatively low productivity in terms of meat and milk emphasises the adaptive nature of the breeds.

2.2.2. Dairy potential and limitations

Although the milk production capacity of the breeds of indigenous cattle in the tropics is generally low relative to the temperate cattle, a considerable milk yield potential is possible if specific constraints can be removed. Mahadevan (1966) reported that the milk yield of indigenous tropical cattle varies with the prevailing climatic and environmental conditions. As such, the climate and associated factors in most parts of Africa, especially nutrition, disease challenge and parasite environment favour the use of germ plasm with varying component of tropical cattle that can adapt to the environment stresses to achieve desirable increases in milk production (Trail and Gregory, 1981). Whereas, the climatic environment per se can only be modified to a limited extent, substantial improvement can be made both in the quantity and quality of forages availability and total nutrition

provision as well as control of specific diseases and parasites that would result in optimal milk production. The dairy potential of the indigenous breeds of cattle can also be enhanced by employing a breeding programme that is in consonance with the tropical environment and the prevailing economics of production.

Among the limitations to economic dairy producitivity of indigenous breeds of tropical cattle is the migratory nature of the cattle herds which does not allow for proper evaluation of the milk yield potential of the cows; the requirement of calf at foot to induce milking cows to let down milk and the small sizes of dairy herds that does not allow adequate evaluation of milk producing capacity of cows for genetic improvement to be achieved. Where crossbreeding programmes involving indigenous breeds of cattle and high producing sub-tropical breeds or temperate breeds have been undertaken, the resulting high producing progeny have to be sustained by provision of adequate nutritional environment as well as good management and a drastic control of the diseases and parasites so that the productivity of the resulting cows can be realised. There are other factors that limit the optimal milk yield of indigenous breeds of cattle.

2.2.2.1. Late age at first calving

Late first calving is common in most breeds of tropical cattle. Late age at first calving and long calving interval are the two most important traits that contribute to the

unproductive life of these cattle. To improve economic dairy production per se in the tropics, a reduction in age at first calving is necessary. Decreasing the age at first calving, would apart from reducing the animals unproductive life, also reduce the generation interval which would result in an increase in the rate of genetic progress, whilst also making progeny testing of sires more feasible. Judging by the current age at first calving of the tropical African breeds of cattle, the time when progeny test information is obtained will be so late as to make most of the sires unsatisfactory for service due to old age.

A trend of the age at first calving of some breeds of tropical African cattle can be obtained from Table 2:1. The average age at first calving ranges between 34 and 67 months.

Table 2:1. Age at first calving of some tropical African breeds of cattle

Breed	No. of records	Average age (months)	References
Ankole	153	51.3	Sacker and Trail (1966)
Arsi	62	34.4	Kiwuwa et al. (1983)
Azaouk	32	37.0±5.1	Wheat (1972)
Baggara	135	66.7±13.0	Osman (1970)
Boran	157	40.7±13.6	Trail and Gregory (1981)
Maure	71	42.3	ILCA (1978)
Ndama	231	39.4	Touchberry (1967)
Northern Sudan) Shorthorn zebu)	315	44.0	Osman and EL Amin (1971)
Northern Sudan) Shorthorn zebu)	241	44.2±6.4	Osman (1970)
Zebu	112	51.7	Sacker and Trail (1966)
Shorthorn zebu	100	42.0	Marples (1964)
Wadara	103	52.4±6.6	Wheat (1975)
Sokoto Gudali	75	40.8±9.8	Wheat and Broadhurst (1972)
Sokoto Gudali	34	43.4±7.7	Wheat and Broadhurst (1972)
Bunaji	433	41.8±10.1	Wheat et al. (1972)
Bunaji	46	42.0±8.0	Wheat and Broadhurst (1968)
Boran	418	36.4±0.4	Trail et al. (1984)
Kenana	85	38.4	Alim (1960)
East African Zebu	568	42.7	Galukande et al. (1962)

2.2.2.2. Long calving interval

Long calving interval is characteristic of most tropical breeds of cattle. The economics of dairying in the tropics can be improved by reducing the calving interval. This will reduce the unproductive life of the breeds of cattle and enhance the rate of genetic progress by decreasing the generation interval. With the present calving interval, progeny tested bulls would be too old to be of use for breeding service.

A summary of the calving interval of some breeds of tropical African cattle is shown in Table 2:2. The mean calving interval ranges between 11 and 18 months. For Bunaji cattle, Wheat and Broadhurst. (1968, 1972) recorded average calving interval of 11 to 15 months, while for Sokoto Gudali cattle, Wheat et al. (1972) obtained mean calving interval of 15 to 17 months.

2.2.2.3. Short lactation

African breeds of cattle are noted for their short lactation production. As the duration of lactation probably exerts more effect on milk yield than any other factor because of the significant positive correlation between milk yield and length of lactation (Mahadevan, 1956; Asker et al., 1965), the short lactation of indigenous African breeds of cattle inevitably results in an overall low milk production. As such to improve the overall milk yield of indigenous tropical breeds of cattle, the duration of lactation must be appreciably increased.

Among indigenous African breeds of cattle, temperament which is associated with milk letdown interference could result in short lactations because of nervous instability during milking of the animals. However, milk letdown refusal resulting in short lactation is not fully understood and needs investigation. While some workers exclude short lactation milk yields because of milk letdown interference, other workers argued for inclusion on the basis that the phenomenon is breed characteristic (Kiwuwa et al., 1983). In a study which involved examination of data and conditions under which certain indigenous African breeds of cattle displayed apparent milk letdown interference, Kiwuwa et al. (1983) concluded that lactations in which peak yields were reached (generally peak attained between 21 and 60 days) and later concluded by the cows themselves should be regarded as normal records provided no extraneous factors caused cessation of milk yield.

2.2.2.4. Low milk yield under good nutrition

The low milk yield of indigenous breeds of African cattle has been attributed among other factors to inadequate good nutrition. However on the prospect for increased output, Miller (1961) referred to the studies carried out by Rains and Simpson (Unpublished) on the effect of level of supplementary feeding on milk production which indicated that for practical purposes, the Zebu cattle do not respond on a scale which justified heavy concentrate feeding. In an

investigation involving thirty-two Bunaji cattle divided into two groups of 16 cows each, supplemented and unsupplemented respectively with concentrate ration, Olaloku and Oyenuga (1976) reported positive and significant correlations between dry matter intake, dry organic matter intake, organic matter intake and milk yield. The workers contended that the digestibility of the organic matter of the feeds consumed by the Bunaji cows used in their study was generally below the range considered necessary to promote maximum voluntary intake. They further stated that although the correlations between milk yield and the feed intake, especially the digestible organic matter intake would tend to suggest the possibility of increased milk yield by the Bunaji cattle through use of more digestible feed, it was doubtful whether any of the regression equations were sufficiently precise to be useful for the prediction of the feed intake or the requirements for animal production of the breed. They suggested the need for further investigation of the factors involved in the intake and utilisation of feed for milk production of the Bunaji cattle using more animals. On the apparent correlations between feed intake and milk yield, Crampling (1966) suggested that the correlated response which implies response to indirect selection, may be due to the rationing of concentrates according to yield as well as the energy relationship. Similarly, Curran and Holmes (1970) reported that the significant milk yield term was not entirely due to correlations

with concentrate feeding. Consequently, it is evident that African indigenous breeds of cattle may produce low milk yield even under good concentrate nutrition.

2.2.3. Previous selection efforts and results

When observable phenotypic variability in economic traits in cattle is not entirely environmental, part of this variability has heritable prospects and selection can be applied to improve productivity in the economic traits per se. However, Mahadevan (1965) reported that from the available information and the results obtained, selective breeding for increase in milk production within the indigenous cattle of East Africa has failed to produce any worthwhile response. This is because low selection pressure was applied, resulting in low selection differential, uneconomic dairy returns in the attempt to increase milk production of the animal stock. As the East African cattle used did not possess the genetic potential for increased milk yield, an infusion of the temperate germ plasm would have created the required genetic variability that selective breeding would draw upon to achieve the desired increase in milk production. Working with the Bunaji and Sokoto Gudali breeds of cattle, Foster (1960) reported that on the basis of selective breeding carried out on the two breeds over twenty-four years, the annual genetic improvement in lactation milk yield was about 1.5% for each of the breed.

It is pertinent to note that Foster (1960) reported that line-breeding within each breed was practised most of the time, and this led to some amount of inbreeding within the respective breeds and this situation was thereafter corrected by outcrossing within each breed. However, the report of Robertson (1950) on the Bunaji cattle covering a period of 25 years also showed that the annual genetic improvement in milk yield was two percent. This genetic progress of two percent in milk production in both the Bunaji and Sokoto Gudali cattle is comparable to the genetic response of one to two and a half percent annual genetic progress in the temperate breeds of cattle (Johansson and Rendel, 1968), although the level of milk production in the tropical breeds of cattle is less than that of temperate breeds of cattle. It is possible that desired environmental factors especially nutritional and overall management that would support optimal genetic expression for economic production may be lacking.

2.3. Parameters of dairy production and their significance

The parameters influencing dairy production can be classified as:

1. Reproduction performance
2. Lactational performance

2.3.1. Reproduction performance

The factors influencing reproduction performance in dairy animal.

2.3.1.1. Age at first calving

The age at first calving is the age of the cow when her first calf is born. This, in addition to calving interval are two important traits that affect the rate of genetic progress in improving dairy productivity. The productive life of dairy cows can be increased by reducing the age at which the cows calve for the first time. This has the effect also of decreasing the unproductive life of the cows, reducing the otherwise long generation interval, while rapid genetic progress would be achieved in the process. From the literature, the mean age at first calving for indigenous African breeds of cattle ranges between 34 and 67 months (Table 2:1). Johansson and Rendel (1968) reported that there was a linear relationship between the age at first calving (within 23 and 38 months) and milk yield in the first lactation for the Swedish Red and White heifers but that the relationship was curvilinear for age interval between 20 and 49 months. Thus when the age at first calving exceeds about three years, there is no further increase in milk yield for the increase in age at calving. Osman (1970) reported that age at first calving did not affect average daily milk yield in the Northern Sudan Zebu cattle.

2.3.1.2. Calving interval

Calving interval is the period between the birth of cows' two consecutive calves. Calving interval along with the age at first calving is a most important contributor

to the observed unproductive life of tropical indigenous breeds of cattle. A reduction in the interval between successive calvings as well as a decrease in the age at first calving will increase the total productive life of dairy cows and will also achieve appreciable genetic progress in milk productivity of cows. A search through the literature indicated that the mean calving interval for some indigenous breeds of tropical cattle ranges between 11 and 18 months (Table 2:2). Johansson and Rendel (1968) suggested that acceptable value lies between 12 and 14 months.

Calving interval can be subdivided into two parts namely, the service period - which is from calving to the next conception, and the gestation period. The small differences usually observed in gestation lenth are partly hereditary as evidenced by the significant breed differences for the trait. National Council Zambia (1970) reported on the gestation length of Angoni, Africander and Mashona breeds of cattle in Zambia, with comparable values of 285.9±13.2 days and 286.5±12.4 days for Angoni and Mashona breeds while the Africander cattle had gestation length of 297.5±11.5 days. In the same study, the Africander cattle had significantly longer calving interval of 425.7±130.9 days compared with 379.0±85.8 days and 387.8±113.6 days respectively for Angoni and Mashona breeds. Asker et al. (1965) reported calving interval of 397 days for Iraq zebu, and also reported a service period of 103 days for the same cattle. Since service period and calving interval would be highly correlated for biological reasons, the effect of both on milk yield should

be comparable, especially where the average service period is long. Calving interval can also be subdivided into lactating period and the dry period (ILCA, 1978). A short calving interval will lead to a lower milk yield in both the current and the succeeding lactation, while a long calving interval operates in the opposite direction. A short calving interval also leaves little allowance for a long dry period. Milk yield is influenced both by the preceeding calving interval and the number of days pregnant during the current lactation (Mason and Buvanendran, 1982). As the relationship between length of calving interval and milk yield is curvilinear, regression using linear and quadratic terms should be used to estimate the correction factors.

2.3.2. Lactational performance

Different measures have been adopted for estimating milk yield.

2.3.2.1. Milk yield at 305 days

Milk yield during the first 305 days or less (depending on when the animal was dried after calving) has been internationally accepted as a standard period to measure milk production of dairy animals. However, as progeny testing of bulls can be carried out as early as possible in their life-time, other shorter periods such as 70, 100, 180, 200 and 300 days have been tested with satisfactory results. However, the heritability of milk production in the first 305 days was highest for first lactation exotic heifers, the

Table 2:2. Calving interval of some tropical African breeds of cattle

Breed	Number of records	Average calving interval (months)		References
Ankole	153	11.4	(all calving interval)	Sacker and Trail (1966)
Arsi	202	14.6	(all calving interval)	Kiwuwa et al (1983)
Azaouk	39	15.3±0.4	(first calving interval)	Wheat (1972)
Azaouk	128	14.5±1.7	(all calving interval)	Wheat (1972)
Boran	498	13.7±0.3	(all calving interval)	Trail and Gregory (1981)
Maure	71	16.3	(first calving interval)	ILCA (1978)
Maure	225	15.7	(all calving interval)	ILCA (1978)
Peul	27	16.3	(first calving interval)	ILCA (1978)
Peul	216	15.8	(all calving interval)	ILCA (1978)
Ndama	111	15.2±0.4	(all calving interval)	Sada (1968)
Ndama	926	15.6	(all calving interval)	Touchberry (1967)
West African Shorthorn Zebu)	99	14.8±0.5	(all calving interval)	Sada (1968)
Northern Sudan) Shorthorn zebu)	1084	14.3	(all calving interval)	Osman and EL Amin (1971)
Boran	647	14.0±0.2	(all calving interval)	Trail et al (1984)
Iraq zebu	121	13.2	(all calving interval)	Asker et al (1965)

Table 2:2 (Continued)

Breed	Number of records	Average calving interval (months)		References
Zebu	112	11.6	(all calving interval)	Sacker and Trail (1966)
Zebu	94	15.0	(all calving interval)	Kiwuwa et al (1983)
Shorthorn zebu	100	13.1	(all calving interval)	Marples (1964)
Rahaji	62	19.1±0.5	(first calving interval)	Wheat (1972)
Rahaji	92	17.9±0.5	(all calving interval)	Wheat (1972)
Wadara	176	18.8±0.4	(first calving interval)	Wheat (1975)
Wadara	82	15.1±0.4	(first calving interval)	Wheat (1975)
Wadara	309	17.8±0.3	(all calving interval)	Wheat (1975)
Wadara	188	14.8±0.3	(all calving interval)	Wheat (1975)
Bunaji	385	13.6±0.2	(first calving interval)	Wheat et al (1972)
Bunaji	44	13.1±0.4	(first calving interval)	Wheat and Broadhurst (1968)
Bunaji	36	15.0±0.7	(first calving interval)	Wheat and Broadhurst (1968)
Boran	540	13.7±0.7	(all calving interval)	Gregory et al (1984)
Bunaji	1336	13.7±0.1	(all calving interval)	Wheat et al (1972)
Bunaji	129	11.3±0.2	(all calving interval)	Wheat and Broadhurst (1968)
Bunaji	101	14.5±0.4	(all calving interval)	Wheat and Broadhurst (1968)
Sokoto Gudali	60	15.6±0.6	(all calving interval)	Sada (1968)
Sokoto Gudali	132	14.6±0.4	(all calving interval)	Wheat and Broadhurst (1972)

Table 2:2 (Continued)

Breed	Number of records	Average calving interval (months)		References
Sokoto Gudali	85	16.5±0.5	(all calving interval)	Wheat and Broadhurst (1972)
Sokoto Gudali	46	15.3±0.4	(first calving interval)	Wheat and Broadhurst (1972)
Sokoto Gudali	31	16.9±0.9	(first calving interval)	Wheat and Broadhurst (1972)
Bunaji	374	12.2	(all calving interval)	Knudsen and Sohael (1970)
Angoni	-	13.3±2.8	(all calving interval)	National Council for Scientific Research, Zambia (1970)
Africander	-	14.2±4.4	(all calving interval)	
Mashona	-	12.9±3.8	(all calving interval)	
East African Zebu	568	12.2	(all calving interval)	Galukande et al. (1962)

value was 0.43 (Johansson and Rendel, 1968). Tropical, especially, African breeds of cattle are known for their low milk production. The average 305-day milk yield of some breeds of African cattle in their first and subsequent lactations are given in Table 2:3. The mean milk yield for the first lactation in most of the breeds ranges from 603 to 1303 kg, while the averages for all lactations varies from 616 to 2088 kg. It is thus apparent that the average 305-day milk yield for the first lactation reflects the production trend since the increase between the first lactation and the lactation of maximum milk yield in tropical cattle is relatively small.

2.3.2.2. Total milk yield

This is the milk production in a complete lactation, and is controlled by the genetic capacity of the animal and duration of milk yield. While most of the tropical breeds of cattle produce milk yield for a period less than 300 days, some tropical cattle however give milk yield whose period of production is more than 305 days. For the total milk yield given in less than 305 days, there usually is no adjustment of milk yield for lactation length as the production represents the genetic impulse of the animal concerned. However, the total milk yield produced over a period greater than 305 days is conventionally truncated to a uniform 305 days so that a comparison of milk productivity of cows can be made over a constant period.

Since the calving interval is composed of lactation length and dry period, a total milk yield produced in a relatively long period would underline a short dry period for the animal or a longer than usual calving interval between the present and the following calving.

Total milk yield of a cow is influenced by the average daily milk yield, persistency and duration of lactation.

2.3.2.2.1. Average daily milk yield

The average daily milk yield is the mean of the total amount of milk produced over a full lactation. The average daily milk yield is important because the peak average daily milk yield is closely associated with the total lactation milk yield especially when part lactation milk yield is used to estimate total milk yield of cows (Johansson, 1961). The average daily milk yield of some indigenous African breeds of cattle is presented in Table 2.4. The average daily yield ranges between 1.5 and 5.7 kg per day.

2.3.2.2.2. Persistency of milk yield

Persistency is the monthly milk yield divided by the previous month's milk yield expressed as a percentage. The significance of persistency of milk yield lies in the indication of the probable sustained or declining level of milk yield as the lactation milk yield progressed.

Table 2.3. Average 305-day milk production of some tropical breeds of cattle

Breed	No. of records	Average yield (kg)	References
Ankole	153	754.5 (first lactation)	Sacker and Trail (1966)
Zebu	112	603.0 (first lactation)	" " " "
Ankole	153	883.0 (Subsequent lact)	" " " "
Zebu	112	615.6 (Subsequent lact)	" " " "
East African zebu	152	911.0 (all lactations)	Kiwuwa (1973)
East African zebu	175	1303.0 (first lactation)	Kiwuwa (1973)
East African zebu	278	1294. (all lactations)	Kiwuwa (1973)
Shorthorn zebu	100	952.5 (all lactations)	Marples (1984)
Iraq zebu	99	1027 (all lactations)	Asker et al. (1965)
Bunaji	573	1047.0 (first lactation)	Johnson et al (1984)
Sokoto Gudali	315	1115.8 (first lactation)	" " " "
Bunaji	573	1069 (all lactations)	" " " "
Sokoto Gudali	315	1143.8 (all lactations)	" " " "
Bunaji	159	789.5 (all lactations)	Foster (1960)
Wadara	419	862.6 (all lactations)	Colonial Advisory Council (1957)
Northern Sudan Shorthorn zebu	743	2088.0 (all lactations)	Osman and EL Amin (1971)
Bunaji	55	775.4 (first lactation)	Knudsen and Sohael (1970)
Bunaji	374	837.0 (all lactations)	" " " (1970)
Maure	225	586.0 (all lactations)	ILCA (1978)
Peul	216	522.0 (all lactations)	ILCA (1978)
Kenana	84	479.9 (first lactation)	Alim (1960)

Table 2.3 (Continued)

Breed	No. of records	Average yield (kg)	References
Kenana	293	696.2 (all lactations)	Alim (1960)
White Nile	117	1405.4 (all lactations)	Boyns (1947)
Kenana	66	1555.2 (all lactations)	Boyns (1947)
Dongola	57	1187.8 (all lactations)	" "
Shorthorn zebu	100	354.2 (first lactation)	Marples (1964)
East African zebu	568	317.0 (all lactations)	Galukande et al (1962)

Table 2.4. Average daily milk yield (kg) of some tropical breeds of cattle

Breed	Number of records	Average daily milk yield (kg)	References
Arsi	233	2.7	Kiwuwa et al (1983)
Zebu	104	2.8	Kiwuwa et al (1983)
Bunaji and Sokoto Gudali	16	2.8	Miller (1961)
Wadara	419	3.4	Colonial Advisory Council, U.K. (1957)
Bunaji	737	2.6	Foster (1960)
Bunaji	374	3.4	Knudsen and Sohael (1970)
Nguni	122	1.5	Brown (1961)
Dongola	57	5.6	Boyns (1947)
White Nile	117	5.4	Boyns (1947)
Kenana	66	5.7	Boyns (1947)
Nganda	100	3.8	Mahadevan and Marples (1961)
Bunaji	573	4.2	Johnson et al (1984)
Sokoto Gudali	315	4.3	" " " "
East African zebu	163	4.6	Kiwuwa (1973)
East African zebu	152	3.6	Kiwuwa (1973)
East African zebu	278	4.7	Kiwuwa (1973)

Lactation length represents the number of days in milk production and is an important factor that determines the total milk yield. Of these factors influencing the total milk yield, the duration of lactation probably exerts more effect on total milk yield because of the highly significant correlation and regression between milk yield and length of lactation (Mahadevan, 1956; Asker et al., 1965). The average total milk yield of some tropical breeds of cattle over a period greater than 305 days is presented in Table 2.5. The total milk yield for the breeds of cattle ranges between 809 and 1766 kg. The average for the Bunaji and Sokoto Gudali cattle reported by Foster (1960) ranged from 1578 to 1766 kg.

Table 2.5. Average total milk yield of some tropical breeds of cattle

Breed	Number of records	Average yield (kg)	References
Arsi	233	809.0	Kiwuwa et al (1983)
Zebu	104	929.0	Kiwuwa et al (1983)
Bunaji	124	1578.1	Foster (1960)
Sokoto Gudali	50	1766.5	Foster (1960)

2.3.2.3. Lactation length

This is the number of days in milk production from the calving to the termination of lactation. Tropical breeds of cattle manifest short lactation lengths which appear to have a genetic basis.

As calf death can result in short lactations in zebu cattle that have a strong maternal instinct, correction of milk yield for calf mortality would seem desirable. However, an upward bias may be introduced especially in animals having a low impulse for lactation length (Mason and Buvanendran, 1982). Sacker and Trail (1966) reported that lactation length exerts a considerable influence on milk yield. Conventionally, the milk yield over a period of 305 days from calving irrespective of the length of lactation is used for purposes of uniform comparison. However, where animals have potential for milk yield of less than 305 days, the milk production recorded is not adjusted for short lactation. The average lactation length of some breeds of tropical cattle is given in Table 2.6. The mean lactation length for the breeds ranges from 220 to 261 days for first lactation, while the range was 143 to 294 days for all lactations. The manifestation of short lactation by the indigenous breeds of cattle is apparent from the values recorded in the literature. The prospect of low milk yield by indigenous breeds of cattle would thus be expected since the lactation length exerts a considerable influence on the milk yield in a lactation. Johansson and Rendel (1968) reported that for temperate breeds of cattle, the length of lactation period is highly dependent on how soon the cow becomes pregnant again after calving.

Table 2.6. Average lactation length of some tropical breeds of cattle.

Breed	No. of records	Average/lactation length (days)	References
Ankole	153	238.0 (Subsequent lactations)	Sacker and Trail (1966)
Zebu	112	226.0 "	" " " "
Ankole	152	243.0 (First lact.)	" " " "
Zebu	112	244.0 "	" " " "
Lucerne	11012	256.0 (all lact.)	Stonaker and Knapp (1974)
East African Zebu	257	261.0 (First lact.)	Kiwuwa et al (1983)
Shorthorn zebu	100	259.0 (all lact.)	Marples (1964)
Bunaji	191	220.0 (First lact.)	Johnson et al (1984)
Sokoto Gudali	105	229.0 (First lact.)	" " " "
Bunaji	573	255.0 (all lact.)	" " " "
Sokoto Gudali	315	266.0 (all lacts.)	" " " "
Iraq zebu	99	219.0 (all lacts.)	Asker et al (1965)
Maure	255	249.0 (all lacts.)	ILCA (1978)
Peul	216	258.0 (all lacts.)	" "
East African zebu	66	143.0 (all lacts.)	Trail and Gregory (1981)
Wadara	419	251.0 (all lacts.)	Colonial Advisory Council (1957)
Bunaji	737	250.0 (all lacts.)	Foster (1960)
Northern Sudan) Shorthorn zebu)	1001	294.0 (all lacts.)	Osman and EL Amin (1971)
Bunaji	374	246.0 (all lacts.)	Knudsen and Sohael (1970)
East African zebu	568	239.0 (all lact.)	Galukande et al (1962)
White Nile	117	259.0 (all lact.)	Boyns (1947)
Kenana	66	270.5 (all lact.)	Boyns (1947)
Dongola	57	222.5 (all lact.)	Boyns (1947)

2.3.2.4. Yield per day of calving interval

From the economics of milk production, it is the average daily milk yield during the calving interval that is important (Johansson and Rendel, 1968). Milk yield per day of calving interval is the total lactation milk yield divided by the calving interval (days) and this is expressed as kg per day of calving interval. Thus in assessing the milk yield of individual cow's production, consideration should be given to calving interval. That is why the yield per day of calving interval is important, for a longer calving interval would result in a lower milk yield per day of calving interval. As such, the reproductive capacity as indicated by the relative short calving interval and the milk producing capacity of an animal are reflected in the milk yield per day of calving interval. The average milk yield per day of calving interval of some breeds of tropical cattle is presented in Table 2.7. The average yield per day of calving interval ranges from 1.10 to 4.87 kg/day.

2.3.2.5. Dry period

This is the period of rest between the current lactation milk production and the start of the following lactation. Dry period allows for a satisfactory development of the developing calf in its later part of gestation just before calving and also promotes an appreciable milk yield in the next lactation period. A relatively shorter dry period would result in a comparable lower milk yield in the following lactation.

Johansson and Rendel (1968) reported in the temperate breed of cattle, that the length of dry period is a measure of the cow's persistency for milk production during the lactation, where other factors enhancing good milk production are prevailing. The average dry period for some tropical breeds of cattle is shown in Table 2.8. It ranges from 97 to 222 days.

Table 2.7. Average milk yield per day of calving interval for some tropical breeds of cattle

Breed	No. of records	Yield per day of calving interval (kg/day)	References
Arsi	149	1.34	Kiwuwa et al (1983)
Zebu	90	2.10	Kiwuwa et al (1983)
Ankele	153	2.58	Sacker and Trail (1966)
Zebu	112	1.77	Sacker and Trail (1966)
Shorthorn zebu	100	2.42	Marples (1964)
Iraq zebu	99	2.59	Asker et al (1965)
Northern Sudan) Shorthorn zebu)	743	4.87	Osman and EL Amin (1971)
Bunaji	374	2.29	Knudsen and Sohael (1970)
Maure	225	1.25	ILCA (1978)
Peul	216	1.10	ILCA (1978)
East African zebu	568	0.88	Galukande et al (1962)

Table 2.8. Average dry period (days) for some breeds of tropical cattle.

Breed	No. of records	Average dry period (days)	References
Ankole	153	97.0	Sacker and Trail (1966)
Zebu	112	106.0	Sacker and Trail (1966)
Shorthorn zebu	100	134.0	Marples (1964)
Iraq zebu	93	182.0	Asker et al (1965)
Maure	225	222.0	ILCA (1978)
Peul	216	216.0	ILCA (1978)
Arsi	152	165.0	Kiwuwa et al (1983)
Zebu	92	154.0	Kiwuwa et al (1983)
Northern Sudan) Shorthorn zebu)	854	114.0	Osman and EL Amin (1971)
East African zebu	568	123.0	Galukande et al (1962)

2.4. Environmental factors affecting different traitS

The environmental factors which affect different traits in dairy production includes:

2.4.1. Year of calving

Year of calving has been noted to influence some of the traits that determine the total milk production of dairy cattle, Osman (1970) reported significant effects of year of calving on the average daily milk yield of zebu cattle in Sudan over a period of 26 years. The year effects was recorded to contribute about 6% of the variation of the milk yield by the author.

The year effects was suggested to reflect possible changes in the genetic make up among the animals, changes in feeding regime, general management as well as the climatic conditions that contribute to the animals herd environment. However, continuous selection practised in the herd for increase milk production and possible introduction of inbreeding could have also contributed to the effects of year of cavling. Kiwuwa et al (1983) reported significant effects of year of calving on the calving interval of Arsi and Zebu breeds of cattle in East Africa over a period of eight years. The effects of year of calving on calving interval underlined an increase of 13 days per year in the calving interval over the study period. However, Johnson et al (1984) recorded that the year of calving had no significant effects on milking yield, lactation length and calving interval for both Bunaji and Sokoto Gudali cattle over a three year study. Similarly, ILCA (1978) reported no significant effects of year of calving on lactation yield and daily milk yield among Peul and Maure cattle in East Africa. On the contrary, Kiwuwa et al (1983) recorded significant effects of year of calving on lactation yield, lactation length and yield per day as well as dry period for Arsi and Zebu breeds of cattle in East Africa. This is supported by the report of Trail and Gregory (1981) who reported that year of calving had significant effects on the lactation milk yield of East African Zebu cattle. Also ILCA (1978) reported significant effects of year of calving on calving interval for Peul and Maure cattle.

Thus, since environmental conditions are not constant yearly, these changes can cause observable influence of year of calving on the production traits of dairy cattle.

2.4.2. Month of calving/season of calving

As the amount of herbage available to lactating cows varies from one month to another due to differing water precipitation, month of calving or season of calving may affect dairy animal productivity. Osman (1970) reported no significant effects of month of calving on daily milk yield of Sudan Zebu cows, under a management where cows calve throughout the year. He suggested that this situation was due to a relatively constant feed supply throughout the year. The author also reported that the month of calving contributed less than 3% of the variation in milk yield. However, ILCA (1978) reported significant effects of month of calving on lactation yield and yield per day of calving interval for Maure and Peul breeds of cattle in East Africa. Similarly, Trail and Gregory (1981) reported significant effects of month of calving on lactation milk yield of East African Zebu cattle.

Kiwuwa et al (1983) reported no significant effects of season of calving on lactation yield, lactation length and yield per day for Arsi and Zebu cattle, although significant effects of season of calving was recorded for dry period for the two East African breeds of cattle. Similarly, Kiwuwa and Redfern (1969) recorded significant season of calving effects on milk yield in Nganda. On the contrary, Sikka (1931), Tomar and Nittal (1960), Sidhu (1964) and Rao and Taylor (1971) have

separately found no significant season of calving effects on milk yield in their studies. It is thus apparent, that the effects of season of calving and month of calving on milk yield and milk production traits in the tropics and subtropics studied by several workers have produced rather conflicting results. However, despite the divergent results, there seems to be evidence for month and seasonal effects on dairy traits, especially as animal management in the tropics relies on pasture grazing practices in the wet and humid areas and on stall feeding in the hot and dry climatic regions. Kiwuwa (1973) reported significant effects of season of calving on lactation yield and daily milk yield but not on lactation length in East African Zebu cattle. On the other hand, Bodisoo et al (1966) noted in Venezuela that cows calving during the dry months of the year produced less milk than those calving during the rainy months. However, Alim (1962) did not find significant seasonal effects on milk yield of Butana cattle in Sudan.

2.4.3. Parturition number

Parturition number is the number of times a cow has calved, and because the development of the cows progresses until the mature size is attained, parturition number can exert effects on dairy productivity of animals. Trail and Gregory (1981) reported that parturition number had significant effects on the calving interval of East African Zebu cattle. Supporting evidence was recorded by Kiwuwa et al (1983) who stated that parturition number underlined the declining calving interval from the first to the fourth parturition in Arsi and East

African zebu cattle. The authors also reported that parturition number had significant effects on lactation yield, lactation length and yield per day but not on the dry period. ILCA (1978) recorded significant effects of parturition number on the milk yield of Maure and Peul breeds of cattle. Similarly, Johnson et al (1984) reported that parturition number had significant effects on milk yield, lactation length and calving interval for both Bunaji and Sokoto Gudali breeds of cattle. Trail and Gregory (1981) recorded that parturition number had significant effects on lactation yield for the first and second lactations in East Africa.

2.4.4. Previous calving interval/subsequent calving interval

Previous calving interval is the number of days between the first and second calvings; while the subsequent calving interval is the number of days between the second and third calvings for a cow, or the days between any two consecutive calvings following the first calving interval. Thus as milk yield is influenced by the previous calving interval (Mason and Buvanendran 1982), a short preceding calving interval would result in a lower milk yield both in the current and the suceeding lactation, whereas a relatively long calving interval operates in the opposite direction (Johansson and Rendel, 1968). Similarly a short subsequent calving interval would result in a lower milk yield in the following lactation, because a short subsequent calving interval allows for no prospect of a long dry period.

Thus, optimal length of calving interval for a breed should be aimed at, since this seems to give the highest average milk yield over a period of several years. Therefore good cows should have the average previous and subsequent calving intervals for their breeds. If these are coupled with the possession of the breed's average age at first calving by the cows, a manifestation of a breeding efficiency would result which would support a relative declining subsequent calving intervals and an increased milk yield up to the fourth lactation (Kiwuwa et al (1983). This situation would enhance the overall reproductive performance by the production of an appreciable calf crop that would support herd replacements and sustain good milk yield. However, Marples and Trail (1967) reported that the length of previous calving interval did not influence the milk yield of cows of Guernsey breed in Uganda in the following lactation.

2.4.5. Lactation length

Lactation length has a tremendous effect on milk yield (Asker et al., 1965; Mahadevan, 1956). This situation accounts for the relatively low milk yield of most tropical breeds of cattle which show comparable short lactation lengths. Trail and Gregory (1981) reported that both year of calving and month of calving had significant effects on lactation length and that parturition number also influenced the lactation length of East African cattle. A supporting evidence is given by Kiwuwa et al (1983) who reported that year of calving and parturition number significantly affected lactation length

also in East African cattle. ILCA (1978) recorded significant effects of year and month of calving on lactation length.

2.4.6. Dry period

A short dry period results in a lower milk yield in the following lactation. Dry period is affected by the length of calving interval, since a short calving interval results in little prospect for a long dry period (Johansson and Rendel, 1968). When other factors are suitable, the length of dry period can be used as a measure of the cows' persistency for milk production during the lactation. Kiwuwa et al (1983) reported that year of calving and season of calving affected dry period. Marples and Trail (1967) reported that the length of the previous dry period did not affect subsequent 305-day milk yield. Kiwuwa et al (1983) also reported that the dry period after the first lactation was not significantly longer than the dry period following later lactations, that is the dry period was not affected by the parturition number. ILCA (1978) reported no effects of year of calving on length of dry period and also recorded no significant effects of month of calving and parturition number on length of dry period for both Maure and Peul breeds of cattle. Alim (1960) reported that the preceding dry period did not have any effects on milk production, among the Kenana cattle.

2.5. Repeatability and heritability

Milk yield is influenced by both genetic and environmental factors. As such there is need to separate and estimate the

influence of these factors so as to distinguish and be able to select between genetically superior and inferior animals. The estimation of the important environmental factors as these affect production traits would permit using appropriate corrections before making comparisons among cows. It is only the genetically determined variation that can be employed to effect a permanent improvement in the production traits in a population of animals. Heritability expresses the proportion of the additive variance to the phenotypic variance, that is attributable to the average effects of genes. This is what determines the degree of resemblance between relatives. Thus the function of heritability in a genetic study of quantitative traits lies in its predictive role, by expressing the reliability of the phenotypic value as a guide to the breeding value. Although only the phenotypic value of individuals can be directly measured, it is the breeding value that determines their influence on the next generation. It is mainly the additive effects of genes which can be utilised by selection (Falconer, 1964). Thus the ratio of the additive genetic variance to the total phenotypic variation, which is heritability (h^2) is of vital interest. If all the variation in a group of animals is attributable to environment, selection of the phenotypically superior individuals would result in no improvement in the next generation, hence the need to effect correction to remove known environmental variations. Heritability estimates can be made from relatives, either by estimating the additive genetic variance from the covariance or from the

regression or correlation coefficients. In dairy cattle, dam-daughter pairs can be used within herds to compute correlation and regression between their production. Correlation between half-sibs can also be calculated by the analysis of variance as an intra-class correlation.

Repeatability is the ratio of the between individual component to the total phenotypic variance measured by the correlation between repeated measurements of the same individual. Repeatability thus expresses the proportion of the variance of single measurements that is due to permanent or non-localised differences between individuals both genetic and environmental (Falconer, 1964). Repeatability can be calculated between repeated measurements for example, milk yield in successive lactations of the same animal either by correlation analysis or as an intra-class correlation. Repeatability estimation of a trait separates the component of variance due to special environment but leaves the variance due to general environment confounded with the genotypic variance (Johansson and Rendel, 1968). This component due to general environment can only be separated if the genotypic variance (including the non-additive components) has been estimated. Thus the coefficient of repeatability which includes all the genotypic variation plus general environment component represents an upper limit of heritability (Falconer, 1964).

Repeatability and heritability estimates of production traits.

2.5.1. Age at first calving

Estimates of heritability of age at first calving of some breeds of tropical cattle are presented in Table 2.9. These estimates range from 0.03 to 0.12. All the estimates are low and have rather large standard erros. The estimates on Maure and Peul breeds of cattle are not significantly different from zero. ILCA (1978) reported that a low heritability is usually found for age at first calving and when this is coupled with an extremely low selection intensity, e.g. selection intensity = i = 0.34 as obtained by ILCA (1978), and which was ascribed to high mortality rates among replacement heifers in the dairy herd, would result in the expected genetic reduction in the age at first calving through selection being quite small as it is here indicated by the value of only two days per generation.

2.5.2. Calving interval

Estimates of repeatability of calving interval for some breeds of tropical cattle are given in Table 2.10. These estimates range between 0.06 and 0.31. The estimates of most breeds except Kenana are above 0.10. As the repeatabilities vary from low to medium value, multiple measurements of calving interval may lead to a worthwhile gain in accuracy due to a reduction of the variance due to special environment in the phenotypic variance.

Estimates of heritability of calving interval for some breeds of tropical cattle are shown in Table 2.11.

Table 2.9. Estimates of heritability of age at first calving for some tropical breeds of cattle

Breed	d.f	Method of Estimation	Estimate	References
Northern Sudan) Shorthorn zebu)	117 daughter dam pairs of 15 sires	Intra-sire regression	0.12±0.15	Osman and EL Amin (1971)
Nganda	104	Intra-sire regression	0.08±0.25	Mahadevan and Marples (1961)
Maure	-	Paternal half sib	0.03±0.12	ILCA (1978)
Peul	-	Paternal half sib	0.03±0.12	ILCA (1978)
East African Zebu	-	-	-0.03±0.23	Stobbs (1966 and 1967)

Table 2.10. Estimates of repeatability of calving interval for some tropical breed by cattle

Breed	d.f.	Method of estimation	Estimate	References
Nganda	75	intra-class correlation	0.21	Mahadevan and Marples (1961)
Kenana	-	intra-class correlation	0.06	Alim (1960)
Northern Sudan) Shorthorn zebu)	1083	intra-class correlation	0.24±0.04	Osman and EL Amin (1971)
Shorthorn zebu	-	intra-class correlation	0.14	Marples (1964)
Maure	74	intra-class correlation	0.18	ILCA (1978)
Peul	64	intra-class correlation	0.31	ILCA (1978)

Table 2.11. Estimates of heritability of calving interval for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	References
Nganda	75	intra-sire regression (first)	-0.10	Mahadevan and Marples (1961)
Northern Sudan) Shorthorn zebu)	150 daughter dam pairs of 16 sires	intra-sire regression	0.05±0.07	Osman and EL Amin (1971)

Only two heritability values were found in the literature. The values ranging from negative to positive and not very different from zero, indicate that the expected genetic reduction in the calving interval would be slow based on selection for the trait. However, by increasing the intensity of selection, the rate of response to selection can be improved for the trait, as superior genes in the genotypes are concentrated.

2.5.3 First lactation milk yield

Estimates of heritability of the first lactation milk yield for some breeds of tropical cattle are presented in Table 2.12. These estimates range from 0.20 to 0.54. Estimates obtained for Bunaji by Lecky (1951) was 0.54. Most of the estimates have rather high standard errors. This indicates that the method of estimation has rather high sampling variance, which underlined the fact that the precision of the estimates is not quite the best possible. Only one estimate was based on over 180 d.f. and the estimate was medium. The estimate reported also on Bunaji cattle by Robertson (1950) had a value of 0.32. These two estimates on Bunaji cattle indicate the possibility of obtaining an appreciable expected genetic increase in milk yield for the breed. Robertson (1950) confirmed this in his observation of a probable annual genetic gain of 5.6 kg or 1.4% of the average milk yield in the first lactation in Bunaji cattle during the 13 years of the experimentation.

Table 2.12. Estimates of heritability of first lactation milk yield for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	47	intra-sire regression	0.20±0.32	Mahadevan and Marples (1961)
Kenana	62 daughter dam pairs of 7 sires	intra-sire regression	0.24±0.25	Alim (1960)
Bunaji	-	intra-sire regression	0.32	Robertson (1950)
Northern Sudan) Shorthorn zebu)	88 daughter dam pairs of 13 sires	intra-sire regression	0.22±0.19	Osman and EL Amin (1971)
Bunaji	184 daughter dam pairs	intra-sire regression	0.54	Lecky (1951)

2.5.4. Subsequent lactation milk yield

Estimates of repeatability of subsequent lactation milk yield for some breeds of tropical cattle are shown in Table 2.13. The estimates were from 0.38 to 0.64. Most of the estimates were above 0.40. These moderate repeatabilities indicate there is little special environmental variance, as such the use of multiple measurements would give little gain in accuracy in the subsequent lactation milk yield.

Marples (1964) reported the following correlations between different lactations among the Shorthorn zebu cattle shown in Table 2.13(A). From the results the repeatability values were between medium to high and decrease as the lactation number increases. These results showed that little gain in accuracy would be achieved by use of multiple measurements for milk yield in the breed of cattle under the constraints of the experiment design. As the repeatability value between the first and second lactations milk yield was the largest, the indication is obtained that the least gain in accuracy would be made by repeated measurements at these lactations. On the other hand, the report of Alim (1960) showed that the repeatability between the first and second lactations was low, while repeatability between the first and second lactations was low, while repeatabilities between subsequent paired lactations were medium to high. The significance of this findings is that for Kenana cattle, a whortwhile gain in accuracy can be made by use of both first and second lactaions to measure milk yield, while

Table 2.13. Estimates of repeatability of subsequent lactation milk yield of some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Kenana	-	intra-sires correlation	0.43±0.05	Alim (1960)
Buntana	-	intra-class correlation	0.42	Alim (1960)
Northern Sudan) Shorthorn zebu)	742	intra-class correlation	0.38±0.06	Osman and EL Amin (1971)
Bunaji	-	intra-class correlation	0.60	Robertson (1950)
Shorthorn zebu	-	intra-class correlation	0.64	Marples (1964)
Maure	202 records of 60 animals	intra-class correlation	0.49	ILCA (1978)
Peul	191 records of 50 animals	intra-class correlation	0.60	ILCA (1978)
East African Zebu	567	intra-class correlation	0.59	Galukande et al (1962)

little accuracy would be achieved by the use of of multiple measurements between the second and fifth lactations, Table 2.13(B). Mahadevan and Marples (1961) reported also on the repeatability of milk yield in Nganda cattle between lactations. The results showed that the repeatabilities between paired lactations between lactations one and four were high. The significance of this is that little gain in accuracy would be made by use of multiple measurements for milk yield in the Nganda cattle (Table 2.13(C).

Estimates of heritability of subsequent lactation milk yield for some breeds of tropical cattle are given in Table 2.14. The estimates varied from 0.20 to 0.62. Most of the estimates are over 0.25. These medium to high heritabilities for most of the breeds of cattle indicate that an expected genetic improvement in milk yield would be appreciable through selection. For Bunaji cattle, Lecky (1951) and Robertson (1950) separately reported a heritability of 0.47 suggesting that selection would achieve improvement in milk yield. On the contrary, Foster (1960) recorded a heritability of 0.62 and 0.20 separately for Bunaji cattle. The precision of the method of estimation is evident in the results, for while the paternal half-sib indicates that little genetic improvement can be made through selection, the intra-sire regression showed that selection for milk yield would result in genetic improvement in the Bunaji cattle.

Table 2.13(A). Repeatability of milk yield by lactation in shorthorn zebu cattle

Lactation Number	1	2	3	Reference
2	0.77	-	-	Marples (1964)
3	0.67	0.58	-	" "
4	0.48	0.47	0.66	" "

Table 2.13(B). Repeatability between successive milk yield in Kenana cattle

Lactations compared	Number of pairs	Repeatability	Reference
1 and 2	65	0.14	Alim (1960)
2 and 3	39	0.36	"
3 and 4	38	0.54	"
4 and 5	33	0.69	"
Mean	175	0.38	"

Table 2.13(C). Repeatability of milk yield in different lactations in Nganda cattle

Lactation Number	1	2	3	Reference
2	0.74	-	-	Mahadevan and Marples (1961)
3	0.62	0.77	-	" " " "
4	0.54	0.71	0.78	" " " "

Table 2.14. Estimates of heritability of subsequent lactation milk yield for some breeds of tropical cattle

Breed	d.f.	Method of estimation	Estimate	Reference
East African Zebu	147	intra-sire regression (first)	0.50±0.17	Galukande et al (1962)
Kenana	-	intra-sire regression	0.24	Alim (1960)
Butana	-	intra-sire regression	0.28	Alim (1960)
Northern Sudan) Shorthorn zebu)	104 daughter dam pairs of 13 sires	intra-sire regression	0.26±0.14	Osman and EL Amin (1971)
Northern Sudan zebu	-	intra-sire regression	0.36±0.12	Osman (1970)
Bunaji	187 daughter dam pairs	intra-sire regression	0.47	Lecky (1951)
Bunaji	-	intra-sire regression	0.47	Robertson (1950)
Bunaji	256 daughter dam pairs	intra-sire regression	0.62±0.12	Foster (1960)
Bunaji	256 daughter dam pairs	Paternal-half-sib	0.20±0.20	Foster (1960)

The stardard error for the paternal half-sib method was high and indicated that the precision of this method of estimation is not the best.

2.5.5. Average daily milk yield

Estimates of repeatability of average daily milk yield per day of calving interval for some breeds of tropical cattle is presented in Table 2.15. The estimates varied between 0.39 and 0.62. Most of the estimates were above 0.45, except for that of the Northern Sudan zebu cattle. These moderate to high repeatability values for all the breeds of cattle suggest that no increase in accuracy would be achieved by use of repeated measurements for the trait.

Estimates of heritability of average daily milk yield per day of calving interval for some tropical breeds of cattle are shown in Table 2.16. The estimates were 0.23 and 0.45. These values are medium, suggesting the possible genetic improvement accruing through selection for the dairy trait.

2.5.6. Lactation length

Estimates of repeatability of lactation length for some tropical breeds of cattle are given in Table 2.17. These estimates were from 0.20 to 0.51. Most of the estimates are above 0.27. These repeatabilities varying from moderate to high suggest that no improvement would be made in accuracy by using multiple measurements for lactation length.

Table 2.15. Estimates of repeatability of average daily milk yield for some breeds of tropical cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	47	intra-class correlation	0.62	Mahadevan and Marples (1961)
Northern Sudan Zebu cattle	-	intra-class correlation	0.39±0.05	Osman (1970)
Maure	60	intra-class correlation	0.47	ILCA (1978)
Peul	50	intra-class correlation	0.50	ILCA (1978)

Table 2.16. Estimates of heritability of average daily milk yield for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	47	intra-sire regression (first lactation)	0.23±0.25	Mahadevan and Marples (1961)
Northern Sudan zebu	-	intra-sire regression (first lactation)	0.45±0.16	Galukande, Mahadevan and Black (1962)
East African zebu	178	intra-sire regression	0.45±0.16	Galukande, Mohadevan and Black (1962)

Table 2.17. Estimates of repeatability of lactation length for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	47	intra-class correlation	0.42	Mahadevan and Marples (1961)
Kenana	-	intra-class correlation	0.20	Alim (1960)
Northern Sudan) Shorthorn zebu)	1000	intra-class correlation	0.29±0.03	Osman and EL Amin (1971)
Shorthorn zebu	-	intra-class correlation	0.51	Marples (1964)
Maure	60	intra-class correlation	0.27	ILCA (1978)
Peul	50	intra-class correlation	0.38	ILCA (1978)
East African zebu	567	intra-class correlation	0.34	Galukande, Mahadevan and Black (191962)

Estimates of heritability of lactation length for some tropical breeds of cattle are presented in Table 2.18. The estimates were from 0.11 to 0.50. The heritabilities varying from low to high underlined the prospect that genetic improvement can be achieved in the lactation length of tropical breeds of cattle through selection for those breeds with high values while slow improvement can be made for those breeds with low values by increasing the intensity of selection.

2.5.7. Length of dry period

Estimates of repeatability of length of dry period for some tropical breeds of cattle are given in Table 2.19. The estimates varied from 0.07 to 0.26. Most of the estimates were above 0.15. The fact that majority of the estimates were above 0.23 but below 0.30 suggest that the values are medium and possibly that no increase in accuracy would be achieved by using multiple measurements for this trait.

Estimates of heritability of length of dry period for some tropical breeds of cattle are shown in Table 2.20. These estimates ranged between negative to 0.06, and have rather high standard errors. Since the heritability values are low, an expected genetic reduction in the length of dry period through selection would be small and consequently, the genetic progress in selection for the trait would be slow. The use of family selection is called for here.

Table 2.18. Estimates of heritability of lactation length for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
East African	-	intra-sire regression	0.50	Galukande et al (1962)
Nganda	47	intra-sire regression (first)	0.11±0.26	Mahadevan and Marples (1961)
Northern Sudan) Shorthorn zebu)	127 daughter dam pairs of 10 sires	intra-sire regression	0.11±0.01	Osman and EL Amin (1971)
East African zebu	146	intra-sire regression	0.47±0.20	Galukande et al (1962)

Table 2.19. Estimates of repeatability of dry period for some tropical breeds of cattle.

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	35	intra-class correlation	0.15	Mahadevan and Marples (1961)
Kenana	-	intra-class correlation	0.07	Alim (1960)
Northern Sudan	853	intra-class correlation	0.26±0.04	Osman and EL Amin (1971)
Maure	49	intra-class correlation	0.26	ILCA (1978)
Peul	44	intra-class correlation	0.23	ILCA (1978)
East African zebu	567	intra-class correlation	0.12	Galukande *et al* (1962)

Table 2.20. Estimate of heritability of length of dry period for some tropical breeds of cattle

Breed	d.f.	Method of estimation	Estimate	Reference
Nganda	35	intra-sire regression	-0.53±0.32	Mahadevan and Marples (1961)
Northern Sudan) Shorthorn zebu)	141 daughter dam pairs of 16 sires	intra-sire regression	0.06±0.09	Osman and EL Amin (1971)
East African zebu	122	intra-sire regression (first)	0.29±0.22	Galukande et al (1962)

2.6. Phenotypic and genetic relationship between milk production traits

A genetic relationship between two traits is due mainly to pleitropy, although linkage is a cause of transient correlation especially in populations derived from crosses between divergent strains. Pleitropy is the property of a gene whereby it affects two or more traits, so that if the gene segregates it causes simultaneous variation in the traits that are affected (Falconer, 1964). Thus a correlation resulting from pleitropy affects all segregating genes that influences the traits the genes control. Consequently, where the genes affect two or more characters by increasing them, a positive correlation results, but where one character is increased and the other reduced, negative correlation results. Therefore, genetic correlation, r_g is the correlation of breeding values. On the other hand, the association between two characters that can be directly observed is the phenotypic correlation. As phenotypic relationship is due to two causative forces, namely, genetic and environment, which are responsible for the observed association among different traits.

2.6.1. Age at first calving and first lactation milk yield

The relationship between age at first calving and milk production in the first lactation has been studied by different workers using the correlation, regression and analysis of variance techniques. The estimates of phenotypic correlations between these traits found in the literature for some Indian breeds of cattle are presented in Table 2.21(A), while the

estimates of genetic correlations between the traits for the same breeds of cattle are given in Table 2.22(A). Most of the estimates of phenotypic correlations are low and negative. Only one of the estimates was moderate in value. Some of the genetic correlations are low and negative while others are moderate to large and negative and some are moderate to large in values and positive. However, Amble et al (1958) found that the age at first calving had significant effect on milk production in the Red Sindhi and Kangayan herds and also the Thaparker herd. When production in different classes of age at first calving in different herds was plotted, an almost linear relationship was observed between age at first calving and milk yield in first lactation in Tharparkar and Sahiwal breeds (Acharya, 1966). In the Kangayam herd, milk production dropped up to the age of 49-52 months and then increased. In the Red Sindhi, the effect of the age on production was not significant and no relationship was observed between these two traits. Nevertheless, while Singh and Sinha (1960) recorded a significant effect of age at first calving on milk yield at 150 days of the first lactation in Tharparkar cattle, the effect of age at first calving on milk yield at 300 days of the first lactation was not significant for the breed. Thus the association between age at first calving and milk yield at 150 days was curvilinear. Most of the studies made on the European and American cattle on the relationship between these workers who estimated correlations between these traits reported in Table 2.21 did not discuss the nature of this association but have only made inferences from the statistical significance

of the estimate of correlation. Thus if the true relationship in these cases was curvilinear, the linear estimates would not accurately measure the true association. Consequently, with a very late age at first calving as in most tropical African breeds of cattle, hardly any relationship between the production in the first lactation and the age at first calving may be expected.

2.6.2. Age at first calving and calving interval

The estimates of phenotypic correlations between age at age first calving and calving interval as reported on some breeds of Indian cattle are given in Table 2.21(A), while the estimates of genetic correlations between the traits are presented in Table 2.22(A). The estimates of phenotypic correlations were mostly low. The estimates of genetic correlations between the traits were medium to high and positive values and were significant. Thus selection for a relative early age at first calving would result in reducing calving interval period.

2.6.3. Milk yield and calving interval

The estimates of phenotypic correlations between milk yield and calving interval reported on some breeds of Indian cattle and for Bunaji cattle are shown in Table 2.21(B). The estimates of genetic correlations for these traits are given in Table 2.22(B). The phenotypic correlation estimates varied from low positive to medium positive values. Lecky (1951) reported a phenotypic correlation of 0.18 for Bunaji cattle.

The genetic correlations ranged between low negative to high positive values. These estimates suggest that an association exists between milk yield and calving interval and that improvement in one of these traits would result in improvement in the other correlated trait.

2.6.4. Milk yield and lactation length

The only report found on the phenotypic and genetic relationship between milk yield and lactation length was that by Chandiranmani and Dadlani (1967) for Hariana cattle. The phenotypic correlation was high and positive while the genetic correlation was medium and positive (Tables 2.21(B) and 2.22(B). The genetic correlation suggests that an association exists between milk yield and lactation length and that improvement in milk yield would bring about a corresponding increase in lactation length.

2.6.5. Preceding dry period and subsequent milk yield

The only report found on the phenotypic and genetic association between the preceding dry period and subsequent milk yield was recorded by Dadlami and Prabhu (1968). These correlations are given respectively in Tables 2.21(C) and 2.22(C). The phenotypic correlation was medium and negative, while the genetic correlation was low and negative for Hariana cattle. The genetic correlation being negative suggests that as improvement is being made in one trait, there would be a deterioration in the other correlated trait.

Table 2.21(A). Estimates of phenotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimate	References
Age at first calving and milk production in the first lactation			
Tharparkar	497	-0.02±0.04	Gurnani et al (1976)
Sahiwal	164	0.07±0.08	" " " "
Hariana	472	0.006±0.44	Singh et al (1968)
Hariana	-	-0.07	Chandiramani and Dadlami (1967)
Tharparker	344	0.38	Singh and Sundaresan (1966)
Hariana	291	-0.01±0.05	Dutt and Tomar (1971)
Age at first calving and calving interval;			
Hariana	472	0.24±0.05	Singh et al (1968)
Tharparkar	497	0.07±0.05	Gurnani et al (1976)
Sahiwal	-	0.15±0.09	Gurnani et al (1976)
Indian Buffaloes	-	0.08±0.05	Kanaujia et al (1974)
Tharparkar	344	0.09	Singh and Sundaresan (1966)

Table 2.21(B). Estimates of phenotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimate	Reference
Milk yield and calving interval:			
Hariana	73	0.16	Dadlami and Chandiramani (1968)
Bunaji	-	0.18	Lecky (1951)
Hariana	-	0.04	Singh et al (1968)
Tharparkar	-	0.26	Gurnani et al (1976)
Sahiwal	-	0.13	" " " "
Tharparkar	344	0.30±0.09	Singh and Sundaresan (1966)
Milk yield and lactation length:			
Hariana	87	0.72	Chandiramani and Dadlami (1967)

Table 2.21(C). Estimates of phenotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimate	Reference
Preceding dry period and subsequent milk yield:			
Hariana	73	-0.23	Dadlani and Prabhu (1968)
Age at first lactation and length:			
Hariana	87	0.19	Chandiramani and Dadlani (1967)
Hariana	391	0.20±0.05	Dutt and Tomar (1971)

2.6.6. Age at first lactation and lactation length

The only reports found on the phenotypic and genetic relationship between age at first lactation and lactation length were by Chandiramani and Dadlami (1967) and Dutt and Tomar (1971) both being on the Hariana cattle. These correlations are presented in Tables 2.21(C) and 2.22(C) respectively. The phenotypic correlations varied from very low non-significant value to medium positive value. The genetic correlations varied from high negative to high positive value. Only one of the authors indicated the method of estimation which was by regression of daughters' records on dams records involving 88 daughter - dam pairs. Age as such exerts effect on production as shown especially by age at first lactation on the lactation length. The genetic correlations showed on the one hand that an improvement in one trait would result in a corresponding improvement in the other trait, while on the other hand, the report of Dutt and Tomar (1971) showed that an improvement in one trait would result in a deterioration of the other trait.

2.7. Estimates of genetic progress

In Nigeria, appreciable amounts of finance and resources are devoted to schemes related to breeding and livestock improvement, although a National Policy on Livestock breeding and production is not clearly defined, thus execution is not properly co-ordinated. It is therefore desirable to assess the genetic gains that are possible through selection and

Table 2.22(A). Estimates of genotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimate	Reference
Age at first calving and milk production in the first lactation:			
Tharparkar	497	0.39±0.39	Gurnani et al (1976)
Sahiwal	164	-0.39±0.6	" " " "
Hariana	472	-0.13±0.22	Singh et al (1968)
Hariana	-	-0.28	Chandiramani and Dadlami (1967)
Tharparkar	344	0.77±0.15	Singh and Sundaresan (1966)
Hariana	291	-0.54±0.32	Dutt and Tomar (1971)
Age at first calving and calving interval:			
Hariana	472	0.04±0.25	Singh et al (1968)
Tharparkar	497	0.42±0.26	Gurnanani et al (1976)
Sahiwal	-	<-1	Gurnanani et al (1976)
Indian Buffaloes	-	0.70±0.23	Panaujia et al (1974)
Tharparkar	344	0.70±0.19	Singh and Sundaresan (1966)

Table 2.22(B). Estimates of genotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimates	Reference
Milk yield and calving interval:			
Hariana	73	0.19	Dadlami and Chandiramani (1968)
Hariana	-	-0.08	Singh et al (1968)
Tharparkar	-	0.89	Gurnani et al (1976)
Sahiwal	-	0.39	Gurnani et al (1976)
Tharparkar	344	0.78±0.14	Singh and Sundaresan (1966)
Milk yield and lactation length:			
Hariana	87	0.34	Chandaramani and Dadlami (1967)

Table 2.22(C). Estimates of genotypic correlations among dairy production traits of some tropical breeds of cattle

Breed	d.f.	Estimates	Reference
Preceding dry period and subsequent milk yield;			
Hariana	73	-0.11	Dadlami and Prabhu (1968)
Age at first lactation and lactation length:			
Hariana	87	0.91	Chandiramani and Dadlami (1967)
Hariana	291	-0.89±0.15	Dutt and Tomar (1971)

improved breeding methods especially in the herds where there is a relatively large concentration of livestock populations.

There have been relatively very few attempts at evaluating genetic improvement through selection in dairy cattle herds in Nigeria. Robertson (1950) reported a probable annual genetic improvement in milk yield of Bunaji cows at Shika of 5.2 kg, which is 1.4% of the mean milk yield. This genetic improvement is quite substantial and is comparable to progress made in temperate breeds of cows, although it would appear that the masking effect of environmental factors have not readily made this detectable as these effects have not all being removed. This estimate of genetic improvement was based on the possible four paths for effecting genetic improvement in milk yield, namely, cow to cow, cow to bull, bull to bull and bull to cow and thus reflect the genetic superiority of the stock used in milk production over a period of 13 years in which selection was practised and in which the total generation interval along the four paths by which genes can be passed from one generation to another was about 25 years.

After correcting for effects of year of calving, Foster (1960) using regression techniques, in which first lactation milk yield was regressed on the year of calving, reported that the annual genetic improvement in milk yield of the Bunaji cows was about 1.4%. The regression coefficient obtained by the author was 13.4 ± (S.E) 5.0 kg in a study which covered

a period of 29 years.

Galukande et al (1962) reported a probable annual genetic gain in milk production for the East African Zebu as a result of the combined selection applied on the dams of cows and dams of bulls at three locations in Uganda respectively as 0.38 kg, 55.6 kg and -0.12 kg. The total generation interval for the respective herd at the three locations were 28.2 years at first location, and 25.8 years at both the second and third lactations.

Osman (1970) recorded a probable annual genetic improvement in milk yield for the Northern Sudan zebu cattle of 0.02 kg, which represented 0.58% of the herd mean yield corrected to first lactation, where the total generation length along the four paths of genetic improvement was 25.8 years.

Thus it is obvious that the probable annual genetic gain in milk yield for tropical breeds of cattle is appreciable comparable to genetic gain realised in the temperate breeds of cattle. It is as such clear that the selection pressure applied is substantial but that the environmental factors may mask the ease of detecting the potential genetic improvement achievable as regard milk yield.

The only few reports on the Bunaji cattle in Nigeria indicate that relative commensurate annual genetic improvement have been obtained for milk production based on the selection intensity used. This suggest that possible substantial

improvement through higher selection pressure within the indigenous breeds of Bunaji cattle may be retarded as a result of the prevailing small herd population sizes.

MATERIALS AND METHODS

The data used for the present investigation are from two herds, one each of the Bunaji and Sokoto Gudali breeds. Both are dual purpose, milk-draught types. They formed part of the cattle herds kept at Shika stock farm by the Agricultural Department of Northern Nigeria.

3.1. Farm and the Breeding stock

The area of the Shika stock farm where the two breeds of cattle were located is made up of 1,200 hectares and lies within the Northern Guinea Savannah ecological zone. The farm is located at latitude 11° 15'N, longitude 7° 32'E at an altitude of 640 m above sea level. The arable area used for production of feed for the animals was about 160 hectares during the period under investigation. The climate is relatively dry, the rains occur during May to September, the average annual rainfall was 2.183 m. The dry season commences with a period of dry, cool weather known as the "Harmattan", lasting from mid October to January, followed by dry, hot weather from February to April. Mean annual minimum and maximum daily temperatures range from 14° to 32°C during the harmattan season, and from 16° to 36°C during the hot season, while the relative humidity varies from 35% during the harmattan to 29% during the hot season. The average temperature and humidity during the wet season were 24.9°C and 73% respectively.

The monthly average of some meteorological observations at Shika and Samaru which is about 9 km from Shika is presented in Table 3.1.

Table 3.1. Monthly average of some metorological observations at Shika[a] and Samaru[b]

Month	Temperatures		Average humidity		Average rainfall (m)
	Average maximum (°C)	Average minimum (°C)	Average (%) Samaru	p.m. (%) 1938-1957	Shika, 1934-57
January	31.3	14.2	29.7	13.9	0.00
February	33.1	15.9	24.4	12.7	0.056
March	35.6	19.6	36.6	16.0	0.123
April	36.2	21.7	56.1	26.6	0.755
May	33.2	21.2	74.4	46.8	2.951
June	31.1	20.1	82.7	59.4	3.515
July	28.6	19.6	87.2	68.7	5.099
August	27.7	19.4	89.5	72.5	7.668
September	29.4	19.3	85.9	64.9	5.102
October	31.7	18.6	76.8	45.8	0.883
November	32.3	15.9	43.7	32.0	0.039
December	31.1	14.3	30.5	16.8	0.00

[a] Agishi E.C. (1985)
[b] Foster, W.H. (1960)

The experimental herd of Bunaji was established in 1929 with 110 cows and 15 bulls acquired from nomadic herds. The female stock was selected on the basis of health and udder development, although the animals were not performance tested before purchase. Additional 24 cows were purchased in 1943, from which 17 heifers were born by these cows. The bulls were selected on the basis of conformation and docility. Two bulls were added to the bull stud in 1943.

The experimental herd of Sokoto Gudali cattle was established in 1933 with 14 cows and 1 bull. Further additions of animals were not made until 1938, when the herd totalled 232 cows and 6 bulls. The selection of both the cows and bulls of the Sokoto Gudali breed was on the same criteria as that for Bunaji stock.

For the Bunaji cattle experimental herd, cows were randomly divided into groups of fifty animals each and one of the stud bulls was randomly assigned to each of these groups. The objective was to carry out progeny testing of the foundation bulls and of first generation bulls. However, in 1946, a policy of line-breeding was started, with individual mating being used.

As this policy of line breeding was felt would increase inbreeding in the herd resulting in decrease in birth weight, viability and calf survival, the line-breeding policy was discontinued in 1954, and matings were arranged to reduce possible inbreeding to a minimum level possible.

In the Sokoto Gudali experimental herd, cows were randomly divided into groups of 45 animals each and one out of the stud bulls was randomly assigned to each of these groups. The same policy of linebreeding was employed with the Sokoto Gudali cattle and was also discontinued in 1954 as was in the case of Bunaji cattle.

3.2. Feeding and management

The animals of both experimental herds were maintained uniformly, being kept in fenced paddocks during the day but brought into open sided-roofed enclosures at night throughout the period of 1929 to 1958.

Calves were bucket-fed for the first three months of their life, thereafter being maintained on concentrate ration until they were weaned at nine months of age. After weaning, the animals were given further concentrate ration for nine months. At 18 months of age, heifers and bull calves were separated, after which combination of a concentrate and roughage maintenance ration were fed only during the dry season. The concentrate ration fed was composed of various fractions of sorghum and bran, cotton seed, groundnut cake, dried blood, soyabean and palm kernel meals. The sweet potato vines and tubers, mucuna hay, sunflower and maize silage and dried sorghum leaves were fed as roughage. In the wet season, grazing rotationally on sown Mucuna/Digitaria pastures or improved savanna was employed for maintenance and supplemented with concentrate ration for milk production and work.

Heifers were mated the first time at about 230 kg but this was reduced in 1951 to about 218 kg. Bulls were used for service between 23 months and 8 years 9 months, with the average age being 4 years and 6 months.

Cows were milked twice per day by hand, with the calves kept at foot to induce milk letdown. In 1951, a small proportion of cows, were machine milked. There was no fixed stage at which lactations were completed, although cows giving less than 2.3 kg milk/day were dried off. Milk yield of each cow was recorded daily.

All new calves were ear-tagged within 24 to 48 hours of birth and weighed. At weaning all calves were branded and performance of each animal were documented regularly.

Routine vaccinations were given to calves against rinderpest, while regular vaccinations against trypanosomiasis, helminthiasis, and other contagious diseases were also given. Animals were sprayed regularly against ticks and other ectoparasites. Annual tests against brucellosis and tuberculosis were carried out. Animals had access to trace minerals in the form of salt block and clean water at all times.

3.3. Selection of breeding stock and breeding policy

In the case of bulls, selection was based primarily on milk producing ability of their ancestors, while consideration was given also to docility and conformation of the bulls themselves. Thus bulls whose dams have lactation lengths comparable or better than the herd average and give milk yield of 900 kg or more in addition to possessing

possessing desirable body conformation were retained while those bulls falling below in performance were culled.

For the cows, milk yield, length of lactation and regularity of calving of the animals were the principal criteria used. Poor yielding cows, but not their progeny were culled from the herd generally after two lactations. In addition, all milking female stock either cows or their progeny whose milk yield were below 900 kg per lactation were culled from the herd. For heifers, those not attaining a live weight of 227 kg by 3 years of age were also culled.

The total records were 3367 of some 825 animals of which 2378 records of 579 cows were for Bunaji breed, while 989 records of 246 cows were for the Sokoto Gudali breed. These records of the two breeds covered a period of 24 years, i.e. 1934 to 1957 inclusive. Some 262 records of the two breed of cattle were excluded, 201 records were for Bunaji cattle while 61 records were for Sokoto Gudali cattle. The records excluded low production, mastisis and death are presented for Bunaji cattle and Sokoto Gudali cattle in Tables 3.2 and 3.3 respectively. Consequently, the total number of records available were reduced to 2177 records of 545 cows for Bunaji cattle and 928 records of 216 cows for Sokoto Gudali cattle, making a total of 3105 records of 761 animals.

Table 3.2. Causes of disposal of animals from the herd for Bunaji cattle

Causes		Number of records disposed	Percentage
1.	Low production	46	1.9
2.	Old age and infertility	60	2.5
3.	Mastisis and other udder disease	19	0.8
4.	Debility and weakness	18	0.8
5.	Tuberculosis	4	0.2
6.	Death	54	2.3
Total		201	8.5

Table 3.3. Causes of disposal of animals from the herd for Sokoto Gudali breed

Causes		Number of records disposed	Percentage
1.	Low production	12	1.2
2.	Old age and infertility	18	1.8
3.	Mastisis and other udder disease	6	0.6
4.	Debility and weakness	9	0.9
5.	Tuberculosis	1	0.1
6.	Death	15	1.5
Total		61	6.1

3.4. Statistical Analysis

The milk production in the first 305 days of lactation milk yield, age at first calving, calving interval, lactation length, length of dry period and milk yield per day of calving interval were the economic dairy traits for which phenotypic and genetic parameters were desired. These characters as shown in the review of the literature are important components of profitable production in the dairy operation. Although all lactation records in the case of economic traits were included in the requisite analyses and the adjusted first three lactation milk yield records in the appropriate analyses of genetic and phenotypic parameters, it is appreciated that the use of only the first lactation milk yield records in the computation of genetic parameters have the following desirable benefits:

a. All mature heifers were maintained so as to complete at least the first couple of lactations in the herd, thus any voluntary selection made would rarely introduce any bias in the estimates from the first lactation record.
b. The first lactation records for each breed gave comparatively the largest volume of data.
c. The first lactation records are expected to be relatively less influenced by environmental and physiological factors than later records and as such require fewer corrections for effects of these

factors thus consequently introducing less bias in the estimates obtained of both genetic and phenotypic parameters.

d. As it was desired to express the later lactation production in terms of the first record so as to correct for age differences, inclusion of only the first lactation in the analyses would result in little bias from errors in age correction factors.

In view of the above genetic parameters computation was made separately for the first three lactation milk yield as well as all lactation combined.

3.4.1. Effects of environmental factors

Separate variance analyses for each breed and for each of the economic traits were computed in which the effects of year of calving, month of calving and parity of calving were investigated. Variance analyses were also made for the two breeds combined to investigate the effects of breed and other environmental factors on each of the economic traits. Analyse on the various traits were made for normal calving only. In the case of birth weight of calves, sex of calves was also included as a factors along with other environmental factors in the variance analyses. In the analytical models, some economic traits were included one at a time to study if the significance can be reduced or removed. All variance analyses were computed as outlined by Snedecor and Cochran (1967).

Factors such as breed, year and month of calving, lactation number, parity and sex of calf (for birth weight only) were assumed to have fixed effects. The effect of each subset of constants were estimated by least squares procedures (Harvey, 1960). As the data have unequal subclass numbers, appropriate mathematical models were formulated in each case. This was achieved by constructing a 48 x 48 systems of normal equations (1 mean, 9 lactations, 24 year, 12 months and 2 breed) for each of the dairy traits except for birth weight which had sex in the equation, making it a 50 x 50 system of normal equations. The equations were reduced to full rank of 44 x 44 systems in case of all traits while that for birth weight was 45 x 45 system, by substracting from each subset the equation which appeared last. This procedure as such ensures that the sum of the effects within each subclass equals zero. The reduced system was solved on a high speed computer CDC Cyber model 72. The size of matrix that could be handled precluded accounting for individual, first, second or even third order interaction terms.

The model used in the least squares analysis of a trait is described as follows:

$$Y_{ijklm} = \mu + A_i + B_j + C_k + D_l + E_{ijklm}$$

where

Y_{ijklm} = the $ijklm^{th}$ animal's record

μ = the effect common to all animals

A_i = the effect of the ith year of calving

B_j = the effect of the jth month of calving

C_k = the effect of the k^{th} breed of cow

D_l = the effect of the l^{th} parity of cow number

E_{ijklm} = the random effect associated with the $ijklm^{th}$ animal.

The environmental and breed effects and their significance were tested by F - test, while significance between two means within a subset were evaluated by t - tests, where

$$t = \frac{a_i - a_j}{S(n_i - n_j)}$$

where a_i and a_j are means within a subset S is standard deviation n_i and n_j are samples number for the means a_i and a_j.

3.4.2. Estimation of genetic and phenotypic parameters

The constants obtained for the effects of year of calving, month of calving, parity of calving and sex of calves (for birth weight only) were used to adjust the data for the appropriate traits for each breed of cattle. The additive correction factor (Cundiff et al., 1966), was used to adjust the records for each trait. From earlier study additive correction had a lower variance than the multiplicative correction factor. Within each breed of sire groups, least squares analysis was carried out fitting constants for sires and progeny's records sired by the same sire.

The model used as follows:

$$Y_{ijk} = \mu + S_i + R_{ij} + E_{ijk}$$

where Y_{ijk} = the ijk^{th} animal record

μ = the effect common to all animals

S_i = the effect common to the i^{th} sire

R_{ij} = the effect common to all records of the j^{th} progeny sired by the i^{th} sire

E_{ijk} = the random effect of the k^{th} record of the j^{th} progeny from the i^{th} sire.

The sires included in the computation of the sire component were those with a minimum of five daughters and each daughter having a minimum of four lactation records. But sires used were for computations based on first lactation records of their daughters.

In the estimation of heritability, genetic and phenotypic correlations for first the first three and all records as the case may be, constants obtained for environmental effects and for sires and progeny records within sires were used to adjust the data within the respective sire groups for each breed, this leaves only the variation between sires. Analyses of variance and covariance were computed within these sire groups, and for each breed. Sire variance and covariance were separated into the between - sire variance and coveriance and the within - sire variance and covariance.

3.4.2.1. Heritability estimation

The components of variance for between sire (σ^2_S) and within - sire progeny groups (σ^2_W) were calculated as

follows:

$$\sigma^2_S = \frac{\sigma^2_S - \sigma^2_W}{K}$$

where σ^2_W = Means squares within sires

σ^2_S = Means squares between sires

K = average number of progeny per sire

$$K = \frac{1}{S-1}\left(n. - \frac{\Sigma ni^2}{n.}\right) \text{ (Becker, 1964)}$$

where S = number of sires

n. = total number of progeny for sires

Σni^2 = sum of squares of progeny for all sires

Assuming a relationship of 0.25 among members of a sire group, half-sibs, additive genetic variance, under the assumptions of no interaction among non-allelic genes, no genotype - environment interaction, no effects due to sex - linkage and no random mating, the additive genetic variance, $\sigma^2_A = 4\hat{\sigma}^2_S$. Using the paternal half-sib correlation, heritability is calculated as:

$$h^2 = \frac{\sigma^2_G}{\sigma^2_R}$$

$$= \frac{4\sigma^2_S}{\sigma^2_S + \sigma^2_W}$$

where $\sigma^2_G = 4\sigma^2_S$

$\sigma^2_p = \sigma^2_S + \sigma^2_W$

σ^2_G = Genetic variance

σ^2_A = Additive genetic variance

h^2 = heritability in the narrow sense

However, σ^2_S, will contain some variance due to the interaction among the additive effects of non-allelic genes and also the variance due to any other factor correlated with the sires.

The standard error of heritability estimates was obtained using the simplified formula by Robertson (1959) which is described as follows:

$$S.E._{h^2} = (h^2 + \frac{4}{K}) \sqrt{\frac{2}{N}}$$

where K = average number of progeny per sire

N = number of sires

h^2 = heritability estimate

3.4.2.2. Genetic correlation estimation

Genetic correlation was estimated from the analyses of variance and covariance, using the paternal half-sib data that were adjusted for all effects as described under section 3.4.2. The genetic correlation between traits i and j can be expressed as:

$$r_g = \frac{\sigma^2_{SiSj}}{(\sigma^2_{Si} + \sigma^2_{Sj})^{\frac{1}{2}}}$$

where r_g = the estimated genetic correlation between traits i and j,

σ^2_{Si} and σ^2_{Sj} = estimates of the genetic variance of traits.

σ^2_{SiSj} = an estimate of the genetic covariance between traits.

Covariance were calculated using the relationship

$$Var_{(i+j)} = Var_{(i)} + Var_{(j)} + 2\ Cor_{(i,j)}$$

$$\text{Thus } Cov_{(i,j)} = \frac{1}{2}\left\{Var_{(i+j)} - Var_{(i)} - Var_{(j)}\right\}$$

The standard error of genetic correlation was calculated according to the method of Robertson (1959) and is described as:

$$S.E._{r_g} = \frac{1 - r_g}{\sqrt{2}}\left\{\frac{(S.E.h_i^2)\ (S.E.h_j^2)}{h_i^2 \quad h_j^2}\right\}^{\frac{1}{2}}$$

where $S.E.h_i^2$ and $S.E.h_j^2$ = standard errors of heritabilities for traits i and j.

r_g = genetic correlation between traits i and j.

3.4.2.3. Phenotypic correlation estimation

The phenotypic correlation were estimated through covariances as:

$$r_g = \frac{\sigma^2_{S_iS_j} + \sigma^2_{e_ie_j}}{\left\{(\sigma^2_{S_i} + \sigma^2_{e_i})\ (\sigma^2_{S_j} + \sigma^2_{e_j})\right\}^{\frac{1}{2}}}$$

where $\sigma^2_{S_iS_j}$ = an estimate of genetic covariance between traits.

$\sigma^2_{e_i}$ and $\sigma^2_{e_j}$ = estimates of the environmental variance of the traits, $\sigma^2_{e_ie_j}$ = an estimate of the environmental covariance between the traits.

The phenotypic correlation between two traits can also be computed as a simple (linear or product moment) correlation between the traits after adjustment for environmental and other effects discussed earlier, following the methods of Snedecor and Cochran (1967).

3.4.2.4. Age correction factors

The effect of age on production was studied in the present investigation by gross comparison method (Gowen, 1920), in which the averages of all records made at different ages were compared by expressing the milk yield in different lactations as a percentage of the first. As this method has the weakness of not necessarily comparing the lactations of the same animal, the effect of age on production was also studied by the paired comparison method (Sanders, 1928), in which a comparison was made between each consecutive pair of records of the same groups of cows by expressing a previous record as a percentage of the next in a consecutive pair of records, and than expressing subsequent records as a percentage of the first by multiplying with the percentages. However, selection would introduce a bias in the opposite direction to that encountered for use of gross comparison, since in paired comparison, lactation records are only incompletely repeatable. As a result, the effect of age on production was also investigated in the present study by expressing the later records as a percentage of the first records of the same cows and also

by expressing deviated later records from the years means as a percentage of the first records of the same animals.

3.4.2.5. Repeatability estimation

Repeatability estimates were computed in the study as an intra-class correlation obtained from the analysis of variance of the different records of the same cows. The production records of an individual can be described as:

$$Y_{ij} = \mu + C_i + E_{ij}$$

where Y_{ij} = the record of the ij^{th} animal

μ = the effect common to all animals

C_i = the effect common to all lactations of the i^{th} cow.

E_{ij} = the random error associated with the record of the i^{th} cow.

It is assumed that:

$$E(C_i) = 0 \text{ and } E(C_i)^2 = \sigma_C^2$$

It is also assumed that:

$$E(E_{ij}) = 0 \text{ and } E(_{ij})^2 = \sigma_e^2$$

Thus repeatability as an intra-class correlation obtained from among and within cow analysis can be defined as:

$$r = \frac{\sigma_C^2}{\sigma_C^2 + \sigma_e^2}$$

where σ_C^2 = estimate of cow variance

σ_e^2 = estimate of the error variance

3.4.2.6. Estimation of genetic gain

Estimates of genetic gain were obtained in the present study from the direct selection for the dams of cows and dams of sires. The phenotypic selection differential for the 305-day milk yield for each breed was obtained for the dams of the cows. For the dams of sires the estimate of superiority of their dams first lactation was obtained as deviation from their contemporarys' means.

The genetic gain:

$$\Delta G = i\sigma_{ph}^2 \quad \text{(ILCA, 1978; Touchberry, 1967)}$$

where i = Selection intensity

$$= \frac{\text{Selection differential}}{\sigma_p}$$

σ_p = phenotypic standard deviation

$$= \left(\sigma_S^2 + \sigma_W^2 \right)^{\frac{1}{2}}$$

σ_S^2 = sire variance component for trait

σ_W^2 = within variance component for trait

h^2 = heritability estimate for trait

$$\text{Genetic gain per year } (\Delta G/yr) = \frac{i\sigma_p h^2}{\text{generation interval}}$$

The generation interval was a summation of the generation interval for dams and sires based on population survival parameters, according to the method of ILCA (1978).

RESULTS AND DISCUSSION

LACTATION TRAITS

4.1. 305-day milk yield

4.1.1. First lactation 305-day milk yield

4.1.1.1. Results

The analysis of variance for effects of breed, year and month of calving on 305 day first lactation milk yield is given in Table 4.1. There were no significant differences (P>0.05) for the effects of breed, year and month of calving on the first lactation 305-day milk yield. The least squares estimate for first lactation milk yield is shown in Table 4.2. Results indicated that the mean first lactation milk yield was 813.9 kg. The first lactation milk yield ranged from 609.6 kg in 1953 to 1036.7 kg in 1948. The first lactation milk yield was 813 kg and 815 kg for Bunaji and Sokoto Gudali breeds respectively.

Age at first calving was included as a covariate in the model to examine its effect on first lactation milk yield. Its effect was non significant (>0.05) (Table 4.3).

Separate analysis of variance computed for each breed revealed no significant effects (P>0.05) of year and month of calving on first lactation milk yield for Bunaji breed (Appendix 1, Table 1), but significant effects (P<0.05) of month of calving on first lactation milk yield for Sokoto Gudali breed (Appendix 1, Table 2).

The separate least squares estimates for Bunaji and Sokoto Gudali breeds are presented in Appendix 1, Tables 2 and 4).

Age at first calving was included as a covariate in the model to evaluate its effect on first lactation milk yield separately for Bunaji and Sokoto Gudali breeds. Its effect was not significant (P>0.05) in the case of each breed (Appendix 1, Table 5; Appendix 1, Table 6). The average first lactation 305 day milk yield pooled over years and months respectively are given in Figs. 2 and 3 for the two breeds.

4.1.1.2. Discussion

The values recorded in the present study for the first lactation 305 day milk yield although lower than that reported by Johnson et al (1984) for Bunaji and Sokoto Gudali breeds, were larger than that recorded by Knudsen and Sohael (1970) for Bunaji and fall within recorded values for zebu breeds.

The fact that inclusion of age at first calving as a covariate in the model to determine its effect on first lactation milk yield revealed a non-significant effects would indicate that in these breeds age at calving is not important and has no apparent influence on the first lactation 305 day milk yield. It is probable that the age at calving is comparable within the population of the breed used in these study. However with mature heifers calving for the first time having divergent ages, the effect on 305 day first

Table 4.1. Analysis of variance for effects of breed, year and month of calving on first lactation milk yield of Bunaji and Sokoto Gudali cattle

Source of variation	D.F.	Mean squares (kg^2)x(10^4)	F. value	Significant level
Main effects	35	24.82	1.17	0.24
Breed	1	0.05	0.00	0.96
Year	23	23.67	2.71	0.83
Month	11	27.83	2.61	0.03
Residual	667	21.29	-	-
Total	702	21.46	-	-

Table 4.2. Estimated least squares constants (L.S.C.) and means for first lactation milk yield (kg) for Bunaji and Sokoto Gudali cattle

Class	Number of animals	L.S.C.	Mean	S.E.
Overall	703	-	813.91	17.41
Year of calving:				
1934	18	-0.13	813.78	108.82
1935	33	153.64	967.55	80.24
1936	25	26.15	840.06	92.28
1937	34	41.06	854.97	79.14
1938	30	41.43	855.34	84.20
1939	18	49.76	863.67	108.82
1940	29	27.65	841.56	85.60
1941	41	-11.76	802.15	72.10
1942	28	-52.56	761.35	87.22
1943	48	-144.36	669.55	66.58
1944	44	-41.28	772.63	69.59
1945	34	-18.64	795.27	79.14
1946	35	-34.51	779.40	77.94
1947	37	4.56	818.47	75.89
1948	22	222.80	1036.71	98.38
1949	16	-160.30	653.61	115.35
1950	24	112.96	926.87	94.16
1951	34	73.73	887.64	79.14
1952	25	-42.81	771.10	92.28
1953	20	-204.30	609.61	103.22
1954	23	-90.08	723.83	96.13
1955	53	81.03	894.94	63.38
1956	19	-10.55	803.36	105.83
1957	13	-23.49	790.42	127.81
Month of calving:				
January	66	58.96	872.87	56.82
February	57	143.40	957.31	61.11
March	51	-29.16	784.85	64.62
April	54	15.94	829.85	62.78
May	56	9.64	823.55	61.69
June	82	-81.60	732.31	50.93
July	44	-64.69	749.22	69.59
August	60	90.11	904.02	59.54
September	66	4.33	818.24	56.82
October	51	-52.02	761.89	64.62
November	45	-100.70	713.21	68.76
December	71	5.79	819.70	54.73
Breed of Animals:				
Bunaji	462	-0.94	812.97	21.47
Sokoto Gudali	241	0.94	814.85	29.73

Within variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used it indicates that the variable did not show a significant difference in the analysis of variance.

Table 4.3. Analysis of variance for effects of breed, year and month of calving on first lactation milk yield (kg) with age as a covariate for Bunaji and Sokoto Gudali cattle

Source variation	D.F.	Mean squares (kg^2) x (10^4)	F value	Significant level
Covariate				
Age	1	3.67	0.17	0.68
Main effects	35	19.09	0.90	0.63
Breed	1	0.68	0.03	0.86
Year	23	22.02	1.04	0.41
Month	11	13.24	0.63	0.81
Pesidual	597	21.11	-	-
Total	633	20.98	-	-

Covariate Age b = 0.03

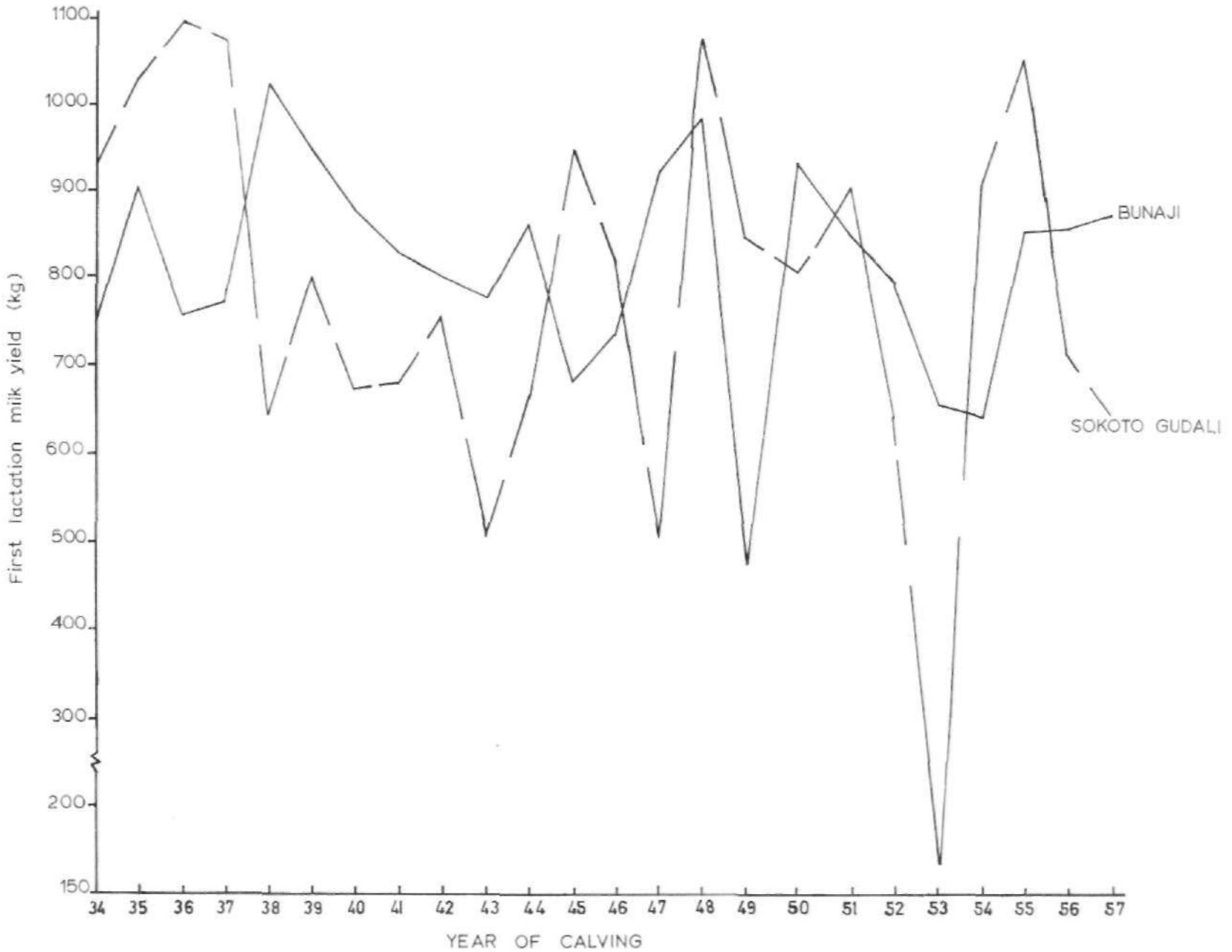


Fig.2 Yearly average first lactation 305-day milk yield for Bunaji and Sokoto Gudali breeds.

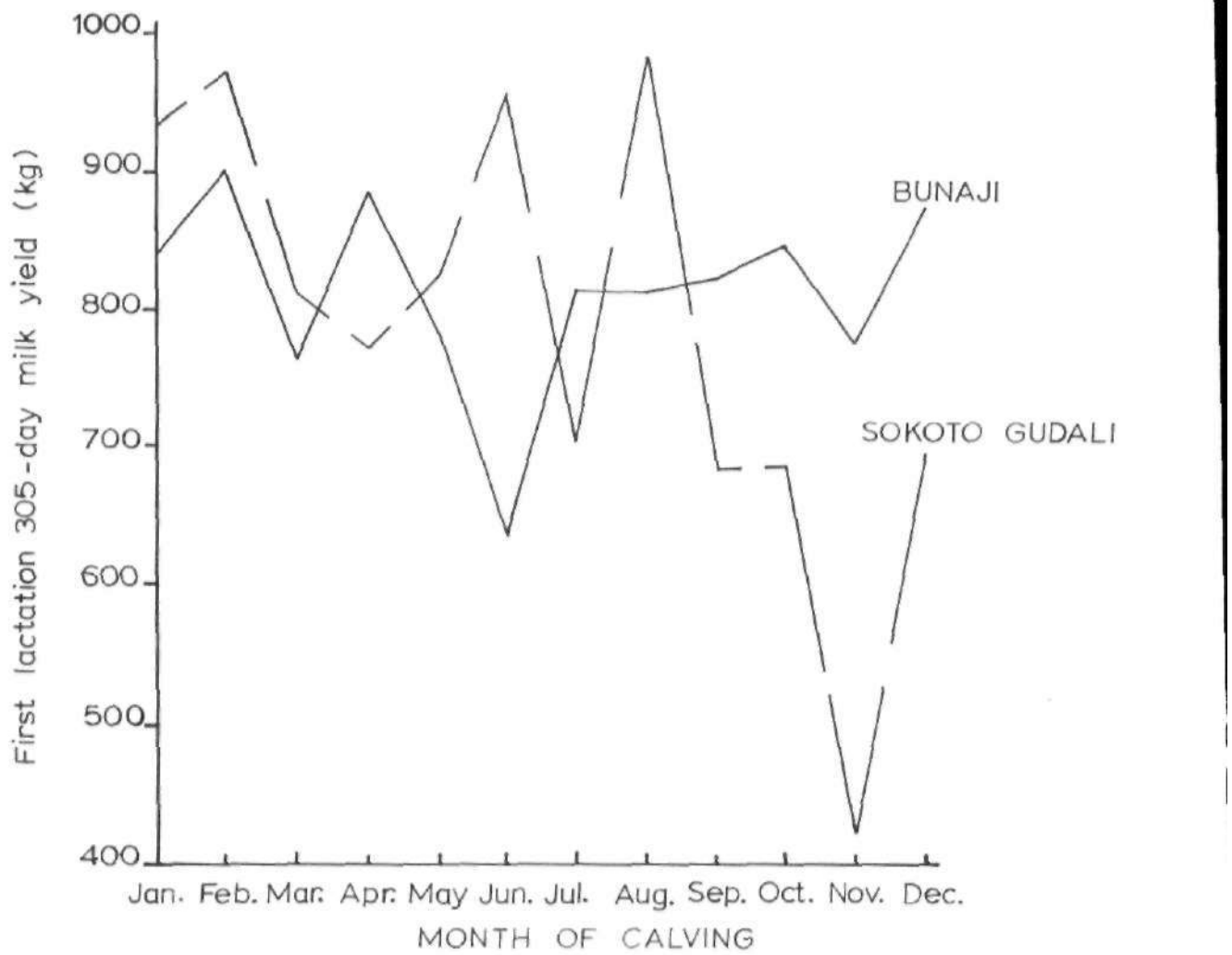


Fig. 3 : Monthly average first lactation 305-day milk yield for Bunaji and Sokoto Gudali breeds.

lactation milk yield may present a different pattern from the present observation.

4.1.2. All 305 day milk yield

4.1.2.1. Results

The analysis of variance for effects of breed, year and month of calving and parity on all 305-day milk yield is shown in Table 4.4. The effect of breed was not significant (P>0.05), but the effects of year and month calving as well as parity were all very highly significant (P<0.001).

The least squares means for 305-day milk yield was 1046.9 kg (Table 4.5). Results indicated that the least squares means varied from 848 kg in 1947 to 1195 kg in 1952. The years 1942 to 1948 showed marked reduction in mean 305 day milk yield.

Dry period was included as a covariate in the model to determine its effect on 305 day milk yield. Its effect was highly significant (P<0.001) (Table 4.6).

Calving interval was included as a covariate in the model to determine its effect on 305 day milk yield. Its effect was highly significant (P<0.001) (Table 4.7).

The analysis of variance when the 305-day milk yield was expressed as a deviation from the years means confirmed the non-significant effects of breed, while the significance levels of both month and parity were unchanged as expected (Table 4.8).

The analysis of variance in which the 305-day milk yield was also deviated from the years' mean and season of calving was included in the model in place of month confirmed the

Table 4.4. Analysis of variance for effects of breed, year and month of calving and parity number on 305-day milk yield of Bunaji and Sokoto Gudali cattle

Source of variation	D.F.	Mean squares (kg^2) x (10^5)	F. value	Significant level
Main effects	43	20.01	9.58	0.001
Breed	1	1.52	0.73	0.39
Year	23	15.97	7.65	0.001
Month	11	9.25	4.43	0.001
Parity	8	52.51	25.15	0.001
Residual	3061	2.09	-	-
Total	3104	2.34	-	-

Table 4.5. Estimated least squares constants and means for 305-day milk yield (kg) of Punaji and Sokoto Gudali cattle

Class	Number of animals	L.S.C.	Mean	S.E.
Overall:	3105		1046.91	8.20
Year of calving:				
1934	84	70.02	1116.93^{j}	49.83
1935	102	20.58	1067.49^{a}	45.24
1936	116	47.69	1094.60^{b}	42.43
1937	132	60.27	1107.18^{c}	39.77
1938	134	62.08	1108.99^{c}	39.46
1939	127	-33.52	1013.39^{d}	40.55
1940	115	35.52	1082.43^{rde}	42.63
1941	145	-40.15	1006.76^{df}	37.95
1942	131	-90.02	956.89^{b}	39.91
1943	160	-147.89	899.02^{n}	36.12
1944	193	-187.54	859.37^{d}	32.90
1945	161	-119.44	927.47^{e}	36.01
1946	191	-111.18	935.73^{e}	33.07
1947	215	-198.56	848.35^{h}	31.17
1948	154	-90.66	956.25^{b}	36.82
1949	96	157.79	1204.70^{m}	46.63
1950	97	127.74	1171.65^{g}	46.39
1951	100	120.58	1167.49^{g}	45.70
1952	131	148.89	1195.80^{hp}	39.91
1953	150	22.45	1069.36^{ai}	37.30
1954	90	23.55	1070.46^{a}	48.15
1955	122	67.20	1114.11^{j}	41.35
1956	116	112.16	1159.07^{q}	42.43
1957	43	-54.56	992.35^{k}	69.66
Parity Number:				
1	703	-212.92	833.99^{a}	17.24
2	686	-190.30	856.30^{b}	17.45
3	546	-81.09	965.82^{c}	19.55
4	412	-40.86	1006.05^{d}	22.51
5	298	64.08	1110.99^{e}	26.48
6	217	125.89	1172.80^{f}	31.02
7	142	30.57	1077.48^{gf}	38.34
8	77	123.95	1170.86^{h}	52.10
9	32	180.68	1227.59^{h}	80.73
Month of calving:				
January	182	85.63	1132.54^{gh}	33.87
February	146	102.17	1149.08^{b}	37.83
March	149	45.11	1092.02^{a}	37.43
April	192	-0.43	1046.48^{a}	32.97
May	179	-5.87	1041.04^{c}	34.15
June	194	-83.94	962.97^{c}	32.80

Table 4.5 (Continued)

Class	Number of Animals	L.S.C.	Mean	S.E.
July	161	-37.74	1009.17[d]	36.01
August	165	26.71	1073.62[e]	35.56
September	224	-28.27	1018.64[f]	30.53
October	212	-50.41	996.50[c]	31.39
November	191	-87.77	959.14[e]	33.07
December	182	34.81	1081.72	33.87
Breed of Animals:				
Bunaji	2177	-7.75	1039.16	9.79
Sokoto Gudali	928	7.75	1054.66	15.00

Within variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Table 4.6. Analysis of variance for effects of breed, year and month of calving and parity on 305-day milk yield with dry period as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2) x (10^6)	F value	Significant level
Covariate				
Dry period	1	59.11	351.16	0.001
Main effects	43	1.89	11.22	0.001
Breed	1	0.77	4.59	0.03
Year	23	1.53	9.44	0.001
Month	11	0.73	4.34	0.001
Parity	8	4.33	25.74	0.001
Residual	2507	0.17	-	-
Total	2550	0.22	-	-

Covariate dry period b = -0.86

Table 4.7. Analysis of variance for effects of breed, year and month of calving with calving; interval as covariate on 305 day milk yield of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2) x (10^4)	F value	Significant level
Covariate				
Calving interval	1	437.97	20.28	0.001
Main effects	35	136.43	6.32	0.001
Breed	1	0.28	0.01	0.91
Year	23	175.90	8.14	0.001
Month	11	71.76	3.32	0.001
Residual	2365	21.60	-	-
Total	2401	23.45	-	-

Covariate calving interval b = 0.27

Table 4.8. Analysis of variance for effects of breed, year and season of calving and parity on 305-day milk yield expressed as deviation from yearly means for Bunaji and Sokoto Gudali breeds.

Source of variation	D.F.	Mean squares (kg^2) x (10^5)	F value	Significant level
Main effects	20	12.02	5.76	0.001
Breed	1	1.52	0.73	0.394
Month	11	9.25	4.43	0.001
Parity	8	52.51	25.15	0.001
Residual	3084	2.09	-	-
Total	3104	2.23	-	-

Table 4.9. Analysis of variance for effects of breed, year and season of calving and parity on 305-day milk yield expressed as deviation from yearly means for Bunaji and Sokoto Gudali breeds.

Source of variation	D.F.	Mean squares (kg^2) x (10^5)	F. value	Significant level
Main effects	11	13.66	6.51	0.001
Breed	1	2.59	1.24	0.27
Season	2	24.57	11.70	0.001
Parity	8	52.39	24.96	0.001
Residual	3093	2.10	-	-
Total	3104	2.23	-	-

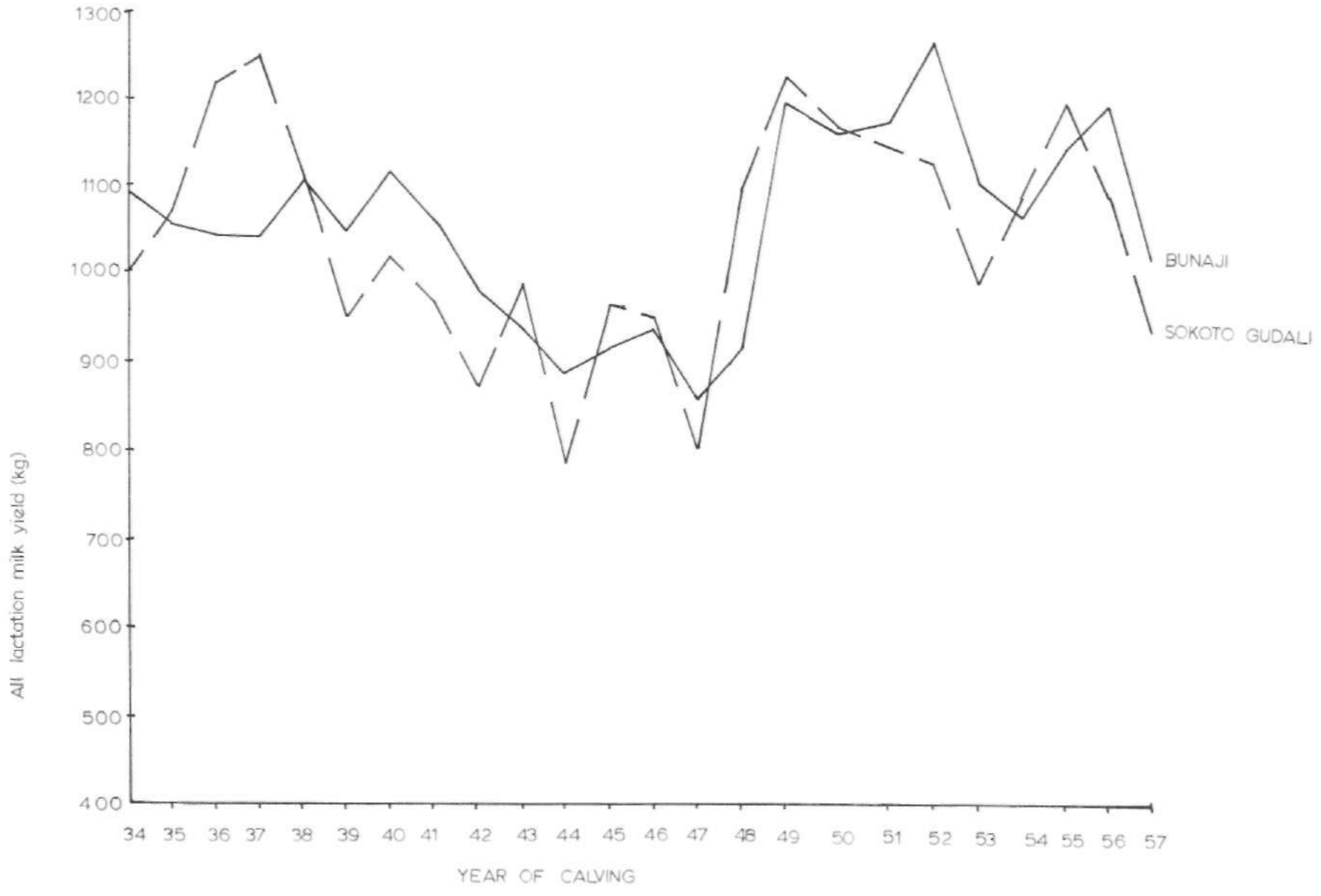


FIG 4. Yearly average all lactation 305-day milk yield for Bunaji and Sokoto Gudali breeds

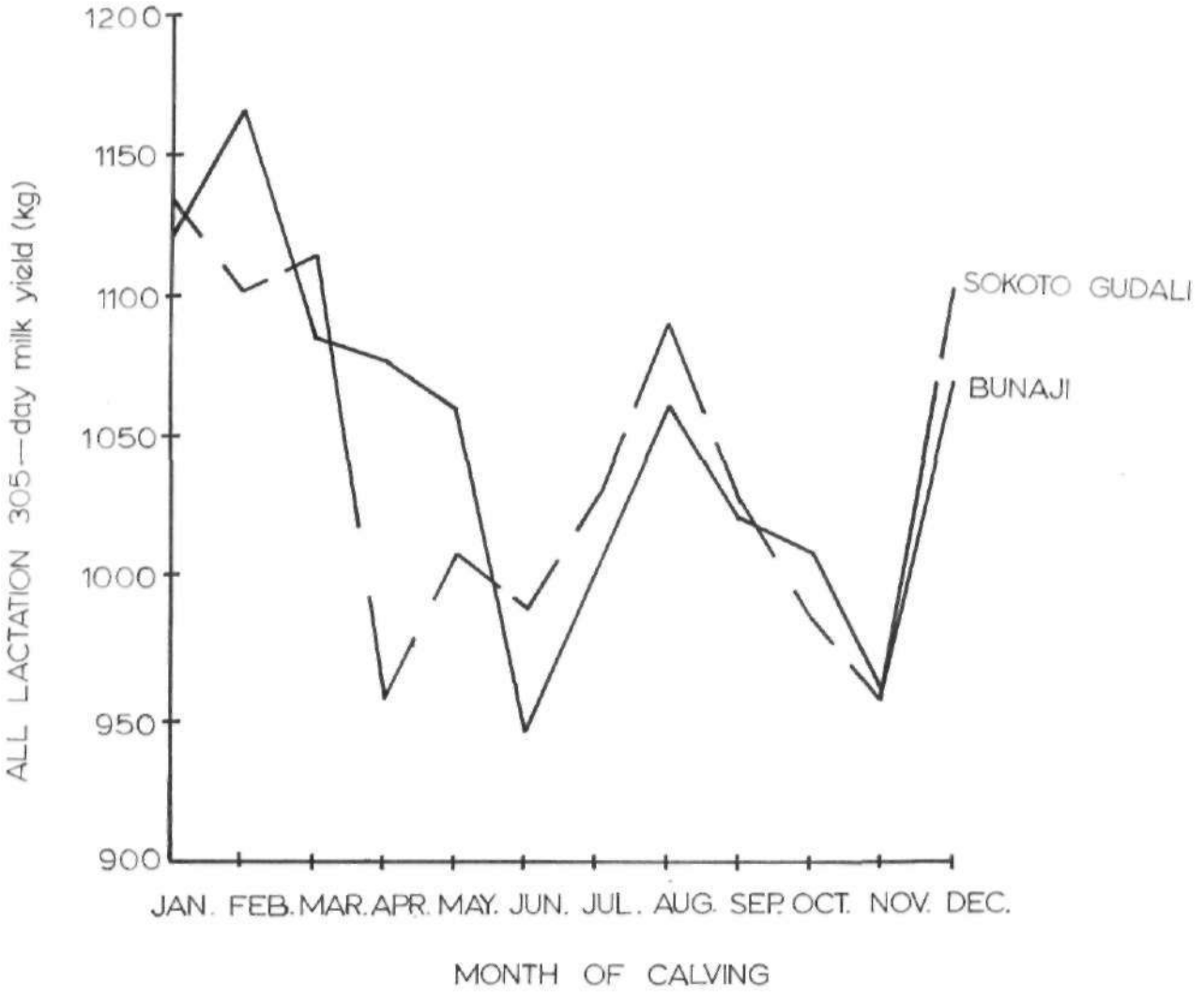


FIG. 5 Monthly average all lactation 305—day milk yield for Bunaji and Sokoto Gudali breed

earlier results, the season of calving was highly significant (P<0.001).

Other variance analyses for effects of year, month and parity on 305-day milk yield showed the three effects as being very highly significant (P<0.001) for Bunaji breed (Appendix 2, Table 7), but year and parity were not significant for Sokoto Gudali breed (Appendix 2, Table 8). The least squares estimates for Bunaji and Sokoto Gudali breeds, respectively for 305-day milk production are shown in Appendix 2, Tables 9 and 10. The average 305-day milk yield for all lactations grouped over the years and months respectively are presented in Figs. 4 and 5 for both breeds.

4.1.2.2. Discussion

The marked reduction in mean 305 day milk yield from 1942 to 1948 may be due to the poorer feed supply especially the available forage resulting from the effects of the prevailing weather condition in those years. The significant effects of year of calving and parity on 305-day milk yield found in this study is in accordance with the report of Johnson et al (1984) for both Bunaji and Sokoto Gudali breeds. The mean yields recorded in this study fall within the range 635 kg and 1130 kg reported for purebred zebu cattle (Armour et al., 1961; Knudsen and Sohael, 1970).

The least squares means for the effect of parity on 305-day milk yield showed a steady increase from parity one to nine except for parity seven where a decline occurred.

Milk yield is expected to rise from the first parity and peak at about the sixth lactation when a decline may set in, thus the observation in this study is as expected, but the increase in yield in parities eight and nine may be attributed to the markedly smaller numbers of animals in milk, the lower producing cows having been culled.

The effect of month of calving on milk yield revealed that with the exception of August, milk yields of the animals commencing lactation during June to November were lower than those of the animals commencing lactation in other months. It would appear that animals calving in the dry season had good nutrition during the latter part of the lactation. Since milk yield increased as lactation progressed, it appears that nutrition during the latter part of the lactation was more important than during the early part. The lower milk yield during June to November cannot be properly attributed to a lower persistency, because it was fluctuating and not steadily declining as would be expected in a declining persistency. It would thus be desirable to mate the cows such that they can calve in the dry season and be in a position to take advantage of the forage availability during the latter part of their lactation to boost the overall lactation milk yield.

The results indicated that both dry period and calving interval exerted significant effects on the 305 day milk yield when they were each included as a coveriate in the model.

This being the case, these effects should be adjusted for in order to properly appraise the 305 day milk yield. It is desirable to ensure that the dry period is not unduly long as this tends to reduce lactation length and eventually the milk yield. The calving interval as a dairy trait should be such that cows should calve yearly and not once in a year and half or even two years. A long calving interval leaves little room for a prolonged lactation, which should be desirable for profitable milk yield.

4.2. Yield per day of calving interval

4.2.1. Results

The analysis of variance for effects of breed, year, month and calving interval number is presented in Table 4.10. Results showed very highly significant effects ($P<0.001$) of year, month and calving interval on milk yield per day of calving interval, but the effect of breed was not significant ($P>0.05$).

The least squares estimates revealed that the overall milk yield per day of calving interval was 2.42 kg (Table 4.11). The milk yield varied from 1.87 kg in 1944 to 2.9 kg/day in 1937. Lower milk yield per day occurred in the years 1944, 1945 and 1947.

Considering the effects of months, milk yield per day varied from 2.2 kg/day in November to 2.7 kg/day in January.

Table 4.10. Analysis of variance for effects of breed, year, month of calving and calving interval number on milk yield per day of calving interval for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2)	F. value	Signi. level
Main effects	42	12.51	8.53	0.001
Breed	1	0.28	0.192	0.66
Year	23	10.86	7.41	0.001
Month	11	4.61	3.15	0.001
Calving interval Number	7	33.67	22.96	0.001
Residual	2519	1.47	-	-
Total	2561	1.65	-	-

Table 4.11. Estimated least squares constants and means for milk yield per day of calving interval for Bunaji and Sokoto Gudali breeds

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	2562	-	2.42	0.024
Year of calving:				
1934	68	0.190	2.61^{a}	0.147
1935	73	0.020	2.44^{b}	0.142
1936	94	0.394	2.81^{c}	0.125
1937	99	0.482	2.90^{d}	0.122
1938	105	0.470	2.89^{d}	0.118
1939	110	0.164	2.58^{e}	0.115
1940	89	0.372	2.79^{c}	0.128
1941	108	0.83	2.50^{f}	0.117
1942	103	0.034	2.45^{b}	0.119
1943	116	-0.194	2.23^{g}	0.112
1944	151	-0.553	1.87^{h}	0.098
1945	195	-0.454	1.97^{i}	0.087
1946	166	-0.339	2.08^{j}	0.094
1947	187	-0.433	1.99^{i}	0.089
1948	143	-0.259	2.16^{k}	0.101
1949	84	0.313	2.73^{d}	0.132
1950	76	0.059	2.48^{m}	0.139
1951	89	0.167	2.59^{e}	0.128
1952	119	0.204	2.62^{a}	0.111
1953	146	-0.106	2.31^{n}	0.100
1954	82	-0.198	2.22^{g}	0.134
1955	73	-0.259	2.16^{k}	0.142
1956	101	0.231	2.65^{p}	0.120
1957	45	-0.388	2.03^{q}	0.180
Month of Calving:				
January	211	0.250	2.67^{a}	0.083
February	160	0.219	2.64^{b}	0.096
March	171	0.228	2.65^{b}	0.093
April	201	-0.018	2.40^{c}	0.085
May	218	-0.064	2.36^{d}	0.082
June	203	-0.194	2.23^{e}	0.085
July	197	-0.094	2.33^{f}	0.086
August	228	0.025	2.45^{g}	0.081
September	274	-0.092	2.33^{f}	0.060
October	262	-0.158	2.26^{h}	0.075
November	233	-0.111	2.31^{f}	0.079
December	204	0.009	2.43^{g}	0.085
Calving interval number:				
1	735	-0.333	2.09^{a}	0.045
2	591	-0.085	2.34^{b}	0.050
3	433	0.215	2.64^{c}	0.058

Table 4.11 (Continued).

Class	Number of Animals	L.S.C.	Mean	S.E.
4	308	0.423	2.84^{cd}	0.069
5	226	0.529	2.95^{e}	0.081
6	153	0.317	2.74^{f}	0.098
7	83	0.505	2.93^{ef}	0.133
8	33	0.371	2.79^{f}	0.210
Breed of Animals:				
Bunaji	1831	0.012	2.43	0.028
Sokoto Gudali	731	-0.012	2.41	0.045

With variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Except for the sixth calving interval, milk yield per day increased from first to the seventh calving interval and dropped in the eight calving interval.

When separate variance analyses were computed for Bunaji and Sokoto Cudali breeds, results confirmed the very highly significant effects of year, and calving interval number on milk yield per day ($P<0.001$) for each breed, but the effect of month was very highly significant only for Bunaji ($P<0.001$) and not for Sokoto Gudali breed ($P>0.05$) (Appendix 3, Tables 11 and 12). The respective least squares estimates for milk yield per day for Bunaji and Sokoto Gudali breeds are shown in Appendix 3, Tables 13 and 14).

4.2.2. Discussion

The significance of milk yield per day of calving interval lies in its being the yield/day of herd life of a cow. A cow is non productive when it is dry. The dairy trait, calving interval includes both the milking and dry period.

The milk yield per day obtained in this study is higher than the value reported by Knudsen and Sohael (1970) (2.42 kg/day vs 2.29 kg/day), but it is within the recorded values for zebu cattle which ranged from 0.88 kg/day for Peul cattle and 4.87 kg/day for the Northern Sudan Shorthorn zebu (Galukande et al., 1962; Osman and EL Amin (1971). Kiwuwa et al (1983) reported values of 1.34 kg/day and 2.10 kg/day respectively for Arsi and Zebu cattle in East Africa.

4.3. Total milk yield

4.3.1. Results

The analysis of variance for effects of breed, year, month and parity on total milk yield with lactation length included as a covariate in the model is given in Table 4.12. Results show that the effects of breed, year, month and parity were all very highly significant ($P<0.001$). Results of the least squares estimates for total milk yield revealed that the overall mean was 1028.5 kg (Table 4.13). The total milk yield varied from 848 kg in 1947 to 1216 kg in 1949. The effect of month on total milk yield showed that total milk yield ranged from 948 kg in June to 1140 kg in February. The total milk yield increased steadily from 816 kg in the first parity to 1200 kg in the ninth parity except for the slight drop in the seventh parity. The breed effect on total milk yield revealed that the Sokoto Gudali breed gave 1038 kg while the Bunaji breed gave 1019 kg milk.

The inclusion of dry period as a covariate in the model made no difference on the significance levels of year, month and parity ($P<0.001$) (Table 4.14). Similarly, when calving interval was included as a covariate in the model for total milk yield, there were no changes in the significance levels of year, month and parity (Table 4.15).

4.3.2. Discussion

The average total milk yield obtained in the present study falls within the values reported in the literature which varied from 809 kg for Arsi to 1766 kg for Sokoto

Table 4.12. Analysis of variance for effects of breed, year and month of calving and parity with lactation length as covariate on total milk yield of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2) x (10^5)	F. value	Signi. level
Covariate				
Lactation length	1	6480.27	9447.02	0.001
Main effects	43	11.25	16.40	0.001
Breed	1	12.62	18.40	0.001
Year	23	11.36	16.56	0.001
Month	11	3.61	5.27	0.001
Parity	8	22.96	33.47	0.001
Residual	3321	0.69	-	-
Total	3365	2.75	-	-

Covariate lactation length b = 4.61

Table 4.13. Estimated least squares constants and means for total milk yield (kg) for Bunaji and Sokoto Gudali cattle

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	3366	-	1028.49	8.00
Year of calving:				
1934	65	79.61	1108.10[a]	50.41
1935	108	13.51	1042.00[b]	44.63
1936	120	47.61	1076.10[c]	42.35
1937	133	72.59	1101.08[a]	40.22
1938	135	72.62	1101.11[a,d]	39.91
1939	128	-24.89	1003.60[c]	41.00
1940	118	47.96	1076.45[c,e]	42.70
1941	149	-37.64	990.85[e,f]	37.98
1942	132	-71.45	957.04[f,g]	40.36
1943	165	-134.29	984.20[g,h]	36.09
1944	200	-178.12	850.37[g]	32.80
1945	171	-139.07	889.42[g,i]	35.45
1946	202	-95.34	933.15[h]	32.64
1947	226	-180.53	847.96[j]	30.85
1948	172	-84.13	944.36[j,k]	35.37
1949	102	187.64	1216.13[i]	45.92
1950	110	141.81	1170.30[m]	44.21
1951	148	97.91	1126.40[m]	38.11
1952	156	108.58	1137.07[d]	37.13
1953	174	-20.52	1007.97[d]	35.16
1954	106	-12.66	1015.83[c]	45.02
1955	134	48.79	1077.28[n]	40.05
1956	124	113.97	1142.46[j]	41.63
1957	67	-53.96	947.53[j]	56.62
Month of calving:				
January	283	102.40	1130.89[a]	27.57
February	223	111.58	1140.07[b]	31.06
March	231	47.35	1075.84[c]	30.51
April	265	4.93	1033.42[d]	28.49
May	281	-7.48	1021.01[e]	27.67
June	301	80.75	947.74[f]	26.73
July	246	-44.92	983.57[g]	29.58
August	297	16.07	1044.56[h]	26.92
September	352	-33.37	995.12[i]	24.72
October	318	-54.96	973.53[j]	26.01
November	285	-76.11	952.38[k]	27.47
December	283	15.26	1043.75[h]	27.57

Table 4.13 Contd.

Class	Number of Animals	L.S.C.	Mean	S.E.
Parity Number:				
1	804	-212.27	816.22[a]	16.35
2	735	-178.26	850.23[b]	17.11
3	591	-87.98	940.51[c]	19.08
4	433	-29.22	999.27[d]	22.28
5	308	69.91	1098.30[e]	26.42
6	226	139.34	1167.83[f]	30.85
7	153	9.71	1038.20[g]	37.49
8	83	117.08	1145.57[h]	50.90
9	33	171.79	1200.28[i]	80.79
Breed of Animals:				
Bunaji	2378	-9.60	1018.89[a]	9.51
Sokoto Gudali	988	9.60	1038.09[b]	14.75

Within variable groups, row means followed by the same letter do not differ significant (P>0.05). If no letter is used it indicates that the variable did not show a significant difference the analysis of variance.

Table 4.14. Analysis of variance for effects of breed, year and month of calving and parity with dry period as covariate on total milk yield of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2) x (10^6)	F. value	Signi. level
Covariate				
Dry period	1	79.84	399.01	0.001
Main effects	43	2.02	10.09	0.001
Breed	1	1.70	8.51	0.004
Year	23	1.68	8.41	0.001
Month	11	0.91	4.57	0.001
Parity	8	4.50	22.48	0.001
Residual	2686	0.20	-	-
Total	2730	0.26	-	-

Covariate dry period b = -0.97

Table 4.15. Analysis of variance for effects of breed, year and month of calving with calving interval as covariate on total milk yield of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2) x (10^5)	F. value	Signi. level
Covariate				
Calving interval	1	62.89	24.64	0.001
Main effects	35	14.37	5.63	0.001
Breed	1	0.89	0.35	0.55
Year	23	18.78	7.36	0.001
Month	11	6.94	2.72	0.002
Residual	2526	2.55	-	-
Total	2562	2.74	-	-

Covariate calving interval b = 0.32.

Cudali cattle (Kiwuwa et al., 1983; Foster, 1960). As the total milk yield and calving interval determine the magnitude of the milk yield per day of calving interval, it will be desirable to keep the total milk yield to be high as the genetic impulse can substain and maintain the calving interval to acceptable level.

The regression coefficient for the covariate lactation length of 4.6 kg indicated that the total milk yield was increasing by 4.6 kg per day of lactation over the lactation length. On the other hand, the regression coefficient for the covariate dry period which was -0.97 show that the total milk yield was decreasing by 0.97 kg per day of dry period. However, the covariate, calving interval show that the total milk yield was increasing by 0.33 kg for each day of calving interval.

4.4. Lactation length

4.4.1. Results

The analysis of variance for effects of breed, year, month and parity is shown in Table 4.16. There was no significant differences ($P>0.05$) for effect of breed, but the effects of year and parity were very highly significant ($P<0.001$), while the effect of month of calving were also highly significant ($P<0.003$).

The least squares estimates of lactation length is presented in Table 4.17. The average lactation length was 237.7 days.

Table 4.16. Analysis of variance for effects of breed, year and month of calving and parity number on lactation length of Bunaji and Sokoto Gudali cattle

Source of variation	D.F.	Mean squares (days^2) x (10^4)	F. value	Signi. level
Main effects	43	3.41	3.93	0.001
Breed	1	0.63	0.73	0.39
Year	23	2.93	3.38	0.001
Month	11	2.27	2.61	0.003
Parity number	8	6.61	7.62	0.001
Residual	3377	0.87	-	-
Total	3420	0.89	-	-

Table 4.17. Estimated least squares constants and means for lactation length of Bunaji and Sokoto Gudali breeds of cattle

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	3421	-	237.69	1.62
Year of calving:				
1934	86	18.71	256.40^{a}	10.21
1935	108	-8.75	228.94^{b}	9.11
1936	120	-11.95	225.74^{c}	8.64
1937	133	-13.45	224.24^{cd}	8.21
1938	135	-14.08	223.61^{e}	8.14
1939	128	-18.07	219.62^{b}	8.36
1940	118	-7.17	230.52^{c}	8.71
1941	149	-12.19	225.50^{f}	7.75
1942	132	7.51	245.20^{g}	8.23
1943	165	3.95	241.64^{h}	7.36
1944	200	10.50	248.19^{h}	6.69
1945	171	-7.49	230.20^{b}	7.23
1946	202	-8.30	229.39^{i}	6.66
1947	226	-23.75	213.94^{j}	6.29
1948	172	-1.69	236.00^{k}	7.21
1949	102	29.26	266.95^{l}	9.37
1950	110	27.01	264.70^{h}	9.02
1951	148	11.69	249.38^{h}	7.77
1952	156	11.78	249.47^{g}	7.57
1953	174	3.39	241.08^{b}	7.17
1954	106	-6.67	231.02^{m}	9.19
1955	134	-4.64	233.05^{l}	8.17
1956	124	27.12	264.81^{cd}	8.49
1957	122	-12.72	224.97	8.56
Lactation number:				
1	825	-13.87	223.82^{a}	3.29
2	751	-23.25	214.44^{b}	3.45
3	604	-19.48	218.21^{c}	3.85
4	436	-10.82	226.87^{d}	4.53
5	308	4.88	242.57^{e}	5.39
6	226	15.42	253.11^{f}	6.29
7	154	-1.67	236.02^{h}	7.62
8	84	19.78	257.47^{h}	10.32
9	33	29.01	266.70^{i}	16.45
Month of calving:				
1	283	17.06	254.75^{a}	5.62
2	223	9.35	247.04^{b}	6.34
3	233	5.54	243.23^{c}	6.20
4	273	-4.97	232.72^{d}	5.73
5	286	-4.93	232.76^{d}	5.59

Table 4.17. Contd.

Class	Number of Animals	L.S.C.	Mean	S.E.
Month of calving:				
6	307	-14.86	222.83^{e}_{d}	5.40
7	249	-4.04	233.65_{b}	6.00
8	302	11.27	248.96_{f}	5.44
9	356	-0.93	236.76_{d}	5.01
10	321	-3.42	234.27_{dg}	5.28
11	294	-6.24	231.45_{dh}	5.52
12	294	-3.83	233.86	5.52
Breed of Animals:				
Bunaji	2418	1.51	239.20	1.92
Sokoto Gudali	1003	-1.51	236.18	2.99

Within variable groups, row means followed by the same letter did not differ significantly ($P<0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

The results show that lactation length ranged from 213.9 days in 1947 to 266.9 days in 1949. The variation in lactation length which was important for lactation number varied from 214.4 days in the second parity to 266.7 days in parity nine. Thus higher parity tended to have longer lactation length except for the seventh parity. The effect of month of calving show that January to March had higher lactation length than April to December except for the month of August.

Analysis of variance for Bunaji and Sokoto Gudali breeds separately confirmed very highly significant effect ($P<0.001$), and significant effects ($P<0.03$) for year and parity for the respective breeds (Appendix 4, Tables 15 and 16), but not for the month of calving. The least squares estimates for the lactation length of Bunaji and Sokoto Gudali breeds are shown in Appendix 4, Tables 17 and 16, respectively.

When calving interval was included as a covariate in the model to investigate its effect on lactation length, it had no changes on the significance levels on the environmental factors (Tables 4.18 and 4.19).

The analysis of variance for effects of breed, year and month of calving on first lactation length showed that they had no significant effects on first lactation length ($P>0.05$) (Table 4.20). The least squares estimates for first lactation length was 221.64 days (Table 4.21). The

Table 4.18. Analysis of variance for effects of breed, year of calving and parity on lactation length with calving interval as covariance for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^3)	F. value	Signi. level
Covariate:				
Calving interval	1	81.90	10.22	0.001
Main effects	31	44.60	5.57	0.001
Breed	1	0.99	0.12	0.72
Year	23	36.05	4.50	0.001
Parity	7	77.76	9.71	0.001
Residual	2563	8.01	-	-
Total	2595	8.48	-	-

Covariate calving interval b = 0.04

Table 4.19. Analysis of variance for effects of breed, year and month of calving on lactation length with calving interval as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Signi. level
Covariate:				
Calving interval	1	8.20	10.03	0.002
Main effects	35	2.95	3.61	0.001
Breed	1	0.51	0.63	0.43
Year	23	3.63	4.51	0.001
Month	11	1.76	2.16	0.015
Residual	2559	0.82	-	-
Total	2595	0.85	—	-

Covariate: Calving interval b = 0.04.

Table 4.20. Analysis of variance for effects of breed, year and month of calving on first lactation length (days) for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Signi. level
Main effects	35	1.52	1.46	0.044
Breed	1	1.59	1.52	0.218
Year	23	1.54	1.48	0.070
Month	11	1.28	1.27	0.268
Residual	789	1.04	-	-
Total	824	1.06	-	-

Table 4.21. Estimated least squares constants and means for first lactation length for Bunaji and Sokoto Gudali breeds

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	825	-	221.64	3.56
Year of calving:				
1934	18	4.88	226.52	24.10
1935	35	24.26	245.9	17.26
1936	26	-0.042	221.60	20.04
1937	34	-17.61	204.03	17.53
1938	30	-2.89	218.75	18.65
1939	18	-5.53	216.11	24.10
1940	29	4.08	225.72	18.96
1941	41	-13.66	207.98	15.97
1942	29	-3.34	218.30	18.96
1943	49	-9.39	212.25	14.60
1944	49	15.55	237.19	14.60
1945	36	2.76	224.40	17.03
1946	36	-8.39	213.25	17.03
1947	39	9.18	230.82	16.38
1948	29	70.39	292.03	18.96
1949	18	-22.33	199.31	24.10
1950	34	22.04	243.68	17.53
1951	59	10.93	222.57	13.30
1952	37	-26.66	194.98	16.81
1953	28	-55.95	165.69	19.32
1954	24	-7.52	214.12	20.85
1955	61	-3.14	218.50	13.08
1956	23	18.77	240.41	21.29
1957	43	-6.39	215.25	15.58
Month of calving:				
January	72	13.28	234.92	12.04
February	63	32.41	254.05	12.87
March	61	-3.25	218.39	13.08
April	67	2.10	223.74	12.48
May	65	2.75	224.39	12.68
June	99	-20.63	201.01	10.27
July	50	11.67	209.97	14.45
August	72	11.88	233.52	12.04
September	80	-8.62	213.02	11.43
October	56	-8.72	212.92	13.66
November	56	-9.82	211.82	13.66
December	84	0.29	221.93	11.14
Breed of Animals:				
Bunaji	563	4.88	226.52	4.31
Sokoto Gudali	262	-4.88	216.76	6.31

Within variable groups row means followed by the same letter do not differ significantly (P>0.05). If no letter is used it indicates that the variable did not show a significant difference in the analysis of variance.

lactation length was therefore increasing with later milk production. The average lactation length grouped by years and months are presented respectively in Figs 6 and 7.

4.4.2. Discussion

The lactation length recorded in the present investigation is of the order recorded by Johnson et al (1984) for all lactation and also for first lactation. The least squares means for lactation length is also within the range recorded for zebu which varied from 224 days for Kenana (Alim, 1960) to 294 days for the Northern shorthorz zebu (Osman and EL Amin, 1971).

Thus considering all the results for the lactation traits, i.e. milk yield,lactation length and milk yield per day of calving interval, it appears that the higher milk yield and milk yield per day of calving interval are due to an increase in lactation length for cows calving during the months of December to May. If this observation is true, then the inclusion of lactation length as a covariate in the milk yield model should decrease the significance of the month of calving or make it non-significant.

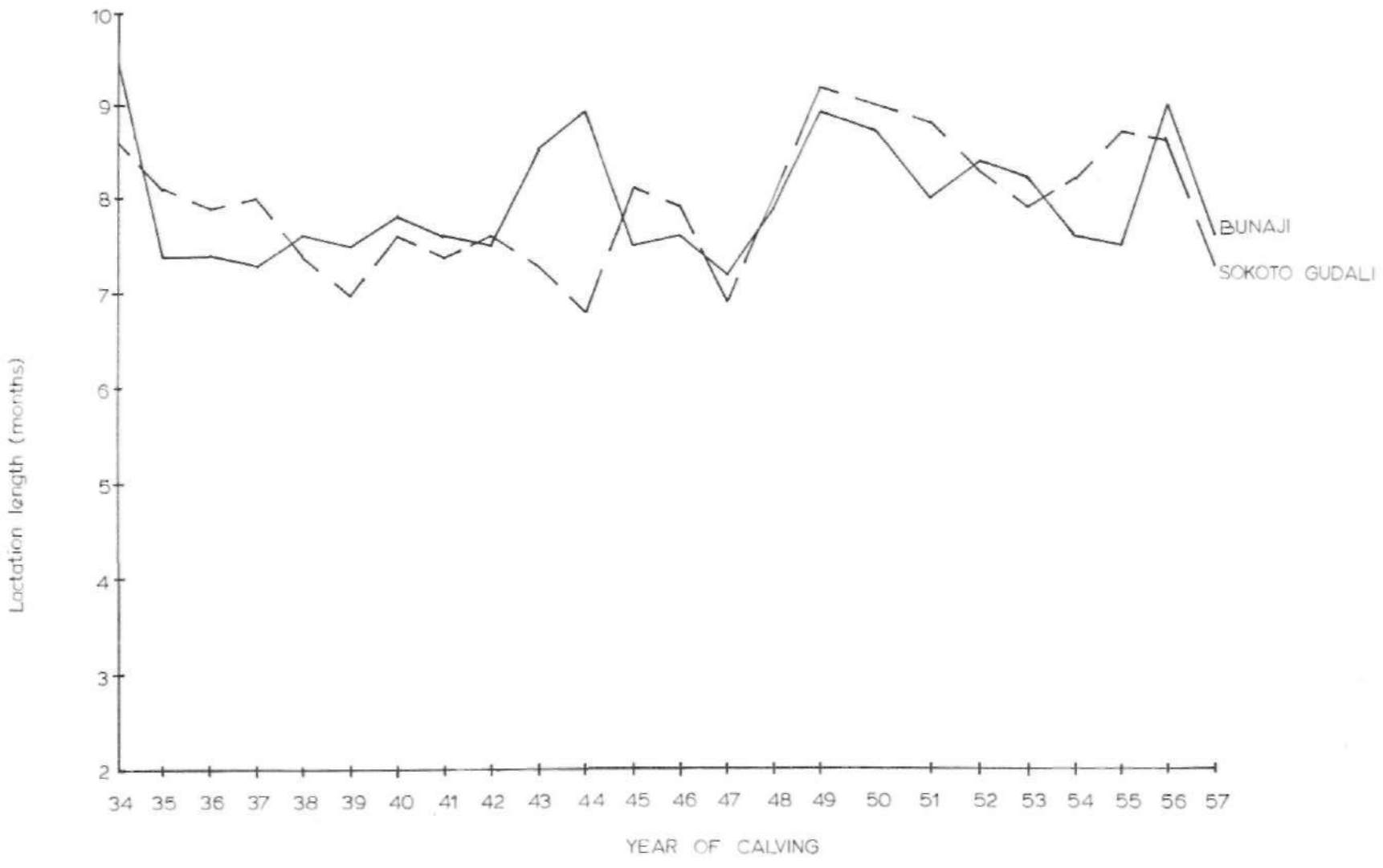


FIG. 6 Yearly average lactation length for Bunaji and Sokoto Gudali breeds.

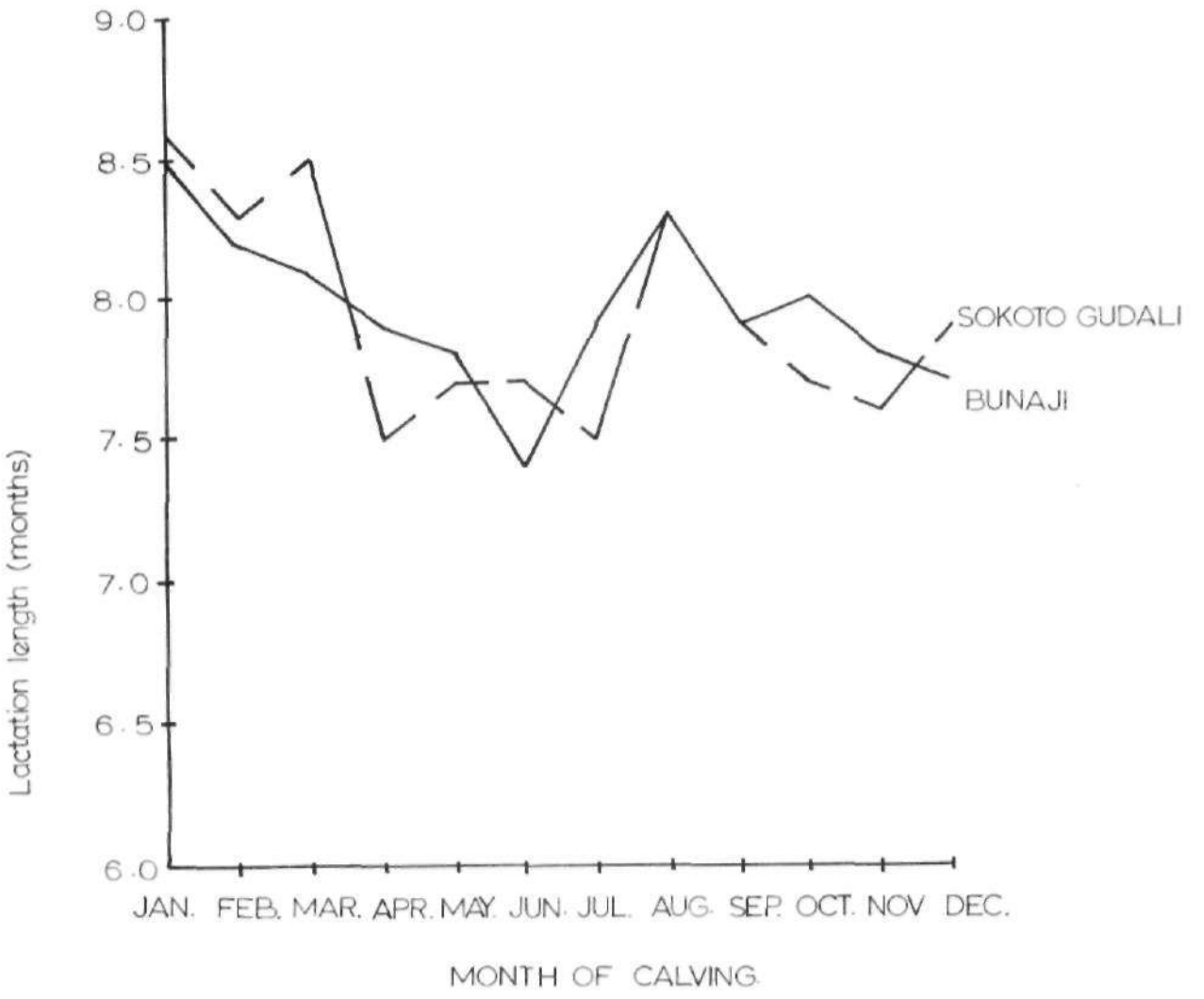


FIG. 7 Monthly average lactation length for Bunaji and Sokoto Gudali breeds

REPRODUCTIVE TRAITS

5.1. Distribution of calvings

5.1.1. Results

The distribution of all calvings in each parity covering a period of twenty-four years which included a total of 2378 calvings for Bunaji breed and 989 calvings for Sokoto Gudali breed is presented respectively in that order in Tables 5.1 and 5.2. In both breeds, the overall calvings over all the years declined from parity one to nine.

5.2. Frequency of calvings for the breeds

5.2.1. Results

The frequency of calvings which was for only normal calvings and comprised a total of 2177 and 928 calvings for Bunaji and Sokoto Gudali breeds respectively is given for first and all calvings by year of calving in Tables 5.3 and 5.4.

Calvings were not equally distributed across the years. Considering first calvings only, Chi-square tests showed a significant deviation ($P<0.05$) from expectations based on equal number of calvings during the different years, with higher trend for 1941, 1944, 1947 and 1955. For all calvings, a significant deviation ($P<0.05$) was also manifested by Chi-square tests from the expectations on the basis of equal number of calvings during the different years 1944 to 1948 also for Bunaji breed, with a higher trend being shown.

Table 5.1. Distribution of parity numbers by year of calving for Eunaji breed.

Year of calving	Parity numbers								
	1	2	3	4	5	6	7	8	9
1934	10	22	19	10	1	3	–	–	–
1935	22	14	15	15	5	2	2	–	–
1936	21	26	12	15	8	4	1	–	–
1937	27	16	22	9	11	4	4	–	–
1938	15	25	11	16	8	11	3	2	1
1939	7	12	19	11	14	5	8	2	–
1940	21	5	11	15	9	13	6	2	–
1941	33	32	5	9	12	10	7	5	–
1942	20	28	23	5	8	7	5	3	2
1943	28	18	31	18	2	9	2	2	2
1944	33	25	20	32	15	5	11	3	–
1945	20	29	18	12	24	9	3	5	–
1946	22	36	37	13	9	20	9	–	–
1947	31	22	33	42	9	6	15	6	1
1948	20	22	18	21	22	9	5	8	–
1949	9	16	14	6	10	11	3	3	2
1950	20	13	7	7	3	4	9	2	1
1951	40	17	14	9	5	2	3	3	1
1952	29	35	10	10	7	6	2	7	2
1953	24	33	31	12	10	5	3	–	2
1954	18	13	14	15	6	3	4	1	3
1955	45	12	8	11	13	7	3	3	1
1956	17	31	7	6	10	7	5	3	2
1957	15	6	11	3	2	6	5	2	–
Overal-2378	547	508	410	322	223	168	118	62	20

Table 5.2. Distribution of parity numbers by year of calving for Sokoto Gudali breed

Year of calving	Parity numbers								
	1	2	3	4	5	6	7	8	9
1934	8	9	4	-	-	-	-	-	-
1935	13	9	9	2	-	-	-	-	-
1936	5	11	9	6	2	-	-	-	-
1937	7	5	12	9	6	1	-	-	-
1938	15	7	3	9	5	3	1	-	-
1939	11	15	8	3	7	5	1	-	-
1940	8	9	5	5	5	5	-	-	-
1941	8	7	8	3	3	5	2	-	-
1942	9	6	5	3	1	3	3	1	-
1943	21	12	7	3	3	-	3	2	2
1944	16	14	9	4	5	3	1	2	2
1945	16	9	9	7	2	3	2	2	1
1946	14	13	8	4	8	3	4	1	1
1947	8	18	14	7	3	6	1	4	-
1948	9	9	12	8	4	1	2	1	1
1949	9	5	6	4	2	-	1	-	1
1950	14	12	4	3	9	1	-	1	-
1951	19	10	11	4	2	8	-	-	-
1952	8	15	10	7	4	2	2	-	-
1953	4	9	16	9	5	3	7	1	-
1954	6	2	2	7	3	3	2	3	1
1955	16	5	2	2	2	-	1	2	1
1956	6	15	3	2	4	2	-	1	3
1957	7	1	5	-	-	2	2	-	-
Overall 989	257	227	181	111	85	59	35	21	13

Table 5.3. Frequency of calvings for first and all calvings grouped by year of calving for Bunaji breed

Year	First calving		All calvings	
	Number of calvings	Percentage of first calving	Number of calvings	Percentage of all calvings
1934	10	2.2	64	2.9
1935	20	4.3	70	3.2
1936	20	4.3	84	3.9
1937	27	5.8	92	4.2
1938	15	3.2	91	4.2
1939	7	1.5	78	3.6
1940	21	4.6	80	3.7
1941	33	7.1	109	5.0
1942	19	4.1	100	4.6
1943	27	5.8	108	5.0
1944	30	6.5	141	6.5
1945	20	4.3	115	5.3
1946	21	4.6	140	6.4
1947	29	6.3	156	7.2
1948	14	3.0	114	5.2
1949	9	2.0	70	3.2
1950	11	2.4	56	2.6
1951	15	3.2	47	2.2
1952	20	4.3	89	4.0
1953	17	3.7	103	4.7
1954	17	3.7	64	2.9
1955	38	8.8	93	4.3
1956	13	2.8	82	3.8
1957	9	2.0	31	1.4
Total	462	100	2177	100

Table 5.4. Frequency of calvings for first and all calvings grouped by year of calving for Sokoto Gudali breed

Year	First calving		All calvings	
	Number of calvings	Percentage first calvings	Number of calvings	Percentage of all calvings
1934	8	3.3	20	2.2
1935	13	5.4	32	3.4
1936	5	2.1	32	3.4
1937	7	2.9	40	4.3
1938	15	6.2	43	4.6
1939	11	4.6	49	5.3
1940	8	3.3	35	3.8
1941	8	3.3	36	3.9
1942	9	3.7	31	3.3
1943	21	8.7	52	5.6
1944	14	5.8	52	5.6
1945	14	5.8	46	5.0
1946	14	5.8	51	5.5
1947	8	3.3	59	6.4
1948	8	3.3	40	4.3
1949	7	2.9	26	2.8
1950	13	5.4	41	4.4
1951	19	7.9	53	5.7
1952	5	2.1	42	4.5
1953	3	1.2	47	5.1
1954	6	2.5	26	2.8
1955	15	6.2	29	3.1
1956	6	2.5	34	3.7
1957	4	1.7	12	1.3
	241		928	

The same pattern was observed for the Sokoto Gudali breed, as Chi-square tests showed a significant deviation ($P<0.05$) from the expectations based on equal number of calvings during the different years for both first calvings and all calvings, with the years 1943 and 1951 being higher for first calvings while 1943 to 1947 and 1951 were higher for all calvings.

The frequency of calvings for first and all calvings grouped by month of calving is shown for Bunaji and Sokoto Gudali cows in that order in Tables 5.5 and 5.6.

Although calvings occurred throughout the year, monthly proportions were not equal. Chi-square analysis showed significant deviations ($P<0.05$) from expectations for first calvings and all calvings for both the Bunaji and Sokoto Gudali cows. In general calvings were greater during the months September to January indicating more conception during the dry season.

5.2.2. Discussion

The trend observed between the years, of a decline in the distribution of calvings may be due partly to the introduction of animals which had their earlier parity [illegible], and the culling of cows that failed to conceive [illegible] consecutive years [illegible]

[illegible] monthly proportions over the years is a reflection of the effects of season on calvings. The trend which pointed to more conception during the dry season as [illegible] calvings

Table 5.5. Frequency of calvings for first and all calvings grouped by month of calving for Bunaji breed

Month	First calving		All calvings	
	Number of calvings	Percentage of first calving	Number of calvings	Percentage of all calvings
January	46	10.1	182	8.4
February	32	6.9	146	6.7
March	29	6.3	149	6.8
April	33	7.1	192	8.8
May	36	7.8	179	8.2
June	57	12.3	194	8.9
July	30	6.5	161	7.4
August	33	7.1	165	7.6
September	48	10.4	224	10.3
October	31	6.7	212	9.7
November	36	7.8	191	8.8
December	51	11.0	182	8.4
	452		2177	

Table 5.6. Frequency of calvings for first and all calvings grouped by month of calving for Sokoto Gudali breed

Month	First calving		All calvings	
	Number of calvings	Percentage of first calvings	Number of calvings	Percentage of all calvings
January	20	8.3	76	8.2
February	25	10.4	62	6.7
March	22	9.1	66	7.1
April	21	8.7	57	6.1
May	20	8.3	84	9.1
June	25	10.4	79	8.5
July	14	5.8	66	7.1
August	27	11.2	104	11.2
September	18	7.5	92	9.9
October	20	8.3	85	9.2
November	9	3.7	79	8.5
December	20	8.3	78	8.4
	241		928	

during September to January is a management strategy which will ensure that during the wet season, the cows would be able to maximise the available fodder to augment both milk production and body growth while the calves would be able to express their genetic impulse for growth during their preweaning period.

5.3. Age at first calving

5.3.1. Results

The analysis of variance for effects of year and month of calving as well as breed on age at first calving is given in Table 5.7. Results showed that there were highly significant differences ($P<0.001$) for year of calving only but not for month of calving ($P>0.05$), while the effect of breed on age at first calving only approached significant level ($P<0.06$).

The least squares mean estimates for age at first calving is presented in Table 5.8. The overall mean age at first calving for the 825 cows was 46.2 months (1386.12 days), while the mean age was 45.7 and 46.7 months respectively for Bunaji and Sokoto Gudali cows. The effect of year indicated that age at first calving ranged from 40.2 months in 1936 to 52.4 months in 1953.

Table 5.7. Analysis of variance for effects of breed, year and month of calving on age at first calving for Bunaji and Sokoto Gudali cattle

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Significance level
Main effects	35	29.64	5.94	0.001
Year	23	40.01	8.01	0.001
Month	11	6.08	1.22	0.27
Breed	1	17.65	3.54	0.06
Residual	789	4.99	-	-
Total	824	6.04	-	-

(P<0.001) = Significance at 1% level.

Table 5.8. Estimated least squares constants (L.S.C.) and means (days) for age at first calving for Bunaji and Sokoto Gudali cattle

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	825	-	1386.12	7.80
Year of calving:				
1934	5	-16.26	1369.86[a]	99.75
1935	22	-42.59	1343.53[b]	47.64
1936	24	-178.81	1207.31[c]	45.60
1937	32	-69.94	1316.18[d]	39.48
1938	33	-120.37	1265.75[e]	38.93
1939	19	-120.25	1265.87[f]	51.25
1940	32	-80.88	1305.24[b]	39.48
1941	44	-49.89	1336.23[f]	33.70
1942	33	-82.84	1303.28[g]	38.93
1943	47	-108.71	1277.41[h]	32.57
1944	49	-59.24	1326.88[i]	31.92
1945	34	88.11	1474.23[j]	38.32
1946	31	37.23	1423.35[b]	40.11
1947	35	44.05	1342.07[k]	37.74
1948	35	-156.76	1229.36[k]	37.74
1949	26	18.83	1404.95[l]	43.81
1950	36	60.97	1447.09[l]	37.24
1951	61	63.17	1449.29[m]	28.61
1952	37	174.13	1560.25[n]	36.75
1953	30	186.33	1572.45[p]	40.77
1954	26	236.96	1623.08[l]	43.81
1955	63	67.11	1453.23[lq]	28.14
1956	23	70.39	1456.51[r]	46.55
1957	48	127.36	1513.48	32.24
Month of calving:				
January	72	-46.47	1339.65	26.32
February	54	-55.53	1330.59	30.40
March	61	-4.65	1381.47	28.61
April	68	-26.72	1359.40	27.08
May	60	45.61	1431.73	28.83
June	95	0.30	1386.42	22.92
July	52	27.42	1413.54	30.99
August	76	16.51	1402.63	25.62
September	85	-17.85	1368.27	24.23
October	61	35.91	1422.03	28.61
November	55	25.61	1411.73	30.11
December	85	-0.14	1385.98	24.23
Breed of Animals:				
Bunaji	579	-16.70	1369.42	9.29
Sokoto Gudali	246	16.70	1402.82	14.25

Within variable groups row means followed by the same letter do not differ significantly (P>0.05). If no letter is used it indicates the variable group did not show a significant difference in the analysis of variance.

Table 5.9. Results indicated very highly significant effects ($P<0.001$) for dam-year of birth only, while the effects of breed and dam-month of birth were not significant ($P>0.05$). The least squares estimates for effects of dam-year, dam-month of birth and breed on age at first calving is shown in Table 5.10. The important factor here is the available pasture which varies from year to year due to the fluctuation of water precipitation. The effect of dam-year of birth on age at first calving showed that the overall age was 46.2 months. The range was 41.2 months in 1933 to 53.8 months in 1950. The effect of dam-year of birth resulted in age at first calving of 45.8 months and 46.5 months respectively for Bunaji and Sokoto Gudali cows. The average age at first calving pooled over years and months respectively for Bunaji and Sokoto Gudali breeds are given in Figs. 8 and 9.

5.3.2. Discussion

The recorded age at first calving for the two breeds in this study falls within the values of 42 months and 50 months recorded by other workers for Bunaji breed (Wheat et al., 1972; Armour et al., 1961) and 43 months recorded for Sokoto Gudali cattle (Wheat and Broadhurst (1972). Mahadevan (1966) observed that irrespective of whether cattle were of Asian, African, European or crossbred origin, their mean age at first calving under a given tropical environment was essentially the same and basically ranged from 3 to 4 years. However, the higher range of age at first calving occuring more in the later years could be partly attributed to reduced availability of supple-

Table 5.9. Analysis of variance for effects of breed, dam-year and dam-month of birth on age at first calving for Bunaji and Sokoto Gudali breeds

Source of variation	d.f.	Mean squares (days^2)x(10^1)	F. value	Significance level
Main effects	33	28.21	5.47	0.001
Breed	1	10.11	1.96	0.16
Dam-year	21	41.77	8.10	0.001
Dam-month	11	3.85	0.75	0.69
Residual	766	5.16	-	-
Total	799	6.11	-	-

(P<0.001) = Significance at 1%

Table 5.10. Estimated least squares constants and means (days) for age at first calving of Bunaji and Sokoto Gudali cattle

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	800	-	1384.60	8.00
Dam year of birth:				
1932	19	-106.02	1278.58[g]	51.89
1933	29	-133.04	1251.56[b]	41.98
1934	37	-95.39	1289.21[c]	37.21
1935	25	-116.01	1268.59[d]	45.25
1936	29	-39.79	1344.81[e]	41.98
1937	42	-96.35	1288.25[c]	34.92
1938	31	-80.31	1305.29[f]	40.62
1939	41	-101.63	1282.97[c]	35.35
1940	55	-75.38	1309.22[f]	30.49
1941	46	57.35	1441.95[g]	33.37
1942	26	8.84	1393.44[h]	44.36
1943	27	-47.74	1336.86[i]	43.31
1944	40	-109.80	1274.80[ad]	35.80
1945	32	128.79	1513.39[j]	39.97
1946	48	60.11	1444.71[g]	32.65
1947	52	42.95	1427.55[k]	31.38
1948	49	95.85	1480.45[l]	32.32
1949	31	223.14	1607.74[m]	40.62
1950	32	229.03	1613.63[m]	39.97
1951	31	162.37	1546.97[n]	40.62
1952	42	28.19	1412.79[p]	34.92
1953	36	-35.16	1349.44[e]	37.71
Dam month of birth:				
January	62	-21.50	1363.10	28.75
February	50	-37.87	1346.73	32.00
March	62	-26.71	1357.89	28.75
April	77	-11.02	1373.58	25.77
May	86	31.30	1415.90	24.41
June	61	-15.10	1369.50	28.97
July	42	16.29	1400.89	34.92
August	67	38.89	1423.49	27.63
September	80	17.62	1402.22	25.31
October	82	-3.42	1381.18	24.97
November	64	-1.57	1383.03	28.28
December	67	13.09	1397.69	27.63
Breed of Animals:				
Bunaji	556	-11.70	1372.90	9.60
Sokoto Gudali	244	11.70	1396.30	14.49

Within variable groups, row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

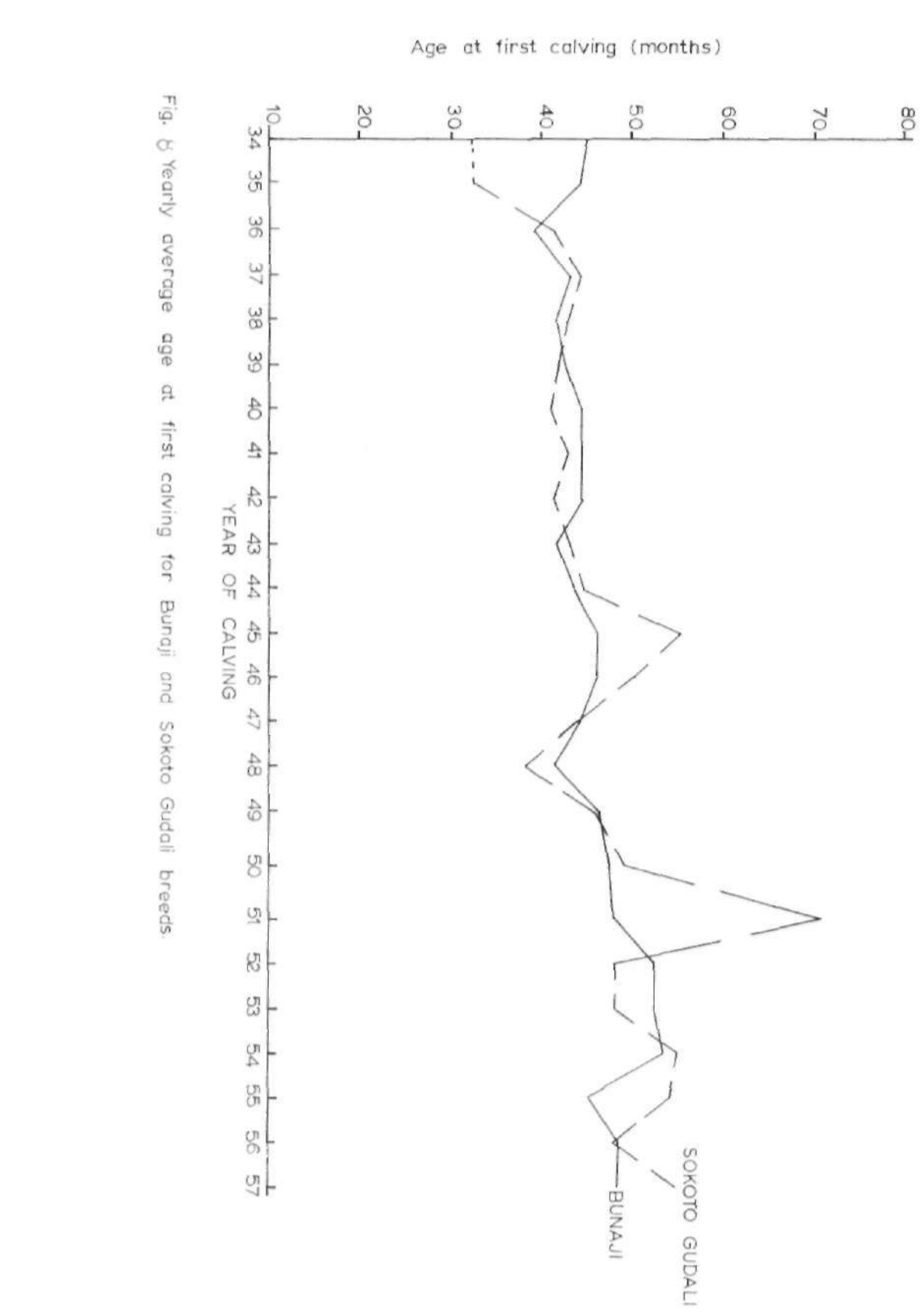


Fig. 6 Yearly average age at first calving for Bunaji and Sokoto Gudali breeds.

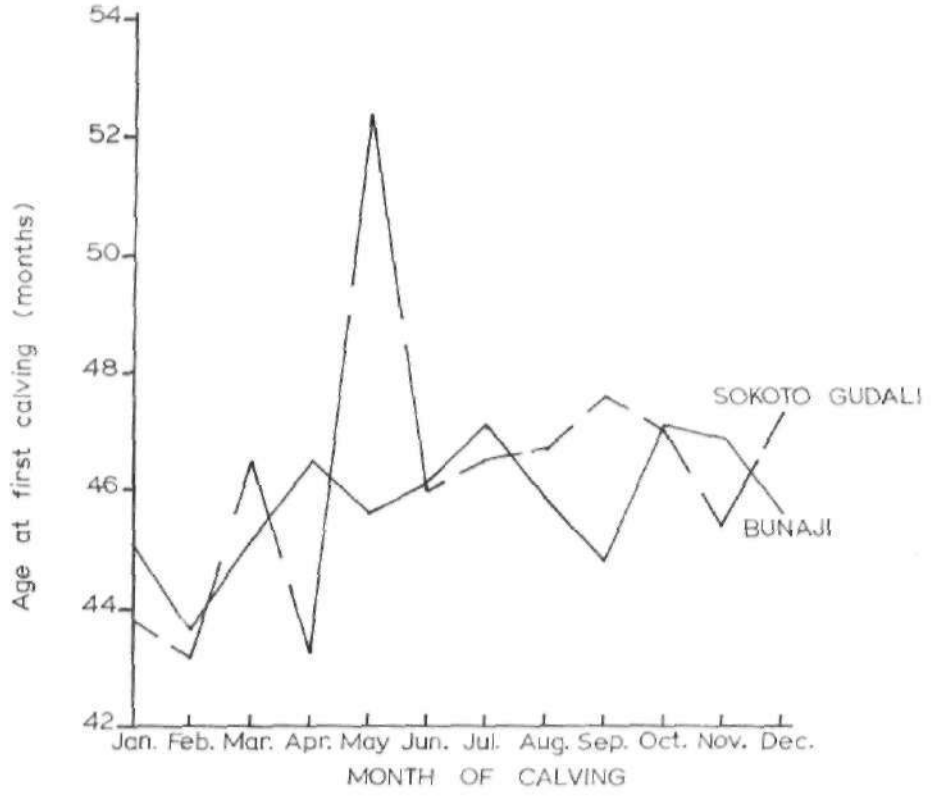


Fig 9 Monthly average age at first calving for Bunaji and Sokoto Gudali breeds.

-mentary feed, poor quality roughage, poor reproductive performance resulting from inbreeding which have a resultant effect of heifers conceiving late or having no conception at the first oestrous manifestation as well as heifers not possessing the body size to enhance sustaining conception. Attempt to reduce the age at first calving is a worthwhile venture which would increase the overall productive life of a cow in a herd and improve the production in the animal industry.

5.4. Effect of age on milk production

The effect of age on milk production was studied using gross comparison and paired lactation comparison methods. The effect of age on milk yield was also investigated by expressing later lactation records and the deviated later lactation milk records from year means as a percentage of the first records of the same cows. The correlation between the lactation number and the actual age in years at which the particular lactation is initiated would be quite high for biological reasons, nevertheless, this situation may not prevail where age at different calvings varies remarkably.

5.4.1. Cross comparison

5.4.1.1. Results

The gross comparison of milk yield in different lactations which was expressed as a percentage of first lactation for Bunaji cows is given in Table 5.11, while that for Sokoto Gudali cows is shown in Table 5.12. For both breeds, the results

Table 5.11. Milk yield in different lactations expressed as a percentage of production in the first lactation for Bunaji breed

Cross comparison

Lactation number	Number of records	Actual yield (kg)	Percentage of first lactation	Average age at calving (months)
1	462	810.0	100	45.9
2	470	829.6	102.4	59.8
3	379	913.7	112.8	73.3
4	304	960.0	118.5	86.5
5	213	1076.8	132.9	99.5
6	160	1119.9	138.3	112.8
7	112	1031.2	127.3	126.2
8	58	1159.1	143.1	139.5
9	19	1354.7	167.2	155.9

Table 5.12. Milk yield in different lactations expressed as a percentage of production in the first lactation for Sokoto Gudali breed

Gross Comparison

Lactation Number	Number of records	Actual yield (kg)	Percentage of first lactation	Average age at calving (month)
1	241	833.6	100	46.7
2	216	861.3	103.3	60.7
3	167	956	114.8	73.8
4	108	986.4	118.3	86.8
5	77	1119.5	134.3	100.1
6	57	1206.3	144.7	113.6
7	30	1040.8	124.9	127.8
8	19	1034.7	124.1	141.3
9	13	1040.1	124.8	154.9

showed a steady increase up to lactation number six and was followed by a decline in lactation, for Bunaji cows, while the Sokoto Gudali cows after the increase up to the sixth lactation, there was a decline which was constant up to lactation nine.

5.4.2. Paired comparison

5.4.2.1. Results

The paired lactation comparison for milk yield in different lactations expressed as a percentage of the first lactation production for Bunaji cows is presented in Table 5.13, while that for Sokoto Gudali cows is given in Table 5.14. The paired comparison indicated a decline from second lactation to ninth with a slight change in the third lactation for both breeds.

5.4.3. Expressing later records as a percentage of their first records

5.4.3.1. Results

Milk production in later lactations expressed as a percentage of their first lactation is given for Bunaji and Sokoto Gudali cows respectively in Tables 5.15 and 5.16. In the case of Bunaji cows, there was an initial peak in the third lactation with an increase of 2.96% the other peaks were in the sixth and eighth lactations with increases of 5.7% and 9%, respectively. With regard to the Sokoto Gudali cows there were variable peaks in the third and sixth lactations. The correction factors for this method of age adjustment are shown for each breed in the requisite Tables.

Table 5.13. Milk yield in different lactations expressed as a percentage of production in the first lactation for Sokoto Gudali cattle

Paired lactation comparison

Lactation number	Number of records	Mean yield (kg)	Percentage	Multiplicative factor
1	241	911.1	100	-
2	180	858.3	94.2	0.94
3	146	968.5	96.1	1.02
4	104	980.4	84.6	0.88
5	70	1112.9	85.4	1.01
6	52	1204.0	81.1	0.95
7	17	1043.7	65.7	0.81
8	17	1082.4	63.1	0.96
9	9	1039.4	55.5	0.88

Table 5.14. Milk yield in different lactations expressed as a percentage of production in the first lactation for Sunaji cattle

Paired lactation comparison

Lactation number	Number of records	Mean yield (kg)	Percentage	Multiplicative factor
1	462	839.2	100	-
2	367	802.9	95.7	0.96
3	329	907.1	97.9	1.02
4	275	944.2	94.0	0.96
5	200	1075.9	94.9	1.01
6	141	1105.5	91.1	0.96
7	104	1012.0	81.1	0.89
8	52	1145.7	77.1	0.95
9	16	1393.2	75.5	0.98

Table 5.15. 305 day lactation milk yield expressed as a percentage of first lactation milk of the same cows for Bunaji cattle

Lactation number	Number of Animals	Percentage of first lactation	Correction factors
1	462	100.00	1.00
2	367	95.67	1.04
3	275	102.96	0.97
4	219	93.84	1.06
5	150	102.98	0.97
6	114	105.71	0.94
7	83	99.57	1.00
8	47	108.99	0.92
9	15	107.11	0.93

Table 5.16. 305 day lactation milk yield expressed as a percentage of first lactation milk yield of the same cows for Sokoto Gudali cattle

Lactation number	Number of Animals	Percentage of first lactation	Correction factors
1	241	100.00	1.00
2	180	94.20	1.06
3	132	97.92	1.02
4	83	86.95	1.15
5	59	91.89	1.09
6	44	94.34	1.06
7	25	78.16	1.28
8	17	80.71	1.24
9	13	75.39	1.32

5.4.4. Expressing deviated later records as a percentage of their first records

5.4.4.1. Results

Milk yield records deviated from the years' means and expressed as a percentage of their first records are presented in Tables 5.17 and 5.18 for Bunaji and Sokoto Gudali cows, respectively. For both breeds of cows, there were peaks in the third, sixth and eighth lactations. The adjustment factors by this method of correction for age are presented in the Tables for each breed.

The milk production in successive lactations expressed in different ways relative to the milk yield in the first lactations are shown in Figs. 10 and 11 for Bunaji and Sokoto Gudali cows respectively.

5.4.5. Discussion

In the gross comparison method of age adjustment for milk yield, the peak attained in the sixth lactation for Sokoto Gudali gave an increase of 45% over the first milk yield, thereafter a decline was observed. However, for the Bunaji cows a peak also obtained in the sixth lactation had an increase of 38% over the first milk yield, with another peak in the ninth lactation with an increase of 67% over the first milk yield. This situation differs much from the expected lactation curve based on the physiological expression of growth and senescence. The age correction by the gross comparison gave an indication of a rise in milk yield at an ever increasing rate for both Bunaji and Sokoto Gudali cows up to the sixth lactation, thereafter a drop in the seventh

Table 5.17. 305 day lactation milk yield deviated for year differences and expressed as a percentage of first lactation for Bunaji cattle

Lactation number	Number of Animals	Percentage of first lactation	Correction factors
1	462	100.00	1.00
2	367	95.74	1.04
3	279	103.52	0.97
4	218	100.21	0.99
5	150	103.11	0.97
6	114	104.75	0.95
7	83	101.71	0.98
8	47	106.72	0.94
9	14	92.92	1.07

Table 5.18. 305 day lactation milk yield deviated for year differences and expressed as a percentage of first lactation for Sokoto Gudali cattle

Lactation number	Number of Animals	Percentage of first lactation	Correction factors
1	241	100.00	1.00
2	179	93.85	1.07
3	132	97.82	1.02
4	83	85.25	1.17
5	59	89.55	1.12
6	44	93.33	1.07
7	25	79.53	1.26
8	17	85.63	1.17
9	13	76.38	1.31

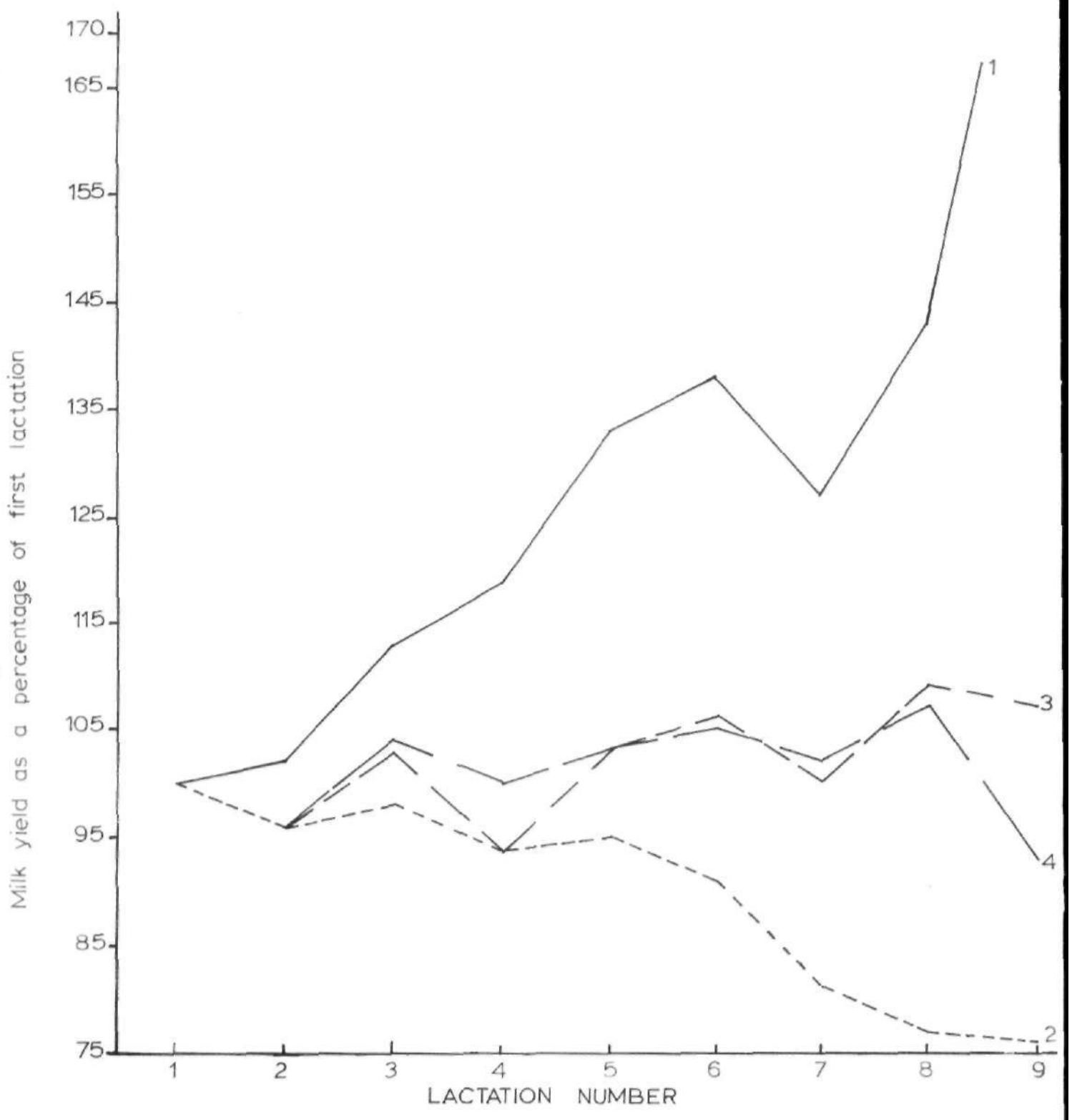


Fig. 10: Milk production in successive lactations expressed in different ways relative to the yield in the first lactation for Bunaji breed.

1. Gross lactation comparison. 2. Paired lactation comparison.
3. Later lactation records expressed as percentage of the first record of same cows.
4. Deviated later lactation records expressed as percentage of the first record of the same cows.

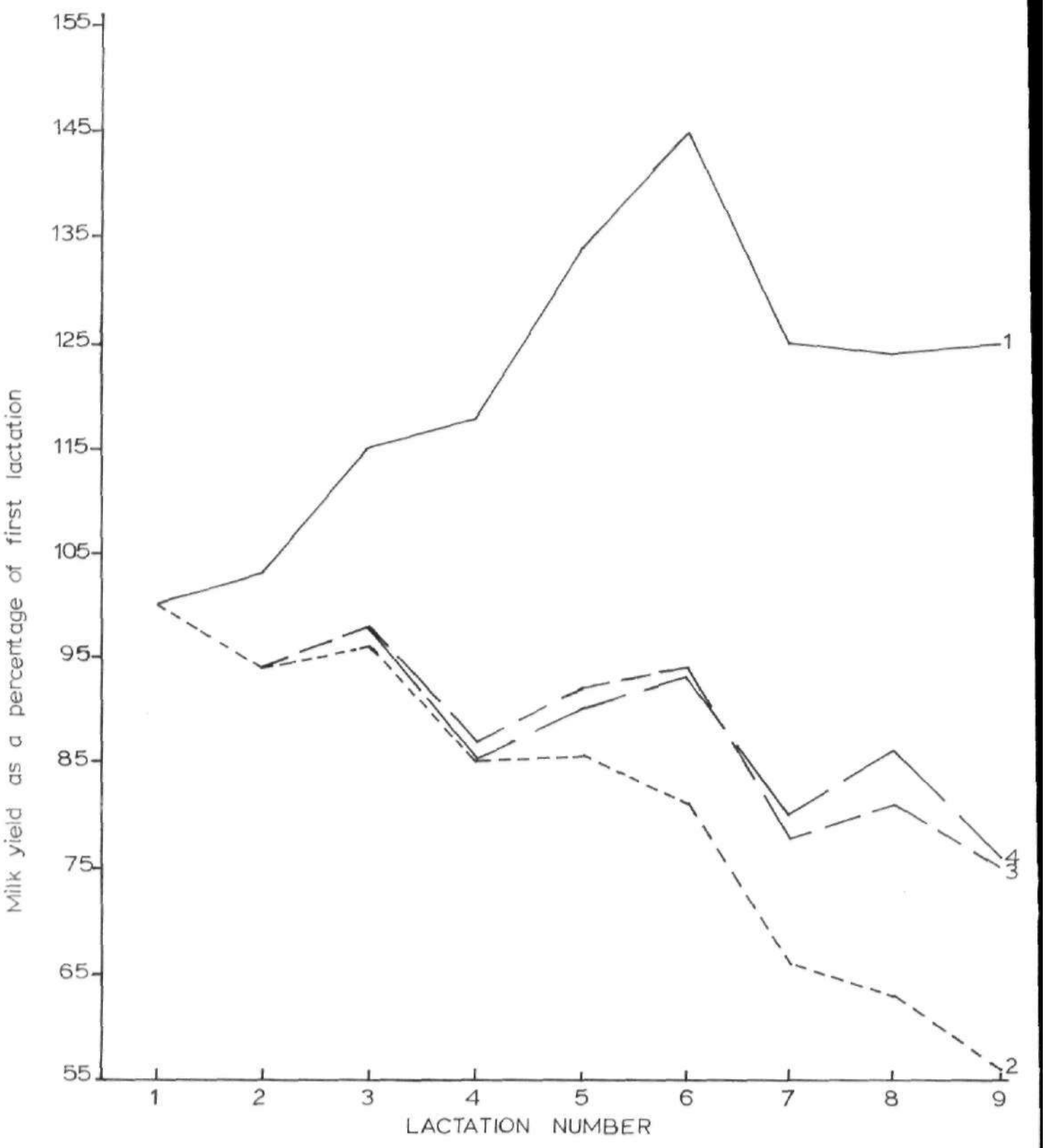


Fig. 11 Milk production in successive lactations expressed in different ways relative to the yield in the first lactation for Sokoto Gudali breed.

1. Gross lactation comprison. 2. Paired lactation comparison.
3. Later lactation records expressed as percentage of the first record of same cows.
4. Deviated later lactation records expressed as percentage of the first record of the same cows.

lactation and followed by increase in Bunaji cows and a drop in Sokoto Gudali cows. Thus the curves as shown by (1) lies on top of the scale, while the paired comparison curve (2) occupies the bottom of the scale and the curves with subsequent records expressed as a percentage of their first records (3) and (4) were intermediate (Figs. 10 and 11). Thus it follows that the true age curve would lie between the paired and the gross comparison curves.

In the paired comparison method for age correction as regards milk yield, subsequent records were first expressed as a percentage of their preceding records. These were then expressed as a percentage of the first lactation yield by multiplying with the different percentages. Thus any error in expressing one record as a percentage of the other would be amplified when percentages are multiplied to express later lactation as a percentage of the first record. Furthermore, since some selection was being practised in the breeds of cattle, the paired lactation comparison will also be biased by the incomplete number of lactations. To correct for this would require that repeatability value be known. In making such a correction repeatability would be assumed to be constant which will be untrue. This is because adjacency of lactations would result in a higher correlation between adjacent records than between records separated by one or more other lactations. In addition, the intensity of selection for the trait being studied should be known, for if culling was accidental, there

will be some bias due to culling in the mean value of the animals retained. This will vary from the mean of all records only by chance. As it may not be possible to know to what extent the culling in a herd was based on desired trait, and since in most cases, reasons for most culling are not accurately recorded, it would be apparent that culling is not entirely accidental and may only have some relation with the desired trait. However, some of the other reasons for culling animals such as udder diseases, certain hormone inbalances that may lead to infertility are directly related to high milk production. Removal of animals for such reasons would cause the mean of the animals retained to be lower than if the same animals were, culled for low production only which will result in the mean of the retained animals being higher. If on the other hand, animals culled for other reasons were also low milk yielders, the animals retained would have higher average yield. Therefore when selection is not based on milk production and the other reasons are not properly indicated, or their relation with production is not clear, the correction for the average production of these animals retained for incomplete repeatability might introduce a larger bias than it would otherwise remove. Because of this no correction for incomplete repeatability was made for the requisite traits in this study. Thus the error inherent in the paired lactation comparison, because of the different percentages being multiplied, was avoided by expressing all records in different lactations

as a percentage of their first lactation records.

The results obtained in expressing subsequent lactation records as a percentage of their first records and using, the deviated records from the years' means and then expressing the production as a percentage of the first records were comparable although these methods of age adjustment may cause a slight loss of information. As the curves show in Figs 10 and 11 these methods presented true picture of lactations' yield expectation.

5.5. Dry period

5.5.1 Results

The analysis of variance for effects of breed, year, month and parity on dry period is shown in Table 5.19. Results revealed that the effects of year and parity were very highly significant ($P<0.001$) while the effects of breed and month of calving were not significant ($P>0.05$). The least squares estimates for dry period was 160.4 days (Table 5.20). The dry period varied from 89.7 days in 1934 to 238.9 days in 1957. The dry period was variable from year to year and with no consistent trend. The dry period showed a decline from parity one to six, then manifested a rise in the next two parities and then dropped in parity nine. Separate variance analyses confirmed the significant effects of year of calving for Bunaji and also for Sokoto Gudali cows (Appendix 6, Tables 21 and 22) while parity was also highly significant for Bunaji breed ($P<0.005$), the month of calving

Table 5.19. Analysis of variance for effects of breed, year, month of calving and parity number on dry period of Bunaji and Sokoto Gudali cattle

Source of variation	D.F.	Mean squares (days²)x(10³)	F. value	Significance level
Main effects	43	83.04	2.73	0.001
Breed	1	11.41	0.38	0.54
Year	23	92.95	3.06	0.001
Month	11	42.45	1.39	0.17
Parity	8	110.95	3.65	0.001
Residual	2708	30.40	-	-
Total	2751	31.22	-	-

Table 5.20. Estimated least squares constants (L.S.C.) and means (days) for dry period of Bunaji and Sokoto Gudali breeds

Class	Number of	L.S.C.	Mean	S.E.
Overall	2752	-	160.39	3.32
Year of calving:				
1934	78	-70.66	89.73[a]	19.75
1935	94	-31.84	128.55[b]	17.98
1936	112	-26.83	133.56[c]	16.48
1937	115	6.56	166.95[d]	16.27
1938	126	- 1.62	158.77[e]	15.53
1939	103	- 2.62	157.77[ne]	17.18
1940	107	- 0.91	159.48[f]	16.86
1941	128	-21.85	138.54[g]	15.42
1942	122	-13.78	146.61[h]	15.78
1943	145	- 9.12	151.27[g]	14.48
1944	151	-13.17	147.22[b]	14.19
1945	138	-31.39	129.00[pg]	14.84
1946	187	-15.62	144.77[i]	12.75
1947	176	24.03	184.42[j]	13.14
1948	103	44.65	205.04[e]	17.18
1949	75	-2.45	157.94[e]	20.13
1950	85	-0.91	159.48[k]	18.91
1951	129	29.89	190.28[pf]	15.35
1952	131	-21.03	139.36[l]	15.24
1953	109	65.11	225.50[m]	16.70
1954	70	30.69	191.08[n]	20.83
1955	100	2.23	162.62[p]	17.44
1956	105	-17.90	142.49[q]	17.01
1957	64	78.54	238.93	21.80
Parity Number:				
1	744	23.53	183.92[a]	6.39
2	630	20.69	181.08[a]	6.94
3	468	-3.31	157.08[b]	8.06
4	342	-11.38	149.01[c]	9.43
5	233	-20.40	139.99[d]	11.43
6	183	-19.46	140.93[d]	12.89
7	110	-13.59	146.80[c]	16.62
8	40	54.03	214.42[e]	27.55
9	2	-30.11	130.28[f]	123.66
Month of calving:				
January	234	-37.05	123.34	11.40
February	183	-10.62	149.77	12.89
March	191	11.75	172.14	12.62
April	203	1.28	161.67	12.24
May	231	10.00	170.39	11.47
June	241	13.67	174.06	11.24
July	185	4.67	165.06	12.82
August	251	-12.98	147.41	11.01
September	286	-18.78	141.61	10.31
October	265	21.94	182.33	10.71

Table 5.20 Contd.

Class	Number of Animals	L.S.C.	Mean	S.E.
November	231	11.65	172.04	11.47
December	250	4.47	164.81	11.03
Breed of Animals:				
Bunaji	1958	2.27	162.66	3.94
Sokoto Gudali	794	-2.27	158.12	3.19

Within variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used , it indicates that the variable did not show a significant difference in the analysis of variance.

Table 5.21. Analysis of variance for effects of breed, year and month of calving on first dry period (days) for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Significance level
Main effects	35	5.97	1.06	0.378
Breed	1	6.05	1.07	0.301
Year	23	6.53	1.16	0.275
Month	11	4.18	0.74	0.699
Residual	884	5.64	-	-
Total	919	5.65	-	-

Table 5.22. Estimated least squares constants (L.S.C.) and means for first dry period for Bunaji and Sokoto Gudali breeds

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	920	-	173.42	7.83
Year of calving:				
1934	20	0.25	173.67	53.13
1935	37	-46.66	126.76	39.06
1936	28	-40.89	132.53	44.90
1937	36	-37.64	135.78	39.58
1938	33	-8.20	165.22	41.30
1939	19	21.52	194.94	54.47
1940	32	-21.09	152.33	41.96
1941	44	-26.50	146.92	35.82
1942	33	-30.64	142.78	41.30
1943	54	-3.31	170.11	32.31
1944	66	62.48	235.90	29.25
1945	45	14.02	187.44	35.40
1946	40	4.12	177.54	37.52
1947	44	59.75	233.17	35.82
1948	35	32.83	206.25	40.12
1949	26	144.03	317.45	46.57
1950	37	-37.83	135.59	39.06
1951	61	22.08	195.50	30.41
1952	37	-18.93	154.49	39.06
1953	30	12.17	161.25	43.34
1954	26	21.18	194.60	46.57
1955	66	-36.43	136.99	29.25
1956	23	-18.71	154.71	49.38
1957	48	-43.26	130.16	34.27
Month of calving:				
January	80	25.93	199.35	26.57
February	67	-28.73	144.69	29.00
March	72	1.63	175.05	27.97
April	75	23.79	197.21	27.43
May	74	8.67	182.09	27.62
June	105	11.32	184.74	23.17
July	55	17.25	190.67	32.01
August	79	-17.99	155.43	26.72
September	91	-40.55	132.87	24.90
October	65	17.80	191.22	29.47
November	64	11.51	184.93	29.69
December	93	-30.63	142.79	24.64
Breed of Animals:				
Bunaji	619	8.97	182.39	9.55
Sokoto Gudali	301	-8.97	164.45	13.69

Within variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

was significant for Sokoto Gudali breed (P<0.05). Least squares estimates showed that for Bunaji cows the mean dry period was 159.7 days (Appendix 6, Tables 23), while the least squares estimates for Sokoto Gudali cows mean dry period was 155.5 days (Appendix 6, Table 24). The average dry period grouped by years and months respectively are shown in Figs. 12 and 13 for both breeds. For Bunaji breed, least squares estimates for dry period varied from 104.6 days in 1934 to 245.5 days in 1957, on the other hand, the dry period for Sokoto Gudali varied from 105.5 days in 1937 to 215.5 days in 1948. For Bunaji breed, dry period varied from first parity to the ninth (186.3 days to 81.9 days) except for the sharp rise to 240.8 days in the eighth parity. The effect of month of calving show that dry period for Sokoto Gudali cows varied from 127.7 days in September to 195.3 days in April.

The analysis of variance for effects of breed, year and month of calving on first dry period showed that all the variables had no significant effects on the first dry period (P>0.05) (Table 5.21). The least squares estimates for first dry period is presented in Table 5.22.

5.5.2. Discussion

The mean dry period obtained in this study falls within the reported values for Zebu breed which ranged from 97 days for Ankole cattle to 222 days for Maure cattle (Sacker and Trail, 1966; ILCA, 1978). Kiwuwa et al. (1983) reported average dry period of 154 days and 165 days respectively

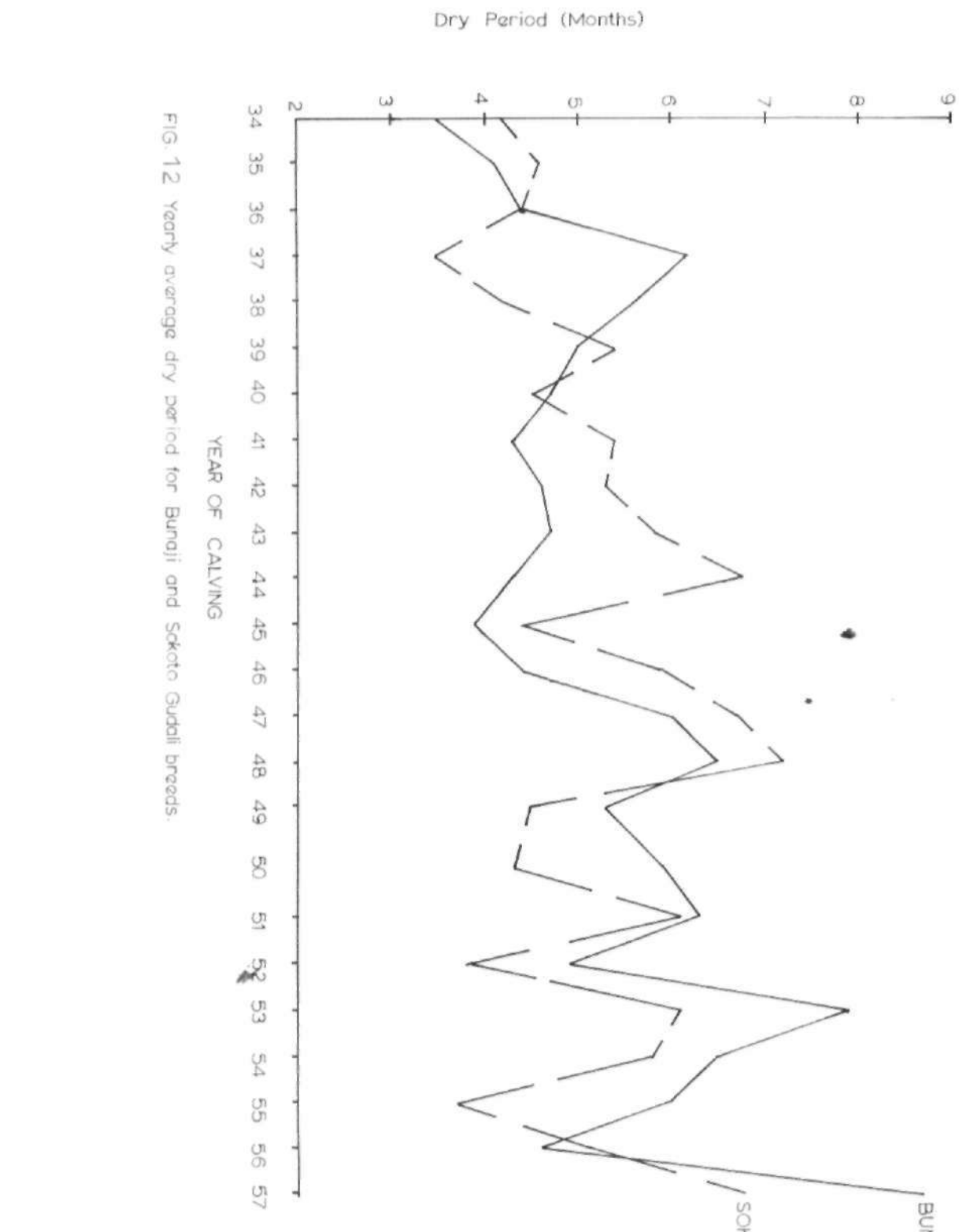


FIG. 12 Yearly average dry period for Bunaji and Sokoto Gudali breeds.

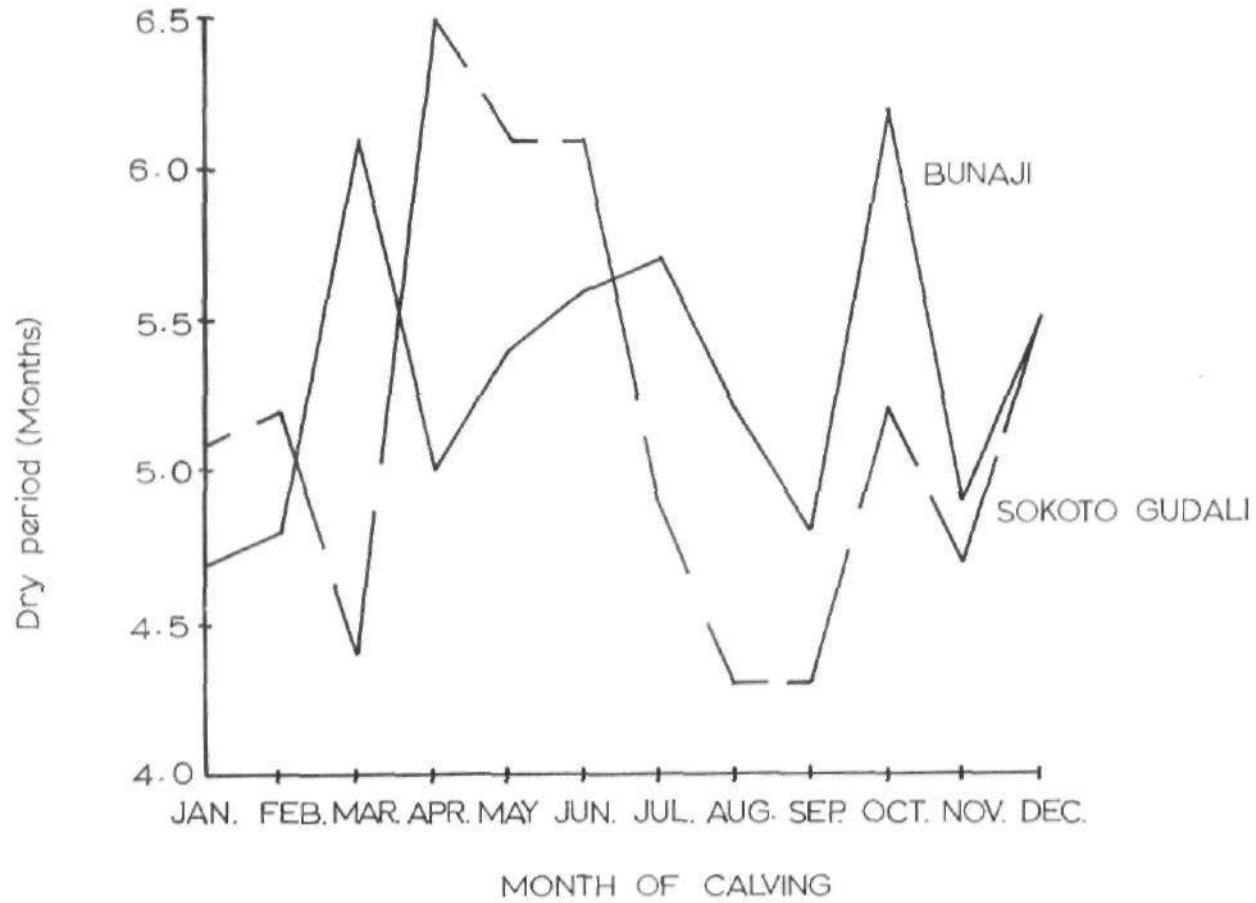


FIG. 13 Monthly average dry period for Bunaji and Sokoto Gudali breeds

for Arsi and Zebu breeds of East Africa. As the dry period is part of calving interval, if the dry period is reduced in length, then the calving interval would not be long and the lactation length can be of such duration as would support commensurate milk yield. However a long dry period may lead to a long calving interval which may result in a relatively short lactation length which will not enhance a good milk yield.

5.6. Calving interval

5.6.1. Results

The analysis of variance for effects of breed, year and month of calving and parity is shown in Table 5.23. Results indicate that there was very highly significant effects ($P<0.001$) of year and significant effect of parity ($P<0.05$) on calving interval. However the effects of breed and month of calving were not significant ($P>0.05$). The least squares estimates showed that calving interval ranged from 356 days in 1947 to 511 days in 1955 (Table 5.24). The least squares means for calving interval was 403.6 days and 403.8 days for Bunaji and Sokoto Gudali cows respectively. Analysis of variance computed separately for Bunaji and Sokoto Gudali breeds confirmed that only the effect of year of calving was significant ($P<0.001$) (Appendix 7, Tables 25 and 26). The least squares estimates for calving interval for each breed are shown in Appendix 7 Tables 27 and 28. The results show that the mean calving interval was 406 days and 398 days respectively for Bunaji and Sokoto Gudali cows. The average calving interval pooled over the years and months respectively

Table 5.23. Analysis of variance for effects of breed, year, month of calving and calving interval number on calving interval of Bunaji and Sokoto Gudali cattle breeds

Source of variation	D.F.	Mean squares (days^2)x(10^3)	F. value	Significance level
Main effects	43	132.23	5.08	0.001
Breed	1	0.05	0.00	0.97
Month	11	25.54	0.98	0.46
Parity	8	50.72	1.95	0.05
Residual	2937	26.03	-	-
Total	2980	27.52	-	-

Table 5.24. Estimated least squares constants (L.S.C.) and means (days) for calving interval of Bunaji and Sokoto Gudali cattle

Class	Number of Animals	L.S.C.	Mean	S.E.
Overall	2981	-	403.70	2.95
Year of calving:				
1934	75	4.12	407.82[a]	18.63
1935	84	-31.25	372.45[b]	17.59
1936	99	-52.54	351.16[c]	16.21
1937	113	-53.53	350.17[c]	15.18
1938	119	-51.46	352.24[c]	14.79
1939	130	-56.27	347.43[c]	14.15
1940	115	-46.13	357.57[c]	15.05
1941	136	-47.54	356.16[c]	13.84
1942	137	-15.79	387.91[b]	13.78
1943	127	29.16	432.86[d]	14.32
1944	168	18.75	422.45[d]	12.45
1945	159	-3.16	400.54[a]	12.79
1946	177	-3.04	400.66[a]	12.13
1947	197	-47.94	355.76[c]	11.49
1948	176	-32.15	371.55[b]	12.16
1949	103	30.12	433.82[e]	15.89
1950	90	49.25	452.95[f]	17.00
1951	96	30.99	434.69[e]	16.46
1952	129	23.29	426.99[d]	14.20
1953	160	36.41	440.11[e]	12.75
1954	91	32.31	436.01[e]	16.91
1955	79	107.51	511.21[g]	18.15
1956	112	20.46	424.16[d]	15.25
1957	109	58.43	462.13[h]	15.45
Parity				
1	820	17.72	421.42[a]	5.63
2	688	-87.07	316.63[b]	6.15
3	491	-1.63	402.07[c]	7.28
4	353	-5.22	398.48[d]	8.59
5	251	5.30	409.00[e]	10.19
6	190	9.62	413.32[ce]	11.71
7	130	3.94	407.64[f]	14.15
8	58	57.34	461.04[f]	21.17
Month of calving:				
January	238	6.85	410.55	10.46
February	170	11.92	415.62	12.37
March	196	21.85	425.55	11.52
April	239	8.85	412.55	10.44
May	249	2.71	406.41	10.22
June	237	-10.60	393.10	10.48
July	223	-8.52	395.18	10.81

Table 5.24 Contd.

Class	Number of Animals	L.S.C.	Mean	S.E.
August	269	-10.51	393.19	9.84
September	326	-2.29	401.41	8.93
October	314	-6.99	396.71	9.10
November	274	-13.39	390.31	9.75
December	246	0.12	403.82	10.29
Breed of Animals:				
Bunaji	2114	-0.14	403.56	3.51
Sokoto Gudali	867	0.14	403.84	5.48

Within variable groups, row means followed by the same letter do not differ significantly (P>0.05). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

are given in Figs. 14 and 15.

5.6.2. Discussion

The present results for calving interval compare well with reported values for Bunaji (Wheat et al., 1972; Wheat and Broadhurst, 1968), and for Sokoto Gudali cattle (Wheat and Broadhurst, 1972; Sada, 1968), and fall within the reported values for Zebu cattle. The results of this study on calving interval indicated that both the Bunaji and Sokoto Gudali cows calved in a duration which was over one year. It is desirable to reduce the calving interval for both breeds, so as to ensure that the cows of both breeds calve once in twelve to thirteen months. As calving interval includes lactation length and dry period, a good rationale would be to reduce the dry period (by allowing a rest period of 60 days for cows) to such a length that would ensure the uterine involution and the cows' readiness for the next conception, while at the same uphold a lactation length that supports good milk yield (by providing good nutrition for body maintenance and milk yield) that would enhance an overall profitable animal production enterprise.

5.7. Subsequent calving interval

5.7.1. Results

The analysis of variance for effects of breed, year, month of calving and parity on subsequent calving interval with lactation length included as a covariate in the model is given in Table 5.25. The effect of year was very highly significant ($P<0.001$), while the effect of parity was

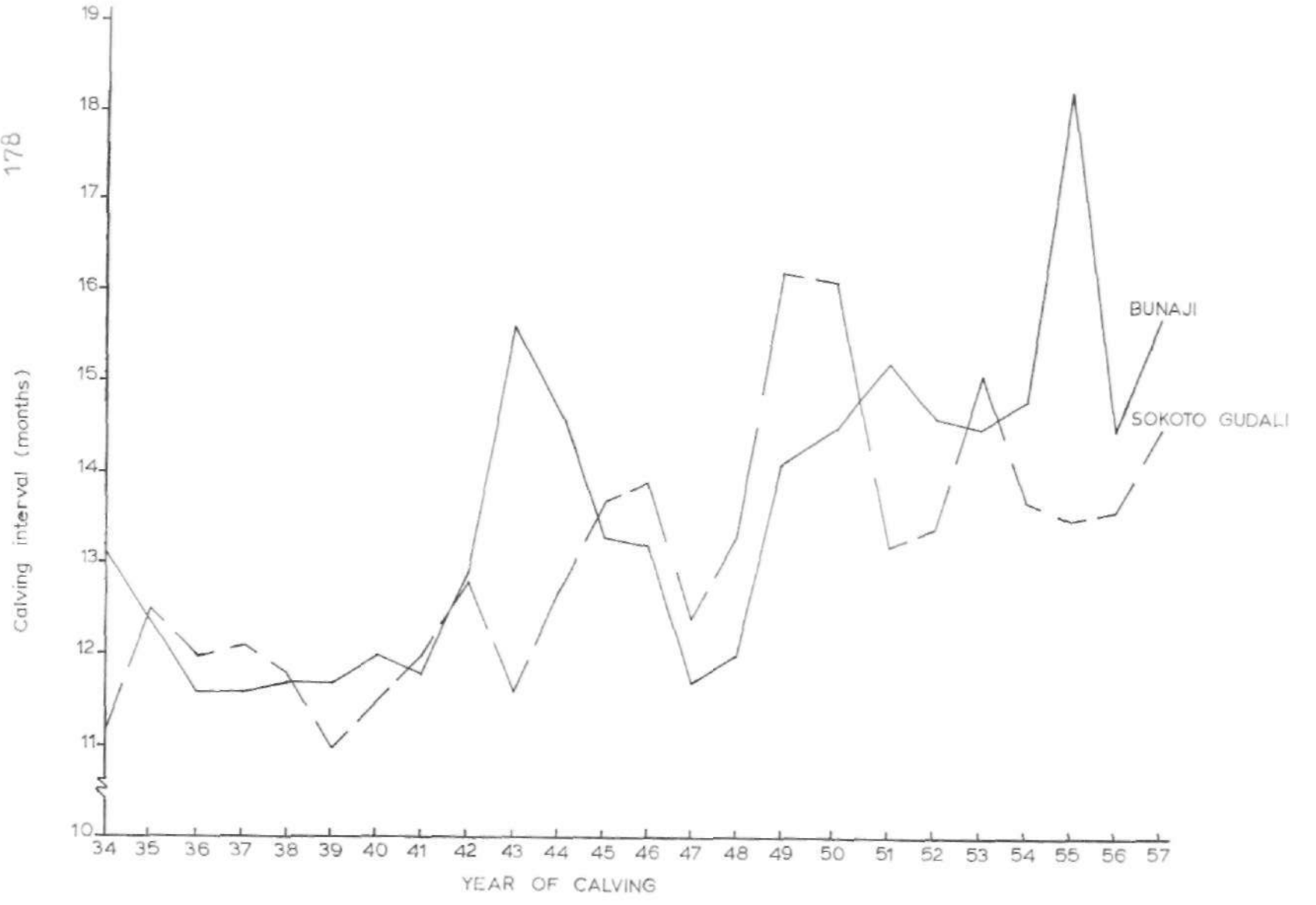


Fig. 1 Yearly average calving interval for Bunaji and Sokoto Gudali breeds.

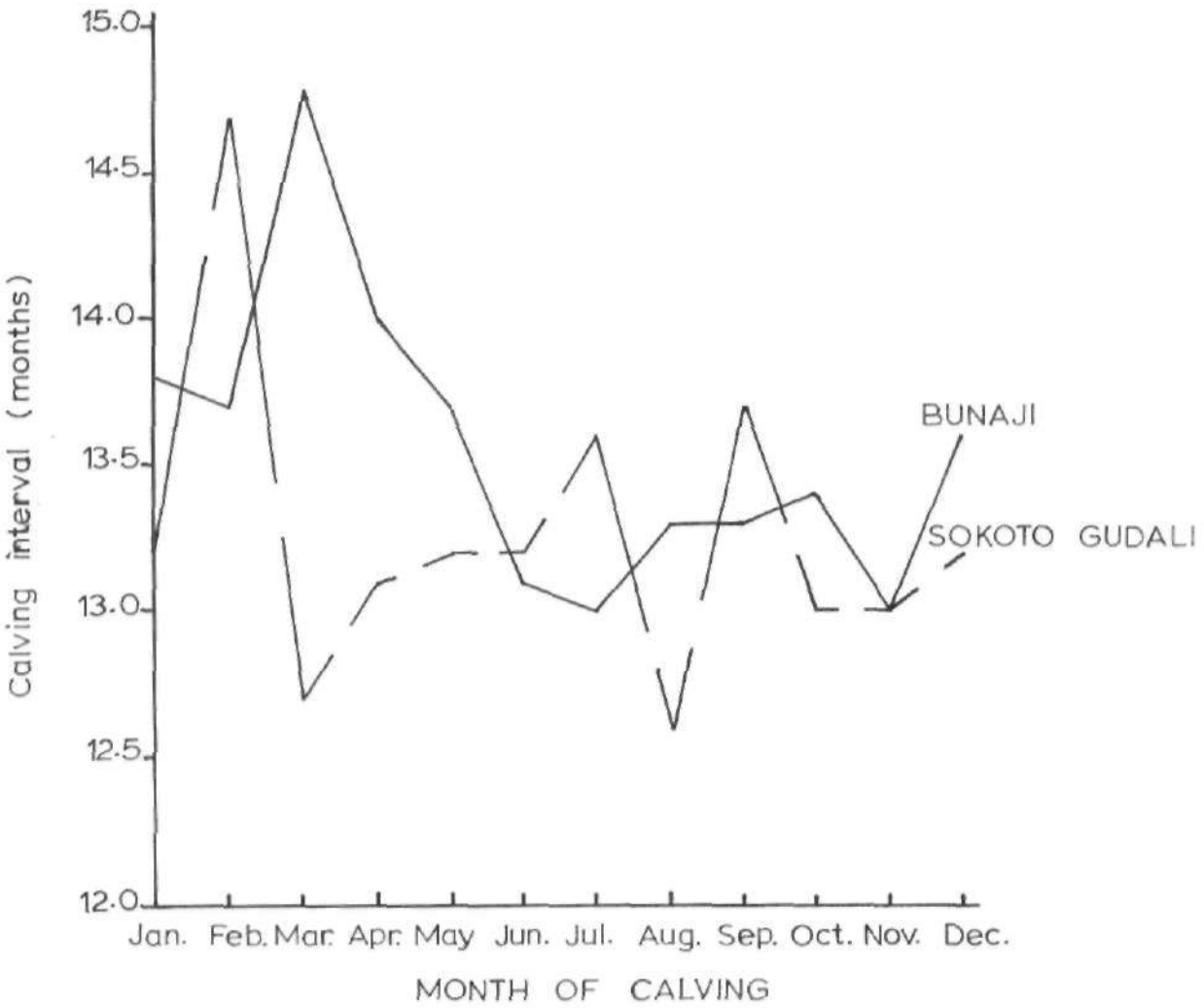


Fig. 15 Monthly average calving interval for Bunaji and Sokoto Gudali breeds.

Table 5.25. Analysis of variance for effects of breed, year and month of calving and parity on subsequent calving interval with lactation length as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Significance level
Covariate:				
Lactation length	1	85.79	33.87	0.001
Main effects	43	9.33	3.69	0.001
Breed	1	0.50	0.20	0.66
Year	23	13.30	5.25	0.001
Month	11	2.48	0.98	0.46
Parity	8	5.63	2.22	0.02
Residual	2708	2.53	-	-
Total	2752	2.67	-	-

Covariate lactation length b = 0.20.

significant (P<0.02). However, the effects of breed and month of calving were not significant (P>0.05). Thus the differences between breeds and month of calving can be partly explained by the variation in lactation length. The regression of lactation length on calving interval was b = 0.20. The mean subsequent calving interval which were similar for both breeds, were 403 and 402 days respectively for Bunaji and Sokoto Gudali cattle.

When dry period was included as a covariate in the analysis fof variance model for subsequent calving interval, year and parity were very highly significant (P<0.001), while breed and month of calving were not significant (P>0.05) (Table 5.26). The variation in dry period also explained partly the differences between breeds and month of calving. The regression of dry period on calving interval was b = 0.81.

The inclusion of 305-day milk yield as a covariate in the model of the analysis of variance of subsequent calving interval indicated that only the effect of year of calving was very highly significant (P<0.001). The effects of breed, month were not significant (P>0.05) (Table 5.27), while the effect of parity showed significant level (P<0.03).

5.7.2. Discussion

The significant regression obtained when lactation length was regressed on subsequent calving interval can be attributed to the fact that lactation length is a part of the subsequent calving interval. The same reason is attributable to the situation when dry period was regressed on subsequent calving

Table 5.26: Analysis of variance for effects of breed, year and month of calving and parity on subsequent calving interval with dry period as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (days^2)x(10^4)	F. value	Significance level
Covariate:				
Dry period	1	5574.47	4079327.55	0.001
Main effects	43	3.51	5.87	0.001
Breed	1	0.04	0.07	0.80
Year	23	4.54	7.60	0.001
Month	11	1.45	2.42	0.006
Parity	8	3.08	5.16	0.001
Residual	2708	0.60	-	-
Total	2752	2.67	-	-

Covariate dry period b = 0.81

Table 5.27. Analysis of variance for effects of breed, year and month of calving and parity with 305-day milk yield as covariate on subsequent calving interval of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean Squares (days^2)x(10^4)	F. value	Significance level
Covariate:				
305-day milk yield	1	18.45	7.04	0.008
Main effects	43	9.84	3.75	0.001
Breed	1	0.56	0.21	0.65
Year	23	14.44	5.51	0.001
Month	11	2.67	1.02	0.42
Parity	8	5.54	2.11	0.03
Residual	2508	2.62	-	-
Total	2552	2.75	-	-

Covariate 305-day milk yield b = 0.02

interval, because dry period is part of calving interval. Thus the lactation length would influence the subsequent calving interval period and can also underline the length of dry period. It is desirable to ensure a lactation length of about 200 days duration that would support high milk yield since in the tropical breeds the lactation length determines the amount of milk given in a lactation. The milk yield per day of calving interval varies just a little between breeds. The dry period should be no longer than 60 days to ensure adequate rest for the cows and prepare them for next conception and calving. As such a proper balance would ensure an adequately long lactation length followed by enough dry period that is not too long to ensure a calving interval that would allow cows calve once in about thirteen months.

The effect of the inclusion of the 305-day milk yield as a covariate in the model for subsequent calving interval emphasised how an unduly long calving interval would result in a lower milk yield in the subsequent calving. Thus animals having a low reproductive performance would manifest a lower milk yield. Thus it would be desirable to ensure a good reproductive performance by cows calving every thirteen months while, in addition, the lactation length should be of a desirable duration that would enhance good milk yield and allow just enough period for dryness of the cows to optimise the calving interval that is not too long.

The results obtained in this study of 405 days (13.5 months) for subsequent calving interval, although slightly

higher than the value of 12.2 months recorded for Bunaji by Knudsen and Sohael (1970), fall within the reported values for Zebu which ranged between 11.3 months (Wheat and Broadhurst, 1968), and 17.9 months for Rahaji cattle (Wheat, 1972). There is a strong necessity to ensure that cows calve once within twelve to thirteen months, and this can be achieved by pursuing a goal of a subsequent calving interval that support an efficient cattle production.

BODY WEIGHT

6.1. Birth weight

6.1.1. Results

The analysis of variance for effects of breed, year and month of calving, parity and sex of calf on birth weight of calves is presented in Table 6.1. Results revealed the very highly significant effects of year, month, parity and sex of calf on birth weight ($P<0.001$). The effect of breed also showed highly significant effect on birth weight of calves ($P<0.004$). The least squares estimates showed that the overall mean birth weight was 22 kg (Table 6.2). The year effect indicated that birth weight ranges from 20.7 kg in 1953 to 23.5 kg in 1947. The birth weight tended to be higher in earlier years, although this trend was not consistent. The effect of parity manifested a consistent pattern and maintained a higher birth weight. The least squares mean for month of calving show that calves born in January and June to October have slightly heavier birth weight. The sex of calves revealed that male calves were heavier than female calves.

The inclusion of dry period as a covariate in the model to investigate its effect on birth weight did not show any effect on the level of significance regarding year, month and parity (Table 6.3). When calving interval was included as a covariate in the model for the analysis of variance of birth weight of calves, the significant levels of the

Table 6.1. Analysis of variance for effects of breed, year, month of calving, parity and sex of calf on birth weight of Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares $(kg^2) \times (10^2)$	F. value	Significance level
Main effects	44	1.31	10.48	0.001
Breed	1	1.05	8.40	0.004
Year	23	0.85	7.11	0.001
Month	11	0.64	5.17	0.001
Parity	8	1.29	10.37	0.001
Sex	1	19.04	152.94	0.001
Residual	3602	0.12	-	-
Total	3646	0.14	-	-

Table 6.2. Estimated least squares constants (L.S.C.) and means (kg) for birth weight of Bunaji and Sokoto Gudali breeds

Class	Number of Animals	L.S.C.	Mean
Overall	3647	-	22.22
Year of calving:			
1934	91	0.19	22.03[a]
1935	114	0.74	22.96[a]
1936	122	0.28	22.50[a]
1937	143	0.65	22.87[b]
1938	144	1.03	23.25[a]
1939	145	0.38	22.60[a]
1940	139	0.75	22.97[b]
1941	176	1.02	23.24[c]
1942	166	-0.34	21.88[c]
1943	171	-0.82	21.40[c]
1944	213	-0.44	21.78[c]
1945	179	-0.67	21.55[a]
1946	199	0.46	22.58[b]
1947	232	1.30	23.52[a]
1948	190	-0.22	22.00[c]
1949	111	-0.64	21.58[b]
1950	118	0.75	22.97[a]
1951	151	0.28	22.50[a]
1952	155	-0.07	22.15[c]
1953	172	-1.49	20.73[c]
1954	106	-0.38	21.84[c]
1955	136	-0.82	21.40[c]
1956	127	-0.42	21.80[c]
1957	147	-1.04	21.18[c]
Parity of calving:			
1	841	-0.97	21.25[a]
2	757	-0.64	21.58[a]
3	651	0.33	22.55[b]
4	468	0.11	22.33[b]
5	330	0.31	22.53[b]
6	240	0.03	22.25[b]
7	181	0.10	22.32[b]
8	123	0.31	22.53[b]
9	57	0.42	22.64[b]
Month of calving			
January	295	0.21	22.43[a]
February	231	-0.23	21.99[b]
March	243	-0.33	21.89[b]
April	301	-0.50	21.72[b]

Class	Number of Animals	L.S.C.	Mean
Month of calving:			
May	308	-0.51	21.71[b]
June	232	0.61	22.83[a]
July	260	0.98	23.12[c]
August	328	0.51	22.73[a]
September	378	0.18	22.40[a]
October	359	-0.12	22.10[a]
November	311	-0.41	2..81[b]
December	310	-0.31	21.91[b]
Breed of Animals:			
Bunaji	2553	-0.18	22.04[a]
Sokoto Gudali	1094	0.18	22.40[b]
Sex of Animals:			
Male	1804	0.73	22.95[a]
Female	1843	-0.73	21.49[b]

Within non crops, variable means followed by same letter do not differ significant (P>0.05). If no letter is used no significance was obtained in the analysis of variance for the variable.

Table 6.3. Analysis of variance for effects of breed, year, month of calving and parity on birth weight with dry period as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares (kg^2)x(10^2)	F. value	Significance level
Covariate:				
Dry period	1	1.66	13.26	0.001
Main effects	43	0.72	5.72	0.001
Breed	1	1.10	8.77	0.003
Year	23	0.70	5.58	0.001
Month	11	0.38	3.05	0.001
Parity	8	1.15	9.19	0.001
Residual	2646	0.13	-	-
Total	2690	1.14	-	-

Covariate dry period b = 0.001.

effects of year, month and parity were not affected (P<0.001), but the significant level of breed was reduced (P<o.06) (Table 6.4). The covariate for dry period was very highly significant (P<0.001), while the covariate for calving interval was negative and not significant (P=0.21). The average birth weight grouped by year and month for the two breeds combined, are presented in Figs. 16 and 17, respectively.

6.1.2. Discussion

The effect of parity on birth weight which showed a consistent pattern of higher birth weight is due to the fact that heavier cows produce heavier calves. Since cows attain heavier body size at later parities, they possess the capacity to produce heavier calves at later parities. However it is not desirable to pursue increased heavier birth weight in calves as this may involve difficulty in calving. On the other hand birth weight per se is not an economic trait but affords the estimation of the preweaning growth rate in calf production and can determine how quickly a calf can attain weaning weight given a uniform weaning age.

The month on birth weight show that calves born during June to October had slightly heavier birth weight, this can be attributed to the cows having available post-rainy forage which would enhance the growth of the calves in the later gestation period. This situation emphasise the importance of the provision of good feeding to gestating cows to enhance the growth of their calves in the late gestation period.

Table 6.4. Analysis of variance for effects of breed, year, parity on birth weight with calving interval as covariate for Bunaji and Sokoto Gudali breeds

Source of variation	D.F.	Mean squares $(kg^2) \times (10^2)$	F. value	Significance level
Covariate:				
Calving interval	1	0.21	1.58	0.21
Main effects	31	0.71	5.32	0.001
Breed	1	0.46	3.48	0.06
Year	23	0.71	5.32	0.001
Parity	7	0.73	5.48	0.001
Residual	2773	0.13	-	-
Total	2805	0.14	-	-

Covariate calving interval b = 0.001

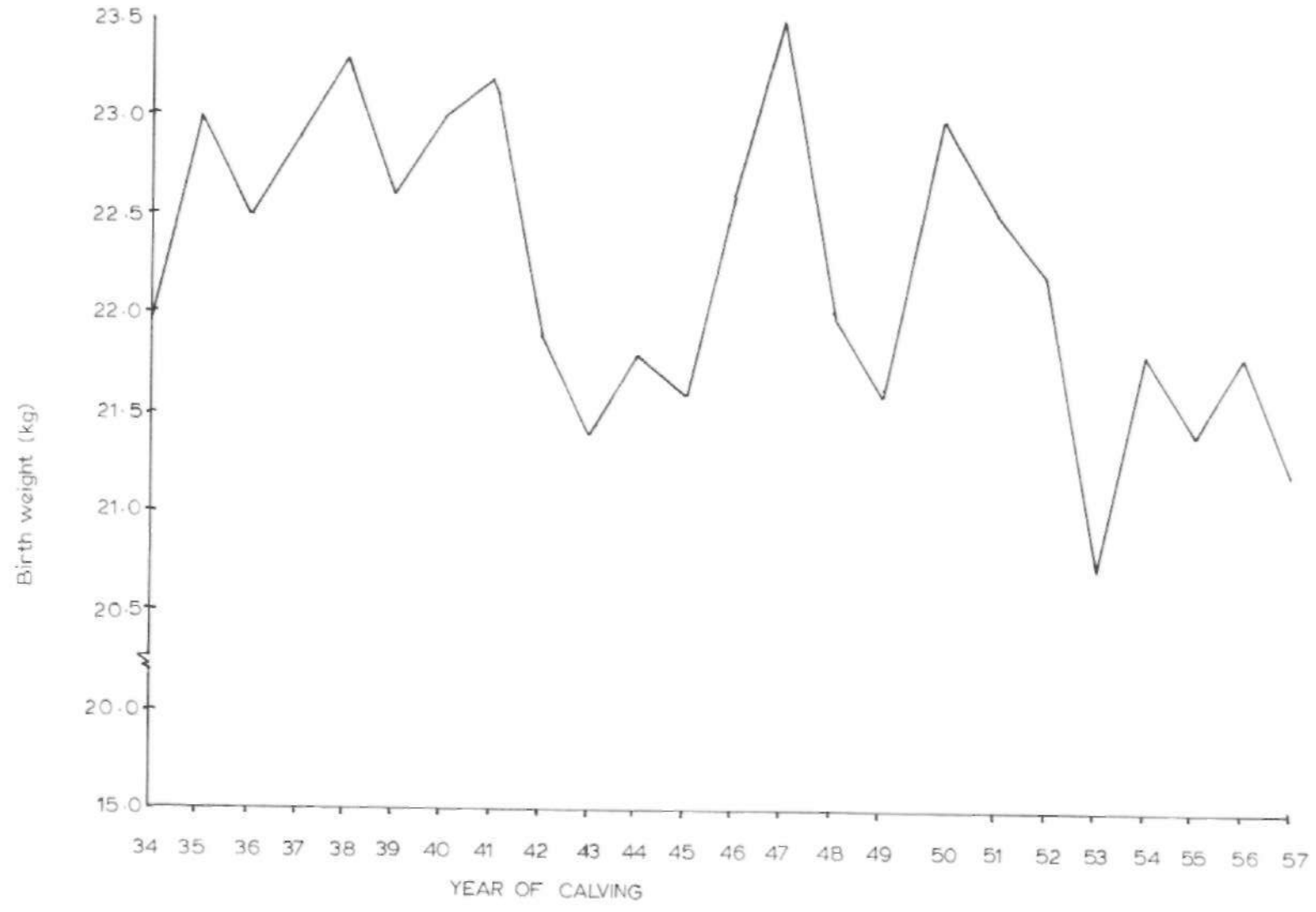


FIG. 16 Yearly average birth wieght of combined Bunaji and Sokoto Gudali breeds.

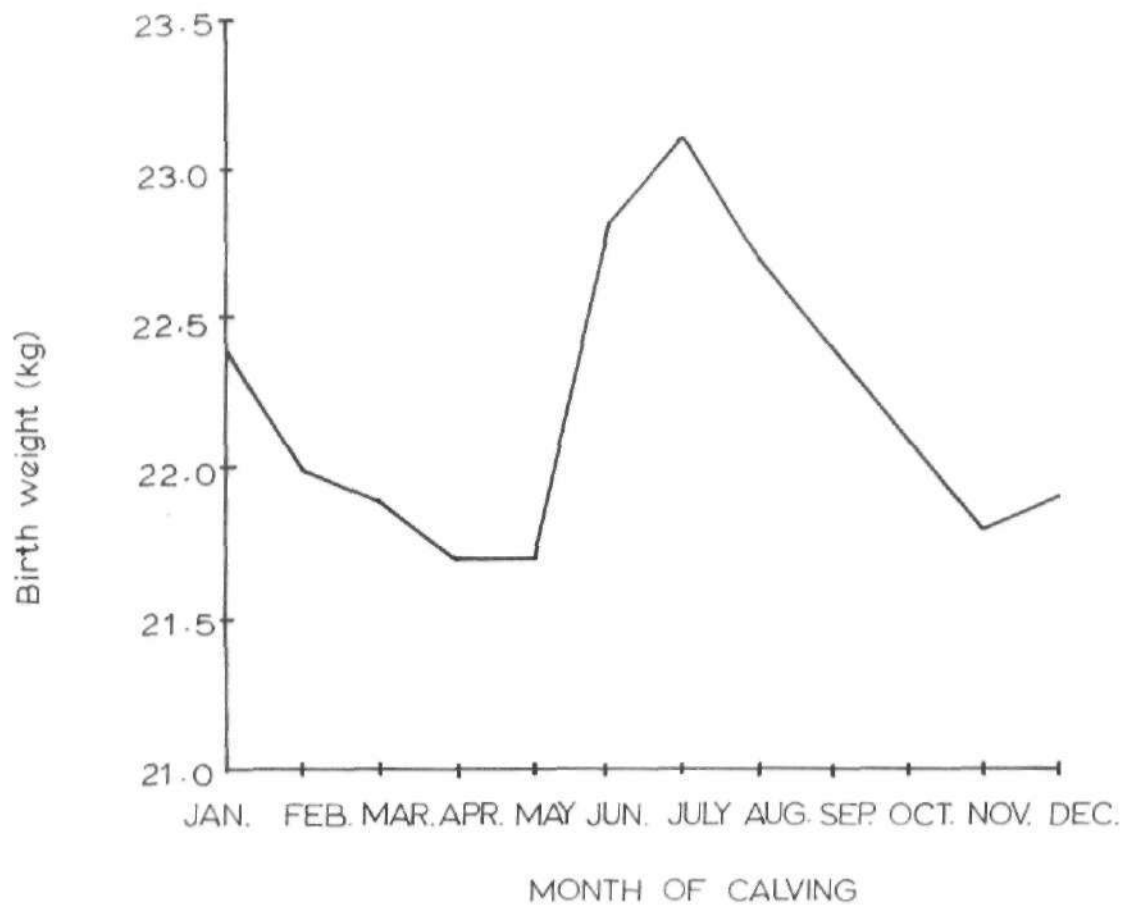


FIG.17 Monthly average birth weight of Combined Bunaji and Sokoto Gudali breeds.

The mean birth weight was 22 kg in this study and is within reported values for Zebu cattle which ranged from 21.6 kg in Azaouak, to 23.4 kg in Rahaji and 22.6 kg in Bunaji (Wheat, 1972; Wheat et al., 1972). The average birth weight for male and female calves of 23 kg and 22 kg reported in the present study falls within the range for male zebu calves of 22.6 kg and 24 kg for Azaouak and Rahaji and 23 kg for Bunaji, while the recorded birth weight for female calves was 20.8 kg and 22.8 kg (Wheat, 1972; Wheat et al., 1972).

CHAPTER SEVEN

GENETIC AND PHENOTYPIC PARAMETERS

7.1. Heritability estimates

7.1.1. Results

The sib analyses for 305 day milk yield, lactation length, calving interval, milk yield per day of calving interval and birth weight are shown in Table 7:1 for Bunaji cattle, while that for Sokoto Gudali cattle are presented in Table 7:2. The heritability estimates for these traits are given for Bunaji cattle and Sokoto Gudali cattle, respectively in Tables 7:3 and 7:4.

7.1.2. Discussion

The heritability estimates of first lactation milk yield for Bunaji cattle is larger than that for Sokoto Gudali cattle (0.59 compared with 0.34). These values are larger than the reported estimate of 0.22 for the Northern Sudan shorthorn Zebu (Osman and EL Amin, 1971). The values however compared with the heritability value of 0.52 reported by Galukande et al (1962) for first lactation milk yield for the East African Zebu. The high heritability values recorded for the first lactation milk yield suggest that the trait is highly heritable and considerable improvement can be achieved if selection is used on milk production in the first lactation. Granted that the first milk yield has less known environmental factors influencing it than subsequent milk yield, the heritability values are a little higher than expected. High heritability values are obtainable where the known environmental effects have

Table 7:1 Sib Analysis for lactation 305 day milk yield, lactation length, calving interval, dry period, age at first calving, milk yield per day of calving interval and birth weight of calves for Bunaji breed

	Mean squares			
	Between sires		Within sires	
Trait	d.f.	x(10^3)	d.f.	x (10^3)
First milk yield(kg^2)	38	483.72	328	185.81
Second milk yield(kg^2)	30	394.77	307	167.52
Third milk yield(kg^2)	21	308.64	216	164.84
All milk yield (kg^2)	56	938.66	1785	166.87
First lactation length ($days^2$)	44	19.95	424	9.82
All lactation length ($days^2$)	59	26.52	2006	7.57
First calving interval ($days^2$)	44	79.86	462	43.37
All calving interval ($days^2$)	55	49.03	1649	24.51
First dry period($days^2$)	46	47.82	465	33.69
All dry period ($days^2$)	56	47.47	1605	28.71
Age at first calving ($days^2$)	43	50.49	451	37.67

	Mean squares			
	Between sires		Within sires	
Trait	d.f.	x(10^1)	d.f.	x (10^1)
Milk yield per day(kg^2)	49	5.08	1458	1.27
Birth weight (kg^2)	65	68.97	2105	14.99

Table 7:2 Sib Analysis for lactation 305-day milk yield, lactation length, calving interval, dry period age at first calving, milk yield per day of calving, interval and birth weight of calves for Sokoto Gudali breed.

	Mean squares			
	Between sires		Within sires	
Trait	d.f.	x(10^3)	d.f.	x(10^3)
First milk yield(kg^2)	14	394.11	131	208.51
Second milk yield(kg^2)	12	232.34	108	150.54
Third milk yield (kg^2)	7	284.63	70	200.28
All milk yield (kg^2)	24	695.71	608	248.81
First lactation length ($days^2$)	14	20.39	146	10.29
All lactation length ($days^2$)	24	25.08	665	8.75
First calving interval ($days^2$)	18	124.83	93	72.81
All calving interval ($days^2$)	23	17.16	543	10.12
First dry period ($days^2$)	18	34.51	183	26.95
All dry period ($days^2$)	23	25.93	517	21.15
Age at first calving ($days^2$)	18	87.52	182	65.99

	Mean squares			
	Between sires		Within sires	
Trait	d.f.	x(10^1)	d.f.	x(10^1)
Milk yield per day(kg^2)	20	3.50	457	1.42
Birth weight (kg^2)	30	49.95	735	16.40

Table 7:3. Heritability estimates for lactation 305-day milk yield, lactation length, calving interval dry period, age at first calving, milk yield per day of calving interval and birth weight of calves for Bunaji breed

Trait	Heritability		
	d.f.	Estimate	S.E.
First lactation milk yield	366	0.59	0.23
Second lactation milk yield	337	0.45	0.21
Third lactation milk yield	237	0.30	0.20
All lactation milk yield	1841	0.51	0.12
First lactation length	468	0.36	0.16
All lactation length	2065	0.28	0.07
First calving interval	506	0.28	0.14
All calving interval	1704	0.13	0.05
First dry period	511	0.15	0.11
All dry period	1660	0.09	0.04
Age at first calving	494	0.12	0.10
Milk yield per day	1507	0.37	0.01
Birth weight	2170	0.40	0.09

Table 7:4. Heritability estimates for lactation 305-day milk yield, lactation length, calving interval day period, age at calving, milk yield per day of calving interval and birth weight for Sokoto Gudali breed.

Trait	Heritability		
	d.f.	Estimate	S.E.
First lactation milk yield	145	0.34	0.20
Second lactation milk yield	120	0.23	0.26
Third lactation milk yield	77	0.17	0.30
All lactation milk yield	632	0.27	0.12
First lactation length	160	0.34	0.27
All lactation length	689	0.26	0.12
First calving interval	200	0.26	0.21
All calving interval	566	0.12	0.08
First dry period	201	0.10	0.15
All dry period	540	0.04	0.06
Age at first calving	200	0.12	0.16
Milk yield per day	477	0.25	0.13
Birth weight	765	0.32	0.12

low effects or can be removed as was done in this study. However, milk yield is a fitness trait, which means the proportionate contribution of the offspring to the next generation, natural selection does not act against milk yield thus heritability of milk yield may be high while natural selection act against reproduction traits. The heritability estimates in the second and third lactation milk yield dropped in both breeds. This may be the manifestation of unknown environmental effects such as poor feeding, poor forage feed, which were not observed in the first lactation. As subsequent lactations are prone to more environmental influences than first lactation this situation is expected. The heritability estimates for all lactations recorded in this study were 0.31 and 0.35, respectively, for Bunaji and Sokoto Gudali cattle. These values appear slightly high, because natural selection does not act against milk yield and these values suggest that there is a lot of potential for improving the milk yield in both breeds by selecting for increased milk production. The high heritability as obtained in the present study underscore the fact that not much selection has been practise in the two breeds and that the potential for increased milk yield may have hitherto been masked by the effects of the environmental factors. The heritability values obtained for all lactation yield fall within the range reported in the literature for Zebu cattle of between 0.24 and 0.62 (Alim, 1960; Foster, 1962). Osman (1970) recorded a

heritability estimate of 0.36 for the Northern Sudan Zebu cattle. The method of estimation used in this study which was paternal half sib tends to give low estimates, and as such could not have influenced the estimate when compared with the regression of daughter on dam method, which always tended to give a higher estimate than the paternal half-sib method.

The heritability estimate for first lactation length recorded in this study for Bunaji and Sokoto cattle were 0.36 and 0.34 respectively. The heritability estimate for this reproductive trait is lower than for milk yield. As lactation length is a fitness trait, which means the proportionate contribution of offspring to the next generation, and natural selection does not act against milk yield, this may result in high heritability for milk. As lactation length in the two breeds are slightly lower than other breeds and this trait has a heritable basis, its lower heritability estimate compared with milk yield is quite apparent. The heritability estimates for first lactation length for the two breeds of cattle fall within the range reported for Zebu cattle of between 0.11 and 0.47 (Mahadevan and Marples, 1961; Galukande et al., 1962). The estimates of heritability for all lactation length obtained in this study, which were 0.28 and 0.26 for Bunaji and Sokoto Gudali cattle are of the order reported for Zebu cattle which varied from 0.11 to 0.50 (Osman and EL Amin, 1971.; Galukande et al., 1962). The tropical breeds of cattle tend to

manifest short lactation length, as such that both Bunaji and Sokoto Gudali cattle show a relatively lower heritability estimates for lactation length as compared with the heritability estimates for milk yield, may be attributed to natural selection enhancing milk yield and acting against lactation length.

The estimates of the heritability of the first and all calving interval obtained in this investigation which were respectively 0.28 and 0.13 for Bunaji and 0.26 and 0.12 for Sokoto Gudali cattle show that the first calving interval was affected less by the natural selection than later calving intervals. The results indicate that a substantial improvement can be made by selection for first calving interval than later calving intervals. The heritability estimates obtained in this study for first calving interval is higher than estimates recorded in the literature which ranged from -0.10 to 0.05. However, the estimates obtained for all calving interval are of the order recorded in the literature (Mahadevan and Marples, 1961; Galukande et al., 1962; Osman and EL Amin, 1971).

The estimates of heritability recorded in this study for first and all dry period of between 0.15 and 0.09 for Bunaji and between 0.10 and 0.04 for Sokoto Gudali cattle are within the reported values in the literature which were -0.53 to 0.29 for first dry period and 0.06 for all dry period (Mahadevan and Marples, 1961; Galukande et al., 1962; Osman and EL Amin, 1971).

The heritability estimates recorded for age at first calving in this study were 0.12 for both Bunaji and Sokoto Gudali cattle. This result indicated that improvement in age at first calving would be slow by selection in both breeds. This result indicate that family selection would be desirable to make improvement for this reproduction trait because of the low heritability estimate. As such a much intense selection must be applied to achieve appreciable improvement in this trait. This is more so as increase in age at first calving beyond 50 months does not result in increase in milk yield because at this age, the relationship between milk yield and age at first calving which was linear between 23 and 38 months of age has now become curvilinear (Johansson and Rendel, 1968). The estimate recorded in this study for age at first calving agrees with the values of between 0.08 and 0.12 found in the literature (Mahadevan and Marples, 1961; Osman and EL Amin, 1971). However, Galukande et al. (1962) reported an estimate of heritability of 0.25 for age at first calving for the East African Zebu cattle.

The heritability estimates for milk yield per day of calving interval recorded in this study were 0.37 and 0.25 respectively for Bunaji and Sokoto Gudali cattle. These results indicate that a substantial improvement can be made by selection for increase for milk yield per day of calving interval in the two breeds.

Since yield per day is the yield per herd life, the improvement can be achieved. However, in tropical cattle there is less variation in milk yield per day, while more variation exists in lactation length, which is the reverse of what is observed in temperate breeds of cattle. The estimates obtained for milk yield per day of calving interval are within the range reported in the literature of between 0.23 and 0.45 (Mahadevan and Marples, 1961; Galukande et al., 1962).

The heritability estimates of birth weight of calves obtained in this study for Bunaji and Sokoto Gudali cattle were 0.40 and 0.32, respectively. These estimates underscored that improvement can be accomplished by selection for heavier calves at birth. However, as birth weight per se is not an economic trait but only assists calf survival and the estimation of the preweaning rate of gain, the emphasis placed on increased birth weight should not be overdone so as not to incur an increased calving difficulty among the cows of the respective breeds. The estimates obtained for heritability for birth weight of calves in this study fall within the reported values of 0.33 for Uganda cattle (Mahadevan and Marples, 1961), and 0.60 for Sokoto Gudali cattle (Wheat and Broadhurst, 1972).

7.2. Genetic correlation

7.2.1. Results

The correction factors for adjusting for fixed effects before estimating the genetic parameters are given in Table 7:5(A) to 7:5(D). In view of the small sample size for each breed of cattle and because of the fluctuation in

the constants within each breed, the pooled population of the two breeds was used to generate the constants used to adjust for the fixed effects for each breed by additive method.

The variance and covariance for first, second and third milk yield are presented for Bunaji cattle in Table 7:6(A), while that for Sokoto Gudali cattle are shown in Table 7:7(A) The genetic correlations between the first, second and third milk yield for Bunaji cattle are presented in Table 7:6(B), while that for Sokoto Gudali cattle are shown in Table 7:7(B).

Results showed that the genetic correlation between the first three milk yield for Bunaji cattle varied between rg = 0.65 and rg = 0.81, while the corresponding values for Sokoto Gudali cattle ranged from rg = 0.68 and rg = 0.99.

The variance and covariance for first milk yield and first yield reproductive traits are given respectively for Bunaji and Sokoto Gudali cattle in Tables 7:8(A) and 7:9(A). The genetic correlations between these reproductive traits and first milk yield for Bunaji and Sokoto Gudali cattle are shown in that order in Tables 7:8(B) and 7:9(B). Results showed that for Bunaji cattle the genetic correlations between first milk yield and first reproductive traits varied between rg = 0.17 and rg = 0.38, while for Sokoto Gudali cattle the values ranged from rg = 0.19 to rg = 0.51.

Table 7:5(A). Additive correction factors for lactation length, calving interval and dry period for both Bunaji and Sokoto Gudali cattle.

Year	Lactation length	Calving interval	Dry period
	Correction factors		
1934	-18.71	-4.12	70.66
1935	8.75	31.25	31.04
1936	11.95	52.54	26.83
1937	13.45	53.53	-6.56
1938	14.08	51.46	1.62
1939	18.07	56.27	2.62
1940	7.17	46.13	0.91
1941	12.19	47.54	21.85
1942	-7.51	15.79	13.78
1943	-3.95	-29.16	9.12
1944	-10.50	-28.75	13.17
1945	7.49	3.16	31.39
1946	8.30	3.04	15.62
1947	23.75	47.94	-24.03
1948	1.69	32.15	-44.65
1949	-29.26	-30.12	2.45
1950	-27.01	-49.25	0.91
1951	-11.69	-30.99	-29.89
1952	-11.76	-23.29	21.03
1953	- 3.39	-36.41	-65.11
1954	6.67	-32.31	-30.69
1955	4.64	-107.51	-2.23
1956	-27.12	-20.46	17.90
1957	12.72	-58.43	-78.54

Table 7:5(A) Continued.

Parity	Lactation length	Calving interval	Dry period
	Correction factors		
1	13.87	-17.72	-23.53
2	23.25	87.07	-20.69
3	19.48	1.63	3.31
4	10.82	5.22	11.38
5	-4.88	-5.30	20.40
6	-15.42	-9.62	19.46
7	1.67	-3.94	13.59
8	-19.78	-58.34	-54.03
9	-29.01	-	30.11
Month of calving			
January	-17.06	-6.85	37.05
February	-9.35	-11.92	10.62
March	-5.54	-21.85	-11.75
April	4.97	-8.85	-1.28
May	4.93	-2.71	-10.0
June	14.86	10.60	-13.67
July	4.04	8.52	-4.67
August	-11.27	10.51	12.98
September	0.93	2.29	18.78
October	3.42	6.99	-21.94
November	6.24	13.39	-11.65
December	3.83	-0.12	-4.47

Table 7:5(B). Additive correction factors for milk yield, first milk yield and yield per day for both Bunaji and Sokoto Gudali cattle

Year	Milk yield	First milk yield	Yield per day
	Correction factors		
1934	-70.02	50.6	-0.19
1935	-20.58	-167.7	-0.02
1936	-47.69	-119.0	-0.39
1937	-60.27	-151.5	-0.48
1938	-62.08	-357.1	-0.47
1939	33.52	-330.8	-0.16
1940	-35.52	-208.8	-0.37
1941	40.15	-160.1	-0.08
1942	90.02	-138.1	-0.03
1943	140.89	-61.0	0.19
1944	187.54	-99.2	0.55
1945	119.44	107.8	0.45
1946	111.18	-36.5	0.34
1947	198.56	-112.6	0.43
1948	90.66	84.9	0.26
1949	-157.79	295.2	-0.31
1950	-124.74	166.1	-0.06
1951	-120.58	354.9	-0.17
1952	-148.89	154.1	-0.20
1953	-22.45	246.6	0.11
1954	-23.55	77.2	0.20
1955	-67.20	-50.0	0.26
1956	-112.16	27.0	-0.33
1957	54.56	436.7	0.39

Table 7:5(B) Continued

	Milk yield	First milk yield	Yield per day
Parity	Correction factors		
1	212.92	-	0.33
2	190.3	-	0.09
3	81.09	-	-0.22
4	40.86	-	-0.42
5	-64.08	-	-0.53
6	-125.89	-	-0.32
7	-30.57	-	-0.51
8	-123.95	-	-0.37
9	-180.68	-	-
Month of calving			
January	-85.63	-6.4	-0.25
February	-102.17	-82.2	-0.22
March	-45.11	-45.5	-0.23
April	0.43	-87.3	0.02
May	5.87	-31.7	0.06
June	83.94	125.0	0.19
July	37.74	-10.4	0.09
August	-26.71	77.4	-0.03
September	28.27	22.4	0.09
October	50.41	-14.9	0.16
November	87.77	67.5	0.11
December	-34.81	-13.8	-0.01

Table 7:5(C). Additive correction factors for first lactation length, first calving interval and first dry period for both Bunaji and Sokoto Gudali cattle

Year	First lactation length	First calving interval	First dry period
	Correction factors		
1934	-18.71	- 4.12	70.66
1935	8.75	31.25	31.84
1936	11.95	52.54	26.83
1937	13.45	53.53	-6.56
1938	14.08	51.46	1.62
1939	18.07	56.27	2.62
1940	7.17	46.13	0.91
1941	12.19	47.54	21.85
1942	-7.51	15.79	13.78
1943	-3.95	-29.16	9.12
1944	-10.50	-18.75	13.17
1945	7.49	3.16	31.39
1946	8.30	3.04	15.62
1947	23.75	47.94	-24.03
1948	1.69	32.15	-44.65
1949	-29.26	-30.12	2.45
1950	-27.01	-49.25	0.91
1951	-11.69	-30.99	-29.89
1952	-11.78	-23.29	21.03
1953	- 3.39	-36.41	-65.11
1954	6.67	-32.31	-30.69
1955	6.64	-107.51	- 2.23
1956	-27.12	-20.46	17.30
1957	12.72	-48.43	-78.54

Table 7:5(C) Continued.

	First Lactation length	First calving interval	First dry period
Month of calving:-			
January	-17.06	- 6.85	37.05
February	- 9.35	-11.92	10.62
March	- 5.54	-21.85	-11.75
April	4.97	- 8.85	- 1.28
May	4.93	- 2.71	-10.0
June	14.86	10.60	-13.67
July	4.04	8.52	- 4.67
August	-11.27	10.51	12.98
September	0.93	2.29	18.78
October	3.42	6.99	-21.94
November	6.24	13.39	-11.68
December	3.83	-0.12	- 4.47

Table 7:5(D) Additive correction factors for age at first calving and birth weight for Bunaji and Sokoto Gudali cattle

	Age at first calving	Birth weight
Year	Correction factors	
1934	16.26	0.19
1935	42.59	-0.74
1936	178.81	0.28
1937	69.94	0.65
1938	120.37	1.03
1939	120.25	0.38
1940	80.88	0.75
1941	49.89	1.02
1942	82.84	-0.34
1943	108.71	-0.82
1944	59.24	-0.44
1945	-88.11	-0.67
1946	-37.23	0.36
1947	44.05	1.30
1948	156.76	-0.22
1949	17.83	-0.64
1950	-60.97	0.75
1951	-63.17	0.28
1952	-174.13	-0.07
1953	-186.33	-1.49
1954	-236.96	-0.38
1955	-67.11	-0.82
1956	-70.39	-0.42
1957	-127.36	-1.04

Table 7:5(D) Continued.

	Age at first calving	Birth weight
Month of calving:	Correction factors	
January	46.47	0.21
February	55.53	-0.23
March	4.65	-0.33
April	26.72	-0.50
May	-45.61	-0.51
June	-2.33	0.61
July	-27.42	0.90
August	-16.51	0.51
September	17.85	0.18
October	-35.91	-0.12
November	-25.61	-0.31
December	0.14	-0.31
Parity		
1	-	-0.97
2	-	-0.64
3	-	0.33
4	-	0.11
5	-	0.31
6	-	0.03
7	-	0.30
8	-	0.31
9	-	0.42
Sex of calf		
Male	-	-0.18
Female	-	0.18

Table 7:6(A) Estimates of variance (diagonal) and covariance (above diagonal) for 1st, 2nd and 3rd milk yield for Bunaji cattle

	First milk yield	Second milk yield	Third milk yield
First milk yield	32.0	21.000	13.400
Second milk yield		21.0	13.400
Third milk yield			13.4

Table 7:6(B) Genetic correllations between the 1st, 2nd and 3rd milk yield for Bunaji cattle.

	First milk yield	Second milk yield	Third milk yield
First milk yield		0.81	
Second milk yield			0.80
Third milk yield	0.65		

Table 7:7(A). Estimates of variance (diagonal) and Coveriance (about diagonal) for 1st, 2nd and 3rd yield for Sokoto Gudali cattle

	First milk yield	Second milk yield	Third milk yield
First milk yield	19.5	8.980	8.970
Second milk yield		8.98	
Third milk yield		- -	8.97

Table 7:7(B) Genetic correlations between the 1st, 2nd 3rd milk yield for Sokoto Gudali cattle

	First milk yield	Second milk yield	Third milk yield
First milk yield		0.68	
Second milk yield			0.99
Third milk yield	0.68		

Table 7:8(A). Estimates of variance (diagonal) and Covariance (above diagonal) for first milk yield and first yield traits for Bunaji cattle

	First milk yield	First milk length	First calving interval	First dry period	Age at first calving
First milk yield	32.0	0.9	3.3	1.3	1.1
First milk length		0.9			
First calving interval			3.3		
First dry period				1.3	
Age at first calving					1.1

Table 7:8(B) Genetic correlations between first milk yield and first milk yield traits for Bunaji cattle

	First length	First interval	First dry	Age first calving
First milk yield	0.17	0.32	0.20	0.19
First milk yield				
First calving interval				
First dry period				
Age at first calving				

Table 7:9(A) Estimates of variance (diagonal) and Covariance (above diagonal) for first milk yield and first milk yield traits for Sokoto Gudali cattle

	First milk yield	First milk length	First calving interval	First dry period	Age at first calving
First milk yield	19.5	0.9	5.1	0.7	2.1
First milk length		0.9			
First calving interval			5.1		
First dry period				0.7	
Age at first calving					2.1

Table 7:9(B). Genetic correlation between first milk yield and first milk yield traits for Sokoto Gudali cattle

	First length	First interval	First dry	Age at first calving
First milk yield	021	0.51	0.19	0.33
First milk yield				
First calving interval				
First dry period				
Age at first calving				

The variance and covariance for milk yield and reproductive traits for Bunaji and Sokoto Gudali cattle are presented respectively in Tables 7:10(A) and 7:11(A), while the genetic correlations between the traits for Bunaji and Sokoto Gudali cattle are given in that order in Tables 7:10(B) and 7:11(B). Results revealed that the genetic correlations varied from rg = 0.17 to rg = 0.21 for Bunaji cattle while for the Sokoto Gudali the correlations ranged from rg = 0.11 to rg = 0.33.

7.2.2. Discussion

All the genetic correlations were positive. The genetic correlations obtained between the first three milk yield tend to underline the adjacency effect of lactations as adjacent lactations showed higher values especially in the Bunaji cattle The genetic correlations between the first milk yield and first reproductive traits revealed that first milk yield had the largest genetic correlations value with first calving interval in both breeds of cattle. However, when milk yield over all lactations and the reproductive trait for all lactations were examined for genetic correlation, milk yield and age at first calving had the highest genetic association. The genetic correlations recorded in this study fall within the values reported for the few report found in the literature (Gurnami et al., 1976; Singh and Sundaresan, 1966; Singh et al., 1968; Chandaramani and Dadlami, 1967; Dadlami and Chandiramani, 1968). That the reproductive traits tended to manifest relatively low genetic correlation with milk yield suggests that possible slow progress would be made in the reproductive traits by selection, when emphasis is placed on increased milk yield unless selection pressure is applied in culling animals that calve

Table 7:10(A). Estimates of variance (diagonal) and covariance (above diagonal) for milk and milk yield traits for Bunaji cattle

	Milk yield	Lactation length	Calving interval ($x10^3$)	Dry period	Age at first calving
Milk yield	24.3	0.85	0.93	0.82	1.7
Lactation length		0.6			
Calving interval			0.8		
Dry period				0.7	
Age at first calving					1.1

Table 7:10(B) Genetic correlations between milk yield and milk yield traits for Bunaji cattle

	Lactation length	Calving interval	Dry period	Age at first calving
Milk yield	0.18	0.18	0.17	0.21
Lactation length				
Calving interval				
Dry period				

Table 7:11(A). Estimates of variance (diagonal) and covariance (above diagonal) for milk yield traits for Sokoto Gudali cattle

	Milk yield	Lactation length	Calving interval	Dry period	Age at first calving
			(x10^3)		
Milk yield	18.77	0.82	0.62	0.54	3.2
Lactation length		0.61			
Calving interval			0.31		
Dry period				0.22	
Age at first calving					2.1

Table 7:11(B) Genetic correlations between milk yield and milk yield traits for Sokoto Gudali cattle

	Lactation length	Calving interval	Dry period	Age at first calving
Milk yield	0.18	0.13	0.11	0.33
Lactation length				
Calving interval				
Dry period				

irregularly or tend to display unduly long calving interval.

7.3. Phenotypic correlation

7.3.1 Results

The estimates of phenotypic correlations between milk yield and preproductive traits for Bunaji and Sokoto Gudali cattle are shown in Tables 7:12 and 7:13. Results show that the phenotypic correlations between milk yield and lactation length, yield per day of calving interval, respectively, were high and positive for both Bunaji and Sokoto Gudali cattle. However, the phenotypic correlation between milk yield and calving interval, dry period varied from negative to positive and low to moderate in value for Bunaji and Sokoto Gudali cattle. The dry period was negatively correlated with yield per day of calving interval as expected, the value obtained in the present study being -0.30 and -0.44 respectively for Bunaji and Sokoto Gudali cattle. The phenotypic correlation between milk yield and calving interval was also negative and moderate. Results also showed that first milk yield was positively correlated with first lactation length. As expected, total milk yield was positively correlated with milk yield per day of calving interval.

7.3.2. Discussion

Although positive correlation was found between milk yield and lactation length, negative correlation was found in the literature for these trait (Chandiramani and Dadlami, 1967). The result from the present study indicated that increase in lactation length would result in increase in milk yield. The present correlations obtained between milk yield and calving interval,

Table 7:12 Phenotypic correlation between milk yield and reproductive traits for Bunaji breed.

Trait	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
305 day milk yield (X_1)	0.05	0.76	-0.29	0.89	-	-					
Calving interval (X_2)				0.20	-						
Lactation length (X_3)				0.69	-						
Length of dry period (X_4)				-0.30	-						
Yield per day of calving interval (X_5)					---	-	-	-	--	-	0.90	0.22
First lactation milk yield(X_6)					-	0.07	0.86	-0.07	-0.27	--		

X_7 = Age at first calving

X_8 = First lactation length

X_9 = First calving interval

X_{10} = First dry period

X_{11} = Total milk yield

X_{12} = Lactation number

Table 7:13. Phenotypic correlation between milk yield and reproductive traits for Sokoto Gudali breed

Trait	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
305 day milk yield (X_1)	0.23	0.81-	0.46	0.90-							
Calving interval				-0.16-							
Lactation length (X_3)				0.72-							
Length of dry period (X_4)				-0.44-							
Yield per day of calving interval (X_5)				- -	- -	-	0.90	0.15			
First lactation milk yield(X_6)				- 0.15	0.88	0.16-	0.48	- -			

X_7 = Age at first calving

X_8 = First lactation length

X_9 = First calving interval

X_{10} = First dry period

X_{11} = Total milk yield

X_{12} = Lactation number

dry period which varied from negative to positive fall within the recorded values in the literature which were 0.04 to 0.30 and -0.23 respectively for milk yield and calving interval, milk yield and dry period (Singh et al 1968, Singh and Sundaresan, 1966; Dadlami and Prabhu, 1968). The negative correclation recorded in this study between yield per day and dry period which were -0.30 and -0.44 respectively for Bunaji and Sokoto Gudali cattle would indicated thatselection should be made separately for each trait, because as improvement is made one trait loss in improvement would be made in the other trait. The correlation between first milk yield and age at first claving which was positive and low in both breeds and were 0.07 and 0.15 in that order for Bunaji and Sokoto Gudali cattle are within recorded values, -0.07 and 0.38 by other workers (Chandiramani and Dadlami, 1967; Singh and Sundaresan 1966). The present results revealed a positive association between milk yield and lactation length and between first lactation milk yield and first lactation length for both breeds, the pattern was manifested between yield per day are total milk yield. However the results demonstrated that the correlations between milk yield and dry period, calving interval and the first milk yield and first dry period, first calving interval, age at first calving were low and negative in value. The implication is that as observable improvement in one trait observable loss would result from the negatively correlated trait.

7.4. Repeatability estimates

7.4.1 Results

The analyses of variance for the repeatability of milk

yield traits and reproductive performance traits of Bunaji and Sokoto Gudali cattle are shown in Table 7.14. The repeatability estimates of the traits for both Bunaji and Sokoto Gudali cattle are presented in Table 7:15. The repeatability values recorded in this study varied from low values for calving interval and dry period in both breeds to moderate estimetes for yield per day of calving interval and lactation length, which suggested that, these traits might not be much repeatable in subsequent production. However, the repeatability estimates of milk yield were approaching high values this might indicate that this trait might be fairly repeatable in subsequent production in both breeds, which implies one measurement should be adequate for accurate assessment for the trait.

Repeatability estimates between paired lactations was computed as simple correlation (Stobbs, 1967). The repeatability estimates between paired first three lactations are shown in Table 7:16. Results showed that repeatability values between first and second, first and third lactations were similar in both breeds by coincidence and higher for Bunaji cattle (0.236 compared to 0.02). However, the estimates between second and third lactations ere negative in both breeds but higher in Sokoto Gudali cattle. The values were 0-046 and -0.019 for Sokoto Gudali and Bunaji breeds.

7.4.2. Discussion

The repeatability estimates obtained for Bunaji cattle for 1st and second, first and third lactations are within value reported for Henana cattle by Alim (1960), although slightly smaller than the estimate recorded by Mahadevan (1952) for

Table 7:14. Analyses of variance for milk yield and reproductive performence traits of Bunaji and Sokoto Gudali breeds.

Source of variation	305 day milk yield		Lactation length		Calving interval		Length of dry period		Yield per day calving interva	
	d.f	(m.s)(10^{x2})	d.f.	(m.s)(10^{x2})	d.f.	(m.s)(10^{x2})	d.f.	(m.s)(10^{x2})	d.f.	M.S
Bunaji breed										
Between Cows	220	598.2	250	174.3	207	59.3	201	56.0	195	3.4
Within Cows	1866	110.1	2204	57.0	2114	37.0	1669	36.3	1547	1.1
Sokoto Gudali breed										
Between Cows	83	508.1	90	156.4	75	21.3	73	21.2	65	3.1
Within Cows	529	173.2	561	81.6	462	17.4	400	17.0	393	1.2

Table 7:15. Repeatability of milk yield and reproductive traits for Bunaji and Sokoto Gudali breeds

Trait	Repeatability	Number of Cows	Number of records
Bunaji breed			
305 day milk yield	0.30	221	2087
Lactation length	0.18	251	2455
Calving interval	0.06	208	2321
Length of dry period	0.06	211	1880
Yield per day of calving interval	0.19	196	1743
Sokoto Gudali breed			
305 day milk yield	0.21	84	613
Lactation length	0.11	71	542
Calving interval	0.03	76	538
Length of dry period	0.04	74	514
Yield per day of calving interval	0.18	66	459

Table 7:16. Repeatability of milk yield between lactations for Bunaji and Sokoto Gudali breeds

	Bunaji breed		
Lactation number	1	2	3
1	-	-	-
2	0.236	-	-
3	0.236	-0.019	-
	Sokoto Gudali breed		
1	-	-	-
2	0.020	-	-
3	0.020	-0.046	-

Sinhala cattle. The values reported in this study for Sokoto Gudali cattle were lower than reported values for other breeds of tropical cattle.

Repeatability estimate is normally the upper limit of heritability. But from the results of the present study some traits gave hertability estimates that were higher than the repeatability estimates. The repeatability of response to selection is not consistent. This depends on the genetic properties of the population, the size and how repeatable the response if a trait is from one generation to the next. It the genes controlling a trait are at low frequencies, then the response to selection will make the repeatability to fade away. Genes at the intermediate frequencies will manifest an initial response to selection but the repeatability of response would wane so that in later generations the situation would no longer hold that repeatability would always be the upper limit of heritability value. In milk yield the genes that influence yield in the first lactation are not exactly the ones that come into play in second and later lactations as milk yield in all lactations is not dependent on identical developmental and physiological processes.

The repeatability estimates obtained in this study are lower than the heritability. This can be attributed to the fact that feeding of the cows are not uniform from year to year, and not all environmental factor are known for purpose

of removing them. The sample size of animals used in measurements may be small. The estimates of heritability vary from one generation to the next and since the genes effect changes, the estimation of heritability may not be repeated.

CHAPTER EIGHT

SELECTION GAIN

8.1. Estimate from direct selection of dams of cows

8.1.1.Results

The phenotypic superiority of cows retained for each subsequent lactation for Bunaji and Sokoto Gudali cattle are given in Tables 8:1 and 8:2. Results showed that the average selection differential of milk yield were 105.7 kg and 113.7 kg for Bunaji and Sokoto Gudali breeds, respectively. The estimates of the phenotypic superiority of dams of bulls first milk yield, deviated from the contemporaries mean first lactation yield for Bunaji and Sokoto Gudali cattle are shown in Table 8:3. Results showed that the superiority of dams of bulls first milk yield over their contemporarys' mean yield was +320.4 kg and +354.5 kg respectively for Bunaji and Sokoto Gudali cattle. The dams of bulls for the Sokoto Gudali cattle manifested greater superiority over their contemporaties than those of the Bunaji cattle. The results showed that the total selection differential realised from the selection applied on the dams and sires in the Bunaji and Sokoto Gudali cattle were respectively, 426 kg and 468.2 kg.

The estimates of the genetic gain for 305-day milk yield for Bunaji and Sokoto Gudali cattle are presented in Table 8:4. The results revealed that the genetic gain per generation for Bunaji cattle was 217.3 kg, while the genetic gain per generation for Sokoto Gudali was 126.4 kg.

Table 8:1. Phenotypic selection differentials for 305-day milk production (kg) for Bunaji cattle

Lactation number	Number of records	Average milk yield (kg)	Number records culled	Average milk yield of culled (kg)	Number selected	Average milk yield selected (kg)	Selection differential (kg)
1	462	812.9	95	711.1	367	839.2	26.3
2	469	829.2	141	691.8	328	887.3	58.1
3	379	913.5	104	725.7	275	984.5	71.0
4	304	959.7	104	747.1	200	1070.3	110.6
5	213	1076.8	72	918.8	141	1157.5	80.7
6	160	1071.6	56	965.0	104	1129.0	57.4
7	112	1030.5	60	874.8	52	1210.2	179.7
8	58	1159.1	42	1059.5	16	1420.7	261.6

Mean selection differential = 105.7 kg

Table 8:2. Phenotypic selection differentials for 305-day milk production (kg) for Sokoto Gudali cattle

Lactation number	Number of records	Average milk yield (kg)	Number records culled	Average milk yield of culled (kg)	Number selected	Average milk yield of selected(kg)	Selection differential (kg)
1	241	833.6	61	604.9	180	911.1	77.5
2	216	860.4	70	672.6	146	950.5	90.1
3	167	957.7	63	692.3	104	1118.4	160.7
4	108	986.5	38	773.1	70	1102.3	115.8
5	77	119.5	25	813.5	52	1266.6	147.1
6	57	1206.2	30	1127.7	27	1293.5	87.3
7	30	1040.9	13	935.8	17	1128.9	88.0
8	19	1034.7	10	906.0	9	1177.6	132.9

Mean selection differential = 113.7 kg.

Table 8:3. Phenotypic superiority estimate of dams of bulls' first milk yield as deviation from contemporarys' mean yield for Bunaji and Sokoto Gudali cattle

Breed	Number of bulls	Average dams yield(kg)	Record of mates	Average milk yield (kg)	Deviated milk yield (kg)
Bunaji	39	941.3	423	620.9	320.4
Sokoto Gudali	15	964.0	226	609.5	354.5

Table 8:4 Estimate of genetic gain for 305 day milk yield for Bunaji and Sokoto Gudali cattle

Statistic	Breed	
	Bunaji	Sokoto Gudali
Heritability (h^2)	0.51	0.27
Standard error h^2 (σh^2)	0.12	0.12
Selection differential (S.D.) cows (kg)	105.7	113.7
Selection differential (S.D. bulls (kg)	320.4	354.5
Total Selection differential (S.D.) Cows and bulls) (kg)	426.4	468.2
Genetic gain per generation (kg) ($S.D.h^2$)	217.5	126.4
Generation intervals (years)	24.5	26.5
Genetic gain per year (kg)	8.88	5.14
Average 305 day milk yield (kg)	1039.0	1055.0
Genetic improvement(%)	0.85	0.49

As mortality rates have a marked effect on generation interval, its estimation was based on the population survival parameters in the study. The average age at first calving was 45.9 months for Bunaji and 46.5 months for Sokoto Gudali cattle. The average calving interval was 13.5 months for both Bunaji and Sokoto Gudali cattle. As a cow must calve 2.8 times to replace herself, the generation interval for cow to cow path was 7.0 years and 7.03 years respectively for Bunaji and Sokoto Gudali cattle. The generation intervals along the cow to bull, bull to bull and bull to cow paths were estimated for Bunaji as 6.4 years, 5.4 years and 5.7 years, while the same estimates for Sokoto Gudali cattle were 6.4 years, 5.5 years and 5.7 years. Thus the generation length (generation intervals) for Bunaji and Sokoto Gudali cattle were 24.5 years and 24.6 years respectively. Results revealed that the genetic improvement of milk yield were 0.9% and 0.5% respectively for Bunaji and Sokoto Gudali cattle.

8.1.2 Discussion

The estimate of genetic gain and improvement obtained in this study indicated a slightly higher rate of genetic improvement in Bunaji cattle compared with Sokoto Gudali cattle. These results compared favourably with other results of genetic improvement which ranged from 0 to 0.8% for East African Zebu cattle (Galukande, Mahadevan and Black 1962), and for Deshi cattle (Moulick et al., 1972). However, the genetic improvement obtained in the present study for Bunaji cattle was slightly lower than the value of 1.0% obtained by Robertson (1950) in a preliminary study on Bunaji cattle at Shika. The computation of the results obtained in the present results is based on the method of Robertson (1950). The realised heritability is only

slightly different from the heritability obtained from data on the unselected population. The conditions for realised heritability to be valid include: (a) the estimate of the selection intensity from the tables of statistics assumes that the parents chosen will contribute equal numbers of progency to the next generation. However, with selection, this rarely happens, for even when precautions are taken, some parents selected may be sterile. This discrepancy may be overcome if the selection intensity is calculated in the form of a weighted selection differential in which the deviations from the unselected mean of the selected parents are weighted for contribution to offspring generation. (b) random mating of the parents is assumed in devising the heritability. However phenotypic assortative mating is practised. (c) Selection, if effective, alters the population gene frequencies and genotypic values resulting from various forms of non-additive gene action. However, the prediction equation and heritability refer to changes in genotypic value resulting from gene frequency changes affecting additive genetic effects alone (Bowman, 1974). The differences in genetic gain between Bunaji and Sokoto Gudali cattle underscored the different inheritance impulse between the two breeds, but the disparity in sample sizes of the breeds may influence the frequency and manifestation of the gene effects responsible for milk yield. The selection pressure employed in the respective breeds of cattle also would influence genes and their effects..

8.2. Indirect selection for milk yield

From the present study conducted in both the Bunaji and Sokoto Gudali cattle, lactation length was positively highly correlated with the 305 day milk yield. An indirect selection

selection was made based on a comparison of direct with indirect selection on the basis of similar proportions of individuals selected. The mean yield of the top 5% to 25% cows selected on milk yield was compared with the mean milk yield of the top 5% to 25% of cows selected on the basis of lactation length.

The cows that gave milk yield greater than the positive confidence limit were selected on the basis of milk or lactation length, with its corresponding milk yield recorded. The top 5% milk yield of animals for example was obtained using the equation:

$$Y = \bar{y} + (S.E.)(t)$$

where

Y = upper limit plus component involving the standard error and t value at appropriate level.

$\bar{y}$ = mean milk yield for cows

S.E.= standard error = $\frac{S.d.}{\sqrt{n}}$

s.d = standard deviation

n = Sample number

t = t value at appropriate level

8.2.1. Results

The results of the comparison of indirect selection for milk yield based on milk yield and lactation length are given for Bunaji cattle in Table 8:5 while the values for Sokoto Gudali cattle are shown in Table 8:6. The results showed that for Bunaji cattle and Sokoto Gudali cattle the loss in milk yield using the indirect selection was -63.9 kg

Table 8:5. Comparison of selection for 305 day milk yield (kg) based on actual milk yield and lactation length for Bunaji cattle

Proportion records selected	Selection for: Actual milk yield (kg)		Lactation length(days)	Difference (B - A)
	direct milk yield		indirect milk yield	
	n	$\bar{x}$ (B)	$\bar{x}$ (A)	
5%	109	1397.8	1333.9	-63.9
10%	217	1405.4	1339.2	-66.2
15%	326	1411.5	1039.3	-71.3
20%	435	1415.4	1341.2	-74.2
25%	544	1416.3	1342.7	-75.7

N = 2177

n = Number of records selected, N = Total Number of records.

Table 8:6. Comparison of selection for 305 day milk yield (kg) based on actual milk yield and lactation lactation length for Sokoto Gudali cattle

Proportion records selected	Selection for: Actual milk yield (kg)		Lactation length (days)	
	direct milk yield		indirect milk yield	Difference
	n	$\bar{x}$ (B)	$\bar{x}$ (A)	(B - A)
5%	46	1466.3	1418.8	-47.5
10%	93	1474.8	1421.3	-53.6
15%	139	1489.5	1425.1	-64.4
20%	186	1486.5	1430.0	-66.5
25%	232	1543.0	1432.9	-110.2
N = 928				

n = Number of records selected; N = Total number of records.

and -47.5 kg respectively. The loss in milk yield by using the indirect selection for milk yield increased in both breeds of cattle as the proportion of records selected increased.

8.2.2. Discussion

The results of the indirect method of selecting for milk yield are consistent in both breeds, with the least loss in milk yield resulting from selecting for the top 5% of the records of the animals. The loss in milk yield was smaller for the Sokoto Gudali cattle, than the Bunaji when the top 5% of the records were selected (-47.5 kg compared with -63.9 kg). However, when the top 25% of the records were selected in both breeds the loss in milk yield using the indirect selection was larger in the Sokoto Gudali cattle than the Bunaji cattle (-110.2 kg compared with -75.7 kg). The use of selecting indirectly for milk yield by using lactation length to improve milk yield would have merit because lactation length varies remarkably in tropical breeds of cattle as was observed in both the Bunaji and Sokoto Gudali breeds in this study, while the milk yield per day of calving interval varies very little. In the temperate breeds of cattle however, lactation length varies not markedly while the milk yield per day of a calving interval changes more markedly. Thus attempt to improve the milk yield in both breeds can be achieved by seeking to improve the lactation length and where selection for higher lactation length is given strong emphasis, the milk yield over 305 days would increase simultaneously. The loss in indirectly selecting for milk

yield by using lactation length involving the top 5% of records of the animals was smallest in both breeds, while using the top 25% of the records of the animals gave a relatively higher loss in Bunaji cattle but a comparatively higher loss in milk in the Sokoco Gudali cattle.

CHAPTER NINE

GENERAL DISCUSSION

The investigation herein reported on the evaluation of the dairy potential of Bunaji and Sokoto Gudali cattle on dairy productive traits revealed that calvings for both breeds in the first and all calvings were influenced by year and month, whose effects should be removed. The year effects would represent the environmental variations in climate and forage availability which cannot be properly duplicated. The effect of month of calving showed a marked effect on calvings in both breeds. As it would appear that the gestating cows required better feeding during the latter part, calvings should be directed to fall during the dry months so that both the cows and the calves can take advantage of the available pasture of the rainy months which would improve both calf's growth and support higher milk yield of the cows as well as ensure preweaning calf survival.

As age influenced milk production the adjustment could effectively be done by expressing later lactations as a percentage of first records of the same cows. This would result in a lactation curve which would be at consonace with established normal lactation curve of cows. As age at first calving influenced milk yield resulting in increased in milk yield upto about twenty four months, beyond which increased age at first calving did not result in increased milk yield it will be desirable to reduce age at first calving of cows of both Bunaji and Sokoto cattle. If age at first calving is effectively reduced and calving interval is also reduced,

the generation interval would not be high and as such the genetic gain attained in milk yield per generation would give a sizeable gain per year. The calving interval of 13.5 months recorded in this study for both breeds could be reduced to ensure that cows calve once within 12 months.

The breed differences in first and all lactation 305 day milk yield would indicate the superiority of the Sokoto Gudali over the Bunaji cattle for this dairy trait. Whereas month and year had no effects on first milk yield, these environmental factors influenced all lactation 305 day milk yield. This results underscore the fact that the first milk yield of cows are less influenced by environmental effects and indicate better the genetic potential of cows for milk yield and would give a better indication of the inheritance of this dairy trait. The non significance of this dairy trait. The non significance of the 305 day milk when it was deviated from the year's mean pointed to the importance of the effects of the variation introduced by year in 305 day milk yield, which previously was very highly significant.

As regards lactation length, results from this study showed non significant effects of breed, would indicate this dairy trait is similar in both Bunaji and Sokoto Gudali cattle. The lactation length recorded in this study of 239 days and 236 days respectively for Bunaji and Sokoto Gudali cattle should be increased by selection as this would result in comensurate increase in milk yield because of the positive association between the two traits. The non significant influence of year and month on first lactation

length emphasised that environmental influences are less on this trait and basically on first dairy production trait and thus indicate the true genetic potential of the animal for this trait. Efforts could be directed to attempt to make first calves to stay longer in milk production by employing nutritional management approach that would support the expression of the inherent milk yield impulse of the cows and also by minimising the environmental disease and parasite challenge while the results revealed the significant effects of breed, month and year on total milk yield the effect of breed was not important for milk yield per day of calving interval. Thus the milk yield per herd life of cows was comparable for Bunaji and Sokoto Gudali cattle. The inclusion of calving interval as a covariate in the model for total milk yield removed the previously important effect of breed of this dairy trait. This is expected as milk yield per herd life was not significantly different between Bunaji and Sokoto Gudali cattle.

Dry period was influenced significantly ($P<0.001$) by year and parity, but breed and month of calving was not important for this trait. Dry period should be reduced so that calving interval should not be unduly long because dry period has a tendency to increase with parity of calving. The dry period obtained in this study of 160 days is fairly long and should be reduced.

Subsequent calving interval of 405 days obtained in this study revealed the important effects of year of calving, and the effect of parity which approached

significant level ($P<0.02$). A long subsequent calving interval would result in a lower milk yield in the previous lactation and underscore that the cows involved do not calve once yearly. It is desirable for profitable dairy operation for cows to calve once yearly and have a relatively short dry period but appreciably long lactation length.

The regression of least squares constants of calving interval on lactation length and dry period for both breeds which gave negative values indicate that efforts were made to reduce calving interval, dry period in the two breeds but at the same time a slight drop in lactation length also occurred over the years which was about 1 day.

The present results showed that the effects of year, month, parity and sex and breed were important for birth weight. However as birth weight per se is not of economic importance except that it ensures survival of calf and assists in the computation of preweaning growth rate, attempt should not be made to increase birth weight unduly because this can result in the danger of increasing the calving difficulty of cows.

The variation in the estimates of heritability of lactation and reproductive traits indicate the inheritance potential of these traits and the prospects of improvement that would be possible through selection.

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The variation in the estimates of heritability of lactation and reproductive traits indicate the inheritance potential of these traits and the prospects of improvement that would be possible through selection.

The estimate of genetic progress for improving milk yield obtained in this study indicated that efforts were made to improve the milk yield of both Bunaji and Sokoto Gudali cattle by selection along the path of dams of cows and dams of bulls but a larger selection intensity would be needed for greater improvement. The genetic gain of 0.9% and 0.5% obtained respectively for Bunaji and Sokoto Gudali cattle compared well with values recorded in the literature.

The selection indirectly for increase in milk yield in both breeds by selecting for lactation length revealed that selecting for the top 5% of the cows gave the least loss in milk yield due to the indirect method of selection used.

SUMMARY AND CONCLUSION

The study herein reported involves the evaluation of the dairy potential of Bunaji and Sokoto Gudali breeds on dairy productive traits in which a total of 3105 records of 761 cows over a period of 24 years were used. The records on birth weight were 3647 for the two breeds. The investigation also included the study on the environmental factors influencing dairy traits and the genetic estimates of the dairy traits.

Results showed that in both breeds the overall calvings over the years declined from parity one to nine, although within each year, number of animals in various parities was not on a continuous decline. For both breeds, the chi-squares comparison showed significant differences for both first and all calvings between years ($P<0.05$). Considering the effects of month, chi-squares comparism also revealed significant differences($P<0.05$) for both breeds for both first and all calvings.

Effect of age on milk production showed that gross comparison method indicated a peak milk yield in the sixth lactation with increases of 45% and 38% respectively over the first lactation for Sokoto Gudali and Bunaji breeds, while a decline occurred thereafter. Whereas the paired comparison method manifested a decline in the second lactation, accompanied by a rise in the third lactation followed by a continuous decline up to the

ninth lactation in both breeds. When later records were expressed as a percentage, as well as when deviated, later records were expressed as a percentage of the first records of the same animals results for Bunaji breed showed peaks at third, fifth, sixth and eighth lactations with increases of 3%, 3%, 6%, 9% and 3%, 3%, 5%, 7%, respectively for both methods for the four lactations which peaked. However, for Sokoto Gudali breed, both methods gave no peak but variable decline.

As regards age at first calving, results, showed that only year of calving had very highly significant effects ($P<0.001$), and similarly also, only the dam year of birth had very highly significant effects ($P<0.001$) on age at first calving. The recorded age at first calving were 45.7 months and 46.7 months for Bunaji and Sokoto Gudali breeds.

For calving interval, results showed very highly significant effects of year ($P<0.001$), and calving interval number was significant ($P<0.05$), respectively. The calving interval recorded for Bunaji and Sokoto Gudali breeds were 13.46 months and 13.45 months.

The first lactation 305 days milk yield was not significantly affected by year, month of calving or breed ($P>0.05$). Even when age was included as a covariate all the effects were still having non significant influence ($P>0.05$) on first lactation milk

production. The first lactation milk yield were 812.9 kg and 814.8 kg respectively for Bunaji and Sokoto Gudali breeds.

Considering all lactation 305-day milk yield results showed that whereas the effects of breed was not significant ($P>0.05$), the effects of year or month of calving as well as parity were all significant ($P<0.001$). The average milk yield for all lactations were 1039 kg and 1055 kg for Bunaji and Sokoto Gudali breeds. When dry period and calving interval were separately included as covariates, the effects of breed were still non significant on all lactations milk yield ($P>0.05$). When the 305-day milk yield was expressed as a deviation from year's mean, breed effects were still non significant, while year of calving was rendered non-significant but month and parity remained significant ($P<0.001$). When deviated 305-day milk yield of all lactations was used with season instead of month of calving, both breed of cattle and year of calving were also non-significant ($P>0.05$), while season and parity were very highly significant ($P<0.001$).

Regarding lactation length, results showed non-significance ($P>0.05$) for effects of breeds, but the effects of year and parity were very highly significant ($P<0.001$), and the effects of month of calving was also highly significant ($P<0.003$). When

calving interval was included as a covariate, the breed still exerted no significant effects on lactation length ($P>0.05$). The lactation length recorded was 239.2 days and 236.2 days for Bunaji and Sokoto Gudali breeds respectively. Considering first lactation length the effects of year, month of calving and breed were all non-significant. The least squares means for first lactation length was 221.6 days for the two breeds combined.

Results for milk yield per day of calving interval revealed highly significant effects ($P<0.01$) of year, month and calving interval number, but the effects of breed was non-significant ($P>0.05$). The least squares mean for milk yield per day was 2.42 kg/day.

Results for total milk yield indicated that the effects of breed, year, month and parity number were all very highly significant ($P<0.001$). The least squares means were 1018.9 kg and 1038.1 kg, respectively for Bunaji and Sokoto Gudali breeds. When lactation length and dry period were included separately as covariates, all the effects were very highly significant ($P<0.001$), but when calving interval was included as a covariate only the effects of breed was not significant ($P>0.05$).

As regards dry period, results revealed that the effects of year and parity were very highly significant ($P<0.001$), while the effects of breed and month of calving were non-significant ($P>0.05$). The least

squares means for dry period was 160.4 days. Results showed that the effects of breed, year, month of calving all had no effects on first dry period ($P>0.05$).

Results of subsequent calving interval showed very highly significant effects of year ($P<0.001$), significant effects of parity ($P<0.02$), but effects of breed and month of calving were non-significant ($P>0.05$). When various factors were included as covariates, such as dry period, the effects of year and parity only were very highly significant ($P<0.001$). The inclusion of calving interval as a covariate, showed the effects of year only as being very highly significant ($P<0.001$), while inclusion of 305 day milk yield revealed that only the effects of year of calving were very highly significant ($P<0.001$). The least squares means for subsequent calving interval obtained in this study was 405 days.

Regression of least squares constants of calving intervals, lactation length and dry period for both breeds on year indicated that there was a decline over the years of 4.75 days, 0.65 days and 2.49 days, respectively for calving interval, lactation length and dry period respectively.

Results for birth weight showed that year, month, parity and sex very highly significantly influenced birth weight of calves ($P<0.001$), while the effects of breed of cattle also showed highly significant effects

(P<0.004). The least squares mean for birth weight was 22 kg.

Heritability estimates obtained in this study for first to third lactations varied fron 0.59 to 0.30 for Bunaji breed and 0.34 to -0.01 for Sokoto Gudali breed. The heritability estimates for age at first calving, calving interval lactation length, milk yield per day dry period, all lactation milk yield and birth weight were 0.12, 0.13, 0.28, 0.37, 0.09, 0.51 and 0.40 for Bunaji breed, while the values for Sokoto Gudali breed were, 0.12, 0.12, 0.26. 0.25, 0.04, 0.21 and 0.32.

The genetic correlation varied from negative to positive values in Sokoto Gudali breed, while positive and small to large values were recorded in Bunaji breed. The genetic correlations obtained between the first three and all lactations also varied in both breeds.

The repeatability estimates varied from low values in dry period to medium values in 305 day milk yield, 0.06, 0.30 and 0.04, 0.21, respectively for these traits in Bunaji and Sokoto Gudali breeds.

The phenotypic correlations varied from negative to positive values in both breeds.

The estimate of genetic progress revealed that the genetic improvement of 0.9% and 0.5% were obtained respectively for Bunaji and Sokoto Gudali breeds.

Selection for improvement in milk yield indirectly through selection for lactation length showed the least loss in accuracy when selection is made for the top 5% as compared with the 25%.

The results of this study revealed that over the 24 years, improvement has made in the milk yield of both Bunaji and Sokoto Gudali breed and improvement can be achieved in milk yield be selecting indirectly for lactation length with the least loss in accuracy if the top 5% of the cow population is used in Bunaji and Sokoto Gudali cattle.

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APPENDIX 1

Table 1: Analysis of variance for effects of year and month of calving on first lactation milk yield od Bunaji cattle.

Table 2: Analysis of variance for effects of year and month of calving on first lactation milk yield of Sokoto Gudali cattle.

Table 3: Estimated least squares constants and means for first lactation milk yield for Bunaji cattle.

Table 4: Estimated least squares constants and means for first lactation milk yield of Sokoto Gudali cattle.

Table 5: Analysis of variance for effects of year and month on calving on first lactation milk yield with age as a covariate for Bunaji cattle.

Table 6: Analysis of variance for effects of year and month of calving on first lactation milk yield with age as a dovariate for Sokoto Gudali cattle.

Appendix 1.
Table 1: Analysis of variance for effects of year and month of calving on first lactation milk yield of Bunaji cattle.

Source of variation	D.F	Mean squares (kg2) x (104)	F value	Significance level
Main effects	34	20.66	1.04	0.42
Year	23	20.09	1.01	0.45
Month	11	20.55	1.03	0.42
Residual	427	19.99	-	
Total	461	19.99	-	

Appendix 1.
Table 2: Analysis of variance for effects of year and month of calving on first lactation milk yield of Sokoto Gunaji cattle

Source Variation	D.F	Mean squares (kg2) x (10^4)	F Value	Significance Level
Main effects	34	41.32	1.92	0.003
Year	23	36.93	1.72	0.03
Month	11	39.27	1.62	0.05
Residual	206	21.63	-	
Total	240	24.33	-	

Appendix 1

Table 3: Estimated least squares constants and means for first lactation milk yield (kg) for Bunaji cattle

Class	Number of Animals	L.S.C.	Mean
Overall	1462	-	814.29
Year of calving:			
1934	10	-64.05	750.24
1935	20	94.88	909.17
1936	20	-55.85	753.44
1937	27	-40.70	773.59
1938	15	214.78	1029.07
1939	7	135.23	949.52
1940	21	64.68	878.97
1941	33	15.35	829.64
1942	19	-12.14	802.15
1943	27	-36.22	778.07
1944	30	2.05	816.34
1945	20	-131.98	682.31
1946	21	-78.00	736.29
1947	29	110.12	924.41
1948	14	172.35	986.64
1949	9	-341.79	472.50
1950	11	119.28	933.57
1951	15	39.40	853.69
1952	20	-18.93	795.36
1953	17	-155.38	658.91
1954	17	-170.54	643.75
1955	38	40.31	854.60
1956	13	39.93	854.22
1957	9	57.22	971.51
Month of calving:			
January	46	26.82	841.11
February	32	87.07	901.36
March	29	-49.46	764.83
April	33	71.79	886.08

Appendix 1.
Table: 3 Continued.

Class	Number of Animal	L.S.C	Mean
Month of calving:			
May	36	-30.81	886.08
June	57	-175.63	638.68
July	30	- 0.43	813.86
August	33	- 1.31	812.98
September	48	-17.65	832.24
October	31	32.95	847.24
November	36	-37.41	776.88
December	51	58.77	783.06

Within variable groups, row means followed by the same letter do not differ significantly ($p > 0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Appendix 1
Table 4: Estimated least squares constants and means for first lactation milk yield (kg) for Sokoto Gudali cattle

Class	Number of Animals	L.S.C.	Mean
Overall	241	-	788.65
Year of calving	8	144.70	933.35
1934	8	144.870	933.35
1935	13	242.11	1030.76
1936	5	310.23	1098.88
1937	7	290.27	1078.92
1938	15	-141.35	647.30
1939	11	13.01	801.66
1940	8	113.10	675.55
1941	8	-105.58	683.07
1942	9	-31.18	757.47
1943	21	-282.31	506.34
1944	14	-125.95	662.70
1945	14	162.31	950.96
1946	14	28.85	817.50
1947	8	-288.01	500.64
1948	8	290.77	1079.42
1949	7	60.22	848.87
1950	13	21.41	810.06
1951	19	117.38	906.03
1952	5	-147.10	641.55
1953	3	-619.70	168.95
1954	6	128.15	916.80
1955	15	264.74	1054.39
1956	6	-78.12	710.53
1957	4	-141.75	646.90
Month of calving:			
January	20	148.70	937.35[a]
February	25	185.77	974.42[b]
March	22	34.13	822.78[c]
April	21	-15.77	772.88[d]

Appendix 1 Table 4 (Continued).

Class	Number of Animals	L.S.C	Mean
Month of calving:			
May	20	37.22	825.87^{c}
June	25	169.98	956.63^{ab}
July	14	-86.98	701.67^{e}
August	27	192.58	981.23^{b}
September	18	-102.53	686.12^{e}
October	20	-102.73	685.92^{e}
November	9	-363.95	424.70^{f}
December	20	-96.42	692.23^{e}

Within variable groups row means followed by the same letter do not differ significantly ($p > 0.05$). If no letter is used it indicates that the variable do not show a significant difference in the analysis of variance.

Appendix 1.
Table 5: Analysis of variance for effects of year and month of calving on first lactation milk yield with age as a coverate for Bunaji cattle

Source of Variation	D.F.	Mean squares (kg^2) x (10^4)	F. Value	Significance Level
Covariate				
Age	1	45.49	2.24	0.14
Main effects	34	17.20	0.85	0.72
Year	23	18.63	0.92	0.58
Month	11	14.55	0.71	0.72
Residual	402	20.34	-	
Total	437	20.16	-	

Covariate Age b = 0.15

Appendix 1

Table 6: Analysis of variance for effects of year and month of calving on first lactation milk with age as a covarate for Sokoto Gudali cattle

Source of variation	D.F	Mean squares (kg^2) x (10^4)	F. Value	Significant level
Covariate				
Age	1	5.90	0.14	0.85
Main effects	34	67.44	1.57	0.03
Year	23	67.05	1.56	0.03
Month	11	57.37	1.33	0.25
Residual	160	43.00	-	
Total	195	47.07	-	

Covariate Age b = 0.023

APPENDIX 2

Table 7: Analysis of variance for effects of year and month of calving and parity number on all lactation milk yield for Bunaji cattle.

Table 8: Analysis of variance for effects of year and month of calving and parity number on all lactation milk yield for Sokoto Gudali cattle.

Table 9: Estimated least squares constants and means for 305-day milk yield (kg) for Bunaji cattle.

Table 10: Estimated least squares constants and means for 305-day milk yield (kg) for Sokoto Gudali cattle.

Appendix 2. Table 7: Analysis of variance for effects of year and month of calving and parity number on all lactation milk yield of Bunaji cattle

Source variation	D.F.	Mean squares $(kg^2)x(10^5)$	F Value	Significance level
Main effects	42	14.57	7.39	0.001
Year	23	10.47	5.31	0.001
Month	11	7.02	3.56	0.001
Parity Number	8	37.09	18.81	0.001
Residual	2124	1.97	-	
Total	2176	2.22	-	

Appendix 2. Table 8: Analysis of variance for effects of year and month of calving and parity number on all lactation milk yield of Sokoto Gudali cattle

Source of variation	D.F.	Mean squares $(kg^2) \times (10^5)$	F Value	Significance level
Main effects	42	7.85	3.31	0.001
Year	23	7.75	3.27	0.001
Month	11	2.97	1.25	0.25
Parity Number	8	15.59	6.57	0.001
Residual	885	2.37	-	
Total	927	2.62		

Appendix 2

Table 9: Estimated least squares constants and means 305-day milk yield (kg) for Bunaji cattle

Class	Number of Animals	L.S.C.	Mean
Overall	2177	-	1048.43
Year of calving:			
1934	64	46.40	1094.83[a]
1935	70	9.24	1057.67[b]
1936	84	-4.90	1043.53[c]
1937	92	-4.88	1043.55[c]
1938	91	57.33	1105.76[d]
1939	78	-0.27	1048.16[c]
1940	80	65.51	1113.94[d]
1941	109	-35.40	1013.03[e]
1942	100	-65.93	982.50[f]
1943	108	-110.24	938.19[g]
1944	141	-161.82	886.61[h]
1945	115	-134.69	913.74[i]
1946	140	112.62	935.81[g]
1947	156	-191.06	857.37[j]
1948	114	-135.92	912.51[i]
1949	70	148.00	1196.43[k]
1950	56	111.77	1160.20[l]
1951	47	125.22	1173.65[m]
1952	89	169.50	1217.93[n]
1953	103	55.79	1104.22[p]
1954	64	15.06	1063.49[l]
1955	93	42.93	1091.36[a]
1956	82	144.51	1192.94[k]
1957	31	-33.53	1014.90[e]
Parity Number:			
1	462	-217.50	830.93[a]
2	470	-204.59	843.84[b]
3	379	-95.42	953.01[c]
4	304	-45.45	1002.98[d]

Appendix 2
Table 9 (continued)

Class	Number of Animals	L.S.C	Mean
Parity Number:			
5	213	59.17	1107.60[e]
6	160	92.68	1141.11[f]
7	112	13.43	1061.86[g]
8	58	136.23	1184.66[h]
9	19	261.45	1309.88[i]
Month of calving:			
January	182	74.96	1123.39[a]
February	146	118.09	1166.52[b]
March	149	36.48	1084.91[c]
April	192	28.17	1076.60[c]
May	179	11.80	1060.23[d]
June	194	-102.01	946.42[e]
July	161	-44.86	1003.57[f]
August	165	12.48	1060.91[d]
September	224	-28.82	1019.61[e]
October	212	-39.53	1008.90[f]
November	191	-88.02	960.41[g]
December	182	21.26	1069.69[d]

Within variable groups row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Appendix 2

Table 10: Estimated least squares constants and means for 305-day milk yield (kg) for Sokoto Gudali cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	928	-	1042.04
Year of calving:			
1934	920	-37.27	1004.77[ag]
1935	32	28.15	1070.19[b]
1936	32	178.94	1220.98[c]
1937	40	208.09	1250.13[d]
1938	43	75.97	1118.01[e]
1939	49	-91.70	950.34[f]
1940	35	-22.74	1019.30[g]
1941	36	-73.17	968.87[h]
1942	31	-170.74	871.30[i]
1943	52	-56.12	985.92[j]
1944	52	-256.07	785.97[k]
1945	46	-84.16	957.88[f]
1946	51	-92.76	949.28[f]
1947	59	-239.06	802.98[l]
1948	40	48.42	1090.46[m]
1949	26	184.27	1226.31[c]
1950	41	127.39	1169.43[n]
1951	53	104.71	1146.75[p]
1952	42	84.84	1126.88[c]
1953	47	-54.29	988.75[j]
1954	26	42.47	1084.51[bm]
1955	29	153.64	1195.68[q]
1956	34	45.92	1087.96[m]
1957	12	-105.73	936.31[f]
Parity Number:			
1	241	-201.85	840.19[a]
2	216	-161.38	880.66[b]

Appendix 2 Table 10 Continued.

Class	Number of Animals	L.S.C.	Mean
Parity Number:			
4	108	-61.46	980.58[c]
5	77	75.24	1117.28[d]
6	57	219.20	1261.24[e]
7	30	71.70	1113.74[d]
8	19	78.93	1120.97[d]
9	13	47.37	1089.41[f]
Month of calving:			
January	76	97.17	1139.21
February	62	60.72	1102.52
March	66	72.65	1114.69
April	57	-82.69	959.35
May	84	-33.68	1008.36
June	79	-52.68	989.36
July	66	-13.49	1028.55
August	104	48.61	1090.65
September	92	-16.01	1026.03
October	85	-56.12	985.92
November	79	-85.68	956.36
December	78	61.44	1103.48

Within variable groups, row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

APPENDIX 3

Table 11: Analysis of variance for effects of year, month of calving and calving interval number on milk yield per day (kg/day of calving interval for Bunaji cattle.

Table 12: Analysis of variance for effects of year, month of calving and calving interval number on milk yield per day of calving interval (kg/day) for Sokoto Gudali cattle.

Table 13: Estimated least squards constants and means for milk yield per day of calving interval (kg/day) for Bunaji cattle.

Table 14: Estimated least squares constants and means for milk yield per day of calving interval (kg/day) for Sokoto Gudali cattle.

Appendix 3 Table 11: Analysis of variance for effects of year, month of calving and calving interval number on milk yield per day of calving interval (kg/day) for Bunaji cattle.

Source of variation	D.F.	Mean squares (kg^2)	F. value	Significance level
Main effects	41	9.30	6.51	0.001
Year	23	7.29	5.10	0.001
Month	11	4.11	2.90	0.001
Calving Interval number	7	24.81	17.37	0.001
Residual	1789	1.43	-	
Total	1830	1.60	-	

Appendix 3 Table 12: Analysis of variance for effects of year, month of calving and calving interval number on Sokoto Gudali cattle.

Source of variation	D.F.	Mean squares (kg^2)	F. value	Significance level
Main effects	41	4.65	2.93	0.001
Year	23	4.52	2.85	0.001
Month	11	2.02	1.27	0.001
Calving interval number	7	7.92	5.00	0.001
Residual	689	1.58	-	
Total	730	1.76	-	

Appendix 3 Table 13: Estimated least squares constants and means for milk yield per day of calving interval (kg/day) for Bunaji breed.

Class	Number of Animal	L.S.C.	Mean
Overall	1831	-	2.42
Year of calving:			
1934	55	0.244	2.66[a]
1935	53	0.025	2.45[b]
1936	66	0.331	2.75[c]
1937	66	0.328	2.75[e]
1938	77	0.358	2.78[c]
1939	71	0.230	2.65[a]
1940	61	0.427	2.85[d]
1941	80	0.098	2.52[e]
1942	81	0.100	2.52[e]
1943	84	-0.170	2.25[f]
1944	111	-0.506	1.91[g]
1945	100	-0.435	1.99[h]
1946	124	-0.318	2.10[i]
1947	134	-0.458	1.96[h]
1948	105	-0.254	2.17[j]
1949	65	0.388	2.81[k]
1950	46	0.067	2.49[l]
1951	54	0.056	2.48[l]
1952	79	0.256	2.68[a]
1953	96	-0.014	2.41[m]
1954	59	-0.242	2.18[j]
1955	58	-0.346	2.07[i]
1956	71	0.227	2.65[a]
1957	35	-0.392	2.03[n]
Month of calving:			
January	151	0.230	2.65
February	121	0.319	2.74[b]
March	124	0.210	2.63[a]
April	165	0.036	2.46[c]

Appendix 3 Table 13 Continued

Class	Number of Animals	L.S.C.	Mean
Month of calving:			
May	152	-0.002	2.42[d]
June	146	-0.159	2.26[c]
July	140	-0.131	2.29[c]
August	144	0.050	2.47[c]
September	192	-0.123	2.30[f]
October	193	-0.173	2.25[e]
November	161	-0.161	2.26[e]
December	142	-0.096	2.32[f]
Calving interval number:			
1	508	-0.338	2.08[a]
2	410	-2.237	0.18[b]
3	322	0.230	2.65[c]
4	223	0.433	2.85[d]
5	168	0.481	2.90[e]
6	118	0.388	2.81[f]
7	62	0.564	2.98[g]
8	20	0.479	2.90[e]

Within variable groups, row means followed by the letter do not differ significantly ($P > 0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Appendix Table 14: Estimated least squares constants and means for milk yield per day calving interval (kg/day) for Sokoto Gudali breed.

Class	Number of Animals	L.S.C.	Mean
Overall	731	-	2.30[a]
Year of calving:			
1934	13	-0.102	2.30[a]
1935	20	-0.069	2.33[a]
1936	28	0.554	2.95[b]
1937	33	0.809	3.21[c]
1938	28	0.831	3.23[c]
1939	39	0.075	2.48[d]
1940	28	0.284	2.68[e]
1941	28	0.040	2.44[d]
1942	22	-0.186	2.21[f]
1943	32	-0.263	2.14[g]
1944	40	-0.672	1.73[h]
1945	35	-0.534	1.87[i]
1946	42	-0.369	2.03[j]
1947	53	-0.392	2.01[j]
1948	38	-0.200	2.20[f]
1949	19	0.095	2.50[d]
1950	30	0.012	2.41[a]
1951	35	0.315	2.72[e]
1952	40	0.064	2.46[a]
1953	50	-0.244	2.16[f]
1954	23	-0.053	2.35[g]
1955	15	0.118	2.52[d]
1956	30	0.236	2.64[d]
1957	10	-0.369	2.03[j]
Month of calving:			
January	60	0.31	2.71
February	39	-0.127	2.27
March	47	0.261	2.66
April	36	-0.254	2.15
May	66	-0.181	2.22

Appendix 3 Table 14 Continued.

Class	Number of Animals	L.S.C.	Mean
Month of calving:			
June	57	-0.278	2.12
July	57	0.017	2.42
August	84	0.020	2.42
September	82	0.033	2.43
October	69	-0.093	2.31
November	72	0.033	2.43
December	62	0.259	2.66
Calving interval number:			
1	227	-0.300	2.10[a]
2	181	-1.471	0.93[b]
3	111	0.155	2.56[c]
4	85	0.365	2.77[d]
5	58	0.635	3.04[e]
6	35	0.122	2.52[c]
7	21	0.355	2.76[d]
8	13	0.139	2.54[c]

Within variable groups, means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

APPENDIX 4

Table 15: Analysis of variance for effects of year and month of calving and parity number on lactation length (days) for Bunaji cattle.

Table 16: Analysis of variance for effects of year and month of calving and parity number on lactation length (days) for Sokoto Gudali cattle.

Table 17: Estimated least squares constants and means for lactation length (days) for Bunaji cattle.

Table 18: Estimated least squares constants and means for lactation length (days) for Sokoto Gudali cattle.

Appendix 4 Table 15: Analysis of variance for effects of year and month of calving and parity number on lactation length (days) for Bunaji cattle.

Source of variation	D.F.	Mean squares (days^2)x(10^2)	F. value	Significance level
Main effect	42	27.40	3.38	0.001
Year	23	27.46	3.39	0.001
Month	11	14.96	1.85	0.04
Lactation Number	8	41.[illegible]	5.12	0.001
Residual	2375	8.09	-	
Total	2417	8.43	-	

Appendix 4 Table 16: Analysis of variance for effects of year and month of calving and parity number on lactation length (days) for Sokoto Gudali cattle.

Source of variation	D.F.	Mean squares (days^2)x(10^2)	F. value	Significance level
Main effects	42	17.17	1.75	0.003
Year	2[illegible]	16.[illegible]	1.63	0.03
Month	11	10.[illegible]	1.03	0.42
Lactation Number	8	20.[illegible]	2.02	0.02
Residual	210	10.[illegible]	-	
Total	2418	10.37	-	

Appendix 4. Table 17: Estimated least squares constant and means for lactation length (days) for Bunaji cattle.

Class	Number of Animals	L.S.C.	Means
Overall	2418	-	238.59
Year of calving:			
1934	65	47.18	285.77[a]
1935	75	-15.55	223.04[b]
1936	87	-16.77	221.82[b]
1937	93	-21.00	217.59[c]
1938	92	-11.50	227.09[af]
1940	82	-5.19	233.40[e]
1941	113	-10.70	227.89[f]
1942	101	-14.27	224.32[bd]
1943	112	15.50	254.09[g]
1944	144	26.86	265.45[h]
1945	120	-12.42	226.17[df]
1946	146	-10.27	228.32[f]
1947	165	-22.46	216.13[c]
1948	125	-1.81	236.78[i]
1949	74	27.87	266.46[h]
1950	66	21.59	260.18[j]
1951	94	1.63	240.22[k]
1952	108	11.83	250.42[l]
1953	120	6.66	245.25[m]
1954	77	-12.09	226.50[d]
1955	103	-12.61	225.98[d]
1956	88	30.24	268.83[n]
1957	90	-9.70	228.89[f]
Lactation number:			
1	563	-11.27	227.32[a]
2	519	-23.89	214.70[b]
3	421	-19.59	219.00[c]
4	322	-10.23	228.36[a]

Appendix 4 Table 17 Continued.

Class	Number of Animals	L.S.C.	Mean
Lactation number:			
5	223	2.08	240.67[d]
6	168	9.70	248.29[e]
7	119	0.60	239.19[d]
8	63	20.08	258.67[f]
9	20	32.52	271.11[g]
Month of calving:			
1	202	15.14	253.73[a]
2	157	8.51	247.10[b]
3	160	2.84	241.43[c]
4	212	-0.57	238.02[d]
5	198	-4.30	234.29[e]
6	222	-17.83	220.76[f]
7	176	-0.92	237.67[d]
8	190	10.11	248.70[b]
9	253	-1.04	237.55[d]
10	231	-0.082	238.51[d]
11	211	-5.56	233.03[eg]
12	206	-6.30	232.29[g]

Within variable groups row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

Appendix 4 Table 18: Estimated least squares constants and means for lactation length (days) for Sokoto Gudali cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	1003	-	238.25
Year of calving:			
1934	21	19.66	257.91[a]
1935	33	5.41	243.66[b]
1936	33	0.16	238.41[c]
1937	40	2.22	240.47[b]
1938	43	-17.39	220.86[d]
1939	50	-27.79	210.46[e]
1940	36	-11.02	227.23[f]
1941	36	-17.80	220.45[d]
1942	31	11.41	226.84[f]
1943	53	-19.05	219.20[d]
1944	56	-32.99	205.26[g]
1945	51	5.66	243.91[b]
1946	56	-1.04	237.21[c]
1947	61	-30.72	207.53[eg]
1948	47	1.42	239.67[c]
1949	28	37.37	275.62[h]
1950	44	31.34	269.59[i]
1951	54	26.57	264.82[j]
1952	48	10.92	249.17[k]
1953	54	-2.44	235.81[cl]
1954	29	8.39	246.64[b]
1955	31	23.33	261.58[j]
1956	36	18.80	257.05[a]
1957	32	-19.60	218.65[ab]
Lactation Number:			
1	262	-19.19	219.06[ab]
2	232	-21.31	216.94[a]
3	183	-21.73	216.52[a]
4	114	-17.61	220.64[b]

Appendix 4 Table 18 Continued.

Class	Number of Animals	L.S.C.	Mean
Lactation Number:			
5	85	12.87	251.12[c]
6	58	30.73	269.98[d]
7	35	-12.22	226.03[e]
8	21	17.86	256.11[f]
9	13	30.60	268.85[d]
Month of calving:			
1	81	19.96	258.21
2	66	11.81	250.06
3	73	16.26	254.51
4	61	-14.29	223.96
5	88	-7.22	231.03
6	85	-7.05	231.20
7	73	-12.31	225.94
8	112	11.37	249.62
9	102	-0.62	237.63
10	90	-6.85	231.40
11	83	-9.66	228.59
12	88	-1.40	236.85

Within variable groups row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

APPENDIX 5

Table 19 Estimated least squares constants and means for age at first calving for Bunaji cattle.

Table 20: Estimated least squares constants and means for age at first calving for Sokoto Gudali cattle.

Appendix 5 Table 19: Estimated least squares constants (L.S.C.) and means for age at first calving for Bunaji cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	579	-	1373.84
Year of calving:			
1934	5	-5.93	1367.91[a]
1935	21	-31.82	1342.02[b]
1936	21	-194.10	1179.74[c]
1937	25	-74.65	1299.19[d]
1938	16	-122.84	1251.00[e]
1939	7	-88.67	1285.17[f]
1940	22	-36.20	1337.64[b]
1941	35	-36.82	1337.02[b]
1942	20	-30.66	1343.18[b]
1943	31	-116.23	1257.61[e]
1944	34	-55.50	1318.34[g]
1945	25	16.64	1390.48[h]
1946	23	9.72	1383.56[h]
1947	25	-37.56	1336.35[b]
1948	25	-133.49	1240.35[i]
1949	12	21.74	1395.58[h]
1950	22	51.11	1424.95[j]
1951	41	67.77	1441.61[k]
1952	29	204.59	1578.43[l]
1953	26	204.93	1578.77[l]
1954	18	236.49	1610.33[m]
1955	45	-9.87	1363.97[a]
1956	17	81.00	1454.84[n]
1957	34	80.35	1454.19[n]
Month of calving:			
January	55	-22.06	1351.78
February	36	-62.08	1311.76
March	39	-17.85	1355.99
April	43	19.90	1393.74

Appendix 5 Table 19 Continued.

Class	Number of Animals	L.S.C.	Mean
Month of calving:			
May	41	-5.67	1360.17
June	68	-10.10	1383.94
July	37	38.72	1412.56
August	45	4.40	1378.24
September	64	-30.61	1343.23
October	39	40.04	1413.88
November	47	32.28	1406.12
December	65	-7.17	1366.67

Within variable groups, row means followed by the same letter do not differ significantly($P>0.05$). If no letter is used it indicates that the variable did not show a significant difference in the analysis of variance.

Appendix 5 Table 20 Continued.

Class	Number of Animals	L.S.C.	Mean
Month of calving:			
May	19	181.66	1570.96
June	28	-7.95	1381.35
July	15	6.81	1396.11
August	31	10.87	1400.17
September	21	37.83	1427.13
October	22	21.60	1410.90
November	8	-27.99	1361.31
December	20	28.67	1417.97

Within variable groups row means followed by the same latter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significant difference in the analysis of variance.

APPENDIX 6

Table 21: Analysis of variance for effects of year, month of calving and parity number on dry period (days) for Bunaji cattle.

Table 22: Analysis of variance for effects of year, month of calving and parity number on dry period (days) for Sokoto Gudali cattle.

Table 23: Estimated least squares constants and means for dry period (days) for Bunaji cattle.

Table 24: Estimated least squares constants and means for dry period (days) for Sokoto Gudali cattle.

Appendix 6 Table 21: Analysis of variance for effects of year, month of calving and parity number on dry period (days) for Bunaji cattle.

Source of variation	D.F.	Mean squares ($days^2$) x (10^3)	F. value	Significance level
Main effects	42	84.50	2.35	0.001
Year	23	94.28	2.62	0.001
Month	11	40.94	1.14	0.33
Parity	8	99.41	2.76	0.005
Residual	1915	35.97	-	
Total	1957	37.02	-	

Appendix 6 Table 22: Analysis of variance for effects of year, month of calving and parity number on dry period (days) for Sokoto Gudali cattle.

Source of variation	D.F.	Mean squares (day^2) x (10^3)	F. value	Significance level
Main effects	42	29.59	1.82	0.001
Year	23	32.18	1.98	0.004
Month	11	29.25	1.80	0.05
Parity	8	14.50	0.89	0.52
Residual	751	16.26	-	
Total	793	16.97	-	

Appendix 6 Table 23: Estimated least squares constants (L.S.C) and means for dry period (days) for Bunaji cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	1958	-	156.74
Year of calving:			
1934	58	-55.19	104.55[a]
1935	64	-35.89	123.85[b]
1936	80	-27.22	132.52[c]
1937	82	27.09	186.83[d]
1938	87	8.13	167.87[e]
1939	66	-9.09	150.65[f]
1940	75	-19.85	139.89[g]
1941	97	-30.91	128.93[c]
1942	91	-22.22	137.52[g]
1943	101	-20.03	139.71[g]
1944	114	-31.59	128.15[c]
1945	96	-42.53	117.21[h]
1946	137	-29.03	130.71[c]
1947	132	20.08	179.82[i]
1948	76	35.48	195.22[j]
1949	56	-018	159.56[k]
1950	48	17.16	176.90[i]
1951	79	30.49	190.23[l]
1952	94	-13.87	145.87[m]
1953	79	78.05	237.79[n]
1954	51	36.59	196.33[j]
1955	73	21.06	180.80[i]
1956	75	-22.37	137.37[g]
1957	48	85.74	245.48[p]
Parity Number:			
1	515	26.54	186.28[a]
2	441	28.68	188.42[a]
3	335	3.78	163.52[b]
4	255	-10.63	149.11[c]

Appendix 6 Table 24: Estimated least squares constants (L.S.C) and means for dry period (days) for Sokoto Gudali cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	794	-	155.51
Year of calving:			
1934	20	-29.52	125.99[a]
1935	30	-18.89	136.62[b]
1936	32	-23.67	131.84[c]
1937	33	-50.00	105.51[d]
1938	39	-28.48	127.03[e]
1939	37	6.68	162.19[f]
1940	32	-21.80	133.71[g]
1941	31	6.99	162.50[h]
1942	31	4.41	159.92[h]
1943	44	19.16	174.67[i]
1944	37	48.67	204.18[j]
1945	42	-24.31	131.20[ce]
1946	50	21.44	176.95[i]
1947	44	46.07	201.58[j]
1948	27	59.98	215.49[k]
1949	19	-21.40	134.11[c]
1950	37	-27.28	128.23[e]
1951	50	25.95	181.46[f]
1952	37	-41.40	114.11[g]
1953	30	26.19	181.70[f]
1954	19	18.11	173.62[i]
1955	27	-43.87	111.64[g]
1956	30	-2.20	153.31[l]
1957	16	49.17	204.68[j]
Parity Number:			
1	229	24.69	180.20
2	189	2.52	165.03
3	133	-4.05	151.46
4	87	12.44	167.95

Appendix 6 Table 24 Continued.

Class	Number of Animals	L.S.C.	Mean
Parity Number:			
5	68	-15.03	140.43
6	47	-3.56	151.95
7	26	8.22	163.73
8	14	4.56	160.07
9	1	-36.79	118.72
Month of calving:			
January	68	-1.94	153.57[a]
February	57	1.01	156.52[a]
March	57	-24.28	131.23[b]
April	43	39.77	195.28[c]
May	70	26.07	181.58[d]
June	64	26.56	182.07[d]
July	49	-9.58	145.93[e]
August	92	-26.14	129.37[b]
September	78	-27.78	127.73[b]
October	75	-0.35	155.16[a]
November	68	-14.17	141.34[e]
December	73	10.83	166.34[f]

Within variable groups row means followed by the same letter do not differ significantly (P>0.05). If no letter is used, it indicates that the variable did not show a significantly difference in the analysis of variance.

APPENDIX 7

Table 25: Analysis of variance for effects of year and month of calving and calving interval number on calving interval of Bunaji cattle.

Table 26: Analysis of variance for effects of year and month of calving and calving interval number on calving interval of Sokoto Gudali cattle.

Table 27: Estinated least squares constants and means for calving interval of Bunaji cattle.

Table 28: Estinated least squares constants and means for calving interval of Sokoto Gudali cattle.

Appendix 7 Table 25: Analysis of variance for effects of year and month of calving and calving interval number on calving interval of Bunaji cattle.

Source of variation	D.F.	Mean squares $(days^2)x(10^4)$	F. value	Significance level
Main effects	42	13.56	4.35	0.001
Year	23	20.41	6.54	0.001
Month	11	3.62	1.16	0.31
Parity	8	5.41	1.73	0.09
Residual	2071	3.12	-	
Total	2113	3.32	-	

Appendix 7 Table 26: Analysis of variance for effects of year and month of calving and calving interval number on calving interval of Sokoto Gudali cattle.

Source of variation	D.F.	Mean squares $(days^2)x(10^4)$	F. value	Significance level
Main effects	42	3.92	3.16	0.001
Year	23	5.80	4.68	0.001
Month	11	1.51	1.22	0.27
Parity	8	2.19	1.77	0.09
Residual	824	1.24	-	
Total	866	1.37	-	

Appendix 7 Table 27: Estimated least squares constants and means for calving interval of Bunaji cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	2114	-	406.45
Year of calving:			
1934	62	-12.36	394.09[a]
1935	62	-34.17	372.28[b]
1936	70	-57.45	349.00[c]
1937	78	-59.35	347.10[c]
1938	90	-56.69	349.76[c]
1939	85	-55.98	350.47[c]
1940	73	-47.78	358.67[d]
1941	93	-53.97	352.48[ce]
1942	99	-18.90	387.55[f]
1943	89	61.66	468.11[g]
1944	120	34.15	440.60[g]
1945	116	-8.99	397.46[a]
1946	133	-11.63	394.82[a]
1947	143	-55.10	351.35[ce]
1948	130	-45.83	360.62[d]
1949	82	15.50	421.95[i]
1950	56	28.94	435.39[j]
1951	58	50.70	457.15[k]
1952	85	30.15	436.60[j]
1953	108	27.19	433.64[j]
1954	65	38.39	444.84[k]
1955	60	138.65	545.10[l]
1956	79	27.48	433.93[j]
1957	78	65.39	471.84[g]
Calving interval Number:			
1	561	15.02	421.47
2	479	-93.86	312.59
3	360	-3.04	403.41
4	260	-7.44	399.01

Appendix 7 Table 27 Continued.

Class	Number of Animals	L.S.C.	Mean
Calving interval Number:			
5	180	-1.06	405.39
6	139	3.33	409.78
7	96	1.46	407.91
8	39	85.59	492.04
Month of calving:			
January	171	6.67	413.12
February	126	3.93	410.38
March	142	37.62	444.07
April	194	12.32	418.77
May	169	5.33	411.78
June	170	-15.01	391.44
July	156	-17.29	389.16
August	172	-6.56	399.89
September	227	-8.33	398.12
October	230	-4.58	401.87
November	188	-15.78	390.67
December	169	1.68	408.13

With variable groups, row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used, it indicates that the variable did not show a significance difference in the analysis of variance.

Appendix 7 Table 28: Estimated least squares constants and means for calving interval of Sokoto Gudali cattle.

Class	Number of Animals	L.S.C.	Mean
Overall	867	-	398.09
Year of calving:			
1934	13	-16.65	336.44[a]
1935	22	-21.65	376.44[b]
1936	29	-37.28	360.81[c]
1937	35	-36.52	361.57[c]
1938	29	-44.99	353.10[d]
1939	45	-66.96	331.13[e]
1940	42	-51.94	346.15[f]
1941	43	-38.12	359.97[c]
1942	38	-15.64	382.45[g]
1943	38	-48.93	349.16[f]
1944	48	-16.17	381.32[g]
1945	43	13.05	411.14[h]
1946	44	19.38	417.47[i]
1947	54	-26.08	372.01[j]
1948	46	2.19	400.20[k]
1949	21	89.11	487.20[l]
1950	34	83.35	481.44[m]
1951	38	-085	397.24[n]
1952	44	5.05	403.14[k]
1953	52	54.59	452.68[l]
1954	26	13.68	411.77[h]
1955	19	6.75	404.84[k]
1956	33	10.16	408.25[kp]
1957	31	36.61	434.70[q]
Calving interval number:			
1	259	26.93	425.02
2	209	-113.07	285.02
3	131	-4.43	393.66
4	93	4.64	402.73

Appendix 7 Table 28: Continued.

Class	Number of Animals	L.S.C.	Mean
Calving interval Number:			
5	71	25.86	423.95
6	51	31.64	429.73
7	34	9.68	407.77
8	19	18.75	416.84
Month of calving:			
January	67	-2.72	395.37
February	44	42.54	440.63
March	54	-17.07	381.02
April	45	-3.95	394.14
May	80	-2.24	395.85
June	67	-2.94	395.15
July	67	9.98	408.07
August	97	-20.77	377.32
September	99	14.27	412.36
October	84	-9.49	388.60
November	86	-6.80	391.29
December	77	-0.81	397.28

Within variable groups, row means followed by the same letter do not differ significantly ($P>0.05$). If no letter is used it indicates that the variable did not show a significant difference in the analysis of variance.