ILCA Research Report No. 12

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February 1986

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
ADDIS ABABA, ETHIOPIA

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# Evaluation of the productivity of crossbred dairy cattle on smallholder and Government farms in the Republic of Malawi

Kwaku Agyemang[1] and Lidie P. Nkhonjera[2]

[1] Highlands Programme, ILCA,
P.O.Box 5689, Addis Ababa, Ethiopia.

[2] Department of Animal Health and Industry,
Ministry of Agriculture, Lilongwe, Malawi.

ILCA Research Report No. 12
A joint report by the Government of Malawi and
the International Livestock Centre for Africa
February 1986

ORIGINAL: ENGLISH

February 1986


## ABSTRACT

The productive and reproductive performance of Friesian–'off-type' (Sussex x Brahman-type x Africander-cross) crossbred cattle on smallholdings in the Southern Region of Malawi was evaluated. The performance of Friesian–'off-type', Friesian–Malawi Zebu and pure-Friesian cattle on smallholdings and government stations was also evaluated. It was found that advanced age at first calving and long calving intervals were common both on smallholdings and on government stations, which was believed to be due to inadequate levels of feeding. Feed resources have not increased with the introduction of improved breeds of cattle and larger herds, and improved and local cattle are kept under the same management conditions on smallholdings. Productivity of the cattle has been decreasing since 1979, possibly due to climatic factors, but poor management was not ruled out. It was found that Friesian–Malawi Zebu crosses performed at the same level as the larger Friesian–'off-type' crosses, and the authors believe that the use of the Malawi Zebu in producing crossbred cattle could lead to increased milk production, particularly in areas where feed is in short supply.



## KEY WORDS

/Malawi//livestock management//animal performance//reproductivity//milk production//small scale farming//state farms//dairy cattle//crossbreds//calves/



## RESUME

*Ce rapport est consacré à une étude des performances de production et de reproduction de bovins issus de croisements entre la race Frisonne et une race métissée (Sussex x type Brahman x Africander métissée) élevés dans de petites exploitations du Sud-Malawi, ainsi qu'aux performances de bovins Frisonne x race métissée, Frisonne x zébu Malawi et Frisonne pur-sang élevés dans de petites exploitations et dans des stations d'Etat. On a attribué à une alimentation insuffisante l'âge avancé au premier vêlage et les longs intervalles entre vêlages observés dans ces deux types de situation. L'introduction des races améliorées et l'augmentation des effectifs n'ont pas été accompagnées par un accroissement des ressources fourragères, ni par une amélioration de la conduite du bétail dans les petites exploitations. La baisse de productivité des bovins enregistrée depuis 1979 est peut-être imputable à des facteurs climatiques, mais pourrait également être due à une mauvaise gestion. Les performances des Frisonne x zébu Malawi ayant égalé celles des Frisonne x race métissée de plus grand format, les auteurs de l'étude estiment que des croisements avec la race zébu Malawi devraient permettre d'augmenter les rendements laitiers, en particulier dans les régions où le disponible fourrager est insuffisant.*



## MOTS-CLES

*/Malawi//conduite du bétail//performance zootechnique//performance de reproduction//production laitière//petite exploitation//ferme d'Etat//bovin laitier//produit de croisement//veau/*

ISBN 92–9053–072–3

# CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# PREFACE

The development of dairying in Malawi originated with estate crop farmers before independence in 1964. These farmers kept mainly Jersey, Ayrshire and Friesian cattle. Milk produced was used at the estates and in nearby communities. Smallholder dairying is relatively new in Malawi and was started by the Food and Agriculture Organization (FAO) in 1971.

Prior to the establishment of smallholder dairying, research was conducted at the Chitedze Agricultural Research Station on the improvement of indigenous cattle, the Malawi Zebu, for the purpose of producing milk. After a series of selection trials, the results indicated that the genetic potential for the Malawi Zebu was about 2 litres per cow per day, which is too little to provide the basis for a dairy industry. Further research was conducted into introducing Friesian blood into the Malawi Zebu to combine the high milk-producing ability of the Friesian and the adaptation to the local environment of the Malawi Zebu. Other related activities such as forage productivity and management regimes were also investigated at Chitedze.

Another milestone in the development of smallholder dairying in Malawi was the setting up of a cattle multiplication unit in Bwemba to complement the activities at Mikolongwe. These two centres were established to produce crossbred cows for distribution to farmers. The Veterinary Department provided services to smallholder farmers in the form of crossbred cows, artificial insemination and drugs. Extension services include training farmers in all aspects of dairy husbandry including hand milking and heat detection. Another government organisation which played a role in the development of dairying is Malawi Milk Marketing which is responsible for collecting milk at the various milk centres and for processing and distribution of milk.

The emphasis in this report is on the evaluation of reproductive and productive performance of the crossbred cows found most commonly on smallholder farms in the Southern Region of Malawi. The performance of various crossbred cows at Bwemba, Tuchila (near Mikolongwe) and at Chitedze Research Station, as well as that of pure-Friesian cows at Mikolongwe, is also evaluated.

The first section of this report presents analyses of productive and reproductive traits of crossbred cows on smallholder farms. The second section deals with the body weight changes of crossbred female calves at Chizombezi and the general performance of crossbred cows at Tuchila, the third station that provides crossbred cows to smallholder farmers. Section three concerns the performance of crossbred and pure-Friesian cows at Bwemba and Chitedze. Results from the analysis of reproductive and productive traits on the pure-Friesian herd at Mikolongwe are presented in section four.

In the final section an attempt is made to tie together the performances of the various crosses and pure Friesians on smallholder farms and at the multiplication and research centres.

## ACKNOWLEDGEMENTS

The authors wish to thank the Malawi Government for giving permission for this joint study. Special thanks are due Dr Sam Kamvazina, Chief Veterinary Officer and Head of Animal Health and Industry in the Ministry of Agriculture, Malawi, for the interest he showed in the study and also for allowing the second author, Mr Lidie Nkhonjera, to work with ILCA on the study for a 3-month period.

Several people and organisations have contributed to the development of the smallholder dairy scheme in Malawi. The authors wish to acknowledge the contributions of the Food and Agriculture Organization (FAO) as the executing agency of the United Nations Development Programme (UNDP) which initiated the dairy programme, and Drs Cleave Allan and D. Vandiek, Mr J. Kristenssen and Mr Peter Frank, all of FAO, for their work in planning, establishing and running the programme in the early years. The efforts of these people could not have succeeded were it not for the support of various government ministries and departments. The authors wish to acknowledge the Department of Agriculture in Malawi for providing extension personnel and training facilities; the Department of Animal Health and Industry for providing dairy cows, insemination and marketing services, veterinary services and personnel; and the Department of Agricultural Research for providing basic information and data on the management of dairy cows.

The financial contributions of ILCA's Training Committee and the Highlands Programme in Ethiopia, and the personal involvement of Drs Frank Anderson, Martyn Butterworth and John Trail are gratefully acknowledged. The assistance of the staff of ILCA's Computer Unit, especially Mr Jeffrey Durkin and W/z Almaz Teklesenbet, are also acknowledged.

# 1. BACKGROUND

## General introduction

The main objectives in establishing a smallholder dairy industry in Malawi were:

- to provide fresh milk for the increasing population;
- to reduce imports of milk byproducts; and
- to provide an alternative source of income to farmers.

Malawi is a land-locked country with an area of 118 484 km$^2$, a third of which is covered with water. The country lies south of the Equator, between latitudes 9° 30'S and 17°S and longitudes 33°E and 36°E. A map of Malawi showing administrative regions, districts and major towns is shown in Figure 1. The climate is subtropical. Rainfall is unimodal occurring between November and April. The rainy season is followed by a long dry season from May to October. The average annual rainfall ranges from 750 mm in the drier parts of the country to 1000 mm in the wetter parts. The mean annual rainfall for the period 1972–81, recorded at four meteorological stations representative of the area in which the smallholders and multiplication centres operate, is shown in Table 1. The monthly mean rainfall at the Chileka meteorological station for the period 1972–1980 is shown in Table 2.

Table 1. *Annual rainfall at Chileka, Chichiri, Lilongwe and Chitedze meteorological stations, 1972–81.*

| | Rainfall (mm) | | | |
|---|---|---|---|---|
| Year | Chileka | Chichiri | Lilongwe | Chitedze |
| 1972/73 | 559.1 | 948.1 | 622 | – |
| 1973/74 | 1 258.8 | 1 312.2 | 1 079.0 | – |
| 1974/75 | 729.0 | 987.0 | 922.8 | – |
| 1975/76 | 856.0 | 1 335.5 | 885.1 | 982.7 |
| 1976/77 | 1 082.5 | 1 306.6 | 1 153.6 | 983.3 |
| 1977/78 | 1 153.4 | 1 378.7 | 790.3 | 1 129.0 |
| 1978/79 | 750.3 | 877.9 | 882.1 | 645.9 |
| 1979/80 | 852.7 | 1 155.2 | 767.0 | 785.4 |
| 1980/81 | 905.0 | 939.6 | 1 045.5 | 704.6 |
| Average | 905.2 | 994.1 | 836.2 | 871.8 |

Source: Meteorological Department, Chileka, and Chitedze Agricultural Research Station.

Table 2. *Average monthly rainfall distribution, Chileka meteorological station, 1973–81.*

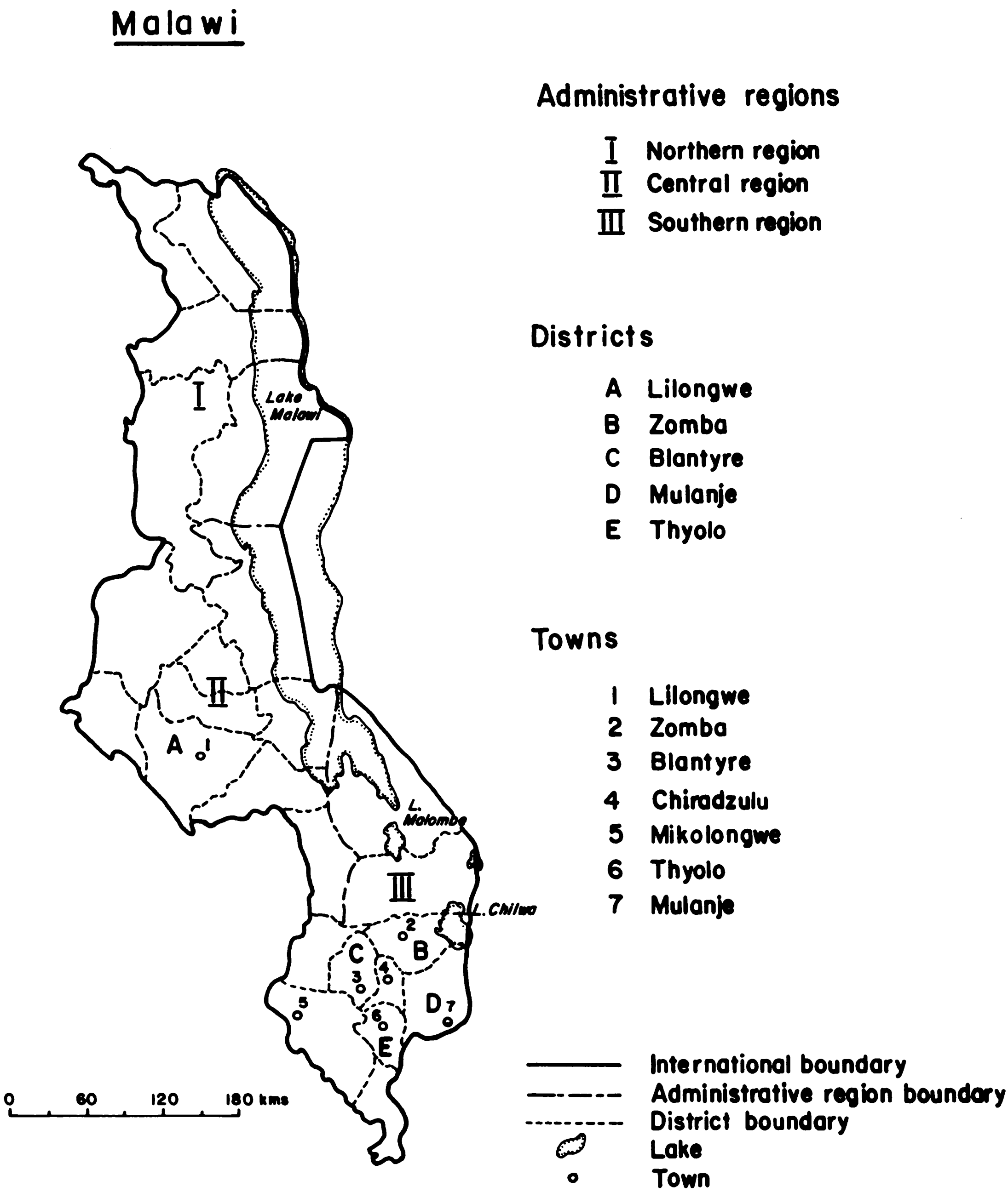
| Month | Rainfall (mm) |
|---|---|
| January | 182.9 |
| February | 204.5 |
| March | 154.6 |
| April | 44.2 |
| May | 9.7 |
| June | 0.9 |
| July | 4.9 |
| August | 1.6 |
| September | 1.8 |
| October | 17.7 |
| November | 82.5 |
| December | 164.3 |

## Objectives of analyses

The objectives of the analyses reported here were to:

- Compare the important reproductive and productive traits of crossbred dairy cattle on smallholder farms and at multiplication and research centres;
- Measure the influence of environment (years, seasons, etc.) on dairy production traits;
- Assess the suitability of various crosses to the different agricultural areas; and to
- Determine the trends in dairy production over the years.

Figure 1. *Map of the Republic of Malawi.*



# 2. ANALYSES OF SMALLHOLDER DAIRY RECORDS

## Introduction

The data used in the analyses were collected from smallholder operations in the Southern Region of Malawi. The region consists of six agricultural development areas, namely Blantyre North, Blantyre South, Mulanje West, Thyolo North, Chiradzulu and Zomba.

The amount of rainfall received differs greatly among the six areas. Blantyre North and Mulanje West are relatively dry compared with the other areas, and maize is the most important crop in these two areas. In the drier parts of the region, the maize crop is usually sufficient to last the farmer and his family for 3–4 months. Cattle sales supplement farm income.

Dairying has become a popular enterprise, as it provides a source of regular income. In order to receive crossbred dairy cattle under the dairy development scheme, the farmer must provide 0.8 ha of pasture for each two cows. The farmer must also attend a 2-week course in dairy management and construction of a dairy parlour and housing facilities for the cows and calves.

## Cattle breeding

The development of crossbred heifers (1/2 Friesian) in the Southern Region of Malawi is based on exotic Friesian bulls and 'off-type' cows, which are a composite of Sussex, Brahman-type and Africander-cross cattle. Figure 2 shows the movement of crossbred cattle from the point of origin at Chizombezi to the smallholder's farm.

In Chizombezi, where the 1/2-Friesian calves are produced, three lines of cattle are kept:

1. Single and multiple sire Sussex;
2. Single and multiple sire Brahman-type; and
3. 'Off-type' Sussex–Brahman-type–Africander-crosses.

The 'off-type' cross animals originate from an intermixing of surplus cows from the pure lines (Sussex and Brahman-type) and Africander crosses. The composition of 'off-type' cattle at Chizombezi is, therefore, not exactly known. The 'off-type' female cattle are mated to Friesian bulls supplied from Mikolongwe to produce the 1/2-Friesian calves at Chizombezi. The 1/2-Friesian calves are sent to nearby Chikowa at 6 months of age, where female calves and castrated males are reared. Female yearlings are sent to Tuchila where they are inseminated with imported Friesian semen. Calving takes place at Tuchila. Cows are sold to smallholder dairy farmers 3 to 4 weeks after calving. The 3/4-Friesian calves are reared at Tuchila. Male calves are castrated when 6 weeks old. Heifers are inseminated at 2 1/2 years of age to produce 7/8-Friesian calves, after which the 3/4-Friesian cows are sold to smallholders. Similarly, some 7/8-Friesian cows are sold to smallholders after producing 15/16-Friesian calves. The 15/16, 31/32 and higher-grade Friesians are retained at Tuchila for milking or sold to commercial dairy farmers.

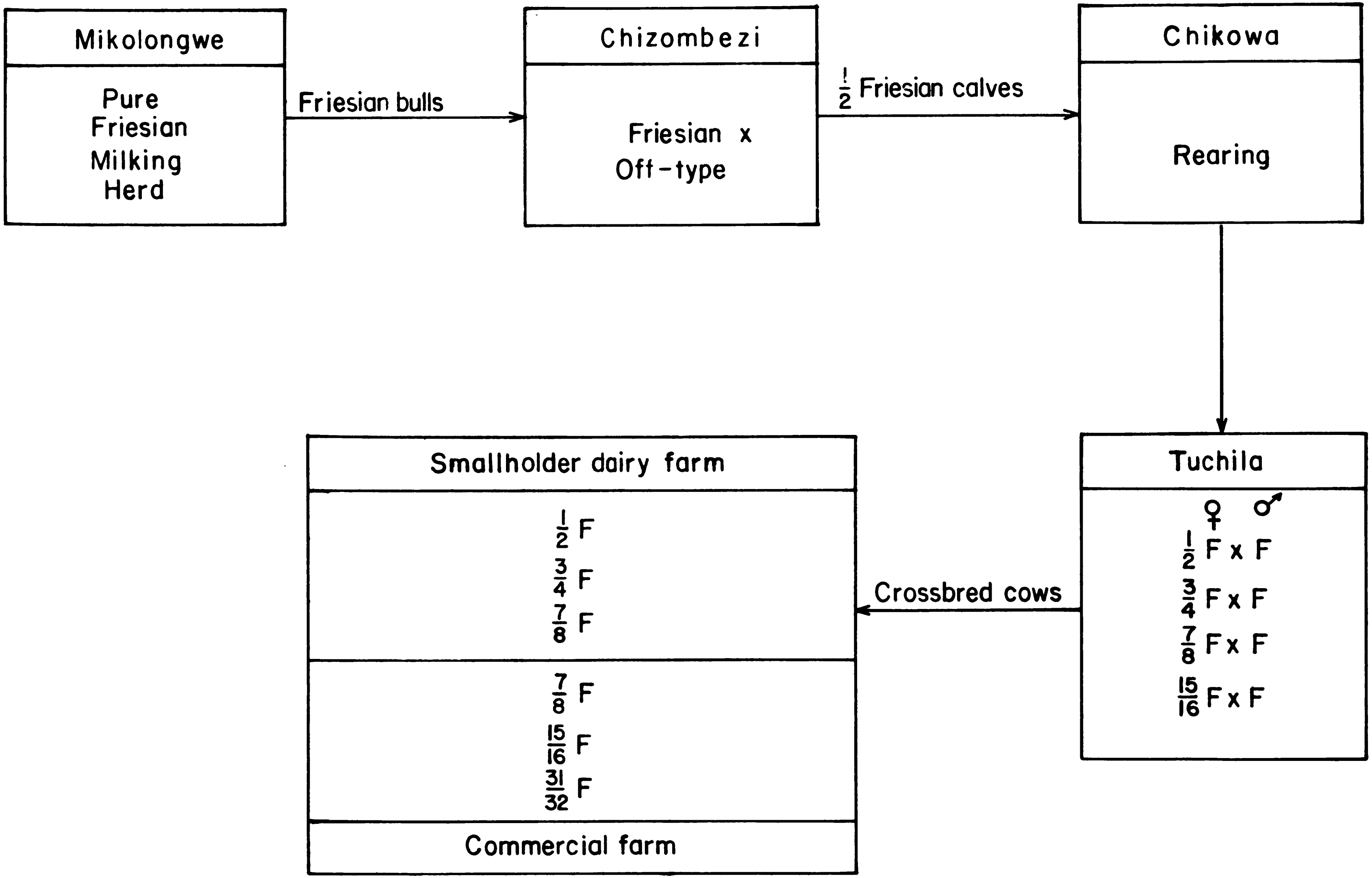
## Data preparation

### Problems encountered and bases for exclusions

Some management practices at Chizombezi, Chikowa and Tuchila and on smallholder farms lead to difficulty in identification of the cows and their sires, both of which are vital to genetic analysis of production records. Some of these management practices are described below.

- Records were not kept on which breeds went into the formation of the 'off-type' line. As a result the exact composition of the 'off-type' females used in producing 1/2-Friesian crosses was not known.
- Because several Friesian bulls were put in with a herd of 'off-type' females (multiple breed-

Figure 2. *Movement of crossbred cattle from government units to small farms in Malawi.*



ing), the sires of the 1/2-Friesian crosses were not known.

- New identification or tag numbers were assigned to animals that lost their original identification or tag numbers while in transit in Chikowa and Tuchila and when on smallholder farms. In most cases no reference was made to the original identification and the animals received entirely different identification numbers. As a result, where information on a cow was missing at the smallholder level, the cow could not be traced to any of the transit stations.
- Accurate and easily verifiable production information was not kept for all crossbred cows that were milked while in transit at Tuchila. Thus some smallholders did not know the calving date of the cow, the breed of the cow, its parity or its partial production while at Tuchila.
- Extension specialists who visited smallholders did not record production each month but waited for several months and tried to record several months' information at one time. This led to inconsistent recording of information, gaps in information, wrong calving dates and failure to record dry-off dates.

Given these problems, only records that provided information that could be used to obtain reproductive or productive performance or both were included for analysis. To this end the following actions were taken:

1. The identification or tag number on the 'Life History and Lactation Sheet' was checked against calf registers from Chizombezi and Tuchila. The breed of the cow could be determined from the register, and its date of birth used to confirm the reported parity number. Where the parity number was missing, a 'most likely' parity number was assigned according to the age of the cow.
2. Effort was made to determine the partial milk yield of the cow while it was awaiting sale at Tuchila, so as to credit the cow with its full yield.
3. Where most of the relevant information, such as birth date of cow, calving date, parity number, total yield and drying-off date, were available but cow identification was missing, an arbitrary but unique four-number identification was assigned to the cow.
4. Where there was no indication that the cow was dried-off but the cow had been milked for more than 5 months, both the cumulative yield and the last milking date were recorded.

Records were rejected if:

- The breed of the cow was not indicated or found.
- The date of birth of the cow, date of calving and parity were all missing.
- Information was available for only one lactation and the birth date of the cow was missing and where only partial lactation yield was available (no drying-off date) covering less than 5 months.
- Information was available for only one lactation with no date of birth and where data on more than 30 days of milk yield while in transit at Tuchila were not found.

A total of 350 records were excluded from the data following this process. The data set used in these analyses therefore represent a subset of all data that were recorded. The authors believe that the final subset of data used in the analyses represents a random sample of the population and that the results from the analyses will not be biased as a result of the editing procedure. All subsequent analyses are subject to the constraints and assumptions listed above.

### Cow performance traits

Individual records were built up for each cow for each parturition and for each trait to enable differential, as opposed to joint, editing of records. Thus for example, cows with no information on number of days open were excluded from the analysis of days open but were included in the analysis of milk production or lactation length. This gave rise to unequal numbers of records for the various traits. Basic information for each cow for a given trait included parturition number, breed, date of birth (when known), current and previous calving dates, lactation milk yield and drying-off date.

The individual traits analysed in this study were age at first calving, calving interval, days open to conception, lactation length, milk yield per day of lactation, length of dry period and annual milk yield.

## Data analyses

All characters were analysed by least squares procedures (Harvey, 1977) using fixed effects models. The Harvey's Least Squares program sets up the normal least squares equations after imposing sigma ($\sigma$) restrictions on the parameters such that, within a given effect, the solutions to the various levels of that effect sum to zero. Typical models used included fixed effects of breed group, area, year of birth or parturition, parity number (a proxy for age of cow) and interaction between breed group and area. Due to the limitations of the Harvey's Least Squares program in terms of the number of effects or levels of effects that can be fitted at one run, herd effects were not included in the models used when considering all smallholder records from all six agricultural areas. In order to study the influence that herds may have exerted on the various traits, the two areas with the largest number of records were selected and data analysed with models that included herd effects.

The residual mean square was used as the error term to test the significance for each character analysed. Linear contrasts of least squares means were computed to determine the significance of differences between two groups. More comparisons were made than the number of degrees of freedom. Therefore, not all comparisons are independent, and the error rate over the entire set of comparisons may be different from that indicated by the level of probability. Tests of significance associated with linear contrasts, although not independent, can be taken as guides as to whether the observed values could have occurred by chance.

### Notations

In this report the term 'least squares mean' refers to a linear function of least squares solutions to certain effects in the statistical model used for the analysis. Specifically, the least squares mean for row i (or level i of an effect) is defined as the arithmetic average of the cell means (solutions) for all cells in row i. Since the Harvey's Least Squares program imposes the restriction that the solutions of all levels of a given effect sum to zero, the least squares mean of a level of an effect is the sum of the least squares solution to the overall mean effect and that of the particular level of an effect.

The manner in which the various sums of squares are computed means that the hypothesis being tested in the Analysis of Variance table is that of 'equality among means for levels of an effect, after accounting for all other effects in the model', so that the significance or non-significance of differences among levels of a main effect is independent of other main effects and interactions in the model.

Where a mean square (MS) generated for the Analysis of Variance table is exceptionally large or small, the figure is truncated or magnified and multiplied by the appropriate power of 10 which is indicated in the column under which the mean squares are presented. Thus a mean square of 10 464 may be presented as 1046 in a column headed by MS x $10^{-1}$. All other figures appearing under the same column are modified to conform to this pattern. Similarly a mean square of 0.173 may be presented as 173 in a column headed by MS x $10^3$. Thus all figures recorded as mean squares in the various Analysis of Variance tables should be read as 'derived mean squares after the original mean square has been modified by the operation indicated at the top of the column under which the figure appears'.

Unadjusted or raw means and standard deviations for the various traits considered in this study are presented in this report as X ± SD and must be differentiated from the 'overall mean' reported in the tables showing least squares means.

## Management of smallholder dairy farms

Each farmer established a pure stand of leucaena, and a mixed stand of Napier grass and Silverleaf desmodium *(Desmodium uncinatum)*. In the drier areas Rhodes grass *(Chloris gayana)* was also planted. A minimum area of 0.8 ha per two-cow unit was required. Cattle were zero-grazed on ad libitum basis. During the dry season hay was fed to cattle in the drier areas while silage was fed in the wetter areas. Liberal amounts of a mixture of maize bran *(medeya)* and dried leucaena leaves were fed when available. Dry cows received this mixture once every day. All cows were confined to stalls as a means of conserving energy, for easy detection of heat and to avoid contact with local Malawi Zebu bulls.

After parturition calves stayed with their dams for 5 days, after which they were separated. Hand milking started on the fifth day. The calf suckled for 30 minutes twice a day, after the morning and evening milking. Calves were weaned at 12 to 15 weeks old, depending on the physical condition of the calf. Male calves were castrated 3 weeks after weaning and reared for fattening. Cows were sprayed once a week. Deworming was done twice a year, before and after the rains. Each farmer kept daily records on milk yields, breeding and calf birth dates.

## Results and discussion of analyses

### Reproductive performance

Three measures of female reproductive performance, namely age at first calving, calving interval and days open, were analysed with the aim of identifying environmental factors that might have influenced these characters and to obtain unbiased linear estimates of the differences in the relevant environmental factors. Reproduction in dairy cattle contributes to herd replacement and is the precursor of milk production. Reproductive traits are more important to the smallholder dairy farmer who has one or two cows than to the owner of a large herd, since failure to reproduce means a complete loss of income. Also, culling a barren cow is more difficult for a smallholder than for the owner of a large herd.

***Age at first calving:*** The mean age at first calving for 165 heifers (110 half-Friesian and 55 three-quarter-Friesian crosses) was 37.7 ± 6.8 months with a coefficient of variation (CV) of 18%. Birth dates of cows were grouped into four seasons; April–May, June–August, September–October and November–March.

The analysis of variance for age at first calving is shown in Table 3. Only breed group and year of birth of the cows had significant effects ($P < 0.05$) on age at first calving. The estimated least squares means for age at first calving are given in Table 4.

Table 3. *Analysis of variance of age at first calving for smallholder herds, 1970–83*

| Source | d.f. | MS x $10^{-1}$ |
|---|---|---|
| Area | 5 | 2 248 |
| Breed | 1 | 21 553* |
| Year of birth | 7 | 10 358* |
| Season of birth | 3 | 10 125 |
| Breed x season | 3 | 9 606 |
| Breed x area | 5 | 6 487 |
| Remainder | 140 | 4 359 |

* $P < 0.05$

Heifers born prior to 1974 calved later than those born after 1974 but the downward trend seems to have changed since 1977. A regression of the estimated least squares means on years (coded 1 to 9) showed that age at first calving has been decreasing by 8 days per year.

The mean age at first calving of 38.4 months obtained in this study is comparable to that of 36 months for $F_1$ crosses between US Friesian and native Indian cattle reported by McDowell and Schermerhorn (1978) but higher than that of 34.2 months reported by Kiwuwa et al (1983) for 1/2 Friesian-1/2 Zebu and 3/4 Friesian-1/4 Zebu crosses in the highlands of Ethiopia.

Table 4. *Estimated least squares means for age at first calving for smallholder herds, 1970–83.*

| Variable | Number | Age at first calving (months) |
|---|---|---|
| **Overall** | 165 | 38.4 |
| **Area** | | |
| Blantyre South | 19 | 38.1 |
| Blantyre North | 24 | 40.1 |
| Chiradzulu | 27 | 36.6 |
| Thyolo North | 50 | 38.5 |
| Mulanje West | 22 | 38.2 |
| Zomba | 23 | 38.8 |
| **Breed group** | | |
| 1/2 Friesian | 110 | 36.7a |
| 3/4 Friesian | 55 | 40.1b |
| **Year of birth** | | |
| 1970 | 18 | 37.6 a |
| 1971 | 24 | 37.2 a |
| 1972 | 20 | 41.8 bd |
| 1973 | 33 | 42.2 bc |
| 1974 | 20 | 39.5 acd |
| 1975 | 18 | 36.8 a |
| 1976 | 16 | 34.5 a |
| 1977/78 | 16 | 37.9 acd |
| **Season of birth** | | |
| Nov–March | 38 | 37.0 |
| April–May | 42 | 41.9 |
| June–August | 43 | 37.3 |
| Sept–October | 42 | 37.5 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

There was a significant difference in age at first calving ($P < 0.05$) between breeds, heifers with 50% Friesian inheritance calving for the first time 3 months earlier than cows with 75% Friesian inheritance (Table 4). This apparent inconsistency was also observed by Kiwuwa et al (1983), who found that heifers with 87.5% Friesian blood calved for the first time later than heifers with a lower percentage of Friesian inheritance. The significant differences in age at first calving among years of birth of the cows appear to have followed the rainfall pattern over the years. Rainfall in 1972/73 amounted to 559 mm in Chileka and 948 mm in Chichiri, while the corresponding figures for 1975/76 were 856 mm and 1336 mm (Table 1). Age at first calving of heifers born in these years were 42 months and 35 months, respectively. This effect may be related to the availability of maize for supplementary feed. In years of poor rainfall yields of maize are low, and all the maize is used for human consumption. Thus the mean age at first calving of 38.0 months obtained on smallholder farms was achieved probably without much feed supplementation. This suggests that modest levels of feed supplementation with maize bran and rice bran could further reduce age at first calving.

***Calving interval and days open:*** Calving interval refers to the period between consecutive calvings and is a function of days open (period from calving to next conception) and gestation length. Since gestation length is more or less constant for a given breed, the number of days open to conception becomes the sole variable of calving interval. Long open periods, and hence long calving intervals, generally reflect problems associated with management but may also give some indication of the condition of the cow's reproductive apparatus. Thus, reasonably short calving intervals of 12–13 months indicate an optimum combination of good management and sound physiological condition of the cow. The analyses of variance for days open to conception and calving interval, based on 591 and 577 records, respectively, showed that none of the factors tested (area, breed group, year and month of previous calving) had a significant effect at the 5% level of probability. The mean calving interval was 510 ± 168 days with a CV of 32%. The corresponding figures for days open were 231 ± 170 (CV = 70%). The least squares means for calving interval and days open are presented in Table 5.

The long calving interval of almost 16.7 months observed in this study is attributable to the long days-open period of almost 7.5 months. The period of 7.8 months from calving to conception observed in Zomba was possibly the result of deficiency of phosphorus in the soil and hence phosphorus deficiency in the animals' diet. The smallholders' reluctance to allow artificial insemination of their cows in the early phase of the project, failure of the farmers to detect heat and inefficiency in the artificial insemination service all tended to extend the days-open period. Although lactation number did not have a significant effect on calving interval and days open, these characters appeared to decrease with increasing lactation number (Table 5).

## Productive performance

Milk production traits considered in this study were total lactation yield, lactation length, milk yield per lactation day and dry period.

Analyses of variance for total lactation yield, lactation length, milk yield per lactation day and dry period are shown in Table 6 and estimated least square means are given in Table 7.

***Total lactation milk yield:*** The mean total lactation milk yield was 2225 ± 1040 kg (CV = 46%). Agricultural area, breed group, year and month of calving, and area by breed interaction each had a significant effect on total lactation milk yield (Table 6). Total milk yield was highest in Zomba and Thyolo North where feed resources are more uniform throughout the year and where the majority of smallholders were new to livestock enterprise. Farmers in these two areas were prepared to accept innovations from extension agents more readily than their counterparts elsewhere who had previous experience in raising the Malawi Zebu and who resisted the idea that crossbred cows should be managed differently. Also, smallholder dairy operations were first started in Thyolo North and hence farmers in that area had gained more experience in handling crossbred dairy cows than farmers elsewhere. Cows with 75% Friesian inheritance produced significantly more milk than cows with 50% Friesian inheritance (2424 kg vs 1953 kg). A separate analysis that included 18 cows with 87.5% Friesian blood showed that the mean total lactation yield for the 7/8 Friesians was 3206 kg. These levels of production were achieved on smallholder farms with the same management regime for all breed groups. Ignoring differences in lactation length (401 vs 391 days), milk yield of cows with 75% Friesian inheritance on smallholdings in Malawi was similar to cows with 75% Friesian inheritance on smallholder farms in Ethiopia (2424 kg vs 2317 kg) (Kiwuwa et al, 1983).

A regression of lactation yield on years showed that total lactation yield decreased by 90 kg per cow per year. However, fewer records were available after 1979, which may, in part, account for the lower estimates of milk yield in later years. As the herd size increased beyond the limit of 2 milking cows set by the extension agency there was no corresponding increase in land allocated to pasture, with the result that the amount of feed

Table 5. *Estimated least squares means for calving interval and days open for smallholder dairy herds, 1973–83.*

| Variable | Number | Calving interval (days) | Number | Days open |
|---|---|---|---|---|
| **Overall** | 577 | 485 | 591 | 213 |
| **Area** | | | | |
| Blantyre South | 54 | 461 | 54 | 188 |
| Blantyre North | 147 | 512 | 160 | 233 |
| Chiradzulu | 87 | 463 | 87 | 193 |
| Thyolo North | 165 | 498 | 165 | 229 |
| Mulanje West | 87 | 477 | 88 | 201 |
| Zomba | 37 | 501 | 37 | 238 |
| **Breed Group** | | | | |
| 1/2 Friesian | 432 | 488 | 441 | 216 |
| 3/4 Friesian | 145 | 482 | 150 | 211 |
| **Lactation Number** | | | | |
| 1 | 241 | 527 | 242 | 242 |
| 2 | 176 | 509 | 179 | 227 |
| 3 | 91 | 483 | 93 | 214 |
| 4 | 34 | 466 | 39 | 208 |
| 5 | 19 | 471 | 20 | 203 |
| 6+ | 16 | 455 | 18 | 188 |
| **Year of Calving** | | | | |
| 1973 | 16 | 471 | 16 | 210 |
| 1974 | 32 | 434 | 32 | 171 |
| 1975 | 53 | 544 | 53 | 277 |
| 1976 | 72 | 488 | 72 | 216 |
| 1977 | 101 | 494 | 101 | 221 |
| 1978 | 118 | 473 | 119 | 203 |
| 1979 | 96 | 471 | 96 | 202 |
| 1980 | 61 | 519 | 59 | 252 |
| 1981 | 28 | 472 | 29 | 204 |
| 1982 | – | – | 14 | 179 |
| **Month of calving** | | | | |
| January | 46 | 503 | 50 | 231 |
| February | 57 | 465 | 57 | 194 |
| March | 39 | 563 | 41 | 280 |
| April | 47 | 459 | 47 | 188 |
| May | 47 | 463 | 47 | 189 |
| June | 45 | 486 | 48 | 219 |
| July | 54 | 474 | 56 | 208 |
| August | 51 | 460 | 51 | 190 |
| September | 49 | 540 | 50 | 271 |
| October | 50 | 458 | 50 | 186 |
| November | 58 | 481 | 60 | 206 |
| December | 34 | 467 | 34 | 200 |

available for each cow has decreased over the years.

Month of calving also had a significant influence on milk production (Table 6). Cows that calved in November through April produced more milk than those that calved in May through October (2308 vs 2075 kg). These differences followed closely the monthly rainfall distribution, which determines the availability of feed. One could, therefore, adopt breeding management strategies that would result in cows calving in November through April, but the need for a continuous supply of milk to the urban centres and the small herd size per smallholder do not justify

Table 6. *Analyses of variance of total lactation milk yield, lactation length, milk yield per day of lactation and dry period for smallholder dairy herds in Malawi, 1973–83.*

| | | Lact. yield | Lact. length | Yield/day | | Dry period |
|---|---|---|---|---|---|---|
| Source | d.f. | MS x $10^{-4}$ | MS x $10^{-1}$ | MS x 10 | d.f. | MS x $10^{-1}$ |
| Area | 5 | 1 181** | 4 428 | 789** | 5 | 533 |
| Breed group | 1 | 2 327** | 3 792 | 798** | 1 | 2 033 |
| Lactation number | 5 | 102 | 3 761 | 107 | 5 | 1 034 |
| Year of calving | 9 | 445** | 5 281* | 255** | 9 | 1 624 |
| Month of calving | 11 | 208* | 4 148* | 41 | 11 | 1 955 |
| Breed group x month | 11 | 105 | 3 709 | 32 | 11 | 2 405 |
| Area x breed | 5 | 253* | 1 871 | 270** | 5 | 1 598 |
| Remainder | 733 | 108 | 2 254 | 60 | 496 | 1 458 |

* = $P < 0.05$

** = $P < 0.01$

seasonal breeding to take advantage of the abundant feed supply in the rainy season.

There was a significant effect of area of operation by breed interaction on milk production. In Blantyre North and Mulanje West, where rainfall is poor and feed supply is inadequate, cows with 50% Friesian inheritance and those with 75% Friesian inheritance gave similar milk yields. However, in areas with adequate feed supply, such as Zomba, Thyolo and Blantyre South the 3/4 Friesians produced about 1000 kg of milk more than the 1/2-Friesian crosses. Rhodes grass for hay and cottonseed hulls are being introduced into the dry areas of Blantyre North and Mulanje to increase feed supplies.

***Lactation length:*** The mean lactation length was 390 ± 150 days with a CV of 38%. Analyses of variance in Table 6 show that year and month of calving had significant effects ($P < 0.05$) on lactation length. Regression analysis of the estimated least squares means on years, coded one through 10, shows that lactation length decreased by 14 days per lactation. The effect of month of calving on lactation length closely followed that on total lactation yield. The figures indicate that where farmers realised that cows that calved in a favourable month were capable of producing more milk there was a tendency to milk those cows longer. In general the long lactation periods found in this study reflect the problems encountered by farmers in getting their cows pregnant by artificial insemination. This observation is supported by the long lactation periods during the first 4 to 5 years of the smallholder dairy scheme, when heat detection was difficult for smallholders.

***Milk yield per day of lactation:*** The mean milk yield per day of lactation was 5.9 ± 2.4 kg with a CV of 41%. Area of operation, breed group and year of calving had significant effects ($P < 0.01$) on milk yield per day of lactation. The effect of breed group on milk yield per day of lactation was similar to the effect of breed on total lactation yield. Cows with 50% Friesian inheritance produced an average of 5.3 kg of milk/day, compared with 6.2 kg/day for cows with 75% Friesian inheritance. In a separate analysis, 7/8 Friesians gave an average of 7.3 kg of milk per day of lactation.

***Dry period:*** The mean dry period observed in this study was 128 ± 120 days with a CV of 94%. Analysis of variance showed that none of the factors tested had a significant effect on this trait. However, the data show a trend that dry period increased as lactation length decreased. This suggests that the shortening of the lactation period was not due to an improvement in the lactation cycle by the smallholder farmer but was a result of constraints, most likely feed availability, that forced cows to dry up while the foetuses they were carrying were still young.

## Dairy productivity

As stated by Kiwuwa et al (1983), varying milk output over different lactation lengths makes it difficult to compare animal performance directly using the individual traits of lactation milk yield, lactation length, dry period and calving interval. To overcome this problem, we studied annual milk yield per cow, which combines reproductive and productive performance.

Table 7. *Estimated least squares means for total lactation milk yield, lactation length, milk yield per lactation day and dry period for smallholder dairy herds in Malawi, 1973–83.*

| Variable | No. | Lact. yield (kg) | Lact. length (days) | Milk yield /day (kg) | No. | Dry period (days) |
|---|---|---|---|---|---|---|
| **Overall** | 781 | 2 188 | 392 | 5.7 | 544 | 107 |
| **Area** | | | | | | |
| Blantyre South | 59 | 2 147 ad | 391 a | 5.4 a | 49 | 107 |
| Blantyre North | 189 | 1 761 a | 417 a | 4.3 b | 144 | 113 |
| Chiradzulu | 114 | 2 085 de | 376 ab | 5.7 a | 74 | 106 |
| Thyolo North | 225 | 2 513 b | 390 ab | 6.6 c | 156 | 116 |
| Mulanje West | 126 | 1 851 ae | 361 bc | 5.2 a | 87 | 117 |
| Zomba | 68 | 2 772 b | 417 a | 7.1 c | 34 | 83 |
| **Breed group** | | | | | | |
| 1/2 Friesian | 554 | 1 953 a | 382 | 5.3 a | 403 | 116 |
| 3/4 Friesian | 227 | 2 424 b | 401 | 6.2 b | 141 | 98 |
| **Lactation number** | | | | | | |
| 1 | 286 | 2 089 | 392 | 5.4 | 227 | 115 |
| 2 | 254 | 2 139 | 368 | 5.9 | 166 | 121 |
| 3 | 127 | 2 078 | 384 | 5.5 | 85 | 106 |
| 4 | 61 | 2 376 | 402 | 5.9 | 31 | 132 |
| 5 | 29 | 2 340 | 364 | 6.5 | 18 | 99 |
| 6+ | 24 | 2 106 | 443 | 5.3 | 17 | 71 |
| **Year of calving** | | | | | | |
| 1973 | – | – | – | – | 7 | 44 |
| 1974 | 29 | 2 061 ad | 437 ade | 5.0 ae | 28 | 81 |
| 1975 | 49 | 2 510 ab | 443 ae | 5.8 ace | 49 | 107 |
| 1976 | 74 | 2 463 ae | 414 ade | 6.0 ac | 71 | 107 |
| 1977 | 122 | 2 523 bef | 440 a | 5.9 adf | 77 | 120 |
| 1978 | 160 | 2 580 cbe | 402 ef | 6.8 b | 78 | 102 |
| 1979 | 149 | 2 444 ab | 386 ef | 6.6 cb | 79 | 134 |
| 1980 | 106 | 2 285 abf | 384 cdf | 6.3 bcd | 53 | 144 |
| 1981 | 45 | 1 864 d | 373 bdf | 5.0 ef | 26 | 132 |
| 1982 | 36 | 1 701 d | 352 bdf | 5.0 ae | 12 | 103 |
| 1983 | 11 | 1 451 d | 289 bc | 4.8 ad | – | – |
| **Month of calving** | | | | | | |
| January | 74 | 2 144 a | 402 ab | 5.5 | 46 | 84 |
| February | 78 | 2 240 a | 409 ab | 5.6 | 56 | 89 |
| March | 50 | 2 764 b | 454 a | 6.0 | 34 | 125 |
| April | 65 | 2 352 b | 402 ac | 6.1 | 41 | 101 |
| May | 52 | 2 113 a | 438 ad | 5.4 | 42 | 88 |
| June | 62 | 2 167 a | 357 bc | 6.0 | 42 | 99 |
| July | 72 | 2 176 a | 375 bcd | 6.0 | 48 | 119 |
| August | 67 | 1 954 a | 374 bcd | 5.2 | 44 | 121 |
| September | 71 | 2 061 a | 369 bc | 6.0 | 47 | 170 |
| October | 63 | 1 982 a | 348 bcd | 5.7 | 51 | 114 |
| November | 73 | 2 304 a | 394 ac | 5.9 | 58 | 89 |
| December | 54 | 2 045 a | 381 bcd | 5.4 | 35 | 89 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

***Annual milk yield per cow:*** Annual milk yield per cow was calculated as total lactation milk yield divided by calving interval (days) x 365. The mean annual milk yield for 516 records was 1721 ± 706 kg with a CV of 41%.

Area of operation and breed group had significant effects (P < 0.01) on annual milk yield per cow (Table 8).

Table 8. *Analysis of variance of annual milk yield per cow for smallholder dairy herds in Malawi, 1974–83.*

| Source | d.f. | MS x $10^{-3}$ |
|---|---|---|
| Area | 5 | 3 228** |
| Breed group | 1 | 8 235** |
| Lactation number | 5 | 1 059 |
| Year of calving | 7 | 900 |
| Month of calving | 11 | 347 |
| Breed group x month | 8 | 425 |
| Area x breed | 5 | 823 |
| Remainder | 473 | 499 |

** = P < 0.01

Estimated least squares means for annual milk yield per cow are laid out in Table 9. The differences in annual milk production and total lactation yield between 1/2 Friesians and 3/4 Friesians were 471 and 364 kg, respectively. The larger difference in annual yield reflects the superior reproductive performance of the 3/4 Friesians. A similar analysis of the performance of cows in the most productive area, Zomba, and the least productive area, Blantyre North, gave differences of 1010 kg for total lactation yield and 730 kg for annual milk yield. The smaller difference in annual milk yield reflects the longer calving interval of cows in Zomba, and hence their poorer reproductive performance.

Table 9. *Estimated least squares means for annual milk yield per cow for smallholder dairy herds in Malawi, 1974–83.*

| Variable | No. | Annual milk yield (kg) |
|---|---|---|
| **Overall** | 516 | 1 872 |
| **Area** | | |
| Blantyre South | 44 | 1 828 ac |
| Blantyre North | 129 | 1 557 a |
| Chiradzulu | 70 | 1 826 a |
| Thyolo North | 152 | 2 100 cd |
| Mulanje West | 84 | 1 632 a |
| Zomba | 37 | 2 288 bd |
| **Breed group** | | |
| 1/2 Friesian | 384 | 1 689 a |
| 3/4 Friesian | 132 | 2 054 b |
| **Lactation number** | | |
| 1 | 213 | 1 653 |
| 2 | 162 | 1 770 |
| 3 | 83 | 1 804 |
| 4 | 28 | 1 877 |
| 5 | 16 | 2 223 |
| 6+ | 14 | 1 903 |
| **Year of calving** | | |
| 1974 | 27 | 1 729 |
| 1975 | 50 | 1 811 |
| 1976 | 71 | 1 933 |
| 1977 | 99 | 1 944 |
| 1978 | 107 | 2 082 |
| 1979 | 87 | 2 007 |
| 1980 | 51 | 1 803 |
| 1981 | 24 | 1 665 |
| **Month of calving** | | |
| January | 43 | 1 749 |
| February | 56 | 1 802 |
| March | 31 | 1 930 |
| April | 40 | 1 936 |
| May | 41 | 1 896 |
| June | 39 | 2 043 |
| July | 47 | 1 944 |
| August | 44 | 1 816 |
| September | 45 | 1 722 |
| October | 44 | 1 750 |
| November | 54 | 1 975 |
| December | 32 | 1 899 |

Within variable groups, row means followed by the same letter do not differ significantly (P < 0.05). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

## Analyses of productive performance traits in Blantyre North and Thyolo North

The limitation on the Harvey's Least Squares program as to the number of classes of fixed effects that could be analysed at one time made it impossible to study the effects that herd management might have had on reproductive and productive traits on the entire set of smallholder dairy records. As a compromise, Blantyre North and Thyolo North were chosen for the study of herd effects on milk production traits. The two areas were chosen because they had the largest number of records and also represent two extreme environments. Blantyre North lies in a low-rainfall area and thus has limited feed resources, while Thyolo North has adequate rainfall and feed resources. A further restriction imposed on the data from these two areas was that herds with only one record were excluded from the data before analysis.

Whether or not concentrate (maize bran) is fed and differences in the levels of concentrate fed are among the most-readily recognised management practices that could be expected to influence animal productivity. However, information was not available in the data used for this study to distinguish between farmers who fed or did not feed concentrate to their dairy animals. Thus, statistically significant differences among herds found in this study were assumed to be partly due to differences in health care, watering and feeding in general, without distinguishing between concentrate and non-concentrate feedstuffs.

***Total lactation milk yield, lactation length and yield per lactation day:*** The means for total lactation milk yield, lactation length and milk yield per lactation day were 1742 ± 600 kg, 386 ± 125 days and 4.7 ± 1.5 kg, respectively, for Blantyre North with CVs of 34, 33 and 32%. The corresponding figures for Thyolo North were 2722 ± 1197 kg, 397 ± 147 days and 7.0 ± 2.2 kg, with CVs of 44, 37 and 31%.

Analyses of variance for the three traits in the two areas are presented in Table 10.

There were highly significant differences ($P < 0.01$) between herds for all three traits in Blantyre North but differences were significant only for yield per lactation day in Thyolo North ($P < 0.01$). This indicates that management practices have a greater effect on production parameters where resources (e.g. feed) are insufficient. Breed did not have a significant effect on any of the three traits in Blantyre North but had a significant effect ($P < 0.05$) on total lactation yield in Thyolo North. This reinforces the observation that breed groups are likely to express their full potential only when resources are optimal. Year of calving influenced total lactation yield and milk yield per day of lactation in Blantyre North and total lactation yield and lactation length in Thyolo North, while month of calving influenced only total milk yield in Blantyre North, indicating that month to month variation in the availability of resources is more critical in resource-deficient areas.

***Annual milk yield per cow:*** The mean annual milk yield per cow was 1527 ± 363 kg with a CV of 24% in Blantyre North. The corresponding figure for Thyolo North was 2039 ± 746 kg with a CV of 37%.

Analysis of variance of annual milk yield is laid out in Table 11.

Herd effects were highly significant in Blantyre North ($P < 0.01$) and were also significant in Thyolo North ($P < 0.05$) (Table 11), emphasising that differences in management practices have a greater effect in resource-deficient areas. Year of calving had a highly significant effect ($P < 0.01$) on annual milk yield in Blantyre North but not in Thyolo North. Breed group, month of calving, lactation number and breed by month interaction had no significant effect on annual milk yield per cow in either Blantyre North or Thyolo North.

Table 10. *Analyses of variance of total lactation milk yield, lactation length and milk yield per day of lactation for Blantyre North and Thyolo North.*

| | | Blantyre North | | | | Thyolo North | | |
|---|---|---|---|---|---|---|---|---|
| | | Lact. yield | Lact. length | Yield/day | | Lact. yield | Lact. length | Yield/day |
| Source | d.f. | MS x $10^{-2}$ | MS x $10^{-1}$ | MS x $10^{2}$ | d.f. | MS x $10^{2}$ | MS x $10^{1}$ | MS x $10^{2}$ |
| Herd | 34 | 7 289** | 2 499** | 608** | 49 | 17 112 | 1 819 | 833** |
| Breed group | 1 | 3 158 | 5 376 | 6 | 1 | 86 464* | 6 992 | 1 270 |
| Lactation number | 5 | 1 853 | 540 | 121 | 4 | 25 469 | 3 742 | 660 |
| Year of calving | 9 | 16 418** | 1 065 | 1 612** | 6 | 55 552** | 8 127** | 692 |
| Month of calving | 11 | 6 323** | 2 292 | 258 | 11 | 12 340 | 3 530 | 671 |
| Breed group x month | 10 | 5 191 | 1 821 | 301 | 11 | 16 842 | 2 394 | 1 138* |
| Remainder | 112 | 3 598 | 1 597 | 228 | 129 | 14 257 | 2 148 | 488 |

* = $P < 0.05$

** = $P < 0.01$

**Table 11.** ***Analysis of variance*** *of annual milk yield per cow for Blantyre North and Thyolo North.*

| | Blantyre North | | Thyolo North | |
|---|---|---|---|---|
| Source | d.f. | MS x $10^{-2}$ | d.f. | MS x $10^{-2}$ |
| Herd | 26 | 4 892** | 32 | 9 676* |
| Breed group | 1 | 320 | 1 | 2 449 |
| Lactation number | 5 | 1 812 | 3 | 4 340 |
| Year of calving | 7 | 6 240** | 5 | 1 556 |
| Month of calving | 11 | 1 915 | 11 | 3 889 |
| Breed group x month | 9 | 1 817 | 11 | 3 663 |
| Remainder | 60 | 1 319 | 66 | 5 579 |

* = $P < 0.05$

** = $P < 0.01$

# 3. ANALYSES OF FEMALE CALF BODY WEIGHT DATA FROM CHIZOMBEZI AND SUMMARY OF COW PERFORMANCE AT TUCHILA MULTIPLICATION CENTRE

## Introduction

As was observed in Section 2, the exact breed composition of the 'off-type' female cattle that were used to produce the crossbred calves was not known but was believed to be a mixture of Sussex, Brahman-type and Africander-cross cattle. In this section the birth weight of $F_1$ female calves produced from Friesian bulls and 'off-type' females, and their growth rate from birth to weaning are analysed. Crossbred cows, mainly 3/4, 7/8 and higher-grade Friesians, are kept at Tuchila to provide milk for growing calves left behind by the $F_1$ heifers sold to smallholders, and their performance is also summarised. The number of records at Tuchila did not warrant detailed analysis. However, the means presented are the best available figures from a station-type operation with which performance of the crosses at the smallholder farms can be compared.

## Management practices at Chizombezi and Tuchila

The two main breeding seasons at Chizombezi were from the middle of May to August and from December to March. 'Off-type' heifers at Chizombezi were put to a number of Friesian bulls from Mikolongwe at 2 to 2 1/2 years old or at a breeding weight of about 300 kg.

Pregnant heifers were steamed up by feeding a production ration from the seventh month of pregnancy. The production ration was usually compounded from soya bean, pigeon pea, maize, maize bran and cottonseed cake, depending on the availability of these materials on the market. Pregnant heifers were separated from the rest of the females about two weeks before calving, and were introduced to milking-shed practices. After parturition calves stayed with the dams for 24 to 48 hours, after which they were placed in a calf pen and bucket fed milk diluted with increasing amounts of water over a period of 10 weeks and then weaned. The male 3/4-Friesian calves were castrated at 4 to 6 weeks old. Females were inseminated with Friesian semen at 2 1/4 years old to produce 7/8-Friesian calves. Half- and 3/4-Friesian cows were usually sold to smallholder farmers while 7/8-Friesians and higher grades were kept at Tuchila.

In the absence of a weighing scale approximate birth and weaning weights were obtained for calves by the use of a weigh-band. All animals at the station were dipped in Supona solution every week and were drenched regularly.

## Calf performance at Chizombezi

On the basis of the frequency of births in the various months at Chizombezi, four seasons of calving were created for the analyses of the birth-weight and growth-rate data on 1/2-Friesian female calves. These seasons were November to March, April to May, June to August and September to October, and comprise the two main breeding seasons and accidental breedings occurring between the main breeding seasons.

### Birth weight, daily weight gain and actual and adjustad weaning weights

Analyses of variance of calf birth weight, actual weaning weight, 200-day adjusted weaning weight and daily weight gain up to weaning are presented in Table 12.

Table 12. *Analyses of variance of female calf birth weight, actual and 200-day adjusted weaning weights and daily weight gain of 1/2-Friesian calves at Chizombezi multiplication centre, 1974–83.*

| Source | d.f. | Birth wt. MS | d.f. | Weaning wt. MS | 200-day weaning wt. MS | Daily wt. gain MS x $10^3$ |
|---|---|---|---|---|---|---|
| Season of calving | 3 | 130.9** | 3 | 2 422** | 5 701** | 173** |
| Year of calving | 8 | 230.4** | 6 | 2 548** | 3 930** | 81** |
| Remainder | 568 | 13.2 | 313 | 508 | 491 | 11 |

** = P < 0.01

Season of birth and year of birth had significant effects (P < 0.01) on all four traits (Table 12).

The estimated least squares means for the four traits are laid out in Table 13.

**Birth weight:** The mean calf birth weight for 580 female calves was 30.1 ± 3.6 kg with a CV of 12%. Calves born between April and August were significantly heavier than those born between September and March (P < 0.05).

With the exception of 1983, calf birth weight at Chizombezi has been declining since 1974 (Table 13). A regression of female calf birth weight on years (coded 1 through 9) from 1974 to 1983 indicated that birth weight has been decreasing by 0.16 kg per year, although the regression coefficient was not statistically significant.

***200-day adjusted weaning weight and daily weight gain:*** The mean 200-day adjusted weaning weight and daily weight gain for 323 female calves were 136.2 ± 22 kg and 0.53 ± 0.11, respectively. The respective CVs were 16 and 21%. Calves born in September through March were significantly heavier (150.5 kg vs 134.2 kg) than calves born in April through August at 200-days postpartum, despite the heavier birth weights of the latter. Similarly calves born in September through March on average gained 0.1 kg per day more than calves born in April through August.

Table 13. *Estimated least squares means for calf birth weight, actual and 200-day adjusted weaning weights and daily weight gain of 1/2-Friesian calves at Chizombezi multiplication centre, 1974–83.*

| | No. | Birth weight (kg) | No. | Actual weaning wt. (kg) | 200-day adjusted wt. (kg) | Daily wt. gain (kg) |
|---|---|---|---|---|---|---|
| **Overall** | 580 | 30.5 | 323 | 135.1 | 142.3 | 0.56 |
| **Season of birth** | | | | | | |
| Nov.–March | 62 | 29.8 a | 33 | 131.7 a | 151.4 a | 0.61 a |
| April–May | 279 | 30.9 b | 183 | 131.0 a | 131.5 b | 0.50 b |
| June–Aug. | 73 | 31.8 b | 39 | 133.2 a | 135.9 b | 0.52 b |
| Sept.–Oct. | 166 | 29.3 a | 68 | 144.3 b | 149.6 a | 0.60 a |
| **Year of birth** | | | | | | |
| 1974 | 31 | 31.0 a | 31 | 142.1 acd | 146.3 a | 0.57 a |
| 1975 | 16 | 29.6 a | 16 | 135.2 acd | 145.9 a | 0.58 a |
| 1976 | 31 | 33.9 c | 30 | 147.1 ac | 161.5 b | 0.64 b |
| 1978 | 31 | 31.0 a | 29 | 115.0 b | 140.2 c | 0.55 ac |
| 1979 | 127 | 29.9 a | 121 | 135.6 ce | 141.7 ae | 0.56 a |
| 1980 | 104 | 29.5 bd | 42 | 136.4 ae | 133.7 cef | 0.52 ce |
| 1981 | 99 | 29.5 bd | 54 | 134.0 de | 127.0 df | 0.49 de |
| 1982 | 73 | 27.0 b | – | – | – | – |
| 1983 | 68 | 33.0 c | – | – | – | – |

Within variable groups, row means followed by the same letter do not differ significantly (P < 0.05). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

The 200-day adjusted weaning weight and daily weight gain of calves decreased between 1974 and 1981 (Table 13). The regressions of 200-day weaning weight and daily weight gain on years indicated that these characters had been decreasing by 3.6 and 0.16 kg/year, respectively. The regressions were significant at the 10% level of probability.

The seasonal effects on calf birth weight, 200-day adjusted weaning weight and daily weight gain follow the patterns of rainfall and availability of feed. Calves born after the major rainy season were heavier as a result of more green feed being available to their dams during the later phases of pregnancy, while calves born in September through March were lighter at birth due to poor nutrition of dams in the dry season which begins in June. However, the calves born at this time benefited from the increased feed availability during the next rainy season and hence weaned 15 kg heavier than calves born in other seasons.

# Comparison between cow performance at Tuchila and on smallholder farms

## Reproductive performance

The unadjusted means of reproductive parameters calculated for crossbred cows kept at Tuchila are given in Table 14. The few data available suggest that age at first calving has been increasing over the years. This is contrary to the trend found with data from the smallholder farms. On the other hand the mean calving interval of 432 ± 16 days and the mean days open of 154 ± 16 days found for 60 cows at Tuchila were much lower than figures estimated for smallholder herds (510 and 231 days). There do not seem to be any year trends in calving interval and days open at Tuchila.

## Productive performance

The mean total lactation milk yield for 52 crossbred cows at Tuchila was 3121 ± 211 kg (Table 15). A breakdown of milk yield by breed of cow gave figures of 1240 kg for 1/2 Friesians, 3850 kg for 3/4 Friesians, 2962 kg for 7/8 Friesians and 4840 kg for 15/16 Friesians. The higher mean total lactation yield observed at Tuchila compared with the mean for smallholder herds (2225 kg) is the result of the higher percentage of high-grade cattle and the better feeding strategy at Tuchila. The lower mean yield for the 1/2 Friesians at Tuchila compared with 1/2 Friesians on smallholder farms (1950 kg) could be explained by the fact that the 1/2 Friesians kept at Tuchila were those that failed the minimum milk yield standard of 5 kg per day during the first 3 weeks postpartum and hence were not sold to smallholders.

The milk yield per day of lactation in Tuchila was fairly stable from 1977 to 1980 but fell in 1981. This trend was also observed in the smallholder herds, which suggests that the government farms and research stations also suffered from feed shortages as a result of the poor weather in 1981.

Table 14. *Raw means and standard deviations (SD) of reproduction parameters at Tuchila, 1976–82.*

| Year | Age at first calving (months) | | Calving interval (days) | | Days open | |
|---|---|---|---|---|---|---|
| | No. | Mean ± SD | No. | Mean ± SD | No. | Mean ± SD |
| Overall | 23 | 38.9 ± 1.8 | 60 | 432 ± 15.5 | 60 | 154 ± 15.5 |
| 1976 | 5 | 34.0 ± 2.1 | 4 | 413 ± 22.0 | 4 | 135 ± 22.0 |
| 1977 | 10 | 34.7 ± 3.2 | 9 | 433 ± 23.3 | 10 | 150 ± 24.4 |
| 1978 | 5 | 35.1 ± 1.5 | 10 | 415 ± 19.3 | 10 | 137 ± 19.3 |
| 1979 | 3 | 50.1 ± 1.8 | 8 | 367 ± 15.2 | 8 | 87 ± 15.2 |
| 1980 | – | – | 15 | 469 ± 43.9 | 14 | 198 ± 46.5 |
| 1981 | – | – | 8 | 406 ± 27.9 | 8 | 128 ± 27.9 |
| 1982 | – | – | 5 | 431 ± 26.4 | 5 | 153 ± 26.3 |

Table 15. *Raw means and standard deviations (SD) of production parameters at Tuchila, 1977–81.*

| Year | No. | Lactation yield (kg) Mean ± SD | Lactation length (days) Mean ± SD | Yield/lact. day (kg) Mean ± SD |
|---|---|---|---|---|
| Overall | 52 | 3121 ± 211 | 327 ± 13.5 | 9.1 ± 0.5 |
| 1977 | 4 | 2816 ± 899.5 | 267 ± 65.5 | 8.8 ± 2.3 |
| 1978 | 13 | 3605 ± 426.0 | 357 ± 23.8 | 10.0 ± 0.8 |
| 1979 | 10 | 3579 ± 384.8 | 343 ± 14.8 | 10.3 ± 0.8 |
| 1980 | 6 | 3166 ± 555.6 | 291 ± 23.7 | 10.7 ± 1.3 |
| 1981 | 17 | 2643 ± 413.5 | 322 ± 31.3 | 7.4 ± 0.8 |

# 4. ANALYSES OF PRODUCTION RECORDS FROM CHITEDZE AND BWEMBA

## Introduction

The Chitedze Agricultural Research Station and the Bwemba Livestock Multiplication Centre are both in the Central Region of Malawi, located about 10 km apart and are within 16 km of Lilongwe. Most of the innovations in dairy-herd management practised on smallholder dairy farms in Malawi were tested first at the Chitedze Research Station, which thus has close links with smallholder dairy operations. Bwemba Livestock Multiplication Centre has served as the main station from which crossbred heifers are issued to smallholder dairy farmers in the Central and Northern Regions. The analyses of dairy production records from these two centres are therefore integral to the overall evaluation of the productivity of crossbred cattle in Malawi and also provide background information to which the productivity of the smallholders' dairy cattle could be related.

## Chitedze Agricultural Research Station

Chitedze Agricultural Research Station is situated about 16 kilometers west of Lilongwe, at 14° S, 33° 45'E and 1050 metres a.s.l. It was established in 1959 primarily to conduct research on crops. Research on beef and dairy cattle started much later. The objectives of the livestock research at Chitedze are to:

1. Improve the indigenous Malawi Zebu cattle by selection within the breed;
2. Improve milk production through crossbreeding Malawi Zebus with imported Friesian semen;
3. Improve beef production through crossbreeding Malawi Zebus with exotic breeds, e.g. Brahman cattle; and to
4. Study the utilisation of local forages and crop residues by livestock.

### Management practices

***Breeding and milking cows:*** Heifers were mated for the first time when they attained a minimum weight of 340 kg at about 29 months of age. Until November 1983 seasonal breeding was practised, the breeding season being December to February. Pregnant heifers were separated from the other heifers and were placed in a semi-intensive feeding facility and then brought to the main cow herd to await calving. Cows and heifers were 'steamed up' from the seventh month of pregnancy until calving. Cows and heifers in their last month of pregnancy were separated from the main herd for parturition. Calves stayed with their dams for 2 days, during which the dams were not milked. From the 3rd to the 7th day postpartum the cows were milked once a day in the morning, after which the calves were suckled. From the 8th day the cows were milked twice a day. Milk from each cow was weighed at each milking. The calves were suckled by the dams for 30 minutes after morning and evening milkings. Calves were weaned at 12 weeks old, and male calves were castrated about 3 weeks after weaning. Since 1981 calves have been weighed every 2 weeks until weaning.

***Weaner calves:*** Weaners were kept at the station for a year, during which they were allowed to graze during the day but were penned at night. Each weaner received 1.5 to 2.0 kg of maize bran per day. After one year, female yearlings were put in a semi-intensive facility where they grazed day and night and received maize-bran supplements. The yearlings were kept under this system until they reached a minimum weight of 340 kg, at about 2 1/4 years old, and were then served.

Yearling steers were put on feeding trials or were fattened for slaughter.

***Health management:*** The cattle were drenched against worms and flukes every 3 months, and were sprayed once a week. The most common health problems on the station were diarrhoea among calves and weaners, and footrot and mastitis among cows. Mortality among both old and young stock was minimal.

# Bwemba Livestock Multiplication Centre

The Bwemba centre was established in 1973 as one of several livestock centres set up to facilitate the livestock activities of the Ministry of Agriculture, which were concentrated in Mikolongwe in the Southern Region.

The functions of the Bwemba Centre are to:

1. Maintain pure-bred Friesians to supply raw milk to Malawi Milk Marketing in Lilongwe;
2. Serve as a steaming-up centre for pregnant crossbred heifers from the Likasi Livestock Breeding Station, which are released to smallholder dairy farmers after calving;
3. Produce pure-Friesian steers and to raise crossbred steers for the Likasi breeding station, from where the steers are released to stall-feeder farmers; and to
4. Serve as a demonstration centre for smallholder dairy farmers in all aspects of management.

The movements of cattle between Bwemba and Likasi are depicted in Figure 3.

## Management practices

Pregnant crossbred cows from Likasi were put together with pregnant and non-pregnant pure Friesians on their arrival at Bwemba. Cows in the final month of pregnancy were isolated in a partly-roofed pen, where calving took place. Cows were fed concentrate during milking at a rate of 1 kg concentrate per 2 kg of milk produced. Silage (Rhodes grass/maize/Napier grass) and Rhodes grass hay were fed ad libitum.

Most cows were machine-milked twice daily, but those going to farmers were hand milked. The milk produced by each cow was weighed at each milking.

Calves were suckled by their dams for 48 hours after birth and then separated from their dams. Calves were sent to a calf pen where each received 6 litres of milk per day, 3 litres in the morning and 3 in the afternoon, for a period of 3 to 4 weeks. Calf-ration concentrate was also fed ad libitum. At 20 weeks of age calves that met health standards and body conformation criteria were sent to Likasi where females were reared to join the breeding herd and steers were sold to stall-feeder farmers. Calves that failed to meet the selection criteria were treated for worm infestation and fed to a standard condition before being sent to Likasi for rearing.

# Reproductive performance of cows at Chitedze

## Age at first calving

Analysis of variance of age at first calving of Friesian–Malawi Zebu crossbred cows and Friesian cows at Chitedze is shown in Table 16.

Table 16. *Analysis of variance of age at first calving at Chitedze, 1969–83.*

| Source | d.f. | MS x $10^{-2}$ |
|---|---|---|
| Breed group | 3 | 715 |
| Year of birth | 9 | 2 118** |
| Season of birth | 1 | 418 |
| Breed x season | 3 | 444 |
| Remainder | 63 | 371 |

** = $P < 0.01$

Only year of birth of the heifer had a significant effect ($P < 0.01$) on the age at which the heifer calved for the first time (Table 16).

The mean age at first calving was 42.0 ± 6.3 months (CV 15%). The means of age at first calving for heifers born between 1970 and 1974 and between 1975 and 1978 were 40 and 45.5 months, respectively, with a peak of 54.5 months for heifers born in 1977 (Table 17). There was no apparent reason for the observed increase in age at first calving.

Although the effect of breed group on age at first calving was not significant, there was a trend for heifers with a larger proportion of Friesian inheritance to be older at first calving. This suggests that feeding levels at the station were inadequate for both the crossbreds and the pure Friesians.

Figure 3. *Movement of crossbred cattle between Likasi and Bwemba.*

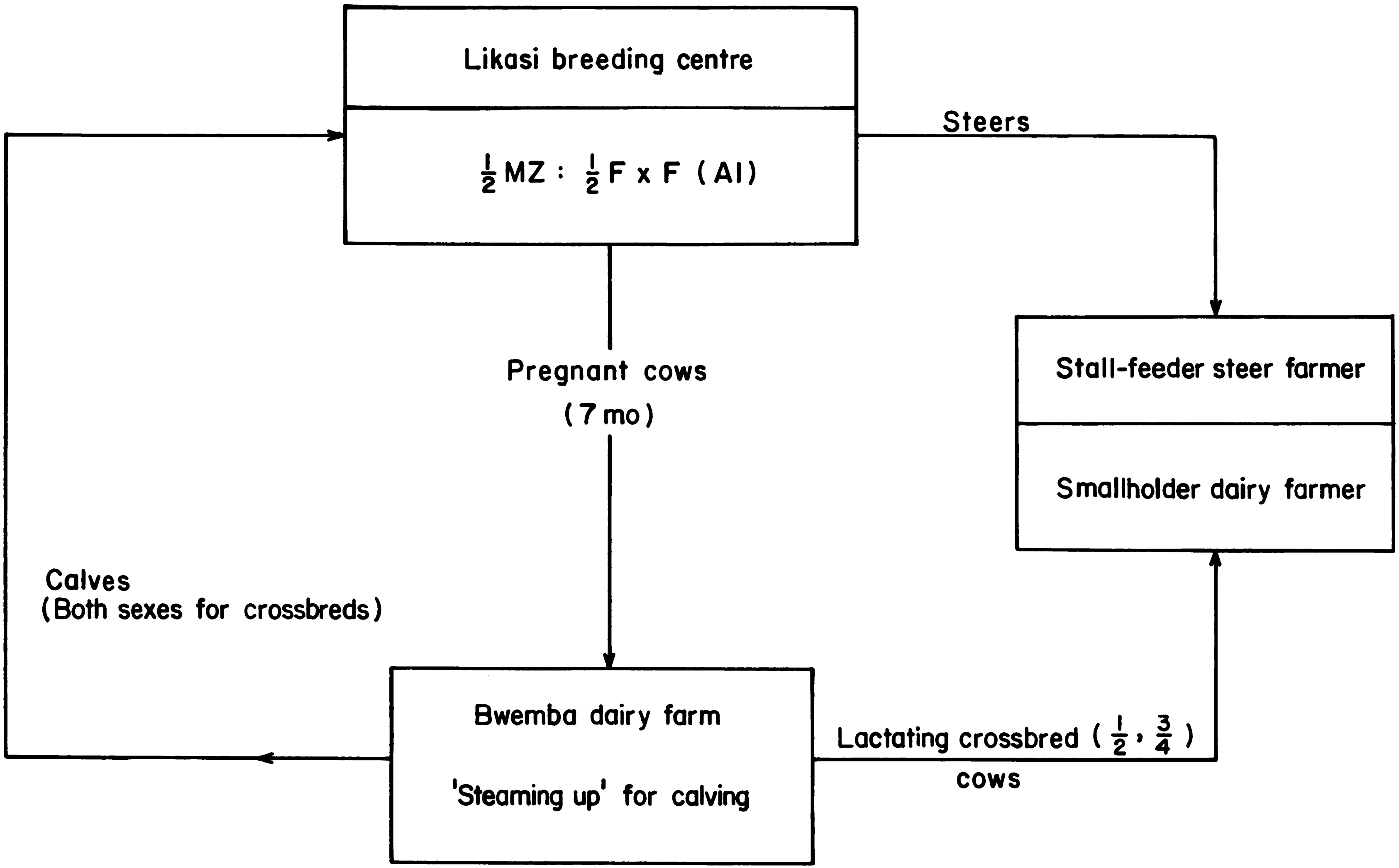


Table 17. *Estimated least squares means for age at first calving at Chitedze, 1969–83.*

| Variable | Number | Age at first calving (months) |
|---|---|---|
| **Overall** | 80 | 41.7 |
| **Breed group** | | |
| 1/2 Friesian | 7 | 33.1 |
| 3/4 Friesian | 39 | 42.7 |
| 7/8 Friesian | 24 | 45.8 |
| Friesian | 10 | 45.5 |
| **Year of birth** | | |
| 1969 | 5 | 52.6 a |
| 1970 | 5 | 39.7 bjh |
| 1972 | 7 | 35.6 cbh |
| 1973 | 11 | 38.5 bdg |
| 1974 | 12 | 34.9 be |
| 1975 | 11 | 42.2 dfj |
| 1976 | 7 | 43.1 cgj |
| 1977 | 4 | 54.5 a |
| 1978 | 12 | 42.2 dhj |
| 1979 | 6 | 34.0 b |
| **Season of birth** | | |
| January–June | 37 | 43.0 |
| July–December | 43 | 40.4 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

## Calving interval and days open

The mean calving interval and days open for 208 calvings at Chitedze were 468 ± 131 days and 190 ± 129 days, respectively, with CVs of 28 and 68%.

Analyses of variance of calving interval and days open are shown in Table 18.

Year of previous calving and breed group by season of previous calving interaction had significant effects on both calving interval and days open (Table 18). Calving interval was significantly longer in 1977 (543 days) and 1980 (598 days) than in other years (Table 19). The corresponding figures for days open were 268 and 316, respectively. These differences may have been due to residual effects of experimental treatments imposed on the cows, but the possibility of nutritional stress due to climatic effects in these years cannot be ruled out.

The breed group by season of calving interaction indicates that Friesians that had calved previously between January and June calved again 143 days later than those that calved previously between July and December. This trend was also observed for the 1/2-Friesian–1/2-Zebu crosses, but the difference was only 42 days. Cows that calved in January through June were exposed longer to the period of feed shortage (May through October) after calving than were cows that calved in July through December. The magnitudes of the differences also indicate that cows with more Friesian inheritance were more vulnerable than those with less Friesian blood. This is also supported by the estimated least squares means of 407, 484 and 513 days calving interval for the 1/2-, 3/4- and 7/8-Friesian cows, respectively, though the differences were not statistically significant.

Table 18. *Analyses of variance of calving interval and days open at Chitedze, 1972–83.*

| Source | Calving interval | | Days open |
|---|---|---|---|
| | d.f. | MS x $10^{-1}$ | MS x $10^{-1}$ |
| Breed group | 3 | 2 672 | 3 524 |
| Lactation number | 5 | 2 644 | 2 711 |
| Year of calving | 9 | 5 717** | 5 464** |
| Season | 1 | 2 168 | 1 313 |
| Breed group x season | 3 | 4 268* | 4 552* |
| Remainder | 186 | 1 679 | 1 669 |

* = $P < 0.05$

** = $P < 0.01$

# Productive performance of cows at Chitedze

## Total lactation yield, lactation length, milk yield per lactation day and dry period

The means for total lactation yield, lactation length, milk yield per day and dry period were 2116 ± 602 kg, 330 ± 84 days, 6.5 ± 1.7 kg and 141 ± 114 days, respectively, with corresponding CVs of 28, 25, 26 and 81%.

Analyses of variance of total lactation yield, lactation length, milk yield per lactation day and dry period are presented in Table 20.

Breed group and year of calving had significant effects ($P < 0.01$) on total lactation yield and yield per lactation day but not on lactation length. Lactation number also had a significant effect ($P < 0.05$) on yield per lactation day (Table 20).

Table 19. *Estimated least squares means for calving interval and days open at Chitedze, 1972–83.*

| Variable | No. | Calving interval (days) | No. | Days open |
|---|---|---|---|---|
| **Overall** | 208 | 476 | 208 | 198 |
| **Breed group** | | | | |
| 1/2 Friesian | 49 | 407 | 49 | 130 |
| 3/4 Friesian | 116 | 484 | 116 | 205 |
| 7/8 Friesian | 17 | 513 | 17 | 235 |
| Friesian | 26 | 498 | 26 | 219 |
| **Lactation number** | | | | |
| 1 | 58 | 467 | 59 | 189 |
| 2 | 54 | 438 | 54 | 166 |
| 3 | 42 | 465 | 40 | 164 |
| 4 | 31 | 494 | 32 | 235 |
| 5 | 15 | 432 | 17 | 176 |
| 6+ | 8 | 556 | 6 | 258 |
| **Year of calving** | | | | |
| 1972 | 6 | 434 ab | 6 | 145 a |
| 1973 | 14 | 422 a | 14 | 147 a |
| 1974 | 14 | 462 ac | 14 | 181 ac |
| 1975 | 20 | 489 ac | 20 | 213 ac |
| 1976 | 19 | 442 a | 22 | 181 a |
| 1977 | 37 | 543 bc | 37 | 268 bc |
| 1978 | 23 | 471 ac | 22 | 188 a |
| 1979 | 37 | 475 a | 35 | 194 a |
| 1980 | 27 | 598 b | 27 | 316 b |
| 1981 | 11 | 419 a | 11 | 144 a |
| **Season of calving** | | | | |
| January – June | 79 | 490 | 78 | 209 |
| July – December | 129 | 461 | 130 | 186 |

Within variable groups row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

The total milk yield and yield per lactation day were similar for the 3/4, 7/8 and pure Friesians, and were greater than those of the 1/2 Friesians. Total lactation yield peaked at the fifth lactation, though the yield at this lactation was not significantly different from those of the other lactations except for the first (Table 21).

The significant effect of year of calving on total lactation yield and yield per lactation day was due to the very poor yields in 1977 and 1980, which were about 30% lower than overall mean yields. The significant effect of year on dry period ($P < 0.01$) also resulted from the unusually long dry periods in 1977 and 1980, which were 59% and 77% longer than the overall mean. There was no obvious difference in the rainfall patterns in 1977 and 1980 that would explain the deviations from average performance in those years.

## Annual milk yield

The mean annual milk yield per cow was 1671 ± 592 kg, with a CV of 35%.

Analysis of variance of annual milk yield per cow is presented in Table 22.

Breed group, lactation number or parity and year of calving had significant effects ($P < 0.01$) on annual milk yield (Table 22). The estimated least squares means are laid out in Table 23.

Table 20. *Analyses of variance of total lactation milk yield, lactation length, milk yield per day of lactation and dry period at Chitedze, 1972–83.*

| Source | d.f. | Lact. yield MS x $10^3$ | Lact. length MS x $10^{-2}$ | Yield/day MS x $10^{-2}$ | d.f. | Dry period MS x $10^{-2}$ |
|---|---|---|---|---|---|---|
| Breed group | 3 | 2 834** | 136 | 1 539** | 3 | 112 |
| Lactation number | 5 | 381 | 128 | 725* | 5 | 182 |
| Year of calving | 10 | 3 003** | 56 | 3 019** | 9 | 546** |
| Season of calving | 1 | 314 | 21 | 5.4 | 1 | 83 |
| Breed x season | 3 | 341 | 167 | 672 | 3 | 252** |
| Remainder | 257 | 354 | 70 | 297 | 182 | 126 |

* = $P < 0.05$

** = $P < 0.01$

Table 21. *Estimated least squares means for total lactation milk yield, lactation length, milk yield per day of lactation and dry period at Chitedze, 1972–83.*

| Variable | No. | Lact. yield (kg) | Lact. length (days) | Milk yield/day (kg) | No. | Dry period (days) |
|---|---|---|---|---|---|---|
| **Overall** | 280 | 2 221 | 331 | 6.9 | 204 | 149 |
| **Breed group** | | | | | | |
| 1/2 Friesian | 52 | 1 677 a | 307 | 5.6 a | 47 | 116 |
| 3/4 Friesian | 151 | 2 345 b | 331 | 7.1 b | 115 | 145 |
| 7/8 Friesian | 42 | 2 495 b | 365 | 7.3 b | 17 | 157 |
| Friesian | 35 | 2 366 b | 321 | 7.4 b | 25 | 179 |
| **Lactation number** | | | | | | |
| 1 | 84 | 2 075 a | 356 | 6.1 a | 59 | 132 |
| 2 | 60 | 2 157 ab | 324 | 6.7 b | 53 | 127 |
| 3 | 50 | 2 212 ab | 318 | 7.0 b | 39 | 131 |
| 4 | 40 | 2 168 ab | 316 | 6.9 b | 30 | 176 |
| 5 | 29 | 2 398 b | 348 | 7.1 b | 17 | 113 |
| 6+ | 17 | 2 315 ab | 325 | 7.4 b | 6 | 217 |
| **Year of calving** | | | | | | |
| 1972 | 6 | 2 511 ae | 324 | 7.9 ae | 6 | 99 a |
| 1973 | 14 | 2 383 ae | 336 | 7.4 ae | 14 | 107 a |
| 1974 | 14 | 2 497 ae | 345 | 7.5 ae | 14 | 132 a |
| 1975 | 19 | 2 449 ae | 349 | 7.2 ae | 19 | 146 ae |
| 1976 | 23 | 2 145 ae | 341 | 6.4 a | 20 | 124 ae |
| 1977 | 38 | 1 544 bc | 321 | 5.1 bc | 37 | 228 b |
| 1978 | 26 | 2 093 e | 326 | 6.6 a | 22 | 133 ad |
| 1979 | 38 | 2 165 ef | 345 | 6.7 a | 34 | 142 ad |
| 1980 | 37 | 1 681 c | 388 | 5.1 c | 27 | 265 c |
| 1981 | 20 | 2 489 af | 317 | 7.8 e | 11 | 117 ade |
| 1982 | 45 | 2 470 a | 300 | 8.1 e | – | – |
| **Season of calving** | | | | | | |
| January – June | 98 | 2 264 | 335 | 6.9 | 76 | 158 |
| July – December | 182 | 2 177 | 327 | 6.8 | 128 | 140 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

Table 22. *Analysis of variance of annual milk yield per cow at Chitedze, 1972–83.*

| Source | d.f. | MS x $10^{-3}$ |
|---|---|---|
| Breed group | 3 | 2 131** |
| Lactation number | 5 | 1 104** |
| Year of calving | 9 | 3 393** |
| Season of calving | 1 | 32 |
| Season x breed | 3 | 169 |
| Remainder | 189 | 350 |

** = P < 0.01

Table 23. *Estimated least squares means for annual milk yield per cow at Chitedze, 1972–83.*

| Variable | No. | Annual milk yield (kg) |
|---|---|---|
| **Overall** | 211 | 1 852 |
| **Breed group** | | |
| 1/2 Friesian | 51 | 1 383 a |
| 3/4 Friesian | 117 | 1 995 b |
| 7/8 Friesian | 17 | 1 959 b |
| Friesian | 26 | 2 071 b |
| **Lactation number** | | |
| 1 | 59 | 1 582 a |
| 2 | 54 | 1 870 bf |
| 3 | 42 | 1 952 bf |
| 4 | 31 | 1 949 bf |
| 5 | 17 | 2 148 ef |
| 6+ | 8 | 1 610 ab |
| **Year of calving** | | |
| 1972 | 6 | 2 534 a |
| 1973 | 14 | 2 375 a |
| 1974 | 14 | 2 221 ag |
| 1975 | 20 | 2 126 ahj |
| 1976 | 22 | 1 804 dgh |
| 1977 | 37 | 1 092 c |
| 1978 | 23 | 1 743 dj |
| 1979 | 37 | 1 689 d |
| 1980 | 27 | 1 001 f |
| 1981 | 11 | 1 935 adh |
| **Season of calving** | | |
| January – June | 80 | 1 834 |
| July – December | 131 | 1 870 |

Within variable groups, row means followed by the same letter do not differ significantly (P < 0.05). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

The pattern of influence exerted by breed group, lactation number and year of calving on annual milk yield per cow was similar to that observed for total lactation yield and yield per lactation day. Productivity was again lowest in 1977 and 1980.

## Reproductive performance of cows at Bwemba

### Age at first calving

The mean age at first calving for 145 crossbred heifers born at Bwemba was 36.8 ± 6.6 months, with a CV of 18%. None of the factors studied (breed group, year and month of birth and breed group x month of birth interaction) had a significant effect on age at first calving. The estimated least squares means for age at first calving are laid out in Table 24.

### Calving interval and days open

The mean calving interval and days open for 338 calvings at Bwemba were 407 ± 90 days and 129 ± 93 days, respectively.

Breed group, month of previous calving and breed group by month interaction showed significant effects (P < 0.01) on calving interval (Table 25) and breed group (P < 0.01) and breed by month of calving had significant effects (P < 0.05) on days open. Lactation number or parity and year of calving did not show any significant effect on days open and calving interval. The estimated least squares means for calving interval and days open are laid out in Table 26.

There is an apparent pattern in the length of calving interval (Table 26), in which cows that calved previously in December through March had the longest calving intervals and those that calved previously in April through July had the shortest calving intervals: the calving intervals of cows that calved previously in September through November were of intermediate duration. This pattern appears to be contrary to that which would be expected from the rainfall pattern, and hence the availability of green feed, but follows the pattern of availability of supplementary feed.

Table 24. *Estimated least squares means for age at first calving at Bwemba, 1971–83.*

| Variable | Number | Age at first calving (months) |
|---|---|---|
| **Overall** | 145 | 37.7 |
| **Breed group** | | |
| 7/8 Friesian | 39 | 37.0 |
| 15/16 Friesian | 47 | 37.2 |
| 31/32 Friesian | 29 | 39.5 |
| Friesian | 30 | 36.9 |
| **Year of birth** | | |
| 1971 | 5 | 38.5 |
| 1972 | 6 | 40.1 |
| 1973 | 15 | 40.2 |
| 1974 | 13 | 36.6 |
| 1975 | 17 | 33.9 |
| 1976 | 15 | 37.6 |
| 1977 | 18 | 38.2 |
| 1978 | 30 | 32.7 |
| 1979 | 18 | 38.5 |
| 1980 | 8 | 40.3 |
| **Month of birth** | | |
| January | 7 | 39.3 |
| February | 14 | 41.4 |
| March | 21 | 41.5 |
| April | 16 | 38.5 |
| May | 9 | 38.5 |
| June | 7 | 40.1 |
| July | 7 | 35.8 |
| August | 13 | 35.5 |
| September | 15 | 36.5 |
| October | 19 | 35.9 |
| November | 5 | 37.2 |
| December | 12 | 32.0 |

# Productive performance of cows at Bwemba

## Total lactation yield, lactation length, milk yield per lactation day and dry period

The means for total lactation yield, lactation length, milk yield per lactation day and dry period were 2492 ± 772 kg, 294 ± 103 days, 8.8 ± 2.6 kg and 116 ± 136 days, respectively, with corresponding CVs of 31, 35, 30 and 118%.

Analyses of variance of the four traits are presented in Table 27.

Year of calving had significant effects ($P < 0.01$) on total lactation yield, lactation length and yield per lactation day, and lactation number had a significant effect ($P < 0.01$) on lactation yield (Table 27). None of the factors studied had a significant effect on dry period.

The estimated least squares means for the four traits are laid out in Table 28.

Total milk yield increased from lactation one through five after which it fell. Total lactation yield and yield per lactation day were highest in 1977 and 1979 and were lowest in 1981.

***Dairy productivity:*** The mean annual milk yield per cow was 2405 ± 802 kg, with a CV of 33%.

Analysis of variance of annual milk yield per cow is shown in Table 29.

Lactation number or parity and year of calving showed highly significant effects ($P < 0.01$) on annual milk yield per cow. Month of calving and breed group were not significant.

The estimated least squares means for annual milk yield are presented in Table 30.

Table 25. *Analyses of variance of calving interval and days open at Bwemba, 1974–83.*

| | Calving interval | | Days open | |
|---|---|---|---|---|
| Source | d.f. | MS x $10^{-1}$ | d.f. | MS x $10^{-1}$ |
| Breed group | 3 | 5 786** | 3 | 2 744** |
| Lactation number | 5 | 325 | 5 | 384 |
| Year of calving | 8 | 1 197 | 8 | 1 424 |
| Month of calving | 11 | 2 580** | 11 | 1 435 |
| Breed x month | 27 | 1 673** | 28 | 1 319* |
| Remainder | 283 | 826 | 283 | 860 |

* = $P < 0.05$

** = $P < 0.01$

Table 26. *Estimated least squares means for calving interval and days open at Bwemba, 1974–83.*

| Variable | No. | Calving interval (days) | No. | Days open |
|---|---|---|---|---|
| **Overall** | 338 | 431 | 339 | 146 |
| **Breed group** | | | | |
| 7/8 Friesian | 45 | 414 a | 45 | 124 a |
| 15/16 Friesian | 200 | 392 a | 200 | 116 a |
| 31/32 Friesian | 30 | 502 b | 30 | 203 b |
| Friesian | 63 | 419 a | 64 | 140 a |
| **Lactation number** | | | | |
| 1 | 109 | 438 | 109 | 155 |
| 2 | 81 | 436 | 79 | 151 |
| 3 | 54 | 443 | 57 | 152 |
| 4 | 40 | 429 | 39 | 153 |
| 5 | 25 | 412 | 26 | 124 |
| 6 + | 29 | 430 | 29 | 138 |
| **Year of calving** | | | | |
| 1974 | 11 | 456 | 11 | 168 |
| 1975 | 21 | 466 | 21 | 180 |
| 1976 | 29 | 419 | 29 | 132 |
| 1977 | 54 | 421 | 53 | 136 |
| 1978 | 49 | 398 | 49 | 110 |
| 1979 | 37 | 417 | 38 | 129 |
| 1980 | 48 | 446 | 47 | 155 |
| 1981 | 43 | 439 | 44 | 166 |
| 1982 | 46 | 423 | 46 | 135 |
| **Month of calving** | | | | |
| January | 26 | 488 acd | 26 | 174 |
| February | 44 | 454 ad | 44 | 175 |
| March | 39 | 519 a | 41 | 198 |
| April | 31 | 375 be | 32 | 98 |
| May | 25 | 393 bc | 25 | 117 |
| June | 20 | 434 abc | 20 | 150 |
| July | 12 | 386 ce | 12 | 102 |
| August | 35 | 434 cd | 35 | 154 |
| September | 36 | 407 ce | 36 | 126 |
| October | 32 | 445 cd | 31 | 168 |
| November | 19 | 395 cd | 18 | 116 |
| December | 19 | 447 ce | 19 | 167 |

Within variable groups, row means followed by the same letter do not differ significantly (P < 0.05). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

Table 27. *Analyses of variance of total lactation milk yield, lactation length, milk yield per day of lactation and dry period at Bwemba, 1977–83.*

| Source | d.f. | Lact. yield | Lact. length | Yield/day | d.f. | Dry period |
|---|---|---|---|---|---|---|
| | | MS x $10^{-3}$ | MS x $10^{-1}$ | MS x $10^{2}$ | | MS x $1^{-1}$ |
| Breed group | 3 | 1 006 | 839 | 152 | 3 | 1 638 |
| Lactation number | 5 | 3 651** | 1 240 | 5 625 | 5 | 1 983 |
| Year of calving | 5 | 6 502** | 3 105** | 5 068** | 5 | 4 041 |
| Month of calving | 11 | 588 | 1 659 | 754 | 11 | 1 247 |
| Breed x month | 31 | 625 | 1 305 | 485 | 29 | 2 027 |
| Remainder | 265 | 594 | 1 052 | 674 | 209 | 1 906 |

** = P < 0.01

Table 28. *Estimated least squares means for total lactation milk yield, lactation length, milk yield per day of lactation and dry period at Bwemba, 1977–83.*

| Variable | No. | Lact. yield (kg) | Lact. length (days) | Milk yield/day (kg) | No. | Dry period (days) |
|---|---|---|---|---|---|---|
| **Overall** | 321 | 2 659 | 293 | 9.3 | 263 | 112 |
| **Breed group** | | | | | | |
| 7/8 Friesian | 44 | 2 641 | 280 | 9.4 | 35 | 79 |
| 15/16 Friesian | 187 | 2 484 | 283 | 9.1 | 151 | 105 |
| 31/32 Friesian | 33 | 2 720 | 320 | 9.4 | 27 | 132 |
| Friesian | 62 | 2 790 | 290 | 9.5 | 50 | 133 |
| **Lactation number** | | | | | | |
| 1 | 95 | 2 174 a | 317 a | 7.4 a | 78 | 149 |
| 2 | 72 | 2 443 b | 276 b | 8.8 b | 59 | 113 |
| 3 | 49 | 2 838 cd | 282 ab | 10.2 cd | 45 | 108 |
| 4 | 39 | 2 833 df | 301 ab | 9.8 cd | 34 | 131 |
| 5 | 27 | 2 872 de | 291 ab | 10.3 ed | 20 | 78 |
| 6+ | 39 | 2 791 cfe | 294 ab | 9.5 ce | 27 | 95 |
| **Year of calving** | | | | | | |
| 1977 | 56 | 3 290 a | 331 a | 10.2 a | 48 | 66 |
| 1978 | 56 | 2 413 be | 283 bc | 8.6 bc | 47 | 75 |
| 1979 | 47 | 2 956 c | 288 abd | 10.7 a | 38 | 102 |
| 1980 | 80 | 2 617 bd | 255 cd | 10.1 a | 47 | 144 |
| 1981 | 46 | 2 202 e | 302 ab | 7.9 c | 39 | 152 |
| 1982 | 55 | 2 474 de | 302 ab | 8.4 cd | 44 | 134 |
| **Month of calving** | | | | | | |
| January | 30 | 2 755 | 271 | 10.1 | 19 | 96 |
| February | 38 | 2 908 | 298 | 9.8 | 36 | 121 |
| March | 36 | 2 671 | 355 | 8.4 | 32 | 61 |
| April | 30 | 2 689 | 280 | 9.6 | 27 | 91 |
| May | 16 | 2 758 | 285 | 9.8 | 15 | 121 |
| June | 19 | 2 300 | 254 | 9.4 | 13 | 144 |
| July | 11 | 2 741 | 291 | 9.3 | 9 | 83 |
| August | 30 | 2 609 | 313 | 8.4 | 28 | 105 |
| September | 34 | 2 394 | 349 | 8.2 | 26 | 179 |
| October | 31 | 2 972 | 307 | 9.7 | 25 | 123 |
| November | 22 | 2 630 | 266 | 9.4 | 16 | 101 |
| December | 24 | 2 478 | 253 | 9.5 | 17 | 122 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

Table 29. *Analysis of variance of annual milk yield per cow at Bwemba, 1974–83.*

| Source | d.f. | MS x $10^{-3}$ |
|---|---|---|
| Breed group | 3 | 1 304 |
| Lactation number | 5 | 3 634** |
| Year of calving | 8 | 3 906** |
| Month of calving | 11 | 698 |
| Breed x month | 28 | 737 |
| Remainder | 251 | 644 |

** = P < 0.01

Table 30. *Estimated least squares means for annual milk yield per cow at Bwemba, 1974–83.*

| Variable | No. | Annual milk yield (kg) |
|---|---|---|
| **Overall** | 307 | 2 580 |
| **Breed group** | | |
| 7/8 Friesian | 43 | 2 581 |
| 15/16 Friesian | 176 | 2 647 |
| 31/32 Friesian | 26 | 2 471 |
| Friesian | 62 | 2 620 |
| **Lactation number** | | |
| 1 | 94 | 2 142 a |
| 2 | 66 | 2 404 a |
| 3 | 51 | 2 742 be |
| 4 | 37 | 2 787 cde |
| 5 | 26 | 2 983 bd |
| 6+ | 33 | 2 419 ae |
| **Year of calving** | | |
| 1974 | 7 | 2 884 ace |
| 1975 | 9 | 2 905 ae |
| 1976 | 14 | 2 708 ace |
| 1977 | 51 | 2 950 ad |
| 1978 | 53 | 2 207 cf |
| 1979 | 38 | 2 930 a |
| 1980 | 49 | 2 410 def |
| 1981 | 41 | 1 945 bc |
| 1982 | 45 | 2 276 bef |
| **Month of calving** | | |
| January | 25 | 2 653 |
| February | 40 | 2 536 |
| March | 34 | 2 279 |
| April | 32 | 2 782 |
| May | 19 | 2 851 |
| June | 16 | 2 324 |
| July | 11 | 2 782 |
| August | 30 | 2 313 |
| September | 30 | 2 371 |
| October | 29 | 2 835 |
| November | 20 | 2 789 |
| December | 21 | 2 439 |

Within variable groups row means followed by the same letter do not differ significantly (P < 0.05). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

# 5. ANALYSES OF DAIRY PRODUCTION DATA FROM MIKOLONGWE LIVESTOCK UNIT

## Introduction

The Mikolongwe livestock unit supplies Friesian bulls for the production of $F_1$ crossbred cows at Chizombezi (see Figure 2). Analysis of production records from Mikolongwe livestock unit provides useful information about the expected performance of crossbred cows produced from Friesian bulls and 'off-type' females.

## Mikolongwe livestock unit

The Mikolongwe livestock station was founded in the early 1930s as a private estate. The government took over the estate in the early 1950s to serve as a centre for livestock and poultry improvement. The station was essentially a multiplication centre, while the Chizombezi, Chikowa and Tuchila substations, which are part of Mikolongwe, either bred or reared animals.

Dairying activities started in Mikolongwe and the substations in 1973. The Mikolongwe livestock station maintains a milking herd of pure-Friesian cattle and supplies Friesian bulls to Chizombezi station, which produces crossbred heifers for smallholder dairy farms.

### Management practices

Pure-Friesian heifers were inseminated for the first time when they attained a minimum weight of 320 kg at about 18 months of age. Heifers and cows in their seventh month of pregnancy were 'steamed up' until calving. Pregnant heifers also received training in milking-shed practices. Cows and heifers in the last two weeks of pregnancy were separated from the herd and went into calving boxes. The calf stayed with the dam for 48 hours. The dam was not milked on the first day, but on the second day the dam was milked after the calf had been suckled. From the third day calves were separated from the dams and artificially reared, receiving 4 kg of milk/day. Calves were fed with either milk diluted with water or skim milk in addition to calf ration from the second week until weaning at 16 weeks of age. The calves received calf-ration supplements until 20 weeks of age, after which they grazed and received silage and hay supplements during the dry season. Bull calves were not castrated unless they showed signs of abnormalities. All heifers joined the breeding herd except those that showed abnormalities such as blindness or loss of teat. Culling took place after the first calving.

The cows were milked twice daily. Milk was weighed for each cow at each milking. Calves were weighed both at birth and at weaning. All animals were dewormed at 3 month intervals. Cattle were dipped against ticks once every week in a solution of Supona. The major health problem was eye infection. Post-weaning mortality among calves was about 10%.

The dairy cattle herd at Mikolongwe as of May 1984 comprised 60 milking cows, 15 heifers of breeding age, 39 young heifers and 50 calves.

## Reproductive performance

### Calving interval and days open

The means for calving interval and days open for 213 calvings at Mikolongwe were 470 ± 145 days and 192 ± 148 days, respectively, with corresponding CVs of 32 and 77%.

Analyses of variance of calving interval and days open are presented in Table 31.

Only lactation number or parity had a significant effect ($P < 0.05$) on calving interval and days open (Table 31).

The estimated least squares means for calving interval and days open are laid out in Table 32.

Calving intervals were longer after the fourth parity.

Table 31. *Analyses of variance of calving interval and days open at Mikolongwe, 1974–83.*

| Source | Calving interval | | Days open | |
|---|---|---|---|---|
| | d.f. | MS x $10^{-1}$ | d.f. | MS x $10^{-1}$ |
| Lactation number | 5 | 5 447* | 4 | 6 168* |
| Year of calving | 8 | 3 596 | 8 | 3 754 |
| Month of calving | 11 | 3 419 | 11 | 3 184 |
| Remainder | 188 | 2 200 | 189 | 2 201 |

* = $P < 0.05$

Table 32. *Estimated least squares means for calving interval and days open at Mikolongwe, 1974–83.*

| Variable | No. | Calving interval (days) | No. | Days open |
|---|---|---|---|---|
| **Overall** | 213 | 481 | 213 | 192 |
| **Lactation number** | | | | |
| 1 | 42 | 438 a | 41 | 159 a |
| 2 | 47 | 469 ab | 47 | 193 a |
| 3 | 37 | 495 ac | 36 | 215 a |
| 4 | 29 | 424 a | 30 | 148 a |
| 5 | 22 | 538 bc | 59 | 246 b |
| 6+ | 36 | 521 bc | | |
| **Year of calving** | | | | |
| 1974 | 31 | 545 | 31 | 258 |
| 1975 | 32 | 513 | 32 | 226 |
| 1976 | 22 | 499 | 22 | 213 |
| 1977 | 19 | 495 | 19 | 200 |
| 1978 | 27 | 473 | 27 | 188 |
| 1979 | 26 | 496 | 26 | 208 |
| 1980 | 18 | 420 | 18 | 131 |
| 1981 | 27 | 427 | 27 | 136 |
| 1982 | 11 | 460 | 11 | 169 |
| **Month of calving** | | | | |
| January | 17 | 484 | 17 | 195 |
| February | 26 | 439 | 26 | 154 |
| March | 27 | 475 | 27 | 187 |
| April | 23 | 388 | 23 | 102 |
| May | 28 | 427 | 28 | 141 |
| June | 19 | 496 | 19 | 208 |
| July | 12 | 454 | 12 | 165 |
| August | 5 | 580 | 5 | 292 |
| September | 10 | 514 | 10 | 224 |
| October | 11 | 502 | 11 | 212 |
| November | 19 | 539 | 19 | 248 |
| December | 16 | 473 | 16 | 178 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

# Productive performance

## Total lactation yield, lactation length, milk yield per day of lactation and dry period

The means for total lactation yield, lactation length, yield per lactation day and dry period for the Friesian herd at Mikolongwe were 3407 ± 1241 kg, 354 ± 110 days, 9.3 ± 2.4 kg and 101 ± 103 days, respectively, with corresponding CVs of 36, 31, 26 and 102%. Analyses of variance for the four traits are presented in Table 33.

Lactation number or parity had significant effects on total lactation yield ($P < 0.05$), yield per lactation day ($P < 0.01$) and dry period ($P < 0.05$) but not on lactation length. Year of calving significantly influenced lactation yield, yield per lactation day and lactation length ($P < 0.01$) but not dry period. Month of calving had a significant effect only on yield per lactation day ($P < 0.05$) (Table 33).

The estimated least squares means for the four characters are displayed in Table 34.

The fifth lactation gave the highest total yield, but yield per lactation day was highest during the fourth lactation (Table 34).

Total lactation yield and yield per lactation day have been declining since 1979. Total milk yields in 1980, 1981, 1982 and 1983 were 17, 56, 59 and 69% lower than the mean, respectively. The same trend was found in yield per lactation day.

# Dairy productivity

## Annual milk yield per cow

The mean annual milk yield per cow was 3077 ± 960 kg, with a CV of 31%.

Analysis of variance for annual milk yield is shown in Table 35.

Lactation number and year of calving had significant effects ($P < 0.01$) on annual milk yield per cow.

The estimated least squares means for annual milk yield per cow are presented in Table 36.

Annual milk yield per cow generally increased with increasing parity number and peaked during the fourth lactation as a result of the shorter calving interval associated with the fourth lactation. The pattern of influence of year of calving on annual milk yield was the same as on the total lactation yield and yield per lactation day, i.e. a drastic drop in milk yields from 1980 onwards. The decline in production coincided with deficiencies in feed supply as a result of poor weather during this period.

Table 33. *Analyses of variance of total lactation milk yield, lactation length, milk yield per day of lactation and dry period for pure-Friesian cows at Mikolongwe, 1974–83.*

| Source | d.f. | Lact. yield MS x $10^{-4}$ | Lact. length MS x $10^{-2}$ | Yield/day MS x 10 | d.f. | Dry period MS x $10^{-1}$ |
|---|---|---|---|---|---|---|
| Lactation number | 5 | 387* | 107 | 448** | 4 | 2 688* |
| Year of calving | 9 | 8 155** | 1 033** | 4 024** | 8 | 1 498 |
| Month of calving | 11 | 177 | 112 | 130* | 11 | 1 411 |
| Remainder | 322 | 154 | 119 | 57 | 189 | 1 079 |

* = $P < 0.05$

** = $P < 0.01$

Table 34. *Estimated least squares means for total lactation milk yield, lactation length, milk yield per day of lactation and dry period of pure-Friesian cows at Mikolongwe, 1974–83.*

| Variable | No. | Lact. yield (kg) | Lact. length (days) | Milk yield/ day (kg) | No. | Dry period (days) |
|---|---|---|---|---|---|---|
| **Overall** | 348 | 3 515 | 354 | 9.7 | 213 | 99 |
| **Lactation number** | | | | | | |
| 1 | 75 | 3 001 a | 367 | 8.0 a | 41 | 70 a |
| 2 | 72 | 3 555 bc | 355 | 9.7 bc | 47 | 93 ab |
| 3 | 59 | 3 620 c | 348 | 9.9 c | 37 | 113 ab |
| 4 | 43 | 3 593 bd | 337 | 10.8 de | 30 | 83 a |
| 5 | 32 | 3 772 be | 379 | 9.7 be | 50 | 134 b |
| 6+ | 67 | 3 547 bc | 339 | 10.0 bc | | |
| **Year of calving** | | | | | | |
| 1974 | 38 | 4 864 ag | 401 ag | 12.7 ac | 32 | 146 |
| 1975 | 35 | 4 559 ab | 391 ac | 11.8 ab | 31 | 117 |
| 1976 | 29 | 5 235 g | 448 g | 11.9 ab | 22 | 87 |
| 1977 | 25 | 4 958 ag | 365 ab | 13.7 c | 19 | 108 |
| 1978 | 32 | 4 000 b | 375 ac | 10.8 b | 27 | 77 |
| 1979 | 35 | 4 525 a | 384 ac | 11.8 a | 25 | 77 |
| 1980 | 43 | 2 931 c | 319 bd | 9.3 c | 19 | 70 |
| 1981 | 47 | 1 551 de | 344 cb | 4.5 de | 27 | 89 |
| 1982 | 43 | 1 442 ef | 285 de | 4.9 ef | 11 | 117 |
| 1983 | 21 | 1 083 f | 231 e | 5.4 f | – | – |
| **Month of calving** | | | | | | |
| January | 29 | 3 714 | 370 | 9.4 ace | 17 | 89 |
| February | 27 | 3 412 | 318 | 10.1 abe | 25 | 117 |
| March | 38 | 3 657 | 344 | 10.7 bde | 27 | 115 |
| April | 40 | 3 732 | 364 | 10.1 abe | 21 | 49 |
| May | 50 | 3 731 | 365 | 9.9 abe | 29 | 60 |
| June | 25 | 3 675 | 359 | 10.2 ade | 19 | 98 |
| July | 20 | 3 655 | 344 | 10.3 ad | 12 | 89 |
| August | 19 | 3 699 | 383 | 9.4 af | 5 | 98 |
| September | 18 | 3 376 | 327 | 10.0 af | 11 | 140 |
| October | 25 | 2 902 | 347 | 8.3 c | 11 | 104 |
| November | 26 | 3 511 | 386 | 8.8 cef | 20 | 142 |
| December | 21 | 3 112 | 349 | 8.9 ac | 16 | 83 |

Within variable groups, row means followed by the same letter do not differ significantly ($P < 0.05$). No letter following indicates that the variable group did not show a significant difference in the analysis of variance.

Table 35. *Analysis of variance of annual milk yield per cow for pure-Friesian cows at Mikolongwe, 1974–83.*

| Source | d.f. | MS x $10^{-4}$ |
|---|---|---|
| Lactation number | 5 | 292** |
| Year of calving | 8 | 2 256** |
| Month of calving | 11 | 162 |
| Remainder | 205 | 92 |

** = $P < 0.01$

Table 36. *Estimated least squares means for annual milk yield per cow for pure-Friesian cows at Mikolongwe, 1974–83.*

| Variable | No. | Annual milk yield (kg) |
|---|---|---|
| **Overall** | 230 | 3 002 |
| **Lactation number** | | |
| 1 | 52 | 2 540 a |
| 2 | 51 | 3 045 bf |
| 3 | 40 | 2 897 ab |
| 4 | 29 | 3 432 cf |
| 5 | 22 | 3 100 cbd |
| 6+ | 36 | 2 998 cbe |
| **Year of calving** | | |
| 1974 | 32 | 3 802 ag |
| 1975 | 32 | 3 431 ab |
| 1976 | 22 | 3 697 afg |
| 1977 | 19 | 4 027 g |
| 1978 | 27 | 3 240 bf |
| 1979 | 26 | 3 670 afg |
| 1980 | 30 | 2 598 c |
| 1981 | 31 | 1 360 d |
| 1982 | 11 | 1 194 de |
| **Month of calving** | | |
| January | 18 | 3 127 |
| February | 28 | 3 067 |
| March | 29 | 3 208 |
| April | 24 | 3 578 |
| May | 30 | 3 293 |
| June | 19 | 3 099 |
| July | 15 | 2 957 |
| August | 6 | 2 882 |
| September | 11 | 3 037 |
| October | 12 | 2 517 |
| November | 22 | 2 676 |
| December | 16 | 2 584 |

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

# 6. A UNIFIED ANALYSIS OF DAIRY PRODUCTION CHARACTERS ON SMALLHOLDER FARMS AND GOVERNMENT UNITS

## Introduction

In this section dairy production characters as reported for the smallholder herds and various government dairy units are compared, bearing in mind the differences in management regimes at the various units. The comparisons are across different breed compositions and across different geographical areas, and hence across different rainfall and feed-availability zones. The expected performance of $F_1$ crossbred cows is considered first, using estimated figures reported elsewhere in this report and some assumptions.

## Predicted performance of $F_1$ crosses between Friesian and local cattle

The average performance of $F_1$ crossbred cows for a given character can be predicted if the mid-parental mean for that character and the average percent heterosis are known. The predicted performance is calculated as $0.5 (P_1 + P_2) + (\% \text{ heterosis} \times 0.5(P_1 + P_2))$, where $P_1$ and $P_2$ are the average performances of the parents.

The estimated average performance of purebred Friesians at Mikolongwe, and rough estimates for the 'off-type' cows at Chizombezi and for Malawi Zebu cows in terms of lactation milk yield, lactation length, yield per lactation day and calving interval are shown in Table 37.

The approximate percentages of heterosis for lactation milk yield, lactation length, yield per lactation day and calving interval, derived from figures reported by McDowell (1983), are shown in Table 38, with the predicted and actual performance for $F_1$ cows, and the differences between predicted and actual values.

Table 37. *Average performance of Friesian and local cattle for four milk production parameters.*

| Trait | Type of cattle | | |
|---|---|---|---|
| | Pure Friesian | Off-type[1] | Malawi Zebu[2] |
| Lactation milk yield (kg) | 3 500 | 1 000 | 450 |
| Lactation length (days) | 350 | 250 | 180 |
| Yield/day (kg) | 10.0 | 4.0 | 2.5 |
| Calving interval (days) | 480 | 530 | 600 |

[1] 'Off-type' cattle formed from Sussex, Brahman-type and Africander-cross cattle.

[2] Figures on Malawi Zebu based on observations by extension staff.

Table 38. *Predicted and actual production of Friesians and local $F_1$ crosses in Malawi.*

| Trait | Approximate % heterosis | $F_1$ performance | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1/2 Friesian – 1/2 off-type | | | 1/2 Friesian – 1/2 Malawi Zebu | | |
| | | Predicted | Actual | Difference | Predicted | Actual | Difference |
| Total milk yield (kg/cow) | 6.0 | 2 380 | 1 950 | 430 | 2 090 | 1 680 | 410 |
| Lactation length (days) | 6.0 | 320 | 379 | −59 | 283 | 307 | −24 |
| Yield/day (kg) | 7.0 | 7.5 | 5.4 | 2.1 | 6.7 | 5.6 | 1.1 |
| Calving interval (days) | 9.0 | 460 | 488 | −28 | 490 | 407 | 83 |

The actual production of $F_1$ crosses (1/2 Friesian–1/2 'off-type') on smallholder farms was about 20% less than the predicted performance, and lactation length was longer than expected, mainly because some of the cows had difficulty conceiving (Table 38). Calving interval was only about 6% longer than the predicted value. Figures for the 1/2 Friesian–1/2 Malawi Zebu at Chitedze Research Station followed the same trends. These observations are, however, subject to the appropriateness of the heterosis percentages used for the various traits. If lower values for heterosis were used, the differences between the predicted and actual values would be smaller. The figures presented in Table 37 and 38 suggest that, theoretically, the $F_1$ crossbred cows both on the smallholder farms and at the stations are performing at close to the level that could be expected from their genetic make-up. However, as shown earlier, the productivity of the animals has been declining, and year-to-year analysis would reveal a wider gap between predicted and actual performances.

## Cow body size

No accurate data on mature cow body weight are available from any of the livestock centres in Malawi because none of the stations have weighbridges. Mature body weights were taken using a weigh-band, which is adequate for the purpose of administering drugs, such as during drenching, but is of no use in evaluating breed productivity.

Mature body weights, obtained using a weigh-band, of a sample of 1/2-, 3/4- and 7/8-Friesian cows on smallholder farms were 400, 410 and 500 kg, respectively. The corresponding figures at Tuchila rearing centre were 432, 400 and 490 kg. No figures were available for Friesian–Malawi Zebu crossbred cows, but visual observations indicate that they are smaller and lighter than Friesian–'off-type' crosses.

## Comparisons among breeds at government units and on smallholder farms

Milk yield per lactation day and annual yield per cow were used in comparisons among breeds at government stations and on smallholder farms. The two traits were chosen because milk yield per lactation day overcomes the problem of differences in milk yield over various lactation lengths, while annual yield per cow takes into account different calving intervals.

### Performance of 7/8 Friesian – 1/8 Malawi Zebu and Friesian cows at Chitedze and Bwemba

Chitedze and Bwemba are about 10 km apart, and are both government units. Both have 7/8 Friesian–1/8 Malawi Zebu and pure-Friesian cows. The aim of the comparison was to determine how the different objectives of the two units–Chitedze is a research station and Bwemba is a multiplication centre – and hence possible differences in their management practices, might have influenced the performance of the two breeds of cattle.

Age at first calving for the 7/8 Friesian–1/8 Malawi Zebus was 37 months and that of pure Friesians was 36.9 months at Bwemba. The corresponding figures at Chitedze were 45.8 and 45.4 months. Thus there was no difference between the two breeds for age at first calving, but heifers at Bwemba calved at 8 months younger than the heifers at Chitedze. Yields per lactation day for the 7/8 Friesians and the pure Friesians were 9.4 and 9.5 kg, respectively, at Bwemba, and 7.3 and 7.4 kg, respectively, at Chitedze. Annual milk yield per cow at Bwemba was 2580 kg for the 7/8 Friesians and 2620 kg for the Friesians and 1960 and 2070 kg, respectively, at Chitedze. Thus, the performances of the 7/8 Friesians and the pure Friesians were similar at the two units, while age at first calving was 20% lower and milk yield 30% higher at Bwemba than at Chitedze.

The most readily identifiable differences in management between the two centres which might account for the observed differences in performance are the seasonal breeding practices and the constant level of concentrate feeding at a rate of 4 kg per cow per day at Chitedze, as opposed to continuous breeding and differential concentrate feeding according to production as practised in Bwemba.

### Performance of Friesian – Malawi Zebu crosses and Friesian – 'off-type' crosses

The crossbred cattle on smallholder farms in the Southern Region of Malawi were developed from Friesian bulls and 'off-type' cows (a mixture of Sussex, Brahman-type and Africander-cross cattle), while the crossbred cattle at Bwemba, Chitedze and on smallholder farms in the Central Region were based on the Friesian and the Malawi Zebu. A comparison was made between the performance of the larger, Friesian–'off-type' crosses in the relatively feed-deficient Southern Region and the smaller Friesian–Malawi Zebu crosses in the Central Region. Because there were no data on crossbred cattle on smallholder farms in the Central Region the mean performance of Friesian–'off-type' cattle on smallholder farms and at Tuchila was compared with the performance of the Friesian–Malawi Zebu at either Chitedze or Bwemba or their mean performance at the two stations.

Ages at first calving for 3/4 and 7/8 Friesians were 35 and 36 months, respectively, in the Southern Region, and 43 and 46 months in the Central Region. The mean yields per lactation day for the 1/2, 3/4 and 7/8 Friesians in the Southern Region were 5.2, 8.2 and 8.3 kg, respectively, compared with 5.6, 7.1 and 8.1 kg in the Central Region. The mean annual milk yield per cow of the 7/8 Friesians at Tuchila in the Southern Region was 2600 kg, compared with 2580 kg at Bwemba in the Central Region. The mean annual milk yield per cow of the 15/16-Friesians was 3000 and 2650 kg at Tuchila and Bwemba, respectively.

Thus, apart from the lower age at first calving of the crosses in the Southern Region, the Friesian–Malawi Zebu crossbred cattle in the Central Region performed at the same level as the Friesian–off-type' crossbred cattle in the south, in spite of the larger body size of the Friesian–'off-type' crosses. These data suggest that there is little reason why the Malawi Zebu should not be used to produce crossbred cows for smallholders in the Southern Region. The smaller body size of the Friesian–Malawi Zebu crosses is an advantage in the Southern Region where feed resources are less than in the Central Region.

## Performance of Friesian cattle at Mikolongwe, Bwemba and Chitedze

Information on age at first calving was not available for Mikolongwe because birth dates of cows were not known. Pure Friesians at nearby Tuchila, under similar management, calved first at 37 months of age, which was the same as observed at Bwemba, but 8 months younger than the estimated figure for Chitedze.

Mean yields per lactation day for Friesians were 9.7, 9.5 and 7.4 kg at Mikolongwe, Bwemba and Chitedze, respectively.

Thus, the performances of Friesian cattle at Mikolongwe and Bwemba were very similar in spite of the differences between the environments. This suggests that herd management can minimise the effects of environmental factors that have short-term influences on dairy production. The difference between the figures from the research station at Chitedze and the multiplication units suggests that there is a lack of consultation between research and field activities relative to the development of a common direction in national livestock policies and goals.

# CONCLUSIONS AND RECOMMENDATIONS

The data used in the analyses of dairy productivity on smallholder farms were only a sample of all possible data. The sample data were obtained after much effort in retrieval and editing. This points to rather inadequate systems of data recording on the smallholder farms and of data storage at various govenment offices. If data recorded on the smallholder farms are to be used to monitor the progress of the dairy industry and as a source of information for implementing breeding programmes, a better system of cow and sire identification should be introduced at the centres where crossbred cows are produced, at rearing and steaming-up centres and on smallholder farms. A recording system that will reduce the amount of paper work involved should replace the present system. To minimise the effort involved in recording the data, smallholders should be provided with small weighing scales or measuring cylinders, and the extension officers who visit farmers each month should be provided with pocket calculators.

The information obtained from smallholder farms and government units revealed problems in reproductive performance among dairy cattle. Advanced age at first calving followed by long calving intervals were very common. Long days-open periods were identified as a major cause of the long calving intervals. Feed deficiency appears to be a main causal factor in lengthening the reproductive cycle. The upgrading of the cattle on smallholder farms and increases in herd size have not been accompanied by increases in feed resources. Crossbred cows with more Friesian blood and larger feed requirements are managed in the same way as lower grade cattle in the herd. Herds have expanded beyond the recommended size as there is no market for the surplus calves. The decline in dairy productivity on both smallholder and government farms since 1979 may be due in part to the effects of changes in the climate but a possible decline in the quality of management cannot be ruled out.

Any management strategy that will reduce feed requirements, especially on smallholder farms, could improve the situation and probably reverse the fall in dairy productivity. In this connection, an attractive option is to introduce smaller crossbred cows and to develop a system to absorb surplus calves from the smallholder farms. A crossbreeding programme based on the Friesian and the Malawi Zebu could replace the larger Friesian–'off-type' crossbred cows on the smallholder farms in the Southern Region.

# REFERENCES


Harvey W R. 1977. *Users' guide for least-squares and maximum likelihood computer program.* Ohio State University, Columbus.

Kiwuwa G H, Trail J C M, Kurtu M Y, Getachew Worku, Anderson F M and Durkin J. 1983. Crossbred dairy productivity in Arsi Region, Ethiopia. *ILCA Research Report* 11. Addis Ababa.

McDowell R E and Schermerhorn E C. 1978. Planning breed improvement programs for dairying in tropical areas. In: *Proceedings of the Third Regional Livestock Meeting, Dairy Cattle Production.* Kingston, Jamaica. (Cited in McDowell, 1983).

McDowell R E. 1983. Strategy for improving beef and dairy cattle in the tropics. *Cornell International Agriculture Mimeo* 100.

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**International Livestock Centre for Africa**

**P.O. Box 5689**

**Addis Ababa, Ethiopia**

Printed by ILCA, Addis Ababa, Ethiopia