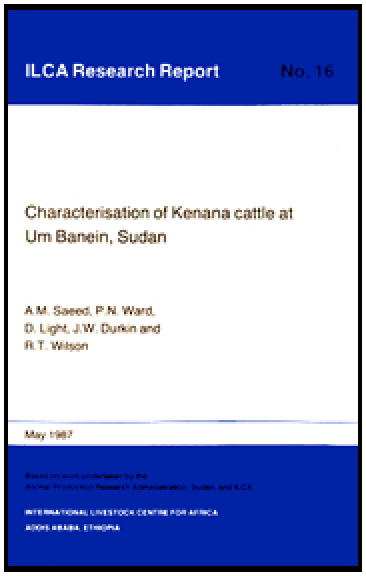
Characterization of Kenana cattle at Um Banein, Sudan



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Abstract

The Kenana is an important cattle breed indigenous to northern Sudan with potential as a producer of both milk and beef. This document reports results of analyses of data collected on Kenana cattle at Um Banein Livestock Research Station from 1957 to 1984. Reproductive performance, reflected by both age at first calving and calving interval, improved throughout the 1960s but deteriorated during the 1970s and 1980s. Calf birth weights also reached a peak in the late 1960s and have declined since. Milk production parameters showed a pattern similar to that exhibited by weight and reproduction. About 40% of all deaths on the station occurred in the period 1970-75. These trends are believed to be related to high stocking rates from the late 1960s onwards, coupled with declining rainfall and the inability of the station management to assure adequate basic and supplementary feed supplies on a long-term, year-round basis.

A destocking policy carried out in recent years appears to have reversed the declining trends revealed by the analyses. Suggestions for future management and research are made.

KEY WORDS

Sudan//Kenana cattle//reproduction//growth//lactation//milk//mortality//management/

Résumé

Originaires du nord du Soudan, les bovins Kenana constituent une importante race au bon potentiel de production mixte (viande et lait). Le présent rapport est consacré aux résultats d'analyses de données sur des bovins Kenana collectées entre 1957 et 1984 a la station de Um Banein. Les performances de reproduction, appréciées en fonction de l'âge au premier vêlage et de l'intervalle entre mises bas, ont progressé pendant les années 60 mais régressé au cours des deux décennies suivantes. Le poids des veaux à la naissance a également atteint un maximum à la fin des années 60 pour décroître par la suite. Les mêmes tendances appliquent à l'évolution de la production laitière. Environ 40% de la mortalité globale des effectifs de la station correspond à la période 1970-75. Ces pertes de productivité sont attribuées à une charge excessive à partir de la fin des années 60, associée à une pluviosité insuffisante et à des difficultés d'approvisionnement en fourrages et en aliments de supplémentation.

La politique de réduction des effectifs mise en oeuvre ces derrières années semble avoir renversé les tendances négatives révélées par les analyses. Le rapport se termine par des suggestions sur la gestion des effectifs et les recherches à mener.

MOTS CLES

Soudan//bovin Kenana//reprodroduction//croissance//lactation//lait//mortalité/gestion/

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1. Introduction

Latest estimates (FAO, 1985) of the livestock population of Sudan indicate that there are 19.6 million cattle, 20.0 million sheep, 13.0 million goats and 2.5 million camels in the country.

An estimated 1.47 million cattle are slaughtered annually with an average dressed carcass weight of 165 kg, yielding 243 000 tones of meat. The number of dairy cows in the national herd is estimated at 2.02 million, each with a lactation yield of 500 kg, providing 1.01 million tones of milk. The average total energy intake of the human population is 2332 Kcal/person per day, of which only about 12% (300 Kcal) comes from livestock products. Protein availability is estimated at 65.6 g/person per day, of which about 28.5% (18.8 g) is provided by livestock products.

Livestock are thus a more important source of protein in Sudan than in most Third World countries. Increased animal production would, however, not only improve the diet of the Sudanese people but also could create a surplus for export. Conscious of these facts, the Government of Sudan, soon after independence, created a number of livestock research stations in various parts of the country to study and improve the productivity of native breeds.

Livestock stations related to the principal breeds of cattle in northern Sudan were set up at Um Banein in Blue Nile Province (Kenana), at Atbara in Northern Province (Butana) and at Ghazala Gawazat in South Darfur (Western Baqqara). Stations to study the productivity of the Sudan Desert sheep and its sub-breeds have also been set up, notably at El Huda in the Gezira.

Former attitudes towards the supposedly low inherent productivity of indigenous breeds of African livestock have given-way to a realization that, in most cases, such breeds have been selected for extremely adverse environments in which survival was the main adaptive trait. They are thus well adapted to the conditions in which they are raised and under improved management, nutritional and health regimes should be able better to realize their true productive potential.

Attempts to introduce exotic "improver" and/or "improved" blood have led in some cases to the extinction or near-extinction of many local types of domestic livestock. This has led to widespread concern for the conservation of such strains, a concern that is motivated by the fear that the genetic resources of indigenous breeds, and particularly the complex of traits adapted to climatic and environmental stress, may be lost. Recently, FAO has attempted to establish a catalogue of indigenous breeds of intrinsic value, the improvement and conservation of which could lead to increased livestock output in specific situations. The Kenana and Butana breeds of Sudan are considered to possess such attributes.

None of the major breeds of Sudanese cattle appears in imminent danger of disappearance and there has, so far, been little dilution of the main gene pool through out-crossing to exotic (i.e. in this case non indigenous) breeds. However, the pace of development at present is such that in the medium term there is considerable risk that Sudanese native breeds will be subject to dilution. Before this happens, their major productive traits should be characterized.

Since the establishment of the livestock research stations in the late 1950s, considerable amounts of valuable data have been collected on Sudanese native breeds. These data have been subject to varying levels of analysis, usually piecemeal and often related to the particular interests of individual research workers. The analyses reported here appear to be the first attempt to characterize the Kenana breed based on all the data collected between 1957 and 1984. We have not attempted to re-analyze data for which analyses have been carried out previously on particular aspects of productivity, but in the interests of providing as full a characterization of the Kenana breed as possible we have drawn freely on these and incorporated them in this report. We have as far as possible acknowledged these sources in the text. It has not always been possible, however, to establish particular responsibility for particular pieces of work and we have, therefore, included a bibliography on the Kenana breed, incorporating all internal documents of Um Banein station as well as all published work. We hope that our predecessors will consider this an appropriate form of acknowledgment and of recognition of the value of their work.

2. Materials and methods

Um Banein livestock research station

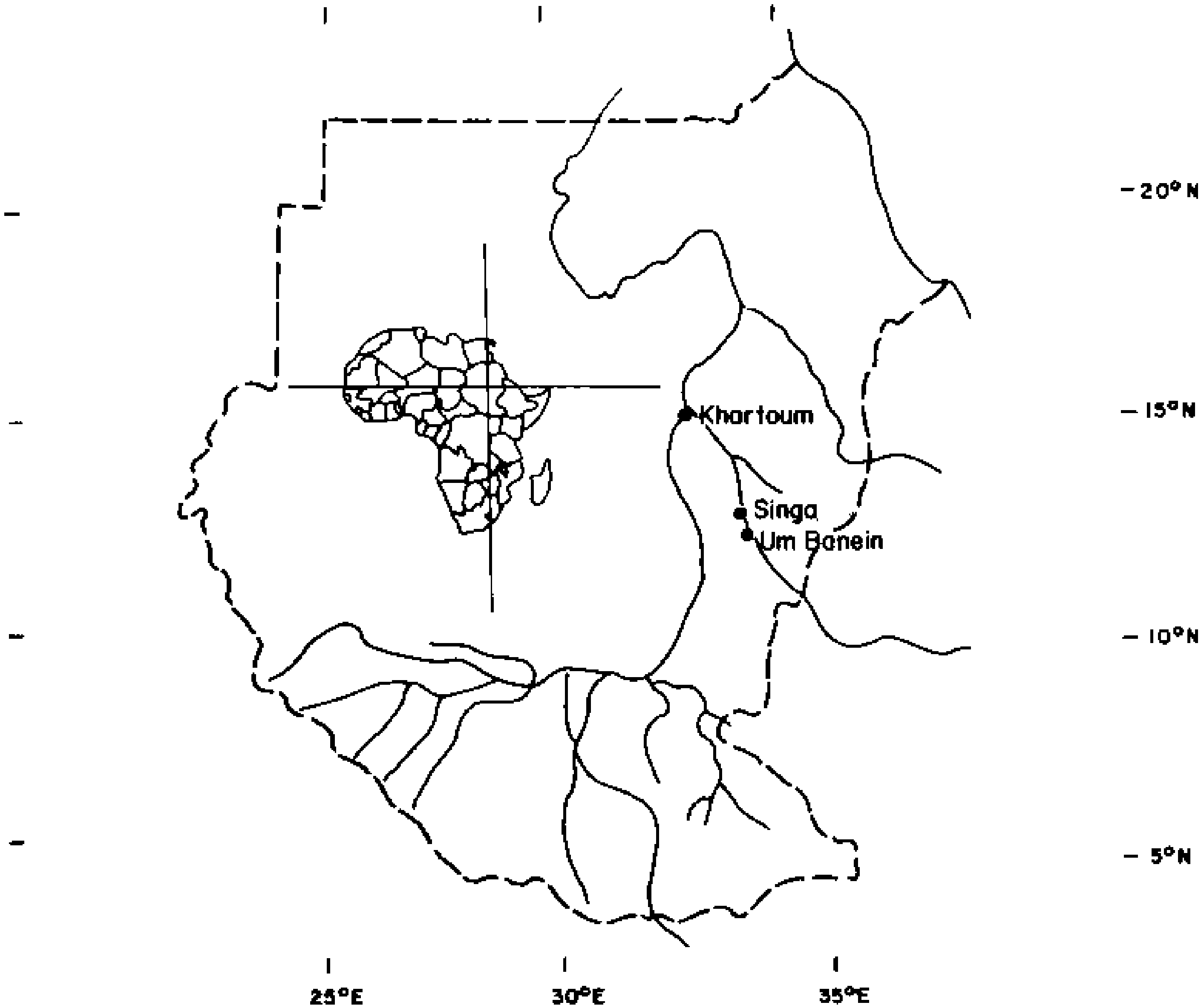
Um Banein Livestock Research Station was established in 1957 in Blue Nile Province (Figure 1). It is situated on the western bank of the Blue Nile river, about 360 km south of Khartoum and 9 km south of Singa, approximately latitude 13°04' N and longitude 33°57' E and at 435 meters above sea level.

The station has a total area of 945 ha, of which 190 ha are potentially irrigable, although only about half of this is currently being irrigated. The non-irrigable area provides natural grazing.

The station was established in order to:

- improve the Kenana breed of cattle for milk and beef production by continuous selective breeding so as to evolve a Sudanese dairy cow;
- produce elite Kenana bulls and to distribute them to farmers near the station and in other districts; and
- carry out research on forage production and animal nutrition.

Figure 1. Location of Um Banein in Sudan and Africa.



Climate

- Rainfall
- Temperature
- Humidity

Climate has an important influence on the nature of the natural vegetation, the characteristics of the soils, the crops that can be grown and hence the type of farming that can be practiced. At Um Banein there are three marked seasons: winter (November - February); hot summer (March - June); and wet summer (July - October).

Rainfall

In tropical areas the rainfall regime is the most important climatic factor influencing agriculture and vegetation. In the Um Banein area there is a clearly defined rainy season from July to October, with some showers in May and June. The annual rainfall at the station in the period 1963-84 ranged from 323 to 649 mm, with an overall mean of 521.5 mm (Figure 2).

Temperature

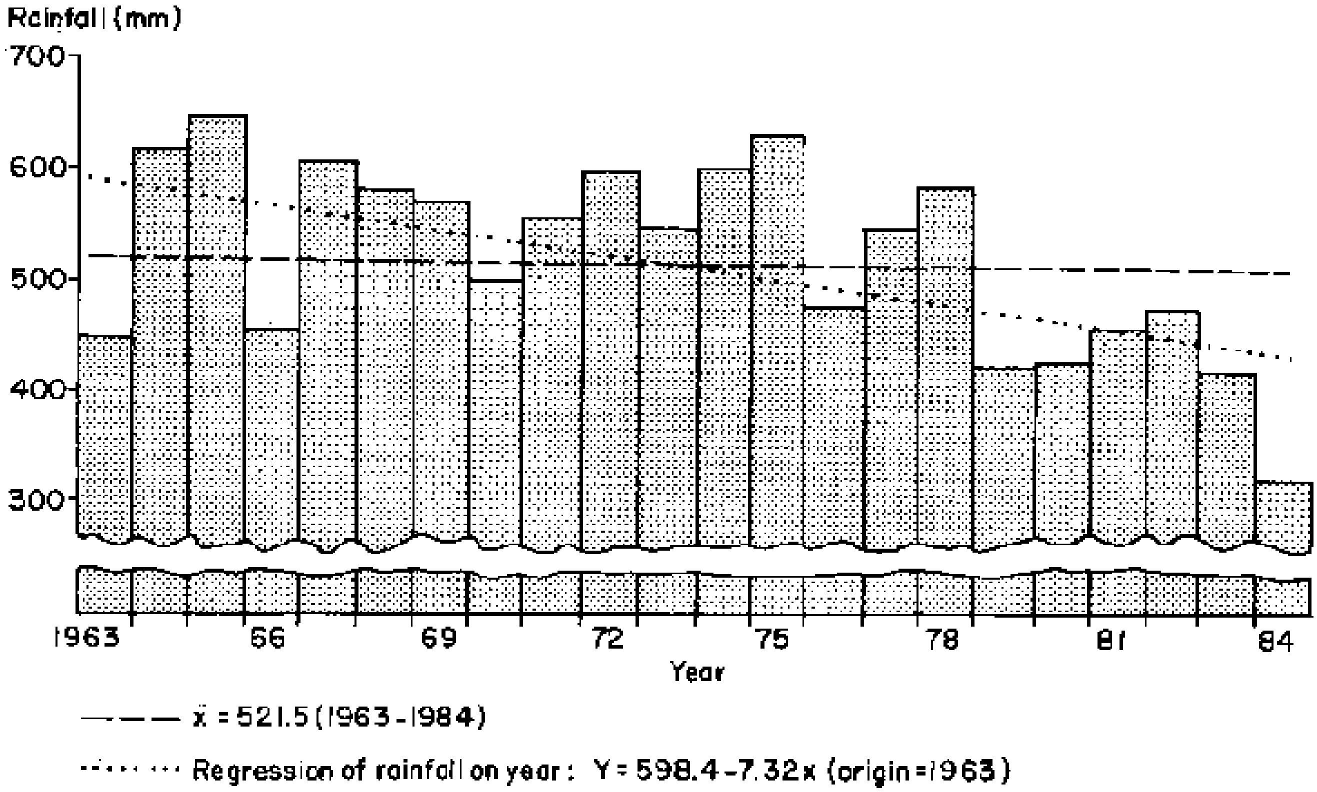
The highest daily maximum temperature of 45.5°C occurred in April, while the lowest minimum of 6.0°C was registered in January. Mean maxima and mean minima were also recorded in these months.

Humidity

Humidity is uniformly high in the wet season (July - October) and relatively low in the dry season (November-June).

The annual cycle of these climatic parameters is shown in Figure 3.

Figure 2. Annual rainfall at Um Banein, 1963-1984.



Soils and vegetation

The soil of Blue Nile Province results from the alluvial action of the Nile, and is a heavy cracking clay of the Vertisol type.

The irrigable area of the station is fed by a main canal from the Blue Nile using two 12" Ruston Diesel pumps. Fodder grown on this area includes varieties of *Sorghum bicolor* (Abu Sabain, Feterita, Um Banein and Tozi), *Sorghum sudanense*, an *S. bicolor x S. sudanense* hybrid (Pioneer 988), *Dicanthium annulatum, Brachiaria mutica* (Pare grass) and *Chloris gayana* (Rhodes grass). Legume fodders include *Clitoria ternata*, *Lablab purpurea* and *Vigna aconitifolia* (Phillipesara).

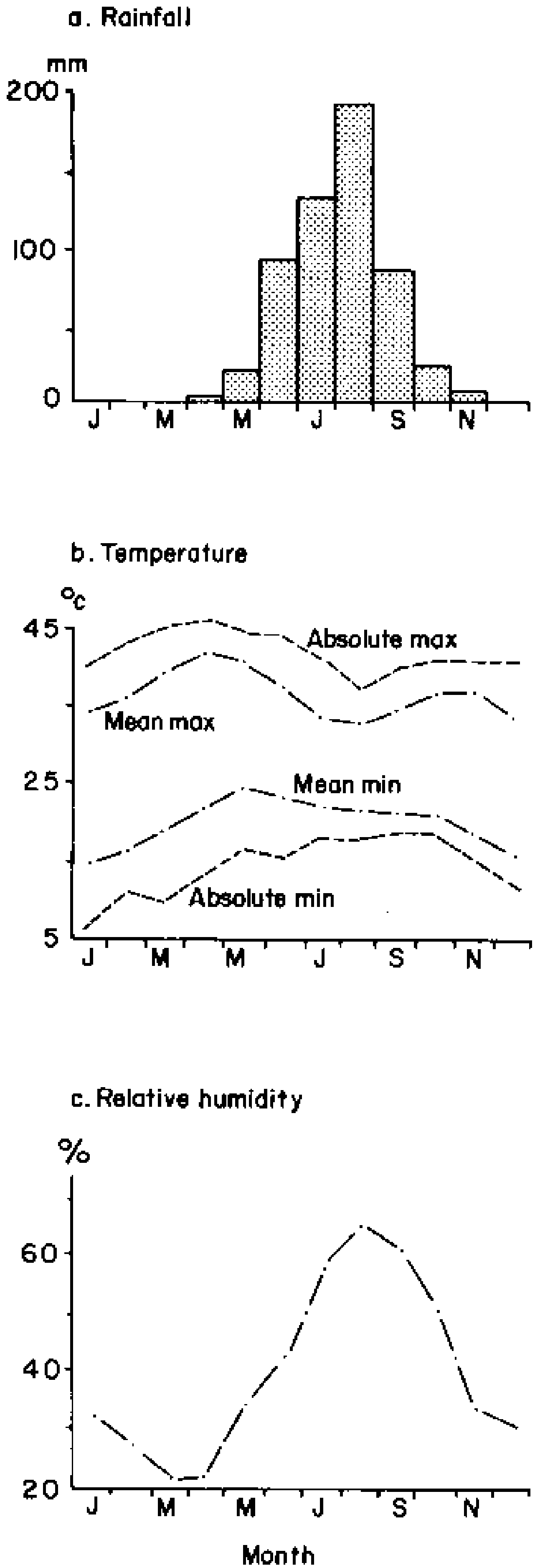
The rainfed area has a variety of natural grasses including *Shoenefeldia gracilis*, *Chloris virgata, Dactyloctenium aegyptiacum, Cynodon dactylon, Brachiaria* spp. and *Oryza* spp.

Kenana cattle

Kenana cattle are a sub-type of the Northern Sudan Shorthorned Zebu (Mason and Maule, 1960). They are generally considered to have resulted from interbreeding Sanga cattle with shorthorn zebu during tribal migrations before recorded history (Rouse, 1972).

The characteristic color of the Kenana is light blue-gray, with gradations from nearly white to steel-gray, shading to nearly black on head, neck, hump, hindquarters and legs. Points (muzzle, horns, tail tip, hooves) are black. The individual hairs are black at the base and white (or occasionally red) at the tip. Darker coat colors, and darker areas, are due to the hairs having a broader black band. In calves some of the hairs have a red tip; this may apply to the hairs on the poll only or to the whole body. Thus calves are frequently born red and change to grey after 3 or 4 months. Exceptionally, the red tip remains in the adult.

Figure 3. Climatic normals at Um Banein Livestock Research Station.



Horns are short, 15 to 20 cm in length with a maximum of 30 to 35 cm, and measure 5 x 6 cm at the base in females and 6 x 7.5 cm in males. Loose horns are common. The face is thin, with a convex (but sometimes straight) profile. The hump, which is cervico-thoracic, is large in the male and has a tendency to hang over at the rear: it is much less well developed in females and castrates. The dewlap is large, as is the sheath in males. The sacrum is higher than the withers. The udder is of good shape and size with large, well placed teats.

Mature cows (Figure 4) may be 130 cm tall at the shoulder and weigh up to 450 kg. Bulls (Figure 5) can be 141 cm tall and weigh 550 kg.

The Kenana is found east of the confluence of the Blue and White Niles at Khartoum and south to the Ethiopian border. It is commonest in the Blue Nile (Fung area), White Nile and Gezira provinces. This is a roughly triangular area bounded by Sennar, Singa, Roseires and Kosti and lying approximately between latitudes 10° and 13° north and longitudes 32° and 34° east. The total population of Kenana cattle has been estimated at 2 million head, owned mainly by nomadic and semi-nomadic tribes including the Kenana, the Rufaa El Hoy and the Bent Meharib. Traditionally, they are used as dairy, beef and draught animals.

The station herd

The herd was established in 1957 by the purchase from local nomadic and semi-nomadic herds of 120 cows with calves at foot. Foundation bulls were selected from the former Gezira Research Farm herd. The herd subsequently remained closed until 1981 when additional bulls were purchased from traditional herds.

The changes in livestock numbers from the establishment of the station to 1984 are shown in Figure 6. As can be seen, sheep contributed considerably to the total stocking rate at a time when this was already very high.

Figure 4. An elite Kenana cow in the Um Banein herd.

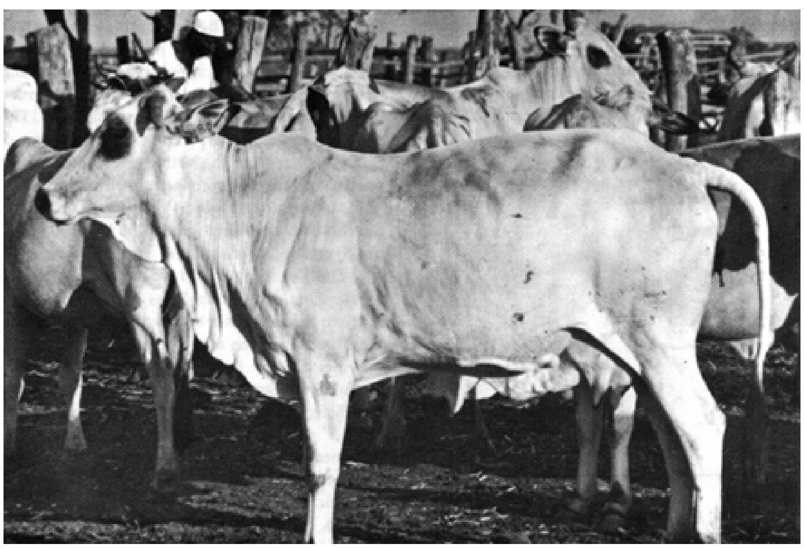


Figure 5. A stud bull of the Kenana breed at Um Banein.

Data collection and initial preparation

The data used in this study were extracted from the station records, which have been collected since the herd was established in 1957. These records were kept in a series of field books and on individual animal record cards. From these sources computer coding sheets were established, which included:

- a "Base record", comprising information on calving date (or date of entry for purchased animals), identification number, sex, date of exit and reason for exit;
- a "Weight record" containing calving date, calf number, dam and sire numbers, birth weight, and (where available) monthly weights to 6 months of age and weaning weight and date; and
- a "Lactation record" with cow number, calving date, calf number, monthly milk yield, days in lactation, lactation number, number of services, conception date and date of next calving.

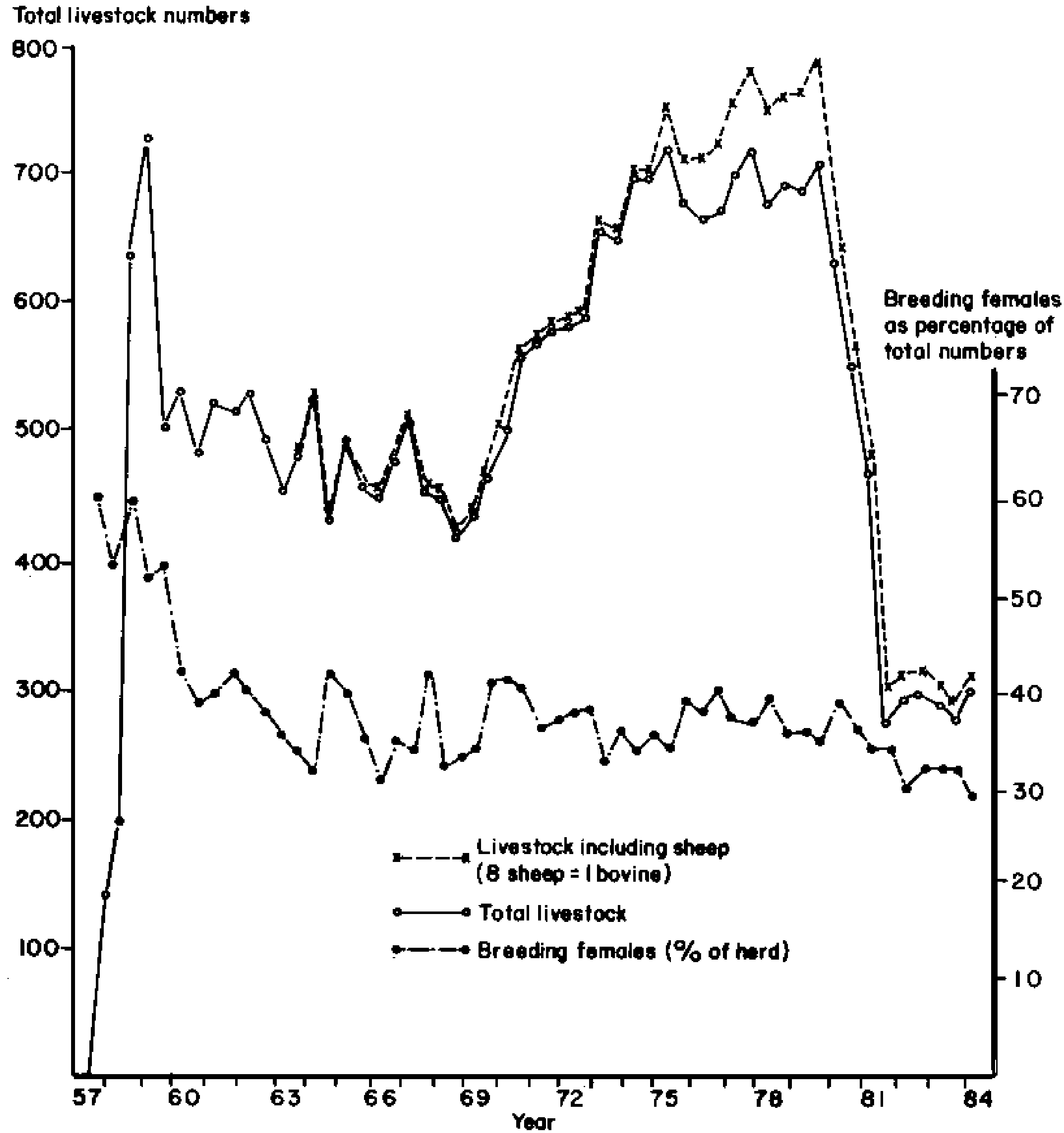
Other information used for the purposes of analysis and interpretation were: adult cow weights for 1984-85; meteorological data; and notes on herd management.

Data analysis

The major analyses were carried out using least-squares fixed-and mixed-model procedures (Harvey, 1977). Unequal and disproportionate subclass numbers gave unbalanced factorial designs for which conventional analysis of variance techniques would not have been applicable.

None of the foundation animals had sire or dam records. In addition, the use of individual sires was often confounded with month and year of use and with dam, so sire groups could not be used in analyses except for the single trait of birth weight.

Figure 6. Fluctuations in livestock numbers at Um Banein from 1957 to 1984.



The models used included: the random effects of the dam (where she appeared in the analytical matrix more than once) and fixed effects of origin (purchased or born on station); parturition number or age of cow; year of birth or parturition (or groups of years where preliminary analyses showed these to be more appropriate); month of birth or parturition; and sex of calf. The specific factors included in the models will be evident when results are presented for each character analyzed, although it should be noted that, after initial analyses, origin was removed from the matrix and only records for station-born cows were taken into account. Where considered relevant, some of these initial analyses are referred to in the results sections.

The residual mean square was used as the error term to test the significance of all differences evaluated among groups. Linear contrasts of least-squares means were computed to determine the significance of differences within groups for all characters where the difference was significant in the analysis of variance. More comparisons were made using the least-squares means than there were independent degrees of freedom. Therefore, not all of the 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 the linear contrasts, although not independent, can be taken as guides as to whether the observed values could have occurred by chance.

Repeatability were calculated using the variance components among and within cows.

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3. Herd management

General organisation

The Um Banein herd was established not only to utilize rainfed grazing and available byproducts (sorghum stover and cotton stubbles), as in village herds, but also to use irrigated forage crops and grasses together with locally available concentrate feeds, in order to allow the Kenana to exhibit fully its productive potential.

Cattle are yarded by night and milking cows are also usually yarded from 1200 to 1600 hours. Thatched shades provide shelter from sun and rain. Cattle are grouped according to age, and adult cows are divided into lactating, late pregnant and dry groups.

The cattle are grazed traditionally and controlled by herdsmen; forage sorghum and sorghum stover are usually cut, carried and fed in the yards.

Nutrition and feeding

The feeding policy was established in 1958. A general outline of forage availability during different seasons is shown in Table 1. Lactating cows were supplemented with sorghum grain in winter and in the dry summer. The irrigable area at the end of 1958 was some 200 feddans or 84 hectares (1 feddan = 0.4 ha).

Some changes to the general pattern outlined in Table 1 have taken place over the years either as a deliberate policy or due to circumstances prevailing at particular times. The main changes have been:

1958 - Sorghum grain fed from April to June and in November and December. Concentrates not fed during the rains.

Irrigation pump installed and 32 ha under irrigation by the end of the year.

1959 - Oil-seed cake introduced as 25% of the concentrate mix, the remaining 75% being sorghum grain. Cows were fed 3.5 kg of concentrate per head per day during the first 60 days of lactation and then 2.0 kg per cow per day until drying off. In practice 0.93 kg of concentrate was fed per kg of milk produced (December figures: 6474 kg milk from 5997 kg concentrate).

1960 - Irrigable area increased to 120 ha.

1962 - Elaborate system of year round supply of fresh legumes, fresh non-legumes and dry fodder in operation, the feed being produced from 160 ha of irrigated and 140 ha of rainfed cropping. Proportions of feeds varied with time of year.

1964 - Small flock of 30 Merino sheep introduced.

1970 - Irrigation no longer possible in dry summer.

1975 - A new flock of 220 head of Watish (Sudan Desert) sheep introduced. Sorghum grain replaced by molasses and wheat bran in the concentrate mix.

1976 - Merino flock dispersed.

1977 - Watish flock now 400 head.

1978 - Majority of non-milking stock grazed regularly off-station for 4 to 5 months of the year. Watish flock now 475 head.

1980 - A series of poor rains and little natural grazing through until 1984.

Cows fed concentrates at rate of 1 kg per 2.4 kg milk. Watish flock now 650 head.

Severe culling carried out (and continued until 1982) to reduce overall stocking rate.

1982 - Molasses/urea feeding introduced during the dry summer.

1984 - Cows fed 1 kg of concentrate per head per day.

Low rainfall and lack of fuel for irrigation.

Table 1. General pattern of forage availability at Um Banein station.

Season	Milking cows	Other stock
Winter November-February	Irrigated fodder + sorghum stover	Natural grazing + sorghum stubbles
Hot summer March-June	Sorghum stover, silage + hay (limited irrigation before 1970)	Sorghum stover, hay + cotton stubbles
Wet summer July-October	Natural grazing + some irrigated grazing or fodder	Natural grazing

Milking regime

Cows have always been milked twice a day at Um Banein, with the exception of June 1962, when milking three times a day was tried. From 1957 until 1961 partial suckling was carried out, with calves suckling all the milk from two quarters but the milk from all quarters being weighed on recording days.

Starting in 1961, half of the cows were milked in the absence of the calf, the other half using the calf only to stimulate milk let-down. By 1971, all cows were being milked in the absence of their calves. Eight cows were machine milked from 1981 to 1984.

Cows were normally dried-off at 305 days but from 1984 cows have been dried-off 60 days prior to the next calving.

Calf management

Calves were originally allowed to suckle part of their dams' milk and given access to sorghum grain, but were not weaned until the lactation ended. From 1959 calves no longer received half the dam's milk but were still used to stimulate milk let-down. In 1961 most calves were weaned at 6 months old. From July 1962 calves were bucket fed. In 1963 a standard weaning age of 4 months was established and oil-seed cake was included in the concentrate. Starting in 1977 calves were individually penned until weaning, whereas previously they had been penned in groups. In 1983/84 some early weaning trials were carried out, calves being weaned at 2 instead of 4 months old.

A summary of the major practices in relation to calf management is given in Table 2.

Breeding

In 1958 bulls ran with the appropriate herd groups, but from 1959 to 1980 cows seen on heat were taken to the bull for service. Consequent on trials to improve fertility in the herd, bulls have again been run with the cows since 1981.

Heifers were usually mated at first oestrus, as this was considered to occur when the animal was sufficiently well grown to breed; heifers therefore generally joined the breeding herd at about 2 years of age.

Breeding bulls were selected from the highest yielding dams in the herd until 1981, when five additional bulls were purchased from traditional herds.

All females were retained and selected according to their first lactation yield. Culling tended to be carried out on an ad hoc basis related to requests for animals until the end of 1984. At that time a system to increase selection pressure on milk production was introduced.

Pregnancy was checked by rectal palpation about 3 months after service and ovarian massage was given in cases of delayed oestrus after parturition.

Disease control

Animals were vaccinated against the major infectious livestock diseases in Sudan, sprayed monthly against ectoparasites and drenched for internal parasites as required; few problems have been encountered with these diseases. The herd has been tested regularly for tuberculosis and trypanosomiasis, with no positive results. Cows were tested for brucellosis and reactors were culled. Mastitis has been a problem, although improved milking techniques and hygiene have reduced the incidence of this disease.

General management

The station had 12 directors in the 28-year period 1957–84. Only three of these were at the station for longer than 2 years.

Table 2. Calf management practices at Um Banein.

Date		Management practices
January	1958	Calves allowed half (milk from two quarters) of dam's output. Not weaned until cow dried-off
September	1958	Sorghum grain (1 kg/head per day) fed to calves. Earlier weaning (but at variable ages) practiced. Calves taken to dams to encourage let-down
March	1959	Calves bucket-fed with rubber teat
July	1961	Half of the number of calves weaned at 6 months. Milk provided at 4.5 kg/head per day

July	1962	Calves fed from bucket by rubber tube ('bizza') instead of by teat
January	1963	Weaning standardized at 4 months: milk provided at rate of 3.6, 2.7, 2.2 and 1.5 kg/day in months 1 to 4 respectively. Concentrate supplement included oil-seed cake
	1977	Calves penned individually in pre-weaning period
	1983	Experimental weaning of a number of calves at 2 months old. Experiment continued in 1984

4. Reproductive performance

Introduction

Reproductive performance is of major importance in a dairy enterprise. The percentage calf crop is crucial for herd replacement, and milk production is heavily dependent on regular reproduction. The rate of genetic progress is also closely linked with reproductive efficiency.

The main traits related to reproductive performance are age at first calving, the interval between successive carvings and, from these two, the potential lifetime production. Under station conditions, age at first calving depends not only on the rate of growth achieved by calves but is also influenced by the management policies with regard to weight or age at first mating and whether or not seasonal breeding is practiced. Calving interval is influenced by such factors as cow and bull fertility, lactation anoestrus and possibly by other effects of lactation on fertility. Calving interval is also affected by management policy in relation to a service period, by the number of services required per conceptions by effects of season and year of last calving and by the effects of the age of the cow.

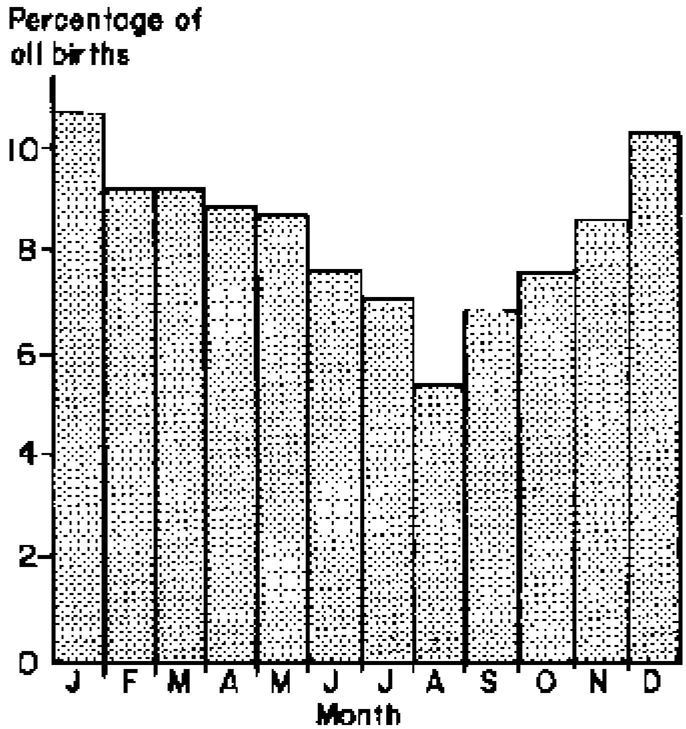
Seasonality

The distribution by month of 3988 births over the period 1957 to 1984 is shown in Figure 7. There were significant differences ($X^2 = 125.3$, d.f. = 11, $P<0.001$) among months in the number of births, most births taking place in December and January and least between July and September. Most conceptions therefore occurred during part of the hot summer in March and April and least in the late wet summer and early winter from October to December.

Although there were significant differences among months in the number of carvings (and by implication, in the number of conceptions), the observed differences were not as marked as expected for an area with the climatic pattern of Um Banein. Farther west in Sudan, in Darfur and under traditional management, the seasonality is very marked, with more than 60% of all carvings taking place in a 3-month period related to conception in the previous rainy season (Wilson and Clarke, 1976). Similarly, in central Mali, where climatic variation is equally marked, the calving pattern is close to that observed in Darfur (Wilson, 1985). At Um Banein, the reduced seasonality is undoubtedly related to supplementary feeding during lactation as most cows reconceive during this period, at about 180 days postpartum. The monthly pattern of carvings at the Gezira research farm for 1939 to 1957 was similar to that at Um Banein (Alim, 1960).

In Kenya cattle, oestrus occurs throughout the year but in some seasons the oestrus period is short and the signs are not pronounced (Mohamed et al, 1985). The system of hand mating practiced from 1959 to 1980 may thus be partly responsible for the slight seasonality, as it could be expected that herdsmen would miss some of the silent or less pronounced heats. The greater number of conceptions during the hot dry summer is rather surprising, however, as is the lower number of services per conception during the wet summer and dry winter periods.

Figure 7. Monthly distribution of calvings at Um Banein for the period 1957-84 (n = 3988).



Age at first calving

The mean ± S.E. of age at first calving was 1502 ± 12.4 days with a coefficient of variation of 17.7%. Figure 8 shows the percentage distribution of age at first calving grouped by 90-day periods and also the differences in ages at first calving among years and months.

The mean squares from the analysis of variance for age at first calving are laid out in Table 3. This analysis showed that only the year of a heifer's birth significantly affected the age at which she first calved. Her own month of birth had no overall effect on the age at which she first calved.

The least-squares means for age at first calving are shown in Table 4. The effects of year of the heifer's birth on age at first calving were highly significant. Following a rather advanced age for the few heifers born in 1958, the age was reduced for those born from 1959 to 1961. The age at first calving then increased for animals born from 1962 to 1965 before decreasing for those born in 1966 to 1969. Animals born in these last 4 years had the youngest age at first calving overall. Age at first calving increased sharply for animals born during or after 1970.

Table 3. Mean squares from the analysis of variance for age at first calving.

Source of variation	d.f.	MS
Month	11	68 740

Year	14	1 836 024***
Error	430	70 323

*** p<0.001

At Um Banein, heifers are put into the breeding herd at about 2 years old. The mean age at first calving (50.1 months) calculated from the present data set is thus very late. Over a 22-year period, the delay between introduction to the breeding herd and conception averaged about 18 months. The least-squares analysis (Table 4) shows increasing age at first calving over time and this has become more marked since the early 1970s. Average age at first calving for the period 1960-70 has previously been determined at 45.2 ± 7.6 months (El-Khidir et al, 1979) for Um Banein. Earlier studies on Kenana cattle at other locations in Sudan have shown even earlier ages at first calving than the best period for Um Banein: 40.6 months at the Gezira research farm (McLaughlin, 1955); 38.4 months, again at the Gezira farm (Alim, 1960); and 42.9 months at Khartoum University (Khalifa and Shafei, 1965).

In addition to the increased age at first calving over the years at Um Banein, the standard errors as a percentage of the respective annual means have increased. This indicates that there could now be major problems of infertility or sub-optimal fertility in the herd, although it is probable that this is closely related to the nutritional status of heifers. In 1978/79 in a small trial in which 16 heifers were provided with 2 kg concentrate per day and *ad lib* groundnut hay for a period of 12 months from 6 months of age, the age at first calving was 38.4 months compared with 82.7 months in a control of 36 heifers.

Figure 8. Distribution of ages at first calving for (a) all observed data (n = 475) and as affected by (b) year and (c) month of the heifer's birth.

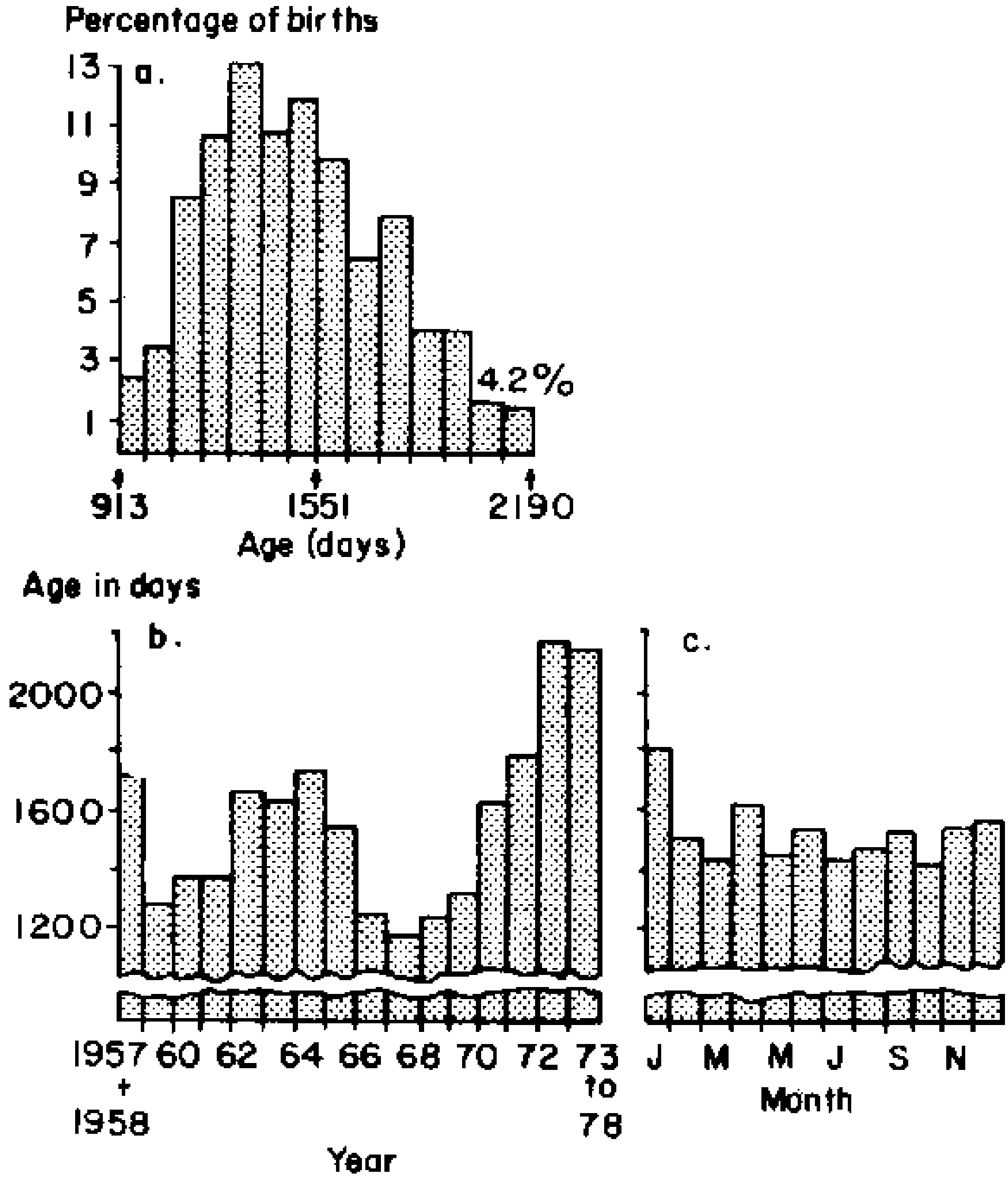


Table 4. Least-squares means for age at first calving.

Variable		n	$\bar{x}$ (days)
Overall L.S. mean		456	1535
Month:	January	25	1617
	February	45	1502
	March	56	1522
	April	40	1525
	May	48	1455
	June	52	1536
	July	43	1502
	August	25	1511

	September	27	1547
	October	31	1536
	November	27	1559
	December	37	1607
Average S.E.			45.9
Year:	1958	10	1754^{ai}
	1959	17	1313^{ncf}
	1960	15	1365^{c}
	1961	16	1402^{cdg}
	1962	39	1680^{ai}
	1963	17	1635^{aei}
	1964	23	1731^{ai}
	1965	44	1550^{defh}
	1966	39	1257^{bc}
	1967	35	1190^{b}
	1968	37	1233^{b}
	1969	50	1311^{bg}
	1970	62	1620^{ah}
	1971	32	1790^{i}
	1972	20	2191^{j}
Average S.E.			54.0

Within variables, means without a common superscript differ significantly (P<0.05).

Table 5. Mean squares from the analysis of variance for parturition interval.

Source of variation	**d.f.**	**MS**
Dam	403	45 747***
Month	11	16 162
Year group	3	103 314**
Lactation number	6	154 006***
Error	857	23 948

*** P<0.001; ** P<0.01.

Table 6. Least-squares means for parturition intervals.

Variable		**n**	$\bar{x}$ **(days)**
Overall L.S. mean		1281	534
Month:	January	118	526
	February	116	494
	March	125	537
	April	105	551

	May	121	549
	June	95	541
	July	89	538
	August	81	551
	September	93	529
	October	107	528
	November	96	526
	December	135	536
Average S.E.			20.4
Year group:	1964-1967	154	621^{a}
	1968-1971	370	530^{b}
	1972-1975	469	521^{b}
	1976-1980	288	463^{c}
Average S.E.			22.6
Lactation number:	1	364	457^{a}
	2	295	465^{ab}
	3	225	496^{b}
	4	162	503^{b}
	5	111	544^{c}
	6	65	580^{c}
	>7	59	692^{d}
Average S.E.			19.2

Within variables, means without a common superscript differ significantly ($P<0.05$).

Calving interval

The unadjusted mean calving interval was 485 ± 5.1 days with a coefficient of variation of 36.2%. The percentage distribution of these intervals is shown in Figure 9 and the effects of year and parturition number in Figure 10.

The mean squares from the analysis of variance for calving interval are shown in Table 5 and the least-squares means for this trait are laid out in Table 6. Month of previous parturition did not significantly affect the subsequent interval and most intervals were clustered about the mean. In the least-squares analysis the effects of year group showed a shortening interval with the passage of time. The interval increased with advancing age of the cow, intervals after the fourth and subsequent parturitions being considerably longer than those observed in younger cows.

The repeatability of the interval considered as a trait of the dam was 0.23 ± 0.031.

There is no policy for a required period of time post-partum before cows are bred. The calving interval at Um Banein is longer than intervals recorded for other Kenana cattle. Three other data sets are available for comparison, although all relate to animals at the Gezira farm: Hattersley (1951) recorded 368 days; McLaughlin (1955) noted 408 days; and an interval of 395 days was calculated by Alim (1960).

Figure 9. Distribution of calving intervals in Kenana cows at Um Banein (n = 1782).

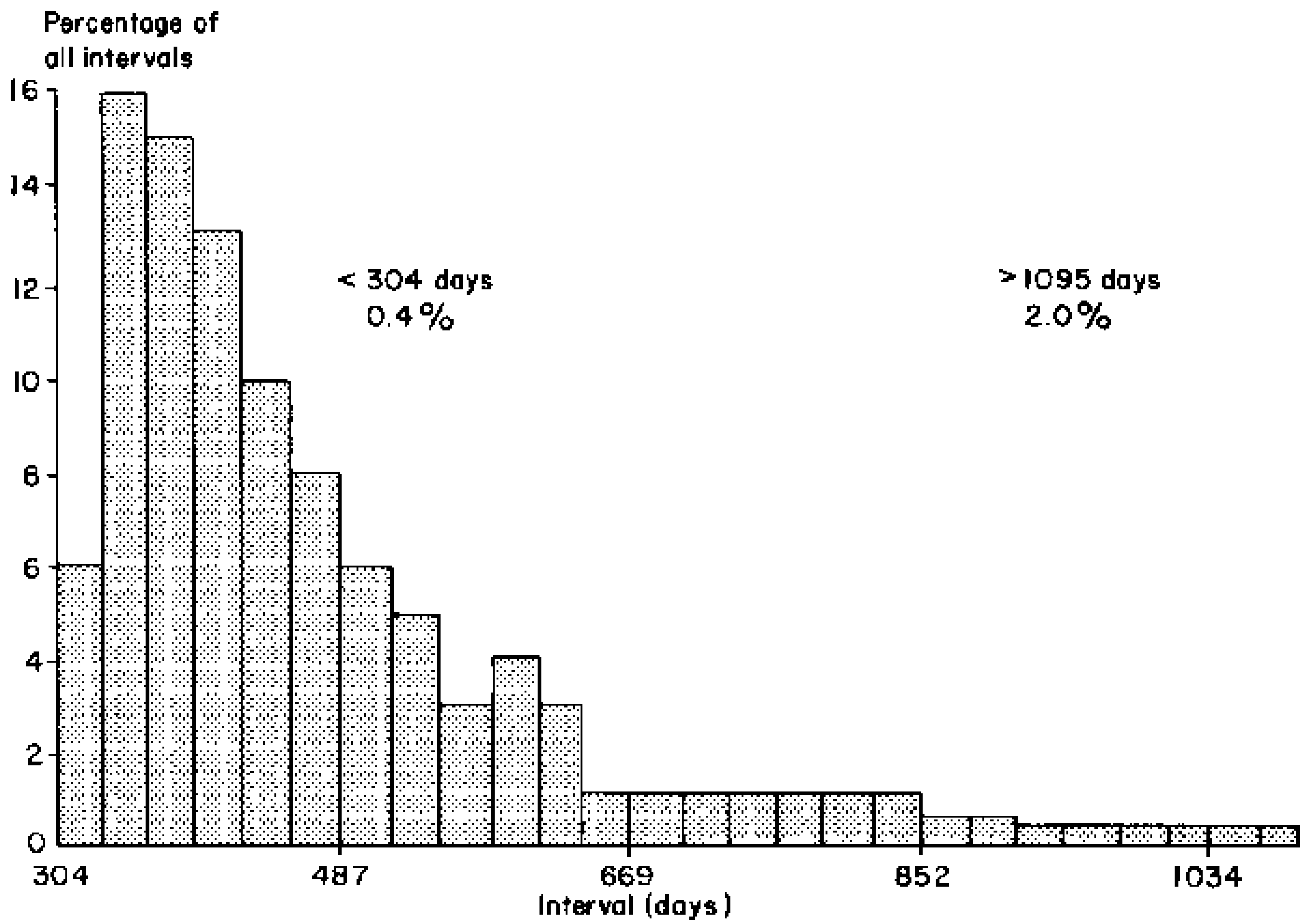
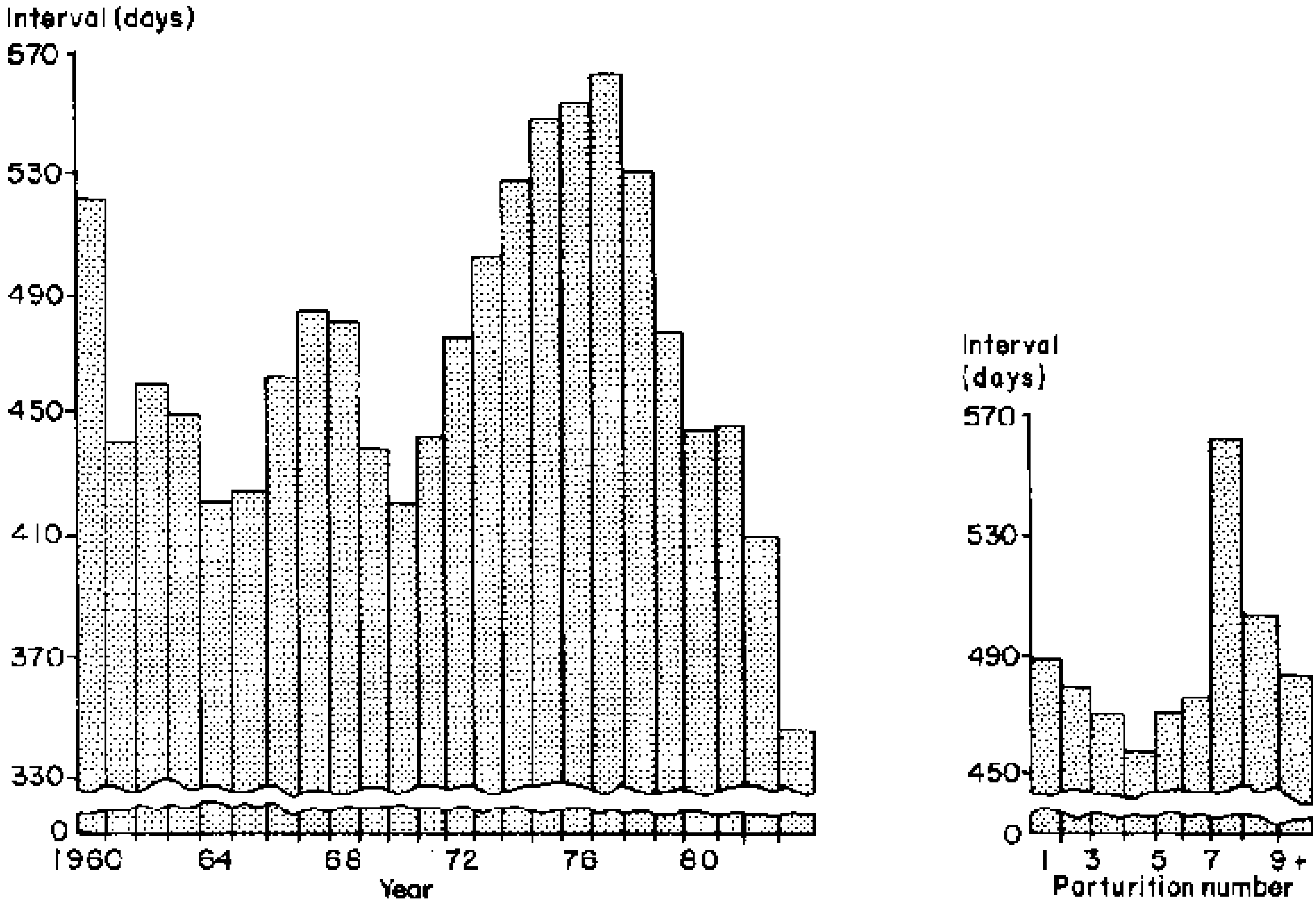


Figure 10. Effects of year of calving and parturition number on subsequent parturition intervals of Kenana cows.



The repeatability found in the current study is higher than that estimated for Kenana cows by Khalafalla and Khalifa (1983) and is also higher than most other estimates for this trait in other African cattle (Mahadevan, 1965).

Length of reproductive life

The analysis for length of reproductive life (for cows born on the station and having already left the herd) is shown in Figure 11. One cow had 12 calves but most were culled or left the herd after the sixth parturition. The mean number of calves born per cow was 4.02.

This mean compares with that of 5.4 calculated by Alim (1965) for the Gezira herd. Long reproductive lives assist in maintaining a high intensity of selection for economic characters and, providing that the cows with the greatest numbers of lactation are the highest producers, keeping them in the herd to advanced ages might be good policy. Increased longevity is also instrumental, however, in increasing the generation length and the balance between these two parameters needs to be considered in deciding the overall breeding policy.

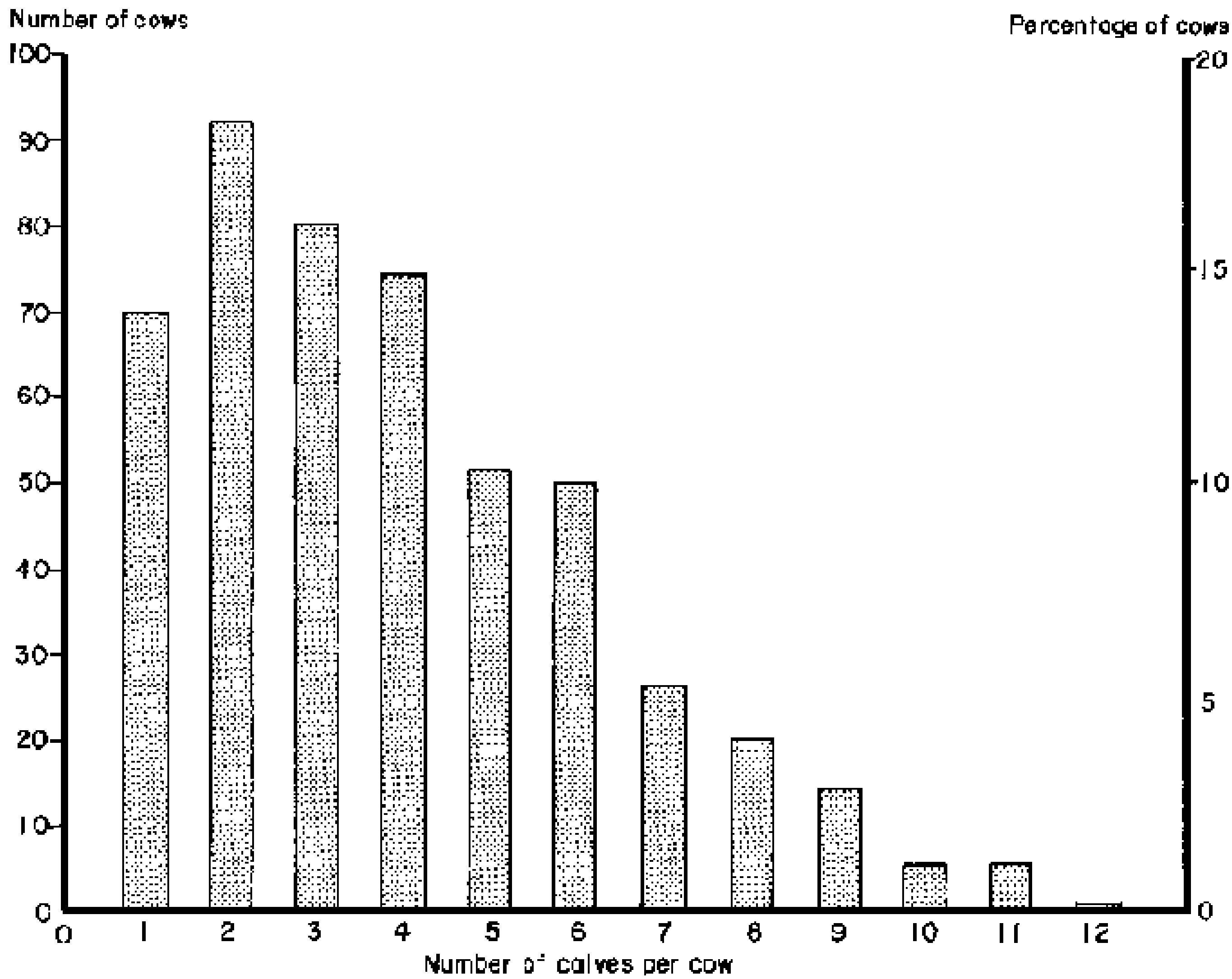
Number of services per conception

Data relating to the number of services per conception were available for 1229 cases. The distribution of the number of services per conception is shown in Figure 12, the mean number of services being 1.21 per conception.

Earlier analyses (Mohamed et al, 1985) indicated 1.41 services per conception for the period

1970-74 (n = 1215 services) or a conception rate of 70.9%, but the number of services per conception increased to 1.84 (n = 412 services, conception rate = 54.3%) during 1980/81. In both these periods, fewer services were required per conception (Table 7) in the dry summer than in the other two seasons. This finding is consistent with the higher total number of conceptions in the dry summer. The reason for the apparently higher fertility and fecundity at this time of year needs to be investigated.

Figure 11. Distribution of cow reproductive life, expressed as number of calves born per cow, for cows born on the station and already exited.



Gestation length

Gestation lengths recorded as being outside lower and upper limits of 265 and 305 days respectively were eliminated from the analysis. The calculated mean and standard error were 286.5 ± 0.20 days with a coefficient of variation of 6.38% (Figure 13).

The gestation period of 286.5 days is as expected. In an earlier analysis (Khalafalla and Khalifa, 1983) the mean period was calculated as 287 ± 0.3 days: that study showed significant effects (P<0.001) of sex of calf on the period, male calves being carried 1.7 days longer than females, but there were no significant effects (P>0.05) due to age of cow.

Figure 12. Number of services per conception expressed as percentage of all recorded

conceptions.

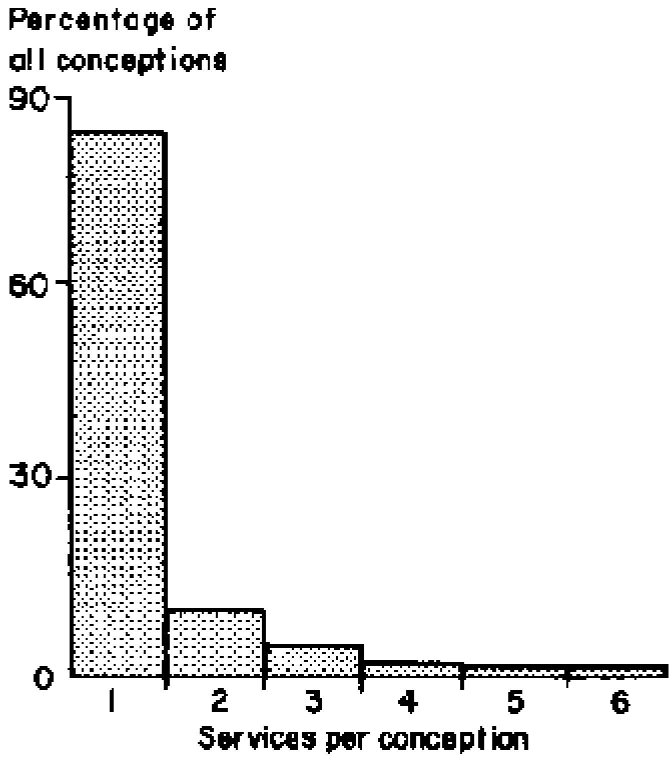


Figure 13. Percentage distribution of gestation periods about intervals of 5 days.

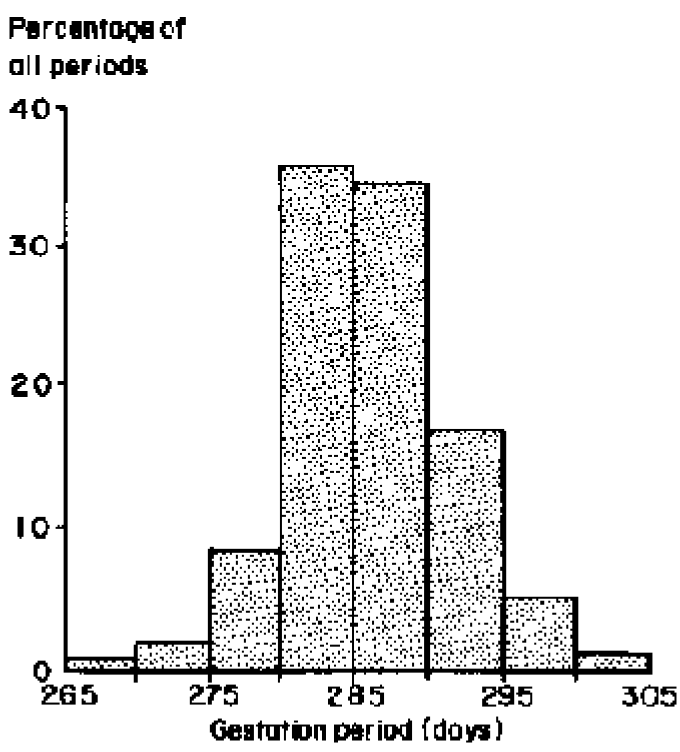


Table 7. Conception rates and number of services per conception for two year-groups and three seasons.

Season	1970-1974			1980-1981		
	Number of services	Conception rate(%)	Services per conception	Number of services	Conception rate(%)	Services per conception
Winter	277	68.9	1.45	114	52.6	1.9

Dry summer	443	74.5	1.34	118	79.2	1.4
Wet summer	495	68.7	1.45	180	47.8	2.1
Overall	1215	70.9	1.41	412	54.3	1.8

5. Weight and growth

Introduction

A high growth rate is of economic importance for both beef and dairy enterprises. In the case of beef, animals that grow faster reach slaughter weight earlier and therefore overhead costs are lower. In the case of dairy animals, culling can be more rigorous and stock can be replaced earlier if growth rates are higher, as heifers can calve at a younger age and hence increase their lifetime productivity in terms of calves and milk.

At Um Banein, more emphasis has been placed in the past on milk production than on growth, except when particular station directors or researchers have had a special interest in aspects of growth and weight. While a complete series of birth weights is available, data on other weights tend to have been unevenly recorded over the life of the station. This chapter analyses the available data in order to provide results for comparison with future data, which should be more rigorously collected.

Birth weight

Birth weights of 3466 calves were recorded in the period 1957-84. The unadjusted mean and standard error were 23.2 ± 0.05 kg (range 8.0-43.0 kg) with a coefficient of variation of 13.4%. The frequency distribution of these weights is shown in Figure 14.

The management system at Um Banein has not allowed the use of an analytical model in which dams could be analyzed within sire groups. Separate mixed models were therefore used to analyze the influences of individual dams and sires on birth weight. The mean squares from the analysis of variance for the dam effects are shown in Table 8 and the least-squares means in Table 9. The mean squares from the sire analysis are shown in Table 10 and the least-squares means in Table 11.

In both series of analyses it was shown that month of birth did not have a significant influence on birth weight, while year-group, sex of young and age of the dam had significant effects. There were no significant effects of the dam on birth weight but there were highly significant differences due to the sire.

Male calves were significantly heavier than females at birth. Calves born during the period 1968-75 were generally heavier than calves born during other periods, but in the dam analysis calves born in the period 1981-84 were heavier than calves born in any period except 1968-71. In the sire analysis, calf birth weights declined from a peak in 1968-1971. In the dam analysis; calf birth weights declined from dams more than 10 years old, while in the sire analysis weights increased throughout the life of the dam.

Figure 14. Frequency distribution of birth weights of Kenana calves born at Um Banein.

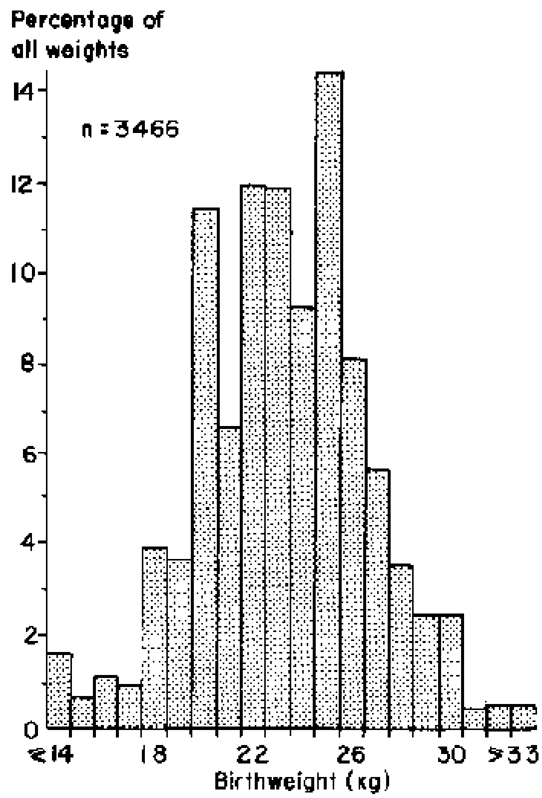


Table 8. Mean squares from the analysis of variance for birth weight (dam model).

Source of variation	d.f.	MS
Dam	744	13.2***
Month	11	10.8
Year group	5	167.4***
Sex	1	1201.9***
Damage	9	26.5***
Error	1638	7.3

*** P<0.001.

Table 9. Least-squares means for birth weight of Kenana calves (dam model).

	Variable	n	$\overline{X}$ (Kg)
Overall L.S. mean		2409	22.7
Month:	January	222	22.6
	February	206	22.7
	March	210	22.9
	April	210	22.3
	May	215	22.4
	June	180	22.7
	July	194	22.7
	August	153	22.8
	September	198	23.4
	October	195	22.6
	November	189	22.8
	December	237	22.3
Average S.E.			0.26
Year group:	1961-1963	55	20.8^{a}
	1964-1967	308	21.3^{a}
	1968-1971	548	23.8^{b}
	1972-1975	680	22.9^{c}
	1976-1980	545	22.6^{ac}

	1981-1984	273	24.6[b]
Average S.E.			0.42
Sex:	female	1207	21.8[a]
	male	1202	23.5[b]
Average S.E.			0.14
Dam age (years):	<4	165	23.2[a]
	4 - 5	345	23.4[a]
	5 - 6	425	23.2[a]
	6 - 7	345	23.4[a]
	7 - 8	300	23.1[a]
	8 - 9	222	22.9[a]
	9 - 10	177	22.8[ab]
	10 - 11	140	22.1[bc]
	11 - 12	103	21.6[cd]
	>12	187	21.1[d]
Average S.E.			0.29

Within variables means without a common superscript differ significantly (P<0.05).

Table 10. Mean squares from the analysis of variance for birth weight (sire model).

Source of variation	d.f.	MS
Sire	90	19.1***
Month	11	11.6
Year group	5	108.2***
Sex	1	1635.4***
Dam age	9	42.9***
Error	2292	8.8

*** P<0.001.

Table 11. Least-squares means for birth weight of Kenana calves (sire model).

Variable		n	$\bar{X}$ (Kg)
Overall L.S. mean		2409	23.2
Month:	January	222	23.1
	February	206	23.2
	March	210	23.5
	April	210	23.2
	May	215	22.9
	June	180	23.2
	July	194	22.8
	August	153	23.3
	September	198	23.7
	October	195	23.4
	November	189	23.2
	December	237	23.0
Average S.E.			0.29
Year group:	1961-1963	55	23.9[ab]
	1964-1967	308	23.8[a]
	1968-1971	548	24.7[b]
	1972-1975	680	23.4[a]
	1976-1980	545	22.2[c]
	1981-1984	273	21.1[d]
Average S.E.			0.38
Sex:	female	1207	22.3[a]
	male	1202	[b]

			24.1
Average S.E.			0.21
Dam age (years):	4	165	22.1[a]
	4 - 5	345	22.5[ab]
	5 - 6	425	22.9[bc]
	6 - 7	345	23.6[cd]
	7 - 8	300	23.5[cd]
	8 - 9	222	23.5[cd]
	9 - 10	177	23.5[cd]
	10 - 11	140	23.3[bcd]
	11 - 12	103	23.2[bcd]
	>12	187	23.9[d]
Average S.E.			0.29

Within variables means without a common superscript differ significantly (P<0.05).

Repeatability of birth weight (as a trait of the dam) was found to be 0.200 ± 0.022. Heritability (estimated as a trait of the sire) was 0.190 ± 0.048.

The mean birth weight found in this study is less than that reported by Khalifa and Khalafalla (1979) but slightly heavier than that reported by Hattersley (1951) for Kenana cattle. Male calves in the current study were 1.7 kg heavier than female calves, compared with an earlier difference of 1.3 kg (Khalifa and Khalafalla, 1979). The decline in birth weight from 1968 to 1971 can be attributed to shortage of feed due to the high stocking rates during those years (c.f. Figure 6). The effect of dam age on birth weight in the sire analysis in this study is in agreement with that found by Khalifa and Khalafalla (1979), who reported that birth weight tended to increase with age of dam, reaching a maximum in cows more than 7.5 years old.

The heritability and repeatability of birth weight in this study estimated at 0.190 ± 0.048 and 0.200 ± 0.022 respectively were lower than those reported by Khalifa and Khalafalla (1979). This could be due to the deterioration of management and fluctuation of environmental conditions in the period 1972-84.

Weights from birth to weaning

Weight measurements after birth were made on calves born in 1958 and 1959, in 1978 and then from 1980 onwards. The earlier measurements were made on calves born of foundation dams and the later ones on calves of station-bred dams. The later weights were taken following a long period of overstocking and during a prolonged drought. It should therefore be recognized that the observed weights are probably lower than long-term weights would be and that growth rates would also be lower.

Calf weaning weights

The unadjusted mean and standard error of weaning weight at 120 days for calves born in 1980 to 1984 were 52.4 ± 0.57 kg with a coefficient of variation of 22.3%.

Table 12 presents the mean squares from the analysis of variance for weaning weight. Only the sex of the calf and year of birth had significant effects on this trait. Season of birth and dam age showed no significant effect on weaning weight.

Least-squares means of weaning weight are shown in Table 13. Calves weaned in 1983 and 1984 were significantly heavier than those weaned in other years. Males were significantly heavier than females. There was a slight but non-significant increase in weaning weight as dam age increased.

Table 12. Mean squares from the analysis of variance for 120-day weaning weight.

Source of variations	d.f.	MS
Season of birth	2	43 402
Year of birth	4	45 517*
Sex	1	192 126**
Dam age	9	19 231
Error	323	21 085

*P<0.05; ** P<0.01.

Table 13. Least-squares means of 120-day weaning weight of Kenana calves.

Variable		n	$\bar{X}$ (Kg)
Overall L.S. mean		340	51.2
Season:	winter	155	51.0
	hot summer	65	51.9
	wet summer	120	50.6
Average S.E.			2.39
Year:	1980	55	50.3[a]
	1981	73	49.0[a]
	1982	69	48.0[a]
	1983	77	52.4[b]
	1984	66	56.1[b]
Average S.E.			1.60
Sex:	female	182	49.5[a]
	male	158	52.8[b]
Average S.E.			1.07
Dam age (years):	<4	4	41.5
	4 - 5	14	47.3
	5 - 6	48	50.8
	6 - 7	36	52.9
	7 - 8	33	53.2
	8 - 9	29	51.1
	9 - 10	39	51.8
	10 - 11	36	52.9
	11 - 12	33	56.2
	>12	68	53.8
Average S.E.			2.40

Within variables, means without a common superscript differ significantly (P<0.05).

In a trial carried out on the station, weight gains and growth rates of calves weaned at 60 days of age were compared with those of calves weaned at 120 days. Table 14 shows the least-squares analysis of variance of this comparison while least-squares means of body weight and daily gains are shown in Table 15 for the two different groups. It is clear from these two tables that early weaning did not affect subsequent growth up to the age of 120 days.

There are, apparently, no earlier comparative data available on the weaning weights of Kenana calves.

The high weaning weights in 1983 and 1984 are due to these calves being fed green legumes and concentrate *ad lib* from the age of 1 week onwards. Male calves outweighed female calves by 2.8 kg and this could be due to the fact that the calves that were heaviest at birth were heaviest at weaning (Mukhtar, 1961; Osman and Rizgalla, 1968). The absence of significant effects of season and dam age on this trait is as expected, since calves were artificially reared.

Early weaning (60 days) did not affect subsequent growth of calves at least until the age of 120 days. In this case, liquid milk could be saved for human consumption and farmers would be able to sell the surplus to maximize profit. A 60 day-old calf weighing 35.5 kg consumes 2.2 kg of milk per day (Table 2). If this amount were saved and sold, it would provide an income of LSud 3.74 per cow per day if sold at the Khartoum market price of LSud 1.70 per litter (LSud 3.00 = US$ 1.00).

Calf body weights from birth to 180 days

Data for growth rate from birth to 180 days of age were available for 156 calves (97 males and 59 females) born from 1980 to 1984.

Mean squares from the analysis of variance for body weights from birth to 180 days of age are shown in Table 16. Season of calving had a significant effect on birth weight only and did not affect weights at older ages. Year of calving affected birth, 30-day, 60-day and 90-day weights significantly. Sex had a significant effect on both birth weight and 30-day weight. Dam age had a significant effect only on birth weight.

Least-squares means of body weights from birth to 180 days of age are given in Table 17. Calves born in winter had significantly higher birth weights than those born in the hot and wet summers. Season had no significant influence on body weights from 30 days up to 180 days. Year of calving affected body weights from birth to 180 days in an increasing pattern, being low in 1980 and high in 1984. Males were significantly heavier at birth than females and were still significantly heavier at 30 days old. Dam age significantly affected birth weight, calves from older dams being generally heavier, but had no effect on body weight at other ages.

Table 14. Mean squares from the analysis of variance to compare calves weaned at 60 days with those weaned at 120 days.

Source of variation	d.f.	Mean square at age (days)					Mean square ADG (range of days)			
		Birth	30	60	90	120	0–30	30–60	60–90	90–120
Season	2	37.3*	3.0	86.9	45.7	24.5	62 047*	65 452	34 562	4 072
Year	5	13.9	196.3***	374.9***	481.4***	669.3***	152 619***	40 489*	26 304	17 616**
Sex	1	226.3***	182.2**	135.0	203.9+	643.8*	2 602	3 919	7 802	13 467*
Dam age	9	29.9**	47.6*	72.1	119.7	167.1	8 325	13 935	13 950	17 612
Weaning age	1	0.58	6.9	55.4	17.0	64.9	12 765	25 825	12 229	17 158
Error	334	11.6	24.7	44.2	74.3	125.4	17 236	13 308	14 573	21 582

+P<0.10; * P<0.05; * P<0.01; *** P<0.001.

Table 15. Comparison of body weights and growth rates of early-weaned calves (60days) with calves weaned at 120 days old.

	Weight (kg) at age (days)						ADG (g) for period (days)			
	n	Birth	30	60	90	120	0-30	30-60	60-90	90-120
Weaned at 120 days	318	20.4	28.5	35.5	42.8	49.7	269.1	235.2	240.6	229.9
Weaned at 60 days	35	20.2	29.0	37.0	43.6	51.3	291.9	267.5	218.4	256.2

Table 16. Mean squares from the analysis of variance for body weights of Kenana calves from birth to 180 days of age.

Source of variation	d.f.	Mean squares at age (days)						
		Birth	30	60	90	120	150	180
Season	2	26.2*	11.6	35.3	17.5	2.6	166.2	482.7
Year	4	34.2**	172.5***	306.1***	284.0**	191.8	111.7	78.7
Sex	1	75.2**	94.9*	67.6	69.7	139.6	135.1	29.3
Dam age	8	35.4***	35.6	42.7	64.5	112.4	113.7	113.8
Error	140	7.9	19.4	34.7	62.8	105.9	129.1	153.3

Calf growth rate from birth to 180 days

Data available for this analysis were the same as those for weights to 180 days.

The mean squares from the analysis of variance of growth rate are shown in Table 18. Season had a significant effect on growth from 30 days to 60 days, 120 to 150 days and 150 to 180 days. Year of calving affected growth significantly from birth to 30 days of age only. Dam age and the sex of the calf had no significant effects on growth rate at any stage.

Least-squares means of growth rate are presented in Table 19. Growth rates from 30 to 60 days were significantly higher for calves born in the dry summer than for those born in the winter and wet summer periods. Calves born during the wet summer had significantly higher growth rates from 120 to 150 days and from 150 to 180 days of age than calves born in other seasons. Year of calving significantly affected growth rate from birth to 30 days, 1984 calves growing fastest, but had no effect on growth rate at later ages.

Growth rates declined as age advanced there being a particularly marked reduction in average daily gain (ADG) after weaning at 120 days (Figure 15).

The high ADG in the summer, from 30 to 60 days of age, was probably due to supplementary feeding of cotton stubble's and hay to these calves in this season (see Table 1). After weaning at 120 days, these calves were kept on natural grazing, this being reflected by the high ADG in wet summer from 120 to 180 days of age.

The high ADG from birth to 30 days in 1984 was probably due to the high birth weight, the calves that were heaviest at birth growing fastest (Mukhtar, 1961; Osman and Rizgalla, 1968). From Table 19, it can be seen that ADG declined as age advanced, with a sharp drop just after weaning.

Phenotypic correlations at different ages for body weight and growth rate

Table 20 shows the phenotypic correlations between body weights and growth rate from birth to 180 days of age. The negative correlations between birth weight and growth undoubtedly are a result of the fixed amounts of feed provided to calves: heavier calves have to devote more to maintenance and less to growth than their lighter-born contemporaries.

Breeding cow weights

Adult cows were not weighed regularly at Um Banein, except during 1984 and 1985, when all breeding cows on the station were weighed four times in order to establish the magnitudes of seasonal changes. The observed pattern of changes (Table 21) was similar to that already recorded for growing stock. Maximum weights were achieved following the rainy season and minimum weights at the end of the hot dry summer just prior to a rapid increase in weight at the onset of the rains.

In 1985, 46 cows and heifers within 2 weeks before parturition weighed an average of 308 kg, with post-partum weights within 2 weeks of having given birth averaging 268 kg, the loss being equivalent to 13% of body weight.

Table 17. Least-squares means of body weight for Kenana calves from birth to 180 days of age.

Variable	Weight (kg) at age							
	n	Birth	30	60	90	120	150	180
Overall L.S. mean	156	20.9	29.0	36.2	43.0	49.2	53.5	56.7
Season:								
winter	79	21.7[a]	29.1	35.4	42.7	49.1	51.6	53.6
dry summer	26	20.3[b]	29.4	37.5	43.8	49.5	53.8	57.1
wet summer	51	20.5[b]	28.3	35.7	49.0	55.0	55.0	59.4
Average S.E.		0.48	0.74	0.99	1.33	1.74	1.92	2.09
Year:								
1980	10	19.2[a]	25.6[a]	32.3	39.0[a]	46.8	51.9	54.3
1981	45	19.9[a]	27.1[a]	33.8	40.4[a]	46.6	51.8	56.1
1982	40	21.1[b]	29.4[b]	35.9	42.6[a]	48.2	52.1	55.3
1983	35	21.1[ab]	28.8[ab]	36.2	43.4[a]	50.3	54.3	58.4
1984	26	22.9[c]	33.9[c]	42.9	49.3[b]	54.1	57.2	59.3
Average S.E.		0.62	0.97	1.30	1.75	2.28	2.51	2.74
Sex:								
female	97	20.1[a]	28.1[a]	35.5	42.2	48.2	52.4	56.2
male	59	21.6[b]	29.8[b]	36.9	43.7	50.2	54.5	57.2
Dam age (years):								
<5	8	19.9[abc]	26.6	32.3	38.1	42.1	45.3	47.9
5 - 6	23	18.1[b]	27.2	34.7	42.0	49.3	53.4	57.3
6 - 7	13	20.7[acd]	27.5	35.5	41.6	47.1	52.7	57.0
7 - 8	15	21.3[acd]	29.3	36.8	43.9	51.9	56.2	57.8
8 - 9	13	20.9[acd]	29.7	37.9	44.9	52.1	54.6	57.5
9 - 10	17	22.7[d]	31.0	38.7	45.7	51.6	55.6	59.4
10 - 11	16	20.0[d]	28.4	35.8	43.3	49.8	55.6	59.4
11 - 12	10	22.1[acd]	30.2	36.6	42.1	47.1	52.0	55.3
>12	41	22.0[ac]	30.6	37.6	45.2	51.7	56.2	59.2
AverageS.E.		0.78	1.22	1.63	2.20	2.85	3.15	3.44

Within variables, means in the same column without a common superscript differ significantly ($P<0.05$).

Table 18. Mean squares from the analysis of variance of growth rate of Kenana calves from birth to 180 days of age.

Source of variation	d.f.	Mean square for ADG (range of days)					
		0-30	30-60	60-90	90-120	120-150	150-180
Season	2	27 951.8	32 513.8*	12 079.4	7 305.6	193 270.0***	91 696.6**
Year of calving	4	61 189.5**	26 466.8*	3 152.6	25 792.3	17 900.4	25 333.8
Sex	1	1 273.6	2 521.1	12.7	13 311.9	44.2	42 573.8
Dam age	8	9 656.1	6 813.4	8 141.5	18 543.1	13 338.6	10 522.8
Error	140	12 966.2	10 589.5	15 162.2	17 917.0	18 313.2	15 434.9

* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

Table 19. Least-squares means of average daily gain (ADG) of Kenana calves from birth to 180 days of age.

Variable	n	ADG (g/day) for period					
		0-30	30-60	60-90	90-120	120-150	150-180
Overall L.S. mean	156	269.7	241.9	224.6	207.5	142.0	106.5
Season:							
winter	79	245.5	211.9[a]	242.9	211.9	83.9[a]	64.7[a]
dry summer	26	303.4	267.4[b]	212.0	189.7	140.7[ab]	109.8[ab]
wet summer	51	260.1	246.5[ab]	219	220.9	201.4[b]	145.1[b]
Average S.E.		19.23	17.38	20.80	22.60	22.85	20.98
Year:							
1980	10	212.8	221.8[ab]	225.0	259.4	168.9	80.3
1981	45	240.0	222.2[a]	220.9	205.1	173.5	141.9
1982	40	274.7	218.5[a]	222.7	187.4	129.9	105.8
1983	35	257.3	245.5[a]	241.5	228.2	133.4	135.1
1984	26	363.6	301.7[b]	213.2	157.3	104.4	69.6
Average S.E.		25.18	22.76	27.23	29.60	29.93	31.67
Sex:							
female	97	266.5	246.4	224.3	197.3	142.6	124.8
male	59	272.8	237.5	224.9	217.9	141.4	88.3
Average S.E.		16.01	14.47	17.32	18.83	19.04	17.47
Dam age (years):							
<5	8	224.8	188.4	192.0	134.7	105.5	85.7
5 - 6	23	304.2	250.7	241.7	243.9	135.6	129.2
6 - 7	13	226.5	266.1	200.9	184.5	186.7	143.8
7 - 8	15	265.4	249.3	236.5	267.3	144.7	52.6
8 - 9	13	293.4	270.8	235.3	238.4	83.3	95.9
9 - 10	17	276.9	256.3	232.4	198.3	131.7	127.6
10 - 11	16	280.9	246.3	248.3	215.5	178.6	113.2
11 - 12	10	268.4	215.7	182.6	165.8	162.6	110.7
>12	41	286.6	233.7	251.9	219.0	149.3	100.3
Average S.E.		31.60	28.55	34.17	37.14	37.55	34.47

Within variables, means in the same column without a common superscript differ significantly ($P<0.05$).

Figure 15. Average daily gain for specified periods after birth of Kenana calves at Um Banein.

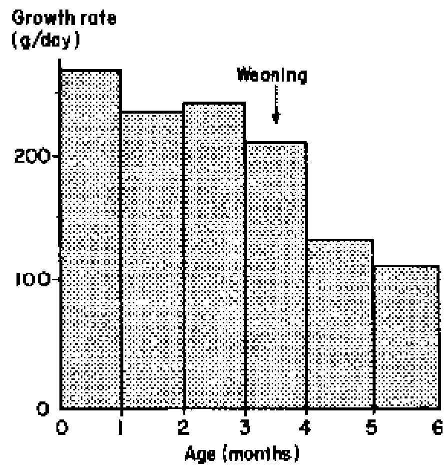


Table 20. Phenotypic correlations between body weights and growth rate of Kenana calves from birth to 180 days of age.

Trait	Weight at age (days)							Growth for period (days)					
	Birth	30	60	90	120	150	180	0–30	30–60	60–90	90–120	120–150	150–180
Weight													
Birth	1.00	0.63***	0.44***	0.30***	0.20**	0.12	0.12	−0.01	−0.06	−0.05	−0.07	−0.18*	0.02
30		1.00	0.86***	0.73***	0.64***	0.57***	0.54***	0.77***	0.21**	0.19*	0.19*	−0.01	0.05
60			1.00	0.89***	0.79***	0.73***	0.68***	0.75***	0.68***	0.33***	0.26**	0.03	0.04
90				1.00	0.93***	0.85***	0.78***	0.69***	0.68***	0.71***	0.42***	0.02	−0.02
120					1.00	0.93***	0.86***	0.65***	0.61***	0.61***	0.74***	0.08	0.01
150						1.00	0.95***	0.64***	0.58***	0.67***	0.71***	0.43***	0.12
180							1.00	0.60***	0.53***	0.58***	0.67***	0.49**	0.41***
Growth													
Birth – 30								1.00	0.33***	0.29***	0.30***	0.14	0.05
30 – 60									1.00	0.36***	0.22***	0.08	0.00
60 – 90										1.00	0.50***	−0.01	−0.10
90–120											1.00	0.17*	0.06
120–150												1.00	0.32***
150–180													1.00

* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

Table 21. Seasonal variation in weight of breeding cows at Um Banein, 1984/85.

Parameter		Season of weighing			
		Late wet summer	**End of cold winter**	**End of hot summer**	**Early wet summer**
Number of cows		89	95	89	90
Mean weight	(kg)	315.4	261.9	253.1	299.4
	(s.d.)	50.3	40.0	41.5	48.1
	(range)	210-430	180-390	175-400	200-440

6. Milk production

Introduction

The profitability of a dairy enterprise depends on obtaining as high a level of milk production as possible within local nutritional constraints, relative to the maintenance cost of the animals.

The milk production parameters studied were total lactation yield, lactation length, yield per day of lactation and annual milk yield. The last was calculated in an attempt to combine reproductive performance and milk production in order to define one of the most important parameters of a dairy enterprise. Lactation curves were also established, bearing in mind their potential importance in the nutritional management of Kenana cattle.

Uncorrected means and standard deviations for the main parameters of milk production are shown in Table 22. The data relating to parturition interval have already been presented in Figure 10.

Production traits

The uncorrected mean lactation milk yield for all cows calculated for the years 1957-83 was 1160 ± 17.8 kg with a coefficient of variation of 74.3%. The highest yield was 4530 kg. This mean for both station-bred and foundation cows included many zero yields which were largely due to missing data in the early years of the station: when these records were discarded, the mean for station-bred cows was 1511 ± 18.7 kg with a coefficient of variation of 44.4%. Uncorrected means for years and for lactation number are shown in Figure 16.

The mean lactation length of all cows was 198 ± 2.4 days, with a coefficient of variation of 59.3%. For station-bred cows, excluding zero yields, it was 257 ± 1.9 days with a coefficient of variation of 26.7%. Variation of lactation length with year of calving is shown in Figure 17.

The mean milk yield per day of lactation for all cows was 4.6 ± 0.06 kg, the coefficient of variation being 64.9%. For station-bred cows, with zero yields excluded, it was 5.7 ± 0.06 kg per day, with a coefficient of variation of 35.0%. The effects of year of calving and of lactation number on this variable are shown in Figure 18.

Lactation curves established from the uncorrected data are shown in Figure 19. The month in which lactation started did not appear to affect the shape or height of the curve. Year had a considerable effect on the height of the curve (i.e. the total amount of milk produced) but, with the exception of 1973, did not appear to affect the shape. In 1973, peak yield was not achieved until the second month whereas in all other years yield peaked in the first month.

Table 22. Lactation milk yield, lactation length and milk yield per day of lactation in Kenana cattle at Um Banein.

Class of cow	n	Lactation yield(kg)	Lactation length(days)	Yield per day of lactation (kg)

		x̄	±	s.d.	x̄	±	s.d.	x̄	±	s.d.
Foundation + station-bred	2362	1160		863.3	198		117.8	4.6		2.32
Foundation + station-bred without zero yields	1564	1497		728.8	251		73.2	5.7		2.28
Station-bred	1995	1162		831.9	202		117.8	4.6		2.82
Station-bred without zero yields	1281	1511		671.2	257		68.6	5.7		1.99

Figure 16. Total lactation yields of Kenana cows at Um Banein in relation to (a) year in which lactation started and (b) lactation number.

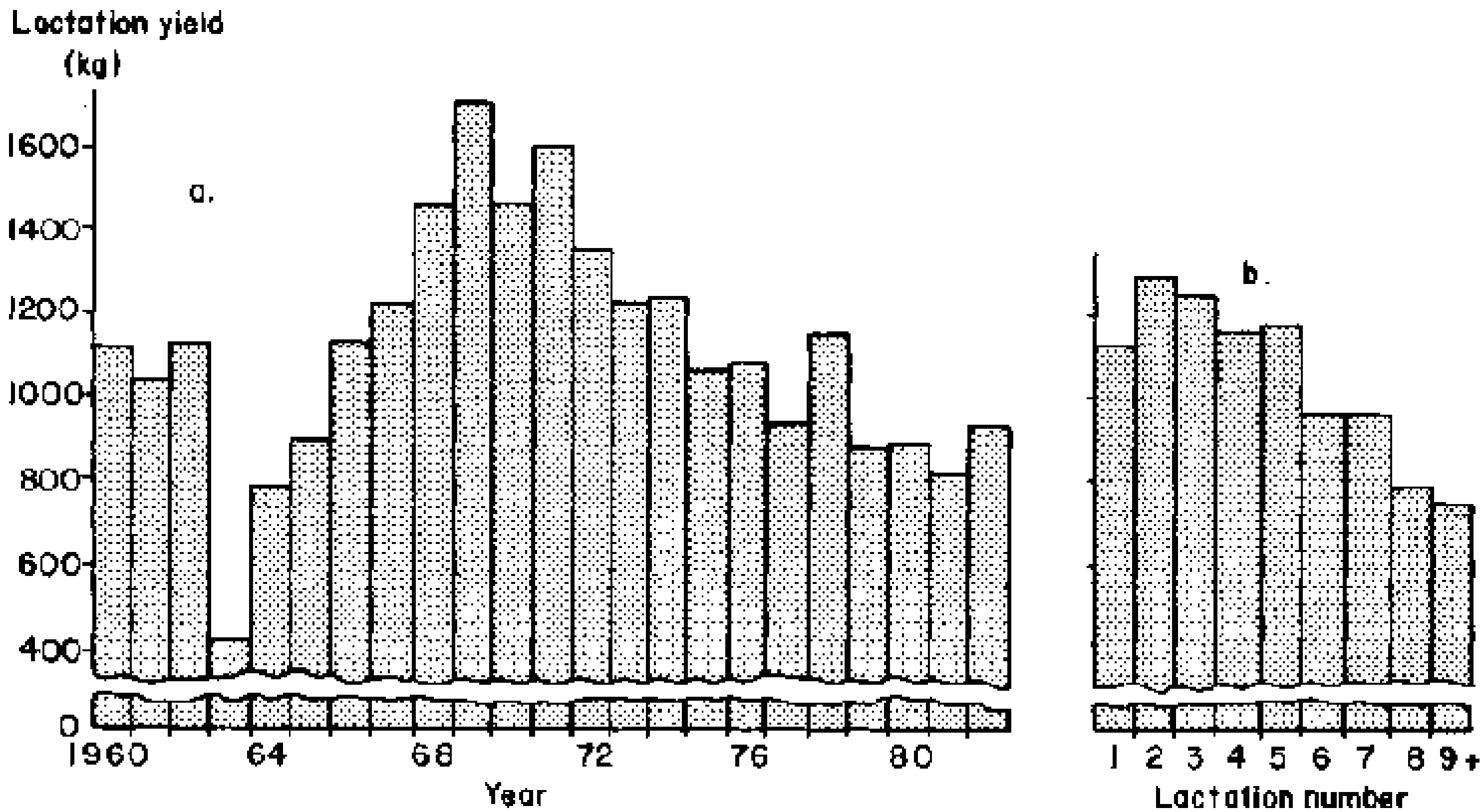


Figure 17. Lactation length of Kenana cows at Um Banein in relation to (a) year of commencement and (b) lactation number.

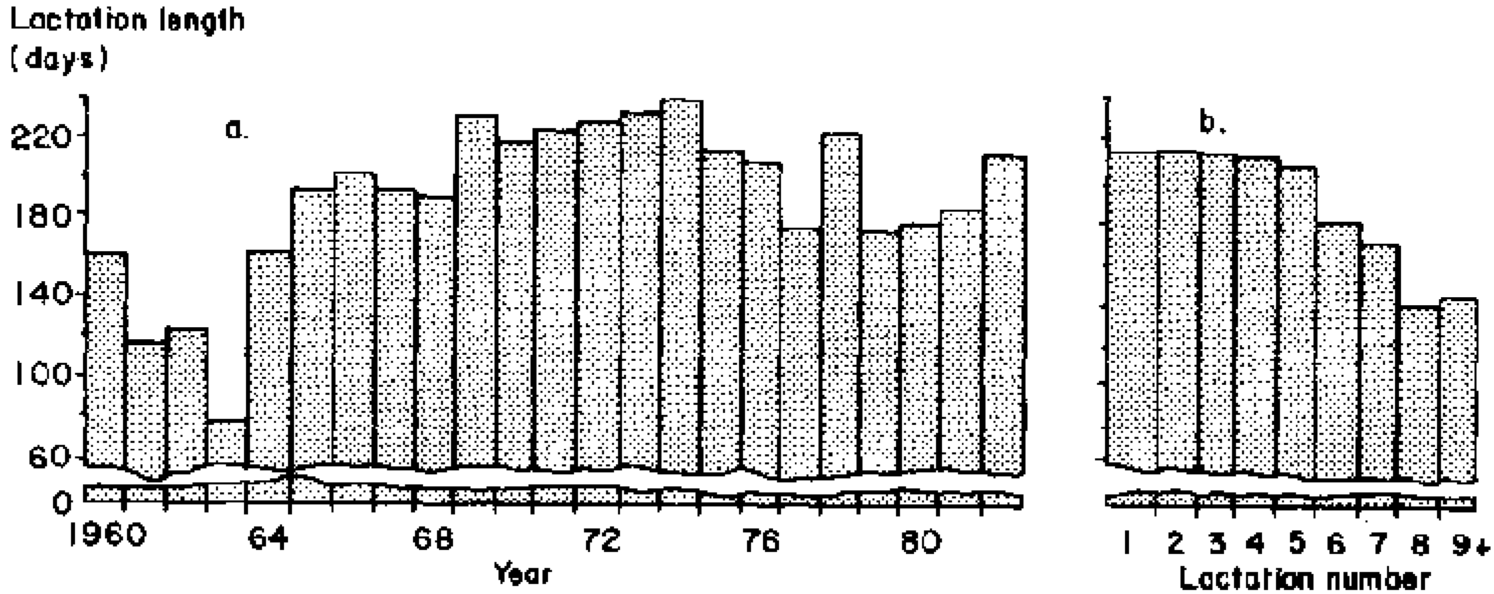


Figure 18. Milk yield per day of lactation of Kenana cows at Um Banein in relation to (a) year in which lactation started and (b) lactation number.

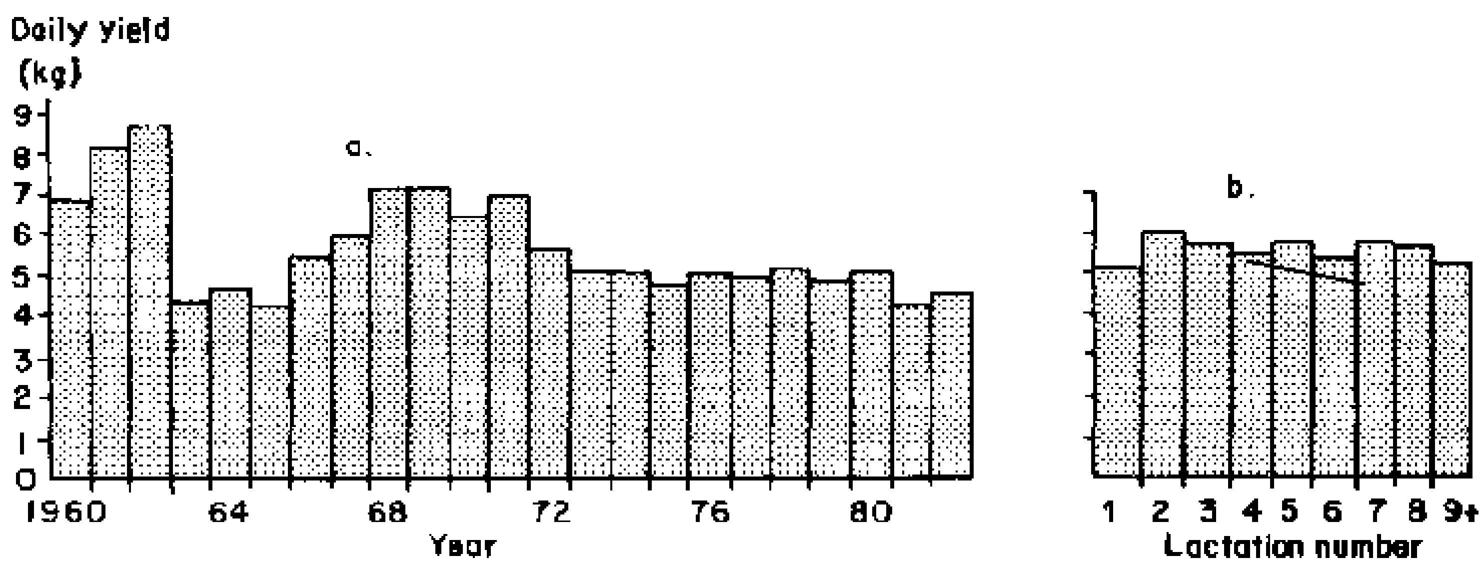
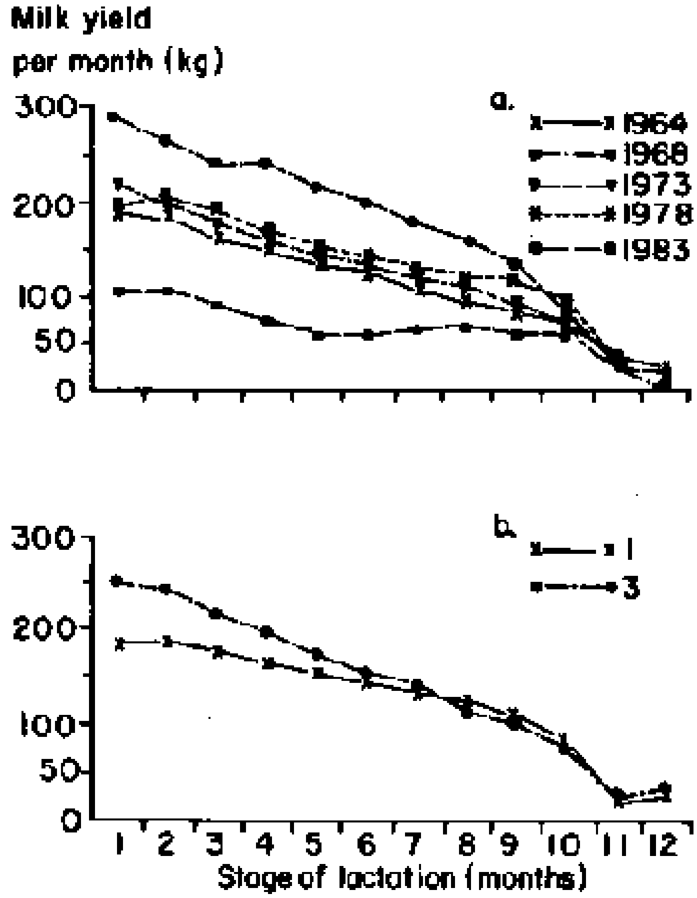


Figure 19. Lactation curves of Kenana cows at Um Banein for (a) selected years and (b) lactation numbers.



Effects of lactation number appeared to be similar for all lactations except the first. The first lactation had a slightly delayed peak monthly yield and high levels of production persisted longer than in later lactations.

The mean squares from the analysis of variance are shown in Table 23. Dam was included in the analysis to remove the effects of repeat observations. Lactation yield was significantly affected by lactation number and year of calving but not by month of calving: similar effects were evident for yield per day of lactation, calving interval and annual yield. There were no significant effects of any of the fixed effects tested on lactation length.

The least-squares means for lactation yield, lactation length, milk yield per day of lactation, calving interval and annual yield are shown in Table 24.

Lactation yield increased significantly from the first to the third lactation. The year of calving also had a significant effect, with highest yields occurring in the period 1968-71.

Average daily yield as affected by lactation number and year showed a pattern very similar to lactation milk yield, mainly because lactation length differences were non-significant.

Annual yield increased from first to third lactations with fourth and fifth lactations not differing significantly from the first. Sixth, seventh and subsequent annual yields were very much less than those from younger cows.

When cow origin (foundation or station-born) was considered as a source of variation in the analysis for these traits, it was shown to have no significant effect.

The repeatabilities of the traits (established only for station cows, with zero yield excluded) were 0.37 ± 0.030 for lactation yield, 0.29 ± 0.030 for lactation length, 0.34 ± 0.030 for yield per day of lactation, 0.23 ± 0.031 for calving interval and 0.27 ± 0.030 for annual yield. There were highly significant differences ($P<0.001$) among dams for all traits studied.

The unadjusted mean lactation milk yield of 1497 kg is lower than that reported for the Gezira Research Farm and the Khartoum University herds (Table 25), although the Um Banein sample was larger and short lactations were not discarded.

The variation in milk yield with parity, exhibiting a significant increase from first to second and third lactations as shown in the least-squares analysis, follows the pattern for Friesians (Wood, 1969).

Table 23. Mean squares from the analysis of variance for lactation yield, lactation length, milk yield per day of lactation, calving interval and annual milk yield.

Source of variation	d.f.	Lactation yield	Lactation length	Milk yield per day of lactation	Calving interval	Annual variation yield
Dam	403	811 300***	8 898***	5.8***	45 747***	594 017***
Lactation number	6	2 629 485***	2 426	37.1***	154 006***	3 525 656***
Month of calving	11	225 483	2 597	1.4-	16 162	207 937
Year group of calving	3	7 678 337***	1 861	110.2***	103 314**	7 432 414***
Error	857	210 812	2 356	1.8	23 948	205 789

** P<0.01; *** P<0.001.

Table 24. Least-squares means for lactation yield, lactation length, milk yield per day of lactation, calving interval and annual milk yield.

Variable		n	Lactation yield (kg)	Lactation length (days)	Yield per day of lactation (kg)	Calving interval (days)	Annual yield (kg)
Overall L.S. mean		1281	1415.1	251.5	5.4	534	1067.0
Lactation number:	1	364	1415.5^{ad}	261.5	5.1^{a}	457^{a}	1189.3^{a}
	2	295	1547.5^{b}	258.6	5.8^{b}	465^{ab}	1288.9^{bc}
	3	225	1645.8^{c}	259.0	6.1^{c}	496^{b}	1334.0^{c}
	4	162	1487.8^{ab}	250.1	5.7^{b}	503^{b}	1185.9^{ab}
	5	111	1475.8^{ab}	252.3	5.6^{b}	544^{c}	1108.8^{a}
	6	65	1301.6^{d}	242.9	5.1^{a}	580^{c}	866.5^{d}
	>7	59	1031.6^{e}	236.0	4.2	692^{d}	495.6^{e}
Average S.E.			64.17	6.76	0.18	19.2	60.01
Month[1]:	January	118	1377.9	246.0	5.3	526	1034.3
	February	116	1417.1	249.6	5.4	494	1156.3
	March	125	1542.9	262.2	5.7	537	1177.1
	April	105	1420.5	253.9	5.4	531	1048.1
	May	121	1348.5	245.0	5.3	549	1012.0
	June	95	1398.9	246.4	5.3	541	1031.0
	July	89	1337.4	243.3	5.3	538	982.3
	August	81	1490.6	257.8	5.6	551	1087.4
	September	93	1410.0	248.2	5.4	529	1047.1
	October	107	1408.9	252.0	5.3	528	1079.8

	November	96	1413.3	254.3	5.3	526	1079.1
	December	135	1415.0	259.1	5.3	536	1069.7
Average S.E			66.93	7.06	0.19	20.4	63.03
Year group[1]:	1964-1967	154	1162.7^{a}	243.9	4.5^{a}	621^{a}	733.8^{a}
	1968-1971	370	1724.9^{a}	248.3	6.7^{b}	530^{b}	1350.2^{b}
	1972-1975	469	1328.2^{a}	251.6	5.1^{a}	521^{b}	1011.5^{c}
	1976-1980	288	1444.5^{a}	262.1	5.3^{a}	463^{c}	1172.5^{b}
Average S.E.			73.50	7.72	0.21	22.6	69.55

[1] Refers to month and year-group of commencement of lactation.

Within variables, means in the same column without a common superscript differ significantly ($P<0.05$).

The significant effects of year-group can be related mainly to the levels of management and stocking rates on the station. For example, when analysis was carried out for individual years rather than year-groups, cows calving in 1969 had a significantly higher milk yield than cows calving in all other years except 1968. The 1969 yield was attained after overcoming the early critical management problems of the station but before stocking rates became excessive during the 1970s (Figure 6). As can be seen from Table 25, the unadjusted mean of 1718 kg for 1969 is within the range of yields from the other Kenana herds. Lactation yields were lower during the 1970s, this being related to the higher stocking rates in those years.

The number of yields in excess of 2000 kg has also followed a similar pattern (Figure 20). A total of 192 cows gave 381 lactations of over 2000 kg, the majority being foundation cows or cows born in the 1960s. These yields represent some 16% of lactations used in the analyses.

The large variation in milk yield due to year of calving, related to stocking rate and management levels, implies that selection should be based on comparison of yields within years and not between or among years.

The lack of effect of month of calving on lactation yield at Um Banein, despite very marked seasonal climatic variation, may be explained by the provision of some irrigated fodder in the earlier years and supplementary feeding provided in the dry season. Alim (1960) also reported no effects due to month of calving, with similar seasonality of irrigation. In later years, when there were shortages of fodder during the dry summer, the weight changes of the cows may have had a buffering effect which prevented significant milk yield differences.

Table 25. Lactation data from Kenana cattle herds.

Herd and source of data	n	Lactation yield (kg)	Lactation length (days)	Calving interval (days)	Annual yield (kg)
Gezira Research Farm (Alim, 1960)	539	1613	224	395	1491
Khartoum University (El Amin, 1969)	1537	1860	294	428	1568
Um Banein (present study)	2362	1497	251	479	1141
Um Banein (1969 only)	102	1718	230	432	1451

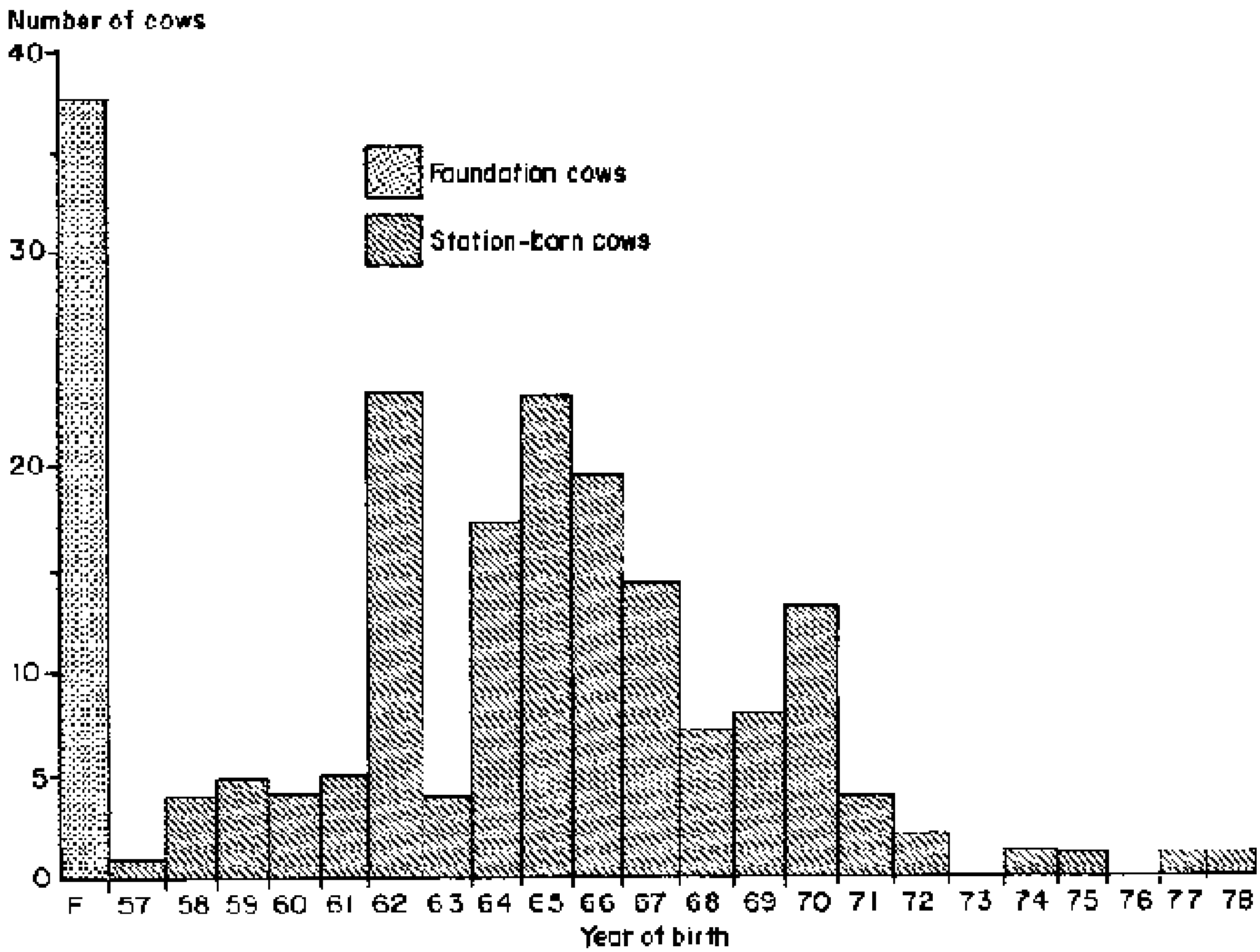
The Kenana would appear to compare favourably with other zebu breeds in Africa in terms of lactation yield; Kimenye (1981) reported an average yield of 1455 kg from 3995 records from the Kenyan National Sahiwal Stud.

The lactation length reported from these data can be compared with records from other Kenana herds (Table 25) and is intermediate between the two others quoted.

Milk yield per day of lactation followed a similar pattern to that outlined for lactation milk yield as regards the effect of parity because lactation length showed no significant variation with parity. Similarly, the significant effect of year-group of calving showed a maximum daily yield in the period 1968-71 with a continuing fall thereafter.

The conclusions to be drawn from the effect of the variables investigated on annual milk yield are of importance as this parameter amalgamates the individual lactation traits with reproductive performance. The effect on annual yield of a longer calving interval combined with lactation traits shows a fall in productivity from the fifth to the seventh lactation, which suggests the need to consider culling all but the highest yielding cows at this time. As with other lactation traits, year-group had a significant effect. This may be related to improved management during the 1960s. The maximum adjusted mean was again observed in 1969. The high stocking rate of the 1970s must largely explain the fall in annual yield. The increased lactation length and decreased calving interval noted after the destocking in the early 1980s may have ameliorated the effect of lower yield per day of lactation and thus caused a small increase in annual milk yield.

Figure 20. Numbers of cows (foundation and station-born) having records in excess of 2000 kg of milk per lactation.



Although lactation yield at Um Banein was only slightly lower than in the other herds (Table 25), the long calving interval meant that the annual yield was much lower. The figure for the "best" year (1969) at Um Banein, with higher yields and a shorter calving interval is, however, similar to the other data. The analysis shows the importance of matching animal numbers to feed supply by controlling stocking rates.

The effect of parity on the lactation curve is as could be expected from references to Friesians (Wood, 1969) and zebu cattle (Rao and Sundaresan, 1979). The lactation curves were characterized by peak yields occurring immediately after calving, whereas in most cattle the peak occurs 42 to 60 days after calving. These results imply that cattle at Um Banein were underfed before parturition and until 60 days after parturition. Further investigations on changing the pattern of supplementary feeding, with more emphasis on these earlier stages and a reduction in feed supply in late lactation, would seem to be warranted. A study on 37 cows carried out during the "best" period of Um Banein showed that peak lactation occurred 56 days after calving (Bashir, 1969).

7. Mortality and offtake

Introduction

High survival rates are important in dairy enterprises not only to ensure a continuing supply of replacement heifers for the milking herd but also to provide a flow of males for subsidiary beef enterprises and for sale as improver bulls. Low survival rates reduce the possibilities of high intensities of selection for desired production characteristics and, by increasing the generation interval, lead to slower rates of genetic gain.

Reasons for exit of 3767 animals from Um Banein were noted in the period 1958-84 and have been used in these analyses.

General pattern and reasons for exits

The data were classed into six principal reasons for exit. The overall numbers and percentages for these are shown in Table 26. It appears that most animals have been culled in recent years, this probably resulting in part from the policy of destocking carried out on the station. Most animals sold for breeding were disposed of during the late 1970s and in the 1980s. Sales for meat in the 1980s are also consonant with the destocking policy.

Abortions were more common in the early years after the establishment of the station. In the ten years 1976-85 there were only six abortions (7.8% of exits for this reason), three of which occurred in 1984. The small number of stillbirths recorded does not show any particular temporal pattern. Highest mortalities were recorded soon after the establishment of the station and again in the early 1970s.

In general, it would appear that Um Banein has achieved some success in one of its stated aims, by making available a total of almost 1000 animals for breeding off the station. Males were disposed of when young, the majority before 2 years old (Figure 21). The principal reason for sale of males was under the rubric "meat", but as 72.5% of males were sold at under 2 years old and weighing less than 100 kg, most were apparently sold for growing on. Most females left the station at 4 to 5 years old, corresponding to sales of in-calf heifers. Culling for low productivity after the first lactation also accounted for some sales at this age and for most of the offtake of 5- to 6-year-old cows. Some females were also culled for infertility at these youngish ages.

Figure 21. Patterns of offtake (sales and culling) related to sex and age for Kenana cattle at Um Banein.

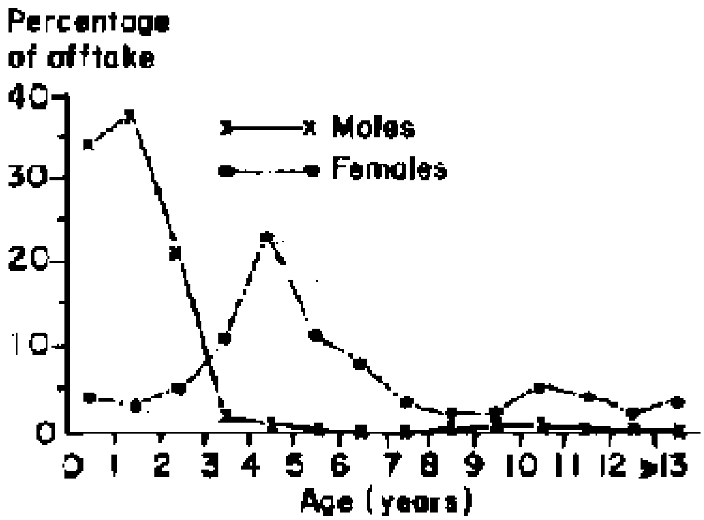


Table 26. Reasons for exit of cattle from the Um Banein herd.

	Reason for exit					
	Sold for meat	**Sold for breeding**	**Culled**	**Abortions**	**Stillbirths**	**Death**
Number	756	969	1230	77	16	719
Percentage	20.1	25.7	32.7	2.0	0.4	19.1

Mortality

Age-specific mortality

Figure 22 shows the age-specific hazard rates for Kenana cattle at Um Banein and the percentage of animals surviving at a given age. The risk of dying is greatest during the neonatal period (including abortions and stillbirths) and up to the age of 1 week. From 1 week old to weaning at 120 days the mortality rate was considerably lower. After weaning, calves were again at risk and there was a slight increase in the mortality rates in the two periods 91 to 180 and 181 to 270 days of age. Survival rates were in general quite high once these crisis periods had been passed.

The overall mortality rate to 1 year was about 16.6%. For animals more than 1 year old, mortality levels were much reduced, such that 75.6% of all animals born survived to 10 years of age (animals sold or culled are, of course, not included in calculations of mortality rates).

The effects of environmental influences on the mortality rate are shown in Figure 23. There were significant differences in mortality rates due to the effects of season of birth ($P<0.01$), the period of birth in relation to station establishment ($P<0.001$) and to the sex of the calf ($P<0.001$).

More calves born in the wet summer died than those born in the cold winter and hot summer seasons. Highest levels of mortality after the neonatal period were evident in calves born in the wet summer in the age ranges 181 to 270 and 271 to 365 days. These periods correspond with the late winter and the whole of the hot summer.

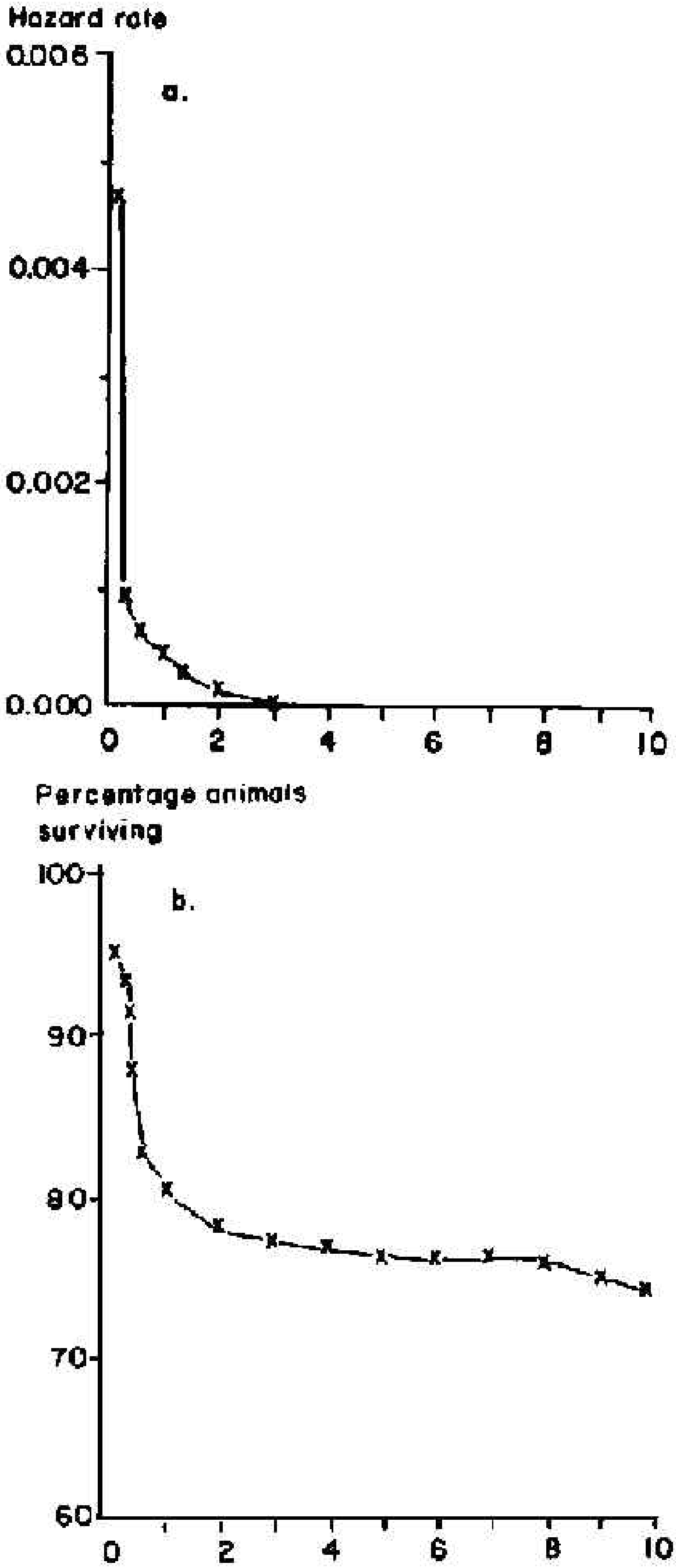
High levels of mortality were evident in the early years after station establishment and again in the early 1970s. The mortality rate for all five groups of years followed the general trend, irrespective of total within-group levels, in that the highest mortality risk was met within the first year of life. Quite high levels of risk did, however, occur in cattle born in the period 1971-75 well into their third year of life, and there was a similar although less pronounced pattern in animals born prior to 1965. The group of animals born since 1981 shows a constant high level of mortality through 1985 due, undoubtedly, to the low and poorly distributed rainfall in this last period.

Females had higher survival rates than males at all stages of life except for animals in excess of 8 years old: there were, of course, very few males of this age in the herd at any one time and these would all be breeding bulls.

Causes of death

Deaths (other than abortions and stillbirths) were assigned to five principal causes. Three of these poor nutrition, disease and digestive problems were responsible for more than 97% of all losses. An analysis of the losses by year grouping is shown in Table 27.

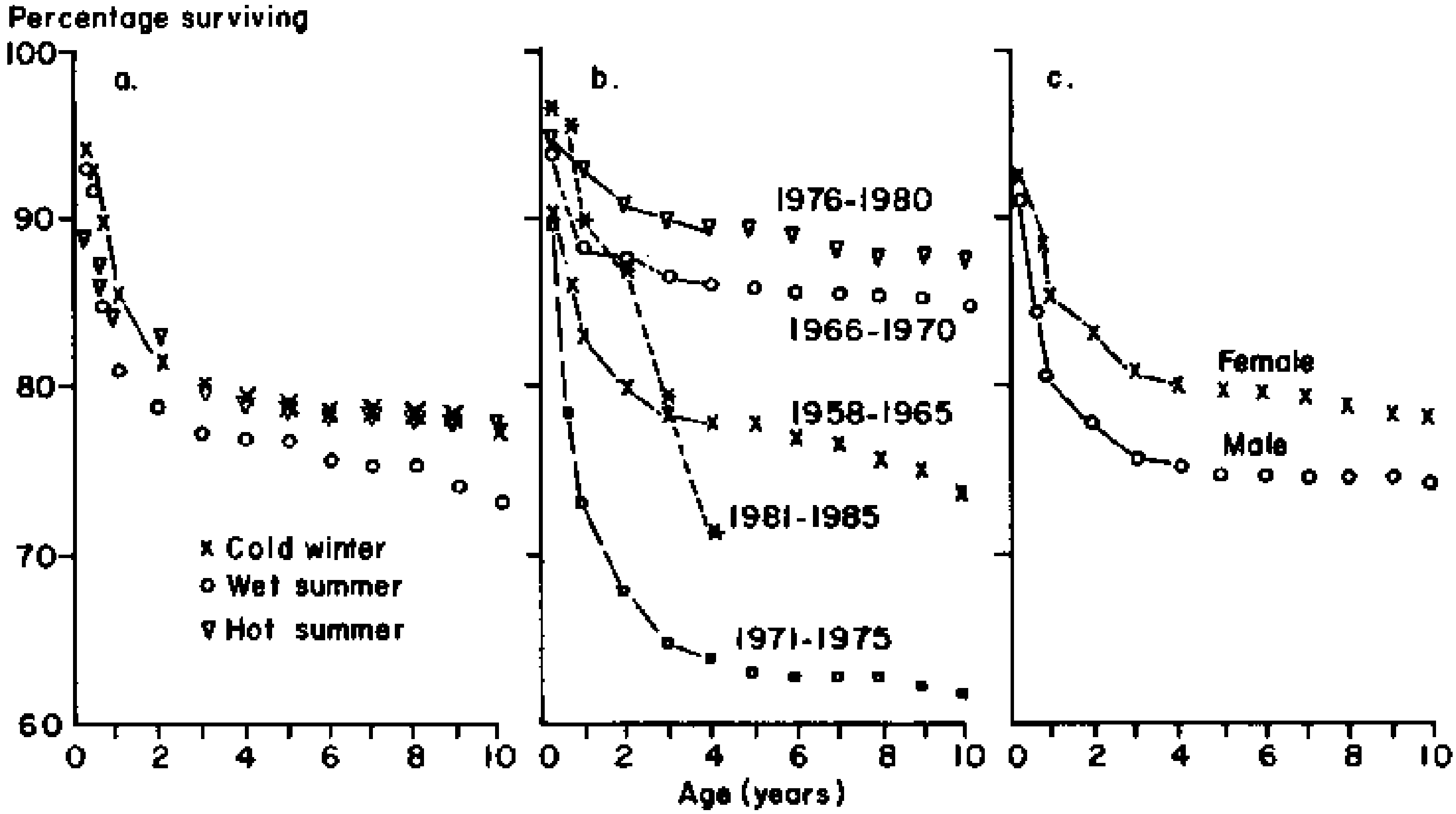
Figure 22. Overall age-specific hazard rates (a) and cumulative percentage of animals surviving (b) at different ages for Kenana cattle at Um Banein.



Age (years)

Figure 23. Effects of (a) season of birth; (b) year group of birth and (c) sex on percentage of

Kenana castle surviving at Um Banein.



Culling

A total of 1230 animals was recorded as culled. The principal reasons were similar to those recorded for deaths but with the addition of low production (i.e. milk) and infertility. These two causes together accounted for 65.2% of all animals culled, while mastitis and old age together accounted for a further 19.0%. A full breakdown of reasons for culling by time period is given in Table 28.

Discussion

The culling policy has been partially effective in removing from the herd low-yielding cows and those with poor reproductive performance. Several cows were, however, culled for disease (with contagious bovine pleuro-pneumonia being the principal one) and for "digestive problems" as well as for low inherent productivity. There is evidence that in recent years disease and digestive problems have been largely overcome and that at the same time culling on performance has become more rigorous. In fact, about 25% of all cows culled for low milk production in the history of the station were removed from the herd in 1985.

Table 27. Causes of mortality (except abortion and stillbirth) in Kenana cattle at Um Banein (n = 719).

Year group	Cause of mortality (%)						Total
	Poor nutrition	Old age	Disease[a]	Digestive problems	Calving difficulty	Other	
1958-1965	1.1	0.0	14.6	14.6	0.3	0.1	30.7
1966-1970	0.1	0.0	4.0	4.2	0.1	0.1	8.5
1971-1975	20.0	0.1	13.1	6.3	0.4	0.6	40.5
1976-1980	6.1	0.1	1.4	3.2	0.0	0.2	11.0
1981-1985	5.4	0.0	0.0	2.1	0.3	0.4	8.2

Not recorded	0.7	0.0	0.3	0.1	0.0	0.0	1.1
Total	33.4	0.2	33.4	30.5	1.1	1.3	100.0

[a] Estimated 88% due to contagious bovine pleuro-pneumonia.

Table 28. Reasons for culling of animals from the Um Banein herd (*n = 1252*).

Year group	Reason for culling (per cent)							Total
	Poor nutrition	Low production	Infertility	Old age	Mastitis	Disease[a]	Other[b]	
1961-1965	0.6	2.8	10.8	0.0	0.0	1.1	0.2	15.5
1966-1970	0.3	4.0	7.4	1.1	1.9	0.4	0.7	15.8
1971-1975	1.5	1.5	8.6	1.0	1.3	1.6	0.1	15.6
1976-1980	1.9	3.2	14.3	2.9	3.7	0.7	0.5	27.2
1981-1985	1.5	7.3	5.2	4.6	2.4	2.9	0.5	24.4
Not recorded	1.1	0.0	0.1	0.1	0.0	0.2	0.0	1.5
Total	6.9	18.8	46.4	9.7	9.3	6.9	2.0	100.0

[a] Mainly brucellosis; [b] Includes digestive problems, lameness, calving difficulty and injuries.

The policy of early sale of males or their transfer to places in which feed conditions are better should be pursued vigorously in conjunction with attention to culling females on productivity. The aim should be to reduce as much as possible the number of non-productive animals on the station in order that the proportion of breeding cows in the herd approaches or exceeds 50°%.

Mortality rates to 1 year of age are comparable to or even higher than those found in traditional systems (Wilson and Clarke, 1976), which do not have the same theoretical access to supplementary feed supplies and veterinary care. Special attention should be paid to reducing the neonatal death rate and to increasing survival in the immediate post-weaning period. Not all the weaned animals, however, encounter the same risks. Calves born in the wet summer have a higher mortality rate than other young animals, largely as a result of heavy post-weaning mortality. Winter and hot summer management of these animals should aim at giving them preferential access to feed resources during this period in order to increase their survival rate.

The dangers of high stocking densities and concomitant poor nutrition at any time are amply demonstrated by this analysis. These effects persist even when, as has happened in the 1980s, stocking rates are reduced. The high death rate in older stock in this last period probably results in part from the earlier overgrazing which has reduced primary production from the station over the medium term.

8. Conclusions and recommendations

Introduction

The analyses show large variations in most of the production traits studied: nevertheless, the data support earlier suggestions that the Kenana might be among the most productive African dairy breeds. Although, for reasons which have already been discussed, growth and reproductive performance were not outstanding in the herd over the period studied, results from specific short-term studies of cattle under improved nutrition show that the performance of Um Banein cattle compares favourably with that of other Kenana herds and with other breeds.

An important point emerging from the analyses is that a large proportion of the variation in the major production traits can be accounted for by effects of year and year-group. Most traits showed improvement throughout the 1960s, but deterioration during the 1970s. Some traits then apparently showed a slight improvement during the 1980s.

The effects of management and climate are clearly important in the context of these analyses. A consideration of the rainfall (Figure 2) does not explain fully the variation in the traits, but a consideration of the livestock numbers (Figure 6) shows that the pattern would seem to be related to the very high stocking rates in the 1970s, which would have reduced the nutritional levels of all stock.

The destocking implemented since 1980 appears to have had a beneficial effect, despite a further reduction in the carrying capacity of the farm due to declining rainfall, irrigation problems and lack of funds for purchased feeds and fertilizers.

Excessive stocking rates not only reduced productivity per cow, but also total farm productivity. Table 29 illustrates this point in its comparison of 1969, the year with the highest performance, and 1979, the year with the highest stock numbers. It is therefore important that the station management should match stock numbers to the carrying capacity of the farm, taking into account the probable supply of home-grown fodder and the budget available for purchased feeds. These management policies should be related to immediate short-term possibilities as well as to a longer term plan.

Table 29. A comparison of cattle productivity and milk production in "best" and "worst" years at Um Banein.

Year	Total cattle	Total calvings	Total milk production (kg)
1969	430	175	366 625
1979	700	145	212 280

Variations due to management could also be minimised by reducing the rapid turnover of research staff. It is appreciated that some transfers and promotions are required, but in order to limit the disruptions due to these, it would seem preferable to define management guidelines for the longer term.

Future management of the station

Herd size and structure

In view of the importance of matching stock numbers to feed resources, the recommended herd size would be about 430 cattle, including 180 adult cows (Table 30). The cow herd could be increased to 220 without increasing total numbers if age at first calving were to be reduced to 3 years.

A carrying capacity of 430 cattle assumes that the pumping equipment currently being installed will operate satisfactorily on a permanent basis and that the station budget will not decrease in real terms; at present (January 1986) the station can only support a total herd of 200 animals and the increase in herd size to 430 head should only be attempted gradually, as and when fodder availability is assured.

Table 30. Suggested total herd size and composition at Um Banein.

Class of stock	Herd composition	
	%	numbers
Adult cows	42	181
Heifers (3-4 yrs)	10	42
Heifers (2-3 yrs)	11	46
Heifers (1-2 yrs)	12	50
Calves (0-1 yr)[a]	23	101
Breeding and replacement bulls	2	10
Total herd	100	430

[a] Both sexes.

Culling policy

The data show that in the past a large proportion of culling has been due to such reasons as disease, digestive problems and infertility rather than due to milk production *per se*, although rather more culling on production has occurred in recent years.

Most disease and digestive problems appear to have been overcome as preventative animal health measures have become part of the normal management routine. Large numbers of animals have been culled for infertility in the past and although this might remain a major reason for culling, especially in older animals, the number of maiden heifers and younger cows in the breeding herd has been very high; this would seem to be related to the pre-1985 policy of keeping all females regardless of the dam's yield.

A new policy, implemented since 1985, was the culling of female calves from low yielding dams immediately after birth, unless they were needed as replacements.

A strict system of culling adult cows based on a "Most Probable Producing Ability" (MPPA) should now be followed, those animals with the lowest index being culled.

The MPPA is calculated as:

$$\text{MPPA} = \frac{\text{Herd average} + nr \times (\text{Individual yield} - \text{Herd average})}{1 + (n-1)r}$$

where

n = Number of records for the individual
r = Repeatability of the trait

In this formula, individual production records should be adjusted for lactation number, then expressed as deviations from herd-year mean and then averaged. Selection and culling policies based on this index would then be as outlined in Table 31. This system is to be recommended in that it gives a framework for culling on milk yield rather than the ad hoc basis apparently used previously. Bull calves not required for the herd or for distribution should be sold as soon after birth as possible, as should heifers not required as replacements.

Calf rearing

The low calf weaning weights underline the importance of good calf management. Weaning at 60 days can be recommended to maximise profit. Milk should be given at the rate of 10% and 8% of liveweight for the first and second month respectively. Special attention to the nutrition of weaned calves (i.e. 4 to 12 months old) is recommended to avoid deaths. This applies especially to those calves born in the wet summer and being reared over the winter and hot summer.

Research at Um Banein shows that a concentrate is required and that molasses-based supplements do not appear to be capable of producing the growth rates required in Kenana calves of this age.

Heifer rearing to first calving

Heifers will inevitably be reared on a system based on the poorer forages available and so it is unlikely that maximum growth rate can be achieved economically; however, dry-season supplementation based on molasses/urea diets has been shown to support growth rates that allow heifers to calve first at 36 months old and this should be adopted as station policy. Improved nutrition will also help to improve the poor reproductive performance.

Dairy cow management

An important point arising from the analyses is the importance of matching stock numbers to feed resources not only in the long-term but also in individual years. Subjecting dairy cows to prolonged nutritional stress reduces annual production, and in this context the dry summer is the most critical period at Um Banein. One of the easiest ways to overcome the shortage of good-quality feed is to conserve sorghum as high-quality silage rather than as low-quality straw. If straw has to be fed, adequate supplementary feed should be provided. Minerals, which have been used only sporadically, should be provided routinely.

The shape of the lactation curve at Um Banein implies that feeding pre- and immediately post-parturition is inadequate and that high-quality forage and concentrate should be provided during these periods.

Table 31. Proposed selection policy for Um Banein based on "Most Probable Producing Ability" of cows.

Herd	Percentage of herd	Current yield(kg)[a]		Destination of calves group	
		$\bar{x}$	range		
Elite ('E')	10	2107	1725-2760	Bulls:	stud at Um Banein, other stations or nucleus herds
				Heifers:	Um Banein herd
'A'	30	1568	1445-1724	Bulls:	distribution in traditional sector
				Heifers:	Um Banein
'B'	30	1161	800-1444	Bulls:	curled for meet
				Heifers:	culled (unless numbers from 'E' end 'A' groups insufficient to maintain Um Banein herd)
Low yielders ('L')	10	342	5-799	Bulls:	culled
				Heifers:	culled
				(Cows:	culled as soon as numbers in other groups sufficient)
First calf heifers	20	-	-		-

[a] Station average yield currently assumed to be 1445 kg.

The drop in production after the sixth lactation implies that most cows should be considered for culling at that stage unless in the 'E' or 'A' groups.

Research

The research carried out at Um Banein should be of an applied nature aimed at helping producers overcome the main constraints on milk production. Surveys in the Singa area and at the Gezira Dairy Co-operative (Devine, pers. comm.) have shown that cows do not produce to their genetic potential in farmers' herds and that feeding is the principal factor limiting milk production. Thus research and development on applied nutrition should be the priority.

Some aspects requiring further study are listed below.

Two-month weaning

Further studies should be carried out to provide information on the types and quantities of forage and concentrate ingredients which can be used in this system. Earlier weaning may also be attempted.

Post-weaning growth (weaning to 1 year)

At present, results indicate that a concentrate is needed to maintain adequate growth rates and that molasses-based diets are not adequate; further work on the most cost-effective concentrate is required.

Heifer rearing

Heifers will normally be reared on rainfed grazing and crop stubbles, with irrigated fodder being used for milking cows and calves; thus work should continue on dry-season supplementation. Molasses/urea-based diets have been shown to be useful in this respect and further studies should be carried out in addition to trials on treatment of crop residues.

Genetic potential of the kenana

The current analyses show that the true potential of the Kenana is still not known. A trial should thus be carried out on a group of 'E' cows using high-energy (sorghum grain) and high-protein concentrates together with *ad lib* green fodder or silage for a complete lactation cycle. A parallel trial could also be conducted using the other main Sudanese breed, the Butana: animals from Atbara Research Station should be brought to Um Banein for this comparison.

Such an experiment can only be carried out if adequate funding is provided, and at present the station cannot carry out such work due to lack of funds. (Work is possible with calves and heifers as the additional cost is small.)

Supplementary feeding

A series of trials should be carried out to assess production from *ad lib* feeding of the main forages, alone and with varying levels of concentrate, to establish the response curves to concentrate feeding in the Kenana. Further studies should also be carried out on the total amount and the distribution of concentrate feeding over the whole lactation.

Reproduction

The fact that fertility and fecundity appear to be higher in the hot summer than in other seasons warrants further study as it seems to conflict with the observed effects in most other areas of similar ecology and with related types of cattle.

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Appendix A - Earlier experimental work on growth and weight

These results (which would otherwise not be widely available) are presented in order to show the type of experimental work carried out at Um Banein and elsewhere on Kenana cows. The original copyright owners are thanked for permission to publish.

Effects of dietary protein levels on early growth of calves

In 1977, an experiment was carried out at Um Banein to determine the effects of different levels of dietary protein on growth of calves aged approximately 8 months at the start of the experiment. This section is taken in its entirety from Ahmed and Pollot (1978).

Materials and methods

Forty-five weaned calves (20 males and 25 females) were allocated to three groups in such a manner that mean weights and sexual composition of each group were as similar as possible. Prior to the experiment, calves were weaned at 4 months old and had subsequently been kept on rainfed grazing. The groups were penned separately and fed on groundnut hay for an adaptation period of 3 weeks. The concentrate ration was introduced gradually and at the end of the adaptation period all animals were weighed after an overnight fast. The experimental period was 112 days, animals being weighed every 2 weeks during this time, again after an overnight fast.

The concentrate supplements (Table A.1) were formulated to contain 100, 150 and 200 g digestible protein/kg DM but all rations had a similar concentration of metabolisable energy (ME). Concentrate was provided at 2 kg/head per day until day 35 when it was increased to 3 kg/head per day: groundnut hay was provided *ad lib* throughout. The total ration was provided on a group basis and all refusals were weighed to the nearest 100 g. Clean water was provided *ad lib* and a mineral premix in the form of a block was also available. Each animal was de-wormed at the start of the experiment and sprayed against external parasites: each animal was injected with 1.000.000 I.U. of Vitamin A on two occasions during the experiment.

Results

Liveweight and growth performance data for the groups assigned to the three diets, and for males and females across the groups, are given in Table A.2. Males were significantly lighter ($P<0.05$) at the start of the experiment than females but there was no difference among groups. There were no differences in ages among the groups or between the sexes.

Groups B and C on the medium- and high-protein rations did not differ significantly (P>0.05) either in their final liveweights or in ADG. Both these groups, however, were significantly (P<0.01) heavier at the end of the trial and grew faster than Group A, which was on the low-protein diet.

Group A had a significantly lower (P<0.05) total DM intake than either Group B or Group C, there being no difference between the last two (Table A.3). Crude-protein intake increased from Group A to Group C as expected but Group A had a lower ME intake than the two higher protein groups due to its lower total DM intake. The efficiency of both feed and concentrate utilization increased with the protein content of the diet. Within-group regressions, compared by the pooled deviation method (Snedecor and Cochran, 1967), showed that the regression coefficient of ADG on initial weight did not differ significantly (P>0.05) between Groups A (r = 0.0069) and B (r = 0.0075) but both differed significantly (P<0.01) from Group C (r = 0.0006). There were, in fact, strong positive relationships (P<0.01) between ADG and initial weight for Groups A and B but not (P>0.05) for Group C.

Table A.1. Percentage composition of rations used to determine effects of dietary protein levels on growth of Kenana calves.

Diet composition	Ration and dietary protein level [a]		
	A 100 g/kg DM	B 150 g/kg DM	C 200 g/kg DM
Raw ingredients (%)			
Sesame cake	3	17	34
Sorghum grain	81	67	50
Molasses	15	15	15
Salt	1	1	1
Chemical analysis (g/kg)[b]			
Dry matter	871	874	878
Crude protein	117	155	201
Crude fibre	38	119	62
Ether extract	23	25	27
NFE	770	703	622
Total ash	42	58	78
Metabolisable energy	13.1	12.9	12.6

[a] Group composition: A and B = 7 males and 8 females each, C = 6 males and 9 females.
[b] Except metabolisable energy, which is expressed in MJ/kg.

Table A.2. Weight data and growth performance for three groups and two sexes of Kenana calves on different dietary protein levels.

	Group identity [a]			Sex	
	A	B	C	Male	Female
Number of animals	15	15	15	20	25
Initial age (months)	8.1	7.3	7.3	7.9	7.7
Initial weight (kg)	73	74	70	68	77

Final weight (kg)	135	158	166	147	158
ADG (g)	550	750	850	710	720

[a] For diet composition see Table A.1.

Table A.3. Feed intake and utilisation by three groups of Kenana calves on different dietary protein levels.

			Group identity [a]		
			A	B	C
Intake:	total DM	(kg)	4.3	5.0	5.0
	roughage DM	(kg)	2.0	2.5	2.7
	concentrate DM	(kg)	2.3	2.5	2.3
	crude protein	(g)	443	605	700
	ME	(MJ)	46	52	51
Utilisation efficiency (kg DM/kg gain):					
	total feed		7.8	6.6	5.8
	concentrate		4.2	3.3	2.7

[a] For diet composition see Table A.1.

Discussion and conclusions

Crude-protein levels of the three diets considered as a whole (i.e. including the roughage) were 10.3, 12.1 and 14.0% for Groups A, B and C respectively. These levels were adequate to support growth in Kenana calves, which responded to increased protein content with increased weight gains, although at the two higher levels there were no significant differences between the groups. Lighter animals grew more quickly at the highest protein level, which suggests that heavier calves can be fed lower protein diets without reducing their weight gain. Further work is required to determine if response to protein is related to age or to weight per se.

The efficiency of food conversion also in creased with protein level but between Groups B and C this was due to increased ADG as intake was similar. The lack of differences in ADG and total gain between males and females indicates that, in a dairy enterprise, highest economic returns would be obtained by feeding heifers high-quality rations to encourage early puberty and reduced age at first calving. Protein levels to be fed to beef cattle would depend on the balance among feed cost, gain and the value of the finished animal.

Greater weight gains of 970 g/head per day have been achieved with Kenana cattle fed rations consisting of 75% concentrate instead of the 50% concentrate ration used in this experiment. Greater proportions of roughages thus probably contribute to low ADGs but the need to make best possible use of locally available feed needs to be taken into account when formulating rations. Such locally available resources include molasses, oil-seed cake and wheat bran: further experimentation should incorporate these feeds into the rations to reduce the levels of grain sorghum, savings on which could then be used directly as human food.

Improving growth of pre-pubertal heifers

Two separate experiments were carried out, both of which were designed to increase the growth rates of heifers in order to reduce age at puberty and, as a consequence, at first calving. One experiment was carried out at Um Banein (Pollot and Ahmed, 1979a) and the other at the University of Khartoum using heifers obtained from Um Banein (El-Khidir et al, 1979).

Trials at Um Banein

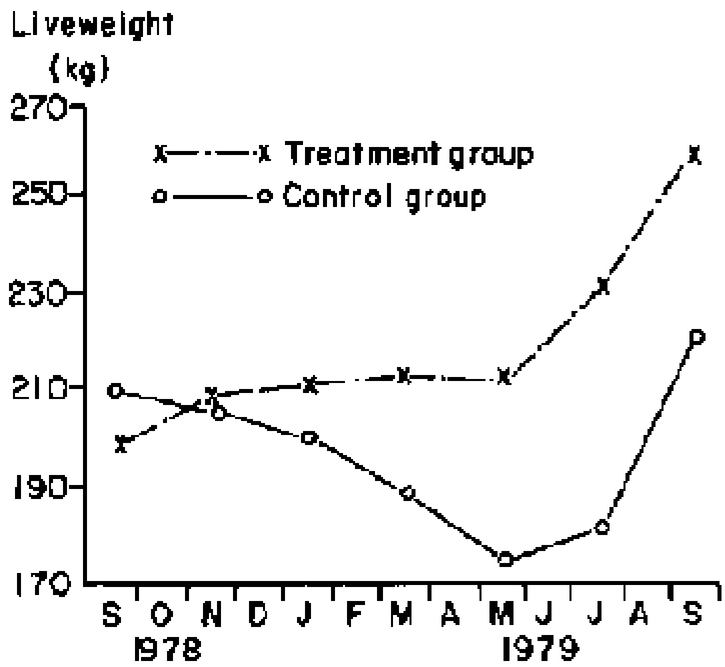
Materials and methods

The experiment was essentially a continuation of the trial on the effects of dietary protein levels on early growth. After the completion of that experiment, 27 heifers were returned to rainfed grazing and in addition received 1 kg/head/day of a concentrate mix. These heifers averaged 200 kg at an age of 1.5 years in September 1978 and were compared during the 12 month experimental period with 22 heifers aged 3.5 to 4.0 years in the main herd weighing 209 kg at the start of the period. The latter group was allowed range grazing only during the experimental period. Both groups of animals were weighed seven times, once at the beginning of the experiment and subsequently at intervals of 2 months.

Results

Patterns of the weight changes of the two groups are shown in Figure A. 1. Animals in the control group started to lose weight in the early dry season, while heifers that were fed concentrates not only maintained weight throughout the cold winter and hot summer periods but also increased on average by 13 kg from September to May. The treatment group also started to gain weight earlier following the onset of rain. During the main part of the rainy season, the control group gained 46 kg compared with 28 kg by the treatment group but control animals were 35 kg lighter than the treatment animals at the end of the experiment in spite of being 9 kg heavier at the start.

Figure A.1. Seasonal changes in weight in two groups of Kenana cattle on range grazing with the treatment group fed 1 kg concentrate per day as a supplement.



Discussion

It was considered that continuous feeding of 1 kg of concentrate was too expensive to be of value but the experiment demonstrates that, under adequate levels of feeding, Kenana heifers could achieve growth rates which induced puberty at an early age. It was suggested that molasses and urea supplements fed at night during the dry season might promote similar growth and enable most heifers to be mated at 3 years old.

Trials at Khartoum university

Materials and methods

Seventeen heifers from Um Banein were divided into two groups. One (the control group) was managed in accordance with the normal practices of the University farm, comprising *ad lib* roughage (lucerne, groundnut hulls or sorghum straw) and an irregular supply of an 18% protein concentrate, depending on availability. Daily allowances of both roughage and concentrate were very variable for the control animals, which were group fed. Animals in the treatment group were fed individually on groundnut hulls and a 17% protein concentrate, both fed separately *ad lib.* Amounts available for the control group were regulated by the management of the University farm, those for the treatment group by the research staff. Both groups were weighed twice weekly after an overnight fast.

Results

There were no significant differences ($P>0.05$) in roughage intake between the groups. The treatment group, however, had significantly higher ($P<0.001$) intakes of concentrates, DM, digestible CP and ME (Table A.4). Heifers in the treatment group gained weight more rapidly than the controls and were heavier throughout the trial period. Control heifers had a food conversion efficiency of 12.4 (kg DM consumed/kg gain) compared with 10.8 for the treatment group. Treated heifers achieved puberty (being considered as age at first oestrus) 68 weeks earlier than the controls ($P<0.001$) and were first served 67 weeks earlier ($P<0.001$).

Discussion

The treatment heifers, although younger, were heavier at first oestrus than the controls. It is possible that the diet was deficient in Vitamin A and thus delayed oestrus (or at least reduced the external symptoms of heat such that oestrus was not detected) until the animals were considerably heavier than might be expected. Some support for this hypothesis is provided by the fact that most treatment heifers came into heat on being fed 2 kg of green lucerne per day, which was estimated to contain 150 000 to 200 000 I.U. of Vitamin A. The experiment showed that adequate nutritional levels can lead to earlier maturity in Kenana heifers, thus shortening the unproductive life of the animals. Other benefits include shortening the generation interval, reducing rearing costs (mainly through less requirement for labour) and increasing overall lifetime reproductive performance. These benefits lead to greater meat production from surplus male animals as well as maximising total lifetime milk production.

Growth from weaning to maturity

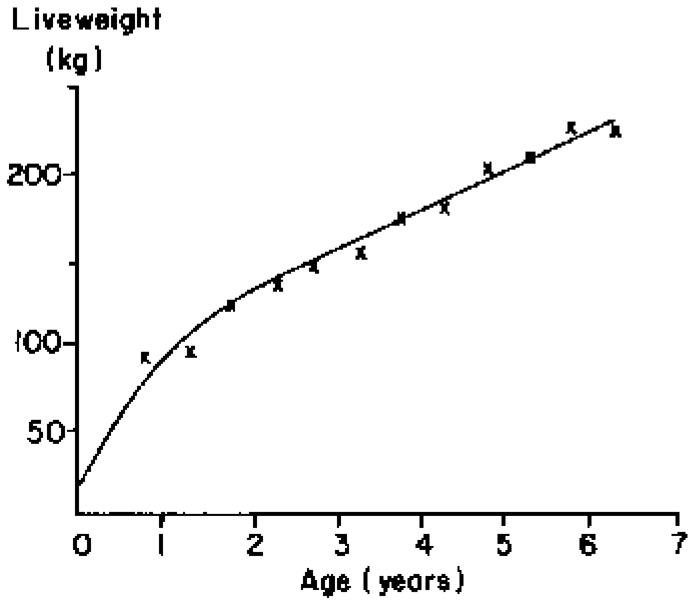
Data are available for a number of heifers whose weights were followed from May 1977 to September 1979. Animals were weighed at intervals of 2 months during this period. Weights were assigned to groups of animals in age classes covering 6 months. Records for 234 heifers, ranging from 6 months to 5 ½ years in May 1977, were available and this group was used until September 1978, when their ages ranged from 1 ½ to more than 6 ½ years. A smaller group of 147 animals was weighed from September 1978 to September 1979. All animals were kept on the natural range area of the station but occasionally had access to crop residues from adjacent areas.

Table A.4. Feed intake, liveweight changes and reproductive performance of two groups of Kenana heifers at Khartoum University Demonstration Unit.

			Control group (n = 9)	**Treatment group (n = 8)**
Daily feed intake:	roughage	(kg)	2.095	2.150
	concentrate	(kg)	0.919^{a}	2.990^{b}
	total DM	(kg)	3.014^{a}	5.140^{b}
	digestible CP	(g)	290^{a}	455^{b}
	ME	(MJ)	26.8^{a}	38.9^{b}
Weight:	at start of experiment	(kg)	83	83
	at first oestrus	(kg)	243^{a}	308^{b}
	at first service	(kg)	245^{a}	314^{b}
	ADG	(g)	138^{a}	470^{b}
Age:	at start of experiment	(weeks)	28	26
	at first oestrus	(weeks)	161^{a}	93^{b}
	at first service	(weeks)	163^{a}	96^{b}

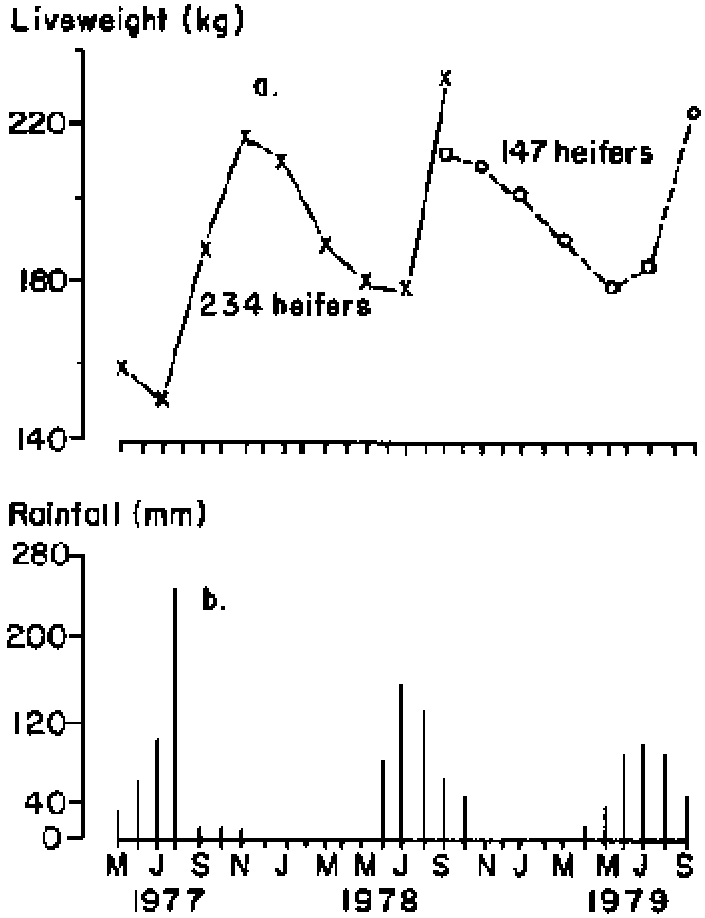
Along rows, means without a common superscript differ significantly ($P<0.001$).

Figure A.2. Average growth curve for Kenana heifers up to about 6 years old at Um Banein.



The growth pattern established for animals from within specified age groups is shown as Figure A.2, the weights in the Figure being averages for groups within age sets over a 2-year period. Overall growth rates from 9 months to 5 years and 3 months of age were very slow, averaging about 70 g/day. Due to the high stocking rates prevailing at Um Banein during the 1970s, post-weaning growth was confined essentially to a 4-month period beginning just after the onset of the rains and ending in November. Compensatory gains during this period of adequate fodder availability were quite good although they varied with the age of the animal. For example, in the age range of 1 to 2 years, the average daily gain was 450 g over a 120-day period: for animals aged 4.5 to 5.5 years, the ADG was about 690 g. Corresponding weight losses during the dry season resulted in net gains of 33 kg in the youngest group and of 19 kg in the oldest group over a 12-month period. The seasonal patterns of fluctuation in relation to rainfall are shown in Figure A.3.

Figure A.3. Effects of season on (a) weights of growing Kenana heifers in relation to (b) patterns of rainfall at Um Banein.


Liveweight (kg)
a.
220
180
140
147 heifers
234 heifers
Rainfall (mm)
280
b.
200
120
40
0
M J S N J M M J S N J M M J S
1977
1978
1979

The Consultative Group on International Agricultural Research

The consultative group on international agricultural research

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