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Productivity of transhumant Fulani cattle in the inner Niger delta of Mali

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ABSTRACT

A range of performance traits and the productivity of transhumant Sudanese Fulani Zebu cattle in the inner Niger delta of Mali were evaluated. The analyses carried out were based on data collected on 2550 animals in three herds from December 1978 to March 1983. The results obtained indicated high calf mortality, low reproductive performance and moderate milk production. A negative correlation was found between milk production and the reproductive performance of cows. Average productivity per cow was low and highly variable over both seasons and years. The results of the study were compared with findings reported in the literature on Sudanese Fulani cattle in Mali and on the related White Fulani strain in Nigeria and the Gobra in Senegal. The major interventions proposed to increase the overall productivity of the Sudanese Fulani cattle in the Niger delta concern improvements of the *harima* pastures through irrigation and fertilization to provide high-quality forage near the village for milking cows, and feed supplementation to improve calf survival and growth rates.

KEY WORDS

/Mali//Zebu cattle//Fulani cattle//productivity//transhumance//reproduction//mortality//growth//milk yield/

RESUME

La présente étude est consacrée à une évaluation de plusieurs paramètres de production et des rendements de bovins Peul soudanais élevés par des pasteurs transhumants dans le delta intérieur du Niger au Mali. Recueillies entre décembre 1978 et mars 1983, les données traitées concernent 2550 animaux provenant de trois troupeaux. Les résultats obtenus montrent que la mortalité des veaux est élevée, les performances de reproduction sont faibles et la production laitière est modeste. Une corrélation négative a été relevée entre la production laitière et les performances de reproduction des vaches. La productivité moyenne par vache est faible et sujette à d'importantes variations saisonnières et annuelles. Les résultats de cette étude ont été comparés aux observations rapportées dans la littérature sur les bovins Peul soudanais du Mali et les souches apparentées White Fulani du Nigéria et Gobra du Sénégal. Les interventions proposées pour améliorer la productivité globale des bovins Peul soudanais du delta du Niger consistent essentiellement à améliorer les pâturages harima *par irrigation et fumure pour produire près des villages du fourrage de haute qualité destiné aux vaches laitières, et à supplémenter la ration des veaux pour améliorer les taux de survie et de la croissance.*

MOTS CLES

/Mali // bovin zébu // bovin Peul // productivité // transhumance // reproduction // mortalité // croissance/ /rendement laitier/

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INTRODUCTION

When ILCA set up its Sahelian programme in 1976, Mali was selected as its focal point because of the country's diversity of production systems and the varying importance of livestock in these systems. The traditional livestock production system in the inner Niger delta, which covers an area of 54 000 km^2 representing only 4% of Mali, contains 25% and 18% of the country's cattle and small ruminant populations, respectively.

The delta is submerged by the River Niger and its tributary the Bani from late July to November in the southeast, and until March in the following year in the northeast. These annual floods influence the vegetation and land-use patterns in the inundation zone. The major production system in the area can be described as pastoral, and it is associated mainly with rice cropping. Pastoral production accounts for about 60% of the household gross revenue (Swift et al, 1983).

The traditional land tenure system practised by the major ethnic population in the delta, the Fulani, takes into account the needs of both the livestock owners and crop cultivators. Recently, however, more land has been claimed by immigrants and government, resulting in decreased floodplain pastures. Social disintegration and the declining resource base are two major constraints to increasing agricultural production in the area.

Throughout the 1960s and early 1970s, studies based on questionnaires and short-term observations were carried out, providing limited information about the production system in the inner Niger delta. These were followed by a 1-year study on cattle productivity by Diallo (1978), which indicated the need to extend the survey in duration and sample size. Parallel with Diallo's work, a study was carried out by Traoré (1978) on the quantity and quality of forage along the route taken by transhumant cattle in 1976/77. An overall assessment of the productivity of Sahelian pastures is given in Breman et al (1982), while the socio-economic aspects of the transhumant Fulani system were described in detail by Gallais (1967).

In late 1978, ILCA began a 4-year interdisciplinary study of the pastoral system in central Mali with the aim of identifying its production potential and constraints. The initial results obtained over the period 1979/1980 were published in an ILCA research report on farming systems in Mali's arid zone (Wilson et al, 1983). The present report summarises the results of the animal productivity part of the study extending until March 1983. Certain constraints limiting the productivity of the Sudanese Fulani cattle in the delta were identified and interventions aimed at eliminating or ameliorating these constraints were suggested.

1. DESCRIPTION OF THE SYSTEM

1.1 THE TRANSHUMANCE ORBIT

The pastoral group studied has grazing rights in the district of Diafarabé, located in the southwest of the Niger delta (Figure 1), and represents a geographic and administrative entity collectively known as the *Jafaraji*. The Jafaraji pastoralists own about 14 000 head of cattle. The herds begin transhumance with the first rains in July, moving from the dry delta to the Sahelian uplands in the northwest, where they remain from August to October grazing rainfed pastures (Penning de Vries and Djitèye, 1982). They return to the delta in November/December when the flood has subsided, and follow its withdrawal to the north until the next rains (Diallo, 1978). These movements along the transhumance orbit (Figure 1) have important implications for herd dynamics and management.

1.2 VEGETATION

Although the Niger delta is in the semi-arid zone and has rainfall ranging from 200 to 600 mm per annum, its vegetation is strongly influenced by the annual flooding of the River Niger. The floodplain pastures consist mostly of tall grass formations which give way to rainfed shrubland and browse trees on *toguérés* (knolls rising above the floodplain) and in areas characterised by late and irregular floods. The vegetation varies according to the flood regime and consists of high-quality *bourgou* pastures (*Echinochloa stagnina*) and perennial Gramineae, such as *Vetiveria nigritiana*, *Andropogon gayanus* and *Oryza longistaminata*. The delta vegetation was described in detail by Boudet (1972), Traoré (1978), Hiernaux (1980) and Hiernaux et al (1983).

Floodplain pastures are grazed from December to July. The quantity of biomass produced annually in the delta was estimated by Hiernaux (pers. comm.), who used the cumulative quantity of regrowth of four representative pasture types as a basis (Table 1). No data were available to calculate the 1978/79 dry-season biomass production, but given the height and duration of the inundation in that season, production was estimated to be between those of 1979/80 and 1980/81.

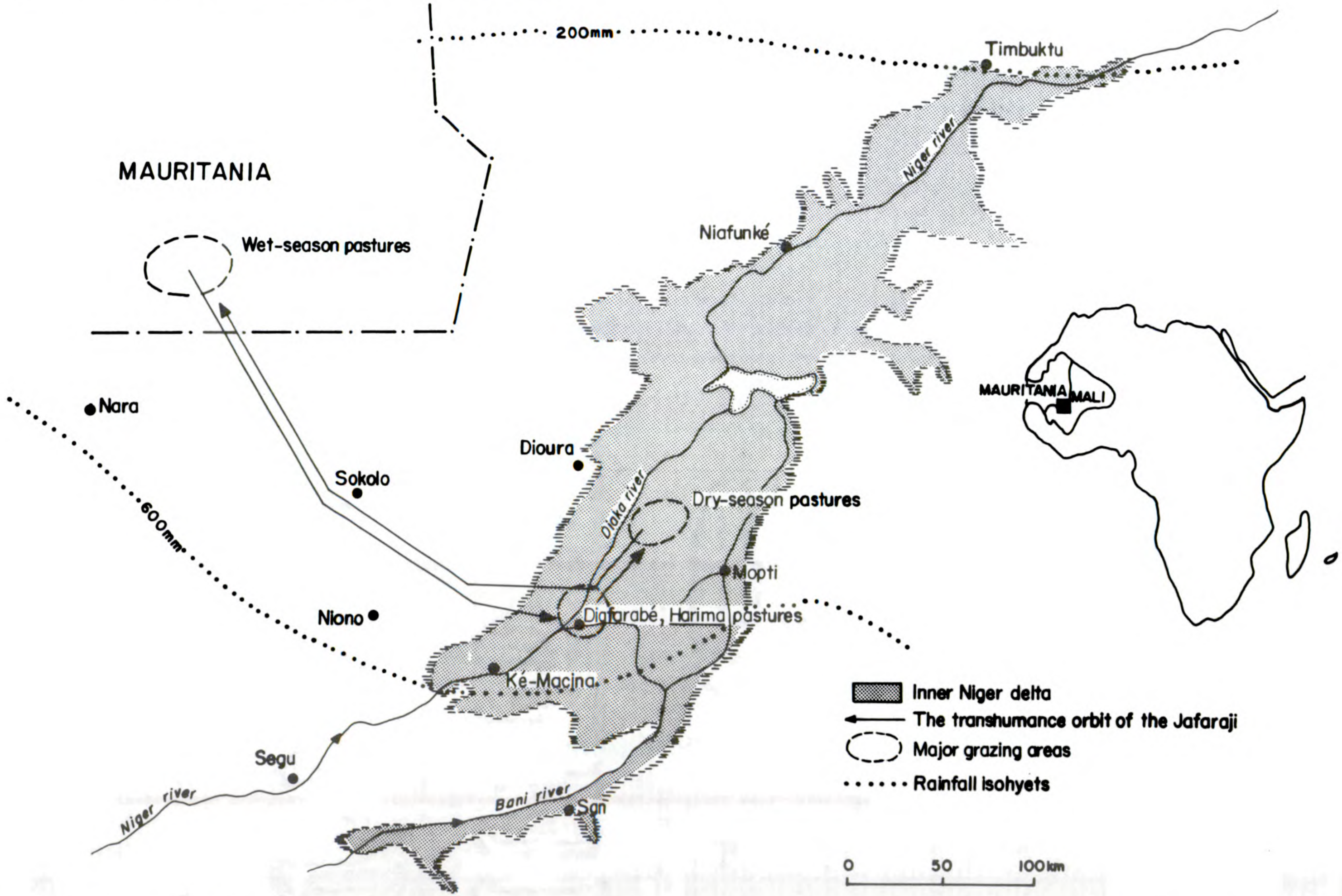
Cattle leave the delta during the wet season to avoid the flood and biting insects, and to prevent damage to rice fields. They migrate northwest towards the Mauritanian border, where they graze high-quality rainfed pastures consisting of annual Gramineae and a tree and shrub cover of varying density. The grass cover is dominated by *Schoenefeldia gracilis*, *Panicum laetum*, *Cenchrus biflorus* and *Diheteropogon hagerupii*, while the woody cover consists mainly of *Pterocarpus lucens*, *Acacia* spp. and *Combretum* spp. (Traoré, 1978). There are large seasonal variations in the quantity and quality of the range resources available in the Sahel, which are due to the sharp climatic contrasts between the single rainy season of 2 to 4 months and the long dry season.

The wet-season forage production in the uplands was estimated by using rainfall data from the areas grazed in a primary production model developed by Hiernaux (1984). The annual biomass production at six grazing sites west of the delta is shown in Table 2.

When the data in Tables 1 and 2 were averaged within years, they showed a steady decline in the quantity of forage produced both in the delta and in the Sahel from 1979 onwards.

There is little information available on the quality of Sahelian pastures. However, research workers on the Dutch-Malian project set up to study primary plant production in the Sahel reported that there is a relationship between rainfall, the quantity of DM produced and its protein and mineral contents (Penning de Vries and Djitèye, 1982). They found that in the northern Sahel, which receives less than 300 mm rainfall per annum, DM production per ha was low but the quality of forage produced was high (Figure 2). The predominantly annual grasses had a high protein content even at maturity, indicating that in this area rainfall is more limiting for plant growth than nitrogen availability. Despite the

Figure 1. *The inner Niger delta and the transhumance orbit.*



Source: Adapted from Breman et al (1978).

Table 1. *Estimated dry-season DM production of four pasture types in the delta, 1979–83.*

Dry season	DM production (kg/ha)			
	Echinochloa stagnina	*Oryza longistaminata*	*Andropogon gayanus*	*Vetiveria nigritiana*
1979–1980	7097	1172	1219	715
1980–1981	6164	924	1215	505
1981–1982	6128	846	650	233
1982–1983	5992	628	1115	86

Table 2. *Estimated wet-season DM production at six stations in the Sahel, 1978–83.*

Year	DM production (kg/ha)					
	Dioura	*Ké-Macina*	*Nara*	*Niafunké*	*Niono*	*Sokolo*
1978	472	1532	2841	821	1542	2539
1979	994	1192	749	676	2420	1535
1980	897	1854	1214	932	1252	1318
1981	1089	1579	961	176	1458	2181
1982	1001	1528	1012	383	1157	1450
1983	592	2728	1293	132	691	852
Average	841	1736	1345	520	1420	1646

Source: Hiernaux (1984).

high quality of these pastures, their utilisation beyond the wet season is limited by the diminishing supplies of drinking water on the return journey.

In the southern Sahel, an inverse relationship between the quantity of DM produced and its quality can be found. In this environment lack of plant nutrients (especially N), not rainfall, is the main constraint to plant production, so that while sufficient dry matter may be produced, the forage is of poor quality for much of the year (Figure 2).

The vegetation along the route followed by the Jafaraji cattle from November 1976 to November 1977 was studied by Traoré (1978). Figure 3 shows that pastures in the northern Sahel had an adequate crude protein (CP) content. In the delta, enough DM was available to support one tropical livestock unit (TLU)[1] on 3 ha in an average year (Breman et al, 1982), but CP content was low and animals lost weight during the dry season. Regrowth after burning (March) and the dried-off *bourgou* (April-May) provided better quality forage; nevertheless only about 20% of the dry-season DM production in the delta was of sufficient quality (cca 1% N) to meet maintenance requirements (Figure 2).

[1] 1 TLU = a standard animal of 250 kg LW.

1.3 BREED

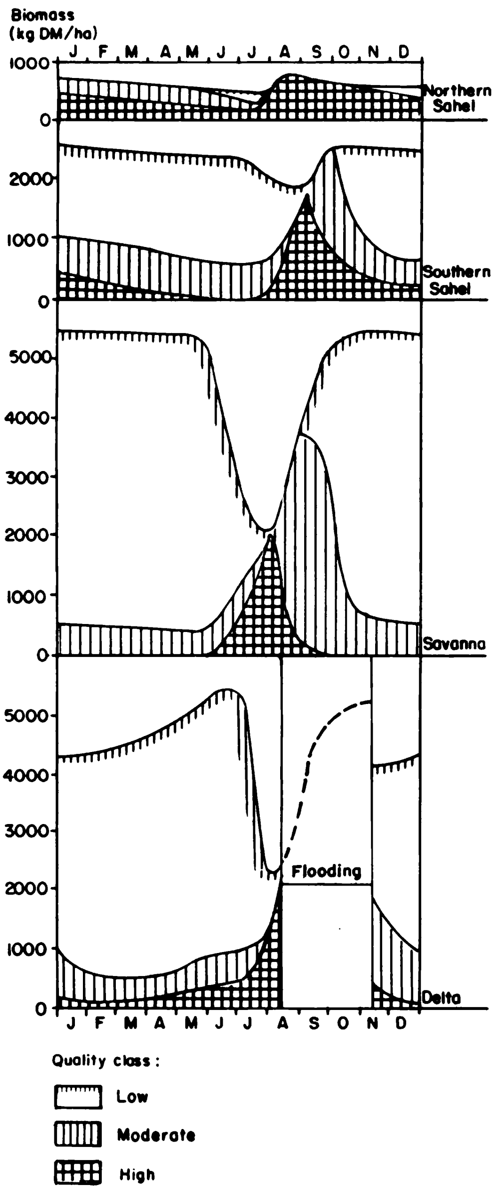
The animals studied belong to the Macinanké variety of the Sudanese Fulani strain, which is a subgroup of the Fulani Zebu breed, related to the White Fulani in Nigeria and the Gobra in Senegal (Mason, 1969). The Macinanké are the most common cattle variety in the delta. They are well adapted to the humid environment and are said to be relatively tolerant to tick-borne diseases (Joshi et al, 1957). Because of their high mobility, crossbreeding with other breeds occurs to an extent, mainly with Maure cattle in the north.

1.4 HERD DIVISION

Cattle owned by individual family members are herded together in communal herds. However, because of the necessity to move the animals where grazing is available, the Fulani divide these herds into units according to specific management criteria (Figure 4).

The core of the herd, known as *garci*, consists of the majority of dry and pregnant cows, most or all of the young bulls and heifers, some older steers and a few breeding bulls. Milking cows with their calves constitute only about 20% of the *garci*, their main purpose being to provide herders with milk for consumption. The *garci* is the only herd unit taking part in the transhumance to

Figure 2. *Quantity and quality of biomass on four types of rangeland in Mali during a year with average rainfall.*



Source: Penning de Vries and Djitèye (1982).

Mauritania from August to October, which explains why the *garci* animals gain more weight during the rainy season than the animals in the other units.

The majority of lactating cows, their calves, a few heifers, steers and breeding bulls form the herd unit known as *bendi*. This unit produces milk for home consumption or sale in the village and is managed accordingly. The *bendi* remains in the vicinity of the home village from December to the end of July or early August, then leaves on a short (100–160 km) transhumant journey northwestwards into the upland Sahel. It returns home together with the *garci* in November. Before reentering the delta the two herd units wait in the transition zone for the Joro's permission to cross the River Diaka. To maintain the productive capacity of the *bendi*, lactating cows from the *garci* are regularly transferred to the *bendi* in exchange for dry cows.

In order to reach the potential market for milk beyond the home village, herd units called *cipi* are separated from the *bendi* and taken to the cultivation areas in the delta during the months of January to March. Often, as much as half the *bendi* is transferred to the *cipi* units to provide enough milk to exchange for rice. The *cipi* units are accompanied by a few pack oxen which are used to transport the rice back to the home village.

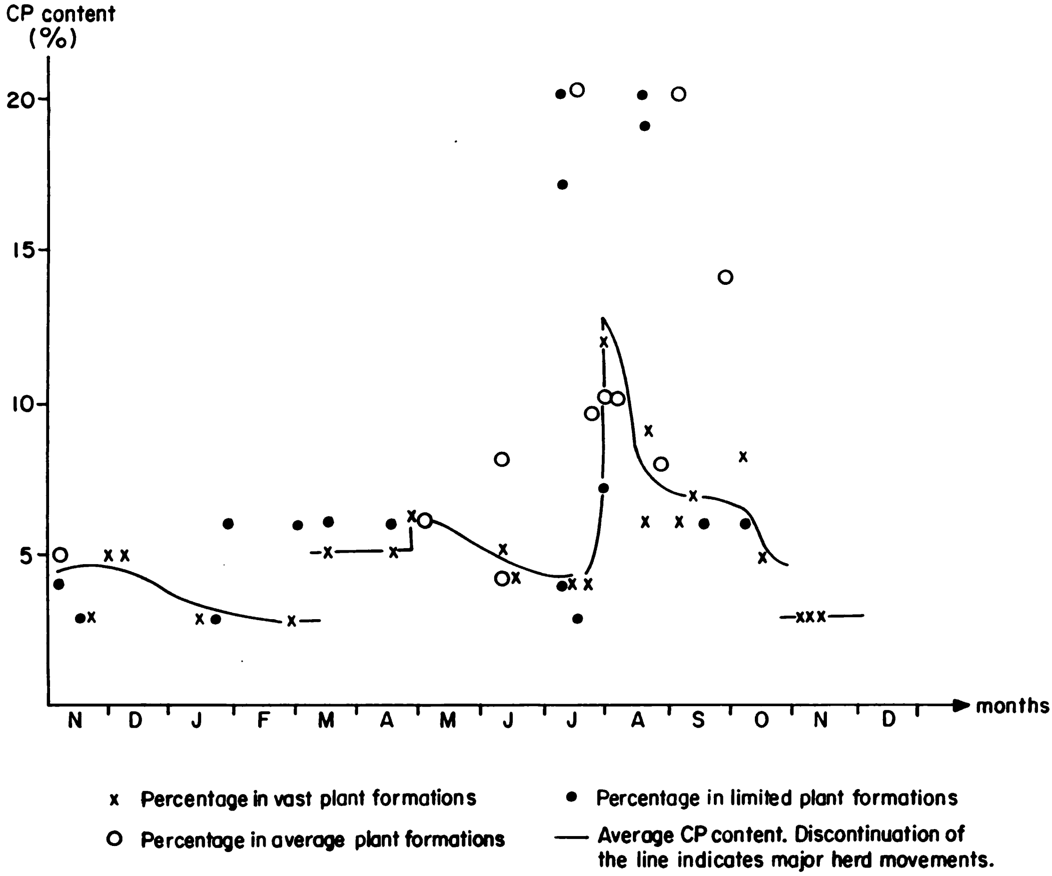
Another fraction, the *dunti*, is separated from the *bendi* during the rainy season. The *dunti* unit consists of two or three lactating cows per family and its main function is to provide milk for the people in the village while the *bendi* is taken to the upland Sahel.

The fifth management unit is the *allooji*, which comprises plough oxen usually belonging to absentee farmers or to those Fulani who also engage in rice cultivation. The *allooji* is kept near the settlements for most of the dry season, as rice fields are ploughed immediately after the harvest (February – March) and again during the first rains (May – July). The *allooji* joins the *bendi* in the upland Sahel in August or at a later date.

In addition to herd division there is a second, completely different type of animal movement: animals in the custody of the herder are transferred to the owner, and vice versa. The herder guarantees proper care of the animals entrusted to him in return for milk for consumption or for sale. He is usually entitled to extract milk from 'fresh' cows for some weeks before the owner withdraws them to augment his own milk supply. Thus sharing of milk offtake results in interminable and highly complex movements between the herd units.

The strategy of herd division aims at an optimal allocation of milking cows in the system and reflects the importance of milk for subsistence. By contrast, the Borana in Kenya (Dahl, 1979) and Ethiopia (Helland, 1980), and the Samburu in Kenya (Dahl and Hjort, 1976), divide their animals into dry and milking herds only, which is a practice reported also from Angola (Cruz de Carvalho, 1974) and Botswana (Carl Bro Int., 1982).

Figure 3. *The CP content of vegetation grazed by transhumant cattle, Mali, November 1976–November 1977.*



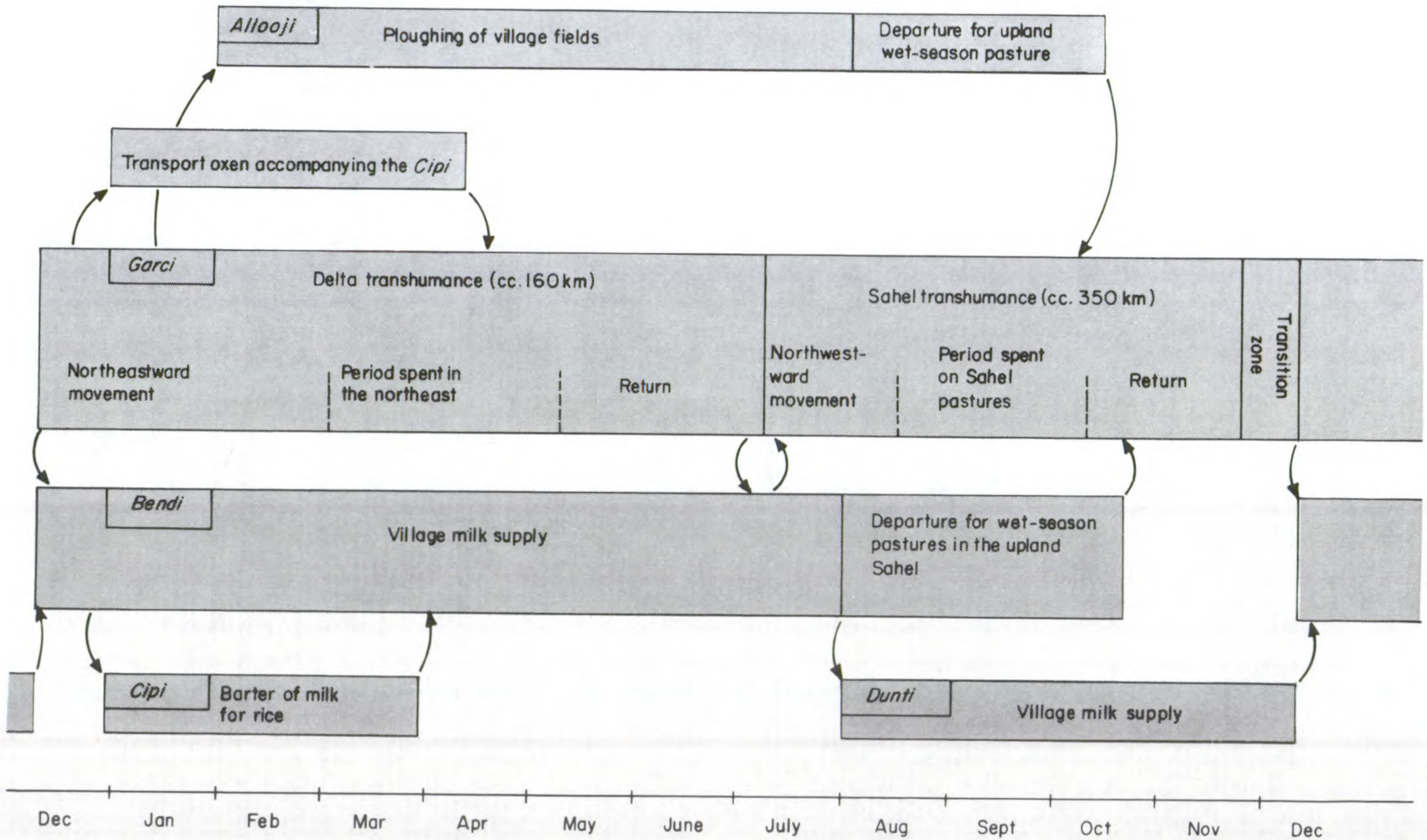
Source: Traoré (1978).

1.5 MANAGEMENT PRACTICES

The Jafaraji have a distinct management policy for calves. In the morning, before the herd leaves the camp for grazing, calves are taken away from their dams. Those younger than 2 months remain in the camp, while the older calves are grazed by boys on nearby pastures. In the evening, before the herd returns to the camp, the calves are tied, according to age and by owner, to a *dangol* (one or more ropes staked to the ground). They are released one by one at sunset and allowed to suckle their dams in order to induce milk let-down. Cows are usually milked only in the evening, on all four teats. After milking, the calves remain with their dams until the following morning. When the calves have reached weaning age, they are either transferred to another herd unit or have a band of thorns tied around their muzzle to prevent them from suckling.

The herds in the study area leave the camp between 8 and 10 a.m. and return at about 6 p.m. According to Diallo (1978), they spend 7 hours grazing on average. After midnight the animals graze for about 2 hours and return to the camp between 5 and 6 a.m. Throughout the year, the herds are watered at least twice daily.

Figure 4. *Herd units and their movements.*



2. METHODS

2.1 DATA COLLECTION

Between December 1978 and March 1983 three transhumant herds belonging to the Jafaraji were studied. Initially a fourth herd was included, but it was abandoned in 1980 because of lack of cooperation on the part of the owners. Data were collected on 2550 animals by four enumerators.

Each herd had one enumerator, who took an active part in herding. As the herds were divided into several units, data were recorded in each unit. In order to facilitate data recording in the *bendi* and *dunti* units, one enumerator was based in Diafarabé. This enumerator also paid regular visits to the *cipi* units in the surrounding cultivation areas.

At the beginning of the study, sex was noted and age was determined on the basis of teeth eruption. In December 1978 animals were eartagged, but subsequently they were identified by name only. The Fulani name their animals after the colours and the pattern of their coats, after the animal's mother or origin, and other individual features.

The enumerators monitored births, deaths, losses, purchases, sales and gifts of animals. Management practices such as weaning and castration were recorded by date, and so were the observed matings. Dates of transfers of animals between the *garci*, *cipi* and *bendi* units were also recorded.

A spring balance was used to weigh the calves. In the first 3 months of life they were weighed weekly, for the next 3 months fortnightly, and from 6 months to 1 year of age monthly. Adult animals were weighed on a mobile scale three times a year: just before and after the transhumance to Mauritania (July and November, respectively), and in the middle of the dry season (March). In order to enlist the cooperation of owners, animals to be weighed were vaccinated against rinderpest, pasteurellosis, CBPP and blackleg. Although vaccines are commonly available, the advantages to the herd owners involved in the study lay in the fact that they did not have to organise and wait for the visit of the vaccinators, while the vaccines were free and delivered fresh from Bamako.

Morbidity among the surveyed animals was determined by veterinarians from the Laboratoire Central Vétérinaire (LCV) in Bamako. They visited the study herds in May 1982 and January 1983, and took samples of blood and faeces to evaluate the level of disease and parasite infestation.

2.2 DATA ANALYSIS

Three computer programs were used in data analysis. Frequency distributions, cross tabulations, scattergrams, analyses of variance and multiple regressions were done using the Statistical Package for Social Sciences (SPSS) (Nie et al, 1975). Fixed-effects models estimated by Harvey's program for least squares analysis (Harvey, 1972) were used to test factors influencing calf and adult growth, milk production and fertility. The distributions of mortality and first calving by age were determined using the survival analysis 1L (actuarial life table) from the BMDP programs (Dixon, 1983).

In the least squares analysis seasons were classified as follows:

- cold dry season – November to March
- hot dry season – April to June
- first rains – July (departure to the Sahel)
- rainy season – August to October (cattle return from the Sahel during the late rains in October).

If a factor was shown to be significant by the least squares analysis, t-tests were used to isolate the contributing differences. Within variable groups, means followed by the same letter (a,b,c) were not significantly different at the 5% level. In order to give an indication of the distribution of values within a population, means were presented with their standard deviations(σ).

3. THE SAMPLE

3.1 HERD COMPOSITION AND AGE STRUCTURE

The Jafaraji keep their cattle in large herds: 44% of all herds comprised more than 200 head of cattle each, the total accounting for 78% of all animals in the Diafarabé area. These proportions were much larger than the 18% and 38%, respectively, found for the delta as a whole (Table 3). The data for the Jafaraji herds were based on counts taken at various water points in November 1977, when the herds returned from the Sahel and had a maximum weight. Thirty-nine herds were counted out of the aggregate total of 48 herds which constitute the cattle population of the Diafarabé area. The largest herds included 700 to 1000 head of cattle whereas the smallest ones had only 50 to 75 head. Herd size frequency distribution in the whole delta was derived from counts made of 609 herds during a low-altitude aerial survey carried out in late October 1980 (Milligan and Keita, 1981).

In January 1979 three sample herds were identified, comprising 820 head of cattle. Herds R and S had 210 head each and were always herded together, while herd V had 400 head of cattle. The composition of the three herds was similar to those reported in the literature for Fulani herds in the delta and for pastoral herds in general (Table 4). The most variable category was that of adult castrated males. The number of males in the herds reflected the importance of cultivation in the region, the occasional sales of castrates to Ivory Coast and, indirectly, the number of calves born by year. Usually after years with a good calf crop, herders were able to sell more adult males.

The increase in the percentage of bulls over the study period was associated with the decreasing percentage of oxen above 4 years of age. It is probable that a considerable number of castrations were not recorded, since these are often done by the owner himself.

Table 3. *Herd size frequency distribution in the Diafarabé area and in the whole delta.*

Area	Herd size					
	<100	100–200	200–300	300–400	400–500	>500
Diafarabé						
No. of herds sampled	15	7	6	5	3	3
% of total herds	38	18	15	13	8	8
% of total cattle	9	13	18	21	17	22
Whole delta[a]						
% of total herds	57	25	11	4	1	2
% of total cattle	39	24	18	9	3	8

[a] Data taken from Milligan and Keita (1981).

The high percentages of females in the three herds studied were consistent with a management strategy aimed primarily at milk production. The population pyramid (Figure 5) shows that there was a rapid reduction in the male component of the herds with increasing age, such that 80% of animals older than 5 years were females.

Table 4. *Combined structure (%) of herds R, S and V in December 1978, 1980 and 1982, compared to herd structures described in literature.*

Animal category	This study			In literature				
	1978	1980	1982	1	2	3	4	5
Females								
calves	10.2	8.2	6.7	11.1	7.9	8.2	10.9	10[a]
heifers[b]	23.0	23.6	23.2	21.9	23.8	22.1	15.8	9
cows	34.3	33.7	37.5	28.9	33.1	34.7	35.5	45
Total % females	67.6	65.5	67.4	61.9	64.8	65.0	62.2	64
Males								
calves	9.0	6.7	6.4	9.7	6.3	6.1	9.8	9[a]
young bulls[b]	9.6	13.0	10.7	11.8	15.4	10.2	12.9	7
bulls	5.4	7.5	10.4	2.1	0.9	–	–	–
bullocks[b]	2.0	1.1	1.1	1.4	–	18.9[c]	15.1[c]	20[c]
oxen ≥ 4	6.4	6.1	4.0	13.1	12.7	–	–	–
Total % males	32.4	34.4	32.6	38.1	35.3	35.2	37.8	36
Sample size	820	910	879	9 923	1 438	15 369	26 118	1 367

[a] The distribution between sexes was estimated by the authors of this report.

[b] Except for SEDES (1975) and Pullan (1979), who reported on 1 to 3-year-old heifers, the category of heifers includes females between 1 and 4 years of age. The category of young bulls and bullocks comprises males between 1 and 3 years of age.

[c] All adult males combined.

Sources: 1. Coulomb (1972), delta Fulani; 2. Diallo (1978), Diafarabé area; 3. OMBEVI (1978), Fifth Region of Mali, Niger floodplain; 4. SEDES (1975), transhumant herds; 5. Pullan (1979), traditionally managed White Fulani, Jos Plateau, Nigeria.

3.2 ENTRIES AND EXITS

The recorded herd entries and exits are given in Tables 5 and 6, respectively. The number of animals which entered or left in a particular year was expressed as a percentage of the herd total in December of that year. Births and deaths will be discussed in more detail in Chapters 4 and 5.

Of the animals purchased by owners, 66% were females with an average age of 1.9 years, while 95% of gifts were also females. Above-average losses occurred in July. Seventy percent of the lost animals were younger than 3 years, and 57% of the total lost animals were females. Seventy percent of sold females were older than 8 years while 70% of sold males were younger than 5 years.

On average, 5.6% of the combined herds were sold, and of this 65% were males. Sales increased from 1979 onwards, reflecting the decreasing herd productivity over the study period and the need to compensate for lower milk offtake by an increased purchase of grains.

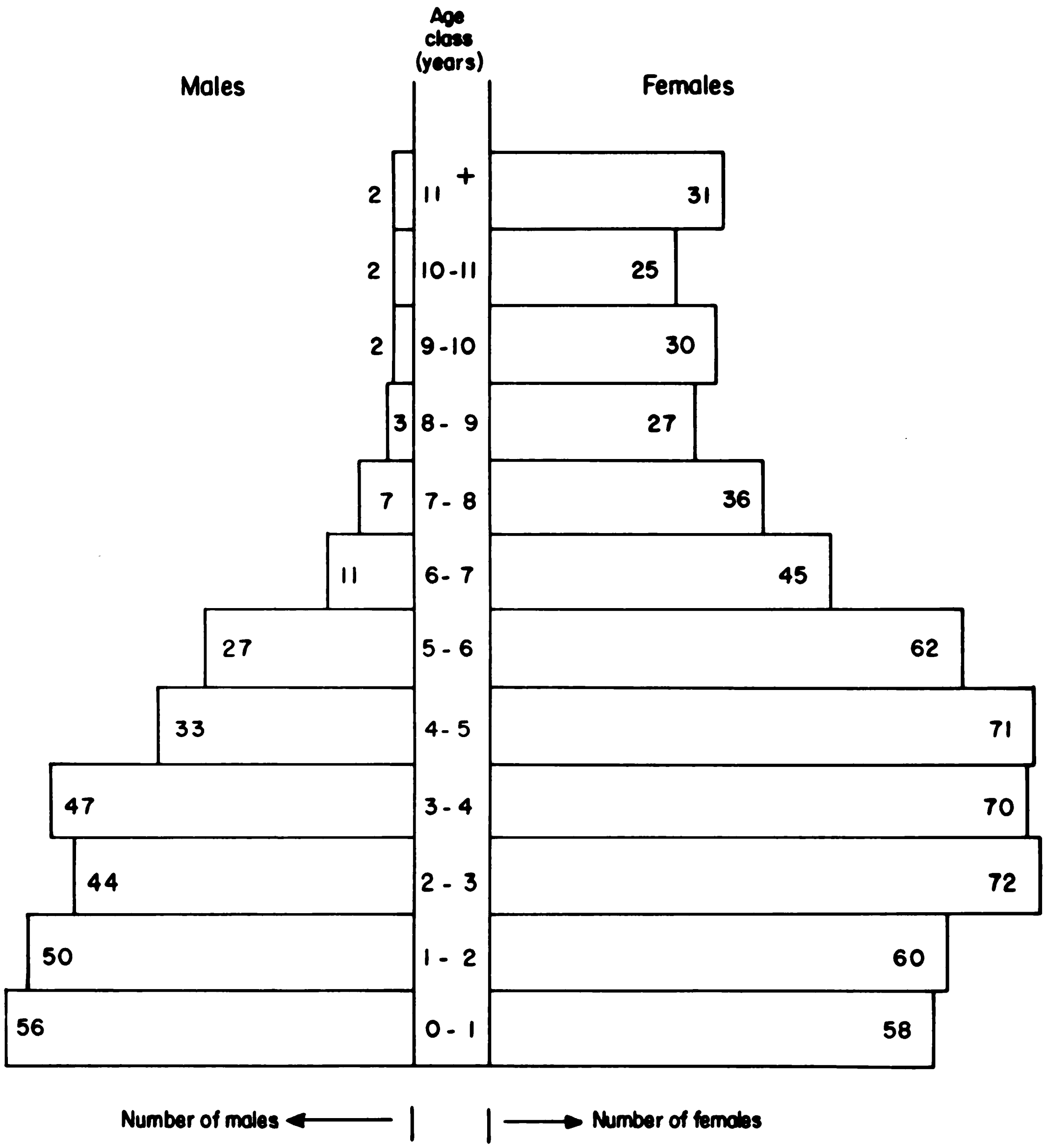
Sixty percent of animals withdrawn by the owner were milking cows, which were returned to the *garci* when they stopped lactating. The withdrawn males (40%) were either sold or trained for draught purposes. Ninety percent of the withdrawn males were younger than 4 years.

The percentage change in herd size was positively associated with climatic factors: it decreased from +12.2% in 1979 to −4.2% in 1982. Herds grew at the rate of 4.5% over the study period, which was higher than the 3 to 4% estimated by other researchers in Mali (Table 7). However, offtake rate was below the 11 to 12% reported in the literature: even if all the males that had been withdrawn by owners were sold, the rate would be no more than 6.6%. The figures in Table 7 suggest that overall herd productivity had decreased by the time of the study.

3.3 OWNERSHIP AND MANAGEMENT

As ownership is likely to have an effect on management strategies and, consequently, on productivity, it may be useful to describe the different categories of ownership observed in the study area. First there is the cattle herder, who owns some animals in the herd and who is the custodian of the animals belonging to his immediate and often extended family. He can manage and exploit these animals as he thinks fit. Then there are

Figure 5. *Population pyramid: composition of herds R, S and V, December 1982.*



cattle owners, who entrust their animals to one or more kinsmen or close friends. The owners are not directly involved in the day-to-day operations but have a strong say in the overall herd management strategy. Absentee owners/investors, such as farmers, fishermen, civil servants and traders, purchase cattle and place them in herds against remuneration in kind or cash. This category of owners became important during the 1972/74 and 1984/85 droughts in the Sahel, when impoverished cattle owners sold their animals to farmers and traders in order to be able to buy food grains. The same trend was observed in Niger (Swift, 1984).

Table 8 illustrates the complex ownership pattern of transhumant herds. There were 48 and 29 owners in herds R and S, respectively, who collectively owned a total of 483 head of cattle. No data could be obtained for herd V. Although the information for herds R and S is believed to be reliable, herders were often reluctant to identify owners. Some 50 to 60% of a herd belonged to 'real' cattle owners and 14 to 33% to 'absentee' owners. The 'unknown' group may have comprised further absentee owners as well as less closely related members of the extended family.

Because of its complex nature, it was impossible to introduce ownership as a factor in the

Table 5. *Entries by herd and year as percentages of herd size, Diafarabé, 1979–82.*

Herd	1979	1980	1981	1982	Annual average
R:					
births	25.6	29.1	22.1	17.8	23.5
purchases	0	0	4.3	6.2	2.7
gift/owner	0	0.4	3.9	4.1	2.1
S:					
births	26.8	20.4	23.2	20.5	22.6
purchases	0	1.6	2.5	0.4	1.2
gift/owner	4.8	2.8	6.1	10.5	6.2
V:					
births	19.0	22.6	22.0	25.3	22.1
purchases	1.7	2.5	4.3	6.2	2.9
gift/owner	9.7	1.9	2.2	2.7	4.1
All herds:					
births	22.8	23.6	22.4	21.7	22.6
purchases	0.8	1.6	3.9	3.1	2.4
gift/owner	5.9	1.7	3.8	5.6	4.2[a]
Annual increase for all herds	29.5	26.9	30.1	30.4	29.2

[a] Of the 4.2% of entries in this category 3% were brought in by owners, which compares well with the 2.5% of animals withdrawn from the herds (see Table 6).

analysis of productivity of the Sudanese Fulani cattle in the delta. Herds were used instead. Statistically significant differences among herds were found for reproduction traits, calf growth, calf mortality and management practices.

Age at castration differed significantly among herds (n = 59, P<0.01), the means being 2.7, 3.0 and 3.4 years for herds S, R and V, respectively. Weight at castration was almost significantly (P = 0.08) affected by herd, ranging from 176 kg in herd S to 198 kg in herd V.

Weaning age differed highly significantly (P<0.001) among herds. Least squares means for weaning age are given in Table 9. Weight at weaning ($\overline{x}$ = 81.0 kg, n = 45) was significantly (P<0.05) influenced only by year of birth.

The 1980 calves were weaned late because of high calf mortality in that year. Cows with calves were milked longer to compensate for the loss of milk from cows whose calves had died. The 1982 calves appear to have been weaned earlier, however this is because calves born towards the end of that year were weaned outside the study period and were not included in the analysis.

Parity did not have a significant effect on weaning age as analysed in Table 9. However, when introduced as a linear regression covariate, parity was significantly (P<0.05) correlated with age at weaning (r = –0.29), confirming the finding of Paterson et al (1980) that young females produce lighter calves which might be expected to be weaned later.

Total milked-out yield from the dam was highly significantly (P<0.001) correlated with weaning age (r = 0.55). A milk offtake of 100 kg above the average corresponded with a weaning age 36 days later than the average.

3.4 MORBIDITY

In May 1982, 12% of the studied animals were positive for brucellosis and in January 1983, 16% (Seck, 1982; 1983). Such rates are common in African pastoral systems (Pullan, 1980a; Clère, 1982; Domenech et al, 1982), and the disease is

Table 6. *Exits by herd and year as percentages of herd size, Diafarabé, 1979–82.*

Herd	1979	1980	1981	1982	Annual average
R:					
deaths	9.7	18.5	16.0	13.7	14.5
losses[a]	0.4	1.7	1.7	1.7	1.6
sales	0.9	6.2	6.9	7.5	5.4
withdrawn	3.1	2.6	3.5	0.8	2.5
given away					0.5
S:					
deaths	6.6	12.4	11.2	14.7	11.4
losses	0	0	0.7	5.3	1.6
sales	3.1	2.0	6.2	8.6	5.1
withdrawn	7.9	0.8	2.9	1.1	3.0
given away					0.4
V:					
deaths	10.7	11.8	16.7	24.2	15.6
losses	1.0	1.1	2.9	7.2	3.0
sales	3.2	3.9	7.9	9.2	6.0
withdrawn	2.7	0.2	1.9	4.4	2.3
given away					0.4
All herds:					
deaths	9.3	13.6	14.9	18.3	14.1
losses	0.6	1.0	1.9	5.1	2.2
sales	2.6	3.9	7.1	8.5	5.6
withdrawn	4.2	1.0	2.6	2.4	2.5
given away	0.6	0.5	0.3	0.3	0.4
Annual decrease	17.3	20.0	26.8	34.6	24.8
Net herd growth	12.2	6.9	3.3	–4.2	4.5

[a] Refers in most cases to weak animals left behind in the bush, and therefore to mortality.

Table 7. *Offtake and herd growth rates for Malian transhumant herds as reported in literature and in this study.*

Offtake (%) (1)	Herd growth (%) (2)	(1+2)	Source
12	2–3	14–15	Wundersee, 1971
11.5	3	14.5	Coulomb, 1972
12	3	15	van de Putte, 1977
11.9	3.7	15.6	FAO/PNUD/OMBEVI, 1978
11–13	3–4.5	14–17.5	Shapiro, 1979
5.6	4.5	10.1	This study

Table 8. *Distribution of ownership in herds R and S, March 1981.*

Type of owner	Herd R (%)	Herd S (%)	R + S (%)
Herders	23	18	20
Non-herding pastoralists	38	32	34
Farmers	2	3	3
Investors	12	30	22
Unknown	25	17	21
Total	100	100	100

suspected of causing serious economic losses. For example, Domenech et al (1982) estimated a 5.8% loss of gross revenue in central Africa when 20% of the herds surveyed were infected with brucellosis.

Brucellosis causes abortions in infected dams, especially during the first two pregnancies. Another symptom of the disease is swelling of the joints of animals in poor condition. Both symptoms were observed in the herds under study. Following the LCV/ILCA surveys in 1982 and 1983, a national committee was established in Mali to study the brucellosis problem in the country (Seck, 1983).

Contagious bovine pleuro-pneumonia (CBPP) and rinderpest were not detected in adult animals, probably because they are regularly vaccinated against these diseases. The presence of post-vaccination antibodies rendered CBPP detection doubtful in 13% of calves younger than 1 year. No rinderpest antibodies were found in 20% of calves in this age group. Such an incidence rate is not unusual in animals that are no longer protected by their dams' antibodies and are not yet covered by vaccination. However, there were no clinical signs of rinderpest in any of these calves.

Very few haemoparasites were found. In May 1982 less than 2% of the animals studied had

Table 9. *Estimated least squares means for age at weaning, Diafarabé, 1979–83.*

Variable	n	Weaning age (days)
Overall mean	72	330.2
Herd***		
R	31	299.7a
S	20	344.9b
V	21	346.0b
Parity		
1	11	351.9
2	16	343.9
3	17	330.6
4	19	318.1
5	9	306.5
Sex of calf		
male	38	327.3
female	34	333.0
Season of birth**		
November–March	20	359.7a
April–June	24	321.6b
July	21	315.1b
August–October	7	324.4ab
Year of birth**		
1979	23	320.7a
1980	12	365.1b
1981	32	348.0b
1982	5	287.0a

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

Within variable groups, means followed by the same letter are not significantly different.

Theileria mutans, but the incidence rate rose to about 15% by January 1983. Only one case of infection with *Trypanosoma vivax* was identified. Strongylidae were found in 58% and 36% of the animals surveyed in May 1982 and January 1983, respectively.

4. REPRODUCTIVE PERFORMANCE

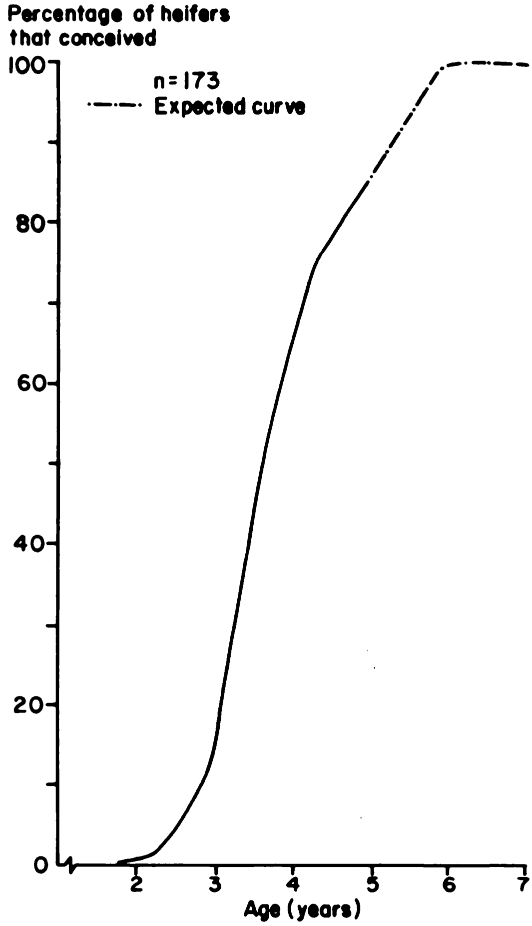
4.1 AGE AT FIRST CALVING

The mean age at first calving for 146 dams was 1528 ± 278 days or 50.2 ± 9.1 months. None of the factors tested in the least squares analysis (herd, season and year of birth of dam, or sex of the calf) significantly affected this parameter. However, a highly significant correlation ($P<0.001$, $r = -0.52$) was found between age at first calving and body weight at 3 years of age. Heifers weighing 10 kg above the average at 3 years of age had their first calf 2 months earlier. No significant correlation was observed between age at first calving and body weight at 1, 2 and 4 years of age.

The cumulative percentage of heifers conceiving with increasing age is shown in Figure 6. About 50% of the animals had conceived by the age of 3.6 years, corresponding to a median age at first calving of 4.3 years. Few data were available on conception in heifers older than 5 years.

Accurate records from birth to first parturition are needed to calculate age at first calving. If these are not available, the population mean can be estimated statistically using a large sample. The average age of 50.2 months (4.2 years) calculated in this study is somewhat higher than the estimates given in the literature, but it is still in the range reported for Sudanese Fulani heifers in Mali (Table 10). Pullan (1980) estimated that the traditionally herded, White Fulani heifers have their first calf at 5 years (60 months) of age, while Otchere (1983) reported 48 to 60 months for the same breed.

Figure 6. *Cumulative percentage of heifers that conceived by certain age, Diafarabé, 1979–83.*



4.2 WEIGHT AT FIRST CALVING

Reviewing studies on the effect of undernutrition on reproductive performance, Topps (1977) found that undernutrition delays the onset of sexual activity in growing heifers. Several researchers also noted that heifers mated too early have considerably longer first calving intervals (Bauer, 1965; Lamond, 1970; Topps, 1977; de Vaccaro et al, 1977; Oyedipe et al, 1982). This is believed to be due to the fact that heifers that have not reached their mature weight at first conception need a longer period for recovery and additional growth before they can conceive again.

Under controlled conditions heifers are mated only after they have attained a certain 'target' weight (Lamond, 1970). For example, Foster (1960) gave a target weight of 228 kg for the genotypically heavier White Fulani heifers in Nigeria, while Wheat and Broadhurst (1968) reported 273 kg. Under extensive grazing, mating is not controlled but Pullan (1980) estimated that the Fulani heifers in his study weighed about 230 kg at mating.

Figure 7 shows the relationship between body weight and first conception. At 175 kg of body weight the proportion of heifers conceiving was less than 30%; at 200 kg conception increased to 80%. The fluctuations at the upper end of the curve were due to a limited number of observations. The median body weight at first conception was 187 kg, which corresponded to a mean weight of 186.7 ± 27.1 kg (n = 146) found using the SPSS frequency analysis. Differences among herds were not significant.

Table 10. *Age at first calving for Sudanese Fulani heifers as reported in literature and in this study.*

Age at first calving (months)	Source
> 48	Lacrouts et al (1965)
36	Payne (1970)
48	Coulomb (1972)
54	Durand (1976; in ILCA, 1978)
48	Diallo (1978)
48.6	OMBEVI (1978)
44.8	ILCA/IER (1978)
48.8	Tamboura et al (1982)
50.2	This study

4.3 CALVING INTERVAL

During the 4 years of the study 441 calving intervals were recorded, averaging 596 ± 155 days or 19.6 ± 5.1 months. The frequency distributions for the sample and by herd are shown in Figures 8 and 9, respectively. The distributions found were essentially unimodal (i.e. calvings occurred year round), with a relatively high concentration of intervals around the mean of 18 months. Denis (1971), Landais et al (1980) and Oyedipe et al (1982) also reported unimodal distributions, but these were more dispersed.

Some data were given in literature on length of calving interval for Fulani Zebu cows. For example, Coulomb (1972) found an average of 20.5 months for Sudanese Fulani cows in the delta in general, and 23.7 months for the cows in Diafarabé. On the Sahel Station in Niono the average was 15.6 months (ILCA/IER, 1978); the significantly shorter intervals observed on the station over the years were thought to be due to improved management. Tamboura et al (1982) reported an average of 16.8 months for pure Zebus on the CNRZ research station in Sotuba, Mali. In Nigeria, calving intervals of White Fulani Zebu ranged from 13–14 months on ranches (Wheat and Broadhurst, 1968; Wheat et al, 1972; Oyedipe et al, 1982), to 24–27 months for traditionally managed animals (Pullan, 1979; Otchere, 1983).

The calculated within-cow repeatability of calving interval was 0.31, which was similar to that on the Niono Station (ILCA/IER, 1978) but much higher than repeatabilities reported elsewhere. Plasse et al (1968), Denis (1971), Pattie and Osborne (1978) and Landais et al (1980) all reported less than 0.10, suggesting that selection based on the post-calving mating performance of lactating cows would not be very effective in improving reproductive performance.

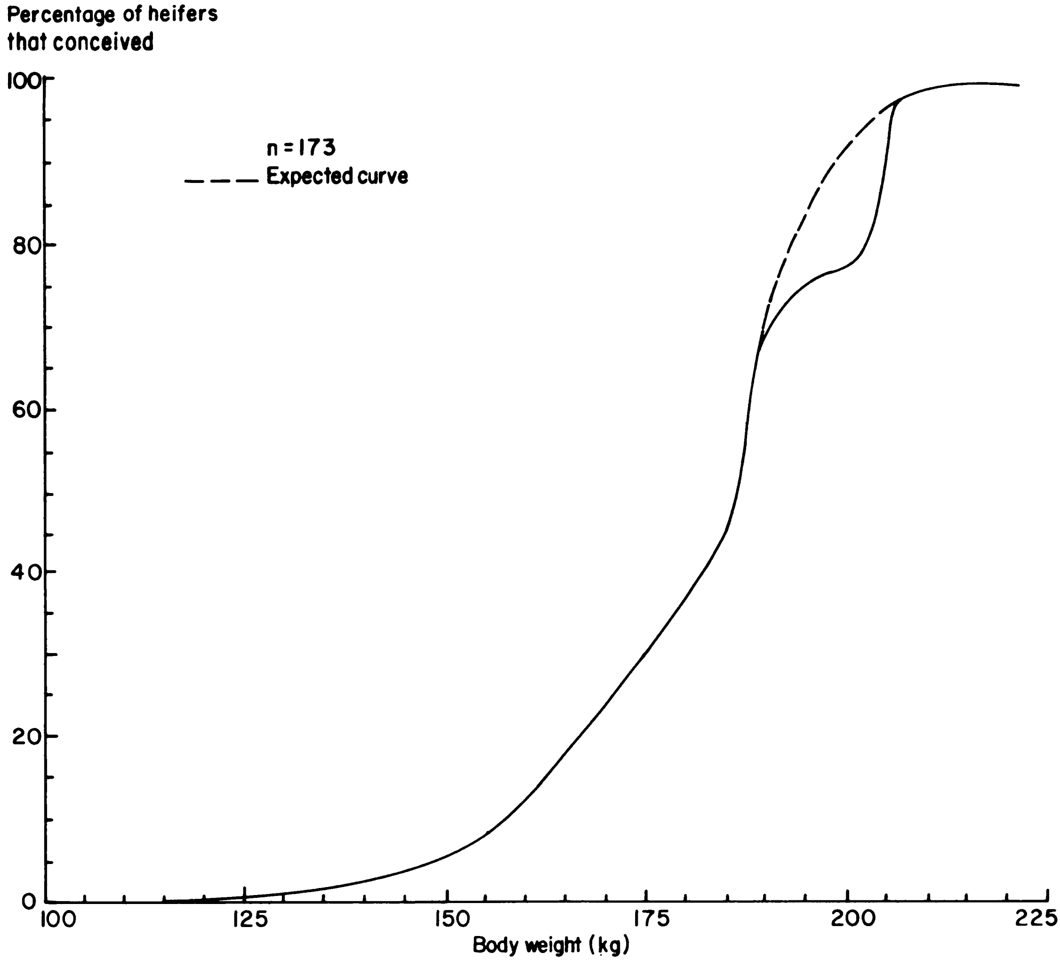
Calving interval was not significantly correlated with either body weight of dam or the birth weights of calves n or n + 1. Lactation length, however, was highly significantly correlated with calving interval ($P<0.001$, $r = 0.53$); an extension of the lactation period by 100 days resulted in a 53-day longer calving interval. The cow had an opportunity to regain body condition during the latter part of lactation (see Table 16), and this resulted in a shorter dry period.

Lactation length was not included in the least squares analysis of calving interval (Table 11), since it is a part of the interval. However, the significant influence of year of calving, calf survival and herd unit on calving interval can be partly explained by their influence on lactation length.

The differences in calving interval found between herds seem to be related to the relatively high number of cows in herd R that conceived during lactation (Section 4.7, p. 19). Cows calving in 1977 or 1978 had significantly ($P<0.01$) longer intervals than those calving in subsequent years. This may have been due to the fact that recording started in January 1979 and information on earlier calvings had to be obtained from herders. The longer calving intervals suggest that births in 1977 and 1978 occurred later than was recalled by the herders.

The highly significant ($P<0.001$) effect of calf survival on calving interval can be explained by the effect calf survival had on lactation length. In most cases, lactation ceased immediately after the death of the calf, so early calf mortality generally resulted in shorter calving intervals. This suggests that calf survival (and thus lactation length) was related to reproductive performance.

Figure 7. Relationship between body weight and the cumulative percentage of heifers that conceived, Diafarabé, 1979–83.



Cows in the *bendi* or *cipi* units had longer calving intervals than the *garci* cows. This difference reflects the more intensive use of the *bendi* and *cipi* cows for milk, resulting in longer lactations and/or longer recovery periods before reconception (see Section 4.7, p. 19).

4.4 REPRODUCTION RATE AND DISTRIBUTION OF BIRTHS

In an average year, 54% of mature females reproduced. This rate was calculated as follows:

$$\frac{\text{No. of calves produced by females} \geq 4 \text{ years}}{\text{No. of females} \geq 4 \text{ years old}} \times 100$$

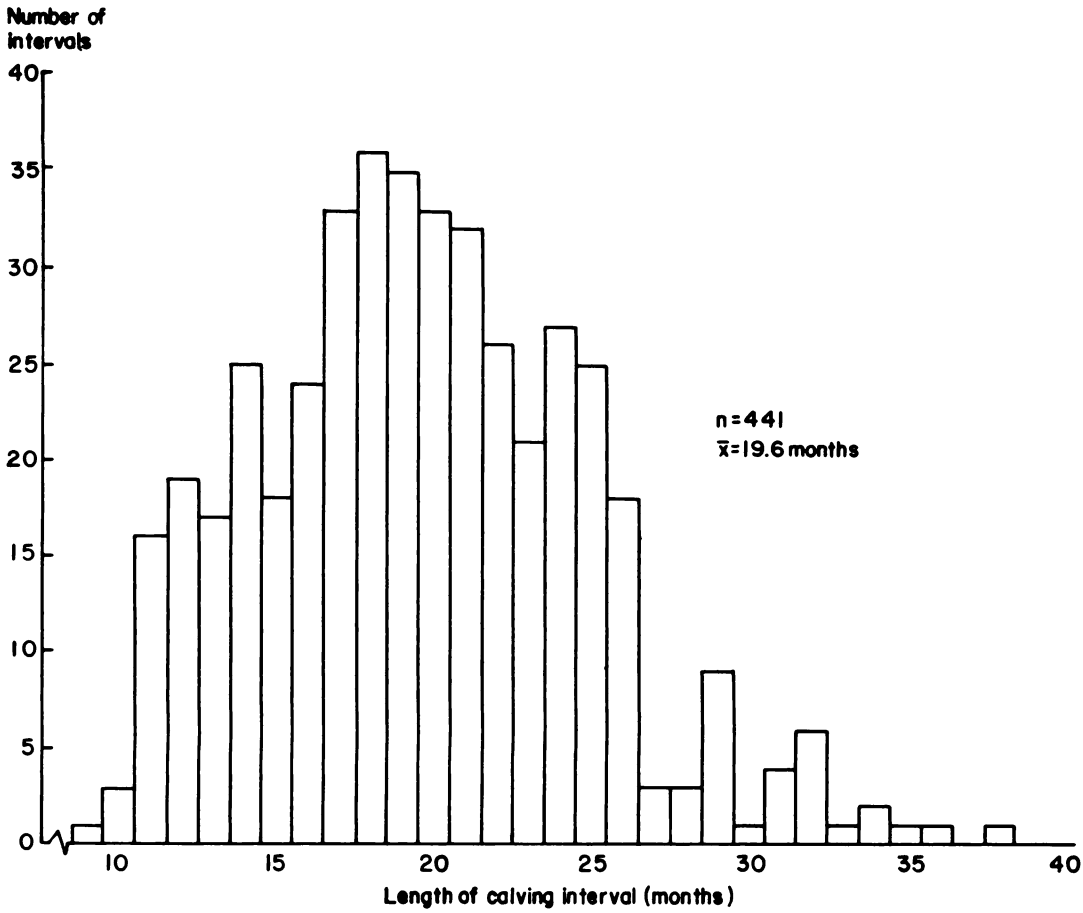
where 'No. of calves produced' includes abortions and stillbirths, and '4 years' is the approximate age at first calving.

The distribution of reproduction rate by herd and year is presented in Table 12. The year means reflect forage availability (see Tables 1 and 2) in the preceding years, and include detected abortions (54 cases out of 808 births i.e 6.7%) and stillbirths (1.8%). Values by age class are in Figure 10 which shows that the reproduction rate of cows between 5 and 10 years of age was fairly constant, ranging from 54 to 58%.

The reproduction rates found in the literature varied in definition: some authors based their estimates on 'all calves produced in the herd' i.e. live births, abortions and stillbirths, while others used as the basis 'the number of live births per 100 reproductive females', which is in fact calving rate (Table 13). Caution should therefore be exercised when comparing rates cited in the literature.

The distributions of births by month, year and herd are shown in Figures 11a and 11b. Large between-year and between-herd differences were evident. There was a pronounced peak in the early rainy season (June, July), which was related to improved body condition during the latter part of the previous rainy season. A lesser peak was observed in the cold dry season (January, February), which might have been due to the intake

Figure 8. *Distribution of 441 calving intervals, Diafarabé, 1979–83.*



of high-quality regrowth or *bourgou* grass available in the northern delta. Coulomb (1972) and Diallo (1978) reported similar distributions of births for Sudanese Fulani cattle in the delta, while Pullan (1979) and Otchere (1983) found similar seasonal patterns for the White Fulani in Nigeria.

4.5 NUMBER OF PARTURITIONS PER COW

The number of parturitions, which included abortions, was estimated by age class. Table 14 shows that 11-year-old cows had an average parity of 5.1 and that the number of cows in the herds decreased rapidly from 11 years onwards. If the average age at culling was 11 years, one would expect 5.2 parturitions per female culled i.e:

11 years = 132 months = 50.2 + (19.6 x Y)

where 50.2 months is average age at first calving, 19.6 months is average calving interval, and Y is the number of completed calving intervals (4.2 at 11 years).

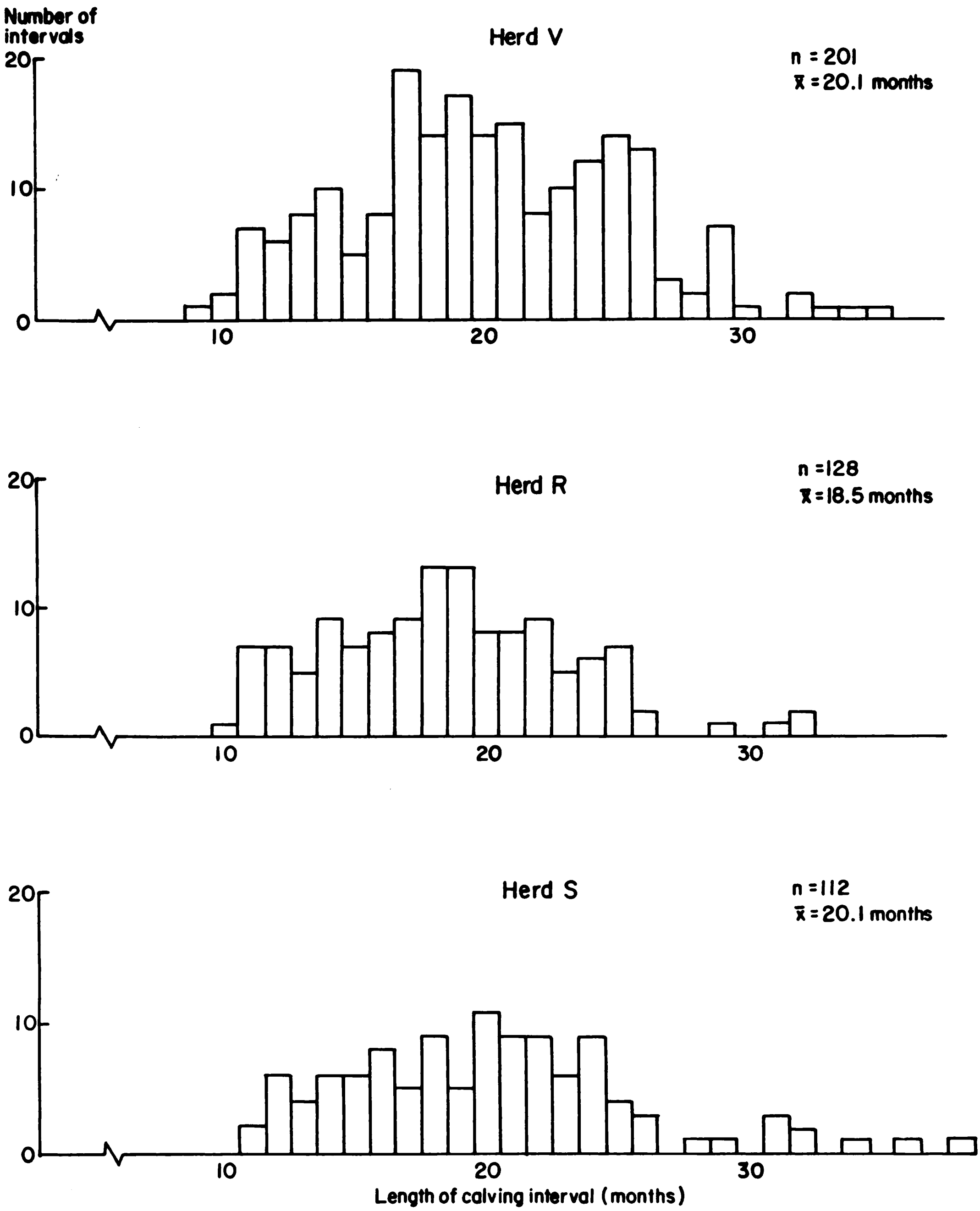
4.6 GESTATION PERIOD

No data could be found in literature on length of gestation for Sudanese Fulani cows. Moreover data on mating in extensive management systems were difficult to obtain. Of the many matings observed over the 1979–1983 study period only 30 resulted in recorded parturitions approximately 9 months later. Gestation period ranged from 260 to 295 days, averaging 283.0 ± 9.2 days. These figures are comparable with data reported by Bartha (1971) for Azawak cattle.

4.7 DISCUSSION

The effect of body weight (or weight change) on reproductive performance had earlier been reported by Donaldson (1969), Lamond (1970), Warnick (1976) and Topps (1977). Most of the correlations between cow body weight and calving interval found in this study were highly significant (Table 15), even though their coefficients were rather low. For example, a 20-kg increase in weight between 90 and 270 days post partum was associated with a 30-day shorter calving interval.

Figure 9. *Distribution of calving intervals in herds R, S and V, pooled over the 1979–83 period.*



Lactation has an indirect effect on reproductive performance by negatively affecting cow body weight. Trail et al (1971) and Topps (1977) reported that lactating cows grazing medium- or low-quality forage use body reserves to maintain milk yield in response to suckling. Such cows need to be supplemented with carbohydrate or protein supplements during lactation to increase their conception rate (Warnick, 1976; Topps, 1977).

Compared with dry cows, lactating cows lose more weight in the dry season and gain less in the rainy season. This is particularly true in the first 6 months of lactation, and the trend was confirmed in the present study (Table 16). After 9 months of lactation daily liveweight gain was almost equal to that of the dry cows, but the loss of body condition that had occurred during the earlier months of lactation was not yet recovered.

Table 11. *Estimated least squares means for calving interval, Diafarabé, 1979–83.*

Variable	n	Calving interval (days)
Overall mean	419	524.9
Herd*		
R	123	499.4a
S	105	535.0b
V	191	540.4b
Parity of calf		
1	113	546.4
2	97	520.5
3	97	533.1
4	66	517.0
5	32	498.6
6+	14	533.9
Season of calving		
November-March	158	532.3
April-June	124	531.4
July	48	529.2
August-October	89	506.7
Sex of calf		
female	207	535.5
male	195	530.8
unknown	17	508.5
Year of calving**		
1977	14	587.8a
1978	70	554.9a
1979	126	499.9b
1980	137	498.9b
1981	72	483.1b
Calf survival***		
abortion/stillbirth	24	459.4a
death < 1 month	39	485.8a
death 1–6 months	45	532.8a
alive at 6 months	311	621.7b
Herd unit**		
garci	201	505.7a
bendi or *cipi*	218	544.1b

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

Within variable groups, means followed by the same letter are not significantly different.

Apart from affecting fertility through loss of body weight, lactation seems to have a direct influence on reproductive performance (Donaldson, 1969; Wettemann et al, 1978; Holness and Jeffers, 1980). Lactational anoestrus is reported to be responsible for a longer interval between first service and conception, and for longer calving intervals in general. This is due to prolactin secretion which suppresses the release of gonadotropins from the pituitary gland, resulting in delays in ovulation and first oestrus after parturition (Topps, 1977; Holness and Jeffers, 1980). However, lactating cows in good body condition do not show this effect (Ward, 1968; Holness et al, 1978; Moore and Magno Campos da Rocha, 1983).

Finally, it should be pointed out that suckling has an even greater inhibitory effect on ovarian activity than milking (Wiltbank and Cook, 1958; Moore, 1984). Wettemann et al (1978) found a positive relationship between the intensity of mammary stimulation and the length of postpartum anoestrus.

The negative relationship between lactational status and reproductive performance is particularly strong in zebu cattle raised under poor grazing conditions. Lactation appears to exert such an effect on these animals that reconception is unlikely before the calf has been weaned (Temple, 1966, cited by de Vaccaro et al, 1977; Denis, 1971; Deutscher and Whiteman, 1971; Warnick, 1976; Swensson et al, 1981; Ngategize, 1982).

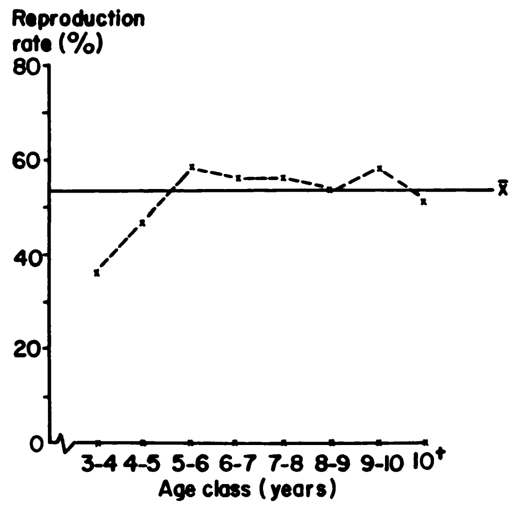
Many authors have emphasised the effect of lactation length on calving interval (Stobbs, 1967; Pullan, 1980; Godet et al, 1980; Tamboura et al, 1982), as well as the positive relationship between total milk production and calving interval (Bartha, 1971; Denis, 1971). The effect of calf survival on reproductive performance was reported by Stobbs (1967), Deutscher and Whiteman (1971), Madalena and Hinojosa (1976), Landais et al (1980), Ngategize (1982), Wilson (1983), Otchere (1983) and Moore (1984), who also mentioned lactation stress as being the main reason for a delayed resumption of oestrus. Based on their findings, 'early' and 'temporary weaning' were proposed as management innovations, the latter being a 1-week interruption of suckling at the beginning of the lactation period to induce the onset of oestrus (Trail et al, 1971; Holness et al, 1978; Ngategize, 1982; Moore and Magno Campos da Rocha, 1983; Moore, 1984).

When introduced as a covariate in the least squares analysis, lactation length proved to have an effect on calving interval. Longer lactations resulted in longer calving intervals, although the dry periods decreased in length. Calf survival was found to have a highly significant effect on calving interval (Table 11). Cows whose calves survived

Table 12. *Reproduction rate (%) by herd and year, Diafarabé, 1979–82.*

Herd	1979	1980	1981	1982	Weighted mean
R	56.2	67.5	60.5	54.2	59.7
S	60.8	50.6	53.8	44.3	51.7
V	50.4	57.3	52.7	46.8	51.7
Weighted mean	54.7	58.0	54.9	47.6	53.6

Figure 10. *Reproduction rate by age class, 1979–82.*



to 6 months of age had a significantly longer calving interval than cows losing their calves at or soon after parturition. Most cows did not conceive until their previous calves had died or had been weaned. In a sample of 255 cows, 66% had dry periods longer than 283 days (Table 17). Average length of dry period was 345 ± 144 days, with significant ($P<0.01$) differences between herds. The average for herd R was 301 days while those for herds V and S were 362 and 365 days, respectively. Only 70 cows conceived during lactation, and of these 15 had more than one short dry period.

Although the relationship between length of dry period and lactation length was highly variable (Figure 12), there was a significant negative correlation ($r = -0.50$, $P<0.001$) between the two parameters. Cows conceiving during lactation (i.e. having a dry period shorter than 283 days) generally had a long lactation during which they rebuilt their condition. Cows which, for one reason or another, had a short lactation recuperated during the subsequent longer dry period. The regression coefficient was –0.55, indicating that an increase of 100 days in the average length of lactation resulted in a decrease of 55 days in the average length of dry period. Although more research will be needed on the subject, the conclusion drawn from the present study is that, for every short lactation the average cow in Diafarabé had a longer dry period. Bartha (1971) reported similar results for Azawak cattle.

The Fulani try to extend the lactation periods of their cows and usually succeed if the calves stay alive (Pullan, 1980). However, the long lactations lead to poor overall reproductive performance. Long calving intervals associated with lactation stress have been reported for several zebu breeds in East and West Africa (Stobbs, 1967; Denis, 1971; Pullan, 1980; Swensson et al, 1981; Ngategize, 1982). There are, however, some zebu breeds in Africa that have been reported to have good reproduction rates under extensive management (Dahl and Hjort, 1976; Bertaudière, 1979). For example, the Kel Tamasheq in Mali claim that their cows conceive during lactation (Wagenaar and Winter, 1982). This may be due to better environment or to selection for this trait in the past.

The decision to concentrate on either milk yield or calf production depends, among other things, on the human population's need for milk, the size of the herd, the price ratio of meat to milk, access to markets and the potential of the breed involved. The objective of the delta Fulani pastoralists is steady milk supply throughout the year, suggesting a preference for good milkers. The Fulani maximise the lactation periods of their cows, which leads to fewer gestations (see also ILCA/IER, 1978; Pullan, 1980). Cow reproductive performance in this system can therefore only be improved if the Fulani's reliance on milk decreases.

Table 13. *Calving rates for traditionally managed Sudanese Fulani cows.*

Calving rate (%)	Source
66	Lacrouts et al (1965)
65	SEDES (1972, 1975)
58.5	Coulomb (1972)
60.3	OMBEVI/IER (1974)
68.7	ILCA (1978)
64.1	Diallo (1978)
59	OMBEVI (1978)
49–55	Diallo and Wagenaar (1983)

Table 14. *Average cow parity by age class, Diafarabé, December 1982.*

Age class (years)	No. of cows	Average parity
2–3	73	–
3–4	70	0.2
4–5	71	0.8
5–6	62	1.1
6–7	44	2.1
7–8	33	2.9
8–9	27	3.4
9–10	29	4.2
10–11	23	4.5
11–12	13	5.1
12+	15	5.2

Figure 11a. *Distribution of births by month, 1979–82.*

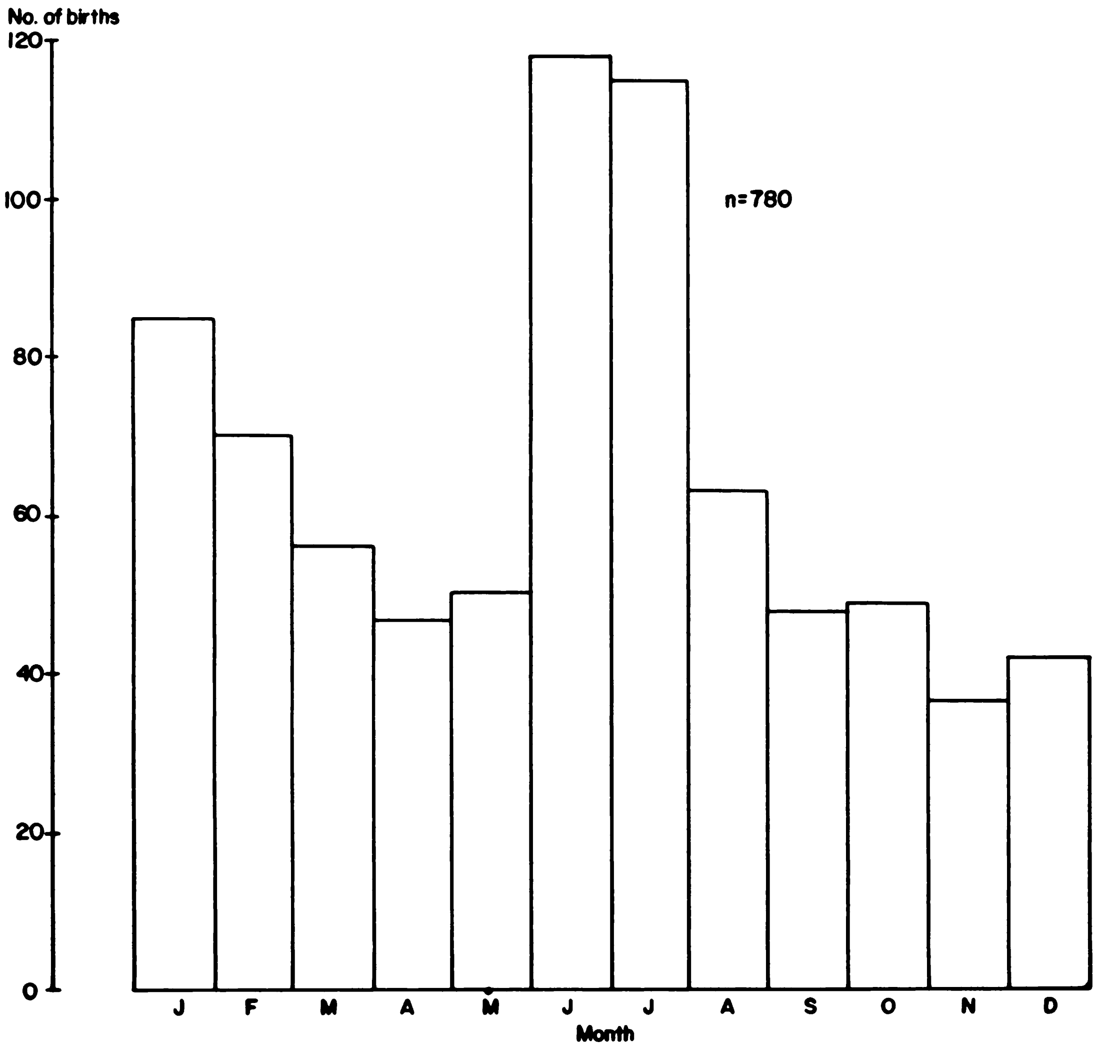


Figure 11b. *Distribution of births by year and by herd, 1979–82.*

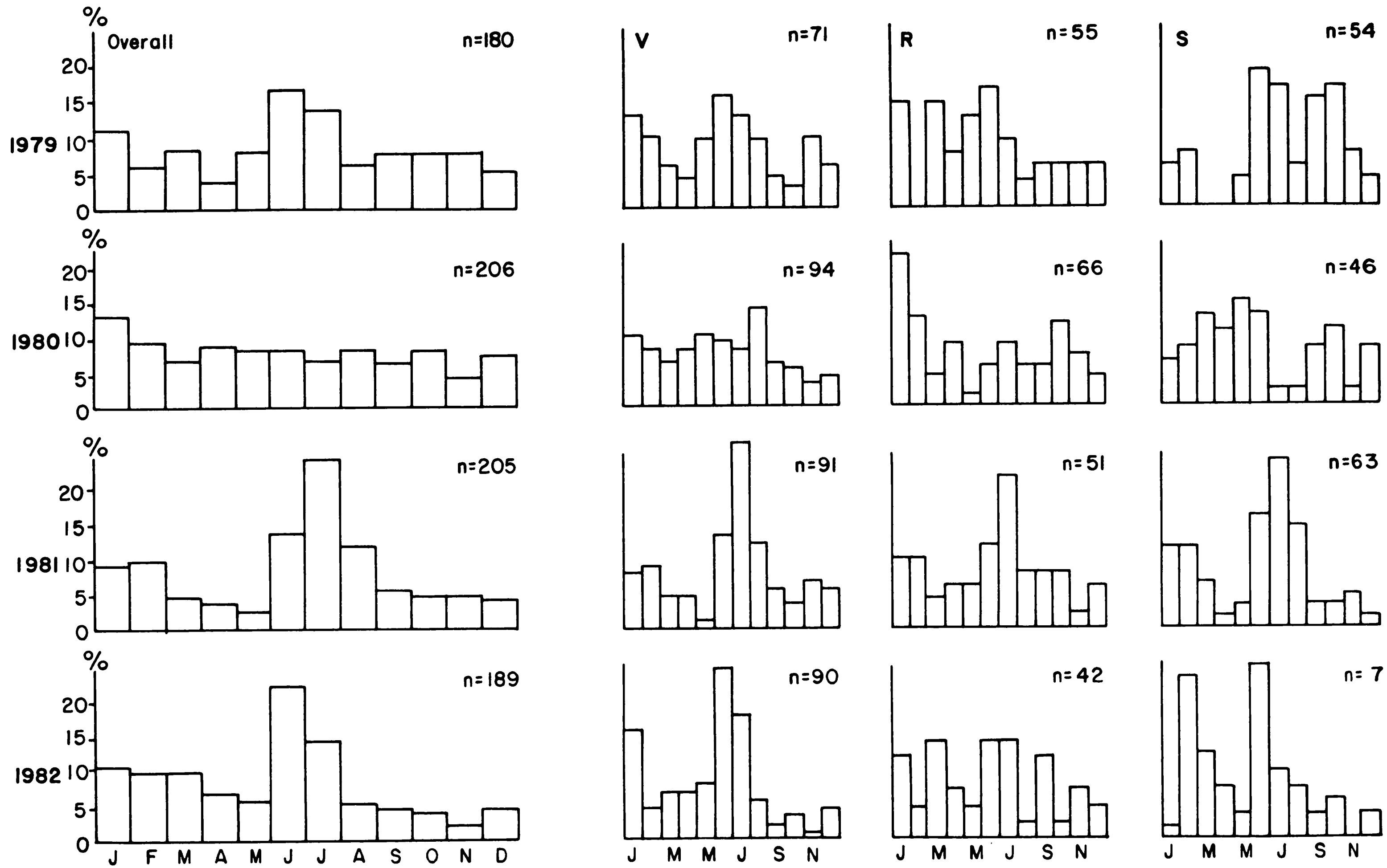


Table 15. *Relationship between length of calving interval (y) and cow body weight or weight change (x), Diafarabé, 1979–83.*

Weight/ Weight change (kg)	n	r	Calving interval (days)	Significance
Weight				
90 days post partum (W90)	225	−0.10	y = 660.4 − 0.5x	n.s.
180 days post partum (W180)	234	−0.17	y = 749.2 − 1.0x	**
270 days post partum (W270)	279	−0.24	y = 857.0 − 1.4x	***
Weight change				
W180 − W90	210	−0.19	y = 542.1 − 2.3x	**
W270 − W180	225	−0.13	y = 547.8 − 1.5x	*
W270 − W90	202	−0.21	y = 545.3 − 1.5x	**

n.s. = not significant; * P<0.05; ** P<0.01; *** P<0.001.

Figure 12. *Relationship between lactation length and length of dry period, Diafarabé, 1979–83.*

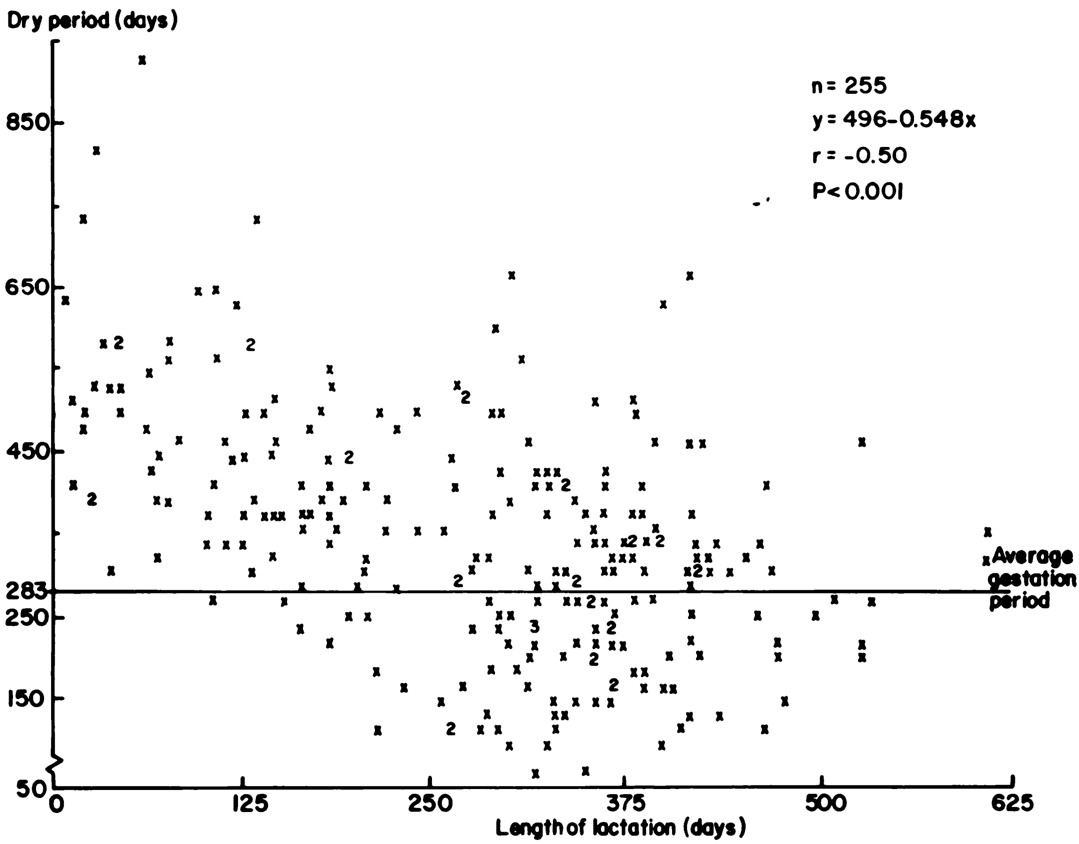


Table 16. *Liveweight gain of dry cows and cows lactating for different periods, Diafarabé, 1979–83.*

Observation period	n	LW gain of dry cows (kg)	LW gain (kg) of cows lactating for:			
			0–3	4–6	7–9	> 9 months
March-June	244	–6	–12[a]	–12[a]	–6[a]	–6[a]
June-Nov	212	+38	+26	+33[a]	+33[a]	+33[a]
Nov-March	279[b]	–15	–25	–30	–30	–18

[a] Due to a limited number of observations, some periods were analysed together and therefore have the same value.
[b] Indicates significant ($P<0.01$) differences between groups.

Table 17. *Distribution of dry periods in a sample of 255 cows, Diafarabé, 1979–83.*

Dry period (days)	n	Relative frequency (%)
0–90	3	1.2
91–180	31	12.1
181–270	46	18.1
271–360	65	25.5
361–450	54	21.1
451–540	33	13.0
> 541	23	9.0

5. MORTALITY

Mortality in traditional pastoral systems in Africa is high, especially in young stock and during the dry season (Coulomb, 1972). In the Diafarabé area, an unidentified disease caused considerable animal losses in the dry season of 1981. In 1982 little forage was available, and when in 1983 the rains completely failed a drought situation similar to that of 1972–1974 was feared. Monitoring in herd V continued until June 1983, in which month 5% of the animals (mainly adults) in the herd died. This signalled the beginning of a new drought period in the Sahel.

5.1 EARLY CALF MORTALITY

Average calf mortality to 365 days of age was 42.8%, including abortions and stillbirths (Table 18). A high percentage of calves born in 1980 died in early 1981.

Herd, year and season of birth had significant effects on calf mortality to 365 days of age (Table 19). Herd V had higher calf mortality (43.5%) than herd R (29.3%) and herd S (29.9%), which might reflect the different management skills of the herders.

The highly significant effect of year of birth on calf mortality to 365 days is corroborated by the data in Table 18. Calves born in April to July had better chances of surviving than those born in other months (28.1% vs 41.5% mortality), because they benefitted from the good grazing and abundance of milk in the rainy season. Sex did not have an effect on calf mortality, which averaged 36.8% for female calves and 35.5% for male calves. This suggests equal treatment of calves of both sexes, which contradicts other findings in Mali (see Table 22).

Table 19. *Analysis of variance of calf mortality to 365 days of age.*

Source of variation	d.f.	MS x 10^{-3}
Herd	2	1226.0**
Year of birth	3	1603.6***
Season of birth	3	645.6*
Parity	5	292.8
Sex of calf	1	23.6
Remainder	523	212.8

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

Calf weight at 180 days was introduced as a covariate in the analysis and was found to have an effect ($P<0.05$) on calf mortality between 180 and 365 days. The survival rate of a calf weighing 10 kg more at 180 days increased from 92 to 96%.

Herd unit could not be included as a factor in the analysis, because surviving calves had been transferred between units. Time spent in each

Table 18. *Calf mortality rates to 365 days, Diafarabé, 1979–83.*

Year of birth	n	Abortions (%)	Stillbirths (%)	Mortality (%) 0–7	8–90	91–180 (days)	181–365	Total (%)
1979	195	4.6	2.1	3.1	3.3	6.7	6.3	26.1
1980	215	6.5	3.3	6.5	11.9	10.8	17.5	56.5
1981	207	8.2	1.0	6.6	9.0	8.6	12.8	46.2
1982	191	7.3	1.0	14.0	11.1	4.8	3.9[a]	42.1

[a] Calculated only for calves born in the first half of 1982.

unit was calculated for all calves and related to the number of deaths in each unit. The fraction:

$$\frac{\text{Calf mortality per herd unit}}{\text{Calf-years spent in herd unit}}$$

gave the following ratios – *garci* 100, *bendi* 90 and *cipi* 182. Calves in the *bendi* unit had a somewhat higher chance of survival than those in the *garci*, while almost twice as many calves died in the *cipi* unit. The latter reflects the more intensive exploitation of milking cows in the *cipi* and the fact that this unit existed only in the dry season. The results also suggest that the policy of exchanging milk for grain adversely affects the survival rate of the *cipi* calves.

5.2 YOUNG STOCK MORTALITY

The mortality rates reported for Sudanese Fulani cattle between 1 and 2 years of age range from 5 to 10%, while most sources give 2% for older stock (see Table 22). The rates for 1 to 4-year-old animals in the study herds R, S and V are presented in Table 20.

Table 20. *Estimated least squares means for mortality in young stock by herd and age group, Diafarabé, 1979–83.*

Herd	Mortality rates (%)		
	1–2	2–3	3–4 (years)
R	5.6	6.1	10.8
S	1.5	2.9	6.6
V	7.7	5.6	9.7
Unadjusted mean	6.3	3.9	5.3
Sample size	319	254	151

Herd, sex and parity of calf and season of birth did not have a significant effect on young stock mortality. However, year of birth had a significant effect on mortality in animals between 3 and 4 years of age. The relatively high proportion of the 1979 calf crop that survived in 1980 (Table 18) was markedly reduced (26% mortality) in 1982/83 due to rain failure, which also explains the dissimilarity between the least squares herd means and the unadjusted mean for the 3- to 4-year age group (Table 20). Mortality in males and females between 1 and 4 years of age averaged 7.6% and 4.9%, respectively.

5.3 MORTALITY OF ADULT ANIMALS

The mortality rate of animals in the 4+ age categories averaged 7.7% over the 1979–1982 period, with an average of 8.3% for females and 5.7% for males. A breakdown by herd and year is shown in Table 21.

Differences among herds were significant in 1979 ($P<0.05$) and in 1980 ($P<0.01$). Herd S had the lowest mortality, which might be explained by the lower level of exploitation of its animals, as reflected in the lower milk offtake and better calf growth in this herd.

Table 21. *Mortality rates for adult stock in herds R, S and V, 1979–82.*

Year of mortality	Mortality rate (%)			Weighted mean
	R	S	V	
1979	3.7	1.1	8.6	5.4
1980	16.1	3.9	6.2	7.9
1981	8.5	5.7	4.8	5.9
1982	14.6	7.9	12.8	11.7
Average	10.7	4.6	8.1	7.7

5.4 DISCUSSION

The high mortality rates recorded over the 1979–1983 period allowed no increase in herd size or offtake. The system would not be viable if the rates were to be regarded as long-term averages. Using Dahl and Hjort's (1976) herd growth model it was calculated that a 1% decrease in the mortality rates in all age classes (or a 4% increase in the reproduction rate) would be needed to keep herd size constant in the long term.

The exceptionally high mortality in 1982 (and early 1983) was due to unfavourable climatic conditions which resulted in heavy cattle losses throughout West Africa. It must be realised, however, that while erratic interannual variations in mortality are an inherent feature of pastoral systems, heavy losses occur only occasionally. The inevitability of occasional high mortality may explain the reluctance of cattle owners to invest in health care, feed supplementation and management innovations.

Despite their high levels in some years, the average mortality rates recorded in this study were within the range of rates reported for Sudanese Fulani cattle in the literature (Table 22).

Survival rates to various ages were calculated using the BMDP 1L statistical program. On average only 55% of the animals studied reached maturity, while 35% had not yet died at 10 years of age (Figure 13). The latter might still have been in the herd, or they might have been sold or withdrawn by owners before reaching 10 years of age.

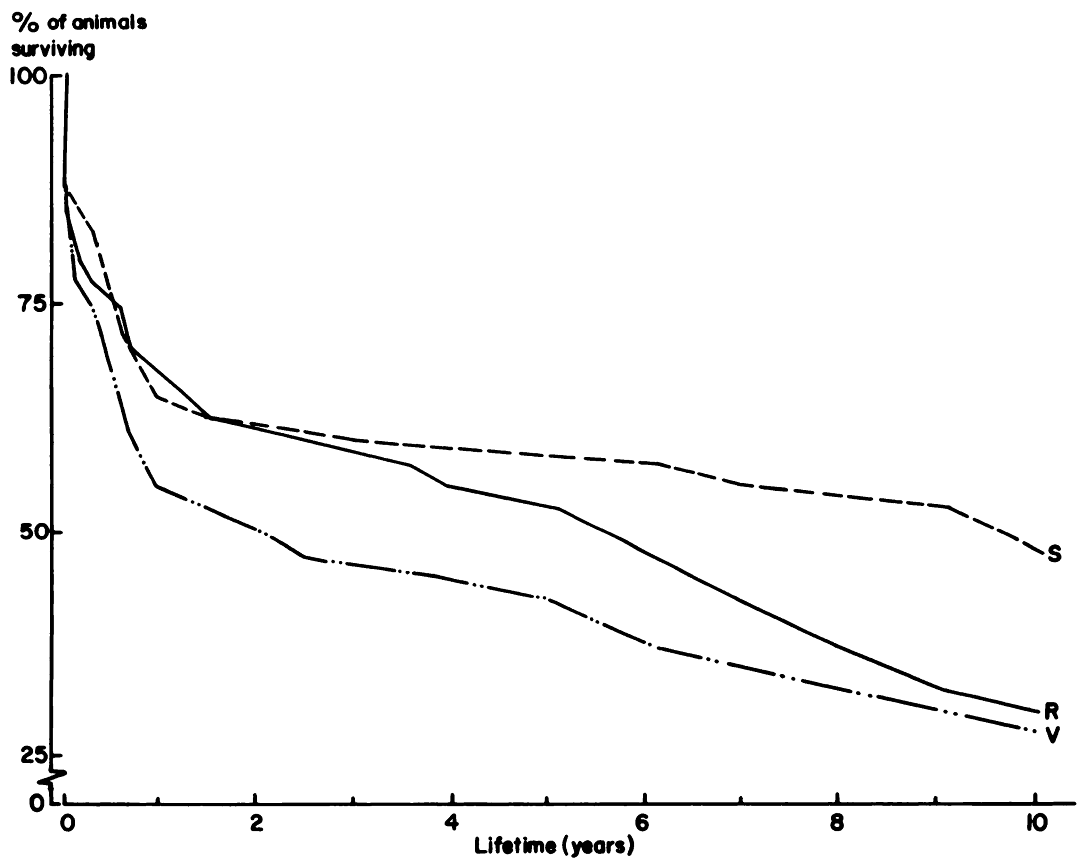
Table 22. *Mortality rates by age class for Sudanese Fulani cattle, reported in literature and in this study.*

Abortions (%)	Mortality (%) 0–1 M	0–1 F	1–2	2–3	>3 years	Source
–	30	30	5–10	2[b]	2	Lacrouts et al, 1965
4.2	37.6	33.2	5.3	–	–	Coulomb, 1972
–	32	27	5	2	2	SEDES, 1975
–	22	10	15(M), 8(F)	6	2	OMBEVI, 1978
3.9	33.2	33.2	7.8[a]	7.8	7.8	Diallo, 1978
10.0	21.8	21.8	5.4	2.8[b]	2.8	ILCA/IER, 1978, Niono ranch
6.7	36.8	35.5	6.3	3.9	7.7	This study

[a] Averaged from the 1- to 2-year age class onwards.

[b] Averaged from the 2- to 3-year age class onwards.

Figure 13. *Percentage of animals alive at a certain age, herds R, S and V, 1979–83.*



6. GROWTH RATE

6.1 CALVES

In a sample of 434 calves, average weight at birth was 16.0 kg for female calves and 17.4 kg for male calves. Birth weight was significantly influenced by year and season of birth, sex and parity of calf, and herd (Table 23).

recurrent effect of season of birth on body weight at 3 and 4 years of age is difficult to explain.

The effect of year of birth on calf growth to 12 months (Table 24) is graphically illustrated in Figure 16, and can be explained by the annual availability of forage in the delta over the study

Table 23. *Factors influencing body weight (kg) of cattle from birth to maturity, Diafarabé, 1979–83.*

Age	n	Unadjusted mean	Year of birth	Season of birth	Herd	Sex	Parity	Herd unit
Birth	434	16.6	***	*	*	***	***	
1 mo	438	25.6	***	*		***	***	*
3 mo	435	40.4	***	***		***	***	
6 mo	382	55.9	***	***		**	***	
9 mo	353	69.8	***	*		*	**	
1 yr	311	80.9	***			*	+	
2 yr	250	124.8				***		
3 yr	167	167.3	+	*		***	*	
4 yr	77	195.5		*		*		
5 yr	84	207.4				***	*	
6 yr	57	221.6				**		
7yr	42	222.3				**		

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

Season of birth significantly influenced growth up to 9 months, but at 1 year this effect was negligible as all calves had by then gone through the annual sequence of nutritional conditions (Figure 14). Up to 3 months of age, calves born in the rainy season grew much faster than those born in the rest of the year, while at 1 year, calves born in November, January and February were the heaviest (Table 24).

From 1 year of age onwards, weight gain was influenced by the seasonal availability of forage and the consequent compensatory growth, as illustrated for calves born in 1979 (Figure 15). The

period (Tables 1 and 2). The effect of parity on growth rate (Table 24, Figure 17) can be attributed to the slower growth of first-parity calves (Paterson et al, 1980). Differences in growth rate between herds and within herd units were not significant (Table 24). Average daily weight gain in the first year was 175 g (Table 25).

6.2 GROWTH AFTER 1 YEAR OF AGE

Growth after 1 year was significantly influenced by sex (Tables 23 and 26); the weight difference between sexes increased steadily from 4 kg at 1 year to 20 kg at 4 years (Figure 18). After 4 years

Figure 14. *Effect of month of birth on calf growth to 12 months, Diafarabé, 1979–83.*

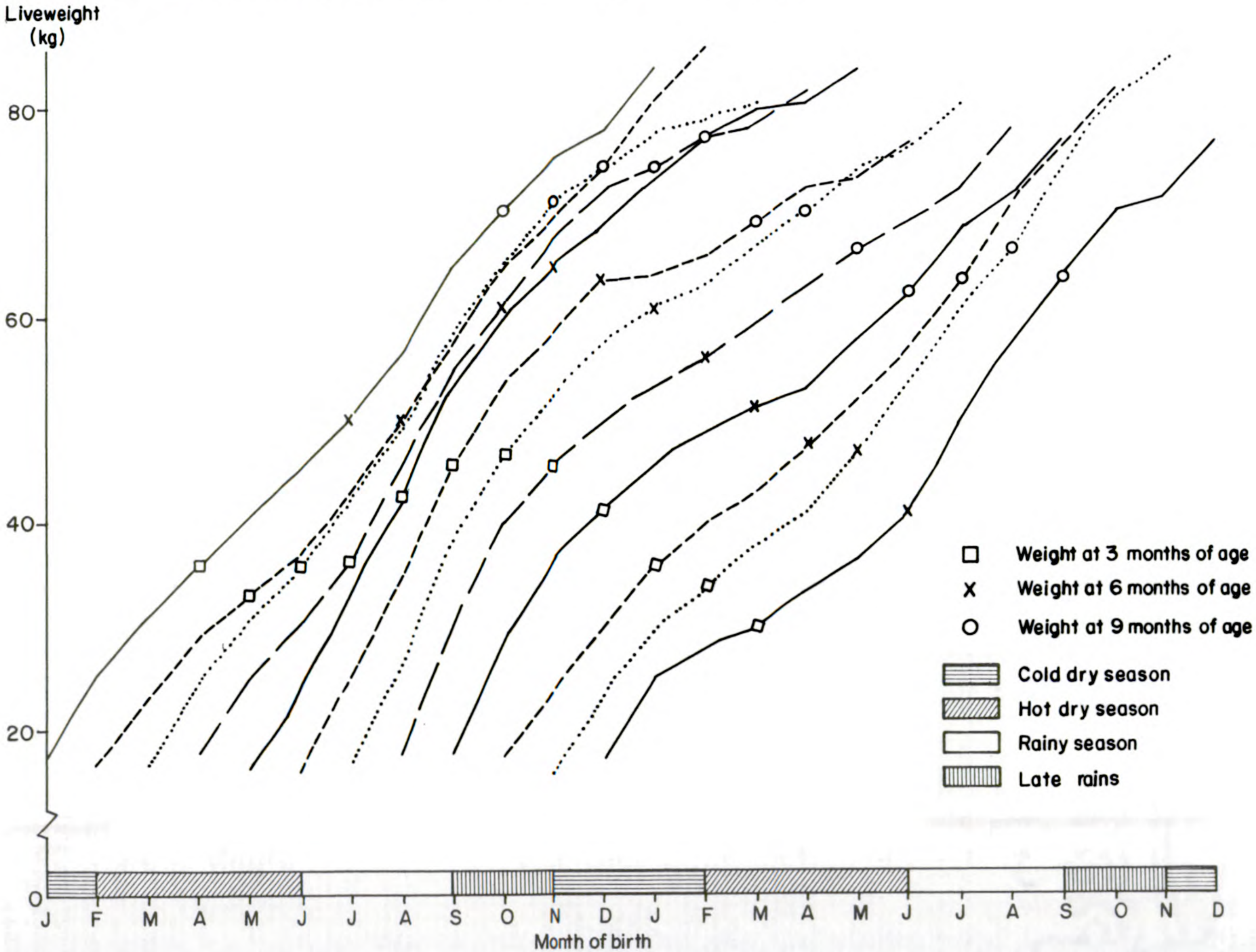


Table 24. *Estimated least squares means for calf weights (kg) from birth to 12 months, Diafarabé, 1979–83.*

Variable	birth		1 month		3 months		6 months		9 months		12 months	
	n		n		n		n		n		n	
Overall mean	434	16.7	438	24.9	435	41.4	382	54.6	353	65.4	311	79.6
Year of birth												
1978	–	–	–	–	–	–	20	51.0a	55	66.4a	77	79.7b
1979	100	17.3b	118	26.2b	122	44.5c	114	61.3ac	109	73.7b	100	85.2c
1980	122	17.3b	106	25.2b	102	41.4b	79	54.9ab	71	66.6a	67	80.3b
1981	115	16.4a	118	25.3b	120	42.7bc	104	53.4ab	86	62.4a	67	73.0a
1982	97	15.7a	96	22.9a	91	37.2a	65	52.2ab	32	58.0a	–	–
Season of birth												
November–March	140	16.6ab	143	24.2a	147	34.1a	125	48.8a	115	62.3ab	104	83.1
April–June	135	16.1a	125	23.8a	126	46.4b	108	60.8b	111	71.1bc	91	78.4
July	55	16.7ab	75	26.8b	83	47.7b	71	57.0bc	64	64.2a	57	77.6
August–October	104	17.3b	95	24.6ab	79	37.5c	78	51.6ac	63	64.2a	59	79.2
Herd												
R	141	16.8a	136	24.3	129	40.8	116	56.7	109	66.5	92	79.8
S	129	16.2b	128	25.0	130	42.4	117	53.9	103	65.2	86	79.9
V	164	17.0a	174	25.2	176	41.1	149	53.2	141	64.7	133	78.9
Sex of calf												
female	224	16.0a	221	23.8a	230	39.9a	201	53.0a	182	63.6a	163	77.6a
male	210	17.4b	217	25.9b	205	42.9b	181	56.1b	171	67.2b	148	81.5b
Parity												
1	103	15.5a	105	23.0a	105	37.3a	89	49.5a	84	60.1a	72	75.3
2	88	16.8b	83	25.3b	79	42.6bc	67	56.4b	68	67.8b	66	81.6
3	82	16.9b	89	25.8b	87	43.6b	82	56.9b	75	68.1b	66	81.5
4	80	17.1b	77	25.5b	84	42.5bc	74	55.3b	69	65.0b	59	79.5
5+	81	17.1b	84	24.6b	80	41.2c	70	54.8b	57	66.2b	48	79.9
Herd unit												
Garci	–	–	361	25.6a	288	41.6	205	55.3	213	67.5	225	80.5
Bendi	–	–	58	27.4b	106	40.1	128	54.8	101	67.4	62	82.7
Cipi	–	–	19	21.6a	41	42.6	49	53.6	39	61.5	24	75.5

Within variable groups, means followed by the same letter are not significantly different at the 5% level.

Figure 15. *Effect of season of birth on weight gain of calves born in 1979.*

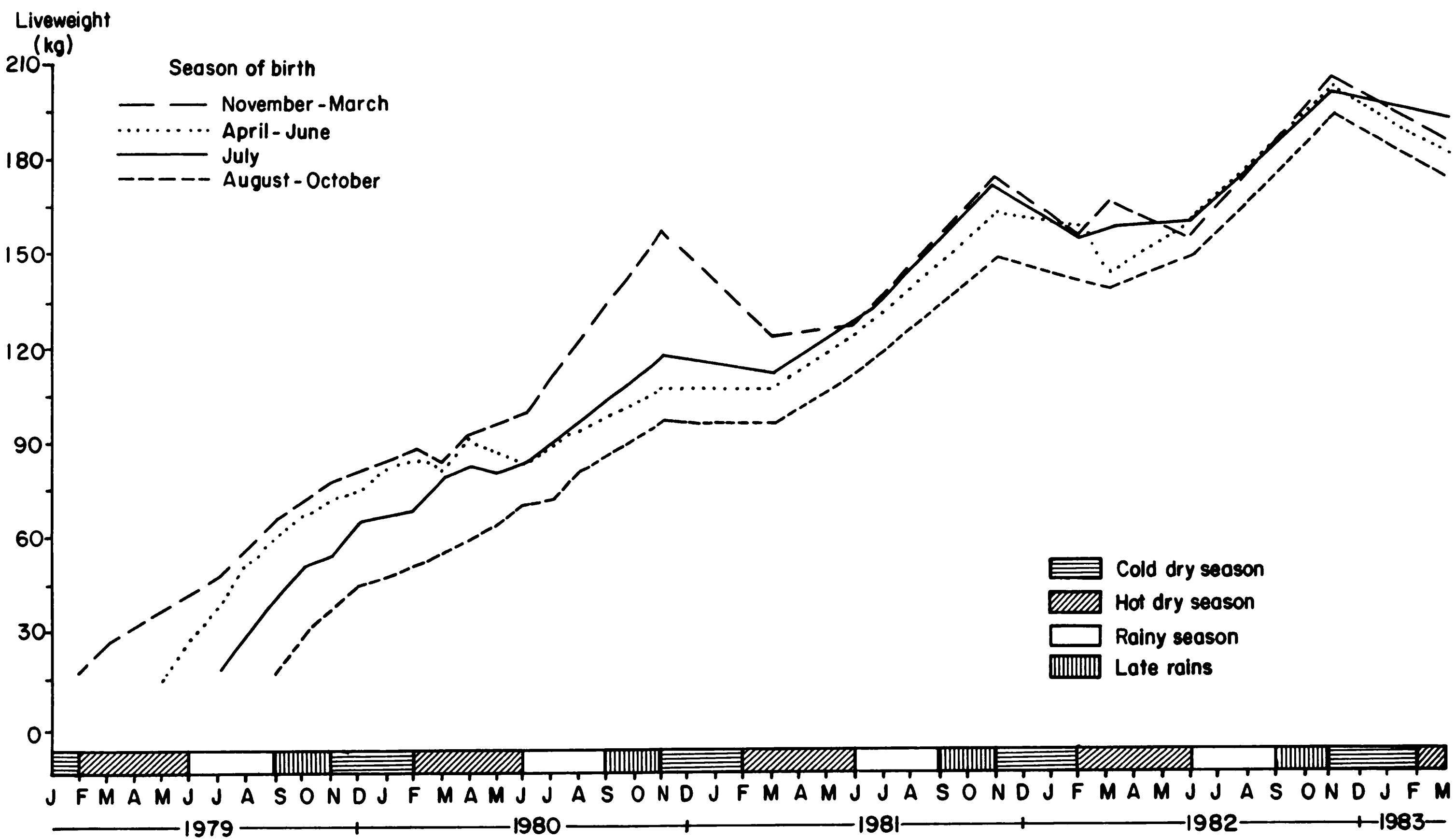
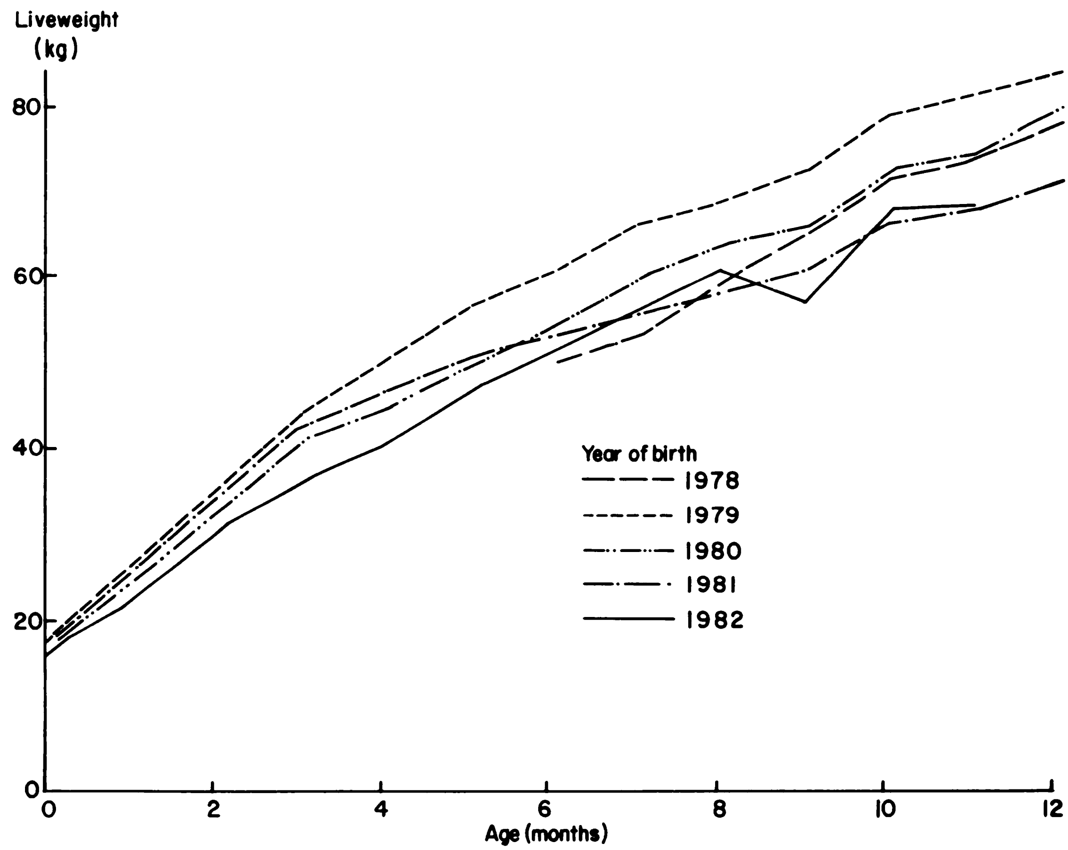


Figure 16. *Calf growth to 12 months by year of birth, Diafarabé, 1979–83.*



females gained weight very slowly, probably because of the stress of first calving and lactation. The average adult weight of females was about 215 kg, while males averaged 260 kg.

The body weight of adult animals fluctuated with season, following a saw-tooth pattern (Figure 19). Even though the November 1979 weighing could not be completed, and the weighing in June 1981 occurred at a time when the animals had already gained some weight, the graph shows well the heavy dry-season losses in body weight, which were up to 20% in 1982. Weight differences between years corresponded well with the ranking of years in terms of the amount of DM produced.

Table 25. *Average daily weight gain to 12 months, Diafarabé, 1979–83.*

Season of birth	Weight gain (g) 0–3	4–6 (months)	7–9	10–12	Average
January–March	198	200	202	122	181
April–June	275	236	115	72	175
July–September	297	127	111	129	166
October–December	183	132	212	181	177
Average	238	174	160	126	175

6.3 DISCUSSION

The growth rates of Sudanese Fulani cattle in the delta were similar to those reported in Nigeria by Pullan (1980; 1980a) and Otchere (1983), and in Mali by Wilson (1983) who recorded an average dry-season weight loss of 9% for cows in the agro-pastoral system. Denis and Valenza (1970) found that the Gobra cows in Senegal lost between 17 and 24% of their body weight from January to July, and attributed the heaviest weight losses to parturition in the dry season and lactation.

Slow calf growth is generally believed to be responsible for low reproductive performance, high mortality and low offtake rates. The growth rates could be considerably improved by lowering stocking rates (ILCA/IER, 1978) or by feed supplementation (Pullan, 1980), but these changes in management would need to be coupled with changes in production objectives.

Figure 17. *Calf growth to 12 months by parity, Diafarabé, 1979–83.*

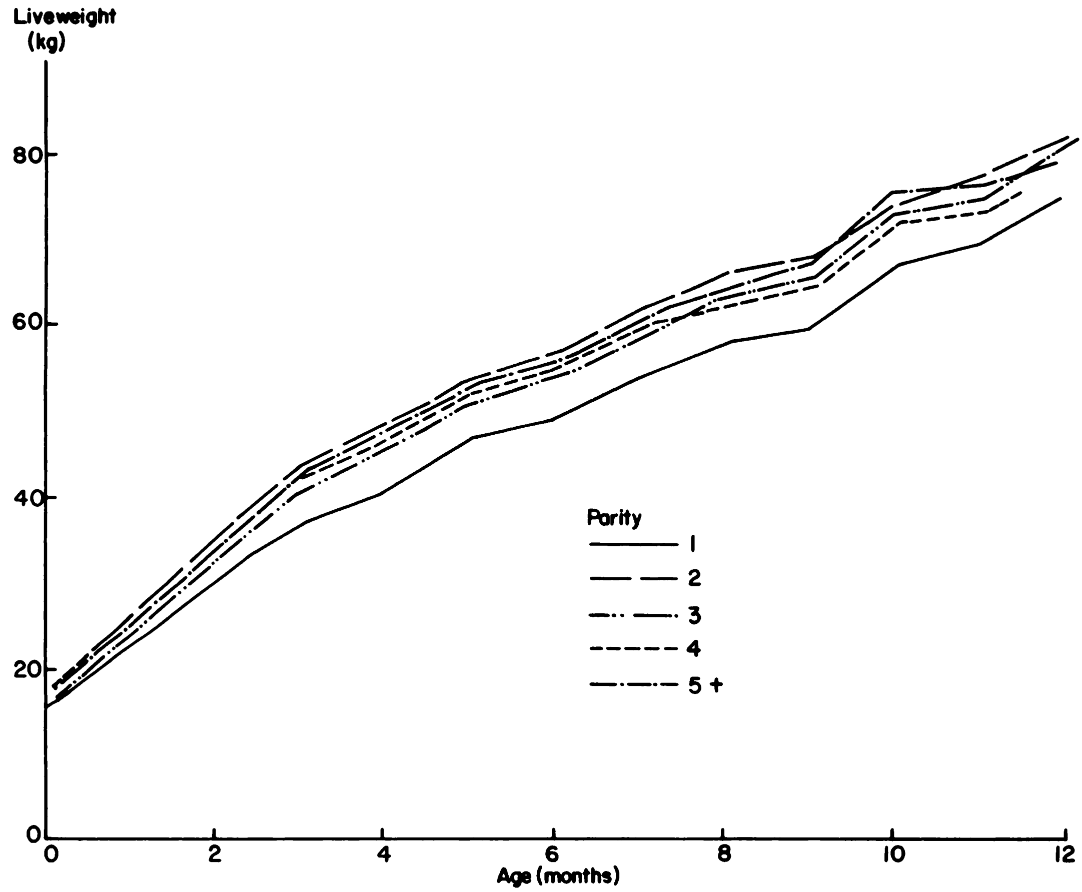


Figure 18. *Growth curves for males and females from birth to 7 years of age, Diafarabé, 1979–83.*

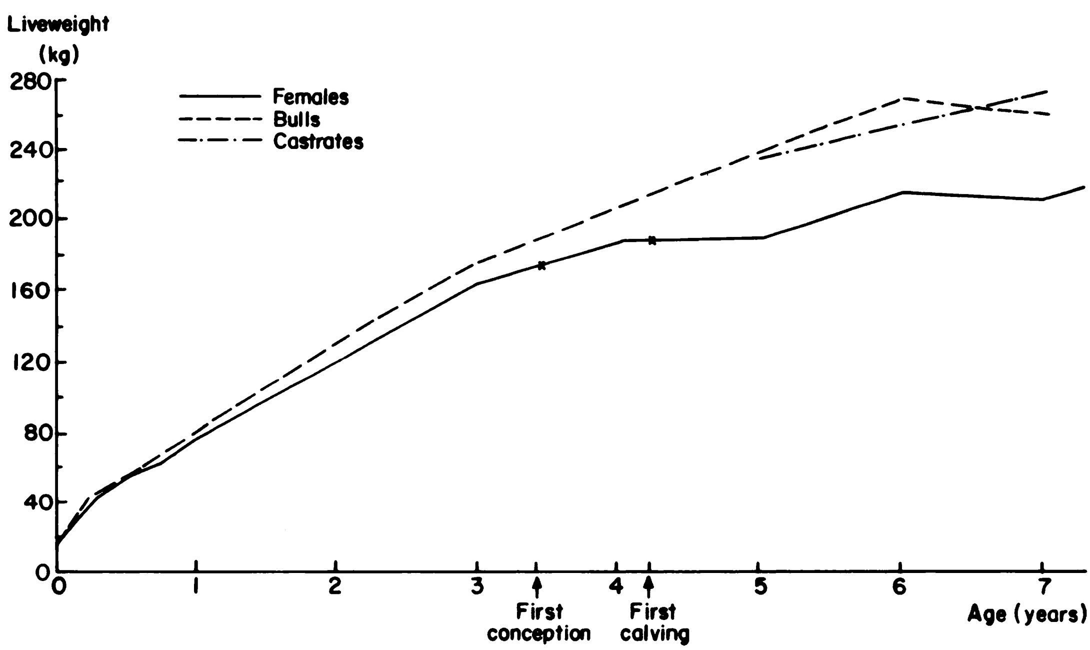
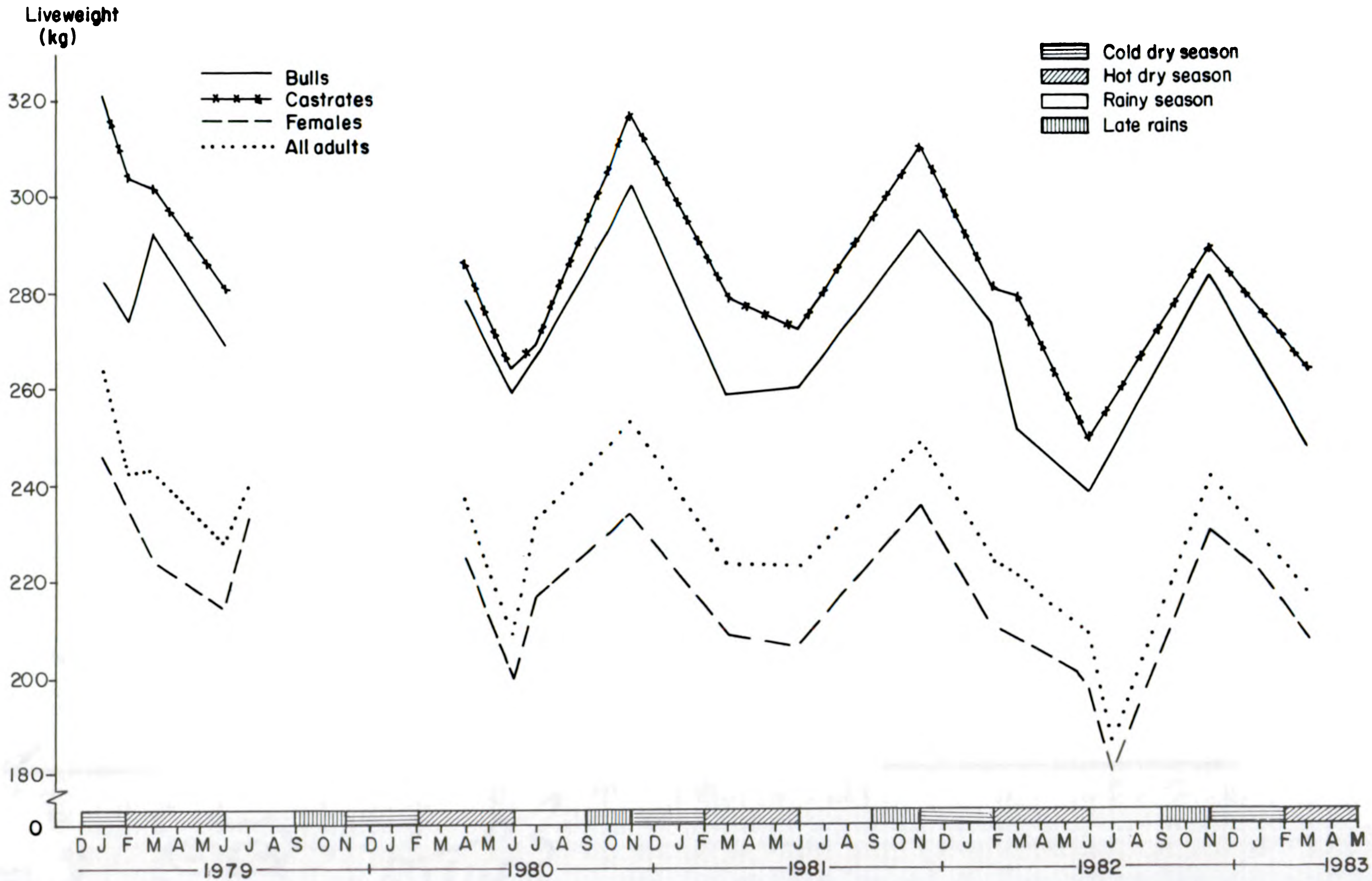


Table 26. *Estimated least squares means for weights (kg) of 2- to 6-year-old animals, Diafarabé, 1979–83.*

Variable	2 years		3 years		4 years		5 years		6 years	
	n		n		n		n		n	
Overall mean	250	125.2	167	169.6	77	198.1	84	221.3	57	244.4
Year of birth										
1973	–	–	–	–	–	–	–	–	11	234.5
1974	–	–	–	–	–	–	12	218.1	11	242.5
1975	–	–	–	–	–	–	17	216.7	17	242.1
1976	–	–	5	158.9	–	–	23	236.4	17	233.3
1977	19	136.4	17	180.1	15	209.9	21	219.8	1	269.7
1978	77	128.4	70	171.7	50	198.3	11	215.4	–	–
1979	92	127.7	66	165.2	12	186.2	–	–	–	–
1980	51	121.5	9	172.2	–	–	–	–	–	–
1981	11	111.8	–	–	–	–	–	–	–	–
Season of birth										
November–March	85	126.9	54	169.6ab	24	210.2a				
April–June	87	121.9	66	164.8b	33	186.5b				
July	34	123.0	19	165.2b	5	196.0ab				
August–October	44	128.9	28	178.9a	15	199.8ab				
Herd										
R	71	122.6	42	166.4	14	198.0	30	227.2	31	245.6
S	63	133.0	42	173.9	16	194.4	24	220.9	11	245.3
V	116	119.9	83	168.5	47	202.0	30	215.8	15	242.3
Sex										
female	143	120.8a	99	162.8a	50	188.4a	68	190.2a	46	214.5a
male	107	129.5b	68	176.4b	27	207.9b	7	238.6b	5	264.7b
castrate	–	–	–	–	–	–	9	235.0b	6	254.0b
Parity										
1	56	121.4	35	163.8a	14	196.2	27	225.7ab	21	250.2
2	58	125.6	44	167.3ab	25	191.1	25	237.3a	16	251.3
3	60	127.8	45	175.4b	21	203.2	19	235.1a	14	246.1
4	41	122.2	21	164.6a	8	193.6	8	204.3b	4	249.6
5+	35	128.8	22	177.0b	9	206.6	5	204.1b	2	224.8

Within variable groups, means followed by the same letter are not significantly different at the 5% level.

Figure 19. *Changes in the weight of adult animals, Diafarabé, 1979–83.*



7. MILK PRODUCTION

7.1 INTRODUCTION

From a macro-economic point of view, meat is the most important product from pastoral systems. For the pastoralists, however, milk is equally if not more important (Shapiro, 1979; Synge, 1980).

In order to ensure daily milk supply for their families, the Fulani aim for a sustained milk output rather than high output over a short period (Stenning, 1959; Pullan, 1980; Diallo and Wagenaar, 1983), and this production objective is reflected in their management practices. Lactating cows are allocated to several herd units so as to distribute available milk according to needs. The *garci* is sent on transhumance to Mauritania to preserve the nearer grazing grounds for the *bendi* animals. Some pastures (the *harima*) around the villages are reserved for lactating cows. Despite insects and high humidity, which seriously affect animal health, the *dunti* cows are kept in the delta during the rainy season to provide milk for human consumption (Joshi et al, 1957; Gallais, 1967; Ketelaars, 1978; Diallo and Wagenaar, 1983). And last but not the least, the Fulani try to extend the lactation periods of their cows, even though this has negative implications for reproductive performance.

When analysing milk production by zebu cattle, it is necessary to distinguish between milk offtake for human consumption (MO) and the quantity of milk consumed by the calf (MC). This distinction is not always clearly made (Dahl and Hjort, 1976). In this report total milk produced (TMP) is defined as the sum of MO and MC.

7.2 LACTATION LENGTH

Most *Bos indicus* cows can be milked only after milk let-down has been induced by suckling. When a calf dies, continued attempts at milking result in very low production over a shorter lactation period (Pullan, 1980; Synge, 1980; Otchere, 1983), and indeed most cows stop secreting milk completely (Ngere et al, 1973; Schaar et al, 1981; Ngategize, 1982). Fulani herdsmen usually try to induce cows whose calves had died to adopt new calves, but only about 5% of the attempted adoptions are successful. The traditional practice is to cover the new calf with the skin of the dead calf, sprinkle a mixture of milk, hot pepper and urine on the nose of the cow while the new calf tries to suckle, and to blow air into the cow's vulva.

In the study area, early calf mortality led to a number of short lactations; 10.7% of the recorded lactations stopped within 60 days (Table 27). If a calf died within 2 weeks of birth (10% of all calves born), the lactation was not included in the analysis. Date of weaning or date of the last recorded daily milk yield was taken to be the end of the lactation.

Mean lactation length was 246 ± 129 days. Lactation length was negatively influenced by calf mortality, since average age at weaning was 330 days, i.e. 'normal' lactations lasted that long. Bremaud and Pagot (1962, cited by Shapiro, 1979) reported average lactation length of 210 days and ILCA/IER (1978) found 266 days for supplemented Fulani cows at the Sahel Station in Niono.

Season of calving and herd unit had significant ($P<0.05$) effects on lactation length. Year effects approached significance ($P = 0.06$) in that lactations in 1980 tended to be shorter than those in 1979 and 1981 (Table 28).

Table 27. *Frequency distribution of lactation length in a sample of 568 recorded lactations, Diafarabé, 1979–83.*

Lactation length (days)	Relative frequency (%)
15–60	10.7
61–120	10.8
121–180	12.3
181–240	12.5
241–300	13.2
301–360	19.9
361–420	13.9
≥421	6.7

Table 28. *Estimated least squares means for lactation length, Diafarabé, 1979–82.*

Variable	n	Lactation length (days)
Overall mean	364	258
Season of calving*		
August – October	76	215a
November – March	123	263b
April – June	99	278b
July	66	278b
Herd unit*		
garci	230	240a
bendi, cipi	134	277b
Year of calving		
1979	123	273
1980	111	231
1981	130	271
Herd		
R	108	257
S	98	272
V	158	246
Parity		
1	88	262
2	72	251
3	77	267
4	68	253
5+	59	259
Sex of calf		
Female	190	250
Male	174	267

* $P<0.05$.

Within variable groups, means followed by the same letter do not differ significantly.

The effect of season of calving on lactation length can be explained by the effect season of birth had on calf mortality. Mortality to 11 months was highest (41%) for calves born in the August to October season, followed by 37%, 26% and 25% for those born in November to March, July and April to June, respectively.

The effect of herd unit on lactation length was such that the *bendi* and *cipi* cows were milked longer than the *garci* cows in order to produce enough milk for home consumption and/or sale. Herd did not have a significant effect, but a chi-square test based on 568 observations showed a significant ($P<0.05$) unequal distribution of lactation periods among herds ($\chi^2 = 15.9$). Cows in herd S were milked considerably longer than those in herds R and V. Parity did not have an effect on lactation length.

Number of milking cows per person is a factor which may influence lactation length. Poor owners are compelled to keep their cows in milk longer in order to ensure an adequate supply of milk for home consumption (Carl Bro Int., 1982; Wilson and Wagenaar, 1983; King et al, 1984). This factor could not be studied because of the complexity of cattle ownership in Diafarabé. However, Diallo and Wagenaar (1983) found significantly shorter lactations (earlier weanings) and better calf growth with increasing herd size. In the fourth herd, which was abandoned in 1980 and which was larger than the remaining three study herds (see Section 2.1), relatively less milk per cow was milked out, resulting in higher milk consumption by calves and shorter lactation periods.

Extending lactations for as long as possible is a common management practice in the Fulani pastoral system (Synge, 1980), even when milk yield drops below 200 ml/day. Pullan (1980) reported that in his study in Nigeria, 65% of the Fulani cows were milked for about 1 year and 26% for over 2 years. He suggested that this phenomenon was related to the herders' reliance on milk. Otchere (1983) reported an average lactation length of 14 months for Fulani cows in Nigeria. In the present study, 20.5% of lactations exceeded 365 days (Table 27), while the longest lactation recorded was 606 days.

In the Fulani system, milk offtake reaches a significant peak during the rainy season, even in lactations exceeding 1 year (Bartha, 1971; Dahl and Hjort, 1976; Godet et al, 1980; Fulton and Toulmin, 1982; Diallo and Wagenaar, 1983). Thus a second rainy season within a single lactation period considerably increases total milked-out yield.

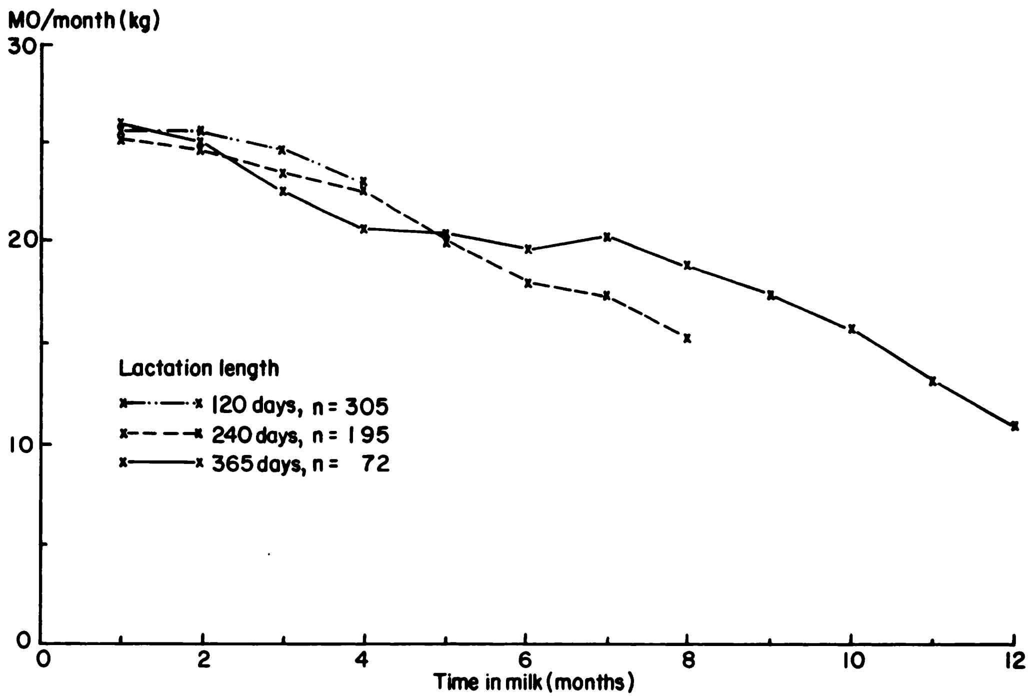
7.3 MILK OFFTAKE FOR HUMAN CONSUMPTION

The amount of milk taken for human consumption (MO) was highly significantly ($P<0.001$) correlated with lactation length ($r = 0.77$). Having found a similar correlation, Stobbs (1967) went a step further and derived a correlation between milk offtake and calf survival.

The considerable within-herd variations in MO found in this study were caused by lactations shorter than 60 days. The coefficients of variation ranged from 35 to 45% (see also Hayman, 1973;

Ngere et al, 1973), suggesting that average MO is a poor indicator of the potential milk yield of a breed. Because of the variability in lactation length, separate analyses were done for lactations extending to 120, 240 and 365 days (Tables 29 and 30). The shapes of the three lactation curves (Figure 20) did not differ much, thus leading to the assumption that if continued, the two shorter lactations would have matched the corresponding sections of the 365-day curve. One might therefore expect MO to weaning (219 kg to 330 days) to be representative of the potential milk offtake of Sudanese Fulani cows in the delta (Table 30).

Figure 20. *Monthly milk offtake for different lengths of lactation, Diafarabé, 1979–83.*



Season and year of calving, as well as herd unit, significantly influenced milk offtake (Table 29). The effect of season of calving was significant up to 240 days of lactation, thus indicating that rainy season had a decisive effect on MO (Figure 21a). This effect decreased towards the end of the annual cycle, as all lactations had by then passed through a wet and a dry season. Nevertheless, total MO at 330 days differed according to season of calving; cows calving in the rainy season, when grazing was abundant, had the lowest MO at the end of the lactation period (Table 30). The reason for this is not clear, but the finding corroborates those of ILCA/IER (1978) in Mali and Schaar et al (1981) in Ethiopia. A possible explanation is that during the period of peak milk production by these cows, demand for milk is relatively low as there is abundance of milk and the herds are far from the milk markets. The ranking of MO by year of calving corresponded to the estimated DM availability during the 1979–1981 period (Table 30).

Milk offtake differed significantly among herd units in the first half of lactation, while in the second half there was only a tendency towards significance (Table 29). Animals sent to the *bendi* or *cipi* units had a considerably higher MO than those remaining in the *garci* (Table 30), reflecting (as with lactation length) a more intensive exploitation of the *bendi* and *cipi* cows. The fact that only the better milk cows are transferred to these herd units also explains their higher milk offtake.

Daily MO per cow was influenced by season of calving (Figure 21a) and climatic season (Figure 21b). Daily MO was highest in the rainy season, matching the availability of good-quality forage (see also Deutscher and Whiteman, 1971; Bartha, 1971; van Raay, 1975; Dahl and Hjort, 1976; Mesnil, 1979; Godet et al, 1980; Synge, 1980; Semenye, 1982; Diallo and Wagenaar, 1983; Nicholson, 1983; Otchere, 1983).

Average daily MO per cow is shown in Figure 22 by year and season. The total amount of

Table 29. ***Analysis of variance of milk offtake per cow at various stages of lactation.***

Source of variation	d.f.	Mean squares		d.f.	Mean squares		d.f.	Mean squares	
		60 days	120 days		180 days	240 days		300 days	330 days
Origin	1	52 413	305 560	1	344 844	480 030	1	223 455	282 157
Herd	2	242	308	2	5 030	8 545	2	8 386	9 034
Sex of calf	1	1 482⁺	4 206	1	1 742	2 271	1	1 132	380
Parity	4	658	2 750	4	3 244	3 349	4	2 682	2 545
Season of calving	3	8 777***	41 523***	3	27 042***	20 122**	3	8 090	7 944
Year of calving	2	1 462*	9 259**	2	28 124***	38 979***	2	28 081**	30 221*
Herd unit	1	3 822**	18 607***	1	23 377**	32 668**	1	18 287⁺	22 659⁺
Herd x year	4	826	2 778	4	4 952	5 936	4	8 085	10 147
Herd x herd unit	2	96	94	2	3 723	6 035	–	–	–
Season x year	6	534	1 866	6	2 615	3 863	–	–	–
Season x herd unit	3	2 212**	7 668**	3	5 170	6 534	3	467	647
Remainder	276	447	1 563	166	2 635	4 018	51	5 622	6 393

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

Table 30. *Estimated least squares means for milk offtake per cow at various stages of lactation up to weaning, Diafarabé, 1979–82.*

Variable	n	MO (kg)		n	MO (kg)		n	MO (kg)	
		60 days	120 days		180 days	240 days		300 days	330 days
Overall mean	305	51.0	98.4	195	133.9	166.2	72	205.5	218.6
Season of calving									
November–March	99	35.2a	67.8a	73	106.7a	149.2a	34	202.9	221.8
April–June	91	55.4b	118.5b	53	158.9b	193.3b	23	233.6	247.3
July	64	65.3c	121.7b	35	152.3b	177.0ab	12	242.9	257.3
August–October	51	48.2b	85.5c	34	117.9a	145.2a	3	142.5	148.0
Year of calving									
1979	93	56.2a	111.4a	67	163.2a	200.9a	24	252.5a	266.0a
1980	93	47.1b	89.5b	48	108.3b	137.5b	17	188.3ab	205.2ab
1981	119	49.8ab	94.2b	80	130.4b	160.0b	31	175.6b	184.7b
Herd unit									
Garci	203	46.3a	88.0a	116	120.0a	149.6a	36	177.7	187.8
Bendi/Cipi	102	55.7b	108.8b	79	147.9b	182.7b	36	233.2	249.5
Herd									
R	93	50.2	98.1	66	142.3	179.6	23	230.7	244.5
S	76	50.0	96.5	47	119.8	149.1	17	182.7	193.8
V	136	52.9	100.5	82	139.7	169.7	32	202.9	217.5
Parity									
1	70	46.1	87.8	39	128.0	160.5	20	180.4	194.1
2	64	53.2	100.6	41	124.6	157.0	12	196.5	209.6
3	64	52.1	100.6	45	132.3	163.3	21	205.2	220.0
4	60	49.2	96.2	41	132.5	164.9	12	222.6	234.8
5+	47	54.4	106.6	29	152.3	185.1	7	222.6	234.6
Sex of calf									
Female	159	48.7	94.4	102	130.7	162.5	36	210.0	221.2
Male	146	53.4	102.3	93	137.2	169.9	36	200.9	216.0

Within variable groups, means followed by the same letter are not significantly different at the 5% level.

Figure 21a. *Average daily milk offtake per cow by season of calving, Diafarabé, 1979–83.*

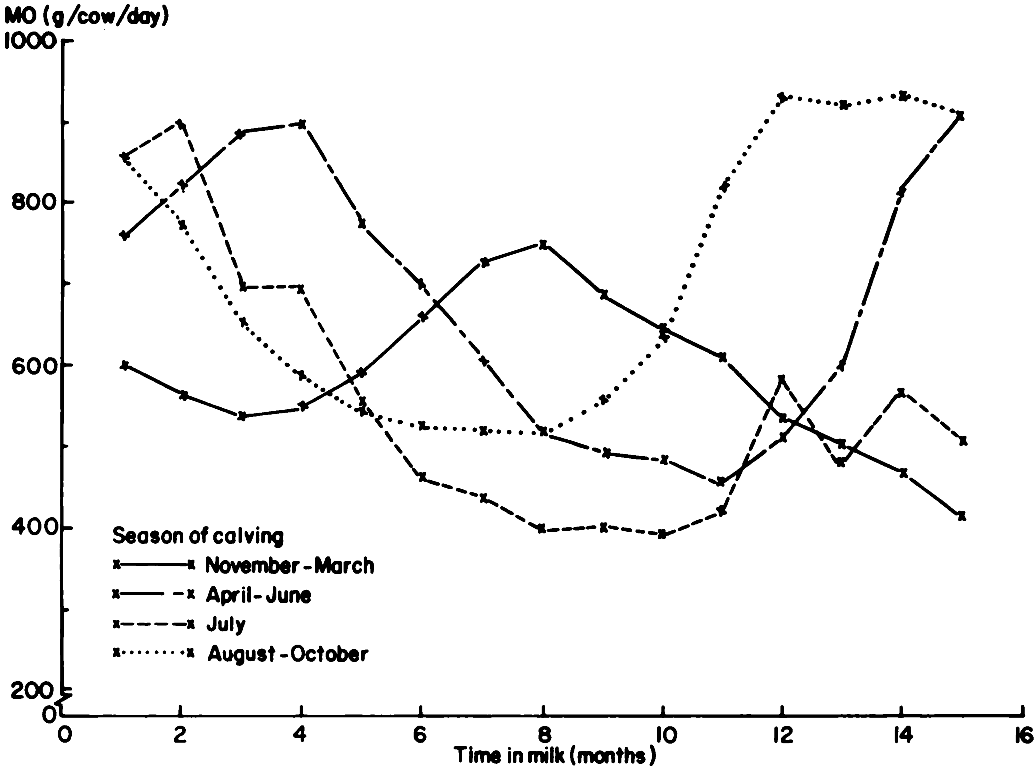


Figure 21b. *Effect of climatic season on average daily milk offtake per cow, Diafarabé, 1979–83.*

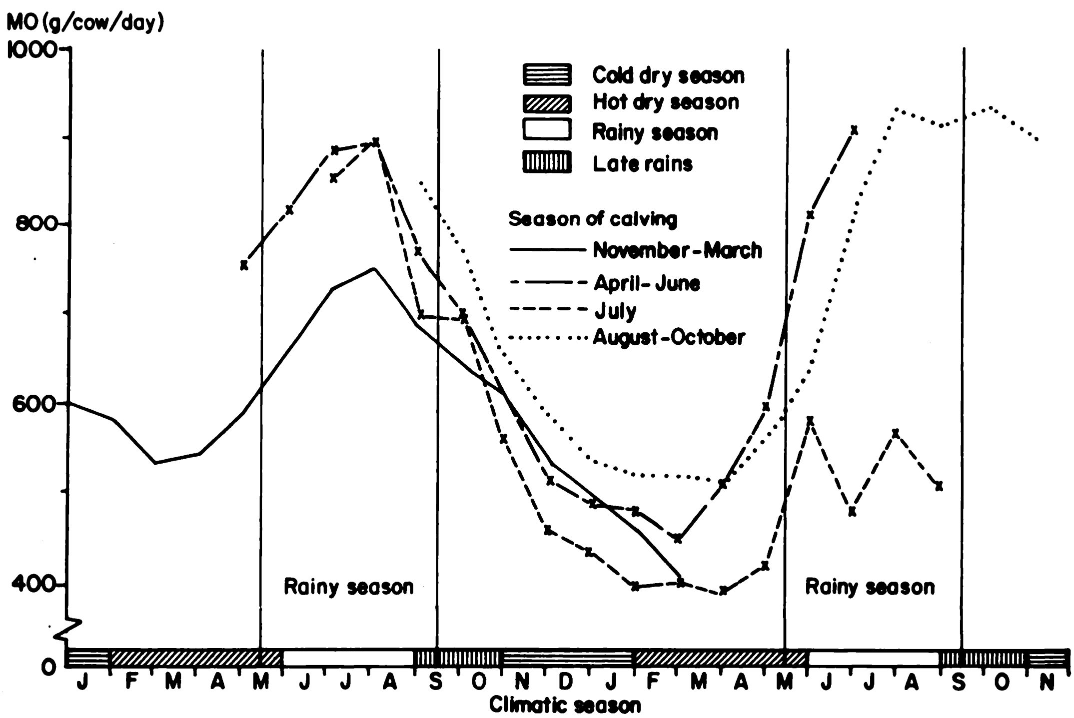
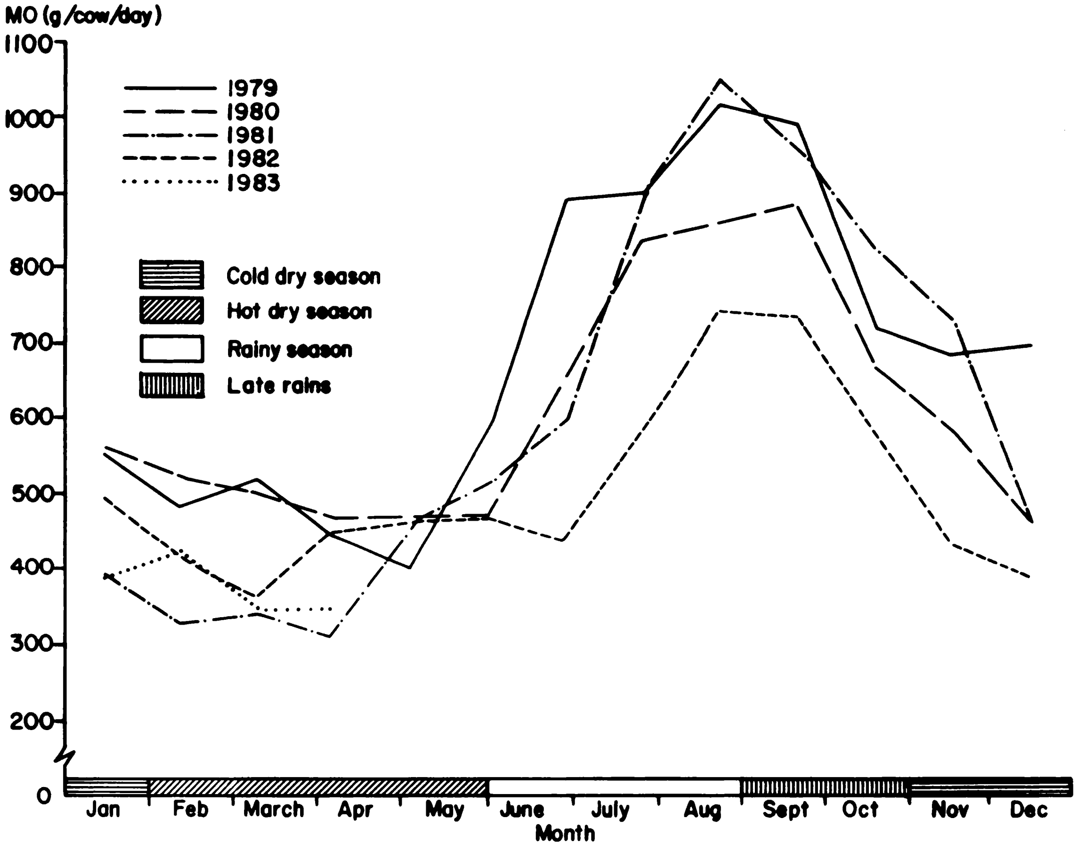


Figure 22. *Average daily milk offtake per cow by year and by season, Diafarabé, 1979–83.*



milk available for human consumption can be calculated by multiplying average daily offtake by the number of cows in milk. In the dry season, the average daily MO was slightly more than 400 g, while in the rainy season it was about 900 g. These figures compare well with data on White Fulani cows in Nigeria and Sudanese Fulani cows in the Niger delta (Table 31).

Doutresoulle (1947) and Bremaud and Pagot (1962, cited by Shapiro, 1979) reported milk yields of 2 to 4 kg/day, which may be TMP rather than MO since the values in Table 31 are all much lower and remarkably uniform. Some data are available on milk offtake from Fulani cattle under improved management: ILCA/IER (1978) reported offtake of 2.2 kg per day for cows at the Sahelian Station in Niono and Coulomb (1972) found that cows supplemented with rice bran had a daily MO of 1.6 to 1.8 kg.

Competition for milk between herders and calves is often mentioned as a critical factor in pastoral production systems: calf growth tends to be depressed when milk is extracted for human consumption. However, the correlation coefficients between MO and estimated calf weight at 30, 60, 90, 120, 150 and 180 days were all highly significant ($P<0.001$) and positive, ranging from 0.36 to 0.48. These values are fairly high since 40 to 45% of the variation in calf weight were already explained as being due to year and season of birth, parity, sex and herd (Table 23). Stobbs (1967) found comparable, highly significant ($P<0.001$) correlation coefficients for Small East African Zebu calves (0.55 for male calves and 0.49 for female calves).

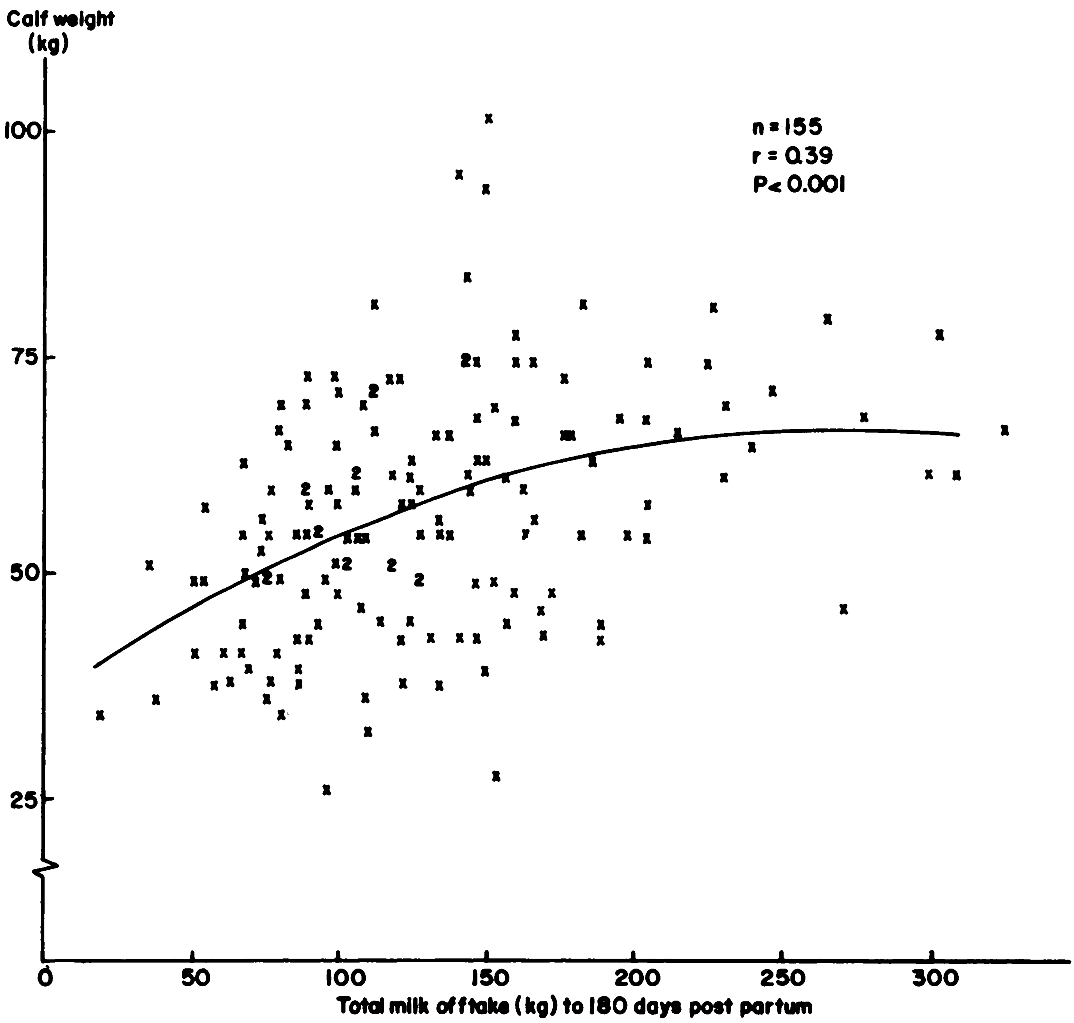
At 180 days post partum the relationship between MO and calf weight seems to take on the shape of the curve $y = 36.95 + 0.225x - 0.00043x^2$ represented in Figure 23. This curve indicates that calf weight at 180 days reached a maximum of 67 kg if MO exceeded 210 kg. For very high MO the correlation might be expected to become negative, but the available data did not allow such an extrapolation.

Despite the high levels of milk offtake in the Fulani system studied, the better cows produced enough milk to enable their calves to grow faster than the average 180-day-old calf (58 kg). Given

Table 31. *Daily milk offtake for Sudanese Fulani cows in Mali and White Fulani cows in Nigeria.*

Location	Daily MO (kg) Dry season	Rainy season	Average	Source
Mali				
Niger delta	–	–	0.75	Gallais (1967)
Niger delta	–	–	0.50	SEDES (1972)
Niger delta	0.60	–	–	Coulomb (1972)
Diafarabé	0.45	0.70	0.55	Diallo (1978)
Nigeria				
Zaria Province	0.50	1.07	0.79	van Raay (1975)
Jos Plateau	0.47	0.81	–	Pullan and Grindle (1980)
Jos Plateau	0.51	0.91	0.71	Synge (1980)
Kachia	–	–	0.69	Otchere (1983)

Figure 23. *Correlation between milk offtake and calf weight at 180 days post partum, Diafarabé, 1979–83.*



the fact that MO and calf growth were positively correlated as early as 30 and 60 days post partum, there is no evidence that season had a confounding effect. The average calf did not lose weight, which shows that the Fulani know how much milk can be extracted without adversely affecting calf growth.

7.4 MILK CONSUMED BY CALVES

The amount of milk consumed by the calf (MC) was calculated from the calf's growth rate. One set of calculations was based on milk conversion figures taken from Montsma (1962) and another on the calculations of maintenance and growth requirements of pre-ruminant calves made by Roy (1980). Details of these calculations are given in the Annex. When calf weight gains were used the MC at 180 days post partum was 332 kg, while calculations based on ME requirements gave 502 kg. These amounts are likely to be underestimated, since the calves in the study area suffered from internal parasites.

The calculated amounts of MC can be used to estimate total amount of milk produced (TMP) and the MO/TMP ratio. Given that MO at 180 days was 134 kg and MC ranged from 330 to 500 kg, 21 to 29% (i.e. less than one third) of the total amount of milk produced per cow was taken for human consumption (Table 32), leaving more than two thirds for the calf.

Table 32. *Milk offtake as percentage of TMP during the first 6 months of lactation, Diafarabé, 1979–82.*

Lactation period (days)	Cumulative MO (kg)	% of TMP[a]	% of TMP[b]
30	26	27	26
60	50	28	25
90	73	28	24
120	95	28	23
150	115	28	22
180	134	29	21

[a] MC calculations based on Montsma (1962).

[b] MC calculations based on Roy (1980).

The MO/TMP ratios differed among herds and herd units, reflecting the different levels of their exploitation (Table 33). Among herd units, calf growth rates were not significantly different, indicating that the amounts of MC were more or less equal. However, MO differed in that more milk was extracted from cows in the *bendi* and *cipi* units than in the *garci* unit. Amongst herds, herd V had the highest MO/TMP ratio.

Table 33. *MO/TMP ratios by herd and herd unit, Diafarabé, 1979–82.*

Herd/Unit	MO/TMP ratio (%)
Herd	
R	28
S	27
V	30
Herd unit	
garci	26
bendi/cipi	31

7.5 DISCUSSION

According to the pastoralists' estimates they leave about 50% of the dam's milk to the calf (Agrotec CRG/SEDES, 1974; Dahl and Hjort, 1976; Carl Bro Int., 1982; Wagenaar and Winter, 1982), but in reality it is much more than that (Table 34).

The data in Table 34 indicate that in traditional pastoral systems, calves consume 65 to 80% of the total milk production of their dams. Herders compete with calves for only 20 to 40% of the TMP (Bertaudière, 1979), confirming that pastoralists will not jeopardise their future access to milk if their present supplies are adequate.

Milking practices are responsible for the high MC/TMP ratio in traditional pastoral systems. The Fulani and Kel Tamasheq (own observation), the Dinka (Dahl and Hjort, 1976) and the Borana (Nicholson, 1983) milk their cows on all four teats, but milk let-down is induced by calves which are allowed to suckle after milking. The amount of MO varies according to the condition of the calf, the number of cows in milk per owner, season of milking, the milk retention ability of the cow and the number of milkings per day. The Maasai (Semenye, 1982), the Batswana (Carl Bro Int., 1982), the WoDaaBe (Swift, 1984) and the Sudan Arabs (Dahl and Hjort, 1976) usually milk on two teats while the remaining two are reserved for suckling.

Apart from management, the cow itself may be responsible for the high MC/TMP ratio. It is not clear to what extent zebu cows are able to 'hold their milk back', but the 65 to 80% of milk consumed by calves confirms that milk retention

Table 34. *Milk offtake in traditional pastoral systems in Africa.*

Period (months)	MO (% of TMP)	Country	Source
6	15–32	Tchad	Bertaudière (IEMVT), 1979
7	25–30	Ivory Coast	Godet et al, 1980
4	22	Botswana	APRU, 1980
4	18–25	Kenya	Semenye (ILCA), 1982
6	19–31	Ivory Coast	Landais (IEMVT), 1983
6	15–31	Mali	Diallo and Wagenaar (ILCA), 1983
11	25–38	Ethiopia	Nicholson (ILCA), 1983
6	20–28	Nigeria	Otchere (ILCA), 1983
6	21–29	Mali	This study

by traditionally managed zebu cows does occur (Stobbs, 1967).

During the last decade more thought has been given to increasing milk production in pastoral systems, and in the process it has become important to know who will benefit from this increase. In Nigeria, Otchere (1983) reported that total milk production of cows supplemented with cottonseed and *Stylosanthes* increased from 477 to 594 kg at 180 days post partum. However, only 18% of the increase was milked out, while the rest contributed to a 20% higher calf weight at 180 days. It is questionable whether pastoralists can be persuaded to invest money and labour in the purchase and transportation of supplements, if the calf is to consume the bulk of the extra milk produced. Synge (1980) reported that when breeding females were supplemented with cottonseed during the dry season, a return of 0.45 kg of milk per kg of cottonseed was essentially realised through better reproductive performance, which led to an increased number of cows in milk.

ILCA/IER (1978) reported that the MO/TMP ratio to 180 days for Sudanese Fulani cows raised under improved management at the Sahel Station in Niono was approximately 40%. Milk offtake increased absolutely as well as proportionally, but the calf still consumed 60% of the milk. The station opted for the strategy of restricted suckling to offset the milk let-down problem in zebu cattle. Trail and Gregory (1982) reported an MC/TMP ratio of 59% for Sahiwal cattle raised on a ranch in Kenya.

The phenomenon known as 'let-down refusal' was also observed in *Bos taurus* x *Bos indicus* crosses (Hayman, 1973; Schaar et al, 1981). Instead of culling all crossbred cows that have difficulties with milk let-down, milking with restricted suckling is now often used, and the strategy appears to be the best for exploiting the potential of crossbred cows for milk production (Stobbs, 1967; Alvarez et al, 1980; APRU, 1980; Swensson et al, 1981). In Central America, crossbred calves were reported to consume between 32 and 38% of TMP (Alpuche et al, 1976; Alvarez et al, 1980), while in Africa the proportion found was 55 to 60% (APRU, 1980; Trail and Gregory, 1982).

8. SYNTHESIS

8.1 PRODUCTIVITY

The productivity of the Sudanese Fulani cattle studied varied between years. Marked interannual variability can be expected in those management systems in which nothing is being done to reduce the influence of climate on productivity. In order to compare different livestock production systems, Trail and Gregory (1982) developed a cow productivity index thus:

[cow viability x calving rate x calf survival x calf weight at 1 year (kg)] + [cow viability x calving rate x milk offtake (kg) divided by 9].

This index represents the weight of a year-old calf plus the calf weight equivalent of milk offtake for human consumption, per cow and per year. The 1979–81 productivity indices calculated for Sudanese Fulani in this study are shown in Table 35.

Table 35. *Productivity indices for Sudanese Fulani cows, Diafarabé, 1979–81.*

Parameter/Index	1979	1980	1981
Cow viability (%)	0.95	0.92	0.94
Calving rate (%)	0.55	0.58	0.55
Calf survival (%)	0.79	0.50	0.62
Calf weight at 1 year (kg)	85.2	80.3	73.0
Milk offtake (kg)	266	205	185
Prod. index/cow/year	49.9	33.6	34.0
Average cow weight (215 kg)			
Prod. index/year/100 kg cow LW	23.2	15.6	15.8

The index for 1982 could not be calculated because calf weights at 1 year and milk offtake were recorded only up to March 1983. The relationship between animal productivity and DM production can be extrapolated from Figures 24 and 25, which show trends in different production parameters and in DM production over the 1978–83 period. Animal productivity was highest in 1979, declining in the subsequent years with worsening environmental conditions. Although the production parameters for 1983 were not recorded in detail, field observations suggest that animal productivity reached a very low level in that year.

Calculated on a herd basis, the productivity indices reveal considerable differences (Table 36). Herd V had the lowest productivity, mainly due to high calf mortality. The differences in productivity between herds R and S are difficult to explain considering that these two herds were managed together, followed the same grazing orbit, and used the same bulls.

The productivity indices of similar production systems in Africa for which sufficient data were found, are given in Table 37. A comparison of the calculated number of kilogrammes of 'calf'

Table 36. *Production parameters and productivity indices for herds R, S and V, 1979–83.*

Parameter/Index	R	S	V
Reproduction rate (%)	59.7	51.7	51.7
Calving interval (months)	16.4	17.5	17.8
Weaning age (months)	9.8	11.3	11.3
Lactation length (months)	8.4	8.9	8.1
Milk offtake (kg)	245	194	218
MO/TMP ratio (%)	28	27	30
Calf weight at 1 year (kg)	79.8	79.9	78.9
Weight at 4 years (kg)	198	194	202
Mortality rate to 1 year (%)	29.3	29.9	43.5
Mortality 1–4 years (%)	7.5	3.6	7.6
Mortality > 4 years (%)	10.7	4.6	8.1
Prod. index/cow/year	44.6	38.3	32.7
Prod. index/year/100 kg cow LW	20.7	17.8	15.2

Figure 24. *Production parameters and productivity indices by year, Diafarabé, 1979–82.*

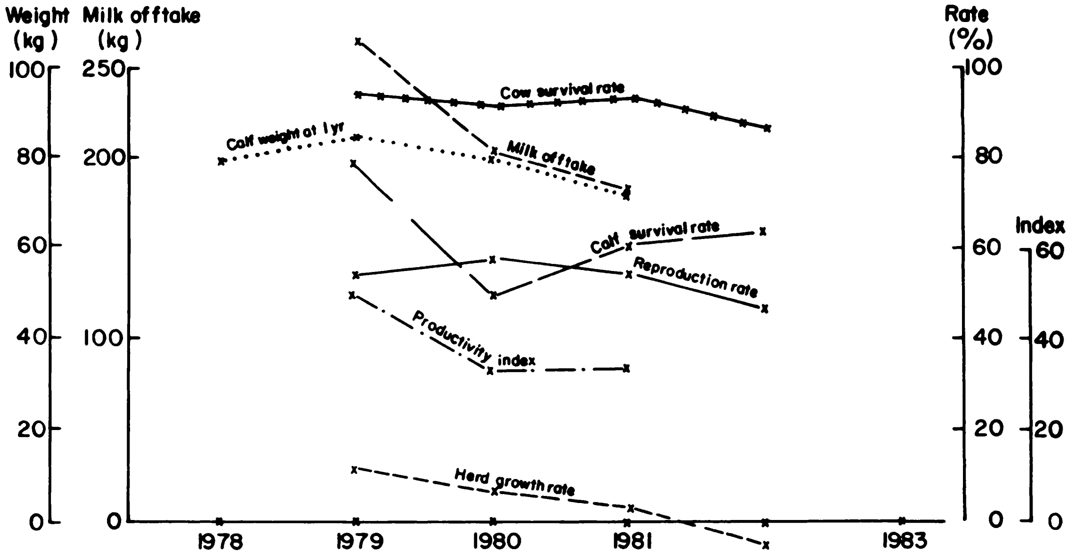
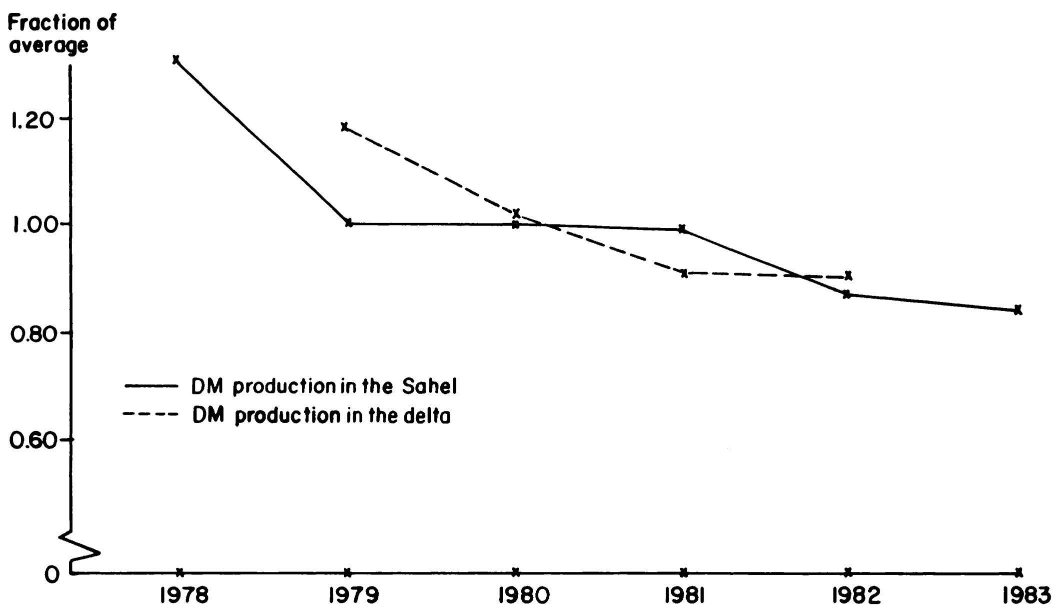


Figure 25. *Annual DM production[a] expressed as fraction of the 1978–83 average for the Sahel and the 1979–82 average for the delta.*



[a] See Tables 1 and 2.

annually produced per 100 kg of cow liveweight (last line) reveals that animal productivity in traditional systems is remarkably similar, despite considerable differences in reproduction rates, liveweights and milk offtake. Results for the Sahel Station in Niono (column 5) show the potential productivity of Sudanese Fulani cattle under improved management conditions.

8.2 TRADE-OFFS BETWEEN MILK AND CALF PRODUCTION

Trade-offs between milk and calf production occur at two levels: higher milk offtake decreases the potential growth and survival chances of the calf, while longer lactations decrease overall calf production.

Table 37. *Productivity indices for some cattle production systems in Africa.*

Parameter/Index	This study	System 1	2	3	4	5
Cow viability (%)	0.92	0.97	0.97[a]	0.96	0.98	0.97
Calving rate (%)	0.54	0.57	0.45	0.46	0.46	0.77[b]
Calf viability (%)	0.64	0.75	0.86	0.88	0.88	0.69
Calf weight at 1 year (kg)	79.6	81	91.1	80	132.5	125
Milk offtake (kg)	218.6	193[c]	286.4	234[d]	162	522
Prod. index/cow/year	37.2	45.7	47.5	42.5	61.2	108.8
Adult cow weight (kg)	215	242	268	245	325	302
Prod.index/year/100 kg cow LW	17.3	18.9	17.7	17.3	18.8	36.0

[a] Assumed value.

[b] Calculated from ILCA/IER (1978).

[c] Calculated from Dicko (1981).

[d] Calculated from Pullan and Grindle (1980).

Systems and sources:

1 Agropastoral system in Mali (Wilson, 1983a)

2 Traditional system of settled Fulani in Nigeria (Otchere, 1983)

3 Traditional system of settled Fulani in Nigeria (Pullan, 1979; 1980)

4 Traditional system in Botswana (de Ridder and Wagenaar, 1984)

5 Sudanese Fulani cattle under improved management, Sahel Station, Niono (ILCA/IER, 1978)

The average MO at 180 days was 134 kg (Table 30), corresponding to an average calf weight of 57.6 kg (Figure 23). A 10-kg heavier calf had a better chance of surviving, but it consumed part of the 134 kg of MO. The amount of milk consumed by the calf was calculated using the ME requirement tables of Roy (1980). Similar calculations were made for calves 10 kg lighter at 180 days and for calves at 90 days of age with the same ± 10 kg variations in weight (Table 38).

A weight gain of 10 kg above the average gave the herder 0.05 and 0.04 more calves at 180 and 365 days respectively, but he extracted 54 to 69 kg of milk less from that calf's dam. The price of 1 kg of milk varies between 150 and 250 Malian francs (MF) on the market, while a 1-year-old calf is worth 15 000 to 20 000 MF. Dahl and Hjort (1976) calculated that the average net energy value of 1 litre of milk is 650–800 kcal, while 1 kg of cold dressed meat represents approximately 2000–2400 kcal (half that per kg liveweight). Offtake of milk therefore seems to be the best choice in terms of net energy as well as in monetary terms. In addition, milk can be marketed immediately, while the potential income from the sale of a calf can be lost if it dies.

The trade-off between milk production and new offspring can be quantified by establishing the relationship between lactation length and calving interval (see Figure 12), which in turn can be used to establish the relationship between lactation length and the approximate reproduction rate. The latter conversion is done using the following equation:

$$Y = \frac{365}{X} \times 100$$

where: Y = reproduction rate (%), and
X = calving interval (days).

Dahl and Hjort (1976) developed a rather simple but useful herd growth simulation model which takes into account only the females in the herd. The model can be used to calculate the long-term annual growth of the base-line herd, using the following assumptions:

- Mortality rates per age class are constant over the years;
- All mortalities occur at the same time, at the end of the year; and
- No females are purchased or sold.

Substituting in this model the reproduction rates as calculated above, and keeping the mortality rates constant, the corresponding herd growth

Table 38. *Relationship between calf weight, milk offtake and survival rate at 90 and 180 days of age, Diafarabé, 1979–83.*

Age	Liveweight (kg)	Weight change (kg)	Milk offtake (kg)	Survival rate (%)
				90–180 days
90 days	33.3	–10	130	0.884
	43.3	average	76	0.934
	53.3	+10	22	0.984
				180–365 days
180 days	47.6	–10	203	0.892
	57.6	average	134	0.932
	67.6	+10	65	0.972

rates were calculated in order to find the relationship between lactation length and annual herd growth (Table 39).

Combining the data in Table 39 with data on monthly MO (Figure 20), Figure 26 shows the relationship between lactation length and a) the average cumulative milk offtake per cow up to 17 months; b) the average fraction of calf produced per cow in the herd; c) the long-term annual herd growth rate; and d) the distribution of active weaning events.

To increase the probability of calf survival, the suckling period should be at least 6 months. Extending lactations beyond 13 months results in

Figure 26. *Relationship between lactation length and the cumulative milk offtake; the fraction of calf produced per cow per year; the percentage herd growth; and the distribution of weaning events, Diafarabé, 1979–83.*

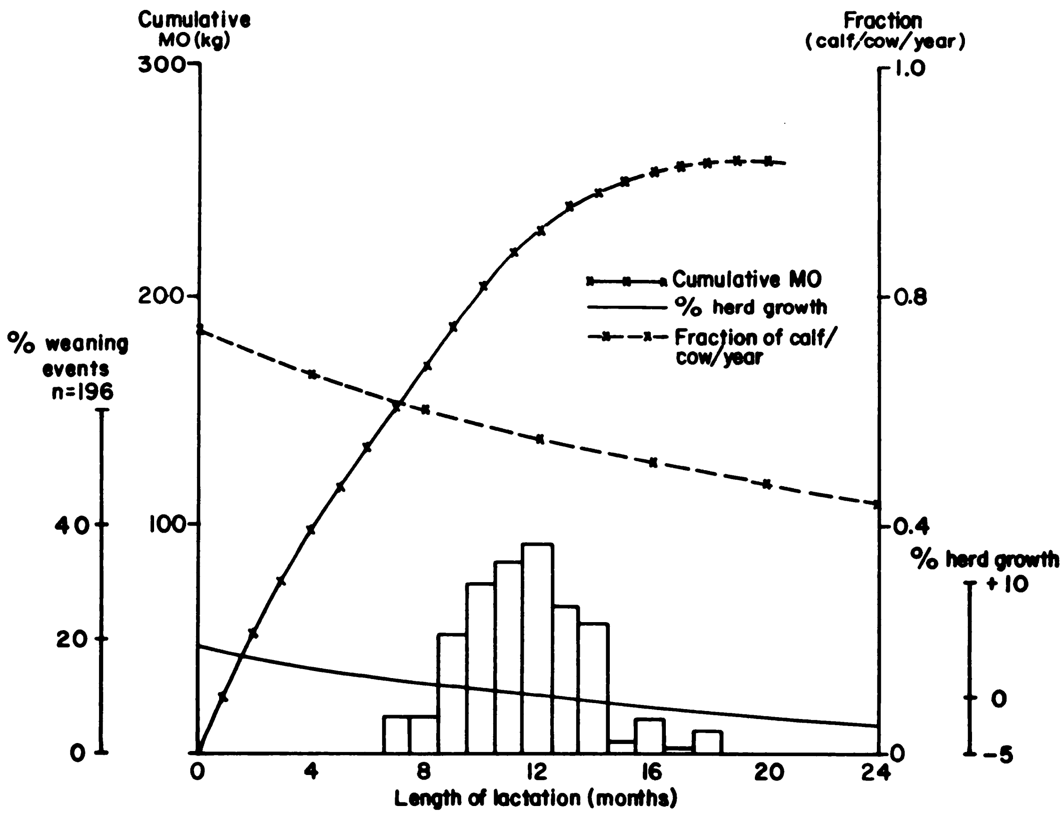


Table 39. *Relationship between lactation length, reproduction rate and annual herd growth, Diafarabé, 1979–83.*

Lactation length (days)	Dry period (days)	Calving interval (days)	Reproduction rate (%)	Annual herd growth (%)
0	496	496	73.6	4.1
122	429	551	66.2	2.5
243	363	605	60.3	1.2
365	296	661	55.2	0.1
487	229	716	51.0	−0.8
608	163	771	47.3	−1.8
730	96	826	44.2	−2.6

a long-term decrease in herd size. Consequently, only between the 6th and 13th month of lactation has the herder/owner a choice between an increased milk offtake and an improved reproductive performance of his cows. If he decides to wean the average calf in his herd at 6 months, the average MO per cow will be 134 kg, and the average cow will produce 0.63 calf per year (Table 40). Weaning at 12 months will yield 230 kg of milk and 0.55 calf per cow on average. Given the monetary values of milk and meat, the owner will most probably decide to continue milking until the 13th month. This is what actually happens, as can be seen from the distribution of weaning events (i.e. lactations not ended due to calf mortality) in the studied herds (Table 40).

Table 40. *Milk offtake, reproductive performance and percentage of calves weaned in relation to lactation length, Diafarabé, 1979–83.*

Lactation length (months)	Cumulative MO/cow (kg)	Annual calf production/cow[a]	Cumulative weanings[b] (%)
6	134	0.63	–
8	170	0.60	6
10	205	0.58	32
12	230	0.55	68
14	245	0.53	93
16	255	0.51	97

[a] Equals reproduction rate/100.

[b] n = 196.

9. SUMMARY AND CONCLUSIONS

The 1979–1983 study of the transhumant pastoral system in the Niger delta revealed that, because of the high interannual variability in rainfall, productivity indices based on 1-year data are misleading and that only extended time series data can provide useful information about the system.

The cattle herds in the study area comprised about 76% females; 35% of the herd total were cows and 23% heifers. Milk production per cow was low. Average milk offtake for human consumption was about 0.7 kg/day/cow, which was about 20 to 35% of the total daily milk production per cow. Cows were milked for 245 days on average, and they needed their calves at foot to stimulate milk let-down and maintain lactation. Average weaning age was 330 days.

Cows usually came on heat after the calf had been weaned or after its death. They were managed so as to calve throughout the year, but a peak could be observed during the early wet season. Reproduction rate was approximately 54%, including abortions and stillbirths. First mating took place when the heifers weighed between 180 and 190 kg, which resulted in first calving at an average age of 50 months.

Calves gained 175 g/day, the slow growth resulting in an average weaning weight of 75 kg. Calf growth was positively correlated with milk offtake per cow, i.e. better calf performance was associated with higher milk offtake for human consumption. The retarded growth to 1 year was responsible for high calf mortality, late reproduction and low offtake rates. Adult weights averaged 215 kg for females and 260 kg for males.

Calf mortality to 1 year averaged 43% (including 7% abortions), and was caused by poor milk production and disease. Mortality in the 1- to 4-year age group was approximately 5%, while for stock older than 4 years it averaged 8%. These rates were higher than the long-term averages and reflected the harsh environmental conditions during the study period. The differences in mortality among herds were due either to the different management skills of herders or to the different levels of exploitation. Unless reproductive performance is increased by 4%, or mortality in all age classes decreases by 1%, it will not be possible to maintain constant herd size in the long term.

Brucellosis affected 12 to 16% of the studied animals, and Strongylidae worms were found in 40 to 60%. Owing to the environmental conditions in the delta, brucellosis is very difficult to eliminate. Treating cattle with anthelmintics could however be expected to decrease the high rate of Strongylidae incidence.

The cattle ownership pattern in Diafarabé has changed markedly over the last decade. During droughts, impoverished cattle owners sold animals to farmers and urban investors, who then hired Fulani herders to do the herding. This might have had negative implications for the overall productivity of the system.

The main objective of the transhumant pastoral system in the Niger delta is to provide milk for human subsistence. Milk offtake also seems to be a better production choice given the energetic and monetary values of milk and meat. Calf survival is essential for continued lactation in Sudanese Fulani cows, and lactations are extended for as long as possible, which contributes to poor overall reproductive performance. To ensure an optimal distribution of available milk, specialised herd units (*bendi* and *cipi*) are formed, which have significantly longer lactations, higher milk offtake and higher MO/TMP ratios than the base herd. The practice of exchanging milk for grain encourages high milk offtake in the *cipi*, which in turn contributes to the considerable calf losses in this herd unit.

The forage resources of the system compare favourably with those of other pastoral systems in Africa, owing mainly to the availability of high-quality floodplain grazing (*bourgou*) in the dry season. However, the dry-season pastures also attract many herds from outside the delta, so that stocking rates of 1 head/ha are not uncommon (de Leeuw and Milligan, 1983). As a result of this dilution of resources, productivity per animal is not much higher than that in the other pastoral systems. The grazing resources in the delta have decreased over the years with expanding rice cultivation. In both quantitative and qualitative terms the increasing availability of rice crop residues is a poor substitute for the loss of *bourgou* pastures.

The Jafaraji pastoralists are primarily interested in improving milk production per cow, but increased milk offtake cannot be obtained without improving calf survival and growth rates. Given the high mortality and low reproduction rates in the system, culling of cows for productivity traits is not practical. Moreover, since management costs are low, even a cow calving once every 3 years is considered productive. The Jafaraji are aware that the Maure breed has a higher potential for milk production than their own cattle, but they also know of the lower disease resistance of the Maure under the humid conditions of the delta, and do not therefore attempt crossbreeding. Instead, they select breeding males from among the bull-calves of their more productive cows.

To minimise or disperse production risks the Fulani prefer to purchase new animals rather than veterinary or nutritional inputs. In general, vaccination is recognised to be an effective health control measure, but until recently cattle owners have not been charged for vaccines. It is therefore difficult to predict to what extent the average owner will vaccinate his animals if he has to pay for the service.

The output of the pastoral system in the delta varies with climatic fluctuations, which act as a disincentive to intensifying management practices. Furthermore, since grazing land in the delta and in the upland Sahel is held in common, there is no incentive for individuals to improve the quality of pastures.

Due to the high mobility of the core of the herd, feed supplementation is limited to the village-bound *bendi* and *cipi*, and particularly to the pregnant or lactating cows in these units. Feed supplementation improved calf growth and the condition of the cows but not very much milk offtake for human consumption. Irrigating and fertilizing the *harima* pastures reserved for milking cows would be a logical and feasible first step towards intensifying the system (Breman et al, 1978). The next step should be improvements in pasture management rather than introducing new grass/legume species (Hiernaux, cited in ILCA/ODEM, 1980).

Calf supplemention appears to be a practice worth exploring, since higher weaning weights would result in lower mortality, earlier maturity, and higher overall productivity. Reducing the human population's reliance on milk by encouraging food grain consumption could create additional scope for improving calf growth and cow productivity. Lower milk offtake would decrease calf mortality, increase cattle sales and ultimately enable the pastoralists to buy more grain.

ANNEX: CALCULATION OF MILK CONSUMED BY CALVES

Although the milk conversion values that had been calculated by Drewry et al (1959) for fast-growing Aberdeen Angus calves in the USA were used by several authors (ILCA/IER, 1978; Otchere, 1983) to estimate the amount of milk needed for calf growth, these estimates are inappropriate for Malian zebu calves. In Africa, milk conversion studies were done mainly with Boran cattle, but also with Sokoto cattle in Ghana, and the latter work (Montsma, 1962) is considered to be the most relevant for the present study.

Montsma estimated the amount of milk consumed by calves (MC) during the first 6 months of lactation on the basis of calf growth, using the following coefficients:

- 7.25 litres milk/kg growth from 0 to 8 weeks of age,
- 7.87 litres milk/kg growth from 9 to 13 weeks, and
- 10.53 litres milk/kg growth from 14 to 26 weeks.

The applicability of these figures to the present study is open to discussion since, in the first place, Montsma worked with a different type of zebu in a different environment. Second, although calves usually start grazing at 2 or 3 months of age, growth to 6 months was attributed entirely to milk intake because it is not known for how long the oesophageal groove function continues and when exactly rumen digestion develops. Third, season of birth, milk production by the dam, grazing management and quality of forage may all have an effect on calf growth. The MC estimates for calves older than 6 months are therefore unreliable.

Fourth, since the MC estimates based on observed calf growth imply that a Fulani calf that barely manages to maintain its weight in the dry season has not consumed any milk at all, the MC figures for slow-growing calves appear to be too low. In order to correct this misrepresentation, the amount of MC was estimated using the metabolisable energy requirement tables calculated by Roy (1980) for maintenance and growth of Friesian pre-ruminant calves. Using the milk composition figures given by Olaloku and Oyenuga (1976) for White Fulani cows, the ME value of extracted milk was calculated to be 3.6 MJ/kg.

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ABBREVIATIONS USED IN TEXT

BMDP	Biometrical computer programs
CBPP	contagious bovine pleuro-pneumonia
CP	crude protein
DM	dry matter
LCV	Laboratoire central vétérinaire
MC	milk consumed by calves
MF	Malian franc
ml	millilitre
MO	milk offtake for human consumption
N	nitrogen
SPSS	Statistical package for social sciences
TLU	tropical livestock unit (250 kg LW)
TMP	total milk produced

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