ILCA Research Report No. 3

Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal

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International Livestock Centre for Africa
Data recorded under the supervision of E. Gueye

September 1982

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
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ABSTRACT

Reproductive performance, viability and growth performance traits of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal were analysed. These traits were then used to build up overall productivity indices for the two species.

KEY WORDS

Reproductive performance, viability, growth, Djallonke sheep, N'Dama cattle, Senegal, productivity index.

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PREFACE

In Casamance, Senegal Oriental and The Gambia are found nearly 30% of the total N'Dama cattle population and nearly 9% of the total Djallonke sheep population of Africa. The Centre de Recherches Zootechniques, Kolda is centrally located in this region and has been recording information on performance traits of these two breeds since 1973.

In 1981 the International Livestock Centre for Africa (ILCA) provided scholarships for two research scientists from the Institut Senegalais de Recherches Agricoles (ISRA) to undertake over a five month period the extraction, analysis and interpretation of available data in collaboration with the ILCA Nairobi breed productivity and trypanotolerance team.

This report presents an analysis of the carefully recorded productivity data collected to 1981. The joint collaboration has enabled data analysis methods to be developed that will permit maximal early use of further information currently being recorded.

THE CENTRE DE RECHERCHES ZOOTECHNIQUES, KOLDA

INTRODUCTION

Since its establishment in 1972, the "Centre de Recherches Zootechniques" (C.R.Z.) has maintained herds of N'Dama cattle and flocks of Djallonke sheep both of which are trypanotolerant. The two species are kept for meat production. Improved management practices include supplementary feeding and veterinary care, with selection programmes aiming at genetic improvement. Information has been collected on traits relating to reproductive performance, body weight and mortality.

THE CENTRE AT KOLDA

The centre at Kolda is situated in Casamance, Southern Senegal, and covers an area of 2600 ha, which is subdivided into 18 plots. Kolda is situated at a height of 23 m with a climate characterized by a wet season lasting 5 months from June to October, and a dry season from November to May. Table 1 shows the monthly rainfall from 1974 to 1980.

The average annual temperature is 27.7°C with a maximum of 34.9°C (April, May and October) and a minimum of 20.4°C (January and August). The average annual relative humidity is 88% with a maximum of 97% (September) and minimum of 21% (February and March).

There are three main types of vegetation on the centre: clear forests and dry bushlands with no underground water, fallow land and dry cultivation, and swamp areas (river beds, rice fields and wet pastures of *Cyperaceae* or *Vetiveria nigritana*). The most important grasses are *Andropogon gayanus*, *A. pseudapricus*, *Anadelphia arrecta* and *Pennisetum subangustum*. Meadows of *Vetiveria* sp. *Cyperaceae* and *Anadelphia* sp. have a low fodder yield but stay green for a considerable time during the dry season. The presence of leguminous plants, e.g. *Stylosanthes gracilis* and *S. humilis* help to improve the natural grazing available. The trypanosomiasis risk is subjectively considered as light to medium.

Table 1. Monthly rainfall at Kolda from 1974 to 1980 (mm)

Month	Year							
	1974	1975	1976	1977	1978	1979	1980	$\bar{x}$
January	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	23	3.2
March	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-
May	15	-	21	-	12	-	1	7.0
June	43	14	72	92	98	139	37	70.7
July	412	411	192	105	220	269	203	258.8
August	274	199	283	149	395	278	175	250.4
September	206	463	317	259	209	126	159	248.4
October	89	25	42	56	139	35	27	59.0
November	10	-	13	-	24	24	-	11.6
December	-	-	-	-	-	-	-	
Total	1049	1112	940	661	1097	871	625	

CATTLE AND SHEEP

Cattle

The N'Dama breed is medium-sized and compact, with a fairly light skeleton. The usual coat colour on the centre is fawn. The foundation herd was made up of 123 heifers and 8 bulls bought from traditional breeders from Casamance and Oriental Senegal. This herd was established between March 1972 and October 1974. By the 31st December 1980, the total stock was 362 head : 18 bulls, 5 oxen, 63 bull calves, 145 cows, 85 heifers, 28 male calves and 18 female calves.

Sheep

The Djallonke has short hair, a thin tail and measures 40 - 50 cms. The coat colour varies between white, white and black or white and red. Rams have a mane covering the neck, withers, shoulders and chest. The foundation herd was made up between November 1974 and September 1975 and consisted of 91 ewes, 30

ewe-lambs, 2 lambs and 2 rams. On the 31st December the total stock was 248 head: 12 rams, 57 lambs, 104 ewes and 75 female lambs.

HERD MANAGEMENT

Cattle

The general organization of the herd is shown in Figure 1. There are five single bull breeding herds (1-5). When cows are in the last months of pregnancy they are gathered into one herd in the paddocks near the cowsheds. After calving, cows are moved into a dam and calf herd in the cowsheds with calves receiving all the milk from their dams. At weaning (6 months), the male and female calves are placed in two separate herds. The calves are branded at weaning, females remaining in the heifer herd until 18 - 23 months of age when they then move into a breeding herd other than that of their sire. Heifers that are too small or weak are culled. Bull calves go into a collective preselection herd until they are 18 months. At this age the best bull calves, chosen by growth and conformation, are put into separate stalls where their growth is carefully recorded. The rest of the bull calves are castrated and either used as draught oxen or fattened. At 24 months the best 1-2 bulls from the individual preselection group (selected on growth, conformation and spermology) are kept to go into the breeding herds. The remainder are sold to improve stock outside the Centre.

Sheep

Breeding flocks each have one ram and lambing occurs within these flocks. When lambs are 4 months they are weaned into separate male and female flocks and ear-tagged. At 9 months, ewes are put into the breeding flock if they have reached a weight of 16 kg. Those that do not reach 16 kg at 12 months are culled. Until 1979 rams were selected at 2 years on growth and conformation, the best kept as sires and the remainder castrated, fattened and sold. Since 1979 males have been selected at 6 months, the best going into a second pre-selection flock, the remainder castrated, fattened and sold. At 12 months rams are selected on weight, daily gain, conformation and coat colour, the best going into the breeding flocks. The remainder are either fattened or sold as rams to improve stock outside the Centre.

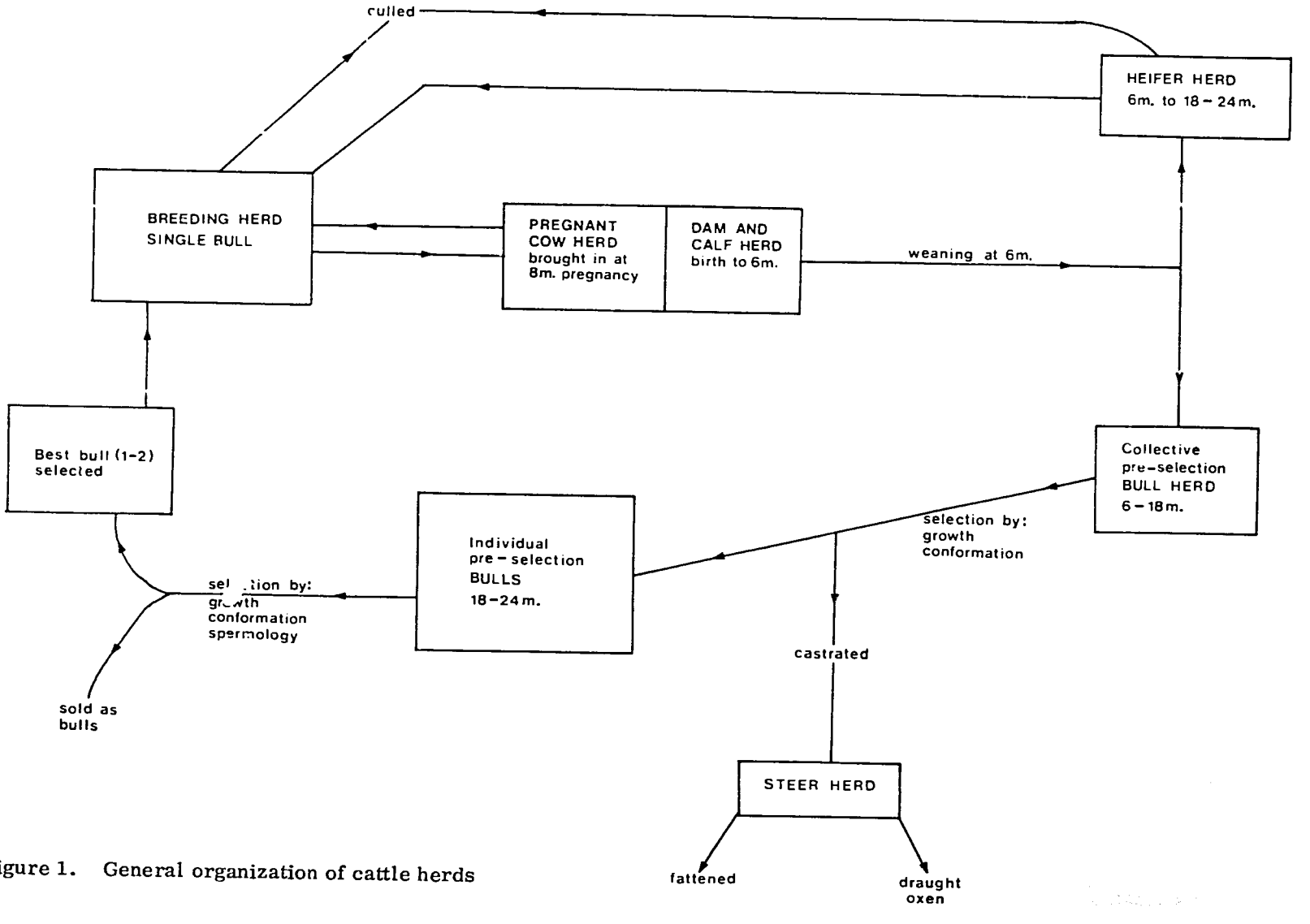

Figure 1. General organization of cattle herds

SUPPLEMENTARY FEEDING

The animals graze on natural grasslands. The quality and quantity of available fodder is optimal during the rainy season but the pastures deteriorate during the dry season, with fodder being least available in May and June.

Supplementation varies throughout the year and according to the class of animal. Table 2 shows the basic quantities of oil cake and cotton seed concentrates fed during the dry season (April to June).

Table 2. Dry season supplementation levels

Supplement	Class of stock	Amount fed per day (kg)
Oil cake	Adult cattle	1.0
	Weaners	0.5
	Sheep	0.2
Cotton seed	Cow and calf	2.0
	Sheep	0.2

Animals are allowed to feed off peanut haulm when available and salt mineral licks are distributed. Animals receiving special supplementation are cows with calves, ewes with lambs, pregnant cows and ewes, and bull calves in the pre-selection groups, especially the individual pre-selection group. There have in the past been many problems of feed availability, etc. so that supplementary feeding has on occasion been interrupted.

ANIMAL HEALTH PROGRAMME

Cattle are routinely vaccinated against pasteurellosis, rinderpest, pleuro-pneumonia and anthrax.

Sheep are vaccinated against ovine pasteurellosis, sheep pox and "peste de petits ruminants".

Periodic action is taken against external and internal parasites of all animals.

DATA RECORDING PROCEDURES

Climatic and animal productivity data are regularly recorded. At birth, the date, sire number, dam number, sex and weight of the new-born animal are recorded. Sheep and cattle are numbered at weaning. Service dates, abortions, deaths, supplementation, sickness and treatment, vaccinations etc., i.e. all daily activities are recorded. Weights and linear measurements are regularly collected. Linear measurements taken for cattle are length and width of head, height at withers, scapulo-ischial length, girth, crop length, width of haunch and height at sternum. Linear measurements taken for sheep are height at withers, scapulo-ischial length and girth. The frequency of collection of weights and linear measurements is

Cattle:	0 - 3 months	-	weekly
	3 - 6 months	-	fortnightly
	6 - 24 months	-	monthly
	2 - 6 years	-	three monthly
Sheep:	0 - 3 months	-	weekly
	3 - 6 months	-	fortnightly
	6 months	-	monthly

DATA PREPARATION AND ANALYSIS

DATA PREPARATION

Sheep

Individual records were built up for each ewe related to each parturition. These gave number, date of birth, origin and type of birth (single or twin), of the ewe herself, and the current parturition date, previous parturition date, type of birth, sex of lamb(s), viability of lamb(s) over 4 stages to 12 months of age, lamb weights and three linear measurements at birth, 2, 4, 6, 8, 10 and 12 months, and ewe's own weight and three linear measurements at parturition and 4 months after parturition. From these data, the age at first lambing, lambing interval, ewe mean weight and three productivity indices were additionally computed. Information on sires and dams of ewes and sires of progeny were noted whenever available. Eventual disposal or death of the ewe was recorded. All available causes of death were obtained from periodical reports and treatment records.

Cattle

Individual records were built up for each cow related to each parturition. These gave number, date of birth and origin of the cow herself, and the current parturition date, previous parturition date, sex of calf, viability of calf over 4 stages to 12 months, calf weight and three linear measurements at birth, 3, 6, 9, 12, 15, 18, 21, 24 and 30 months, and cow's own weight and three linear measurements at parturition and 6 months after parturition. From these data the age at first calving, calving interval, cow mean weight and three productivity indices were additionally computed. Information on sires and dams of cows and sires of calves were noted when available. Eventual disposal or death of the cow was recorded. All available causes of death were obtained from periodical reports and treatment sheets.

DATA ANALYSES

All characters were analysed by least-squares procedures (Harvey, 1972) using both fixed and mixed models. In the analyses, some parameters were measured for further study in their own right and some were measured to account for variation arising, in order that less biased estimates of other parameters could be obtained. Unequal and disproportionate subclass numbers gave unbalanced factorial designs for which conventional analyses of variance techniques were not applicable.

With both sheep and cattle, a considerable number of foundation animals had no sire or dam records. In addition the use of individual sires was often confounded with month and year of use, so use could not be made of sire group in analyses at this stage in time.

Typical models used included the fixed effects of origin (purchased or born on station); parturition number within origin; year of birth or parturition; month of birth or parturition; sex of calf; type of birth (single or twin); and the random effects of individual cow or ewe, nested within origin. The specific factors included in the model used will be evident when results are presented for each character analyzed.

The residual mean square was used as the error term to test the significance of all differences evaluated, except origin, when cows or ewes within origin was used. Linear contrasts of least-squares means were computed to determine the significance of differences between groups for all characters where the difference among groups was significant in the analysis of variance. More comparisons were made using the least-squares means than there are independent degrees of freedom for the characters where the group differences were significant in the analysis of variance. Therefore, all of the comparisons are not independent and the error rate over the entire set of comparisons may be different from that indicated by the level of probability. Tests of significance associated with the linear contrasts, although not independent, can be taken as guides as to whether the observed values could have occurred by chance. Repeatabilities were calculated using the variance components between and within cows or ewes.

SHEEP REPRODUCTIVE PERFORMANCE

INTRODUCTION

Reproductive performance is a trait of outstanding importance in sheep production enterprises, especially when meat production from young animals is the chief aim. In general the more intensive the meat production system, the more desirable the production of large numbers of young per breeding female. Under harsher conditions optimal production levels are achieved by maintaining reasonable levels of performance in the young, while limiting the drain on the resources of the breeding female. The most important components of reproductive performance in sheep are age at first lambing, length of lambing interval, litter size, and length of ewe productive life.

AGE AT FIRST LAMBING

The mean age at first lambing for 115 females born on the station from 1974 to 1980 was 18.8 ± 0.8 months. The significance of environmental influences on age at first lambing over this period is indicated in Table 3.

Table 3. Analysis of variance of age at first lambing

Source	d.f.	Mean squares
Year of birth	6	33912
Month of birth	11	19460
Type of birth	1	30382
Remainder	96	18746

Year of birth, month of birth and type of birth had no significant effects on age at first lambing. The estimated least squares means for age at first lambing

are laid out in Table 4. The coefficient of variation was 24.4%.

Table 4. Estimated least squares means for age at first lambing (days)

Variable	Number	Age at first lambing
Overall mean	115	575
Year of birth		
1974	4	545
1975	16	572
1976	16	624
1977	31	546
1978	20	638
1979	21	622
1980	7	473
Month of birth		
January	11	615
February	8	603
March	12	608
April	6	527
May	11	568
June	4	630
July	5	625
August	4	515
September	5	620
October	10	546
November	18	479
December	21	560
Type of birth		
Single	96	551
Twin	19	598

CONCEPTION RATE BY MONTH

The distribution of 663 conceptions calculated from the recorded lambing dates from 1975 to 1980 are indicated in Figure 2. The mean monthly rainfall over these 6 years is also shown.

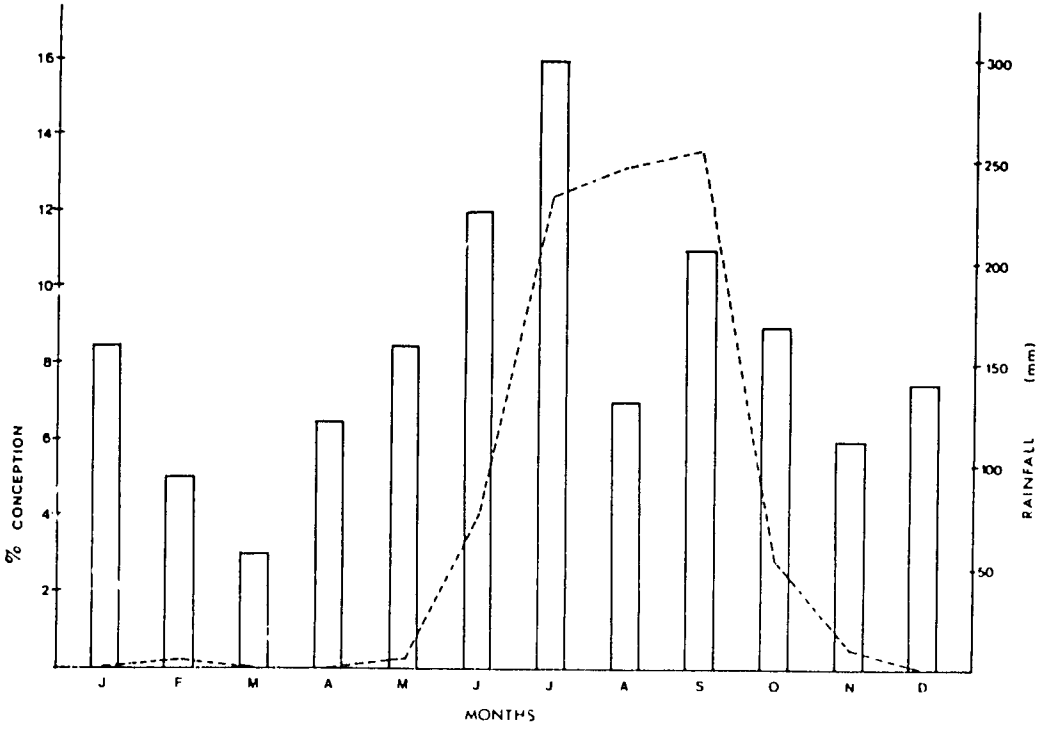

Figure 2. Effect of month on conception rate.

55% of conceptions, or 11% per month, occurred during the main five month wet season from June to October, the remaining 45% or 6.5% per month during the other seven months of the year.

LAMBING INTERVAL

The mean lambing interval for 663 records from 1975 to 1980 was 307 ± 14 days. The significance of environmental and genetic influences on lambing interval over this 6 year period is indicated in Table 5.

The effects of origin of ewe, individual ewes, month of lambing and in the case of foundation ewes only, the lambing number, were significant. The estimated least squares means for lambing interval are laid out in Table 6.

Table 5. Analysis of variance of lambing interval

Source	d.f.	Mean squares
Orig...	1	48441*
Ewes	190	7706**
Year of lambing	5	7409
Month of lambing	11	27767**
Type of lambing	1	1110
Number of lambing/foundation	1	43841**
Number of lambing/born on centre	2	5469
Remainder	451	5485

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

The effects of year of lambing were not important, but month of lambing had a significant effect on lambing interval. Females lambing in December, January, February and March had longer than average lambing intervals, while those lambing in all other months had shorter than average lambing intervals.

The monthly rainfall from 1975 to 1980 is illustrated in Table 1, the period December to April constituting the major dry season. The correlation between lambing interval and rainfall from one month before previous lambing date to one month before conception was - 0.51, while there was a 0.04 day decrease in lambing interval for each additional 1 mm rainfall.

In the case of foundation purchased ewes whose age was unknown, lambing intervals following their first four parturitions on the station were significantly shorter than those following their fifth and subsequent parturitions. In the case of ewes born on the centre the effect of parturition number was not significant.

The repeatability of lambing interval (i.e. the correlation between an individual's successive records) was obtained from the between and within ewes components of variance. The value of 0.11 ± 0.04 is within the range usually reported for this trait.

Table 6. Estimated least squares means for lambing interval (days)

Variable		Number	Lambing interval
Overall mean		663	307
Origin			
Foundation	(1)	474	296
Born on centre	(2)	189	318
Year of lambing			
1975		66	318
1976		122	319
1977		123	305
1978		146	313
1979		107	304
1980		99	280
Month of lambing			
January		45	330
February		73	351
March		59	324
April		40	264
May		51	301
June		57	306
July		32	301
August		21	296
September		42	280
October		58	287
November		80	297
December		105	343
Type of lambing			
Single		583	304
Twin		80	309
Number of lambing/origin 1			
1-4		353	271
5+		121	316
Number of lambing/origin 2			
1		77	305
2		55	313
3+		57	333

LITTER SIZE

Table 6 shows that the 663 parturitions recorded from 1975 to 1980 were made up of 583 singles and 80 twins, the mean litter size being 1.12.

ANNUAL REPRODUCTION RATE

The annual reproduction rate is calculated as the mean litter size x 365 ÷ lambing interval. Overall this was 1.33 lambs per breeding ewe per year.

LENGTH OF EWE PRODUCTIVE LIFE

As the first records of ewes produced on the station start with animals born in November 1974, it is yet too early to assess this trait. In August 1981, the first 40 ewes born between November 1974 and January 1977 had completed an average of 3.7 parturitions, with 17 or 42% still in production. The remaining 23 or 58% had died, been culled or lost. Thus until more information is collected it might be tentatively suggested with the present information that an average of 5 parturitions would be achieved per ewe. Using the mean lambing interval of 307 days, ewes would thus remain for an average of 4.2 years in productive life. This complete replacement of the ewe flock each 4.2 years would represent a turnover of 24%. When age at first lambing is added to the productive life, the average ewe age on completion of productive life would be 5.8 years.

SHEEP MORTALITY

LAMB MORTALITY

Mortality data based on 897 lambs born over a six year period were available. The significance of environmental and genetic influences on pre-weaning mortality, (subdivided into two periods, birth to 3 days and 3 days to 4 months) and post-weaning mortality (4 months to 12 months of age) are indicated in Table 7.

Table 7. Analyses of variance of mortality rates

Source	d.f.	Mean squares			
		Birth - 3 d $x10^4$	3 d - 4 m $x10^3$	Birth - 4 m $x10^3$	4 m - 12 m $x10^3$
Origin	1	80	596	468	11
Ewes	227	504**	174	185	158
Year of birth	5	452	1688**	2023**	1173**
Month of birth	11	373	387**	426**	311*
Type of lambing	1	2976**	151	906*	23
Sex	1	85	26	1	759*
Number of lambing/foundation	1	227	87	192	69
Number of lambing/born on centre	2	190	1386**	1198**	19
Remainder	647	279	164	179	146

* = P < 0.05; ** = P < 0.01.

The estimated least squares means for mortalities over these periods are laid out in Table 8.

Pre-weaning mortality. The mean mortality rate from birth to weaning at 4 months was 33%. The effects of year of birth, month of birth, single or twin, and parturition number of dam were significant (Table 7).

Table 8. Estimated least squares means for mortality rates

Variable		No.	Mortality rates (%) Birth - 3 days	3 days - weaning	Birth - weaning	Weaning - 12 m
Overall mean		897	5.14	28.08	33.09	19.39
Origin						
Foundation	(1)	652	5.52	24.84	30.22	18.96
Born on centre	(2)	245	4.77	31.31	35.96	19.86
Year of birth						
1975		86	1.38	13.96	14.98	15.73
1976		170	6.49	28.15	43.69	40.46
1977		154	5.31	26.56	31.49	13.41
1978		189	7.10	46.89	54.07	23.22
1979		145	3.47	28.83	32.53	18.62
1980		153	7.12	14.28	21.79	4.91
Month of birth						
January		73	0.07	20.77	20.96	26.32
February		92	3.79	13.41	17.48	31.16
March		86	9.62	25.75	35.16	20.31
April		56	5.26	19.83	22.75	32.92
May		58	4.95	15.11	20.25	25.23
June		73	2.63	41.07	43.45	24.41
July		41	9.96	29.62	39.73	9.45
August		24	5.86	45.78	51.79	7.03
September		51	3.43	33.48	36.70	18.37
October		72	4.99	35.41	40.60	10.45
November		123	5.14	31.99	37.17	14.34
December		148	6.17	24.70	31.05	12.69
Type of lambing						
Single		691	2.04	25.87	27.67	18.52
Twin		206	8.25	30.29	38.51	20.26
Sex						
Male		456	5.51	27.44	32.96	22.84
Female		441	4.78	28.72	33.22	15.94
Number of lambing/origin 1						
1-4		464	4.25	22.36	26.54	21.17
5+		188	6.79	27.32	33.91	16.75
Number of lambing/origin 2						
1		93	2.79	51.57	54.48	19.56
2		71	6.38	27.57	34.05	21.79
3+		81	5.13	14.80	19.34	18.11

There were marked year of birth effects on pre-weaning mortality rate ranging from 15% in 1975 to 54% in 1978.

Month of birth had a significant effect, lambs born in March, June, July, August, September, October and November having above-average mortality rates, those born in the remaining five months below-average rates. The correlation between pre-weaning mortality and rainfall over the relevant 4 months was 0.42, there being a 0.014% increase in mortality for each additional 1 mm of rainfall.

Mortality in twin lambs was 38.5%, compared to 27.7% in singles.

There was a 54.5% mortality rate in lambs from first parturition dams, 34.1% from second parturition dams and 19.3% from third and later parturition dams.

When pre-weaning mortality was separated into that occurring from birth to 3 days and from 3 days to weaning, a very contrasting picture emerged. Table 7 indicates that year and month of birth had no effect on mortality from birth to 3 days, but major effects from 3 days to weaning. Single or twin status had major effects on mortality in the first 3 days, but no effect from 3 days to weaning. Parturition number of dam had no effect on mortality from birth to 3 days, but major effects from 3 days to weaning. Finally there were highly significant differences between individual ewes in lamb mortality from birth to 3 days, but not from 3 days to weaning.

Thus lamb mortality in the first three days of life (mean 5.1%) was affected by single or twin status, 2% of single lambs dying compared with 8% of twins. The significant difference between individual ewes gave a repeatability estimate for this early mortality of 0.18 ± 0.04. The parturition number of the dam, reflecting its age, and the year and month of lamb birth, reflecting environmental and climatic conditions, had no effect.

In contrast lamb mortality from 3 days to weaning (mean 28.1%) was not significantly affected by single or twin status and there was no significant repeatability estimate for this trait (0.02 ± 0.10). The parturition number of ewes born on the centre had a major effect; 51.6% mortality in lambs from first parturition ewes, 27.6% from second and 14.8% from third or later. Both year and month of birth

had major effects, lambs born in the wet season months of June to November all having above average mortality rates (mean 36%), those born in the drier season December to May having below average mortality rates (mean 20%). The correlation between mortality from 3 days to weaning and the rainfall over the relevant 4 months was 0.40, there being a 0.013% increase in mortality for each additional 1 mm of rainfall.

Post-weaning mortality. The mean mortality rate from 4 months to 12 months of age was 19.4%. Year and month of birth, reflecting environmental and climatic conditions, had highly significant effects. The very low post-weaning mortality for 1980 was biased in that when the data were prepared for analysis a proportion of the animals born in late 1980 had not yet reached 12 months of age. Males had a significantly higher ($P < .05$) mortality than females. The maternally associated influences such as single or twin status, ewe parturition number and individual ewe had, as expected, no effects on post-weaning mortality.

MORTALITY RATES IN RELATION TO GENETIC IMPROVEMENT

An appropriate definition of mortality rate in the context of genetic progress is the percentage of females that die before lambing. Here, taking account of the actual proportion of singles and twins, it is approximately 51% (43% to 12 months, 8% from 12 months to 18.8 months). The rearing proportion is the proportion of births that produce a female that survives and is fertile. Tl rearing proportion here is about 0.27. This means that only once in 3.6 lambings does a ewe produce a female lamb that will reproduce in the flock. The average length of reproductive life is tentatively taken as 5 lambings: therefore, approximately 72% of the females born are required as replacements to maintain flock size. High mortality rates are inconsistent with genetic progress, and when they can be reduced, a higher intensity of selection can be achieved.

Genetic improvement per unit of time is more important than per animal generation, and high mortality rates have a marked effect on generation interval. The average age at first lambing is 18.8 months, and the average lambing interval

10 months. To replace herself, a ewe must lamb about 3.6 times; thus, the average generation interval is 54.8 months or 4.5 years.

BREEDING EWE MORTALITY

Data on ewe mortality over the 6 years from 1975 to 1980 are presented in Table 9. The overall mortality rate was 14.8% per year.

Table 9. Ewe mortality

Year	Number of ewes	Number of deaths	Ewe mortality (%)
1975	89	5	5.6
1976	139	19	13.7
1977	122	12	9.8
1978	110	21	19.1
1979	120	19	15.8
1980	123	28	22.8
Overall	703	104	14.8

CAUSES OF DEATH

The causes of mortality have been grouped into five classes:- diseases of the alimentary tract; diseases of the respiratory system; other diseases (e.g. nutritional, reproductive); accidents, abscesses, etc; and unidentified.

The percentages of animals dying were examined within the two age groups recorded; young (0-8 months) and adult (over 8 months). The mortality rates related to each of the five classes are shown in Table 10.

Thus 30.5% of mortality is due to problems connected with the alimentary tract; 27.5% to respiratory problems, 12% to other diseases; 6.3% to accidents, abcesses and skin diseases; and the remaining 23.7% undiagnosed.

Table 10. Mortality rate related to cause

Class	0-8 months		> 8 months		Overall
	No. of deaths	%	No. of deaths	%	%
Alimentary	129	28.5	35	32.5	30.50
Respiratory	123	27	30	28	27.50
Other diseases	64	14	11	10	12.00
Accidents, abcesses, etc.	19	4	9	8.5	6.25
Unidentified causes	119	26.5	23	21	23.75
Total	454	100	108	100	

Tables 11 and 12 show the total numbers of animals, the numbers treated and the percentage of animals treated for each of the disease classes within the two different age groups, by year and month.

Table 11. Treatments in each disease class by year and month (animals 0-8 months)

Period	Total No. of animals	Alimentary Treatments		Respiratory Treatments		Other Treatments		Accidents Treatments		Total Treatments	
		No.	%	No.	%	No.	%	No.	%	No.	%
1975	51	14	27.4	1	1.9	8	15.6	19	37.2	42	82.3
1976	110	25	22.7	62	56.3	12	10.9	18	16.3	117	106.4
1977	116	46	39.6	79	68.1	20	17.2	23	18.8	168	144.8
1978	158	101	63.9	93	58.8	22	13.9	14	8.8	230	145.6
1979	96	41	42.7	142	147.9	45	46.6	33	34.3	261	271.9
1980	133	48	36.0	154	40.6	10	7.5	22	16.5	134	100.7
January	104	4	3.8	6	5.7	2	1.9	2	1.9	14	13.5
February	111	6	5.4	3	2.7	1	0.9	2	1.8	12	10.8
March	117	6	5.1	6	5.1	2	1.7	2	1.7	16	13.7
April	111	2	1.8	4	3.6	4	3.6	1	0.9	11	9.9
May	109	2	1.8	5	4.5	2	1.8	2	1.8	11	10.1
June	114	2	1.7	11	9.6	1	0.8	2	1.7	16	14.0
July	109	3	2.7	16	14.6	2	1.8	1	0.9	21	19.3
August	105	2	1.9	14	13.3	0	0	3	2.8	19	18.1
September	108	4	3.7	3	2.7	2	1.8	2	1.8	11	10.2
October	106	4	3.7	2	1.8	2	1.8	7	6.6	15	14.1
November	113	5	4.4	1	0.8	2	1.7	1	0.8	9	7.9
December	120	6	5.0	2	1.6	1	0.8	2	1.6	11	9.1

Table 12. Treatments in each disease class by year and month (animals over 8 months)

Period	Total no. of animals	Alimentary Treatments		Respiratory Treatments		Other Treatments		Accidents Treatments		Total Treatments	
		No.	%	No.	%	No.	%	No.	%	No.	%
1975	86	15	17.4	12	13.9	16	18.6	34	39.5	77	89.5
1976	138	23	16.6	13	9.4	15	10.8	27	19.5	78	56.5
1977	122	14	11.4	41	33.6	13	10.6	16	15.5	84	68.8
1978	109	18	16.5	68	62.3	11	10.0	22	20.1	119	109.2
1979	109	19	16.1	206	174.5	16	13.5	14	11.8	255	216.1
1980	122	33	27.0	41	33.6	1	0.8	16	13.1	91	74.6
January	105	1	0.9	10	9.5	0	0	1	0.9	12	11.4
February	106	1	0.9	8	7.5	1	0.9	1	0.9	11	10.3
March	105	1	0.9	7	6.6	1	0.9	2	1.9	11	10.4
April	112	2	1.7	6	5.3	1	0.8	1	0.8	10	8.9
May	116	1	0.8	4	3.4	1	0.8	1	0.8	7	6.0
June	117	2	1.7	5	4.2	1	0.8	1	0.8	9	7.7
July	123	1	0.8	10	8.1	1	0.8	2	1.6	14	11.4
August	125	1	0.8	5	4.0	1	0.8	2	1.6	9	7.2
September	124	4	3.2	2	1.6	1	0.8	3	2.4	10	8.1
October	121	1	0.8	3	2.4	1	0.8	4	3.3	9	7.4
November	122	2	1.6	3	2.4	2	1.6	1	0.8	8	6.5
December	120	4	3.3	3	2.5	1	0.8	2	1.6	1	8.3

SHEEP BODY WEIGHTS

ENVIRONMENTAL AND GENETIC EFFECTS ON LAMB WEIGHTS AT SEVEN DIFFERENT AGES

Weights at birth, 2 and 4 months were available for 360 lambs, at 4, 6 and 8 months for 298 lambs and at 8, 10 and 12 months for 209 lambs, born in the years 1977 - 1980. Analyses of variance, laid out in Table 13, showed origin, year and month of birth, type of birth, sex, age of dam and individual dams to have significant effects on lamb body weight at different stages.

Table 13. Analyses of variance of weight at seven different ages using all records available to 12 months

Source	d.f.	Mean squares			d.f.	Mean squares			d.f.	Mean squares		
		Birth	2 m x10^2	4 m x10^2		4 m x10^2	6 m x10^2	8 m x10^2		8 m x10^2	10 m	12 m
Origin	1	5010**	4180**	11013**	1	10451**	10866**	8732**	1	7261**	11493**	7189*
Ewes	145	181**	333**	928**	141	779*	942*	1211**	116	877	1121	1392
Year of birth	3	367*	2117**	15064**	3	7917**	16624**	22456**	3	19542**	26590**	28154**
Month of birth	10	258*	266	1252**	11	1032*	1885**	1078	11	2203**	1982*	2186
Type of lambing	1	3186**	8391**	12402**	1	10476**	12521**	9960**	1	2390	1543	793
Sex	1	996**	466	2430*	1	2952*	11142**	17965**	1	1505	5695*	11912**
Number of lambing/ foundation	1	129	213	375	1	1150	1038	254	1	5157*	2362	119
Number of lambing/ born on centre	2	573**	676**	1101	2	768	93	182	2	387	185	313
Remainder	195	110	222	475	136	542	636	731	72	820	967	1193

* = P < 0.05
** = P < 0.01

The estimated least squares means for body weight at seven different ages are shown in Table 14.

Figure 3 illustrates the mean growth of all lambs from birth to 12 months. The coefficients of variation of weight at birth, 2, 4, 6, 8, 10 and 12 months were 19%, 22%, 22%, 20%, 18%, 19% and 19% respectively.

Table 14. Estimated least squares means for weight at seven different ages

Variable		No.	Birth	2 m	4 m	No.	4 m	6 m	8 m	No.	8 m	10 m	12 m
Overall mean		360	1.59	6.06	8.71	298	8.70	11.23	13.53	209	14.03	15.93	17.90
Origin													
Foundation	(1)	225	1.74	6.48	9.39	188	9.48	12.13	14.24	143	14.77	16.85	18.63
Born on centre	(2)	135	1.45	5.65	8.03	110	7.92	10.54	12.82	66	13.30	15.01	17.17
Year of birth													
1977		45	1.48	6.33	10.15	58	8.45	11.15	13.32	7[illegible]	11.26	13.74	16.08
1978		86	1.71	5.40	6.12	53	6.67	8.13	8.99	38	9.11	9.78	11.76
1979		102	1.54	5.57	7.81	76	8.44	11.08	14.46	51	15.84	18.07	19.21
1980		127	1.65	6.95	10.75	111	11.23	14.93	17.36	48	19.92	22.11	24.56
Month of birth													
January		26	1.74	5.59	6.95	18	7.46	9.64	11.87	18	10.71	11.71	14.08
February		34	1.75	6.12	9.09	28	8.73	11.27	12.08	23	12.04	13.91	16.17
March		38	1.48	6.14	9.53	30	9.64	11.71	13.55	33	12.88	15.35	18.31
April		21	1.38	5.81	9.01	9	8.17	10.40	11.73	9	12.80	16.92	19.49
May		28	1.45	6.50	9.11	15	8.41	10.26	12.59	14	12.04	15.90	18.61
June		29	1.60	6.31	8.36	34	7.18	9.00	12.64	25	13.87	16.77	19.27
July		6	1.49	5.01	7.53	7	6.33	9.61	13.08	6	11.75	14.41	13.59
August		-	-	-	-	3	11.85	15.49	19.37	3	21.60	17.29	21.80
September		16	1.74	6.80	9.64	12	9.62	13.57	14.93	11	15.28	18.70	21.11
October		39	1.56	5.53	7.40	33	8.45	11.81	13.12	17	13.81	14.96	14.88
November		64	1.70	6.64	9.66	55	8.88	11.67	13.84	21	15.76	18.70	20.03
December		59	1.62	6.26	9.51	54	9.68	11.88	13.56	29	15.78	16.40	19.49
Type of lambing													
Single		272	1.78	7.01	9.85	225	9.90	12.65	14.70	170	14.89	16.61	18.39
Twin		88	1.41	5.12	7.56	73	7.50	10.02	12.36	39	13.18	15.24	17.41
Sex													
Male		198	1.66	6.22	9.06	151	9.20	12.31	14.77	96	14.53	16.90	19.30
Female		162	1.52	5.91	8.35	147	8.20	10.36	12.29	113	13.54	14.96	16.50
Number of lambing/origin 1													
1-4		93	1.79	6.69	9.66	80	10.06	12.68	14.52	78	16.44	17.98	18.88
5 +		132	1.69	6.29	9.13	108	8.90	11.58	13.97	65	13.10	15.72	18.36
Number of lambing/origin 2													
1		32	1.17	4.68	6.89	21	6.47	10.09	12.12	13	12.23	14.93	15.00
2		39	1.52	5.58	8.11	30	8.36	10.56	12.99	19	14.42	14.56	17.77
3+		64	1.66	6.54	9.10	59	8.94	10.97	13.35	34	13.26	15.52	18.75

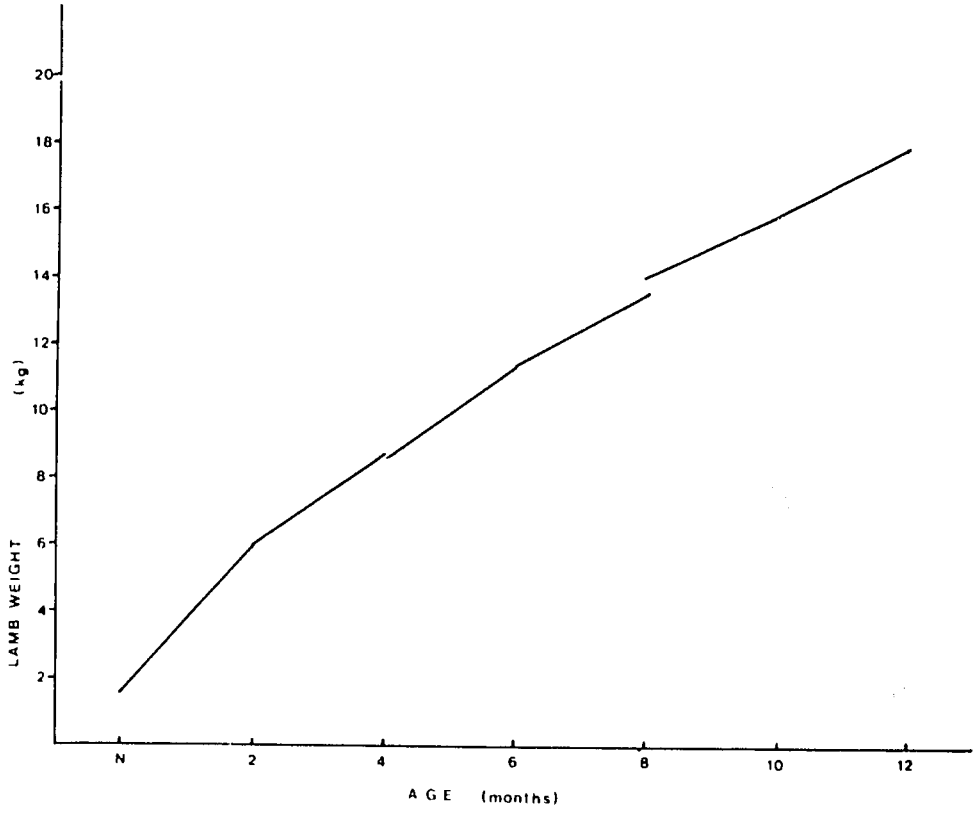

Figure 3. Mean body weights from birth to 12 months.

Effect of year of birth

Table 13 indicates that significant year effects existed for weights at all ages. Lambs born in 1980 were significantly heavier at all ages from 2 months to 12 months than those born in the three other years, while lambs born in 1978 were significantly lighter. The weight differences between lambs born in these two extreme years at 2, 4, 6, 8, 10 and 12 months were 25%, 53%, 59%, 62%, 77% and 71% respectively of the mean weights.

Causes of variation between years in this environment can be annual rainfall affecting pasture availability, and the disease situation, changes in management techniques, genetic progress, etc. Correlations and

regressions between the 4 year means for weight at each stage from 2 months to 12 months and the 4 year means for rainfall from birth to each stage are indicated in Table 15 (Mean birth date taken as July 1).

Table 15. Correlations between and regressions of weight (kg) at 6 ages and rainfall (mm) between birth and that age.

Age	Correlation	Regressions
2 months	-0.77	-0.003
4 months	-0.91	-0.009
6 months	-0.82	-0.011
8 months	-0.74	-0.014
10 months	-0.66	-0.017
12 months	-0.74	-0.018

Table 15 indicates strong negative correlations between weight at all stages and rainfall over the corresponding periods, ranging from 0.66 to 0.91. The regressions of weight on rainfall showed a reduction in weight of 3, 9, 11, 14, 17 and 18 gm for each additional 1 mm rainfall from birth to 2, 4, 6, 8, 10 and 12 months respectively. Table 8 shows the mortality rates from birth to weaning and weaning to 12 months for these four years. The correlation between mortality rate to weaning and weaning weight of survivors was -0.91; and between mortality rate to 12 months and weight at 12 months, -0.92. The weights of survivors at 4 months and 12 months were 142 gm and 237 gm less respectively for each additionall 1% mortality that had occurred during these periods.

Effect of month of birth

Table 13 indicates that the effects associated with month of birth were significant at all ages except 2 and 12 months. Figure 4 shows the weights of animals in each of the month of birth groups, corrected for all other effects evaluated.

The effects of month of birth on later body weights are usually related to the stage in the wet and dry weather cycle at which an animal reaches a given age;

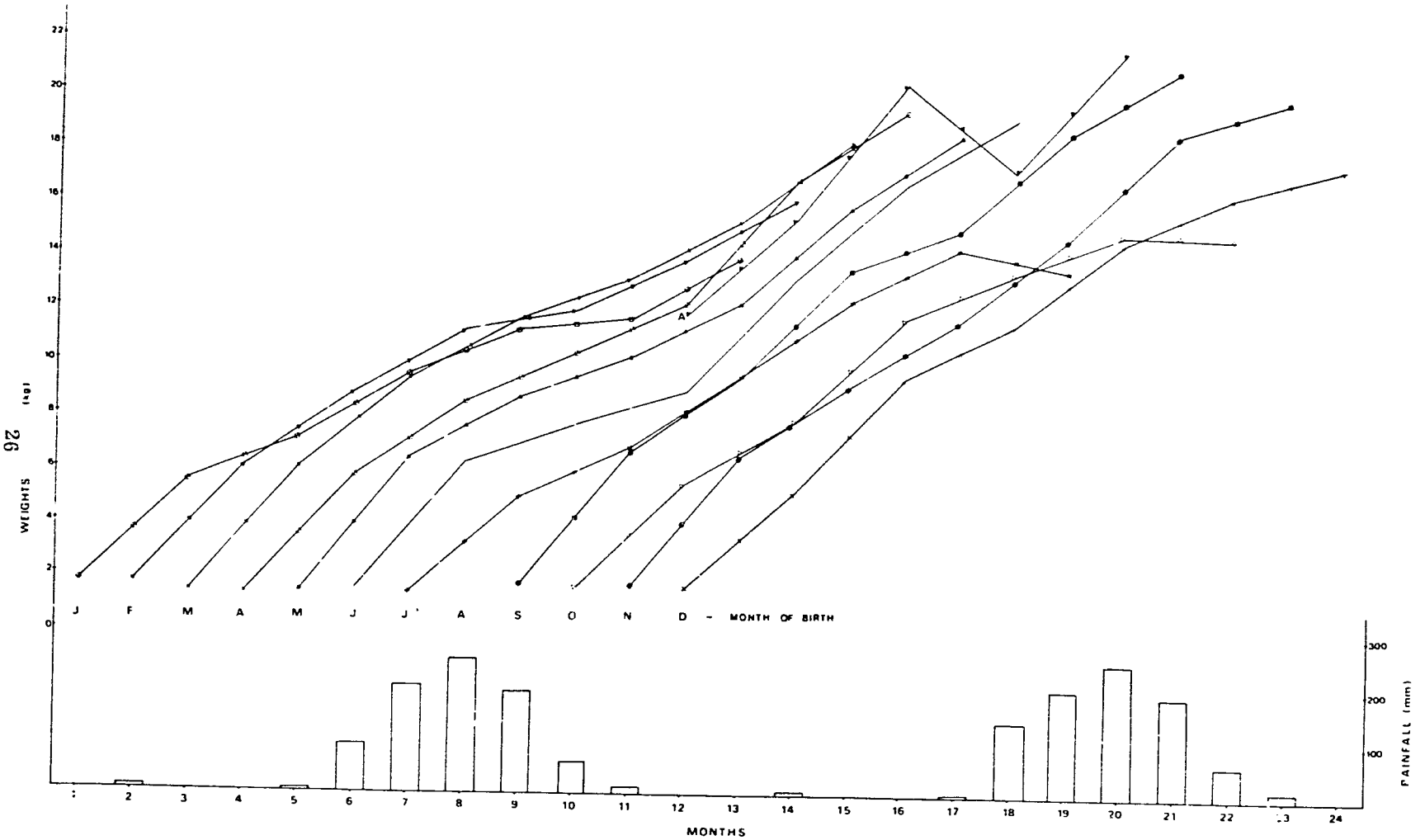

Figure 4. Effect of month of birth on body weight.

and relative rankings of month of birth groups might be expected to change from stage to stage.

Correlations and regressions between the 12 monthly means for weight and the 12 monthly means for rainfall from birth are given in Table 16 for the four ages 4, 6, 8 and 10 months where month of birth effect is significant.

Table 16. Correlations between and regressions of weight (kg) at 4 ages and rainfall (mm) between birth and that age.

Age	Correlation	Regression
4 months	-0.10	-0.001
6 months	-0.29	-0.002
8 months	-0.39	-0.004
10 months	-0.46	-0.005

Table 16 indicates that the correlations and regressions between rainfall and weight at the 4, 6, 8 and 10 month stages were all negati but small.

Effect of type of lambing

Table 13 indicates that type of lambing, single or twin, had a significant effect on all weights from birth to 8 months, twin lambs being 21%, 27%, 23%, 21%, 16%, 8% and 5% lighter than singles at birth, 2, 4, 6, 8, 10 and 12 months of age respectively.

Effect of sex

Table 13 indicates that the effect of sex was significant at all ages except 2 months. At birth, 2, 4, 6, 8, 10 and 12 months, males were 9%, 5%, 8%, 18%, 20%, 13% and 17% heavier than females.

Effect of dam parturition number

Table 13 indicates that the effect associated with dam parturition number was significant at the birth and 2-month stages only. At birth, lambs from second

parturition dams were 30% heavier and lambs from third and later parturition dams 41% heavier, than lambs from first parturition dams. At 2-months of age the respective differences were 13% and 34%.

Repeatability of early lamb weights

The repeatabilities of lamb birth, 2 month and 4 month weights considered as a characteristic of the ewe are indicated in Table 17. Data are from 360 lambs born to 146 ewes.

Table 17. Repeatability of early lamb weights

Trait	Repeatability	s.e.
Birth weight	0.22	0.07
2 months weight	0.18	0.07
4 months weight	0.24	0.08

Phenotypic correlations between lamb body weights at different ages

The phenotypic correlations available between lamb weights are shown in Table 18. These were all positive, with correlations between birth and early weights being lower than those between all other later ages.

Table 18. Phenotypic correlations between lamb body weights

Trait	2 months weight	4 months weight	6 months weight	8 months weight	10 months weight	12 months weight
Birth weight	.41	.29				
2 months weight		.78				
4 months weight			.84	.72		
6 months weight				.86		
8 months weight					.85	72
10 months weight						.86

EWE BODY WEIGHTS

Weights, at lambing and when lamb weaned at 4 months of age, were available for 144 ewes, together with the birth and 4 month weights of their 360 lambs, produced in 316 parturitions. In order to facilitate analyses and obtain correlations between ewe and lamb weights, the ewe weights in the 44 lambings producing twins, were used twice in the analyses. The data referred to lambings over the four years 1977 - 1980. Analyses of variance laid out in Table 19, showed origin, year of lambing and individual ewes to have significant effects on weights at lambing, lamb weaning and their mean. Additionally, month of lambing had a significant effect on weight at lamb weaning and mean weight.

Table 19. Analyses of variance of weights of adult ewes

Source	d.f.	Mean squares x 10^2		
		Weight at lambing	Weight at weaning	Mean weight
Origin	1	71424**	57971**	63299**
Ewes	145	1904**	2284**	1745**
Year of lambing	3	12261**	22386**	17876**
Month of lambing	10	682	2238**	696**
Type of lambing	1	566	865	357
Sex	1	199	56	246
Number of lambing/foundation	1	180	106	180
Number of lambing/born on centre	2	647	431	550
Remainder	195	475	516	269

** = P < .01.

The estimated least squares means for the three measures of ewe body weight are shown in Table 20.

The mean ewe body weight at lambing was 23.8 kg, and at weaning of lamb 23.3 kg, thus an average of 0.5 kg was lost during the 4 months suckling period.

The repeatabilities of ewe weights at parturition, at weaning of lambs 4 months later and the mean of the two, are indicated in Table 21.

Table 20. Estimated least squares means for weights of adult ewes (kgs)

Variable		Number	Weight at lambing	Weight at weaning	Mean weight
Overall mean		360	23.82	23.33	23.47
Origin					
Foundation	(1)	225	25.55	24.88	25.10
Born on centre	(2)	135	22.09	21.77	21.85
Year of lambing					
1977		45	22.94	21.53	22.39
1978		86	22.60	21.04	21.60
1979		102	23.12	23.29	22.95
1980		127	26.62	27.46	26.96
Month of lambing					
January		26	24.35	21.14	22.82
February		34	24.44	23.27	23.91
March		38	23.80	23.85	23.73
April		21	23.68	23.76	23.65
May		28	24.81	22.73	23.75
June		29	22.68	22.06	22.15
July		6	22.39	21.31	21.91
August		-	-	-	-
September		16	24.83	25.57	24.48
October		39	23.28	25.33	23.97
November		64	23.78	23.64	23.65
December		59	23.99	23.95	24.20
Type of lambing					
Single		272	23.58	23.03	23.28
Twin		88	24.07	23.63	23.67
Sex					
Male		198	23.72	23.28	23.36
Female		162	23.93	23.38	23.59
Number of lambing/origin 1					
1-4		93	25.74	24.74	25.29
5+		132	25.37	25.03	24.92
Number of lambing/origin 2					
1		32	21.18	21.05	21.04
2		39	22.59	22.21	22.35
3+		64	22.51	22.05	22.16

Table 21. Repeatability of ewe body weights

Trait	Repeatability	s. e.
Weight at parturition	0. 57	0. 05
Weight 4 months after parturition	0. 60	0. 05
Mean weight	0. 70	0. 04

These repeatability estimates were within the range normally reported for ewe body weights.

The phenotypic correlations between ewe weights and lamb preweaning weights are shown in Table 22.

Table 22. Phenotypic correlations between ewe and lamb weights

Trait	Lamb birth weight	Lamb 2 months weight	Lamb 4 months weight
Ewe weight at parturition	0. 20	0. 38	0. 39
Ewe weight 4 months after parturition	0. 06	0. 27	0. 32
Mean ewe weight	0. 18	0. 36	0. 39

The correlation of ewe weight with lamb pre-weaning weights was about double that between ewe weight and lamb birth weight.

SHEEP LINEAR MEASUREMENTS

ENVIRONMENTAL AND GENETIC EFFECTS ON LAMBS FROM BIRTH TO 12 MONTHS OF AGE

Three linear measurements, height at withers, scapulo-ischial length, and heart girth, together with body weight were available for 360 lambs at birth, 2 and 4 months; 298 at 4, 6 and 8 months; and 209 at 8, 10 and 12 months. Analyses of variance laid out in Table 23 show the significance of environmental and genetic effects on the linear measurements and weight from birth to 12 months. The general situation is that these effects on linear measurements fairly closely resembled their effects on body weight.

The estimated least squares means for height, length, girth and weight at birth 2, 4, 6, 8, 10 and 12 months are given in Table 24.

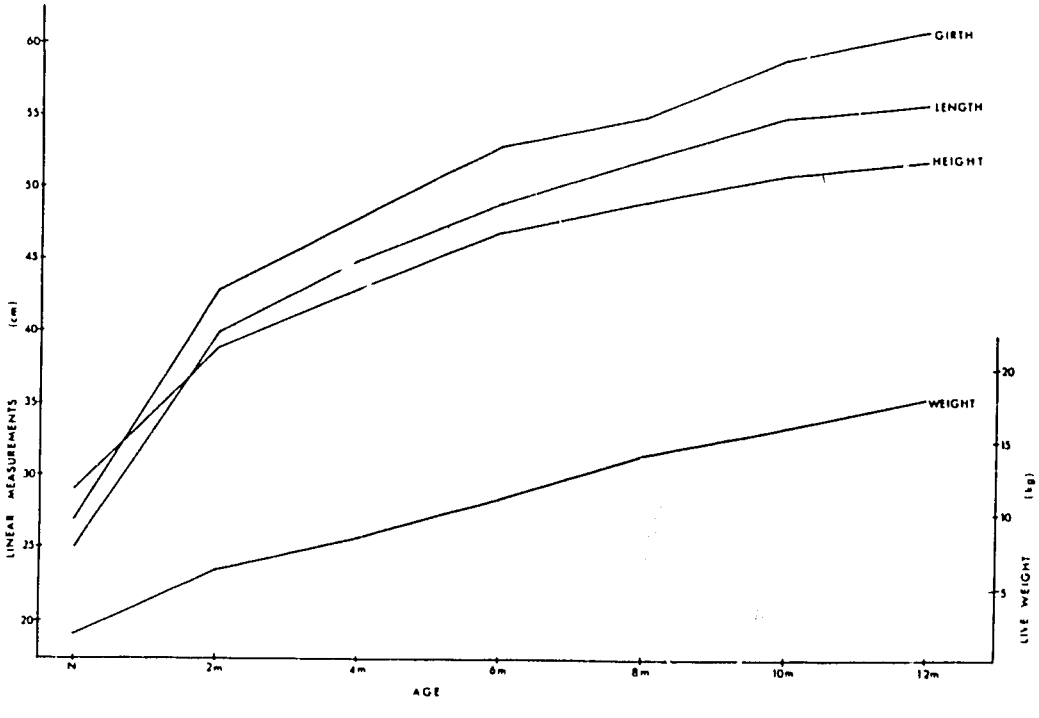

Figure 5. Mean changes in linear measurements and weight.

Table 23. Analysis of variance of weight and linear measurements at seven different ages

Source	d.f.	Mean squares x 10^2 Birth	2 m	4 m	d.f.	HEIGHT Mean squares x 10^2 4 m	6 m	8 m	d.f.	Mean squares x 10^2 8 m	10 m	12 m
Origin	1	15463**	10076**	30955**	1	30203**	14555**	23274**	1	5834*	9892**	8493**
Ewes	145	614**	1015**	1776**	141	1445**	1365	1332	116	1198	1093	1141
Year of birth	3	3644**	9640**	20724**	3	14321**	20894**	23980**	3	17587**	22576**	23658**
Month of birth	10	915*	1301	1385	11	970	1946	2710	11	3510*	3987**	2778**
Type of lambing	1	8329**	14416**	17204**	1	17853**	9703**	16745**	1	9016*	3636	9278**
Sex	1	2418*	3164*	4515*	1	5032*	7512*	6945*	1	502	1374	5082*
Number of lambing/foundation	1	82	165	3188	1	2339	8657	1384	1	5290	8072**	1118
Number of lambing/born on centre	2	471	1136	436	2	651	517	582	2	4230	41	371
Remainder	195	408	712	980	136	927	1163	1880	72	1614	921	896

Source	d.f.	Mean squares x 10^2 Birth	2 m	4 m	d.f.	LENGTH Mean squares x 10^2 4 m	6 m	8 m	d.f.	Mean squares x 10^2 8 m	10 m	12 m
Origin	1	9272**	12595**	26021**	1	27865**	12466**	17398**	1	1717**	17577**	11376**
Ewes	145	926**	1216**	2591**	141	2087	2133	1761**	116	1315	1522	1165
Year of birth	3	412	3648**	2115**	3	12555**	19481**	41[illegible]**	3	2[illegible]**	41[illegible]**	24065**
Month of birth	10	519	1015	2265	11	2782	4557**	[illegible]**	11	[illegible]*	[illegible]	2488*
Type of lambing	1	825	24128**	19621**	1	17[illegible]**	26517**	1[illegible]**	1	[illegible]	4371*	4354
Sex	1	414	1356	16	1	1[illegible]	2[illegible]	1[illegible]**	1	124	117	1087*
Number of lambing/foundation	1	339	60	1330	1	2524	5241	2[illegible]	1	[illegible]*	[illegible]*	2554
Number of lambing/born on centre	2	1159	2178*	3374	2	1[illegible]	1[illegible]	[illegible]	2	[illegible]	[illegible]	1165
Remainder	195	576	683	1730	136	1426	[illegible]	11[illegible]	72	1[illegible]	[illegible]	1141

Source	d.f.	Mean squares x 10^2 Birth	2 m	4 m	d.f.	GIRTH Mean squares x 10^2 4 m	6 m	8 m	d.f.	Mean squares x 10^2 8 m	10 m	12 m
Origin	1	21551**	24733**	47980**	1	52253**	31856**	[illegible]**	1	13521**	[illegible]**	15354*
Ewes	145	635**	1754**	2695**	1	2198**	2045*	2394**	116	1[illegible]	2155	2241
Year of birth	3	848	7[illegible]**	39473**	3	22788**	41130**	53553**	3	41[illegible]**	5[illegible]**	47751**
Month of birth	10	512	1401	4316**	11	3778**	5124**	1269	11	3[illegible]	2[illegible]	3278
Type of lambing	1	11315**	52898**	51882**	1	38738**	37572**	27[illegible]**	1	[illegible]**	[illegible]	6095
Sex	1	4045**	1178	3261	1	3998	10676**	2[illegible]**	1	[illegible]	[illegible]	7132
Number of lambing/foundation	1	90	20	405	1	1815	2070	3[illegible]	1	14[illegible]**	14[illegible]*	2359
Number of lambing/born on centre	2	1648*	5106**	3[illegible]	2	3235	4[illegible]	2[illegible]	2	2112	[illegible]	9[illegible]
Remainder	195	428	841	1[illegible]	136	1[illegible]	1475	1535	[illegible]	13[illegible]	2[illegible]	1316

Source	d.f.	Mean squares Birth x 10^3	2 m x 10^2	4 m x 10^2	d.f.	WEIGHT Mean squares x 10^2 4 m	6 m	8 m	d.f.	Mean squares x 10^2 8 m	10 m	12 m
Origin	1	5010**	4186**	11013**	1	1[illegible]**	1[illegible]**	8732**	1	2[illegible]**	11432**	71[illegible]**
Ewes	145	181**	333**	928**	141	[illegible]	962*	1211**	116	827	1121	1331
Year of birth	3	366*	2117**	15664**	3	7917**	1[illegible]**	2[illegible]**	3	19542**	2[illegible]**	28154**
Month of birth	10	257*	266	1252**	11	1[illegible]	1[illegible]**	1[illegible]	11	2[illegible]**	1382*	21[illegible]*
Type of lambing	1	3185**	8[illegible]**	12401**	1	10[illegible]**	1[illegible]**	[illegible]**	1	2489	1543	793
Sex	1	996**	4[illegible]	2430*	1	2352*	11[illegible]**	17[illegible]**	1	1505	[illegible]**	11911**
Number of lambing/foundation	1	129	213	375	1	1143	1[illegible]	2[illegible]	1	5157*	2382	119
Number of lambing/born on centre	2	573**	676*	1161	2	767	[illegible]	182	2	397	185	312
Remainder	195	169	222	475	136	542	6[illegible]	731	72	829	967	1193

* = P < 0.05
** = P < 0.01

Table 24. Estimated least squares means for weights and linear measurements at seven different ages

Variable	No.	Birth	2 m	4 m	No.	4 m	6 m	8 m	No.	8 m	10 m	12 m	No.	Birth	2 m	4 m	No.	4 m	6 m	8 m	No.	8 m	10 m	12 m
	LENGTH (cm)												GIRTH (cm)											
Overall mean	360	24.9	39.61	45.2	298	45.1	48.71	52.0	209	52.1	54.71	56.5	360	27.2	42.67	48.0	298	48.3	52.64	55.4	209	56.0	59.45	61.4
Origin																								
Foundation (1)	225	25.5	40.33	46.2	188	46.4	49.72	53.0	143	53.0	55.84	57.4	225	28.2	43.68	49.5	188	50.0	54.00	56.[illegible]	143	57.0	60.86	62.5
Born on Centre (2)	135	24.2	38.88	44.2	110	43.8	47.71	51.0	66	51.1	53.58	55.6	135	26.3	41.65	46.6	110	46.5	51.28	54.[illegible]	66	55.6	58.04	60.4
Year of birth																								
1977	45	24.9	40.47	46.6	58	44.5	48.01	51.9	72	48.8	51.85	54.5	45	26.3	43.86	49.5	58	47.6	52.24	54.6	72	51.3	55.45	58.2
1978	86	25.3	38.50	42.3	53	43.1	45.00	46.8	38	46.7	48.41	50.8	86	27.9	41.14	44.5	53	45.8	47.81	48.6	38	49.6	51.31	53.4
1979	102	24.9	38.93	44.1	76	44.8	49.06	52.7	51	54.1	56.38	57.6	102	27.4	41.66	46.3	76	47.2	51.66	56.1	51	57.7	62.45	63.9
1980	127	24.4	40.51	47.8	111	48.1	52.78	56.7	48	58.7	62.21	63.0	127	27.3	43.99	51.8	111	52.6	58.85	62.1	48	65.5	48.59	70.2
Month of birth																								
January	26	26.1	46.69	43.7	18	45.2	48.01	49.5	18	47.9	49.26	52.0	26	28.1	42.38	46.1	18	46.6	49.57	54.4	18	52.5	54.09	57.1
February	34	25.1	41.11	44.5	28	43.9	48.92	51.5	23	50.2	53.37	54.7	34	28.5	43.75	49.0	28	48.6	52.45	54.8	23	53.3	57.62	58.5
March	38	24.8	39.68	46.7	30	46.9	49.90	52.1	33	51.1	54.05	57.1	38	27.1	43.21	49.9	30	49.9	53.95	55.6	33	54.5	59.07	62.6
April	21	24.6	39.09	44.9	9	44.4	48.16	51.2	9	51.2	54.58	57.3	21	26.9	41.43	47.6	[illegible]	46.6	50.5[illegible]	53.3	9	54.7	61.20	62.0
May	28	24.3	39.42	44.7	15	45.4	45.93	49.9	14	48.8	54.98	56.5	28	27.0	43.38	47.4	15	48.3	50.44	54.5	14	53.4	58.92	60.3
June	29	24.6	39.42	44.6	34	43.4	44.64	49.3	25	50.5	54.40	56.2	29	27.3	43.39	47.3	34	45.8	49.32	54.2	25	56.[illegible]	60.35	61.9
July	6	23.7	37.38	43.2	7	41.8	45.70	51.0	6	49.2	50.07	51.4	6	25.4	39.58	44.5	7	42.4	50.45	55.[illegible]	6	54.6	56.63	56.3
August	-	-	-	-	3	43.5	51.51	58.1	3	60.9	60.02	63.3	-	-	-	-	3	53.[illegible]	59.51	57.8	3	60.9	63.04	70.2
September	16	24.9	40.53	46.5	12	46.9	51.84	55.0	11	54.8	57.59	59.3	16	27.3	43.11	48.6	12	50.4	56.79	57.1	11	58.8	61.43	65.7
October	39	26.0	38.56	45.4	33	47.6	49.59	52.2	17	52.2	54.12	54.8	39	26.8	41.51	47.3	33	48.4	53.22	55.3	17	56.9	59.03	58.7
November	64	25.0	39.85	47.1	55	46.6	50.39	52.2	21	53.3	56.72	58.2	64	27.5	43.87	50.7	55	49.9	53.62	56.5	21	58.4	62.95	62.6
December	59	24.4	39.85	46.6	54	45.8	50.17	52.2	29	54.0	56.12	56.8	59	27.6	43.71	50.0	54	50.1	53.70	55.9	29	58.4	59.07	60.2
Type of lambing																								
Single	272	25.1	41.23	46.6	225	46.7	50.62	53.4	170	53.4	55.95	57.6	272	28.3	45.03	50.4	225	50.6	54.92	57.3	170	57.6	60.74	62.8
Twin	88	24.6	37.97	43.8	73	43.5	46.80	50.7	39	50.8	53.48	55.3	88	26.1	40.30	45.7	73	46.0	50.36	53.4	39	54.4	58.16	60.1
Sex																								
Male	198	25.0	39.87	45.2	151	45.5	49.13	53.2	96	52.4	54.85	57.5	198	27.7	42.91	48.4	151	48.9	53.00	56.7	96	56.4	60.67	62.5
Female	162	24.7	39.34	45.2	147	44.7	48.29	50.8	113	51.8	54.57	55.5	162	26.8	42.42	47.6	147	47.7	51.69	54.0	113	55.7	58.23	60.3
Number of lambing/origin 1																								
1-4	93	25.27	40.44	46.78	80	47.35	50.83	53.86	78	55.39	57.65	58.62	93	28.09	43.62	49.77	80	50.80	54.78	57.49	78	59.85	63.70	63.67
5+	132	25.77	40.22	45.78	108	45.50	48.60	52.32	65	50.76	54.03	56.27	132	28.35	43.74	49.22	108	49.34	53.22	55.51	65	54.29	58.01	61.41
Number of lambing/origin 2																								
1	32	2[illegible].3	37.29	42.5	21	42.7	46.03	50.8	13	49.6	54.79	55.6	32	24.8	39.11	44.6	21	43.8	50.13	54.0	13	52.8	58.26	55.7
2	39	24.0	38.97	43.8	30	43.6	48.50	51.2	19	52.2	53.20	54.7	39	26.6	41.99	45.7	30	46.9	51.58	54.7	19	57.5	58.29	62.6
3+	64	25.4	40.38	46.1	59	45.3	48.59	51.0	34	51.6	52.78	56.4	64	27.4	43.35	48.6	59	49.0	52.15	54.0	34	54.7	57.57	62.8

Table 24. Estimated least squares means for weights and linear measurements at seven different ages

Variable	No.	WEIGHT (kgs) Birth	2 m	4 m	No.	4 m	6 m	8 m	No.	8 m	10 m	12 m	No.	HEIGHT (cm) Birth	2 m	4 m	No.	4 m	6 m	8 m	No.	8 m	10 m	12 m
Overall mean	360	1.59	6.06	8.71	298	8.70	11.33	13.53	209	14.03	15.93	17.90	360	28.9	39.38	43.4	298	43.4	46.83	48.7	209	48.6	51.10	52.2
Origin																								
Foundation (1)	225	1.74	6.48	9.39	188	9.48	12.13	14.24	143	14.77	16.85	18.[illegible]3	225	29.7	40.03	44.5	188	44.7	47.74	49.9	143	49.3	51.95	53.0
Born on Centre (2)	135	1.45	5.65	8.03	110	7.92	10.54	12.82	66	13.30	15.01	17.17	135	28.1	38.73	42.2	110	42.1	45.91	47.6	66	48.0	50.24	51.4
Year of birth																								
1977	45	1.48	6.33	10.15	58	8.15	11.15	13.32	72	11.26	13.74	16.08	45	26.8	38.56	43.2	58	42.1	46.30	48.1	72	45.1	48.07	51.5
1978	86	1.71	5.40	6.12	53	6.67	8.18	8.99	38	9.11	9.78	11.76	86	29.8	37.80	40.5	53	40.5	43.14	44.6	38	44.6	45.92	46.3
1979	102	1.54	5.57	7.81	76	8.44	11.08	14.46	51	15.84	18.07	19.21	102	28.9	39.20	43.1	76	43.9	47.01	49.3	51	50.0	52.77	53.5
1980	127	1.65	6.95	10.75	111	11.23	14.93	17.36	48	19.92	22.11	24.56	127	30.1	41.97	46.7	111	47.1	50.86	53.1	48	54.8	57.62	57.5
Month of birth																								
January	26	1.74	5.59	6.95	18	7.46	9.64	11.87	18	10.71	11.71	14.08	26	28.7	38.46	41.5	18	42.3	45.40	47.6	18	44.9	48.04	48.7
February	34	1.75	6.12	9.09	28	8.73	11.27	12.08	23	12.04	13.91	16.17	34	30.1	40.17	44.0	28	43.9	47.36	47.7	23	46.6	48.94	49.0
March	38	1.48	6.14	9.53	30	9.64	11.71	13.56	33	12.88	15.35	16.31	38	29.7	39.90	44.5	30	44.4	48.00	49.4	33	47.4	50.43	51.1
April	21	1.38	5.81	9.01	9	8.17	10.40	11.73	9	12.80	16.92	19.49	21	29.0	38.86	43.9	9	42.7	46.81	46.9	9	45.6	48.47	49.5
May	28	1.45	6.50	9.11	15	8.41	10.26	12.59	14	12.04	15.50	18.61	28	28.5	40.09	43.7	15	43.6	45.57	48.0	14	46.4	48.61	51.7
June	29	1.60	6.32	8.36	34	7.18	9.00	12.64	25	13.87	16.77	19.27	29	28.4	39.22	43.1	34	41.8	44.44	46.5	25	47.2	49.91	51.8
July	6	1.49	5.01	7.53	7	6.33	9.61	12.08	6	11.75	14.41	13.59	6	27.7	37.87	41.7	7	40.5	44.23	45.0	6	46.4	49.17	51.7
August		-	-	-	3	11.86	15.49	19.37	3	21.66	17.29	21.80	-	-	-	-	3	45.5	50.71	54.4	3	56.3	55.22	56.5
September	19	1.74	6.80	9.64	12	9.62	13.57	14.98	11	15.26	18.70	21.11	16	29.7	41.72	43.9	12	44.8	48.72	51.4	11	51.8	54.60	56.0
October	39	1.56	5.53	7.40	33	8.45	11.81	13.12	17	13.81	14.98	14.88	39	27.8	38.67	42.3	33	43.5	46.78	48.9	17	50.6	51.86	52.3
November	64	1.70	6.64	9.66	55	8.88	11.67	13.85	21	15.78	18.71	20.03	64	28.6	39.73	44.4	55	43.6	44.96	48.7	21	49.8	55.49	54.8
December	59	1.62	6.26	9.51	54	9.68	11.58	13.58	29	15.78	16.41	17.49	59	29.8	38.48	44.2	54	43.8	46.95	50.4	29	50.5	53.00	53.2
Type of lambing																								
Single	272	1.78	7.01	9.85	225	9.90	12.65	14.71	170	14.59	16.61	18.39	272	29.8	40.62	44.7	225	44.9	47.99	50.3	170	50.3	52.15	53.1
Twin	88	1.41	5.13	7.56	73	7.50	10.02	12.36	39	13.18	15.24	17.41	88	27.9	38.15	42.0	73	41.8	45.67	47.2	39	47.0	50.04	50.5
Sex																								
Male	198	1.66	6.22	9.06	151	9.20	12.31	14.77	96	14.58	16.90	19.30	198	29.2	39.78	43.9	151	44.0	47.63	49.5	96	48.9	51.57	53.1
Female	162	1.52	5.91	8.35	147	8.20	10.36	12.29	113	13.54	14.96	16.50	162	28.5	38.98	42.9	147	42.7	46.02	48.0	113	48.4	50.62	51.3
Number of lambing origin 1																								
1-4	93	1.79	6.68	9.65	80	10.06	12.68	14.51	78	16.44	17.98	18.89	93	29.86	40.20	45.34	80	45.73	48.75	50.58	78	51.04	54.04	53.80
5-	132	1.69	6.28	9.12	108	8.90	11.58	13.97	65	13.10	15.72	18.38	132	29.61	39.85	43.79	108	43.75	46.74	49.31	65	47.65	49.86	52.24
Number of lambing origin 2																								
1	32	1.17	4.88	6.89	21	6.47	10.09	12.12	13	12.23	14.94	15.00	32	27.3	37.49	41.5	21	40.9	44.81	46.8	13	40.0	51.18	53.1
2	39	1.52	5.53	8.10	30	8.36	10.56	12.99	19	14.42	14.57	17.77	39	28.5	39.03	42.7	30	42.8	46.52	48.2	19	52.8	49.77	50.1
3-	64	1.66	6.53	9.09	59	8.94	10.97	13.35	34	13.26	15.52	18.75	64	28.5	29.67	42.5	59	42.5	46.41	47.7	34	51.	49.78	51.0

Figure 5 illustrates the mean changes in linear measurements and weights from birth to 12 months of age. The coefficient of variation of each of the three linear measurements at all stages was about 8%, while that of weight was around 20%.

CORRELATIONS BETWEEN WEIGHT AND LINEAR MEASUREMENTS

Table 25 presents the correlations between weight and height, length and girth. All were significant.

Table 25. Correlations between linear measurements and weight

Age	No.	Correlations between weight and: Height	Length	Girth
Birth	360	0.56	0.43	0.72
2 months	360	0.74	0.80	0.84
4 months	360	0.81	0.77	0.91
4 months	298	0.81	0.74	0.91
6 months	298	0.78	0.75	0.89
8 months	298	0.60	0.86	0.88
8 months	209	0.66	0.82	0.88
10 months	209	0.64	0.82	0.80
12 months	209	0.65	0.79	0.88

REPEATABILITY OF EARLY LAMB MEASUREMENTS

The repeatabilities of lamb linear measurements at birth, 2 and 4 months considered as a characteristic of the ewe are indicated in Table 26.

Table 26. Repeatability of lamb linear measurements

	Height		Length		Girth	
	r	s.e.	r	s.e.	r	s.e.
Birth	0.18	0.07	0.21	0.07	0.17	0.07
2 months	0.16	0.07	0.25	0.07	0.32	0.06
4 months	0.26	0.07	0.18	0.07	0.32	0.07

SHEEP PRODUCTIVITY

INDICES OF EWE PRODUCTIVITY

The characters of reproductive performance, lamb viability, lamb weaning weight and ewe weight were combined to build three productivity indices. Index 1, the total weight of weaned lamb per ewe per year, was computed for each ewe parturition as the product of total weight of weaned lamb x 365 ÷ interval to next lambing. Index 2, the total weight of weaned lamb per kg of ewe per year, was computed as index 1 ÷ ewe average weight. Index 3, the total weight of weaned lamb per kg of metabolic weight of ewe per year, was computed as Index 1 ÷ ewe average weight$^{.73}$. Data on 397 ewe parturitions were available from 1977 to 1980.

The significance of environmental influences on the three productivity indices is indicated in Table 27.

Table 27. Analysis of variance of productivity indices

Source	d. f.	Mean squares		
		Index 1	Index 2 $x10^{-2}$	Index 3 $x10^{-3}$
Origin	1	676**	5049**	3661**
Year of lambing	3	1270**	18474**	10672**
Month of lambing	11	88	1356	770
Type of lambing	1	426**	4464*	2857*
Number of lambing/foundation	1	140	3916*	1928*
Number of lambing/born on centre	2	499**	7244**	4263**
Remainder	377	55	889	496

* = P < 0.05. ** = P < 0.01.

The estimated least squares means for productivity indices are laid out in Table 28.

Table 28. Estimated least squares means of productivity indices

Variable		Number	Index 1	Index 2	Index 3
Overall mean		397	11.49	465.84	1103
Origin					
Foundation	(1)	229	12.95	505.82	1211
Born on centre	(2)	168	10.02	425.85	995
Year of lambing					
1977		51	13.57	566.47	1332
1978		141	6.45	265.30	626
1979		107	10.78	452.19	1060
1980		98	15.15	579.38	1394
Month of lambing					
January		18	11.46	470.43	1117
February		37	8.90	375.07	877
March		43	11.40	463.10	1096
April		25	13.67	555.59	1316
May		33	13.28	555.74	1304
June		31	10.07	533.10	1259
July		10	10.61	413.84	991
August		7	5.61	230.81	545
September		28	12.57	500.92	1192
October		46	11.39	470.20	1109
November		60	13.59	544.46	1292
December		59	12.28	476.76	1144
Type of lambing					
Single		348	9.82	411.81	966
Twin		49	13.16	519.86	1240
Number of lambing/origin 1					
1-4		112	13.94	558.17	1327
5+		117	11.96	453.48	1095
Number of lambing/origin 2					
1		66	7.25	324.09	745
2		48	9.46	397.14	931
3+		54	13.38	556.33	1310

The mean productivity indices were:-

Index 1. 11.5 kg of weaned lamb per ewe per year

Index 2. 466 gm of weaned lamb per kg of ewe per year

Index 3. 1103 gm of weaned lamb per $kg^{.73}$ of ewe per year.

Year of lambing had very significant effects on productivity. This would be expected, following the major year effects previously found on the different performance traits making up the productivity indices.

Type of lambing had an effect on productivity, ewes producing twins being 34%, 26% and 28% superior to those producing singles, for indices 1, 2 and 3 respectively. This was in spite of the lower individual weaning weights and higher mortality in twin lambs compared with singles.

The effect of parturition number of ewes born on the centre was highly significant, ewes with 3 or more parturitions being 84%, and ewes with 2 parturitions being 30% superior to first parturition females for index 1. Corresponding figures for index 2 were 71% and 22%, and for index 3, 75% and 24%.

FLOCK PRODUCTIVITY

Adjustment of the three ewe productivity indices to account for actual twinning rates found (12%) and actual ewe viability rates (85.2%) give the most accurate estimates of overall flock productivity. These are:

Index 1: 8.7 kg of weaned lamb per ewe per year

Index 2: 362 gm of weaned lamb per kg of ewe per year

Index 3: 850 gm of weaned lamb per $kg^{.73}$ of ewe per year.

CATTLE REPRODUCTIVE PERFORMANCE

INTRODUCTION

Reproductive performance is the trait of outstanding importance in beef cattle enterprises, where if there is no calf, then there is no economic return. The best cows are clearly those that have their first calf at an early age, have minimum calving intervals, and live a long time. Thus the most important measures of reproductive performance in the female are age at first calving, length of calving interval, and length of cow productive life.

AGE AT FIRST CALVING

The mean age at first calving for 101 females born on the station from 1973 to 1978 was 39.8 ± 0.8 months with a coefficient of variation of 14.1%.

The significance of environmental influences on age at first calving are indicated in Table 29, where year of birth had a major effect.

Table 29. Analysis of variance of age at first calving

Source	d.f.	Mean squares
Year of birth	5	356804**
Month of birth	11	12045
Remainder	84	28987

** = $P < 0.01$.

The estimated least squares means in Table 30 show that age at first calving ranged from 47.76 months for animals born in 1974 to 33.19 months for those born in 1978.

Table 30. Estimated least squares means for age at first calving (months)

Variable	Number	Age at first calving
Overall mean	101	39.78
Year of birth		
1973	5	40.42
1974	25	47.76
1975	11	40.30
1976	16	41.73
1977	16	35.31
1978	28	33.19
Month of birth		
January	2	41.26
February	4	46.99
March	6	42.53
April	11	39.01
May	17	39.83
June	10	38.55
July	10	40.22
August	12	41.42
September	6	37.37
October	9	38.68
November	10	39.60
December	4	37.95

CONCEPTION RATE BY MONTH

The distribution of 357 conceptions calculated from the recorded calving dates from 1974 to 1979 are indicated in Figure 6. The mean monthly rainfall over the 6 years is also shown.

48% of conceptions, or 9.6% per month, occurred during the major five month wet season from June to October, the remaining 52% or 7.4% per month during the other 7 months of the year.

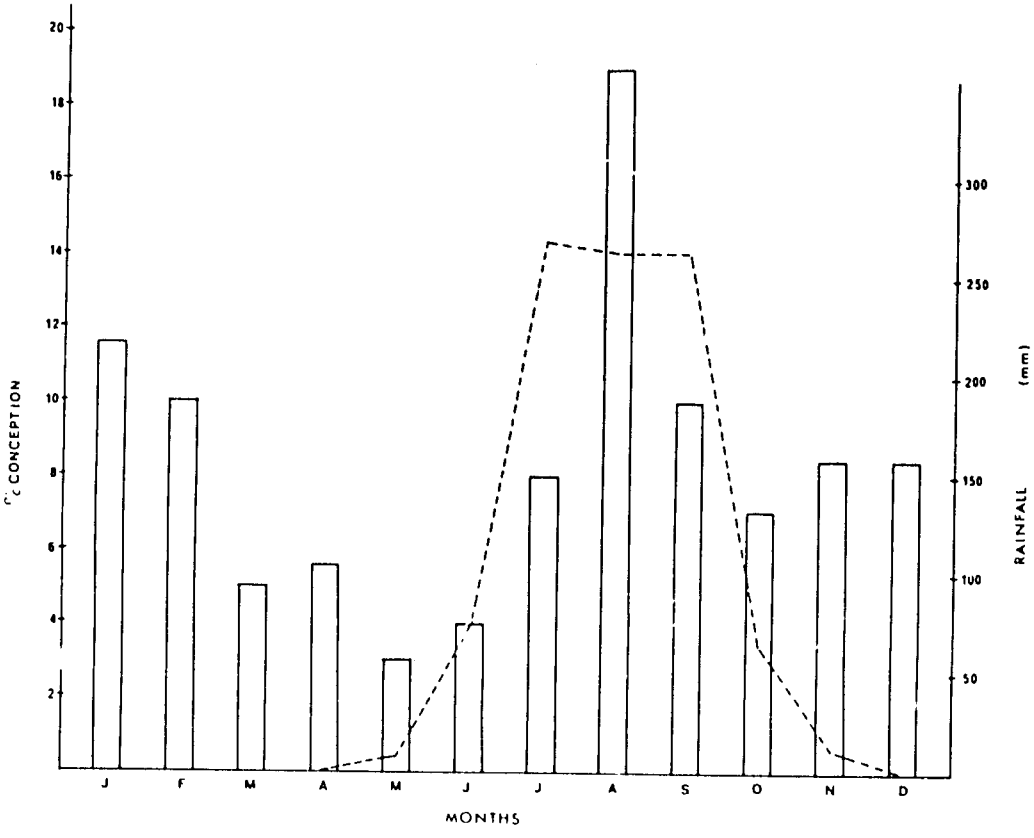

Figure 6. Effect of month on conception rate.

CALVING INTERVAL

The mean calving interval for 357 records from 1974 to 1979 was 495 ± 16 days, with a coefficient of variation of 26%. The significance of environmental and genetic influences on calving interval are indicated in Table 31.

Table 31. Analysis of variance of calving interval

Source	d.f.	Mean squares x 10^{-2}
Origin	1	1820**
Year of calving	5	1732**
Month of calving	11	331
Parturition number	3	938**
Remainder	336	189

** = $P < 0.01$

The effects of origin of cow, year of calving and the parturition number were significant. The estimated least squares means for calving interval are laid out in Table 32.

Table 32. Estimated least squares means for calving interval (days)

Variable	Number	Calving interval
Overall mean	357	495.0
Origin		
Foundation	286	539.7
Born on centre	72	450.2
Year of calving		
1974	67	451.1
1975	36	538.8
1976	52	582.8
1977	44	419.2
1978	83	513.5
1979	75	464.5
Month of calving		
January	20	518.7
February	11	502.1
March	14	465.4
April	28	510.0
May	68	462.5
June	36	489.1
July	26	552.0
August	30	555.5
September	30	487.7
October	41	458.5
November	35	482.3
December	18	455.8
Parturition number		
1	135	547.1
2	97	525.1
3	67	449.4
4+	58	458.3

Year of calving had a significant effect on calving interval. Cows calving in 1974, 1977 and 1979 had a shorter-than-average calving interval, those calving in 1975, 1976 and 1978 had a longer-than-average. There was a positive correlation of 0.56 between calving interval and annual rainfall, with calving interval increasing by 0.2 days for each 1 mm increase in annual rainfall.

Parturition number had an important effect on calving interval. Calving interval decreased from 547 days between the first and second parturitions to 449 between the third and fourth and then increased slightly to 458 days for subsequent parturitions.

Overall, foundation purchased heifers had a significantly longer calving interval (540 days) than those born on the centre (450 days).

LENGTH OF COW PRODUCTIVE LIFE

As the oldest records refer to heifers purchased in 1972-73, it is too early to completely assess this trait. However in August 1981, the first 40 heifers purchased had averaged 4.3 parturitions, with 23 or 57% still in production. The remaining 17 or 43% had died or been culled. Thus until more information is available it is tentatively suggested that an average of 5.5 parturitions would be achieved per cow. Using the mean calving interval of 495 days, cows would thus remain for an average of 7.5 years in productive life. This complete replacement of the cow herd each 7.5 years would represent a turnover of 13.4%. When age at first calving is added to the productive life, the average cow age on completion of productive life would be 10.8 years.

CATTLE MORTALITY

CALF MORTALITY

Mortality data based on 516 calves born over a seven year period were available. The significance of environmental influences on pre-weaning mortality (subdivided into two periods, birth to 3 days and 3 days to 6 months) and post-weaning mortality from 6 months to 12 months of age are indicated in Table 33.

Table 33. Analysis of variance of mortality rates

Source	d.f.	Mean squares x 10^3			
		B - 3d	3d - 6m	B - 6m	6m - 12m
Origin	1	13	92	36	11
Year of birth	6	19	211*	224	28
Month of birth	11	17	116	106	10
Parturition number	3	20	183	244	3
Sex	1	21	45	4	41
Remainder	493	23	90	107	19

* = $P < 0.05$

The estimated least squares means for mortalities over these periods are laid out in Table 34.

Pre-weaning mortality. The mean mortality from birth to weaning at 6 months was 9.6%, with 2.9% occurring in the first 3 days of life and 6.7% from 3 days to 6 months. The only significant effect was that of year of calving on deaths from 3 days to 6 months. The effect of parturition number approached significance, calves born to heifers having a higher mortality rate than those born to subsequent parturitions.

Table 34. Estimated least squares means for mortality rates

Variable	Mortality rates (%)			
	Birth - 3 days	3 days - 6 months	Birth - 6 months	6 months - 12 months
Overall mean	2.87	6.69	9.56	1.32
Origin				
Foundation	1.93	9.21	11.14	2.18
Born on centre	3.82	4.16	7.98	0.45
Year of calving				
1974	1.79	-2.67	-0.89	-0.38
1975	6.45	-1.00	5.44	-0.32
1976	1.69	3.88	5.57	-0.43
1977	0.94	9.21	10.15	-0.13
1978	3.31	4.75	8.06	5.15
1979	1.79	13.30	15.08	3.92
1980	4.16	19.36	23.52	1.41
Month of calving				
January	1.26	8.14	9.40	5.10
February	7.65	2.63	10.28	-1.58
March	0.03	-3.62	-3.59	2.49
April	5.02	3.00	8.02	0.14
May	2.83	6.30	9.13	1.36
June	4.68	9.32	14.00	3.13
July	2.38	9.35	11.73	1.39
August	0.54	12.96	13.50	-0.20
September	0.79	18.89	19.68	-0.29
October	0.92	4.45	5.36	1.37
November	4.84	1.65	6.50	-0.15
December	3.53	7.20	10.73	3.06
Parturition number				
1	2.79	13.21	16.00	0.63
2	1.70	4.02	5.72	1.28
3	1.83	4.78	6.61	0.99
4+	5.17	4.73	9.91	2.36
Sex				
Male	2.22	7.65	9.87	0.40
Female	3.53	5.73	9.26	2.24

Post-weaning mortality. The mean mortality from 6 months to 12 months of age was 1.3%. There were no significant influences found in the analyses.

MORTALITY RATES IN RELATION TO GENETIC IMPROVEMENT

An appropriate definition of mortality rate in the context of genetic progress is the percentage of females that die before calving. Here applying the post-weaning mortality rate of 1.3% per 6 months, to the period to first calving, it is approximately 17%. The rearing proportion is the proportion of births that produce a heifer that survives and is fertile. The rearing proportion here is about 0.40. This means that once in 2.5 calvings a cow produces a heifer calf that will reach lactation in the herd. The average length of reproductive life is 5.5 calvings : therefore, approximately 45% of the females born are required as replacements to maintain herd size. High mortality rates are inconsistent with genetic progress, and when they can be reduced, a higher intensity of selection can be achieved.

Genetic improvement per unit of time is more important than per animal generation, and high mortality rates have a marked effect on generation interval. The average age at first calving is 39.8 months, and the average calving interval 16.2 months. To replace herself, a cow must calve 2.5 times; thus, the average generation interval is 80.3 months or 6.7 years, within the normally reported range for tropical indigenous breeds.

COW MORTALITY

Data on cow mortality over the 6 years from 1975 to 1980 are presented in Table 35. The overall mortality rate was 3% per year.

Table 35. Cow mortality

Year	Number of cows	Number of deaths	Cow mortality (%)
1975	97	1	1.0
1976	121	3	2.5
1977	101	3	3.0
1978	102	5	4.9
1979	143	6	4.2
1980	151	3	2.0
Overall	715	21	2.9

CAUSES OF DEATH

The main causes of mortality in cattle have been grouped into four classes:- diseases of the alimentary tract; other diseases; accidents; and unidentified causes and snake bites. Diseases of the alimentary tract includes all digestive problems such as gastrointestinal parasitism, "other diseases" includes skin problems, nutritional problems, trypanosomiasis and diseases of the respiratory systems. Over the period from birth to $2\frac{1}{2}$ years, the proportions of deaths falling into each group are shown in Table 36.

Table 36. Mortality rate related to cause

Class	% (birth to $2\frac{1}{2}$ years)
Alimentary	20
Other diseases	23
Accidents	9
Unidentified	48

CATTLE BODY WEIGHTS

ENVIRONMENTAL AND GENETIC EFFECTS ON CALF WEIGHTS

Weights at birth, 3, 6 and 9 months were available for 403 calves; at 9, 12, 15 and 18 months for 306 calves; and at 18, 21, 24 and 30 months for 189 calves, born in the years 1974 - 1980, 1974 - 1979 and 1974 - 1978 respectively. Analyses of variance laid out in Table 37 show the significance of effects on calf weight at these different stages.

The estimated least squares means for body weight at the different stages are shown in Table 38.

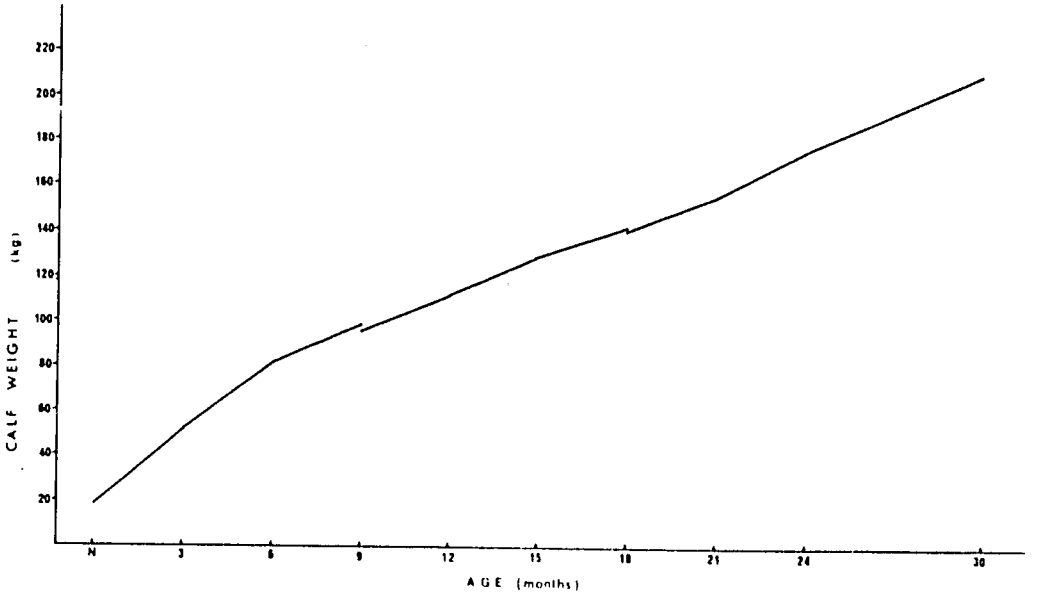

Figure 7. Mean calf body weights from birth to 30 months.

Table 37. Analysis of variance of weights at different ages

Source	d.f.	Mean squares				d.f.	Mean squares				d.f.	Mean squares			
		Birth	3 m	6 m	9 m		9 m	12 m	15 m	18 m		18 m	21 m	24 m	30 m
Origin	1	2	109	107	7	1	18	48	6	5	1	7	179	285	33
Cows	157	11**	182**	376**	466**	-	-	-	56	49	-	73	1793	2853	332
Year of birth	6	25**	170**	1668**	1904**	5	2099**	1263**	899	1494*	4	1815*	3370**	6973**	4029**
Month of birth	11	40**	235**	1196**	554**	11	1188**	784	1087**	3711**	11	2463**	2092**	1517	5356**
Dam parturition number	3	5	260**	572**	648**	3	1143**	1956**	2004**	1758*	3	355	470	1297	1460
Sex	1	49**	227*	1735**	5916**	1	4847**	8358**	14810**	29941**	1	13423**	21143**	17352**	11925**
Remainder	233	8	78	172	246	284	343	450	465	659	168	605	763	1247	1315

* = P < 0.05; ** = P < 0.01

Table 38. Estimated least squares means of weight from birth to 30 months (kgs)

Variable	No.	Birth	3 m	6 m	9 m	No.	9 m	12 m	15 m	18 m	No.	18 m	21 m	24 m	30 m
Overall mean	403	17.7	51.4	81.6	95.0	306	98.3	111.5	128.4	144.1	189	144.0	154.8	175.2	209.6
Origin															
Foundation	300	17.6	50.4	80.1	94.7	250	98.8	112.3	127.5	144.9	169	142.5	162.3	188.6	212.8
Born on centre	103	17.9	52.4	82.1	95.2	56	97.8	110.7	129.2	143.3	20	145.5	147.4	165.8	206.4
Year of birth															
1974	47	16.7	53.8	80.3	96.4	44	105.4	113.3	123.9	138.6	42	136.1	137.9	150.4	191.3
1975	40	16.4	48.5	72.8	83.0	38	90.4	106.0	121.1	131.9	35	131.1	142.1	157.3	196.9
1976	50	18.8	47.7	69.8	93.8	44	92.2	110.6	128.9	145.5	26	149.3	156.7	178.1	211.3
1977	41	17.5	52.5	88.1	101.5	36	103.3	109.4	126.9	144.1	28	151.5	167.6	191.2	227.2
1978	81	18.2	52.4	85.7	93.5	77	92.6	108.5	130.0	150.5	60	152.0	169.8	199.0	221.2
1979	75	17.4	52.5	90.5	106.2	67	105.2	121.1	138.3	153.9					
1980	69	19.1	52.4	80.5	90.8										
Month of birth															
January	12	17.0	45.7	70.7	91.5	11	101.9	117.4	121.1	133.7	10	132.2	157.4	170.8	194.1
February	12	16.8	49.9	83.5	95.4	9	100.8	106.0	120.4	149.4	5	139.2	154.1	161.0	206.4
March	28	16.3	45.6	87.3	100.1	14	104.8	111.8	126.9	163.6	9	167.2	172.7	200.9	248.9
April	32	17.2	51.5	91.2	102.0	25	105.4	113.8	129.8	161.4	13	160.3	167.5	174.2	227.9
May	72	16.0	54.7	91.6	100.6	63	107.4	110.3	136.3	157.1	38	157.2	164.8	176.1	231.3
June	38	16.4	53.0	83.7	97.7	33	97.9	105.6	136.4	149.9	20	154.3	155.1	165.0	220.5
July	35	18.5	59.0	87.3	97.0	21	100.1	108.2	139.4	152.8	12	153.7	151.1	170.5	219.2
August	33	19.3	55.1	80.6	90.8	23	89.2	106.6	129.5	137.2	17	140.1	139.8	165.4	210.3
September	30	20.6	51.1	76.6	82.9	27	83.7	107.4	126.7	131.4	13	126.3	123.2	166.6	188.2
October	40	19.0	52.1	80.7	95.4	35	97.8	123.8	134.0	139.4	19	138.9	151.8	188.6	197.9
November	51	18.6	50.4	69.7	89.1	30	92.0	114.8	122.5	129.3	21	130.1	155.3	184.8	195.0
December	18	16.9	49.9	70.3	99.1	15	97.2	112.1	117.1	123.7	11	128.5	165.2	178.4	175.4
Number of calving															
1	120	17.5	46.6	76.9	94.2	98	90.5	101.4	118.0	134.2	64	138.6	149.2	168.3	198.6
2	118	18.1	52.3	82.8	98.6	94	98.9	110.7	126.2	142.8	69	142.2	152.1	174.1	211.3
3	79	17.7	53.1	84.2	96.5	60	102.0	117.6	133.2	148.8	32	146.3	159.0	184.9	212.2
4+	86	17.6	53.6	80.4	90.5	54	102.0	116.2	136.1	150.5	24	148.7	159.0	173.5	216.1
Sex															
Male	215	18.2	52.4	83.8	100.0	156	102.5	117.0	135.6	154.4	93	153.1	166.3	185.6	218.2
Female	188	17.3	50.4	78.4	89.9	150	92.2	106.0	121.1	133.7	96	134.8	143.4	164.8	201.0

Figure 7 illustrates the mean growth of all calves from birth to 30 months of age. The coefficients of variation of weights at birth, 3, 6, 9, 12, 15, 18, 21, 24 and 30 months were 15%, 17%, 16%, 16%, 19%, 17%, 18%, 17%, 19% and 17% respectively.

Effect of year of birth

Table 37 indicates that significant year effects existed for weights at all ages except 15 months. The weight differences between extreme years at birth, 3, 6, 9, 12, 15, 18, 21, 24 and 30 months was 15%, 12%, 26%, 17%, 14%, 13%, 15%, 21%, 28% and 17% respectively of the mean weights.

Causes of variation between years in this environment can be annual rainfall affecting pasture availability, annual rainfall affecting the disease situation, changes in management techniques, genetic progress etc. Correlations and regressions between the 7 year means for weight at each stage from 3 months to 30 months and the 7 year means for rainfall from birth to each stage were all negative and non-significant.

To determine any linear trends in body weights from 1974 to 1978 for 21, 24 and 30 month weights; from 1974 to 1979 for 12, 15 and 18 month weights and from 1974 to 1980 for birth, 3, 6 and 9 month weights; the regression of the least squares constants on year of birth (represented as 1 - 5, 1 - 6 and 1 - 7) were calculated (Table 39).

Table 39. Correlations and regressions of the least squares constants for weight on year of birth

Trait	Correlation	Regression
Birth	0.65	0.30
3 month weight	0.23	0.30
6 month weight	0.51	1.84
9 month weight	0.38	1.48
12 month weight	0.15	1.28
15 month weight	0.87	2.67*
18 month weight	0.84	4.40**
21 month weight	0.97	8.91**
24 month weight	0.98	13.09**
30 month weight	0.92	8.99**

*P = < 0.05 **P = < 0.01

The regressions were significant from the 15 month stage onwards and indicate that weight for age increased at each stage by the amounts listed in Table 39, per year over the relevant period.

Effect of month of birth

Table 37 indicates that significant month of birth effects existed for weights at all ages except 12 and 24 months. Figure 8 shows the weights of animals in each of the month of birth groups, corrected for all other effects evaluated.

The effects of month of birth on later body weights are usually related to the stage in the wet and dry weather cycle at which an animal reaches a given age; and relative rankings of month of birth groups might be expected to change from stage to stage. This situation is clearly illustrated in Figure 8.

Correlations and regressions between the 12 monthly means for weight and the 12 monthly means for rainfall from birth are given in Table 40 for the seven ages, 3, 6, 9, 15, 18, 21 and 30 months when the effect of month was significant.

Table 40. Correlations and regressions of weight (kg) at seven ages and rainfall (mm) between birth and that age.

Age	Correlation	Regression
3 months	0.84	0.011
6 months	0.86	0.019
9 months	0.68	0.013
15 months	0.74	0.019
18 months	0.80	0.029
21 months	0.55	0.028
30 months	0.79	0.046

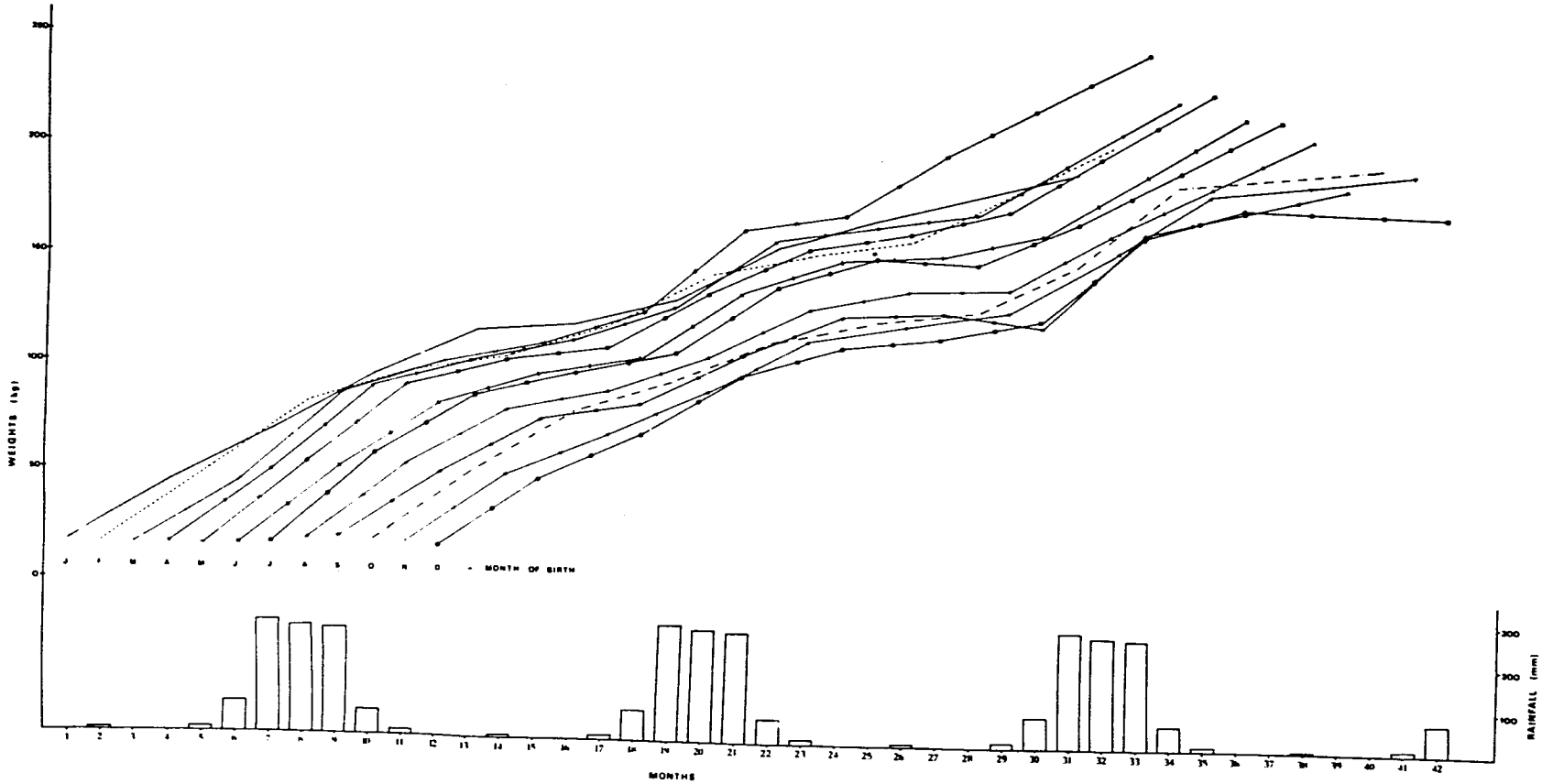

Figure 8. Effect of month of birth on body weight

Table 40 indicates that the correlations and regressions were all positive and significant at these stages.

Effect of dam parturition number

Table 37 indicates that the effect associated with dam parturition number was significant at all ages from 3 months to 18 months. Table 38 shows that at 3, 6, 9, 12, 15 and 18 months calves from first parturition cows were 12%, 7%, 6%, 12%, 10% and 9% lighter than the mean weight of calves from the three other parturition groups.

Effect of sex

Table 37 indicates that the effect of sex was significant at all ages from birth to 30 months. At birth, 3, 6, 9, 12, 15, 18, 21, 24 and 30 months males were 5%, 4%, 7%, 11%, 10%, 11%, 14%, 15%, 12% and 8% heavier than females.

Repeatability of early calf weights

The repeatabilities of calf birth, 3 month and 6 month weights considered as a characteristic of the cow are indicated in Table 41. Data are from 403 calves born to 158 cows.

Table 41. Repeatability of early calf weights.

Trait	Repeatability	s. e.
Birth weight	0.15	0.06
3 month weight	0.36	0.06
6 month weight	0.33	0.06

Phenotypic correlations between calf weights at different ages

The phenotypic correlations available between calf weights are shown in Table 42. These were all positive with correlations between birth and early weights being lower than those between all other later ages.

Table 42. Phenotypic correlations between calf weights

Trait	3 m	6 m	9 m	12 m	15 m	18 m	21 m	24 m	30 m
Birth	.43	.37	.30						
3 m		.72	.61						
6 m			.81						
9 m				.80	.70	.72			
12 m					.78	.67			
15 m						.86			
18 m							.84	.72	.81
21 m								.86	.78
24 m									.76

COW BODY WEIGHTS

Weights, at calving and when calf weaned at 6 months, were available for 103 individual cows over 165 parturitions. Only cows that had complete data on their linear measurements were used in this analysis so numbers were rather small. Analyses of variance laid out in Table 43 show the significance of effects on cow weight at the two stages.

Table 43. Analysis of variance of cow weights at calf birth and weaning (6 months)

Source	d.f.	Mean squares	
		Calving	Weaning
Origin	1	7176*	6425*
Cows	102	1443**	1364**
Year of calving	5	648*	654
Month of calving	11	702**	1131**
Parturition calving number	3	325	67
Sex	1	321	92
Remainder	41	235	349

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

The estimated least squares means for the two cow body weights are shown in Table 44.

Table 44. Estimated least squares mean of cow weights at calf birth and calf weaning at 6 months (kg)

Variable	Number	Weight at calf birth	Weight at calf weaning
Overall mean	165	232.26	235.21
Origin			
Foundation	103	220.36	223.95
Born on centre	62	244.15	246.47
Year of calving			
1975	7	209.82	216.32
1976	26	221.16	229.54
1977	6	216.58	253.62
1978	59	232.16	226.43
1979	46	235.72	246.94
1980	21	278.09	238.40
Month of calving			
January	3	265.70	218.57
February	6	211.70	266.66
March	11	221.01	250.50
April	23	212.18	244.64
May	36	221.74	268.42
June	14	224.10	231.24
July	13	220.88	244.93
August	15	217.56	222.14
September	14	240.59	231.88
October	11	244.47	220.99
November	13	221.88	169.66
December	6	285.27	222.96
Parturition number			
1	48	225.63	222.96
2	49	233.64	231.58
3	34	238.11	239.84
4+	34	230.65	246.45
Sex of calf			
Male	92	229.44	235.72
Female	73	235.07	233.70

The mean cow weight at parturition was 232 kg and at weaning of calf, 235 kg, thus an average of 3 kg was gained during the 6 months suckling period.

The repeatability of cow weight at parturition was 0.78 ± 0.06 and at calf weaning 0.67 ± 0.08. The phenotypic correlation between cow weight at parturition and calf birth weight was 0.37.

CATTLE LINEAR MEASUREMENTS

ENVIRONMENTAL AND GENETIC EFFECTS ON CALF LINEAR MEASUREMENTS

Three linear measurements, height at withers, scapulo-ischial length, and heart girth, together with body weight were available for 403 calves at birth, 3 and 6 months; 306 at 9, 12 and 15 months; and 189 at 18, 21, 24 and 30 months. Analyses of variance laid out in Table 45 show the significance of effects on the linear measurements and weight from birth to 30 months.

The estimated least squares means for girth, height and length from birth to 30 months are given in Tables 46, 47 and 48. Table 38 lays out the corresponding least squares means for weight.

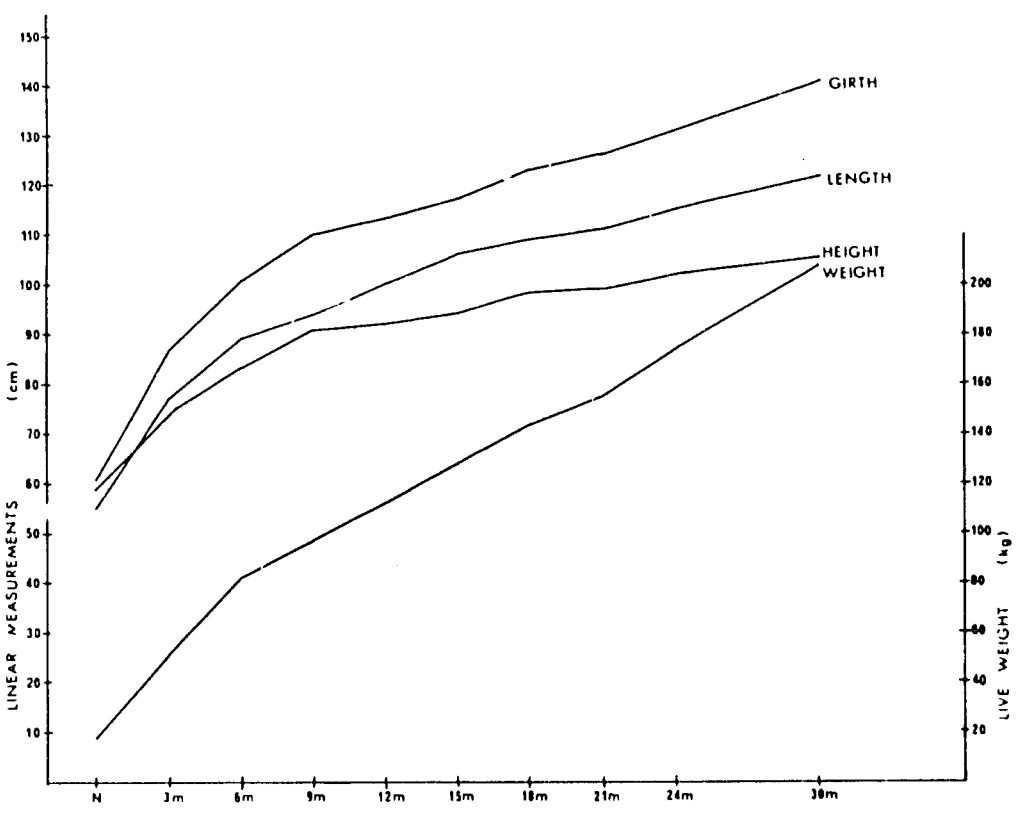

Figure 9. Mean changes in linear measurements and weight.

Table 45. Analysis of variance of weight and linear measurements at ten different ages

WEIGHT

Source	d.f.	Mean squares				d.f.	Mean squares				d.f.	Mean squares			
		Birth	3 m	6 m	9 m		9 m	12 m	15 m	18 m		18 m	21 m	24 m	30 m
Origin	1	2	109	107	7	1	18	48	56	49	1	73	1793	2858	332
Cows	157	11**	182**	376**	466**	-	-	-	-	-	-	-	-	-	-
Month of calving	11	40**	235**	1196**	554*	11	1187**	784	1087**	3711**	11	2463**	2092**	1516	5356**
Year of calving	6	25**	171*	1668**	1904**	5	2089**	1263*	899	1493*	4	1815*	3370**	6973**	4024*
Number of calving	3	5	260*	572*	648	3	1143*	1956**	2044**	1758*	3	355	470	1297	1460
Sex	1	49**	227	1735**	5916**	1	4847**	8358**	14810**	29941**	1	13423**	21143**	17352**	11925**
Remainder	223	8	78	172	246	284	342	450	465	659	168	605	76[illegible]	1247	1315

GIRTH

Source	d.f.	Mean squares			d.f.	Mean squares			d.f.	Mean squares			
		Birth	3 m	6 m		9 m	12 m	15 m		18 m	21 m	24 m	30 m
Origin	1	25	1	5	1	11	11	69	1	1	100	268	5
Cows	157	19**	60**	80**	-	-	-	-	-	-	-	-	-
Month of calving	11	79**	101**	221**	11	190**	85	83	11	238**	211**	149	301**
Year of calving	6	63**	67*	325**	5	175**	225**	145	4	88	157	321**	171
Number of calving	3	0	57	77	3	155*	230**	56	3	11	28	32	104
Sex	1	2	79	97	1	584**	771**	1763**	1	998**	1037**	868**	508*
Remainder	223	18	27	33	284	53	56	98	168	61	66	89	84

HEIGHT

Source	d.f.	Mean squares			d.f.	Mean squares			d.f.	Mean squares			
		Birth	3 m	6 m		9 m	12 m	15 m		18 m	21 m	24 m	30 m
Origin	1	0	2	33	1	22	7	7	1	5	13	12	23
Cows	157	14**	27	39**	-	-	-	-	-	-	-	-	-
Month of calving	11	47**	48	68**	11	60	25	37	11	49*	52**	31	55**
Year of calving	6	37**	21	77**	5	136	144**	67	4	14	40	31	35
Number of calving	3	2	7	8	3	147	76	34	3	19	14	9	8
Sex	1	3	29	126**	1	105	752**	512*	1	375**	500**	269**	316**
Remainder	223	9	27	19	284	85	37	79	168	21	20	21	21

LENGTH

Source	d.f.	Mean squares			d.f.	Mean squares			d.f.	Mean squares			
		Birth	3 m	6 m		9 m	12 m	15 m		18 m	21 m	24 m	30 m
Origin	1	36	48	18	1	0	67		1	0	105	107	2
Cows	157	16**	50**	59**	-	99**	52		-	-	-	-	-
Month of calving	11	69**	98**	199**	11	405**	344**		11	83*	53	34	150**
Year of calving	6	161**	134**	358**	5	83	84	N.A.	4	330**	493**	485**	334**
Number of calving	3	9	35	33	3	476**	645**		3	32	11	33	23
Sex	1	12	61	134	1	38	39		1	857**	1136**	452**	880**
Remainder	223	12	26	30	284				168	37	38	49	56

NA = Not available * = $P < 0.05$ ** = $P < 0.01$

Table 46. Estimated least squares means of girth from birth to 30 months (cms)

Variable	No.	Birth	3 m	6 m	9 m	No.	9 m	12 m	15 m	18 m	No.	18 m	21 m	24 m	30 m
Overall mean	403	60.6	86.6	100.8	111.7	306	108.5	113.3	116.7	123.8	189	122.8	126.4	130.7	140.7
Origin															
Foundation	300	61.0	86.5	100.6	115.2	250	108.9	113.7	117.7	124.1	169	123.0	128.1	133.6	140.3
Born on centre	103	60.1	86.7	101.0	108.3	56	108.1	112.9	115.7	123.4	20	122.6	124.6	127.8	141.1
Year of birth															
1974	47	61.1	89.0	100.6	128.4	44	111.6	115.1	115.5	112.2	42	121.9	124.1	126.6	139.5
1975	40	59.7	85.1	97.8	119.0	33	107.2	112.4	115.6	119.4	33	119.8	122.9	126.0	136.0
1976	50	61.5	84.7	96.4	108.1	44	107.4	112.8	117.0	121.1	26	123.4	126.4	131.5	141.5
1977	41	58.9	86.8	103.8	116.5	36	109.9	112.9	114.4	125.7	28	124.9	128.2	133.3	143.9
1978	81	61.8	86.8	103.7	100.3	77	105.9	110.5	117.4	125.7	60	123.8	130.3	136.2	141.8
1979	75	59.2	86.3	104.0	100.6	67	109.2	116.1	120.4	138.5	-	-	-	-	-
1980	69	61.8	87.5	99.3	109.2	-	-	-	-	-	-	-	-	-	-
Month of birth															
January	12	59.8	84.2	95.8	120.7	11	110.9	115.9	115.8	117.7	10	120.5	129.3	129.6	137.9
February	1[illegible]	60.1	86.6	104.6	118.[illegible]	9	109.8	113.0	114.7	122.3	5	124.6	124.6	125.9	141.2
March	2[illegible]	58.5	82.6	104.9	87.9	14	113.4	113.4	115.7	122.1	9	128.5	131.9	135.2	148.4
April	32	57.9	85.4	104.6	117.4	25	111.1	114.1	116.9	124.3	13	128.7	128.5	130.6	146.4
May	72	58.6	87.8	104.9	117.7	63	110.9	113.1	117.7	125.7	38	126.9	129.6	131.7	146.5
June	38	58.9	88.6	100.7	104.1	33	106.9	111.1	118.9	123.0	20	125.4	125.9	127.0	142.1
July	35	61.5	91.2	102.8	103.1	21	109.4	112.1	120.5	133.6	13	125.4	125.2	128.7	142.1
August	35	62.2	89.6	100.9	106.9	23	105.9	111.2	118.7	119.4	17	120.9	121.6	127.6	140.8
September	30	64.8	86.5	98.8	109.0	27	102.6	111.0	115.9	144.5	13	117.4	116.7	129.4	135.5
October	40	62.7	86.9	99.4	133.1	35	108.2	116.5	117.6	119.6	19	120.0	125.1	135.3	137.8
November	51	62.5	85.4	95.7	105.6	30	105.9	115.1	115.2	116.6	21	118.2	128.2	135.6	137.1
December	18	59.8	84.3	96.5	116.7	15	107.5	113.3	112.9	116.2	11	116.9	129.8	132.1	132.2
Number of calving															
1	120	60.4	84.2	99.8	96.8	98	105.7	109.9	115.3	128.6	64	121.9	124.9	130.3	138.1
2	118	60.6	86.5	101.7	104.5	94	108.9	112.8	117.0	123.1	69	122.4	126.3	131.4	141.8
3	79	60.6	88.0	101.7	116.9	60	109.6	115.7	116.4	122.3	32	123.5	127.3	131.7	141.5
4+	86	60.8	87.8	99.9	128.7	54	109.9	114.8	118.1	121.2	24	123.3	127.0	129.4	141.4
Sex															
Male	215	60.7	87.2	101.4	110.8	156	110.0	114.9	119.2	125.1	93	125.3	128.9	133.1	142.4
Female	188	60.5	86.0	100.1	112.6	150	107.1	111.7	114.2	122.4	96	120.3	123.8	128.4	138.9

Table 47. Estimated least squares means of height to withers from birth to 30 months (cm)

Variable	No.	Birth	3 m	6 m	No.	9 m	12 m	15 m	No.	18 m	21 m	24 m	30 m
Overall mean	403	58.7	74.3	83.4	306	88.9	92.4	94.4	189	97.7	99.3	102.1	105.0
Origin													
Foundation	300	58.7	74.2	82.9	250	88.4	92.1	94.1	169	97.3	99.9	102.7	105.8
Born on centre	103	58.7	74.4	83.9	56	89.5	92.7	94.7	20	88.1	98.7	101.5	104.1
Year of birth													
1974	47	57.6	74.9	82.9	44	89.3	92.8	95.0	42	96.7	98.6	101.8	105.0
1975	40	57.1	73.6	82.6	38	88.1	93.4	95.4	33	97.1	97.5	100.6	103.1
1976	50	59.6	73.0	82.7	44	88.4	91.8	94.9	26	98.6	98.9	101.5	104.9
1977	41	57.7	73.9	84.6	36	88.9	91.5	91.6	28	97.6	100.3	103.2	106.3
1978	81	58.3	74.3	83.4	77	87.1	90.3	94.9	60	98.5	101.2	103.5	105.7
1979	75	59.6	75.2	85.9	67	91.7	94.7	94.4	-	-	-	-	-
1980	69	61.1	75.4	81.9	-	-	-	-	-	-	-	-	-
Month of birth													
January	12	59.1	74.8	79.6	11	87.2	92.4	94.5	10	97.1	99.8	101.8	103.3
February	12	57.3	74.3	82.9	9	89.3	92.9	93.4	5	94.8	97.6	99.6	104.9
March	28	57.2	72.1	84.9	14	89.2	92.0	95.1	9	98.9	101.2	104.4	107.8
April	32	57.5	73.1	86.0	25	90.6	93.9	96.1	13	100.8	101.2	105.5	107.5
May	72	56.5	75.0	83.6	63	89.9	91.9	93.9	38	99.5	101.8	103.6	106.9
June	38	58.4	75.4	85.1	33	92.0	92.8	96.0	20	99.9	99.6	101.5	106.8
July	35	58.4	76.1	85.0	21	89.2	92.2	92.2	13	98.9	100.8	101.8	105.0
August	35	60.6	75.9	84.2	23	89.4	92.8	95.8	17	98.4	99.3	102.3	105.0
September	30	59.6	70.7	82.9	27	86.4	90.1	93.5	13	95.3	94.9	98.6	101.3
October	40	60.8	76.1	83.9	35	88.2	93.7	95.3	19	97.0	98.3	102.0	102.9
November	51	60.3	75.1	81.3	39	87.9	92.4	94.4	21	95.7	98.4	102.6	103.2
December	18	58.9	73.2	79.9	15	87.9	91.9	92.6	11	95.9	98.6	102.8	105.3
Number of calving													
1	120	59.1	73.9	82.5	98	87.6	90.9	92.9	64	96.8	98.2	101.2	104.2
2	118	58.6	74.4	83.1	94	90.5	92.8	94.7	69	96.8	99.2	102.0	105.1
3	79	58.8	74.0	84.1	60	89.9	93.7	95.4	32	98.2	99.7	102.7	105.3
4+	86	58.4	75.0	84.1	54	87.7	92.2	94.7	24	98.9	100.1	102.6	105.4
Sex													
Male	215	58.8	74.7	84.2	156	89.5	94.1	95.8	93	99.2	101.1	103.4	106.4
Female	188	58.6	73.9	82.7	150	88.3	90.8	93.0	96	96.2	97.5	100.8	103.6

Table 48. Estimated least squares means of the scapulo-ischial length from birth to 30 months (cm)

Variable	No.	Birth	3 m	6 m	No.	9 m	12 m	No.	18 m	21 m	24 m	30 m
Overall mean	403	54.5	77.4	89.4	306	96.2	100.3	189	108.1	111.2	114.9	122.4
Origin												
Foundation	300	53.9	76.7	88.9	250	96.2	101.3	169	108.2	113.0	116.7	122.7
Born on centre	103	55.1	78.1	89.7	56	96.2	99.4	20	108.0	109.4	113.1	122.2
Year of birth												
1974	47	49.7	76.4	87.3	44	96.5	98.7	42	104.5	105.4	108.2	116.4
1975	40	54.1	73.7	84.4	38	91.6	96.3	33	102.8	105.5	110.4	119.3
1976	50	55.1	73.5	83.2	44	92.0	97.9	26	109.9	111.3	116.2	125.2
1977	41	53.8	78.5	93.4	36	98.6	102.7	28	111.9	115.4	117.9	126.3
1978	81	55.4	79.8	91.8	77	97.3	100.6	60	111.4	116.4	121.7	124.9
1979	75	53.8	79.4	93.7	67	101.1	105.9	-	-	-	-	-
1980	69	59.8	80.7	91.5	-	-	-	-	-	-	-	-
Month of birth												
January	12	54.7	74.3	84.5	11	96.9	102.7	10	105.5	111.7	113.3	118.0
February	12	55.2	76.8	89.6	9	97.1	98.0	5	105.8	109.2	113.1	119.0
March	28	51.4	74.9	90.6	14	97.4	99.5	9	110.7	113.1	118.6	126.9
April	32	52.8	75.2	90.8	25	97.1	100.8	13	111.4	114.2	117.4	128.0
May	72	53.1	77.8	93.5	63	98.5	100.7	38	110.1	112.0	116.0	125.8
June	38	52.8	77.5	94.5	33	97.6	100.3	20	111.7	112.8	114.6	125.4
July	35	52.5	83.0	91.9	21	96.9	99.9	13	109.9	112.5	113.4	123.8
August	35	56.3	80.1	87.7	23	94.5	98.9	17	107.7	109.1	114.3	123.8
September	30	56.8	78.3	89.0	27	91.7	98.2	13	104.3	106.6	112.2	119.4
October	40	57.2	78.3	89.8	35	96.5	103.0	19	107.1	110.7	113.9	120.5
November	51	56.3	77.5	85.5	30	94.4	101.2	21	106.9	110.2	115.3	120.4
December	18	55.4	74.7	84.9	15	95.6	100.9	11	106.3	112.1	116.3	118.2
Number of calving												
1	120	55.9	75.5	87.6	98	94.2	98.3	64	107.6	111.1	114.8	121.2
2	118	54.8	77.7	89.8	94	95.8	99.8	69	107.3	110.4	114.3	122.2
3	79	53.9	77.9	89.5	60	97.7	101.7	32	109.7	111.6	116.4	123.6
4+	86	53.6	78.5	90.5	54	96.9	101.6	24	107.9	111.8	114.0	122.8
Sex												
Male	215	54.8	77.9	90.1	156	97.5	101.9	93	110.4	113.9	116.5	124.8
Female	188	54.3	76.9	88.6	150	94.9	98.8	96	105.8	108.5	113.2	120.1

Figure 9 illustrates the mean changes in linear measurements and weight from birth to 30 months of age. The coefficient of variation of each of the three linear measurements at all stages was about 7%, while that of weight was around 17%.

CORRELATIONS BETWEEN WEIGHT AND LINEAR MEASUREMENTS

Table 49 presents the correlations between weight and height, length and girth. All were significant.

Table 49. Correlations between weight and linear measurements

Age	No.	Correlation between weight and Height	Length	Girth
Birth	402	0.51	0.52	0.62
3 months	403	0.61	0.74	0.85
6 months	403	0.70	0.76	0.88
9 months	306	0.40	0.80	0.90
12 months	306	0.63	0.80	0.89
15 months	306	0.36	NA	0.65
18 months	189	0.79	0.85	0.91
21 months	189	0.81	0.83	0.92
24 months	189	0.77	0.83	0.91
30 months	189	0.74	0.85	0.89

NA = not available

The repeatability of calf linear measurements at birth, 3 and 6 months, considered as a characteristic of the cow, are indicated in Table 50.

Table 50. Repeatability of calf linear measurements

Age	Height		Length		Girth	
	r	s.e.	r	s.e.	r	s.e.
Birth	.18	.06	.13	.06	.03	.06
3 months	0		.28	.06	.34	.06
6 months	.30	.06	.28	.06	.37	.06

Heart girth is widely recognised as the most satisfactory single linear measurement for estimating body weight. An evaluation of its use at the 12 and 24 month stages is indicated in Table 51. The overall regression equations for calculation of 12 and 24 month weights obtained from the data in Tables 38 and 46 are:

12 month weight : $y = -170.45 + 2.50\,x$

24 month weight : $y = -278.83 + 3.43\,x$

The difference in the estimated weight and the actual weight recorded was calculated as a percentage of the actual weight for the 306 animals at 12 and 189 at 24 months of age. The number of animals whose weights were estimated to within two, five, and ten percent at each stage are presented in Table 51 together with the mean deviations and standard errors.

Table 51. Frequency of percentage differences in actual/estimated weights at 12 and 24 months.

Age	Frequency				Mean deviation (kg)	SE of deviation
	< 2%	2 - 5%	5 - 10%	>10%		
12 m	40	91	104	71	8.2	0.4
24 m	32	45	55	57	15.5	1.1

At 12 months of age the estimated weight came within two per cent of the actual weight in 13% of the cattle (40 out of 306); to within five per cent in 43% of the cattle (40 + 91 out of 306); and to within ten per cent in 77% of the cattle (40 + 91 + 104 out of 306). At 24 months of age, the corresponding values were 17%, 41% and 70%.

CATTLE PRODUCTIVITY

INDICES OF COW PRODUCTIVITY

The characters of reproductive performance, calf viability, calf 9 month weight and cow weight were combined to build three productivity indices. Index 1, the weight of 9 month old calf per cow per year, was computed for each cow parturition as the product of weight of 9 month old calf x 365 ÷ interval to next parturition. Index 2, the weight of 9 month old calf per 100 kg of cow per year, was computed as index 1 ÷ cow average weight x 100. Index 3, the total weight of 9 month old calf per 100 kg of metabolic weight of cow per year, was computed as Index 1 ÷ cow average weight$^{.73}$ x 100. Data on 280 parturitions were available from 1974 to 1980.

The significance of environmental influences on the three productivity indices is indicated in Table 52.

Table 52. Analysis of variance of productivity indices

Source	d. f.	Mean squares		
		Index 1	Index 2	Index 3 (10^{-2})
Origin	1	1998	76	26
Year of calving	6	5122**	879**	168**
Month of calving	11	2333**	360**	70**
Number of calving	3	3425**	184	53
Sex	1	964	143	29
Remainder	257	880	149	28

** = P < 0.01.

The estimated least squares means for productivity indices are laid out in Table 53.

Table 53. Estimated least squares means for productivity indices

Variable		Number	Index 1	Index 2	Index 3
Overall mean		280	70.1	29.1	127
Origin					
Foundation	(1)	224	65.2	28.2	122
Born on centre	(2)	56	75.1	30.1	133
Year of calving					
1974		22	95.7	38.7	171
1975		23	66.7	27.8	121
1976		49	63.2	26.2	114
1977		41	82.5	34.7	151
1978		68	66.3	29.5	127
1979		57	74.4	30.0	132
1980		20	42.1	16.9	74
Month of calving					
January		10	61.4	26.4	114
February		10	60.1	22.5	101
March		17	89.6	35.8	158
April		25	83.7	33.6	148
May		65	78.2	32.4	142
June		27	66.9	29.2	126
July		17	73.9	30.2	133
August		20	54.4	22.6	99
September		21	55.1	24.7	105
October		26	80.2	34.7	150
November		29	73.6	30.1	132
December		13	64.3	27.3	119
Number of calving					
1		75	56.7	26.0	110
2		78	66.7	28.4	123
3		66	77.1	30.7	136
4+		61	80.0	31.4	139
Sex					
Male		157	72.1	29.9	131
Female		123	68.2	28.4	124

The mean productivity indices were:-

Index 1. 70.1 kg of 9 month old calf per cow per year

Index 2. 29.1 kg of 9 month old calf per 100 kg of cow per year

Index 3. 127 kg of 9 month old calf per 100 $kg^{.73}$ of cow per year.

Year and month of calving had very significant effects on productivity. This would be expected, following the major year and month effects previously found on the different performance traits making up the productivity indices.

The effect of calving number was significant on index 1 only, cows with three or more calvings being 15% more productive than second calvers and 27% more productive than first calvers.

HERD PRODUCTIVITY

Adjustment of the three cow productivity indices to account for cow viability (97.1%) give the most accurate estimates of overall herd productivity. These are:

Index 1: 67.6 kg of 9 month old calf per cow per year

Index 2: 28.1 kg of 9 month old calf per 100 kg of cow per year

Index 3: 123 kg of 9 month old calf per 100 $kg^{.73}$ of cow per year.

SUMMARY

Analyses were carried out on the productivities of Djallonke sheep and N'Dama cattle at the Centre de Recherches Zootechniques, Kolda, Senegal. Data available from a range of performance traits covered the period 1974 to August 1981. Both species were maintained for meat production. Environmental and genetic effects relating to origin, month and year of parturition or birth, parturition number, sex, type of birth, individual cow or ewe, etc., were evaluated as appropriate for each performance trait.

In sheep, age at first lambing was 18.8 months, lambing interval 10 months, litter size 1.12 lambs, and ewe productive life 4.2 years in the breeding flock, 5.8 years in total. Lamb mortality rates of 33% from birth to weaning at 4 months and 19% from weaning to 12 months showed a positive correlation with rainfall. The breeding ewe mortality rate was 15% per year, and the average generation interval 4.5 years. Lamb growth was 60 gm per day from birth to weaning at 4 months and 45 gm per day from birth to one year of age, with negative correlations between growth and rainfall at all stages. Ewe mean body weight was 23.5 kg. Three linear measures of animal height, length and girth were analysed and correlated with body weight. The characters of reproductive performance, ewe and lamb viability, and ewe and lamb body weights were combined to build three productivity indices. The overall flock productivity was 8.7 kg of weaned lamb per ewe per year; 362 gm of weaned lamb per kg of ewe body weight per year; and 850 gm of weaned lamb per kg of ewe metabolic body weight per year.

In cattle, age at first calving was 39.8 months, calving interval 16.2 months and cow productive life 7.5 years in the breeding herd, 10.8 years in total. Calf mortality rates were 9.6% from birth to weaning at 6 months and 1.3% from weaning to 12 months. The breeding cow mortality rate was 2.9% per year, and the average generation interval 6.7 years. Calf growth was 0.36 kg per day

from birth to weaning at 6 months and 0.21 kg per day from birth to 30 months of age. Mean cow body weight was 234 kg. Three linear measures of animal height, length and girth were analysed and correlated with body weight. The characters of reproductive performance, cow and calf viability, and cow and calf body weights were combined to build three productivity indices. The overall herd productivity was 67.6 kg of 9 month old calf per cow per year; 28.1 kg of 9 month old calf per 100 kg of cow body weight per year; and 123 kg of 9 month old calf per 100 kg cow metabolic body weight per year.

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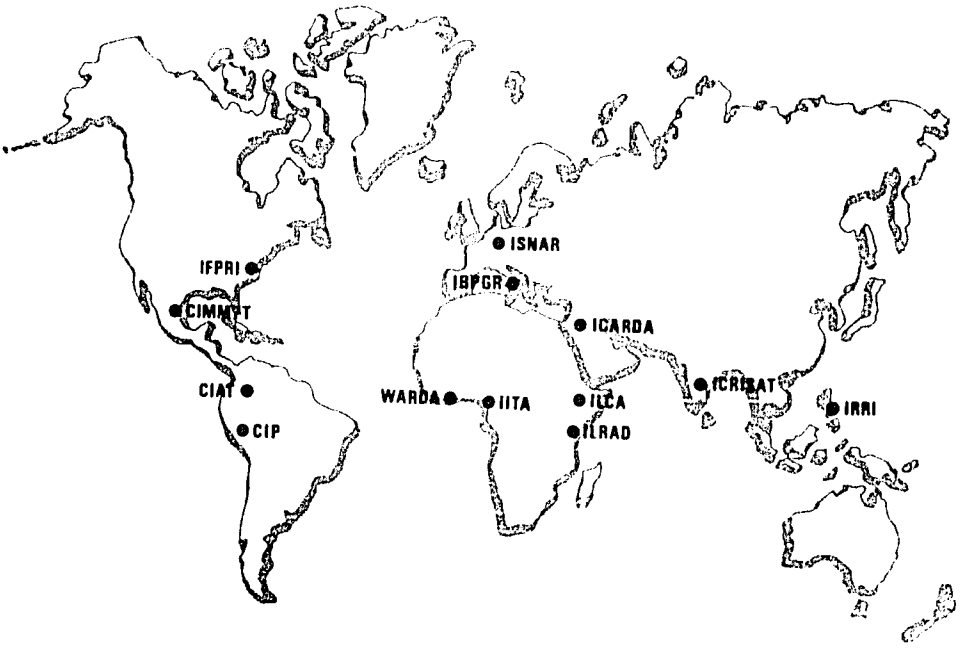

Centro Internacional de Agricultura Tropical (CIAT), Colombia: cassava, field beans, rice and tropical pastures.

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