THE IMPORTANCE OF AGE AT FIRST CALVING, RELATIONSHIP BETWEEN BODY MASS AND FERTILITY AND FEEDING SYSTEMS ON PRODUCTION IN THE BEEF FEMALE

by

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DECLARATION

I hereby declare that the results contained in this thesis are from my own original work and has not been previously submitted by me in respect of a degree at any other university

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ABBREVIATIONS

ADG	Average daily gain
Ca	calcium
CF	crude fibre
CP	crude protein
CV	coefficient of variation
DM	dry matter
h	hour
LSD	least significant difference
m	meter
n	number of animals per group
NPN	non protein nitrogen
NRC	National Research Council
NS	Statistically non-significant
P	phosphorus
SE	standard error
TDN	total digestible nutrients

C O N T E N T S

CONTENTS
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CONTENTS
(Cont.)

GENERAL INTRODUCTION

Beef farming plays an important and integral role in the general farming system in Natal. Despite being South Africa's smallest province and comprising approximately 7,5% of the total area of the Republic, Natal supports 15,2% (1,41 million) of the national beef herd (Department of Agricultural Economics and Marketing, 1977). The gross value of animal production in Natal approached R40 million in 1970/71 (beef being the largest enterprise viz, R16,5 million), and was exceeded at the time only by sugar production (R110 million). In Northern Natal, however, beef consitutes the biggest source of income (approximately 30% - 70% of gross income on White owned land), probably due to approximately 80% of this area being pastoral (Department of Agricultural Technical Services, 1972). Beef production is and will therefore remain an important agricultural enterprise in Northern Natal and should have an assured future.

The general standard of management on beef farms varies tremendously, the calving percentages for example, ranging from 50% to 90%. The reason for this inconsistency in the reproductive performance of different beef cow-herds is largely related to the low production potential of the natural veld over vast areas. The nutritive value of the veld rises sharply after the first rains in Spring and reaches a maximum in November (CP = 8,8%). Thereafter the grass matures, lignification sets in and the CP content gradually starts to decrease and reaches a minimum in July (CP = 3,4%) (du Toit, Louw & Malan, 1940). It is obvious, therefore, that the veld in winter cannot satisfy the requirements of the beef animal, especially the reproducing female, and a severe loss in condition during this period results. Furthermore, on most farms the cow herd receives no or inadequate supplementary feed during the winter, thus aggrevating the problem of loss of condition.

At present no uniform beef production system is being followed in Northern Natal. The degree of intensification varies from area to area and depends upon the availability of arable land. However, the emphasis is on a semi-extensive production system based on veld plus licks. There is no set marketing strategy and it varies from the selling of weaners to the marketing of steers off the veld at an age of two to three years. As the percentage of cultivated land increases on individual farms, there is some intensification. The feed-lot finishing of steers is not a common practice.

Although the natural fertility of the soils in Northern Natal is low, they do react well to balanced fertilization (Farina, 1977). With a fairly long growing season, in excess of 150 days, and a reasonably reliable rainfall (approximately 80% of the mean annual 740 mm falling during summer), it can be concluded that, where arable land is available, this area is well-suited to the production of maize and Eragrostis curvula. These crops are ideally suitable for the production of conserved winter feeds viz maize silage and E. curvula hay. With an active mining industry and the rapid industrial development taking place in Northern Natal, an increasing demand for animal products is envisaged which should ensure a sustained demand for beef.

In an attempt to solve some of the many hazards that beset the beef farmer of Northern Natal, the following investigations were planned and executed. (The data presented in this thesis was recorded from April 1971 until January 1978).

Chapter 1 of this thesis was devoted to the problem of low calving percentages of beef cattle. Different overwintering systems for pregnant and lactating beef cattle were investigated using maize silage and E. curvula hay. Rested winter veld was used as a basis for most comparisons. The effects of supplementing lactating cows with energy and/or protein during the early summer period was also studied.

The effects of two pre calving and three post calving levels of nutrition (calculated on a TDN basis) on the productive and reproductive performance of beef cows were investigated in Chapter 2.

In Chapter 3 the feasibility of allowing heifers to calve for the first time at two years of age, as apposed to three years of age, was studied.

Chapter 4 deals with the relationships between conception of different aged females, and body mass at the start and at the end of the mating season.

PHYSIOGRAPHICAL CONDITIONS UNDER WHICH THE REPORTED INVESTIGATIONS WERE CONDUCTED

Experimental terrain

The investigations were conducted at the Dundee Agricultural Research Station (30° 14' E; 28° 10' S) at an average elevation of 1250 m above sea level.

Geobioclimate

Agro-ecologically, the Research Station falls in the dry phase of the Tall Grassveld (Bioclimatic Group 8, Phillips, 1969). When referring to Northern Natal, however, this area consists mainly of Bioclimatic Groups 6 (Moist Tall Grassveld), 8 (Dry Tall Grassveld) and 10 (Interior and Valley Thornveld) with small intrusions of Group 4 (Highland Sourveld) (Phillips, 1969).

Warm summers (mean 21°C) and cool winters (mean 11°C) with heavy frosts are experienced. The mean annual rainfall is 740 mm of which approximately 80% falls during the period October to March.

The surrounding countryside is characterised by an undulating topography. It is underlain by sandstones and shales of the upper Ecca series and doleritic intrusions are common in the area. The most important soil forms are Avalon, Hutton, Longlands and Glencoe while Katspruit and Rensburg forms are found in the vleis.

The natural grassveld comprises *Hyparrhenia-Tristachya-Digitaria* spp., portions of which are much deteriorated with thorn encroachment due to malpractices such as overgrazing. A large proportion of what appears to be natural grazing actually comprises abandoned old cultivations and the low livestock carrying capacity is low.

CHAPTER 1

NUTRITION OF THE BREEDING COW

A OVERWINTERING SYSTEMS

B EARLY SUMMER FEEDING

INTRODUCTION

The beef industry of Northern Natal is heavily dependent on the natural veld. Acocks (1953) refers to the veld in Northern Natal as Sour Grassveld and Mixed Grassveld and the natural vegetation consists mainly of Hyparrhenia-Tristachya-Digitaria spp., while large areas are devoid of trees. The quantity and quality of the vegetation varies mainly due to climatic and soil fertility conditions and is generally poor in both productivity and feed value.

Following the early summer rains and the accompaning favourable temperatures, the grasses grow lush and soon reach maturity. Thereafter lignification sets in, the digestibility of the grasses decreases, and they become harsh and less palatable. These changes occur within two or three months with the result that the natural vegetation fulfils the requirements of the grazing animal for a limited period only. The veld in Northern Natal is therefore characterised by the following:

(i) an imbalance between crude protein and energy content at the onset of the spring grazing season;

(ii) a drastic decrease in the total protein content of the veld as the grasses reach reproductive maturity;

(iii) a variable availability of plant material due to periodic droughts which in turn makes veld management difficult. The decrease in dry matter intake by the animal during droughts results in lowered animal production, and

(iv) a low calcium and phosphate content of the veld throughout the year.

These fluctuations in the natural vegetation impose limitations on the reproductive performance of the breeding cow and the live mass gain of the growing animal.

In an attempt to determine the major problems that were being accounted in beef production in Northern Natal, a survey was conducted by Meaker (1971). It was very obvious that the main problem amongst the farmers interviewed, was that of low calving percentages, i.e. the number of calves born per 100 cows put to the bull in any one year. In addition, it was evident that at that time few farmers resorted to some form of supplementary feeding during the winter/early spring period. An earlier investigation by Adler (1964) showed that in 22 herds (3 150 cows) in Northern Natal the calving percentage was 65%.

Calving generally starts in August/September in this area and coincides with that time of the year when the nutritional status of the veld is poor. It has long been established that inadequate nutrition, shortly before and after parturition, has an adverse effect on the reproductive performance of the beef cow (Wiltbank, Rowden, Ingalls & Zimmerman, 1964; Hight, 1966, 1968; Wiltbank, 1967; Lamond, 1970; McClure, 1970; Terblanche, 1974; van Marle, 1974). The low calving percentages recorded for animals that grazed almost exclusively on veld in the Northern Natal area are therefore not unexpected.

Conflicting results have been recorded when lactating beef cows were supplied with supplementary energy. Many studies have shown that low levels of energy when fed to lactating cows, irrespective of level of protein, resulted in ovarian inactivity and consequently a prolonged interval to the first post partum oestrus (Bond, Wiltbank & Cook, 1958; Wiltbank, Rowden, Ingalls, Gregory & Koch, 1962; Wiltbank, Bond & Warnick, 1965; Dunn, Ingalls, Zimmerman & Wiltbank, 1969; Lamond, 1970). However, when Bellows, Gibson, Thomas & Pahnish (1968) fed a grain supplement to breeding cows during the annual breeding period, they obtained no improvement in the reproductive performance. The explanation offered was that adequate grass was available in that particular year. This was confirmed by the mass changes observed amongst the cows and calves. Similarly, Zimmerman, Clanton & Matsushima (1961) fed Hereford cows different levels of protein and energy and found that 83% of the cows on a high energy-high protein diet conceived to first service compared to only 38% for those on a high energy-low protein diet. This effect of protein on conception rate was confirmed by Wallace & Raleigh (1967). They recorded increased calf crops when cows were overwintered on diets containing 20% more crude protein than the NRC standards.

Notwithstanding the practicability of the different wintering systems available, the cost of overwintering must always be borne in mind. If the wintering operation is applied without critical evaluation it can offset the profitability of the whole beef enterprise as winter feed, especially in the sour grassveld areas, is the greatest single factor contributing to the cost of beef production. Furthermore, the current inflationary situation which caused the production costs of silage and hay to double over the last couple of years, has created doubt in the minds of many beef producers in Northern Natal as to the economic feasibility of overwintering operations.

In view of the lack of information on the wintering of pregnant beef cows and on the early summer feeding of lactating beef cows in this area three experiments were carried out. The purpose of these studies was to determine:

(i) the effects of supplementary feeding of locally produced feeds during winter, on the reproductive performance of the beef cow (2 experiments), and

(ii) the effects of supplementation of protein and/or energy to lactating cows during the early summer period, on the reproductive performance of the beef cow.

PROCEDURE

Three separate experiments were conducted. Experiment 1 was initiated during the winter of 1971 and was terminated in May 1972. Experiment 2 was based on the findings of Experiment 1 and commenced in June 1972. This latter experiment was terminated in May 1976. Experiment 3 started in November 1973 and terminated in the autumn of 1976.

EXPERIMENT 1

Animals and treatments

Ninety four pregnant Africander, Sussex and Africander cross Sussex cows, aged between five and nine years, were randomly allocated, according to breed, to the following four treatments (systems) at the start of the experiment.

Group 1 : Maize silage ad lib.

Group 2 : E. curvula hay ad lib.

Group 3 : Maize silage ad lib. and E. curvula hay ad lib.

Group 4 : Rested winter veld only.

In addition to the roughages described above, all the cows in the respective treatment groups had free access to a protein/mineral lick consisting of 25% yellow maize meal, 25% salt, 25% dicalcium phosphate, 15% urea and 10% biuret during the winter feeding period.

The treatments commenced on May 20 and terminated on October 7 when all the animals were returned to the veld. The breeding season extended from November 1 until January 5 and only Sussex bulls were used. A pregnancy diagnosis was performed during April to record the percentage cows which had conceived.

Experimental techniques

(a) Live mass

All the cows were weighed at the start of the experiment and thereafter every 14 days. During the winter feeding period only the feed was withheld prior to weighing, while in the summer months, when the cows grazed on veld, neither water nor feed was withheld. All the cattle in the respective treatments were weighed at approximately the same time of the day, viz between 08h00 and 10h00.

(b) Feeding procedure

Each of the three groups of pregnant cows was placed in a winter feeding pen, approximately 1 600 m^2 in size which allowed 0,86 m trough space per cow. Group feeding was practised in all cases.

(c) Calves

The birth mass of the calves was recorded within 24 h of birth. Thereafter the calves were weighed every 14 days until they were weaned (approximately mid April) when their average age was 7,5 months. The calves received no supplementary feeding other than the protein/mineral lick to which the cows had free access.

(d) Statistical analysis

Analysis of variance for samples of unequal size, least-squares analysis of variance and Students t-test were used to compare treatment means (Snedecor & Cochran, 1967).

EXPERIMENT 2

Except for the following changes, the procedure was the same as that described in Experiment 1.

Animals and treatments

Eighty nine pregnant Africander, Sussex and Africander cross Sussex cows were randomly allocated to three systems (treatments), viz Silage, Hay and Silage-Hay groups at the start of the experiment. Grazing of winter veld was omitted and the lick provided during the overwintering period was changed to one which consisted of 31% salt, 34% maize meal, 20% bone meal and 15% urea (CP approximately 48%). This lick was offered from mid March to mid November.

Over the four-year period the quantities of silage and hay fed to the cattle were calculated so that:

(i) the approximate DM intakes by the cows in the respective systems conformed to the minimum DM requirements as laid down by NRC (1970), and
(ii) during the feeding period, comparable mass gains would be achieved by the cows in the three systems.

In order to adjust the intake of silage and hay by the cattle the DM determinations of the silage and hay were carried out on samples once every 14 days. In addition to DM, the silage and hay samples were analysed for CP and CF. Using the CP and CF values, and the tables compiled by Bredon & Meaker (1970), an estimated TDN value was obtained.

The winter feeding treatments commenced on average in mid July and terminated on average the end of October (Table 1.1). From approximately November of each year all the cattle were allowed to graze veld and while grazing a mineral lick comprising of 2 parts bone meal to 1 part salt was fed ad lib.

The cows were bred annually for 65 days, from approximately December 1 to February 4. Each herd (treatment) was managed separately, and the same cows remained within their allotted treatments throughout the experiment. When cows died or when culled due to disease or consistent poor production and reproduction they were replaced, whenever possible, by cows of the same breed, age and pregnancy status. However, due to the limited availability of replacements, the herds gradually decreased in numbers during the course of the experiment. During April of each year all the cows were pregnancy tested.

Experimental techniques

(a) Live mass

All the cows were weighed at the start of the experiment and thereafter every four weeks.

(b) Feeding procedure

Immediately prior to the start of the winter feeding period, all the non pregnant cows from the respective systems were removed and pooled. These cattle received the same treatment as that described for Group 2. The exact dates when feeding started and terminated are shown in Table 1.1.

TABLE 1.1 : Commencement and termination of the overwintering period, mating season and date of weaning of calves

Winter treatment		Mating season		Calves
Started	Terminated	Started	Terminated	Weaned
72.06.22	72.10.24	72.11.20	73.01.25	73.05.14
73.07.13	73.10.19	73.11.30	74.02.05	74.05.20
74.07.23	74.11.04	74.12.02	75.02.07	75.05.20
75.07.30	75.10.27	75.12.01	76.02.04	76.05.19

When approximately 50% of the cows had calved, the ration was adjusted from the minimum DM requirements for pregnancy to that of lactation (NRC, 1970).

(c) Calves

The birth mass of the calves was recorded within 24 h of birth but only during the 1973 calving season. The calves were weighed again at weaning (approximately mid May) when their average age was 7,5 months.

(d) Milk production of the cows

In December 1975 when the calves were approximately 70 days of age, the milk production of the cows was measured. All the calves were separated from their mothers at 18h00 the day preceding the actual test. The calves were penned while the cows returned to grazing. The following day the calves were weighed at 07h00, returned to their dams and allowed to suckle until the first calf stopped suckling. Immediately thereafter the calves were reweighed to the nearest 0,5 kg. This weigh-nurse-weigh method was repeated again at 17h00. The change in mass at each suckling was assumed to equal the quantity of milk consumed by the calf and the total obtained for the two recordings was regarded as the total milk production by the cow for that day.

(e) Post partum oestrus

In mid October 1975, 30 days following the birth of the first calf, observations were initiated to determine the occurrence of the first post partum oestrus. A vasectomised bull fitted with a chin-ball harness was introduced to each of the three treatment groups. Oestrus observations were made early in the morning and late in the afternoon for a 65 day period which terminated in mid December. In addition to the cows that had been marked, a cow was also considered to be in oestrus when she stood while being mounted by another cow.

(f) Cost analysis

Market values and ruling prices of the roughages were used in the economic assessment of the three systems. The following values were used:

E. curvula hay	R34/1 000 kg
maize silage	R12,30/1 000 kg

As maize silage is not a saleable product the following method was used to determine a market value for this feed. Over a two year period Chapman (1976) determined the silage and grain yields of a number of maize cultivars that were planted at varying plant populations at the Dundee Research Station. When the DM content of the silage and the grain was corrected to 33% and 12,5% respectively, it was found that 1 kg of grain was equivalent to 6 kg of silage. With the maize price at R73,60/1 000 kg in 1977 and the ratio of grain to silage at 1 : 6, the "market value" of maize silage was R12,30/1 000 kg.

EXPERIMENT 3

Animals and treatments

This experiment was replicated during 1974, 1975 and 1976 and the number of cows randomly allocated to the four treatments was 58 (1974), 63 (1975) and 68 (1976), respectively. Lactating Africander cross Sussex cows, aged between four and six years, were used in the experiments and the following treatments were applied.

Group 1 : Control - minerals only.
Group 2 : Minerals plus non protein nitrogen (NPN).
Group 3 : Minerals plus protein.
Group 4 : Minerals plus energy.

The different treatments commenced towards the end of October of each year and terminated approximately 100 days later when the mating season ended. The composition of the four supplements is shown in Table 1.2.

The cows in the four treatment groups had access to approximately 180 ha of veld which was divided into 16 camps of equal size. The different groups were rotated once weekly thereby ensuring that each treatment grazed each camp. This procedure was followed to limit possible camp effects. The same breeding season was followed as described in Experiment 2.

TABLE 1.2 : Composition of supplements fed to lactating cows grazing summer veld

		Supplements fed:			
		Minerals only	Minerals + NPN	Minerals + Protein	Minerals + energy
Salt	%	33,3	31	25	25
Maize meal	%	-	34	-	60
Bone meal	%	66,7	20	15	15
Urea	%	-	15	10	-
High protein concentrate	%	-	-	50	-
CP	%	2,0	47,1	49,2	6,4
TDN	%	-	27,2	38,0	48,0
Ca	%	19,9	6,0	7,2	4,5
P	%	9,2	2,8	3,0	2,2

Experimental techniques

(a) Live mass

All the cows were weighed at the start of the experiment and thereafter every 14 days. Due to the cows grazing in paddocks, neither feed nor water was withheld prior to weighing. All the cows in the respective treatments were weighed at approximately the same time of the day namely between 08h00 and 10h00.

(b) Feeding procedure

The four supplements were replenished weekly so as to ensure that the cows had access to adequate supplies.

(c) Grass sampling

Only one camp, situated in the centre of the 16 camps used for this experiment, was used for the collection of grass samples. At 14-day intervals and over a 12 month period, 20 grab samples were collected at random by clipping. The samples were then mixed together and sub-sampled for chemical analysis. Using standard procedures, the grass samples were analysed for CP, Ca and P.

(d) Cost analysis

The following prices for the different components were used in the economic assessment of the experiment:

Salt	R 2,03/50 kg
Maize meal	R 5,77/60 kg
Bone meal	R10,51/50 kg
Urea	R 9,33/50 kg
High protein concentrate (NPN-free)	R10,77/50 kg

RESULTS

EXPERIMENT 1

The average intake of lick, maize silage and E. curvula hay per cow per day, percentage body mass change over the winter period and the mating season and percentage reconception of the cows are summarized in Table 1.3. The results indicated that the cows in the groups which received only silage and veld grazing returned the highest and lowest reproductive performances, respectively. The average change in mass of the cows from the start until the end of the winter period varied considerably. Those cows receiving no supplementation lost an average of 22,3% of their body mass, while the body mass change in the other three groups ranged from -2,4% (Hay) to 5,5% (Silage). The body mass at the end of the winter period was recorded only after the last cow had calved. All the cows gained in mass over the breeding season. The highest gains were made by those cows which showed the highest losses during the overwintering period (Table 1.3).

Following the winter feeding period the cows which were not fed conserved fodder (Veld group) had lost significantly ($P < 0,01$) more body mass than any of the other three treatments (Table 1.4). Of the supplemented groups, the cows which received silage only gained most in mass over the winter

TABLE 1.3 : Feed intakes, changes in body mass and reconception of cows overwintered according to four feeding systems

	Feeding treatments:			
	Silage	Hay	Silage-Hay	Veld
Number of animals per group	24	22	24	24
Average intake of lick (g/cow/day)	618	308	303	435
Average intake of silage (kg/cow/day)	44,7	-	27,4	-
Average intake of hay (kg/cow/day)	-	8,4	3,7	-
Average mass per cow at start of winter (a)	445,3	450,0	447,7	443,6
Average mass per cow at end of winter (b)	470,0	439,4	457,7	344,7
Average gain/loss in mass per cow $\frac{(b-a)}{(a)} \times 100$ (%)	5,5	-2,4	2,2	-22,3
Average mass per cow at start of mating season (c)	422,2	381,7	406,5	334,9
Average mass per cow at end of mating season (d)	435,0	415,2	423,2	377,9
Average gain in mass per cow $\frac{(d-c)}{(c)} \times 100$ (%)	3,0	8,8	4,1	12,8
Reconception (%)	87,5	68,2	79,2	25,0

Maize silage : DM = approximately 32%

E. curvula hay : DM = approximately 91%

TABLE 1.4 : Changes in body mass of cows overwintered according to four systems (kg)

	n	Start of winter	End of winter	Start of mating season	End of mating season	Weaning
Feeding treatments:						
Silage (1)	24	445,3	470,0	422,2	435,0	439,2
Hay (2)	22	450,0	439,4	381,7	415,2	428,4
Silage-Hay (3)	24	447,7	457,7	406,5	423,2	429,3
Veld (4)	24	443,6	344,7	334,9	377,9	398,9
Significance		NS	1 > 2	1 > 2	1,2,3 > 4	1,3 > 4
			1,2,3 > 4	1,2,3 > 4		
LSD P = 0,05 (24 : 24)		25,9	21,9	18,9	21,5	22,9
P = 0,01 (24 : 24)		34,3	29,0	25,0	28,5	30,4
P = 0,05 (22 : 24)		26,5	22,3	19,3	22,0	23,4
P = 0,01 (22 : 24)		35,1	29,6	25,6	29,1	31,1

period, while the cows that received E. curvula hay only, gained the least. The difference in mass between the two groups was highly significant ($P < 0,01$; Table 1.4).

Both at the start and the end of the mating season, the mean mass of the cows overwintered on veld was significantly ($P < 0,01$) poorer than any of the other three treatments. The difference in mean body mass between the Silage and the Hay groups that was significant ($P < 0,01$) at the start of the mating season was no longer significant by the end of the breeding season (Table 1.4).

At weaning, i.e. following the summer period during which all the groups received the same treatment, the mean body mass of the cows in the Veld group was still significantly ($P < 0,01$) poorer than both the groups fed silage and silage plus hay (Table 1.4).

The birth mass of the calves in the Veld group (31,0 kg) was significantly ($P < 0,05$) lower than that of the Silage (33,6 kg) and Silage-Hay (33,7 kg) groups (Table 1.5). Similarly, at weaning the mean body mass of the calves in the Veld group (172,3 kg) was significantly ($P < 0,01$) lower than any of the other three groups, where the weaning masses ranged from 188,7 kg (Hay) to 194,4 kg (Silage).

TABLE 1.5 : Birth and weaning masses of calves born to cows overwintered according to different systems (kg)

		n	Birth mass	n	Weaning mass
Feeding treatments:					
Silage	(1)	24	33,6	24	194,4
Hay	(2)	21	32,7	21	188,7
Silage-Hay	(3)	21	33,7	20	193,5
Veld	(4)	24	31,0	24	172,3
Significance			1,3 > 4		1,2,3 > 4

The three supplemented groups exhibited no significant difference in mean body mass of the calves at weaning.

EXPERIMENT 2

The objective of this experiment was realised in that over the four years of the trial there was no significant difference between the three treatments as regards the body mass recorded on the five different occasions (Table 1.6). There was no consistent pattern of change in mass that evolved during the different winters. In some years the cows gained in mass while in other years they lost somewhat during this time. On the average, the groups receiving either silage, hay or silage and hay lost 1,8%, 4,7% and 3,3% of their body mass over the winter period. All three groups gained in mass during the breeding season, the gains over the four years ranging from 4,6% (Silage) to 6,4% (Hay). The average mass of the cows at weaning was approximately equal to the average mass recorded at the end of the breeding season (Table 1.6).

There was not much variation in the feed value of the two roughages over the four year period (Table 1.7). The average DM, CP and estimated TDN values over the four years for silage and hay were 33,1%, 7,6%, 64,1% and 92,0%, 10,3%, 54,4% respectively.

The average daily silage and hay intakes per cow for the winter periods, commencing in 1972 and continuing until 1975, are shown in Table 1.8, while a summary of the total daily DM, CP and estimated TDN intakes per cow is given in Table 1.9. In order to obtain comparable mass gains during winter it was necessary to adjust the intakes of the cows in the three systems. The approximate DM intakes both pre and post partum did therefore vary somewhat and ranged from 91% to 114% of NRC (1970).

The results indicated that with regard to CP and TDN intakes during the pre partum period, all three systems supplied CP and TDN in excess of the requirements. The CP ranged from 153% to 244% and the TDN varied from 105% to 146%. During the post partum period it was found that the Silage system supplied CP in amounts which equalled the requirements (range 95% to 103%). The TDN was in excess of the requirements (range 100% to 124%). The Hay system supplied CP in excess of the requirements (range 116% to 125%), but was deficient in TDN (range 89% to 96%). The Silage-Hay system was more or less intermediate and supplied an adequate amount of CP (range 98% to 109%) with the TDN being in excess of the requirements (range 100% to 118%) (Table 1.9).

TABLE 1.6 : Changes in body mass of cows during the winter feeding, mating and lactational periods as influenced by the systems of winter feeding

Mass at:	Mean mass per group fed: Silage	Hay	Silage-Hay
1972*			
Start of winter	445	442	438
End of winter	412	399	404
Start of mating season	419	405	411
End of mating season	426	424	422
Weaning	430	434	428
1973			
Start of winter	435,4 ± 17,2	458,1 ± 18,1	451,9 ± 18,1
End of winter	453,3 ± 18,4	461,7 ± 19,4	471,5 ± 19,4
Start of mating season	448,5 ± 16,9	456,3 ± 17,8	471,1 ± 17,8
End of mating season	477,4 ± 17,5	493,7 ± 18,5	507,3 ± 18,5
Weaning	462,6 ± 15,8	487,4 ± 16,7	489,6 ± 16,7
1974			
Start of winter	472,6 ± 16,5	497,5 ± 16,7	501,0 ± 17,0
End of winter	478,4 ± 17,4	481,3 ± 18,0	490,1 ± 18,9
Start of mating season	452,7 ± 14,9	445,1 ± 14,7	463,2 ± 15,2
End of mating season	490,9 ± 14,1	507,1 ± 14,2	511,7 ± 14,5
Weaning	480,6 ± 13,9	492,9 ± 14,0	506,5 ± 14,2
1975			
Start of winter	484,1 ± 15,4	498,0 ± 15,0	495,0 ± 15,0
End of winter	459,0 ± 17,9	464,9 ± 17,5	458,9 ± 17,7
Start of mating season	449,7 ± 14,0	450,7 ± 14,3	460,7 ± 14,5
End of mating season	458,1 ± 14,4	445,8 ± 13,9	468,0 ± 14,2
Weaning	452,7 ± 14,4	462,3 ± 14,0	479,0 ± 14,5

* Standard error not available

19/.

TABLE 1.7 : The composition of the maize silage and E. curvula hay used in the overwintering rations

			Ration:	
			Silage	E. curvula
1972	DM	%	32,30	91,90
	CP	%	7,13	10,20
	CF	%	20,86	35,80
	Estimated TDN	%	64,60	54,30
1973	DM	%	34,00	92,30
	CP	%	7,08	10,80
	CF	%	22,18	34,90
	Estimated TDN	%	63,70	55,00
1974	DM	%	34,40	92,10
	CP	%	8,18	9,84
	CF	%	23,40	36,00
	Estimated TDN	%	63,00	54,10
1975	DM	%	31,70	91,80
	CP	%	7,96	10,30
	CF	%	20,71	35,20
	Estimated TDN	%	65,00	54,70

CP, CF and estimated TDN based on DM = 100%

A number of Africander cows, that had been transferred from the Pongola Research Station (sweet bushveld, Bioclimatic area 10; Philips, 1970), were included at the start of the project. Of these cows only approximately 25% reconceived the following year, perhaps due to the cows not having adapted to the new environment (Bioclimatic area 8). The nett result was that the calving percentages were extremely poor in 1973 (Table 1.10). These Africander cows were therefore removed from the project and replaced by other Africander cows which had been on the Dundee Research Station for at least five years. If the calving percentages recorded in 1973 are ignored, only two year's data are available for calculating an average calving percentage for each system. These amounted

TABLE 1.8 : Average silage and *E. curvula* hay intakes per cow per day from winter 1972 until winter 1975

		Maize silage				*E. curvula* hay			
	CP	As fed (kg)		DM = 100% (kg)		As fed (kg)		DM = 100% (kg)	
	DM = 100%	kg	DM = 100%	CP	Est. TDN	kg	DM = 100%	CP	Est. TDN
Silage Group:									
W 1972									
Pre partum	0,077	23,0	7,429	0,530	4,799	-	-	-	-
Post partum	0,102	32,0	10,336	0,737	6,677	-	-	-	-
W 1973									
Pre partum	0,154	23,0	7,820	0,554	4,981	-	-	-	-
Post partum	0,141	32,0	10,880	0,770	6,931	-	-	-	-
W 1974									
Pre partum	0,141	23,0	7,912	0,647	4,985	-	-	-	-
Post partum	0,136	27,0	9,288	0,760	5,851	-	-	-	-
W 1975									
Pre partum	0,149	24,7	7,830	0,623	5,090	-	-	-	-
Post partum	0,116	33,0	10,461	0,832	6,800	-	-	-	-
Hay Group:									
W 1972									
Pre partum	0,064	-	-	-	-	8,0	7,352	0,750	3,992
Post partum	0,102	-	-	-	-	10,0	9,190	0,937	4,990
W 1973									
Pre partum	0,165	-	-	-	-	8,5	7,846	0,847	4,315
Post partum	0,154	-	-	-	-	10,0	9,230	0,997	5,077
W 1974									
Pre partum	0,083	-	-	-	-	8,0	7,368	0,725	3,986
Post partum	0,100	-	-	-	-	11,0	10,131	0,997	5,481
W 1975									
Pre partum	0,119	-	-	-	-	8,1	7,436	0,766	4,067
Post partum	0,084	-	-	-	-	10,9	10,006	1,031	5,473
Silage-Hay Group:									
W 1972									
Pre partum	0,059	16,0	5,168	0,368	3,339	2,3	2,114	0,216	1,148
Post partum	0,077	23,0	7,429	0,530	4,799	3,0	2,757	0,281	1,497
W 1973									
Pre partum	0,131	16,0	5,440	0,385	3,465	2,5	2,308	0,249	1,269
Post partum	0,122	23,0	7,820	0,554	4,981	2,5	2,308	0,249	1,269
W 1974									
Pre partum	0,090	16,0	5,504	0,450	3,468	2,5	2,303	0,227	1,246
Post partum	0,067	18,0	6,192	0,507	3,901	4,0	3,684	0,363	1,993
W 1975									
Pre partum	0,098	8,1	2,568	0,204	1,669	5,5	5,049	0,520	2,761
Post partum	0,076	16,5	5,231	0,416	3,400	5,4	4,957	0,511	2,711

TABLE 1.9 : Summary of total DM, CP and estimated TDN intakes per cow per day for the three systems

	Pre/Post Partum		Feeding treatments Silage	Hay	Silage-Hay	Feed consumed as percentage of NRC (1970) requirements Silage	Hay	Silage-Hay
1972	Pre	DM	7,429	7,352	7,282	110	109	109
		CP	0,607	0,814	0,643	153	205	163
		TDN	4,799	3,992	4,487	142	119	134
	Post	DM	10,336	9,190	10,186	109	99	109
		CP	0,839	1,039	0,888	96	121	103
		TDN	6,677	4,990	6,296	124	94	118
1973	Pre	DM	7,820	7,846	7,748	114	111	110
		CP	0,708	1,012	0,765	177	244	186
		TDN	4,981	4,315	4,734	146	122	135
	Post	DM	10,880	9,230	10,128	110	92	100
		CP	0,911	1,151	0,925	100	125	99
		TDN	6,931	5,077	6,250	123	89	108
1974	Pre	DM	7,912	7,368	7,807	110	97	103
		CP	0,788	0,808	0,767	188	184	174
		TDN	4,985	3,986	4,714	139	105	124
	Post	DM	9,288	10,131	9,876	91	99	95
		CP	0,896	1,097	0,937	95	116	98
		TDN	5,851	5,481	5,894	100	94	100
1975	Pre	DM	7,830	7,436	7,617	107	98	101
		CP	0,772	0,885	0,822	181	202	189
		TDN	5,090	4,067	4,430	139	107	118
	Post	DM	10,461	10,006	10,188	104	99	102
		CP	0,948	1,115	1,003	103	120	109
		TDN	6,800	5,473	6,111	120	96	108

to 87% for the Silage, 93,2% for the Hay and 91,7% for the Silage-Hay systems.

The birth mass of the calves was recorded only in 1973. There were no significant differences and the masses ranged from 32,0 kg (Hay) to 33,0 kg (Silage) (Table 1.10). Over the four year period the average weaning masses of the calves in the Silage, Hay and Silage-Hay systems were 210 kg, 199,7 kg and 213,8 kg respectively. In 1972 the weaning mass of the calves in the Silage-Hay system was significantly greater ($P < 0,05$) than that of the Hay system. However, in 1975, the weaning mass of the calves in both the Silage ($P < 0,01$) and Silage-Hay systems ($P < 0,05$) was significantly greater than that obtained in the Hay system. None of the other differences were significant (Table 1.10).

The intercalving period recorded is defined as that period between calvings in successive years. Where a cow did not reconceive in a particular year, her intercalving period was ignored. The average intercalving period of the cows in the Silage, Hay and Silage-Hay systems was 378,8, 378,5 and 375,5 days respectively. None of the differences were significant.

The first post partum oestrus was recorded only during 1975 and the averages for the Silage, Hay and Silay-Hay systems were 55,3, 61,9 and 53,1 days respectively. The difference between the Hay and Silage-Hay systems was significant ($P < 0,05$) (Table 1.10).

In December 1975, at approximately 70 days <u>post partum</u>, the milk production was determined over a single day for the cows in all three systems and the results are summarised in Table 1.11. The daily milk production of the cows varied from 4,250 kg (Hay) to 4,639 kg (Silage-Hay) per day and none of the differences were significant. At the time when the milk production of the cows was recorded, the average mass of the calves ranged from 79,0 kg (Hay) to 85,7 kg (Silage-Hay) (Table 1.11).

The results recorded in this experiment indicate that no significant differences were evident for most of the parameters measured. The inconsistency in the average calving percentage could be due to the fact that the average was calculated over only two seasons. However, it is unlikely that even over the longterm major differences in the calving percentage

TABLE 1.10 : Reproductive performance of cows and calf performance obtained when different overwintering systems were used from 1972 until 1975

	Overwintering system: Silage	Hay	Silage-Hay
1972:			
Cows pregnant (n)	27	31	29
Cows calved (n)	27	31	29
Weaning mass calves (kg)	205,2 ± 5,9	199,3 ± 7,3	220,0 ± 7,1
1973:			
Cows mated (n)	25	29	27
Cows calved (n)	18	13	12
Calving (%)	72,0	44,8	44,4
Birth mass calves (kg)	33,0 ± 1,2	32,0 ± 0,5	32,2 ± 0,6
Weaning mass calves (kg)	218,3 ± 8,1	220,7 ± 9,0	231,4 ± 9,0
Intercalving period (days)	393,1 ± 7,5	385,8 ± 3,8	385,3 ± 6,4
1974:			
Cows mated (n)	23	23	24
Cows calved (n)	21	23	24
Calving (%)	91,3	100	100
Weaning mass calves (kg)	221,5 ± 6,3	207,7 ± 6,8	213,6 ± 6,6
Intercalving period (days)	375,1 ± 5,6	381,2 ± 5,1	372,0 ± 3,1
1975:			
Cows mated (n)	23	22	24
Cows calved (n)	19	19	20
Calving (%)	82,6	86,4	83,3
Weaning mass calves (kg)	194,9 ± 6,0	171,2 ± 5,3	190,1 ± 7,2
Intercalving period (days)	368,1 ± 2,8	368,6 ± 4,8	369,1 ± 2,7
Post partum oestrus (days)	55,3 ± 2,8	61,9 ± 2,2	53,1 ± 3,9

Weaning mass 1972: Hay vs Silage-Hay ($P < 0,05$)

Weaning mass 1975: Silage vs Hay ($P < 0,01$), Hay-Silage vs Hay ($P < 0,05$)

Post partum oestrus 1975: Hay vs Silage-Hay ($P < 0,05$)

would have occurred between the three systems applied. For the purposes of the economic assessment of this experiment the following assumptions were made:

(i) calving percentage for all three systems = 86%,

(ii) winter feeding period of 100 days, 45 days pre partum and 55 days post partum,

(iii) weaners of all three systems were valued at 40c/kg, and

(iv) due to the inconsistencies in the lick intakes within the different systems the cost of this supplement was ignored in the economic assessment.

TABLE 1.11 : Milk production of cows that had been overwintered according to three systems

	System: Silage	Hay	Silage-Hay
Average age of calves at recording (days)	69,2 ± 3,9	70,0 ± 3,4	74,3 ± 3,9
Average mass of calves at recording (kg)	82,7 ± 3,6	79,0 ± 3,1	85,7 ± 3,5
Average milk production (kg/cow/day)	4,522 ± 0,205	4,250 ± 0,167	4,639 ± 0,120

The high weaning mass produced by the Silage-Hay system resulted in this system reflecting the highest gross return (R73,55) per cow (Table 1.12). The Silage (R72,24) and Hay (R68,70) systems produced only slightly lower returns. The difference in total feed costs between the three systems was small and the cost varied from R32,19 (Hay) to R33,92 (Silage) per cow per winter. The Silage-Hay system returned the greatest margin above feed costs (R40,38) followed by the Silage (R38,32) and Hay (R36,51) systems (Table 1.12).

EXPERIMENT 3

The intakes of the protein and energy supplements (supplements 3 and 4) were disappointingly low during the 1973/74 season (Table 1.13). This can be attributed largely to the supplements being spoiled by rain as

TABLE 1.12 : Gross returns, winter feed costs and margin above winter feed costs for the three wintering systems

	Wintering system:		
	Silage	Hay	Silage-Hay
	R	R	R
Gross returns			
Calves - Weaning mass:			
Silage - 210,0 kg @ 40c/kg	84,00		
Hay - 199,7 kg @ 40c/kg		79,88	
Silage-Hay - 213,8 kg @ 40c/kg			85,52
Average return per cow:			
Calving percentage = 86%	72,24	68,70	73,55
Feed costs*			
Cow feed costs to produce:	86%	86%	86%
Silage : pre partum - 45 d x 23,4 kg x R12,30/1 000 kg	12,95		
post partum - 55 d x 31,0 kg x R12,30/1 000 kg	20,97		
Hay : pre partum - 45 d x 8,2 kg x R34,00/1 000 kg		12,55	
post partum - 55 d x 10,5 kg x R34,00/1 000 kg		19,64	
Silage-hay: pre partum			
Silage - 45 d x 14,0 kg x R12,30/1 000 kg			7,75
Hay - 45 d x 3,2 kg x R34,00/1 000 kg			4,90
post partum			
Silage - 55 d x 20,1 kg x R12,30/1 000 kg			13,60
Hay - 55 d x 3,7 kg x R34,00/1 000 kg			6,92
Total feed costs	33,92	32,19	33,17
Margin above feed costs	38,32	36,51	40,38

*Only cost of roughages

TABLE 1.13 : Average intake of supplement, CP, TDN, Ca and P per cow for the four supplemented groups

		Supplement:		
	Control	plus NPN	plus protein	plus energy
Intake of supplement (g/cow/day)				
1973/74	145	280	414	334
1974/75	172	290	801	692
1975/76	230	398	1024	902
Average intake of supplement*	201	344	913	797
Feed intake (g/cow/day)				
1973/74 CP	2,9	131,9	203,7	21,4
TDN	-	76,2	157,3	160,3
Ca	28,9	16,8	29,8	15,0
P	13,3	7,8	12,4	7,3
1974/75 CP	3,3	136,6	394,1	44,3
TDN	-	78,9	304,4	332,2
Ca	34,1	17,4	57,7	31,1
P	15,8	8,1	24,0	15,2
1975/76 CP	4,6	187,5	503,8	57,7
TDN	-	108,3	389,1	433,0
Ca	45,8	23,9	73,7	40,6
P	21,2	11,1	30,7	19,8
Average feed intake*				
CP	4,0	162,0	449,2	51,0
TDN	-	93,6	346,9	382,6
Ca	40,0	20,6	65,7	35,9
P	18,5	9,6	27,4	17,5

* 1973/74 intake of supplemented excluded

open containers were used. In subsequent years, troughs were used that protected the supplements from penetration by rain. If the supplement intakes, as recorded in the first year, are disregarded, the average intakes would be 201 g, 344 g, 913 g and 797 g per cow per day for Groups 1, 2, 3 and 4 respectively. The results indicate further that the protein supplement (supplement 3) provided the most CP, Ca and P, while supplement 4 (energy supplement) provided the most TDN per cow per day (Table 1.13).

The results indicated that the cows which received the energy-rich supplement (supplement 4) consistently produced the best reproductive performance followed by those cows receiving NPN and protein (supplements 2 and 3). The latter two groups produced similar results in each season (Table 1.14). The average recalving percentages over the three seasons for the cows receiving supplements 1, 2, 3 and 4 were 73,1%, 85,8%, 85,8% and 96,0%, respectively. In the first and third seasons, the cows in Group 1 did not show significant increases in mass from the beginning to the end of the experimental period, whereas the breeding females in the other three groups were significantly heavier ($P < 0,05$) at the end than at the beginning of the experiment. Due to a shortage of Sussex bulls, some groups were mated to Drakensberger bulls in the second and third seasons. Data on the weaning mass of the calves is therefore available only for one season. The results indicated that there was no significant treatment effect on the weaning mass of the calves, but a tendency for the calves from the protein and energy-enriched groups (supplements 3 and 4) to wean heavier than those from the Control and NPN supplemented groups (supplements 1 and 2) was evident (Table 1.14).

The data on intercalving periods is deceptive as the cows receiving minerals only returned similar or better intercalving intervals than the other groups while, in fact, they produced the poorest reproductive performance (Table 1.14). This anomaly is illustrated in the histogram (Fig. 1) where the cumulative percentage of cows calving during ten day periods commencing at the beginning of the calving season is presented for the four groups. The figure shows that approximately 92% of the cows receiving protein and energy supplements had calved within 30 days of the onset of the calving season while only 75,7% and 82,5% had calved during the same period in the Control and NPN supplemented groups (Fig. 1).

TABLE 1.14 : Average mass of cows, percentage recalving, weaning mass of calves and intercalving period of cows allowed access to four supplements

		Supplement: Control	plus NPN	plus protein	plus energy	Sign.
1973/74:						
S	kg	438,7	462,0	464,8	462,7	NS
E	kg	466,8	497,1	505,9	508,3	2,3,4 > 1
D	kg	28,1	35,1	41,1	45,6	
Significance		NS	< 0,05	< 0,05	< 0,05	
Recalving	%	81,3	92,9	92,9	100,0	
Weaning mass calves	kg	188	191	197	198	NS
Intercalving period	days	381	367	368	375	NS
1974/75:						
S	kg	474,0	475,9	473,0	475,4	NS
E	kg	487,2	500,1	487,6	479,1	NS
D	kg	13,2	24,2	14,6	3,7	
Significance		NS	NS	NS	NS	
Recalving	%	73,3	93,8	93,8	93,8	
Intercalving period	days	359	362	373	364	3 > 1
1975/76:						
S	kg	408,8	413,1	425,1	424,2	NS
E	kg	427,5	455,1	469,2	465,1	2,3,4 > 1
D	kg	18,7	42,0	44,1	40,9	
Significance		NS	< 0,05	< 0,05	< 0,05	
Recalving	%	64,7	70,6	70,6	94,1	
Intercalving period	days	364	372	360	369	2 > 3

S = Start of experiment

E = End of experiment

D = Difference in mass

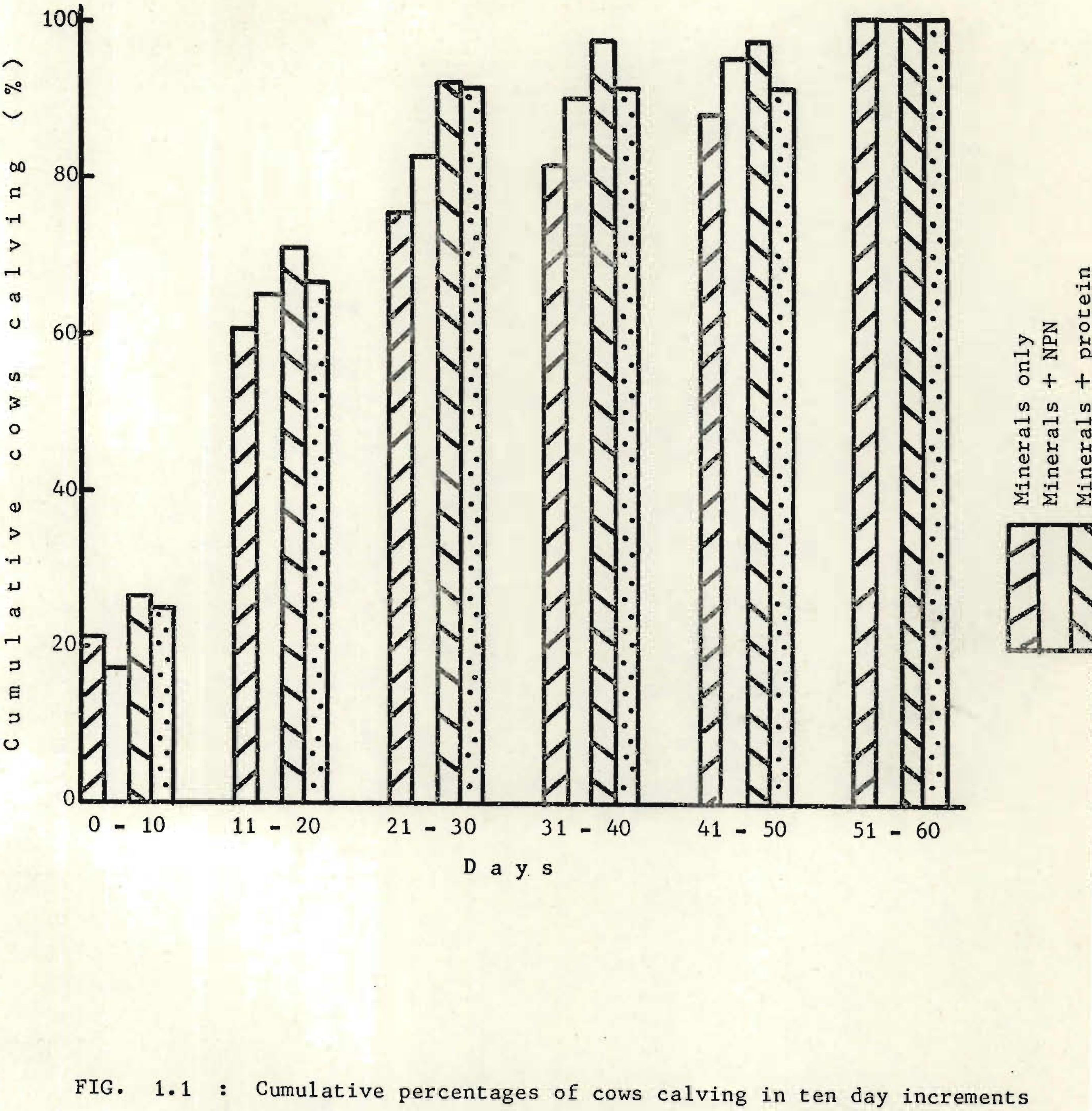

FIG. 1.1 : Cumulative percentages of cows calving in ten day increments from the beginning of the calving season for the four supplemented groups

The CP, Ca and P content of grass samples collected manually on the Dundee Research Station over a 12 month period is presented in Table 1.15. The analyses indicated a pronounced change in CP content of the sward over the 12 months. An arbitrary division of the 12 months into the four seasons, indicated that the CP content varied from 5,9% in summer to 3,8% in winter. The average Ca and P content of the samples showed no great variation over the period studied and the resulting averages were 0,17% and 0,11% for Ca and P, respectively (Table 1.15).

As there was no significant difference in weaning mass of the calves between the four treatments (Table 1.14), an average weaning mass of 195 kg was used for all four groups. Accordingly, the gross returns for the different groups were affected by the differences in calving percentage resulting in substantial differences (Table 1.16). The average cost of the supplement per cow per treatment varied considerably between the four groups and ranged from R3,10 (Control) to R15,34 (protein supplement). This resulted in gross margins above cost of the supplement ranging from R51,58 (protein supplement) to R66,99 (energy supplement) (Table 1.16).

DISCUSSION

EXPERIMENT 1

The results reported here clearly indicate that rested winter veld was unable to supply the necessary nutrients, despite the fact that the cows received a protein (NPN) lick during winter. The poor reproductive performance of the cows maintained on veld throughout the year reflected the low nutritive value of the vegetation (CP of grass during winter = 3,8%) (Table 1.15). Because of the prevalence of "old lands", the veld on the Dundee Research Station must be considered atypical when compared with the average farm in Northern Natal. However, the veld is typical of the flat terrain of large areas of Northern Natal.

Of great importance in these studies was the dramatic increase recorded in reproductive performance of cows when supplemented during winter compared to when cows received no supplementation. In the eastern parts of the Highveld, Reyneke (1971) found that cows had to receive some form of supplementation from the middle of June onwards to ensure sustained

31/

TABLE 1.15 : Crude protein, calcium and phosphorus content of grass samples collected over 12 months at the Dundee Research Station

Month	CP (%)	Ca (%)	P (%)
December	7,30	0,17	0,11
January	5,67	0,19	0,10
February	4,66	0,18	0,15
March	4,48	0,16	0,12
April	4,24	0,20	0,11
May	3,88	0,16	0,09
June	3,35	0,15	0,07
July	4,27	0,17	0,11
August	3,77	0,15	0,09
September	4,66	0,13	0,10
October	5,17	0,16	0,13
November	7,19	0,18	0,11
Summer: (December January February)	5,88	0,18	0,12
Autumn: (March April May)	4,20	0,17	0,11
Winter: (June July August)	3,80	0,16	0,09
Spring: (September October November)	5,67	0,16	0,11

TABLE 1.16 : Gross returns, cost of summer supplements and margin above cost of summer supplement of cows subjected to the supplements provided during the grazing season

	Supplement: Control	plus NPN	plus protein	plus energy
GROSS RETURNS	R	R	R	R
Calves - weaning mass (195 kg) x 40c/kg	78,00	78,00	78,00	78,00
Average return per cow:				
Group 1 - Calving % = 73,1%	57,02			
Group 2 - Calving % = 85,8%		66,92		
Group 3 - Calving % = 85,8%			66,92	
Group 4 - Calving % = 96,0%				74,88
COST OF SUMMER SUPPLEMENT				
Average intake of supplement (g/cow/day)	201	344	913	797
Average period of supplementation (days)	100	100	100	100
Average amount of supplement required/cow/treatment (kg)	20,1	34,4	91,3	79,7
Average cost of supplement (c/kg)	15,4	11,5	16,8	9,9
Average supplement cost per cow per treatment (R)	3,10	3,96	15,34	7,89
Margin above cost of supplement (R)	53,92	62,96	51,58	66,99

production. In the Eastern Cape, Bishop & Kotze (1965) recorded calving percentages in excess of 90 when cows were supplemented with 14 kg of maize silage or 2,7 kg of maize meal per day for the months of August and September. In Rhodesia, Ward (1968) recorded a conception rate of 76% when cows received groundnut cake supplement during winter compared to 38% for the cows receiving no groundnut cake. These findings have been substantiated by the results quoted by Lamond (1970) when he reviewed the influence of undernutrition on reproduction in the cow.

The results that have been obtained in these trials suggest that attention should be given to the DM intakes of animals fed different roughages. It was found that the DM intakes were considerably higher in the Silage and Silage-Hay groups when compared with the Hay group. The cows in the Silage group consumed 3,2% of their body mass in the form of silage, while the cows in the Silage-Hay group consumed 2,7%. The intake of E. curvula hay was disappointingly low despite the fact that the hay was of average quality (CP = 8%). The DM consumption of the cows in the Hay group was only 1,7% of their body mass. Based on the NRC (1976) standard of minimum DM requirements for beef cows, the intake of E. curvula in the Hay group was sufficient for late pregnancy, but inadequate for lactation, hence the lower reconception percentage recorded. The increased reconception rates of the cows in the Silage group and the Silage-Hay group, is in accordance with their voluntary DM intake, i.e. the higher the intake of DM, the higher the intake of protein and energy and therefore the higher the reproductive performance. Reconception figures ranging from 20% to 95% were recorded by Wiltbank, Rowden, Ingalls, Gregory & Koch (1962) when cows were subjected to different levels of nutrition both pre and post partum, indicating that level of nutrition could markedly influence reconception in the mature beef cow suckling a calf.

Pope (1967) found that mature beef cows, when wintered on poor quality forage (3 - 4% CP) plus 0,45 kg of a protein supplement per day, produced 8% more calves over a 14 year life span compared to cows on higher levels. He suggested that cows on the low feed levels were better "rustlers" and more active in their grazing habits. In the present study, where use was made of roughages of a quality as poor as that referred to by Pope (1967), there seemed to be a relationship between change in mass over the winter period and reconception. Those cows gaining most over the winter (Silage) returned the best reconception while the cows that lost most in mass over winter showed the poorest reconception (Veld). Although this trial was carried out over one year only, the effect of winter feeding was clearcut, but somewhat contrary to the findings of Pope (1967).

All the cows gained in mass during the spring/summer breeding season. The cows which received winter supplementation gained from 12,8 kg to 33,5 kg and exhibited reconception percentages ranging from 87,5% to 68,2%. Although the cows on veld throughout the year gained 43 kg in mass over the breeding season only 25% of them became pregnant the ensuing breeding season. The results achieved in this study are therefore at variance with the belief that a breeding animal must be gaining in mass over the mating period in order to conceive (Wiltbank, 1967; Buck, Light, Rutherford, Miller, Rennie, Pratchett, Capper & Trail, 1976). The data presented in Table 1.3 indicate a relationship between body mass at the start of the breeding season and rate of conception. As the body mass of the cows at this time increased from 334,9 kg (Veld) to 422,2 kg (Silage) the reconception rate increased from 25% to 87,5%. This tends to substantiate the findings (Lamond, 1968, 1970; Ward, 1968) which suggest that in breeding cows of a particular genetic background there is a body mass below which low fertility can be expected to prevail.

EXPERIMENT 2

Unlike the significant differences in body mass of the cows in Experiment 1 which occurred due to the <u>ad lib</u>. feeding treatments imposed, no significant differences were recorded in this trial at any of the reported weighings. This was in accordance with the objectives of the experiment.

None of the three systems was able to supply the necessary CP and TDN requirements of the cows (NRC, 1970), both during the pre and the post partum periods. During the former period all three systems supplied amounts of CP and TDN which greatly exceeded the requirements. The Hay system, for example, provided up to NRC plus 144% CP while the Silage system provided up to NRC plus 46% TDN. During the post partum period, however, it was found that the Silage system provided CP (NRC) and NRC plus approximately 12% TDN. The Hay system on the other hand, provided NRC plus approximately 20% CP and NRC minus 8% TDN. The Silage-Hay system was intermediate and supplied NRC plus approximately 3% CP and NRC plus approximately 9% TDN.

Several studies have demonstrated the detrimental effect of energy (Bond, Wiltbank & Cook, 1958; Wiltbank et al., 1962; Wiltbank et al., 1964; McClure, 1970; Lamond, 1970) and protein shortages (Guilbert, 1942; Bedrak, Warnick, Hentges & Cunha, 1964; Pope, 1967; Reyneke, 1971) on the reproductive performance of beef cows. It is obvious that in the trial reported here no serious deficiency existed as regards CP and TDN, but rather an excess of nutrients was supplied. This phenomenon was more pronounced during the pre partum period than post partum. It can be concluded therefore that all three systems managed to supply the necessary nutrients to sustain production and reproduction of the cows over a 4 year period.

The problem of calculating an average calving percentage was discussed earlier. Accepting (i) a calving percentage of 86% for all three systems, (ii) no significant difference in birth mass of the calves and intercalving period of the cows, and (iii) except in two instances, no significant difference in weaning mass of the calves, it can be concluded that all three systems were equally effective in overwintering beef cows and maintaining reproductive performances.

The effect which weaning mass had on the profitability of the systems is clearly illustrated in the economic assessment of this trial. The highest gross margin above feed costs recorded by the Silage-Hay system can be attributed to the weaning mass of the calves, since the calving percentage and price per kg weaner calf were the same for all three systems. Surprisingly there was no major difference in total winter feed cost between the three systems, with the Hay system being the cheapest.

EXPERIMENT 3

The results of this trial demonstrated the beneficial effects which protein and energy supplementation can have on the lactating cow during a 100 day period post partum. Where the diet was supplemented with energy the cows showed the best reproductive performance, while protein supplementation, whether as NPN (supplement 2) or as natural protein plus NPN (supplement 3), was almost as productive (Table 1.14). The findings of this experiment with regard to energy feeding are in accordance with the results of Macfarlane, Somerville, Lowman & Deas (1977), Wiltbank et al. (1964) and Speth, Bohman, Melendy & Wade (1962).

In order to assess the results of this trial, it was necessary to investigate the capacity of the veld to supply the nutrient requirements of the lactating beef cow. The chemical analyses of the grass samples collected during the summer months on the Research Station, revealed that the average CP, Ca and P contents were 5,9%, 0,18% and 0,12% respectively (Table 1.15). If it is assumed that a 450 kg lactating beef cow consumes approximately 9,5 kg DM per day through grazing during summer (NRC, 1976), such a cow will ingest 560 g CP, 17 g Ca and 11 g P which represents 65%, 65% and 42% of the daily requirements of lactating beef cows for CP, Ca and P (NRC, 1976). Furthermore, if the TDN content of summer veld is estimated at 48% (Bredon, 1976), the cow will consume 4,5 kg TDN per day, or 90% of the TDN requirements (NRC, 1976). From the above analyses and assumptions it would appear that lactating beef cows on the Research Station suffer from severe P, moderate to severe CP and Ca, and slight TDN deficiencies during the summer months. The CP deficiency may be merely theoretical as Bredon, Lyle & Swart (1970) suggested that the forage selected by cattle contained a higher percentage of CP and lower percentage of CF than indicated by analysis of clipped samples. They concluded that the difference in CP between grazed and clipped herbage was of the order of 25%. Thus, from a theoretical point of view, it appears that lactating beef cows should be able to satisfy the majority of their nutritional requirements, except P, from veld grazing. However, the performance of the animals in this trial was not in keeping with this hypothesis since the cows receiving TDN or protein supplements consistently exhibited better reproductive performances than those cows receiving only mineral supplementation. The difference in calving percentage between supplements 1 and 4 can be attributed to the effect of energy supplementation. The difference between supplements 3 and 4 appear to be due to biological variation as both groups received virtually the same amount of TDN. On the other hand, the cows receiving NPN equaled the production of the cows in the protein supplemented group, but received far less CP and TDN than the cows in the latter group (Table 1.13). The exact reason for the increase in reproductive performance due to supplementation is not clear, but appears to be primarily due to energy supplementation, with protein supplementation being of lesser importance.

When the economic implications of this experiment were analysed, the results indicated that the cows receiving the energy-rich supplement returned the highest gross margin above cost of supplementation (Table 1.16). This was due to the cows having attained the highest reproductive rate at a relatively low cost of the supplement per cow. On the other hand, the cows which received the protein supplement produced a favourable reproductive performance, but the high cost of the supplement reduced its profitability. Hence, the latter group producing the poorest gross margin of all 4 groups. By continuing with the winter lick until the end of the breeding season, and with a relatively low cost of supplementation, the gross margin for the cows supplemented with NPN compared favourably with the gross margin for the cows receiving energy. Except for supplementation with a natural protein, it was concluded that energy or NPN supplementation is a profitable practice.

GENERAL CONCLUSIONS

When considering the results of the three experiments the following general conclusions can be drawn:

1. The Silage-Hay system, i.e. a combination of maize silage and E. curvula hay as winter feed for cows, resulted in a better gross margin above feed cost than the feeding of maize silage or E. curvula hay alone. However, due to the prevalence of mixed farming in Northern Natal, and in many areas of the Republic, the average farmer has only a relatively small number of pregnant beef cows which must be overwintered each year. The production of both maize silage and E. curvula hay is therefore not always feasible as it demands heavy capital investment in machinery. From these trials it would appear that where maize silage is fed in addition to a winter lick the results are likely to be better than where the silage is replaced by E. curvula hay. There is obviously a place for both maize silage and E. curvula hay in a sound system of beef production. The feeding of either or both these feeds will depend on the size of the farm, the number of stock to be wintered and the availability of capital.

2. Irrespective of whether maize silage or E. curvula hay is used in an overwintering programme, the quality of these roughages is of the utmost importance as this will determine the success or failure of the overwintering system. In Experiment 1 the voluntary intake of E. cur-

vula hay (CP = 8%) was disappointingly low. The low CP value of the hay may have caused the low voluntary intake by the cows since the ARC (1965) suggests that all diets for ruminants should contain at least 9% CP in the DM and that low protein levels are associated with low voluntary intakes of feed. For those years during which Experiment 2 was conducted the E. curvula was cut at a much earlier stage (viz when flowering started), resulting in a hay with a CP content of approximately 10%. Unlike Experiment 1, the cows which received E. curvula hay during the winter in Experiment 2 produced virtually the same results as the cows overwintered on silage. This result emphasizes the importance of quality of feed when measured in terms of CP.

3. One of the most important economic factors in the cow-calf industry is weaning mass (Holloway et al., 1975). When feed intakes were restricted in Experiment 2, no consistent pattern evolved as regards weaning mass of the calves. It would appear, however, that there was a tendency for the calves in the Hay system to wean lighter than the other two systems. When the cows were allowed ad lib. feeding (Experiment 1), significant differences in weaning mass were recorded and this clearly indicated the requirement for, and importance of a sound overwintering programme.

4. Provision of feed for the winter period represents the largest single direct cost to the farmer (Abraham, Forsyth & Heard, 1973). In Experiment 2, winter feed cost (roughages only) represented approximately 39% of the total income. According to Guyer (1976), the present high prices of grain are undoubtedly temporary, but at some point in time high grain prices are likely to be the rule rather than the exception. The need to prepare for the day when beef cattle cannot compete effectively for feed grain, as an important component of the rations, cannot be delayed (Guyer, 1976). This argument also applies to maize silage because of the high percentage of grain in silage (45% to 55% on a dry basis). On the other hand, due to a continuous rise in the price of fertilizer the production cost of E. curvula hay has risen as dramatically as that of maize silage. It is obvious therefore that one should endeavour to decrease winter feeding costs in order to maximise profits. It can be concluded from Experiment 2 that there was an unnecessary wastage of CP and TDN pre partum and that a cheaper feed such as maize stalks, veld hay, rested winter veld or other low grade roughages should have been

used during that period. Thus, by decreasing the winter feeding period, using high cost silage and/or hay, to say 60 days instead of 100 days, and concentrating on the post partum period, appreciable savings can be made as regards winter feeding costs.

5. The beneficial effects of supplementing the diet of lactating cows with energy and/or protein during a 100 day period post partum were clearly illustrated in Trial 3. The exact reasons for the increases in the reproductive performance of the groups that were supplemented with NPN, protein and energy are, however, unknown as the results cannot be ascribed solely to either energy or protein supplementation. The limitations of a field experiment of this nature are clearly borne out by the difficulty encountered in interpreting the results and further studies should be carried out in order to establish the mechanisms which control the responses observed.

6. The chemical analysis of the clipped herbage samples emphasized the poor quality of the sward throughout the year. The results indicated that the grass was incapable of supplying enough protein for most of the year while a severe P deficiency existed throughout the year. The need for strategic supplementation of CP and year-round supplementation of P is therefore vital to ensure sustained production and reproduction of beef cattle. It is, however, accepted that there is a marked difference in the feed value of samples selected by clipping or by the grazing animal (Bredon et al., 1970; Bredon, Torell & Marshall, 1967; Hardison, Reid, Martin & Woolfolk, 1954) which suggests that less emphasis should be placed on the results obtained from the analyses of clipped samples.

CHAPTER 2

PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF BEEF COWS AS INFLUENCED BY PRE AND POST PARTUM LEVELS OF NUTRITION

INTRODUCTION

Numerous reports have dealt with the effects of pre partum (Wiltbank et al., 1962; Reynolds, De Rouen, High, Wiltbank, Warwick & Temple, 1964; Hight, 1966; Corah, Dunn & Kaltenbach, 1975) and post partum (Wiltbank et al., 1964; Hight, 1968; Wiltbank, 1967; Dunn, Ingalls, Zimmerman & Wiltbank, 1969) nutritional levels on the productive and reproductive performance of the beef cow.

Hight (1966) found that a low level of nutrition before calving (18% loss in body mass over the last four months of gestation) reduced the birth mass of the calves by 20% and the weaning mass by 16,5 kg. The calf mortality from birth to weaning was increased by 18% when compared to cows which received a high pre-calving plane of nutrition (Hight, 1966). Corah et al. (1975) assigned first calf Hereford heifers to either a High (H) or a Low (L) level of dietary energy 100 days prior to predicted calving (H - 100% and L - 65% of the recommended level of pre partum energy, NRC 1970). After calving both groups were fed NRC (1970) recommended levels of energy. The results which they recorded were very similar to those published by Hight (1966). It has also been observed that the onset of post partum oestrus was delayed in cows which received a low plane of nutrition during late gestation (Wiltbank et al., 1962; Dunn et al., 1969) and this lead, in some cases, to depressed first service pregnancy rates (Reynolds et al., 1964). In contrast, Pinney et al. (1962) and Pope (1967) found that cows could lose from 10% to 15% of their autumn body mass prior to calving without production being adversely affected, provided they received adequate nutrition after calving. While these differences in productive and reproductive traits were due to differences in the levels of nutrition, the results emphasize the importance of adequate nutrition in late pregnancy in order to sustain production and reproduction in beef cows.

Most authorities are in agreement concerning the effects which nutrition has on the beef cow during the post partum period. Dunn et al. (1969)

found that pregnancy rate 120 days after calving was directly related to the post partum energy level, 87% and 72% of the cows being pregnant following a high or low energy level after calving. They ascribed the depressed pregnancy rates in the cows fed the low energy level to the fact that a large percentage of these cows failed to exhibit oestrus during the post partum period. Pregnancy rates of 71% and 92% have been reported by Wiltbank et al. (1964) when Hereford cows were fed either a low or a high level of TDN after calving. Bauer (1965) recorded a dramatic increase in conception rate (83%) when he provided supplementary feeding to 66 three year old Herefords during the post partum period, compared with only 13% of 70 cows not supplemented. In a 2 x 2 factorial experiment and using the High-High (HH), High-Low (HL), Low-High (LH) and Low-Low (LL) principle for nutritional levels fed both before and after calving, Wiltbank et al. (1962) diagnosed 95% (HH), 77% (HL), 95% (LH) and 20% (LL) of the cows pregnant following the respective treatments. They concluded that the differences among the groups were due largely to a high proportion of the cows on the low level energy diet after calving failing to show oestrus.

Also in a 2 x 2 factorial experiment and applying the HH, HL, LH and LL principle to 140 pregnant Aberdeen Angus cows, Hight (1968) recorded strong compensatory growth gains after calving, particularly in the LH group of cows. The average daily gains for the cows in the HH and LH groups from calving until weaning were 0,38 kg and 0,66 kg, respectively. This phenomenon greatly reduced the pre calving nutritional effects viz, body mass of the cows, weaning mass of the calves and pregnancy rate. Although the subsequent calving percentage was not influenced by the pre partum nutritional levels, the onset of first oestrus and the subsequent calving dates were delayed (Hight, 1968). From the literature it appears therefore that supplementary nutrition would be relatively more beneficial when fed after calving than before.

Since each cow (depending on heridity, age, lactational status and time of year) has a high probability of conception within a certain range of body mass and body condition (Lamond, 1970; Meaker, 1975; Chapter 3), it is important that the mean body mass of the cows at the desired date of conception be known. The poor reproductive rates found in many beef cows herds in Northern Natal (Chapter 1), can therefore be attributed to the nutritional status which exists in this area during the winter months. This generally leads to a loss in body condition through the winter period, resulting in cows not attaining their desired target masses at joining. It is obvious therefore that some form of supplementary feeding during winter is imperative. Knowing the target mass of his cows at joining, the manager must now decide how he should reach the correct body mass which will ensure the maximum fertility. However, since all supplementary feeds are expensive, it is important to know how short this period of supplementation should be to achieve the desired results. The farmer may for instance, have the herd in fat condition at calving and then maintain condition to mating, or allow the cows to lose condition prior to calving and then feed heavily after calving until mating. The objective in both methods would be to reach the desired target mass for the cows at mating. The best method will, however, depend on the farm situation (roughages available, mating/calving season, etc.) and is very much an economic question.

The objective of this study was therefore to determine the effects of two pre calving and three post calving levels of nutrition (calculated on a TDN basis) on the productive and reproductive performance of adult Africander, Sussex and Africander cross Sussex cows.

PROCEDURE

Animals and treatments

Ninety two Africander, Sussex and Africander cross Sussex cows, aged between five and nine years, were randomly allocated, according to breed and age, to the following two pre calving levels of calculated TDN (NRC, 1976):

Pre calving feeding regimes: High - 100% of NRC
Low - 70% of NRC

On the 17th May, 1977 these cows were assigned to the two pre calving treatments. Only 67 cows, i.e. those cows that had calved within the first 42 days of the calving season, were considered for the post partum phase of the trial (Table 2.1). This step was deemed necessary so that both the pre and the post partum feeding periods could be shortened and thereby possible seasonal effects would be reduced. Within 24 h of calving the cows from the two pre calving treatments were subdivided and reallocated to the following three post calving treatments (TDN Standards, NRC 1976): Post calving feeding treatments:

High 100% of NRC
Medium - 85% of NRC
Low - 70% of NRC

TABLE 2.1 : Number of cows utilised during the pre and the post partum phases of the experiment

		Post partum levels of nutrition			Total
		Low	Medium	High	
Pre partum levels of nutrition	Low	11	11	12	34
	High	11	11	11	33
T o t a l		22	22	23	67

The pre partum treatments lasted for between 93 and 135 days depending on the date of calving for each cow. The cows remained on the post partum treatments for 95 days. Fifty days post calving, when the bulling season started, the cows were removed from the respective treatments and placed in an adjacent pen with a fertile Sussex bull. The mating season terminated 45 days later, i.e. when the post partum feeding treatments ended (95 days post calving). Thereafter, the cows were removed from the pens and returned to the veld. A pregnancy diagnosis was performed within 35 to 42 days after the last cows had been removed from the bulls. This test was confirmed by a second person in order to reduce possible errors.

An all roughage diet (E. curvula) was fed during both the pre and the post partum phases of the trial, except for the cows receiving the High plane of nutrition post calving. These cows received the same quantity of E. curvula as those on the Medium plane of nutrition (85% of TDN requirements, NRC 1976), but were fed maize meal in addition to meet the requirements (100% of TDN requirements, NRC 1976). This procedure was necessary, since practical experience and experimental evidence gained in the past (Chapter 1, Experiment 1) showed that lactating cows could hardly satisfy their TDN requirements when they were fed E. curvula hay only. When cows were fed such high levels of hay there was a considerable amount of wastage. Since TDN of the E. curvula hay was not actually determined an estimated value for TDN (Bredon & Meaker, 1970) and average values for DM, CP and CF were used for E. curvula hay which was grown and sampled during 1975 and 1976 on the Dundee Research Station. In addition to the E. curvula hay, all the cows in the respective treatments had free access to a protein/mineral lick consisting of 31% salt, 34% maize meal, 20% dicalcium phosphate and 15% urea (CP approximately 48%).

Experimental techniques

(a) Body mass

The body mass of all the cows was recorded at the start of the experiment and thereafter every 14 days. Within 24 h of calving, the post partum mass of the cows and birth mass of the calves were recorded. Since the start and the end of the mating season of all cows was staggered over 42 days, body masses for these intervals were estimated by interpolation using the live masses of the cows from before and after the said times. The cows were always weighed in the mornings, prior to having been fed, but had access to water at all times.

(b) Feeding procedure

Each of the groups of cows was placed in a winter feeding pen, approximately 1 600 m^2 in size and allowing at least 0,86 m trough space per cow. The cows in all the treatments were group fed once daily, water and the protein/mineral lick being available at all times.

(c) Milk production of the cows

At the start of October 1977, December 1977 and February 1978 when the calves were approximately 30, 60 and 90 days of age, the milk production of the cows was measured. All the calves were separated from their mothers at 17h30 the day preceding the actual test. The calves were penned while the cows returned to grazing. The following day the calves were weighed at 05h30, returned to their dams and allowed to suckle until the first calf stopped suckling. Immediately thereafter the calves were re-weighed to the nearest 0,5 kg. This weigh-nurse-weigh method was repeated again at 11h30 and at 17h30. The change in mass at each suckling was assumed to equal the quantity of milk consumed by the calf and the total obtained for the three recordings was regarded as the total milk production by the cow for that day.

(d) Post partum oestrus

Approximately 30 days following the birth of the first calf, oestrus observations were initiated to determine the occurrence of the first post partum oestrus. A cow was considered to be in oestrus when she permitted a bull or another cow to mount her. The cows were checked for oestrus at least twice daily viz early in the morning and late in the afternoon. Body mass of the cows at first post partum oestrus was determined by interpolation, using their body masses immediately before and after the observed oestrus.

(e) Statistical analysis

Least-squares analysis of variance and analysis of co-variance were used to compare treatment means (Snedecor & Cochran, 1967). Data from cows that did not nurse a calf for the entire 95 day post partum experimental period were excluded from all analyses.

RESULTS

Nutrient intakes

The amounts of TDN consumed by the cows, when fed the different levels of nutrition during the pre and the post partum phases of the experiment, agreed with the suggested feeding regimes (Table 2.2). With regard to the recommended CP requirements (NRC, 1976), the cows received on average 153% (Low) and 200% (High) during the pre- and 103% (Low), 120% (Medium) and 135% (High) during the post partum phase of the experiment. The NPN lick accounted for 43%, and 34% to 41% of the total protein intake of the cows during the pre and the post partum periods. Since not all NPN is converted to true protein (Loosli & McDonald, 1968) it was impossible to determine the actual CP intake. It would appear, however, that the cows in the respective groups received an adequate supply of protein, except perhaps for the cows in the Low group post partum (Table 2.2).

TABLE 2.2 : Daily E. curvula, maize meal, lick and nutrient intakes per cow during the pre and the post partum periods (kg)

	Nutritional levels				
	Pre partum		Post partum		
	Low	High	Low	Medium	High
Intake of:					
E. curvula hay[1]	6,29	8,99	6,74	7,89	7,89
Maize meal	-	-	-	-	1,18
Lick[2]	0,46	0,45	0,63	0,68	0,71
TDN	3,15	4,50	3,37	3,95	4,82
CP	0,78	1,02	0,89	1,02	1,13

[1] Nutrient content of E. curvula hay: DM = 92%
Estimated TDN = 54,4% (DM = 100%)
CP = 9,9% (DM = 100%)

[2] Only CP calculated

Body mass changes

Co-variance was used to adjust the mean body masses of the cows pre and post partum according to their mass at the start of the experiment. The actual body mass gains/losses during the pre and the post partum phases of the experiment are presented in Figs. 2.1 and 2.2, while the adjusted pre calving body mass data is shown in Table 2.3.

Pre calving nutritional levels significantly ($P < 0,01$) affected the pre partum body mass. Cows fed the High level of nutrition before calving gained 16,9 kg from the start of the experiment until calving (93 days to 135 days), while the cows fed the Low level of nutrition lost 21,8 kg (Fig. 2.1, Table 2.3). At calving the cows in the High group lost

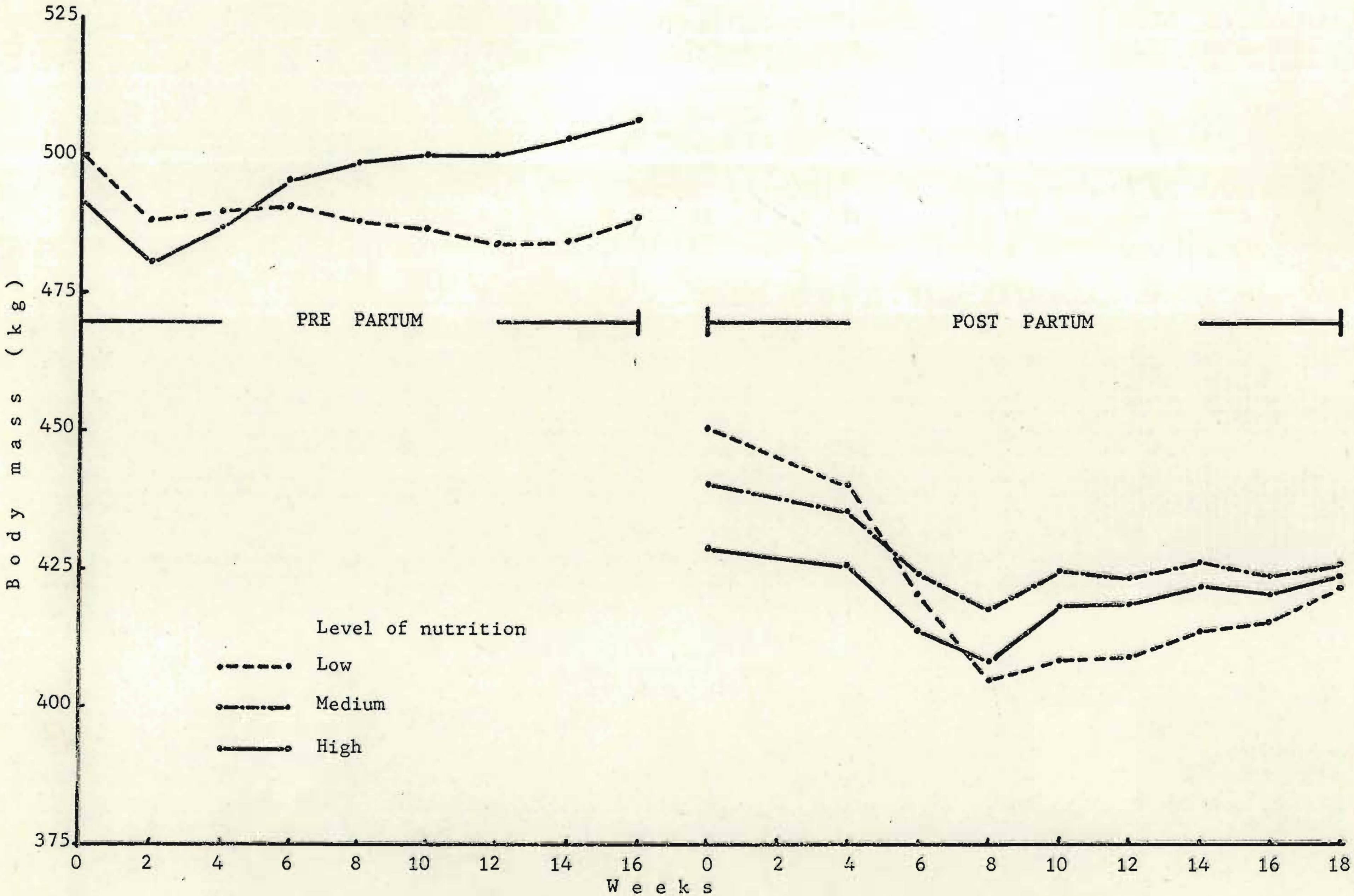

FIG. 2.1 : Body mass of cows during the pre and the post partum phases of the experiment

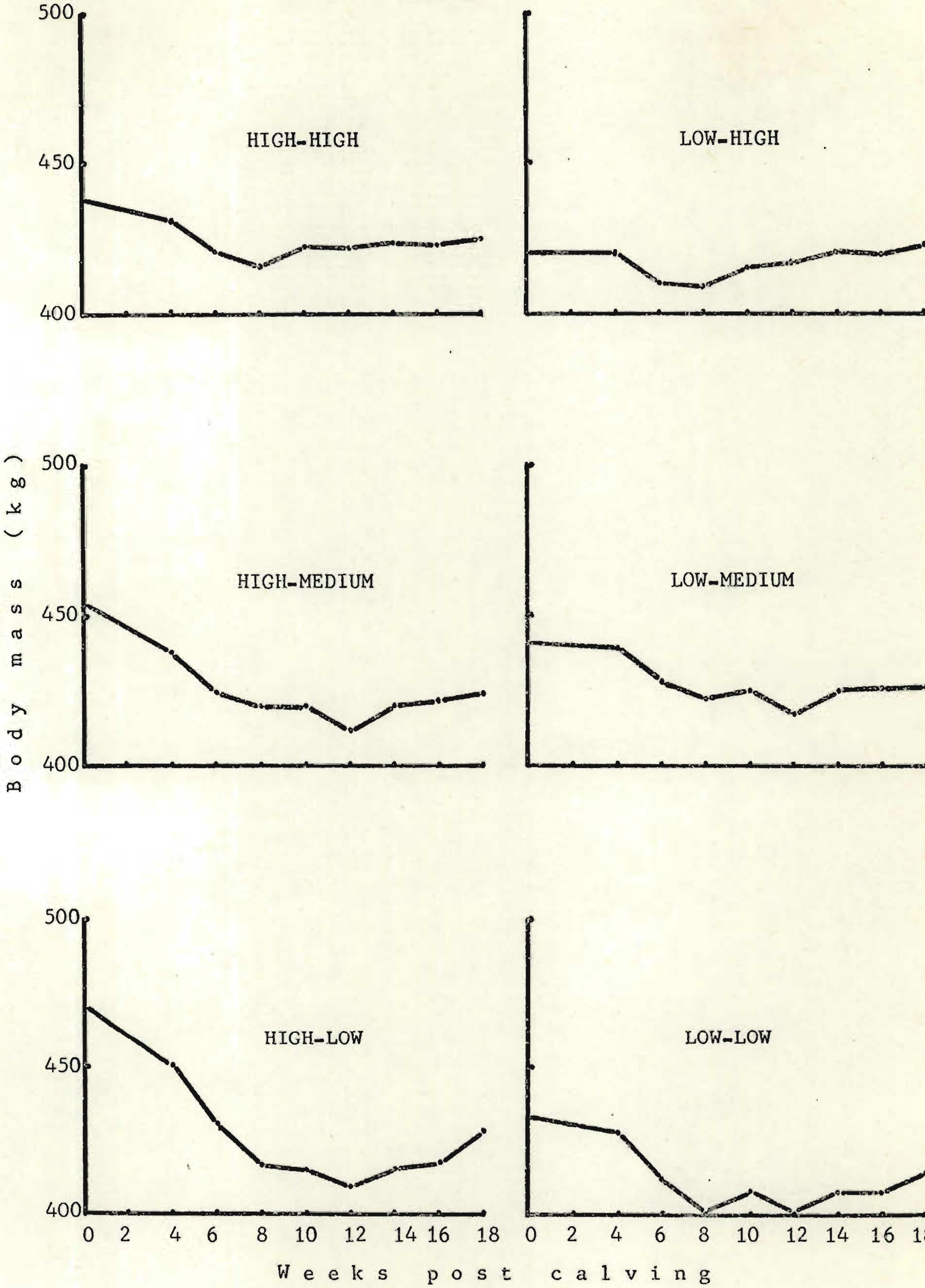

FIG. 2.2 : Body mass of cows during the post partum phase of the experiment

51,5 kg and those in the Low group lost 53,7 kg, both masses being significantly ($P < 0,01$) lower than the pre calving body masses (Fig. 2.1, Table 2.3). The pre calving nutritional levels had no effect on the mean body mass of the calves at birth (Table 2.3).

TABLE 2.3 : Adjusted mean body mass of cows pre and post partum and mean birth mass of calves as influenced by two pre partum levels of nutrition

		Pre partum levels of nutrition		
		Low	High	Significance
Number of animals		34	33	
Mass of cows at start of experiment	(kg)	500,1	492,4	NS
Adjusted mass of cows pre partum	(kg)	478,3	509,3	$P < 0,01$
Adjusted mass of cows post partum	(kg)	424,6	457,8	$P < 0,01$
Birth mass of calves	(kg)	31,3	31,2	NS

Although the cows at calving, were randomly reallocated to the three post calving levels of nutrition, the post partum body mass of the cows in the High group was significantly ($P < 0,05$) less than both the Medium and the Low groups (Fig. 2.1). These differences were not due to any treatment effects, but due entirely to chance.

The post partum nutritional levels that were imposed, significantly ($P < 0,01$) affected the post calving body mass changes. The body mass loss from calving to the start of the mating season (50 days post calving) was -38,9 kg, -26,4 kg and -17,8 kg for the cows in the Low, Medium and High groups (Fig. 2.1). Although all three post calving treatments resulted in a loss in body mass over this period, the greatest loss occurred in the High-Low group (-54,4 kg), while the cows in the Low-High group showed a loss of only 12,6 kg (Fig. 2.2). During the mating season (45 days) the cows in the Low group lost a further 2,8 kg while the cows in the Medium and High groups gained 4,6 kg and 8,3 kg, respectively (Fig. 2.2). Notwithstanding the loss in body mass of the cows in the Low group (-41,7 kg) over the post partum phase of the experiment, there was no significant difference in body mass between the three groups at the end of the mating season (Fig. 2.1).

Conception rate

The level of nutrition pre partum had no effect on the conception rate 120 to 140 days after calving. However, conception rate was partly affected by post partum nutritional level. Nearly 83% of the cows fed the high level of nutrition after calving had conceived compared to 41% and 50% of the cows in the Medium and Low levels of nutrition (Table 2.4). When analysing the interactions in Table 2.4 it is obvious that the main factor contributing to the low conception rate for the cows in the Medium group, was the very poor conception rate recorded with the High-Medium group.

TABLE 2.4 : Percentage reconception of cows as influenced by different levels of nutrition both pre and post partum

		Post partum levels of nutrition Low	Medium	High	Pre partum means
Pre partum levels of nutrition	Low	45,5	45,5	83,3	58,1
	High	54,5	36,4	81,8	57,6
Post partum means		50,0	41,0	82,6	57,9

Occurrence of oestrus

The post calving nutritional levels influenced the interval to first post partum oestrus, while the feeding of a high plane of nutrition pre partum had no effect (Table 2.5). This unexpected finding must be considered together with the occurrence of post partum oestrus within the first 95 days after calving. During that period 78,4% of the cows of the High group had exhibited oestrus compared to only 54,6% and 36,4% of the Low and the Medium groups (Table 2.6). The same trend was observed with the occurrence of post partum oestrus as with conception rates viz, that the cows in the High group exhibited the highest percentage oestrus within 95 days after calving and was followed by the

51/

Low and the Medium groups, (Table 2.6). Another observation made was that a number of cows exhibited oestrus and had not conceived while a few had conceived, but had not been observed to exhibit oestrus (Tables 2.4 and 2.6).

TABLE 2.5 : Occurrence of first post partum oestrus as influenced by different pre and post partum levels of nutrition (days)

		Post partum levels of nutrition Low	Medium	High	Pre partum means
Pre partum levels of nutrition	Low	64,0	71,0	65,2	65,9
	High	78,1	75,6	64,0	71,5
Post partum means		72,3	73,9	64,6	69,0

TABLE 2.6 : Occurrence of post partum oestrus (%) as influenced by different levels of nutrition both <u>pre</u> and <u>post partum</u>

		Post partum levels of nutrition Low	Medium	High	Pre partum means
Pre partum levels of nutrition	Low	45,5	27,3	75,0	49,3
	High	63,6	45,5	81,8	63,6
Post partum means		54,6	36,4	78,4	56,5

Milk production

The two pre calving levels of nutrition had no effect on the mean milk production of the cows at either one, three or five months of age (Table 2.7). There was a tendency, however, for milk production to be increased when the cows were fed a high plane of nutrition prior to calving (Table 2.7). The milk production of the cows at one and at three months was significantly ($P < 0,05$) affected by the post calving nutritional levels. The cows in the High group produced 0,82 kg and 1,29 kg more milk than the cows in the Low and the Medium groups ($P < 0,05$) at one month (Table 2.7). The increased milk production by the cows in the High group gradually decreased after the first month so that by the fifth month there was no significant difference between the three groups of cows. However, the average milk production (i.e. the average of the three milk recordings) of the cows in the High group was still significantly higher than that of the cows in the Low group (Table 2.7).

TABLE 2.7 : Effect of different levels of nutrition both pre and post partum on the mean milk production of the cows at one, three and five months (kg/cow/day)

	Level of nutrition						
	Pre partum			Post partum			
	Low	High	Sign.	Low	Medium	High	Sign.
Milk production at:							
1 month	5,19	5,69	NS	5,32	4,85	6,14	H > L, M
3 months	4,00	4,19	NS	3,53	4,02	4,68	H > L
5 months	3,59	3,81	NS	3,33	3,98	3,75	NS
Average milk production	4,26	4,53	NS	4,01	4,28	4,85	H > L

Body mass changes of calves

Neither the pre nor the post calving nutritional levels had any noticeable effect on the body mass of the calves when recorded at one, three or at five months of age. The mean body mass of the calves at one, three and at five months for the Low, Medium and High groups was 39,8 kg, 40,0 kg and 39,4 kg (one month), 64,8 kg, 69,6 kg and 67,3 kg (three months) and 83,5 kg, 92,6 kg and 94,2 kg (five months), respectively. Although these differences were not significant, there was a tendency for the calves from the High group to gain more rapidly in mass than those in the Low group, hence a difference of 10,7 kg in body mass at five months of age. Furthermore, there was a slight tendency for the pre calving nutritional levels to influence body mass gains in calves, hence a difference of 1,7 kg at five months of age in favour of the High plane of nutrition pre partum.

DISCUSSION

The findings of this experiment are in agreement with those of other workers who have reported that, regardless of the situation before calving, lactating beef cows should receive an adequate supply of nutrients from calving until breeding (Dunn et al., 1964; Wiltbank et al., 1964; Hight, 1968; Scales & Stevenson, 1976). The results in this study showed that the reproductive performance of beef cows was not impaired when cows lost approximately 22 kg (4,4%) during the last 93 days to 135 days before calving, provided they were well fed after calving. Hight (1966) subjected beef cows during the last 90 days of gestation to extremes of nutrition. This resulted in cows losing 18% of their body mass over this period. Apart from decreased birth and weaning masses and increased calf mortality, Hight found that the low-plane feeding during late pregnancy did not affect the subsequent calving percentage if the cows were well fed after calving. It thus seems that beef cows can withstand a fairly drastic reduction in body mass before calving without detrimentally affecting reproduction.

The level of nutrition post calving was not directly related to percentage conception as was reported by Dunn et al. (1964, 1969) in a similar study. Although the cows in the High group showed the highest reconception rates (82,6%), it is impossible to explain the anomaly that originated between the Medium and the Low groups where the cows in the Low group showed a higher reconception rate (50%) than the cows in the Medium group (41%). A possible reason for this discrepancy is that the cows in the Low group started off the post partum phase of the experiment with a mass advantage (Fig. 2.1) over the High and the Medium groups. Although the loss in body mass of the cows in the Low group was fairly drastic over the first six to eight weeks after calving, their body mass at mating was still very much the same as that of the High and the Medium groups. A second and perhaps the more important reason was that the results were confounded by small animal numbers. It is obvious from this experiment that only one or perhaps two cows in a treatment could affect the outcome of the comparisons.

As was the case with conception rate, post calving nutritional levels influenced the interval to first post partum oestrus, while the feeding of a high plane of nutrition before calving had no effect on first oestrus. These findings are in keeping with those of McGinty & Ray (1973) and Corah et al. (1975), and contradictory to work by El-Keraby & Schilling (1977) who found that low levels of feeding prior to calving delayed the interval to first oestrus and the subsequent calving date. The results of this experiment may be explained by the fact that the differences in the levels of nutrition before calving were not great enough to significantly affect the onset of oestrus.

Unfortunately to date the weaning masses for the calves in this experiment are not available. Although the differences in body mass of the calves at five months were not significant, there was a tendency for the body mass of the calves from the High group to be higher than that of the Medium and the Low groups. These results are in agreement with those of Scales & Stevenson (1976) who recorded differences of up to 25 kg in weaning mass of the calves when cows were subjected to different planes of nutrition. Furthermore, the present study revealed no gain or loss in the weaning mass of the calves due to pre calving nutritional levels. Both Corah et al. (1975) and Hight (1966) recorded differences in the weaning mass of the calves when they subjected cows before calving to different levels of nutrition. Failure to observe any pre calving nutritional effects on the growth rate of the calves in this experiment appears to be due to the ability of the beef cow to tolerate fairly drastic nutritional levels before calving. To illustrate this phenomenon the pre partum phase of the experiment needs further scrutiny. Although there was a pre calving nutritional effect of 38,7 kg between the High and the Low groups at calving (Low group lost 21,8 kg and High group gained 16,9 kg), this mass advantage of the cows had no effect on either the mean birth mass of the calves or the mean body mass of the calves at five months of age.

The differences in body mass of the calves at five months of age, recorded in this trial, must undoubtedly be attributed to the milk production of the dam. This is in agreement with work reported by Foot (1964) and Neville (1962). The results reported here show that the biggest difference in daily milk yield in favour of the cows in the High group occurred at one month after calving. This difference gradually decreased until at five months it was no longer significant. On the other hand, there was no difference in body mass of the calves at one month, while at five months the difference in body mass in favour of the calves from the High group approached significance. This study indicated a possible delayed effect of increased milk production during early lactation on the growth rate of the calves.

Another interesting observation made in this study was that, irrespective of level of nutrition imposed, 66% of the first 34 cows to have completed the post partum phase of the experiment and 50% of the remaining cows (33) had conceived. This finding tends to substantiate the work by Reynolds (1967) which showed that cows which became pregnant early in the breeding season one year had a better opportunity to become pregnant the following year.

GENERAL CONCLUSIONS

The following were the main conclusions derived:

1. The body mass gains and losses of the cows in the High and the Low groups before calving (Fig. 2.1) appear to have been related to the TDN intakes. However, during the post partum phase of the experiment, the cows of all three treatments lost in body mass (Fig. 2.2), while it was expected that the cows from the High group would at least maintain condition or gain somewhat in body mass. Therefore, the body mass gains recorded in this study appear to disagree with the energy allowances recommended by NRC (1976) for cows during early lactation. These data show that higher levels of energy than those recommended, should be fed after calving. Furthermore, the low conception rates recorded with the cows in this study were probably due to an extended post partum anoestrous period (Joubert, 1954; Warnick, 1959; Verbeek, 1966; Symington, 1969). This meant that the cows were not served while joined with the bull. A further reason for the poor responses recorded in body mass of the cows that were subjected to the different feeding levels may be due to an over estimation of the TDN value of the E. curvula. In this study all the calculations were based on an estimated TDN value for E. curvula of 54,4% which now appears to have been too high.

2. It was obvious from the discussions in Chapter 1 that beef cows needed some form of supplementary feeding during the winter months to ensure sustained reproduction. The results in this study have indi-

cated that considerable savings can be brought about by allowing the beef cow to lose condition prior to calving, provided she is well-fed after calving. The loss in body mass of the cows on the Low level of nutrition which was induced before calving, should simulate the conditions encountered on most farms during the winter in Northern Natal. Thus, by concentrating on the post partum phase of the reproductive cycle of beef cows, the operator should be able to reduce his wintering costs without impairing fertility.

3. When considering an investigation on reproduction in beef cattle, such as was the case in this experiment, it is of the utmost importance to have large animal numbers per treatment. Due to small group sizes in this experiment, the results were confounded by one or two animals. This appears to be a problem with many studies. Both Lamond (1970) and McClure (1970) suggested that in many studies they reviewed the group sizes had been too small to yield statistically significant differences.

CHAPTER 3

THE INFLUENCE OF AGE AT FIRST CALVING AND WINTER FEEDING ON PRODUCTION AND REPRODUCTION IN THE BEEF COW

INTRODUCTION

In South Africa many beef heifers are not mated until three years of age. This is due to the fact that large areas of the Republic have a low and erratic summer rainfall and the consequent limitation of available grazing results in sub maximal pre- and post-weaning growth. In this environment replacement heifers attain the bodymass which is considered adequate for mating only during the latter stages of their second year of life, hence the delayed age of first calving. In Northern Natal, however, first mating of three-year-old heifers seldom occurs as the majority of farmers are able to mate their heifers at two years of age. Mating of yearling heifers is practised by only a few farmers in this area. Besides the fact that the nutritional level which is commonly maintained does not support a growth rate that would allow mating earlier than at two years of age, many farmers believe that mating at too early an age will greatly delay reconception. The possibility of a permanent stunting of the cow is a further factor which may militate against early mating. It is obvious therefore, that the age at first parturition is highly dependent on the level of nutrition from weaning until first mating (Bernard, Fahmy & Lalande, 1973; Carter & Cox, 1973; Gordon, 1976; Varner, Bellows & Christensen, 1977).

Irrespective of the age at first parturition, it is generally accepted that young growing heifers require good management during the first two years of life to ensure satisfactory overall performance and fertility (Lamond, 1970; Young, 1974; Penzhorn, 1975; Siebert, Playne & Edye, 1976). Likewise, overfatness of the heifer must be avoided as this reduces fertility and leads to an increase in the incidence of dystocia (Arnett, Holland & Totusek, 1971; Beeby, 1971).

The influence of two planes of nutrition (High and Moderate) which were applied over two winter periods after weaning and prior to mating, was studied by Meaker (1976a). The calving percentage, weaning mass of the calves and margin above feed costs of the heifers fed on the High plane of overwintering were 17%, 17 kg and 70% above those of the heifers fed at a moderate rate. In a second experiment, Meaker (1976b) investigated the influence of different planes of nutrition over two winters on the conception rate of heifers. The results indicated that the heifers in the Low-High group maintained the best production, since these heifers recorded the same conception (100%) as the High-High group, but required only one winter's supplementary feeding. The results of both these experiments clearly indicated the importance of proper nutrition and management of the growing heifer calving for the first time at three years of age.

Having defined a management system for Northern Natal for wintering replacement heifers to calve at three years (Meaker, 1976b), it became necessary to investigate the possibility of calving heifers at two years of age. With the existence of a good potential for the production of home produced roughages in Northern Natal it would seem an easy task to satisfy the nutrient requirements of the yearling heifer during the strategic winter months, i.e. from weaning until first mating (first winter) and during the second winter when the heifer is pregnant and/or lactating. Although mating of yearlings is not universally accepted there has been a steady increase in the number of heifers calving at two years (Martin & Ellis, 1976).

According to Young (1974), mating of yearling heifers results in an increased rate of genetic improvement, early culling of less productive animals, increased total lifetime production and assists in selection for high milk production. Pinney, Pope, van Cotthem & Urban (1962) found that beef females calving first at two years of age produced almost 0,8 more calves per cow over their entire production life at 10% less total cost when compared with those females calving first at three years of age.

The objective of the study to be reported here was to examine the influence of early calving (two vs three years of age) and of winter feeding of beef females on their productive and reproductive performance.

PROCEDURE

Animals and treatments

This experiment was replicated during 1973, 1974 and 1975 and the number of heifers randomly allocated to the two treatments each year was 48 (1973), 43 (1974) and 60 (1975), respectively. Africander cross Sussex weaner heifers, approximately 8 months old, were used in the experiments.

Group 1 : Heifers fed on a high plane of nutrition during the first winter and mated as yearlings.

Group 2 : Heifers fed so as to maintain body mass over the first winter and then mated at two years of age.

The experiment started in the winter of 1973 and terminated in the winter of 1977.

The heifers on the High plane of nutrition (Group 1) received maize silage *ad lib*. during the first winter while the DM intake of silage for the heifers in the Low plane (Group 2) was restricted to approximately 1,3% of their body mass. This level of nutrition was necessary to ensure daily gains of 0,1 kg to 0,2 kg. In addition to the silage, both groups had free access to a protein/mineral supplement (CP approximately 42%) comprising 37,5% maize meal, 25% salt, 18,8% dicalcium phosphate, 12,5% urea and 6,2% of a high protein concentrate mixture (free of NPN).

During the winter feeding periods which followed the one which occurred immediately after weaning the heifers of both groups received maize silage and/or *E. curvula* hay plus a protein/mineral supplement. The supplement comprised of 31% salt, 34% maize meal, 20% dicalcium phosphate and 15% urea (CP content approximately 48%). The quantities of silage and/or hay fed to the cattle were calculated to conform with the minimum DM requirements of beef cattle (NRC, 1970). In mid July, on the average, the winter feeding treatments commenced and usually ceased towards the end of October. From approximately November of each year all the animals were allowed to graze veld and was permitted free access to the protein/mineral supplement from approximately mid March until mid November. During the remainder of the year a mineral lick consisting of equal parts of dicalcium phosphate and salt was offered to all the cows.

The heifers on the High and the Low planes of nutrition were exposed to breeding bulls when they were approximately 12 to 13 and 24 to 25 months of age, respectively. Starting approximately October 10, both groups were mated for only 45 days. The heifers that did not conceive and which received the High plane of nutrition were joined with the heifers in the Low-plane and mated as two-year olds. After calving for the first time the heifers of both groups were mated for 65 days and this period started approximately December 1. Only Sussex bulls were used. Each group was managed separately, and the same cows remained within their allotted treatments throughout the experiment.

Experimental techniques

(a) Live mass

All the heifers were weighed at the start of each experiment and thereafter at intervals of four weeks. During the winter feeding period only the feed was withheld prior to weighing, while in the summer months when the animals grazed on veld, neither water nor feed were withheld. All the cattle were weighed between 08h00 and 10h00.

(b) Feeding procedure

Each group was placed in a winter feeding pen, approximately 1 600 m^2 in size and 0,86 m trough space allowed per animal. Group feeding was practised throughout.

(c) Calves

The mass of the calves was recorded within 24 h of birth. Thereafter the calves were weighed when they were weaned at 7,5 months of age. In 1976, the 18 calves born to the heifers of the High plane (Group 1) were randomly allocated, according to sex, to either a High or a Low level of protein in a creep ration. The cows of both sub-groups were treated similarly while the calves had free access to the respective creeps until weaning.

The composition of the two creep rations was:

		Level of CP in creep	
		High	Low
maize meal	%	64,5	90,3
40% high protein concentrate (free from NPN)	%	35,5	9,7
CP content	%	20,0	12,0

Except for the above, the calves received no supplementary feeding other than the protein/mineral lick to which the cows had free access.

(d) Puberty

Within a week after weaning, i.e. at the start of the winter feeding period, three vasectomised bulls equipped with marking harnesses were placed in a pen which was seperate from but adjacent to that in which the groups of heifers were run. The bulls were introduced to the heifers in the late afternoon and removed again the following morning. In addition to those heifers marked during the night a heifer was also considered to be in oestrus if she stood to be mounted by the bull or another heifer. A heifer was assumed to have reached puberty at the time of first oestrus and age at puberty was defined thus as the age at which the heifer exhibited first oestrus. The body mass at puberty was interpolated from the recordings prior to and subsequent to first oestrus.

(e) Body measurements

The growth and development of the experimental females was determined by body mass and body measurements taken at 10, 22, 34, 46 and 58 months of age, respectively. Actual measurements taken were circumference of heart girth, height at withers, height at rump, depth of chest, width at hooks, width at thurls and length of body (brisket to pin bones). At 22 months the body measurements were taken of only the pregnant heifers in the High plane (Group 1) and non pregnant females in the Low plane (Group 2). Thereafter, measurements were taken of only pregnant cows.

(f) Milk production

During the summer of 1976/77 the milk production of cows that calved for the first, second or third time, was measured. These recordings were performed when the calves were approximately 40, 100 and 160 days of age. The milk production was estimated by the "calf nursing" method which involved separating the calves from their mothers at 12h00 the day preceding the actual test. The calves were penned while the cows returned to their grazing camps. At 18h00 the calves were allowed to suckle and thereafter penned again until 05h30 the following day. The calves were then weighed, allowed to suckle until the first calf stopped suckling and immediately thereafter all the calves were reweighed to the nearest 0,5 kg. The same procedure was repeated at 11h30 and 17h30. The change in mass at each suckling was assumed to equal the quantity of milk consumed by the calf and the total obtained for the three recordings was regarded as the total milk production by the cow for that day.

(g) Cost analysis

Ruling prices for the protein/mineral supplement and an estimated market value for maize silage (See Chapter 1) were used in the economic assessment of the experiment. The following values were used:

Protein/mineral supplement	R110/1 000 kg
maize silage	R12,30/1 000 kg

(h) Statistical analysis

Mean differences in data were compared by means of Students t-test, analysis of variance with samples of unequal size and by least-squares analysis of variance.

At the start and at the end of the mating season the recorded body mass of the yearling and the two year old heifers was subdivided into evenly spaced categories of body mass. Body mass means and percentage conception of the heifers within each body mass category were calculated. Linear, square root and quadratic functions were fitted by least squares analysis to this data (Snedecor & Cochran, 1967).

RESULTS

The average daily intake of lick, maize silage and <u>E. curvula</u> hay per cow during the relevant winter feeding periods for cows calving for the first time at either two or three years of age are summarised in Table 3.1. Significant differences ($P < 0,01$) in body mass of cows overwintered on either a high or a low level were recorded only at the end of the first winter and at the start of the second winter (Table 3.2). These differences were attributed to the plane of nutrition during the first winter and to pregnancy during the ensuing summer. Thereafter, i.e. until five years of age, no significant differences in body mass between the two groups of cows were recorded. Although the actual body masses at the start of the first winter differed somewhat, the gains in mass within a group and between years, were remarkebly similar. For example, the cows born in 1972, 1973 and 1974 and calving for the first time at two years of age, all gained approximately 68% (range 68% - 69%) in mass from the start of the first winter until the end of the second winter. Similar gains in mass were recorded when comparable masses were compared between years (Table 3.2).

The average calving percentage, calculated over three years, of heifers calving for the first time at two years of age, was 61,3% which was well below the 83,9% recorded with the heifers calving for the first time at three years of age (Table 3.3). However, subsequent recalving percentages of both groups of cows were very similar. The calf losses due to dystocia were higher amongst the heifers calving at two years of age (8,1% - average over three years) compared with those heifers calving at three years of age (3,2% - average over three years). None of the heifers calving for the first time at three years of age had to be assisted at calving while approximately 11% (average over three years) of the animals had to be assisted when they calved at two years of age (Table 3.3).

Although percentage conception and mean body mass of yearling heifers at the start of the mating season were not significantly correlated, there was a tendency for conception to increase with an increase in body mass (Fig. 3.1). As the mean body mass of the heifers at the start of the breeding season increased from 215 kg to 285 kg, the percentage conception increased from 23% to 81%. However, when the mean body mass of the heifers exceeded 285 kg, the percentage conception tended to decrease (Fig. 3.1).

64/.

TABLE 3.1 : Average daily intakes (kg) of lick, maize silage and E. curvula per cow during the respective winters for cows calving for the first time either at two or three years of age

	Age of cows at first calving							
	2 years				3 years			
	W1	W2	W3	W4	W1	W2	W3	W4
Cows born in 1972:								
Average intake of lick (kg/cow/day)	0,656	0,726	0,267	0,379	0,307	0,595	0,262	0,379
Average intake of silage (kg/cow/day)	15,0	-	-	-	7,5	15,0	-	-
pre partum	-	15,0	5,3	12,0	-	-	5,4	12,4
post partum	-	20,0	11,9	27,0	-	-	11,5	27,0
Average intake of E. curvula hay (kg/cow/day)								
pre partum	-	-	4,7	3,3	-	-	4,8	3,4
post partum	-	-	6,6	-	-	-	6,4	-
Cows born in 1973:								
Average intake of lick (kg/cow/day)	0,826	0,294	0,354	-	0,656	0,258	0,354	-
Average intake of silage (kg/cow/day)	12,5	-	-	-	7,5	7,4	-	-
pre partum	-	4,8	13,0	-	-	-	14,1	-
post partum	-	9,5	25,0	-	-	-	25,0	-
Average intake of E. curvula hay (kg/cow/day)	-	-	-	-	-	4,8	-	-
pre partum	-	4,2	3,6	-	-	-	3,9	-
post partum	-	5,2	-	-	-	-	-	-
Cows born in 1974:								
Average intake of lick (kg/cow/day)	0,484	0,798	-	-	0,502	0,561	-	-
Average intake of silage (kg/cow/day)	14,7	-	-	-	8,4	23,1	-	-
pre partum	-	20,9	-	-	-	-	-	-
post partum	-	22,4	-	-	-	-	-	-

W1, W2, etc. = First winter, second winter, etc. after weaning

TABLE 3.2 : Mean mass of heifers/cows fed different planes of nutrition during the winter and calving for the first time at two or three years of age (kg)

	Mean bodymass of cows first calving at			Mass per Group as % of initial mass for cows calving at	
	2 years	3 years		2 years	3 years
Cows born in 1972:					
Start W1	218,3	213,8	N.S.	100	100
End W1	270,3	235,9	< 0,01	124	110
Start W2	380,1	310,6	< 0,01	174	145
End W2	367,7	371,3	N.S.	168	174
Start W3	440,2	451,5	N.S.	202	211
End W3	421,2	417,5	N.S.	193	195
Start W4	433,4	436,6	N.S.	199	204
End W4	406,6	396,7	N.S.	186	186
Cows born in 1973:					
Start W1	200,9	198,7	N.S.	100	100
End W1	289,9	240,4	< 0,01	144	121
Start W2	344,3	311,0	< 0,01	171	157
End W2	339,9	351,7	N.S.	169	177
Start W3	423,3	446,1	N.S.	211	225
End W3	393,9	379,4	N.S.	196	191
Cows born in 1974					
Start W1	198,7	201,3	N.S.	100	100
End W1	273,5	223,5	< 0,01	138	111
Start W2	343,7	290,7	< 0,01	173	144
End W2	334,3	340,7	N.S.	168	169

W1 = First winter, etc.

TABLE 3.3 : Calving rate, incidence of dystocia and cows assisted at calving, for cows born in 1972, 1973 and 1974 and calving for the first time at 2 or 3 years of age

		Cows calving for the first time at						
		2 years				3 years		
		Annual calvings				Annual calvings		
		1	2	3	4	1	2	3
Cows born in 1972:								
No. of cows mated		24	24	24	22	23	21	21
Cows calved	(%)	62,5	91,7	87,5	86,4	91,3	90,5	71,4
Dystocia	(%)	6,7	18,2	-	-	9,5	-	-
Assisted at calving	(%)	20,0	-	-	-	-	-	-
Cows born in 1973:								
No. of cows mated		22	22	22		21	19	
Cows calved	(%)	72,7	77,3	95,5		90,5	94,7	
Dystocia	(%)	12,5	-	-		-	-	
Assisted at calving	(%)	12,5	-	-		-	-	
Cows born in 1974								
No. of cows mated		41	40			20		
Cows calved	(%)	48,8	90,0			70,0		
Dystocia	(%)	5,0	-			-		
Assisted at calving	(%)	-	-			-		

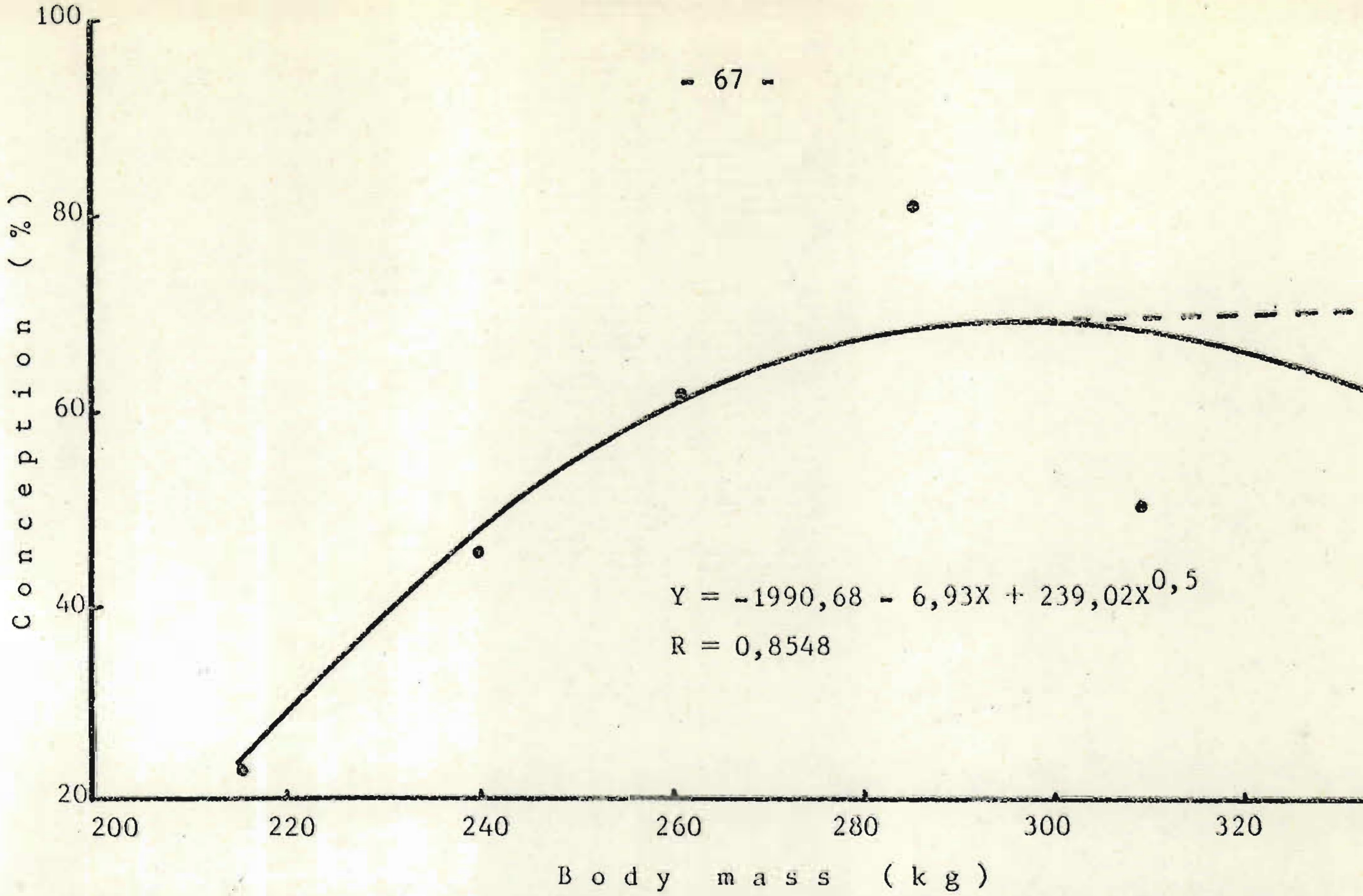

FIG. 3.1 : Relationship between conception and mean body mass of yearling heifers at the start of the mating season

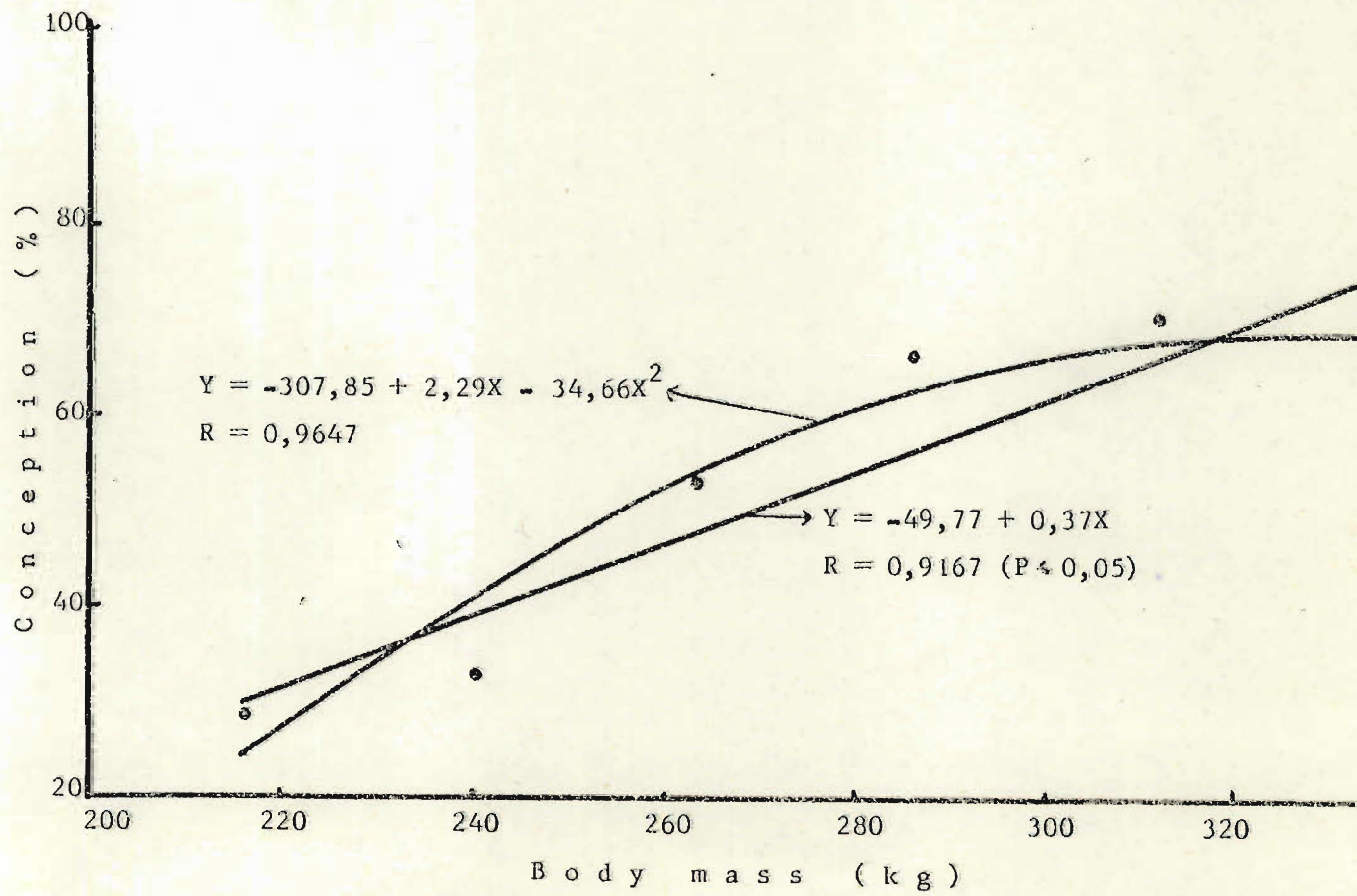

FIG. 3.2 : Relationship between conception and mean body mass of yearling heifers at the end of the mating season

In conformation of this tendency, percentage conception and mean body mass of yearling heifers at the end of the mating season were significantly ($P < 0,05$) correlated. It is doubtful, however, if the response could be linear, since the results indicated no further increase in conception above 311 kg body mass (Fig. 3.2). Square root (Fig. 3.1) and quadratic (Fig. 3.2) functions were accordingly fitted which appeared to more closely follow the trend in observed data.

No trend was observed when the same two parameters were applied to the two-year-old heifers. The conception rate did not differ greatly when the mean body mass of the heifers varied between 285 kg and 385 kg at the start of the mating season.

When the heifers were fed either a high or a low plane of nutrition after weaning, the mean body mass at puberty was 241,2 ± 31,1 kg (n = 68) and 226,5 ± 25,1 kg (n = 27), respectively. The mean difference of 14,7 ± 6,7 kg in favour of the heifers fed a high plane of nutrition was significant ($P < 0,05$). In contrast, the plane of nutrition had no significant effect on the mean age at which the two groups of heifers attained puberty (High - 337,5 ± 52,3 days vs Low - 351,3 ± 50,0 days). In addition, plane of nutrition had no significant effect on the length of the oestrous cycle (High - 21,01 ± 4,07 days, n = 67 vs Low - 21,43 ± 5,87 days, n = 14). Age at first calving also had no significant effect on the interval to post partum oestrus. The mean interval for the cows calving for the first time at either two or three years of age was 73,1 ± 12,9 days (range 43 to 95, n = 18) and 69,9 ± 15,3 days (range 44 to 111, n = 20), respectively.

The birth mass of the calves born to two-year-old cows was lower in all replications of the experiment when compared with calves born to three- and four-year-old cows. The only difference which was significant ($P < 0,05$) was that for calves produced by two-or three-year-old cows (cows born in 1972). It would appear that age of the cow at first calving had no significant effect on birth mass of the calves which were produced at subsequent calvings (Table 3.4).

Exceptionally poor weaning masses were recorded for calves born to the two-year-old cows (Table 3.4). The creep ration provided to the calves' dams born in 1974 resulted in a significantly ($P < 0,01$) improved average weaning mass. The results also indicated that the weaning masses of the calves improved as the age of the cows increased. For example, the cows born in 1972 produced calves with average weaning masses of 129,5 kg, 147,0 kg and 155,1 kg when the cows were two, three and four years of age, respectively. The differences between consecutive years were significant ($P< 0,05$). In addition, calving for the first time at either two- or three-years of age had no significant effect on the average weaning mass of the calves by the time the cows calved as three- and four-year-olds (Table 3.4).

The CP content of the creep rations had no significant effect on the 205 day corrected weaning mass of the calves (Table 3.5). However, it would appear that the weaning mass of the calves was favoured by the 20% CP creep ration, hence a difference of 12,3 kg in weaning mass between the two groups of calves. In addition, the two creep rations had no significant indirect effect on the gain in mass of the cows over the experimental period (Table 3.5).

The level of CP in the creep ration had no significant effect on the milk production of two-year-old cows (Table 3.6). Furthermore, early calving had no significant effect on the average milk production of either three- or four-year-old cows, but four-year-old cows were found to produce significantly ($P< 0,05$) more milk than three-year-old cows and three-year-old cows in turn produced significantly more milk than two-year-olds ($P< 0,05$, Table 3.6).

The effect of calving for the first time at two or three years of age, and calving annually thereafter, on the growth and development of the cow from one year until five years of age, is presented in Figs. 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9 and 3.10. The body measurements recorded and presented graphically, included circumference of heart girth (Fig. 3.3), body mass (Fig. 3.4), height at withers (Fig. 3.5), height at rump (Fig. 3.6), depth of chest (Fig. 3.7), length of body (Fig. 3.8), width of thurls (Fig. 3.9) and width of hips (Fig. 3.10).

The results indicated that early calving (two years vs three years) had no major effect on the eight growth variables that were recorded. Only in two instances were significant differences ($P< 0,05$) noted in the growth and development of the cow viz, body mass at two years (Fig. 3.4)

70/.

TABLE 3.4 : Birth mass and corrected weaning mass at 205 days of calves born to cows of different ages (kg)

	Cows calving for the first time at: 2 years		3 years	
	Birth mass	Weaning mass	Birth mass	Weaning mass
Cows born in 1972 and calving at:-				
2 years	27,4 ± 4,6	129,5 ± 22,7	-	-
3 years	34,1 ± 1,7	147,0 ± 18,2	31,1 ± 3,5	151,1 ± 18,2
4 years	32,1 ± 3,2	155,1 ± 22,7	31,1 ± 4,0	148,8 ± 18,5
Cows born in 1973 and calving at:				
2 years	28,2 ± 3,8	123,1 ± 17,4	-	-
3 years	30,1 ± 3,1	131,8 ± 18,2	30,2 ± 2,7	133,4 ± 12,7
Cows born in 1974 and calving at:				
2 years	26,1 ± 4,1	151,4 ± 22,9		

TABLE 3.5 : Intake of the creep ration by the calves, change in mass of the cows over the creep feeding period and 205 day corrected weaning mass of the calves

	CP content of the creep ration: 20%	12%
Intake of creep ration over 153 days (kg/calf/day)	1,056	0,877
Gain in mass of cows over creep feeding period (kg)	16,4	23,1
205 day corrected weaning mass of calves (kg)	161,6	149,3

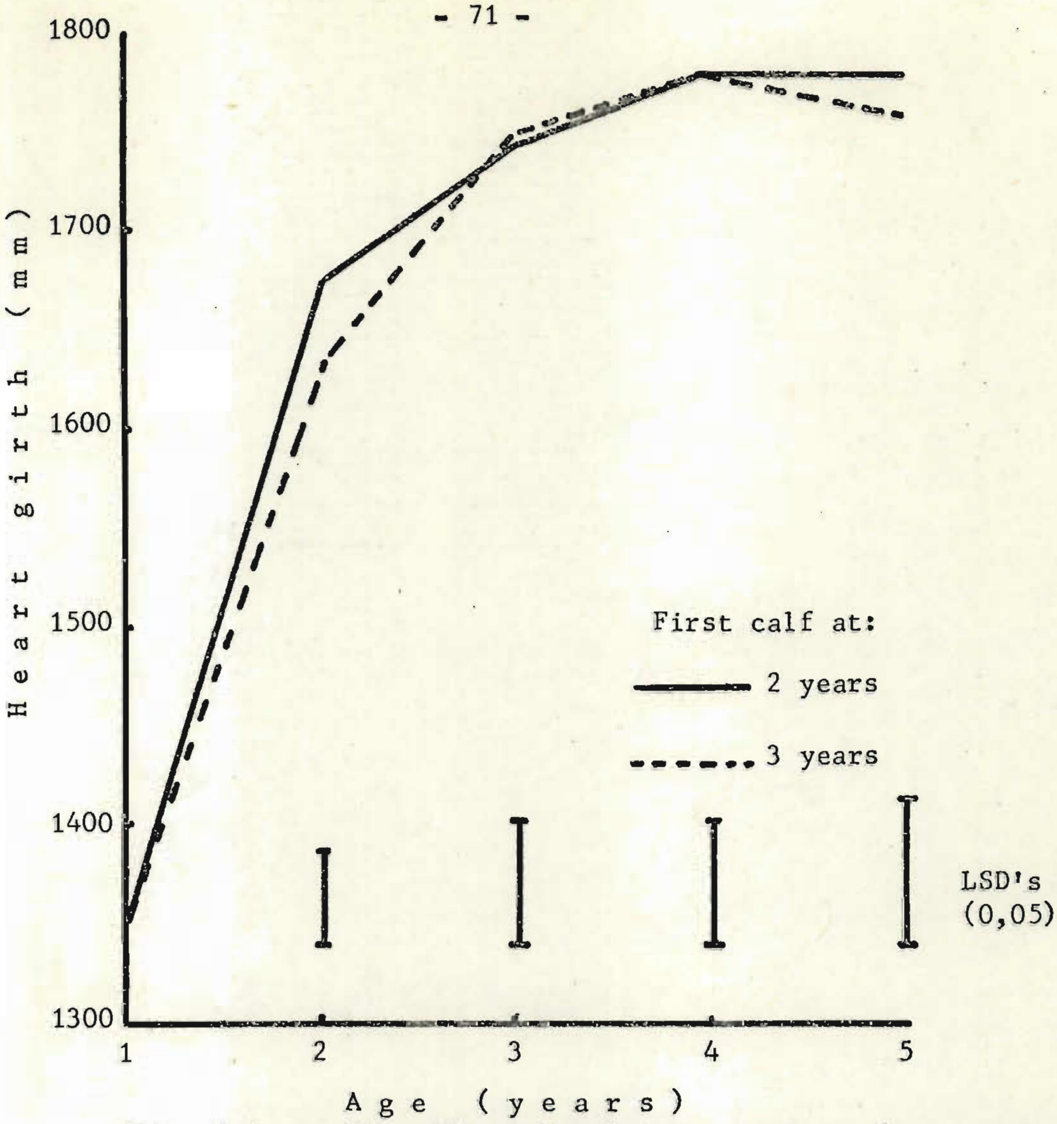

FIG. 3.3 : The effect of calving at two or three years of age on circumference of heart girth over 5 years

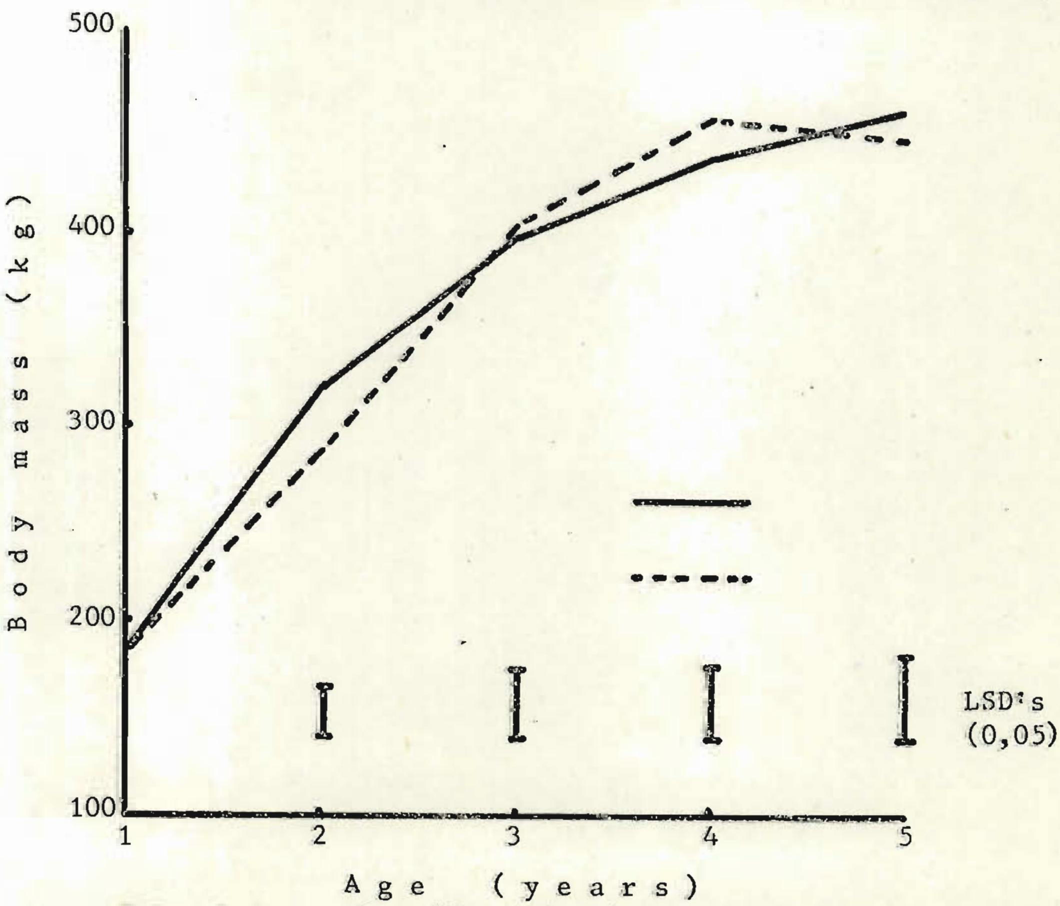

FIG. 3.4 : The effect of calving at two or three years of age on body mass over 5 years

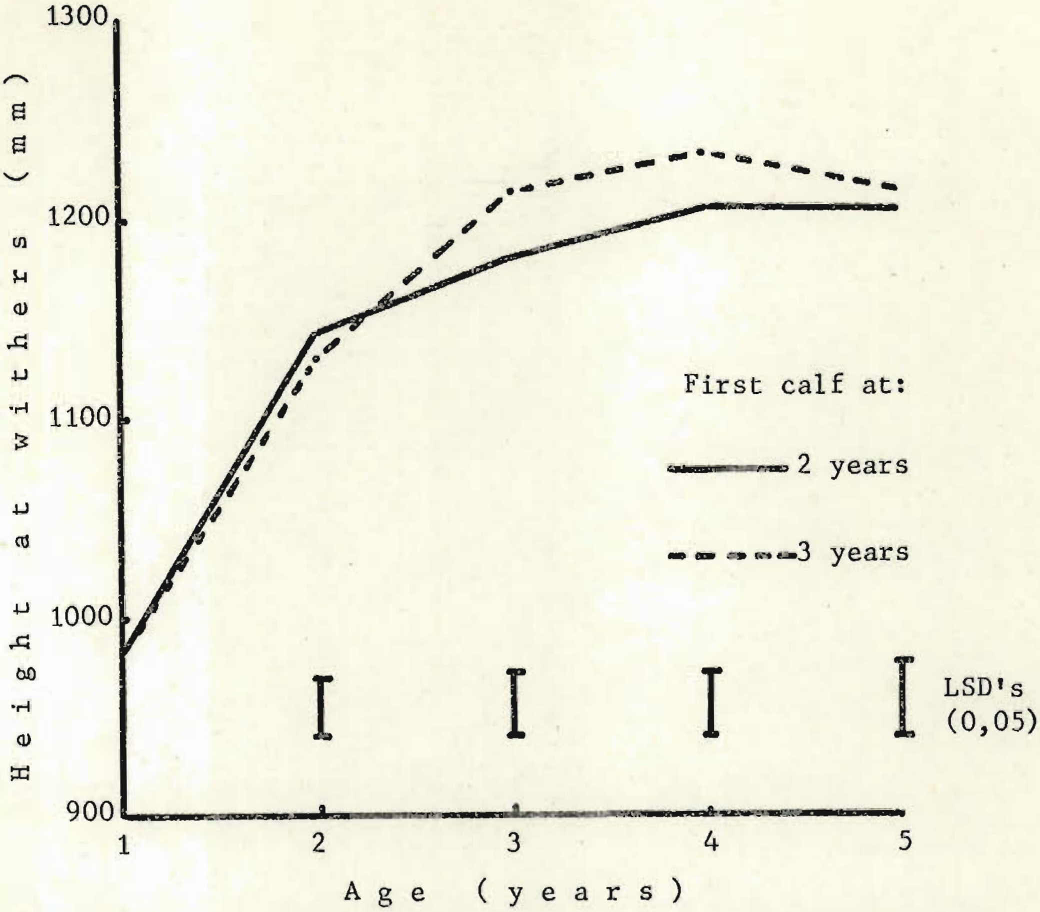

FIG. 3.5 : The effect of calving at two or three years of age on height at withers over 5 years

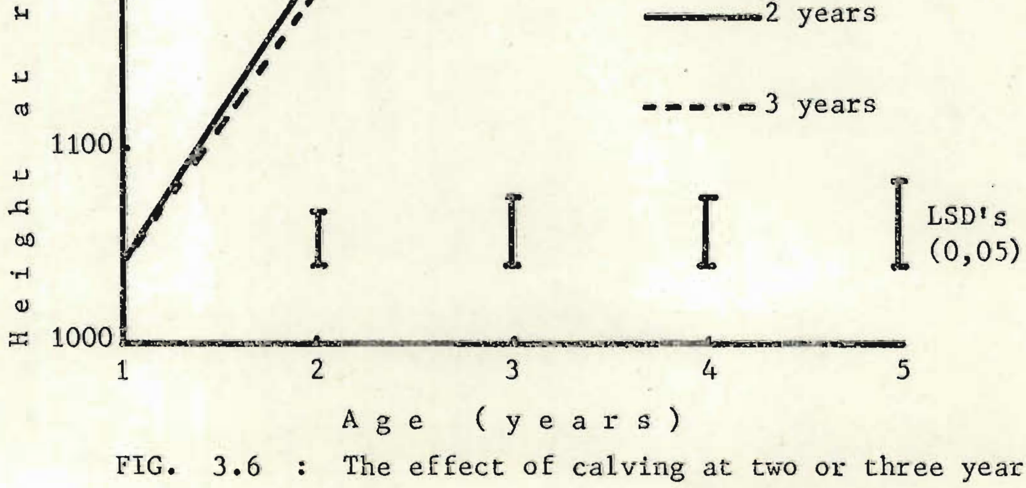

FIG. 3.6 : The effect of calving at two or three years of age on height at rump over 5 years

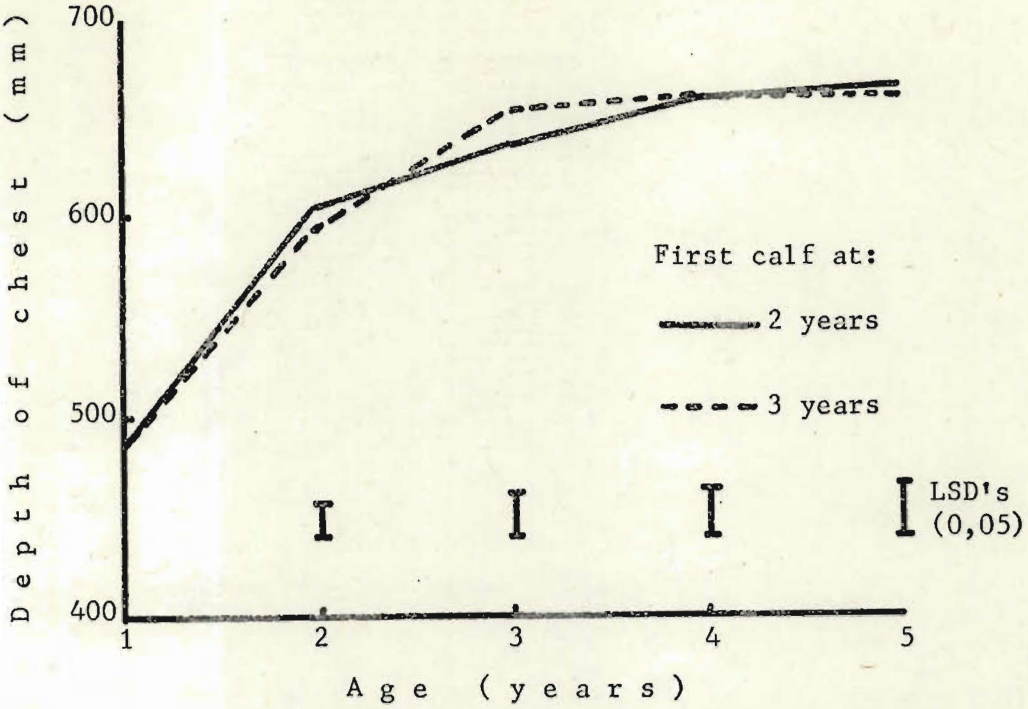

FIG. 3.7 : The effect of calving at two or three years of age on depth of chest over 5 years

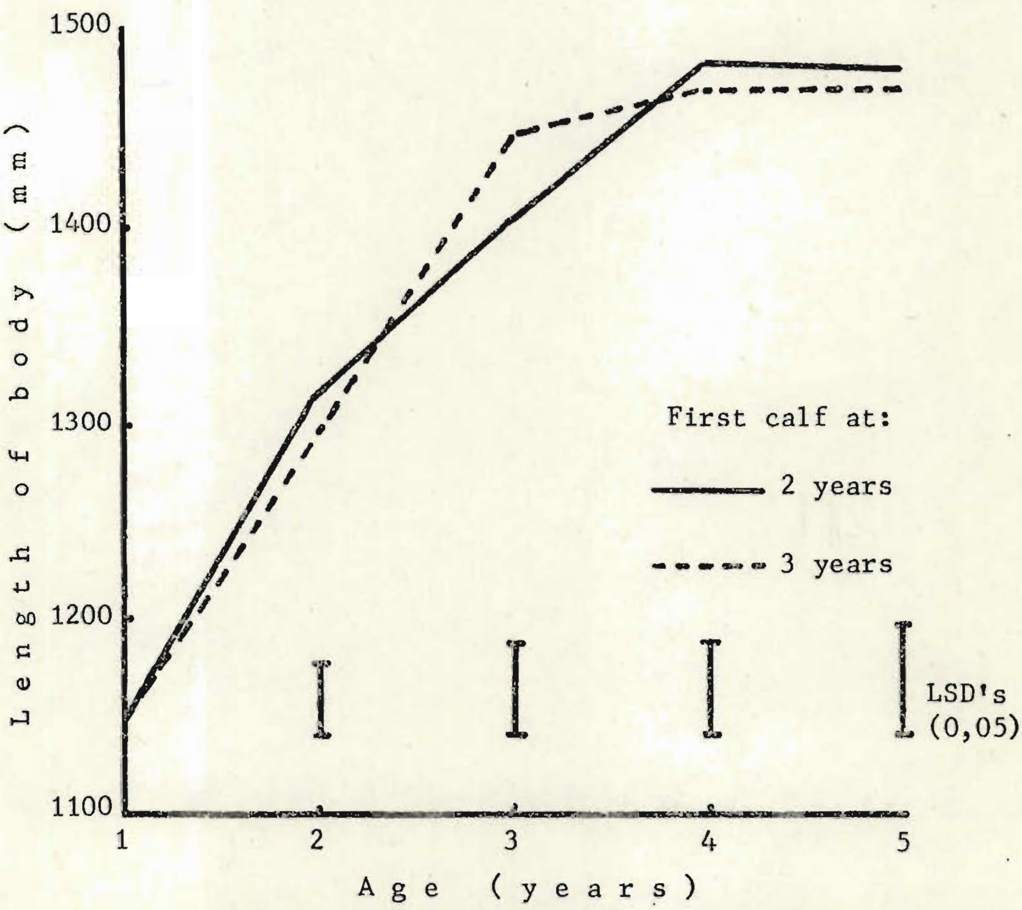

FIG. 3.8 : The effect of calving at two or three years of age on length of body over 5 years

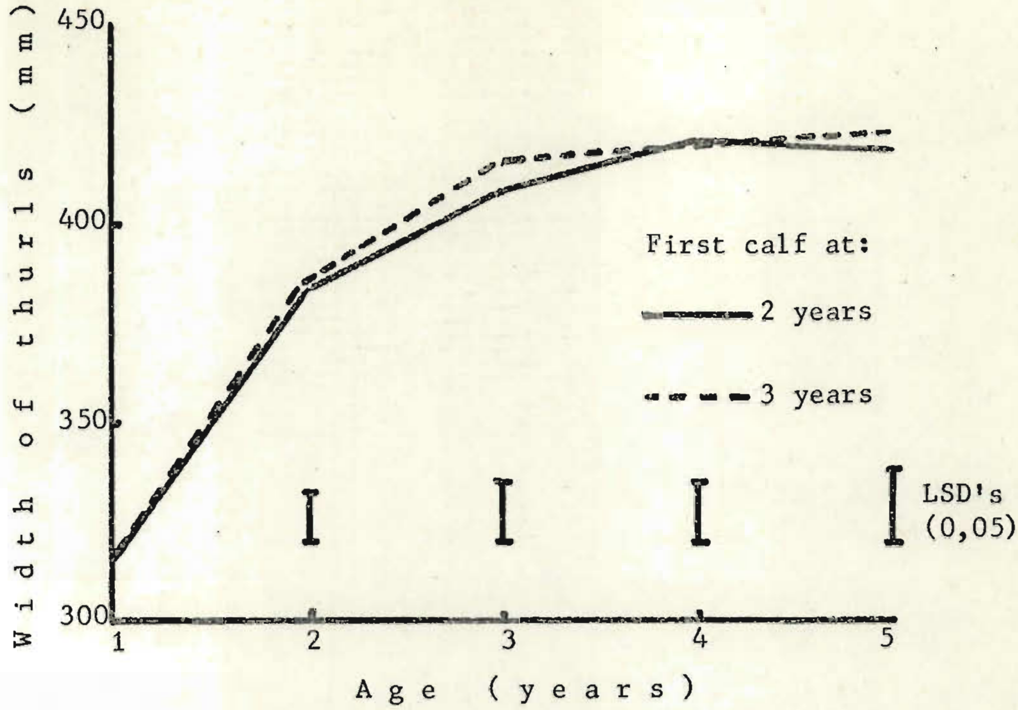

FIG. 3.9 : The effect of calving at two or three years of age on width of thurls over 5 years

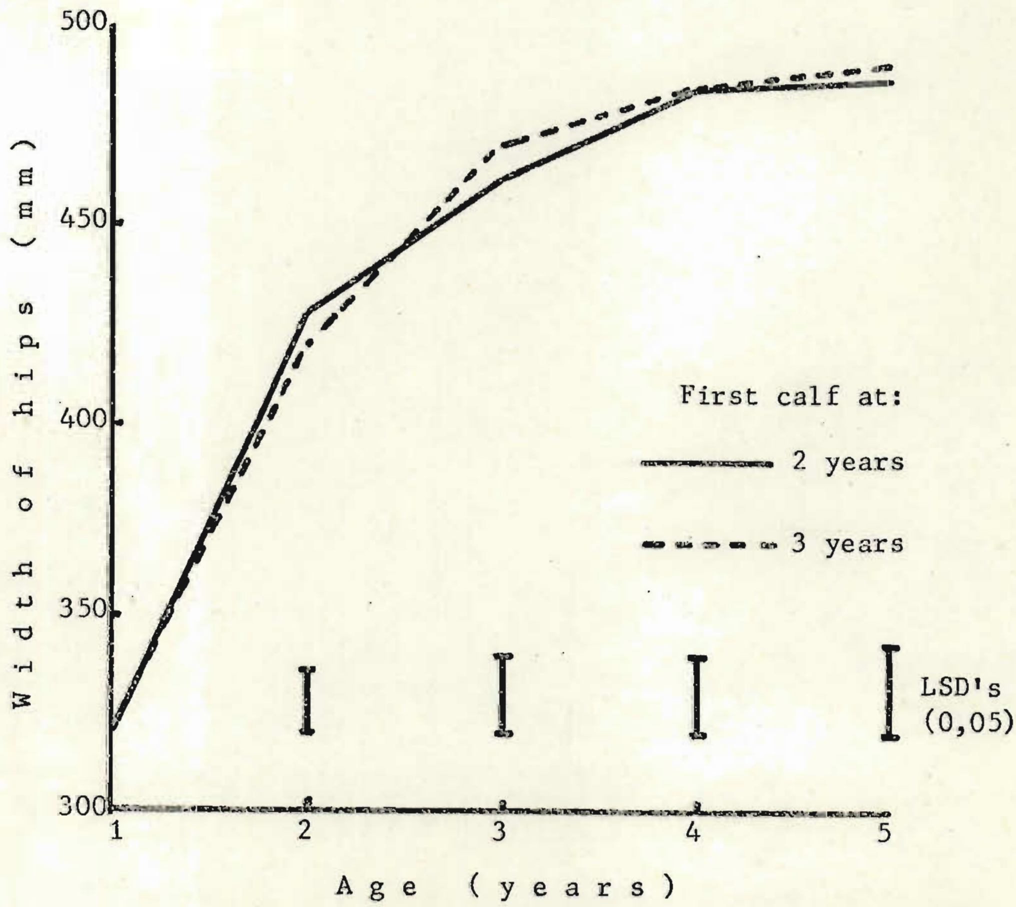

FIG. 3.10 : The effect of calving at two or three years of age on width of hips over 5 years

and height at withers at three years (Fig. 3.5). The results indicated that except for body mass (Fig. 3.4) and length of body (Fig. 3.8), the most rapid growth occurred between the first and second years of life. Thereafter, the growth rate decreased remarkably (Figs. 3.3, 3.5, 3.6, 3.7, 3.9 and 3.10). It would appear from the graphs that no meaningful growth was recorded after four years of age. Although the body mass of the cows diminished gradually as they became older, there was little evidence to suggest that the cows had reached their maximum mass at five years of age (Fig. 3.4). The length of the cows (Fig. 3.8) increased steadily until three years of age and decreased thereafter to reach a maximum at five years of age. This response was unlike that observed for the other growth variables where the most rapid growth occurred within the first two years.

TABLE 3.6 : Effect of two levels of protein in the creep ration of the calves, age of cows and age of cows at first calving on the mean daily milk production of cows at one, three and five months of lactation period (kg)

	Age of cows (years):					
	2		3		4	
	CP content of creep:		Age of cows at first calving (years)			
	20%	12%	2	3	2	3
Milk production of cows at:						
1 month	3,83	4,11	5,24	4,49	5,43	5,06
3 months	2,44	2,72	4,29	3,34	5,46	5,00
5 months	1,81	2,06	2,74	2,74	5,00	4,44
Total	$8{,}08^{a}$	$8{,}89^{a}$	$12{,}26^{b}$	$11{,}00^{b}$	$15{,}89^{c}$	$14{,}50^{c}$

Means having the same superscript are not significantly different from one another

Significant correlation coefficients (R) between body mass and both circumference of heart girth and depth of chest were obtained for all the groups of cows ranging from one year to four years of age and calving for the first time at two or three years of age (n ranged from 11 to 20, Table 3.7). The relationships between body mass and the other variables measured (viz, height at withers, height at rump, width of hips, width

TABLE 3.7 : Correlation between body mass and circumference of heart girth, height at withers, height at rump, depth of chest, width of hips, width of thurls and length of body for cows ranging in age from one year to four years of age and calving for the first time at two or three years of age

		Correlation coefficient													
	n	Heart girth	(P)	Height withers	(P)	Height rump	(P)	Depth chest	(P)	Width hips	(P)	Width thurls	(P)	Length body	(P)
Age of cows:															
1 year	16	0,822	**	0,689	**	0,751	**	0,791	**	0,828	**	0,717	**	0,698	**
2 years															
Pregnancy 1st	20	0,931	**	0,661	**	0,588	**	0,724	**	0,820	**	0,516	*	0,523	*
Non pregnancy	17	0,969	**	0,691	**	0,608	**	0,835	**	0,829	**	0,769	**	0,872	**
3 years															
Pregnancy 2nd	11	0,673	*	0,783	**	0,514	N.S.	0,690	*	0,426	N.S.	0,763	**	0,401	N.S.
Pregnancy 1st	13	0,878	**	0,292	N.S.	0,588	*	0,634	*	0,712	**	0,532	N.S.	0,186	N.S.
4 years															
Pregnancy 3rd	11	0,905	**	0,675	*	0,514	N.S.	0,656	*	0,850	**	0,719	*	0,778	**
Pregnancy 2nd	12	0,933	**	0,312	N.S.	0,106	N.S.	0,915	**	0,774	**	0,648	*	0,946	**

* $P < 0,05$ ** $P < 0,01$ N.S. Not significant

of thurls and length of body, were not consistently related. The results indicated that all the relationships were significant ($P< 0,05$) at one and two years of age, irrespective of pregnancy status. From three years of age no consistent pattern evolved. Age at first calving had no significant effect on the relationship between body mass and circumference of heart girth. This relationship was therefore estimated ($P< 0,01$) by fitting a square root function to all the data and ignoring the age at first calving (Fig. 3.11).

Although the winter feeding costs were higher for the cows calving for the first time at two years of age, these females nevertheless returned the best margin above winter feeding costs, when compared with the cows calving for the first time at three years of age (Table 3.8).

DISCUSSION

Although data for only four years are available, the results of this trial clearly showed the beneficial effects which early calving had on the reproductive performance of cows until five years of age. The average conception rate over the productive life of the two-, three-, four- and five-year-old cows that calved for the first time at either two or three years of age was 81,4% and 62,0%, respectively. Notwithstanding the relatively poor conception recorded with the yearlings (average 61,3%), the difference in conception rate in favour of early calving is undoubtedly attributable to the extra year's breeding (Table 3.3).

Similarly the average percentage calves born alive over the productive life of the cows that calved for the first time at either two or three years of age was 77,9% and 61,2% respectively. The loss of calves at birth was due to calving difficulty or dystocia. The average percentage dystocia recorded with the cows calving for the first time at two or three years of age was 8,1% and 3,2% (Table 3.3). The reasons for these losses are difficult to assess. Factors such as high birth mass of the calves, heifers which were not well grown and extremes of nutrition (Strachan & Wythes, 1976) appear to have contributed to the incidence of dystocia. The frequency of dystocia recorded in this trial is of the same order as that reported by other workers. Pattullo (1973) recorded an overall calf-loss between conception and calf marking of 20,9%, while Wythes, Strachan & Durand (1976) reported that the incidence

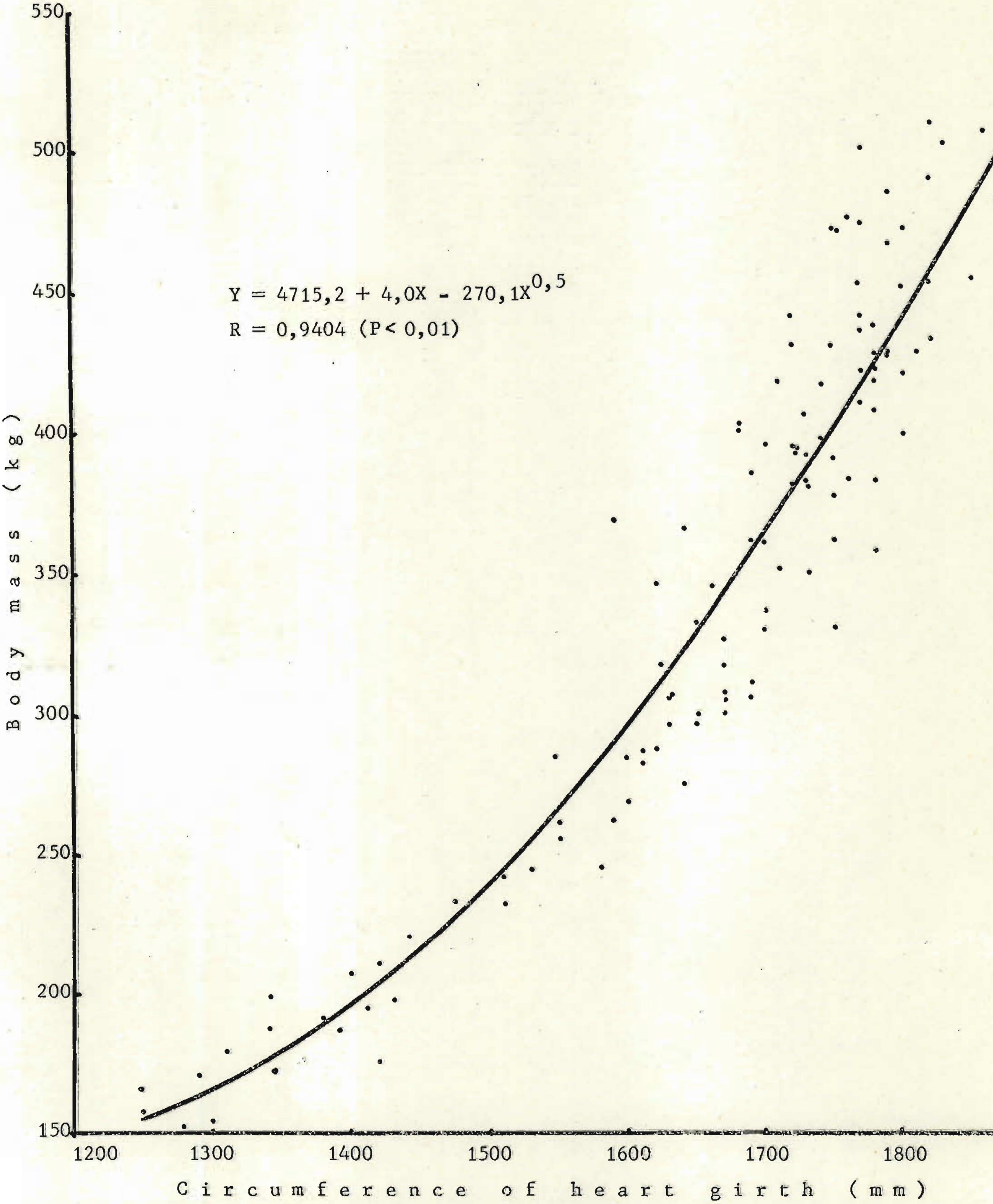

FIG. 3.11 : Relationship between body mass and circumference of heart girth of cows from 1 to 5 years of age (n = 117)

TABLE 3.8 : Gross returns, cost of winter supplementation and margin above cost of overwintering (Silage plus lick only) of cows until five years of age when calving occurred at either two or three years of age

	Cows calving for the first time at: 2 years	Cows calving for the first time at: 3 years
Gross returns		
Calves - Total weaner mass produced per cow (kg)*	420,8	291,0
@ 40c/kg	168,32	116,40
Cost of winter supplementation (R-c)		
W1 - Av. cost of lick	150 d @ 0,655 kg - 10,81	150 d @ 0,488 kg - 8,05
Av. cost of silage	150 d @ 14 kg - 25,83	150 d @ 7,8 kg - 14,39
W2 - Av. cost of lick	120 d @ 0,606 kg - 8,00	120 d @ 0,471 kg - 6,22
Av. cost of silage pre partum	20 d @ 18 kg - 4,43	120 d @ 22 kg - 32,47
Av. cost of silage post partum	100 d @ 22 kg - 27,06	- -
W3 - Av. cost of lick	120 d @ 0,311 kg - 4,11	120 d @ 0,313 kg - 4,13
Av. cost of silage pre partum	55 d @ 22 kg - 14,88	20 d @ 22 kg - 5,41
Av. cost of silage post partum	65 d @ 27 kg - 21,59	100 d @ 27 kg - 33,21
W4 - Av. cost of lick	100 d @ 0,379 kg - 4,17	100 d @ 0,379 kg - 4,17
Av. cost of silage pre partum	45 d @ 23 kg - 12,73	45 d @ 23 kg - 12,73
Av. cost of silage post partum	55 d @ 27 kg - 18,27	55 d @ 27 kg - 18,27
Total winter feed cost per cow over 4 winters	151,88	139,04
Margin above winter feed costs	16,44	-22,64

W1 = First winter, etc.
* = Weaning mass of calves that received a creep ration not included
Silage costs @ R12,30/1 000 kg and lick costs @ R110/1 000 kg

of dystocia was 12%. Short (1976) noted that the loss of calves at birth was 6% when heifers were mated as yearlings. The 18,2% dystocia recorded with the three-year-old cows, of which some had calved at two years, appears to be an exception and may be due to the role of a particular sire plus a high plane of nutrition during the last three months of gestation. These two factors may have resulted in the average birth mass being 34,1 ± 1,7 kg which was well above any of the other averages recorded (Table 3.4).

The 205 day corrected weaning mass of calves born to cows calving for the first time at two years of age was 15,9 kg lighter at weaning than those from cows calving for the first time a year later. The poor weaning mass of the calves recorded with the younger dams suggested that the introduction of a creep ration for the calves which were produced in subsequent years should be considered. Although only one year's data is available regarding this aspect the creep ration resulted in an increase of 25,1 kg ($P < 0,01$) in weaning mass of the calves. Bernard et al. (1973) found that calves born from two-year-old heifers were only 7,9 kg lighter at weaning than those born from three-year-old cows, while Pinney, Stephens & Pope (1972) reported small and inconsistent differences. No mention was made in either of these reports of any creep or additional feed to the calves and it was somewhat surprising that in the present study such a marked effect, both at the first and the second calving was produced (Table 3.4). The concurrent increase in weaning mass with age of the cow, as recorded in this trial, supports the findings of Bernard et al. (1973).

Notwithstanding the detrimental effect which dystocia (Table 3.3) had on the overall percentage calves born alive and the lower weaning mass (Table 3.4) of the calves, the cows calving for the first time as two- or three-year-olds, produced 3,1 and 2,4 calves per cow, respectively, over a productive life of five years. These results suggest that a delay in the age of first calving results in a deficit which is never compensated for. The findings of this experiment are in agreement with other reports on the effect of age at first calving on the lifetime production of a beef cow (Pinney et al., 1962; Pinney, Stephens & Pope, 1972; Bernard et al., 1973; El Amin, 1976).

Several research groups have investigated the effect of level of nutrition on age and mass at puberty (Joubert, 1963; Wiltbank, Gregory, Swiger, Ingalls, Rothlisberger & Koch, 1966; Wiltbank, 1968; Short & Bellows, 1971; Arije & Wiltbank, 1974). The results recorded in this trial are somewhat at variance with these reports, although they did show that the winter feed level influenced the mass and the age at puberty. A high level of nutrition during winter increased the mass by 14,7 kg ($P < 0,05$) and decreased the age by 13,8 days at puberty when compared with a low plane of nutrition. Ignoring the plane of nutrition it would appear that the average mass and age at puberty for Africander cross Sussex heifers was 236 kg and 342 days, respectively. Coetzer & van Marle (1972) recorded an average mass of 289 kg at, and an age of 385 days to, puberty when the same type of animal was used.

It is generally accepted that a relationship exists between the body mass of a heifer at joining and the resultant fertility (Ellis, 1970; Carter & Cox, 1973; Young, 1974; Axelsen & Morley, 1976). Lamond (1970) refers to a genetically determined target mass that a heifer must reach (mass when pregnancy can occur) before high pregnancy rates are obtained. The results of this study indicated similar relationships between fertility and body mass of yearling heifers, both when the mass was recorded at the start and at the end of the mating season (Fig. 3.1 and 3.2). There was a tendency for conception rate to increase linearly when the mass at joining rose from 215 kg to 285 kg at the rate of 8,3% for every 10 kg increase in body mass.

It is obvious that if high calving percentages are to be obtained with two year old heifers, they should at least have shown oestrus during the mating season. Age at puberty, therefore, becomes increasingly critical if management demands that heifers be mated as yearlings. When mated at such an early age a delayed onset of puberty can very often lead to a reduced reproductive performance. Martin (1976) suggest that, given good conditions, there is no reason why calving percentages among yearling mated heifers cannot be in the region of 95 percent. Although the average mass of the heifers at puberty was 236 kg, the highest conception (81%) was recorded when the average mass at joining was 285 kg. There was no justification for a further increase in the body mass at joining. According to the results obtained here it seems unlikely that conception rates as high as 95% can be achieved. Swanson, Hafs & Morrow (1972), presented data on pituitary and ovarian hormones in postpuberal cattle which showed that maturation of the reproductive system continued well beyond the first heat. This means that breeding a heifer after several oestrous cycles may result in a higher conception rate than after the first heat period. This type of response has been observed in gilts mated at either the first, second or third oestrus after puberty (Mac Pherson, Hovell & Jones, 1977). The data recorded in this trial suggest that around the time of puberty the reproductive mechanisms are still developing and the possibility exists that a fair proportion of the heifers may not have ovulated at the first standing heat.

It is generally accepted that the mating of yearling heifers could substantially increase total calf production from the beef herd (Pinney et al., 1972; Bernard et al., 1973; Carter & Cox, 1973; Young, 1974; El Amin, 1976). Despite this potential advantage, mating at such an early age is not commonly practised in commercial beef herds. This is probably due to the belief that mating at too early an age will result in permanent stunting and delayed reconception (McCampbell, 1920 cited by Pinney et al., 1972; Snapp & Newman, 1960; Tracey, 1963). Despite reports of permanent stunting, no scientific evidence, based on skeletal measurements, was found to substantiate these statements.

In this trial body mass and seven skeletal measurements were recorded to indicate growth of the female animal. It is obvious from the results that calving at two years of age had no depressing effect on any of the eight growth variables measured. Only in two instances, body mass at two years (Fig. 3.4) and height of withers at three years (Fig. 3.5), did early calving have a depressing effect ($P < 0,05$) on growth. In both these cases the differences had disappeared by the following year. The slight decrease in body mass and heart girth recorded between the fourth and the fifth year, for the cows calving for the first time at three years, is probably due to the stage of pregnancy at those times. No correction was made in the analyses for stage of pregnancy. Trends which favoured three-year-old calving were revealed for height at withers and height at rump. The findings on height at withers are in accordance with the trend reported by Pinney et al. (1972). They found that earlier maturing traits such as length of the long bones (wither height) were more susceptible to stress. Amongst the cows calving for the first time at three years, the decrease in wither height recorded between the fourth and the fifth year, may be an artefact and simply the reflection of limited animal numbers.

The significant relationships recorded in this trial between body mass and the seven other growth measurements for one and two year old cows, (heart girth, depth of chest, height of withers, rump height, width of hips, thurl width and length of body) substantiates the findings of Shioya, Obata & Fukuhara (1975). The importance of circumference of heart girth for estimating body mass, irrespective of age at first calving, is illustrated by the square root function in Fig. 3.11. On the other hand, Berge (1977) studied 176 heifers and cows ranging in age from 1,84 to 4,49 years and recorded a linear relationship between heart girth and body mass.

The data on milk production indicated that the milk yield of three- and four-year-old cows was not influenced by age at first calving (Table 3.6). Cowan, O'Grady & Moss (1974) found livemass at calving to be related to milk production, and not age at first calving. In the present investigation the milk yield was significantly influenced by the age of the animal. Four-year-old cows produced significantly ($P < 0,05$) more milk than three-year-old cows, while the latter in turn yielded significantly ($P < 0,05$) more than two-year-old cows. The reduction in milk yield from the first until the fifth month of lactation was more marked among the two- and three-year-old cows than the four-year-olds. The difference in milk production, expressed as a percentage of the milk yield at one month, for the two- and the four-year-old cows, was 51% and 10%, respectively. The decline in milk production over the lactation period under discussion, was therefore more rapid among the two-year-old cows than the four-year-olds. When Cummins & Kroker (unpublished data) used two-year-old Hereford heifers they observed a peak yield of 4 kg milk per day which had declined to two kg by the seventh month of lactation (Bishop, Cummins & Morgan, 1975). Very similar milk yields were recorded in this trial after one and five months of lactation.

The objective of the economic assessment of this trial was not to give a complete break-down of all costs involved, but rather to compare the total winter feeding costs (roughages and lick only) with the total weaner production derived from cows calving for the first time at two or three years of age (Table 3.8). The only report encountered which dealt in some way with the economics of early mating was that of Pinney et al. (1962). They found that beef females calving first at two years of age produced almost 0,8 more calves per cow over their entire production life at 10% less cost when compared with those calving first at three years of age. The results recorded in this trial revealed margins above winter feed costs of R16,44 and -R22,64, respectively, for cows calving for the first time at two or three years. The difference in margins is due to the greater weaner mass produced by the cows calving for the first time at two years. Although total winter feed costs were higher for these cows, primarily due to higher feed cost during the first winter, the income from total calf production was such that it offset the increased feed costs and still gave the best margin. Obviously, the difference would narrow if the assessment was made over the entire productive life of a cow. It is doubtful, however, if cows calving for the first time at three years could ever make up for the extra some fraction of one weanling calf produced by the cows calving at two years.

GENERAL CONCLUSIONS

The results recorded in this experiment generally agree with the numerous reports which have dealt with the effect of age at first calving on various productive and reproductive traits. The main conclusions are:

1. Two year old calving had no depressing effect on the eight growth variables measured from one year until five years of age. Although tendencies were observed in certain instances (height at withers and rump height) that favoured three-year-old calving, none were significant. These findings are therefore contrary to what people were led to believe some years ago, viz, that mating at too early an age would result in permanent stunting of the female animal. Other deterrents mentioned by Carter & Cox (1973), are the expectation of calving difficulties, the fear of physical damage to lightweight heifers joined with mature herd bulls and the smaller size at birth and weaning of calves born to two-year-old dams. Although increased calving difficulties and smaller calves at birth and at weaning were recorded with the two-year-old heifers, the advantages overwhelmingly favoured the mating of yearling heifers.

2. After five years, the average cow that had calved first at two years had produced 0,7 more calves and 129,8 kg more weaner mass than

those that calved first at three years. Pittaluga, Rovira & Madalena (1967) recorded 0,71 more calves from early calvers after four years, while Pinney et al. (1962) recorded 0,8 more calf per cow over their entire production life. The difference in weaner production between cows calving for the first time at two years and those at three years ranged from about 140 kg to 107 kg up to seven years (Bernard et al., 1973), and 154 kg over approximately 12 years (Pinney et al., 1972). Yearling mating therefore results in increased total lifetime production.

3. The relationship between body mass at joining and fertility as reported by other workers has been confirmed by the results in this study. Conception in yearlings increased concurrently with increasing joining masses from 215 kg to 285 kg at the rate of 8,3% for every 10 kg increase in body mass. No relationship was apparent for heifers mated at two years of age, indicating that the joining masses of these heifers may have been well above the target mass for two-year-old heifers. Martin (1976) listed a number of target masses (mass at which heifers are sexually mature and capable of production) of different breeds, example:

Breed	Target mass kg
Angus	250
Hereford	275
Shorthorn	245
Red Poll	265
Simmental x Hereford	300

The average mass at puberty of the Africander cross Sussex heifers used in this trial was 236 kg, but maximum conception was only achieved when the average mass at joining was 285 kg. From the literature and the results recorded in this trial it seems that the reproductive events around first breeding have not stabilised and that the exact reasons for non-conception of certain yearling heifers are not known.

4. A new concept in beef farming will only be applied by the farmer if it is an economically viable proposition. From the economic assessment, which was carried out on the results recorded over five years, it is clear that early calving was considerably more profitable than the more

86/.

accepted age at first calving, i.e. at three years of age. However, the difference in profitability was very much exaggerated in this assessment and it is obvious that the difference would diminish if calculated over the entire productive life of the cow. However, it is doubtful if the cows calving for the first time at three years could ever make up the arrears.

CHAPTER 4

THE RELATIONSHIP BETWEEN BODY MASS AND FERTILITY OF BEEF COWS OF DIFFERENT AGES

INTRODUCTION

A considerable amount of research has been devoted to the effects of undernutrition on the reproductive performance of beef cows. Review articles by Lamond (1970), McClure (1970), Terblanche (1974) and Topps (1977) and additional information edited by Cunha, Warnick & Koger (1967) and Preston & Willis (1974) have dealt with this topic rather extensively. Throughout these reports there has been the inference that adequate nutrition, both pre and post partum, is of vital importance in order to sustain good reproductive performance in beef females.

Preston & Willis (1974) maintain that a rising plane of nutrition during the breeding season is the most important requirement to secure high calf crops. This contention is supported by McClure (1965), who supplemented cows with hay from calving until three weeks after service and recorded a 62% conception rate to first service, compared with 13% for unsupplemented animals. Bauer (1965) provided supplementary feeding to 66 three-year-old Herefords of which 83% calved compared with 13% of 70 animals not supplemented. Warnick, Kirst, Burns & Koger (1967) also showed that the change in mass of Brahman and Santa Gertrudis cows during the breeding season significantly affected pregnancy rate. The data of Wiltbank et al. (1962, 1964) and Dunn et al. (1964) provides further evidence to support the belief that breeding cows should be improving in condition during the mating period.

Parker, Waldrip & Marion (1966) did not observe an effect of nutrition on calving performance and concluded that the failure to demonstrate a response was due to the overall fertility of the cows being very high. Similarly, Meaker (1974) recorded only a 25% conception rate among Africander cows that had gained 10 kg in body mass from 14 days post partum until the end of the mating season, whereas the conception rate was 87,5% when cows had lost 54 kg in body mass over the same period. The results achieved by Meaker (1974) are therefore at variance with the belief that a breeding animal must be gaining in mass in order to conceive.

The results also suggested that there was a relationship between body mass at the end of the breeding season and the rate of conception. It was found that as the body mass of the cows at the end of the mating season decreased from 435 kg to 378 kg, reconception decreased linearly from 87,5% to 25%.

This relationship supports the contention that a critical or target mass must be attained before conception can take place so as to result in normal fertility (Lamond, 1970). In more practical terms this means that the reproductive ability of cows will probably decline concurrently with a decrease in body mass below the target mass. Conversely, as body mass increases above the target mass, cows will tend to become subfertile due to excessive deposition of fat. Richardson, Oliver & Clarke (1975) examined the influence of body mass at the beginning and end of the mating season on conception rates. They concluded that the greater the loss in body mass over this period, the lower the subsequent calving rate. The hypothesis as formulated by Lamond (1970) is furthermore supported by the findings of Ward (1968), Trail, Sacker & Fisher (1971), Meaker (1975), Steenkamp, van der Horst & Andrew (1975) and Buck, Light, Rutherford, Miller, Rennie, Pratchett, Capper & Trail (1976).

According to Broster (1974), this positive relationship between live mass and fertility in the cow has not been consistently demonstrated. Munro (1970, unpublished) analysed a large number of data and failed to produce a conclusive result regarding the relationship between fertility and live mass change for cattle (Broster, 1973). Similarly, Whitman, Remmenga & Wiltbank (1975) found that when he fed Aberdeen Angus and Hereford cows, aged 2 - 11 years, various levels of energy before and after calving the cows gaining in mass before calving had a greater likelihood of oestrus 50 days post partum than those which lost mass before calving. However, neither body mass change before breeding nor body condition at first breeding affected the incidence of pregnancy.

Although numerous reports have demonstrated a positive relationship between body mass and fertility, much controversy still exists regarding the target mass concept. For instance, what is the target mass for a specific breed and age of cow? The objective of this study was therefore to determine relationships between body mass at the start and at the end of the mating season and conception of Africander, Sussex and

Africander cross Sussex cows, grouped in age classes ranging in age from two years to adult cows (five years and older).

PROCEDURE

Records on the reproductive performances of 920 Africander, Sussex and Africander cross Sussex cows, ranging in age from yearlings to adults, were examined. The older cows were mostly of Africander type, while the offspring tended to be more of Sussex type. For the purposes of this study, no reference will be made to specific breeds, but rather to types, i.e. the Africander and Sussex breeds will be referred to as Zebu and British beef types.

The data was obtained over a six year period. The animals were maintained on the Dundee Research Station where controlled mating seasons were used viz, 45 days for heifers and 65 days for all other females. Only Sussex bulls were used.

Body mass at the start and at the end of the breeding season was recorded for all the animals. Percentage gain in mass over the mating season, body mass at the start and end of the winter, percentage gain or loss over the winter and peak autumn mass (approximately the first week in March) were also recorded for cows five years and older. All the above recordings were for pregnant and or lactating cows.

In order to examine the relationships between body mass and fertility, the animals were divided into the following age groups (numbers in brackets refer to number of animals used in the calculations):

Age group:

1	Heifers one-year old and mated for the first time	(132)
2	Heifers two-years old and mated for the first time	(87)
3	Cows two-years old and mated for the second time	(47)
4	Cows three-years old and mated for the second time	(38)
5	Cows three-years old and mated for the third time	(36)
6	Cows four-years old, irrespective of the number of calves produced	(98)
7	Cows five-years and older, irrespective of the number of calves produced	(482)

Within each age group, the cows were divided into equally spaced categories of body mass (X) and the percentage conception (Y) was calculated for each category. When animal numbers were limited (e.g. Groups 4 and 5), only a few categories of body mass were possible. On the other hand, when numbers were not limiting (e.g. Groups 6 and 7), the animals were divided into a greater number of body mass categories. It was obvious that only linear regressions could be fitted to some data as animal numbers were limiting. When adequate numbers were available, however, square root and quadratic functions were fitted by least squares analysis. The function of "best fit" was established as that which resulted in the least residual sum of squares or maximum correlation coefficient. The goodness of fit of these functions was also tested by establishing, through observation, that systematic deviations did not exist between the observed and fitted values of Y.

RESULTS AND DISCUSSIONS

The relationships between percentage conception and mean body mass of yearling heifers, at the start and at the end of the mating season, have been discussed in Chapter 3 and were presented in Figs. 3.1 and 3.2. Although the relationship was not significant at the start of the breeding season, it is obvious that there was a tendency for conception to increase with increasing body mass. However, when the mean body mass exceeded 285 kg, the percentage conception tended to decrease, perhaps due to the heifers becoming too fat. It is doubtful, however, if the decrease in conception could be as drastic as presented in Fig. 3.1, hence the dotted line which has been used to illustrate the possible trend. From Fig. 3.1 it appears that the optimum mass at mating for yearling heifers, of British beef type, is approximately 290 kg.

A significant ($P < 0,05$) linear relationship was recorded between percentage conception and mean body mass of yearlings at the end of the breeding season. However, since conception tended to decrease when the mean body mass of the heifers exceeded 310 kg, it is doubtful whether the relationship could be linear, hence the fitting of a quadratic function. From Fig. 3.2 it is therefore possible to predict the conception rate of yearlings when the mean body mass at the end of the breeding season is known.

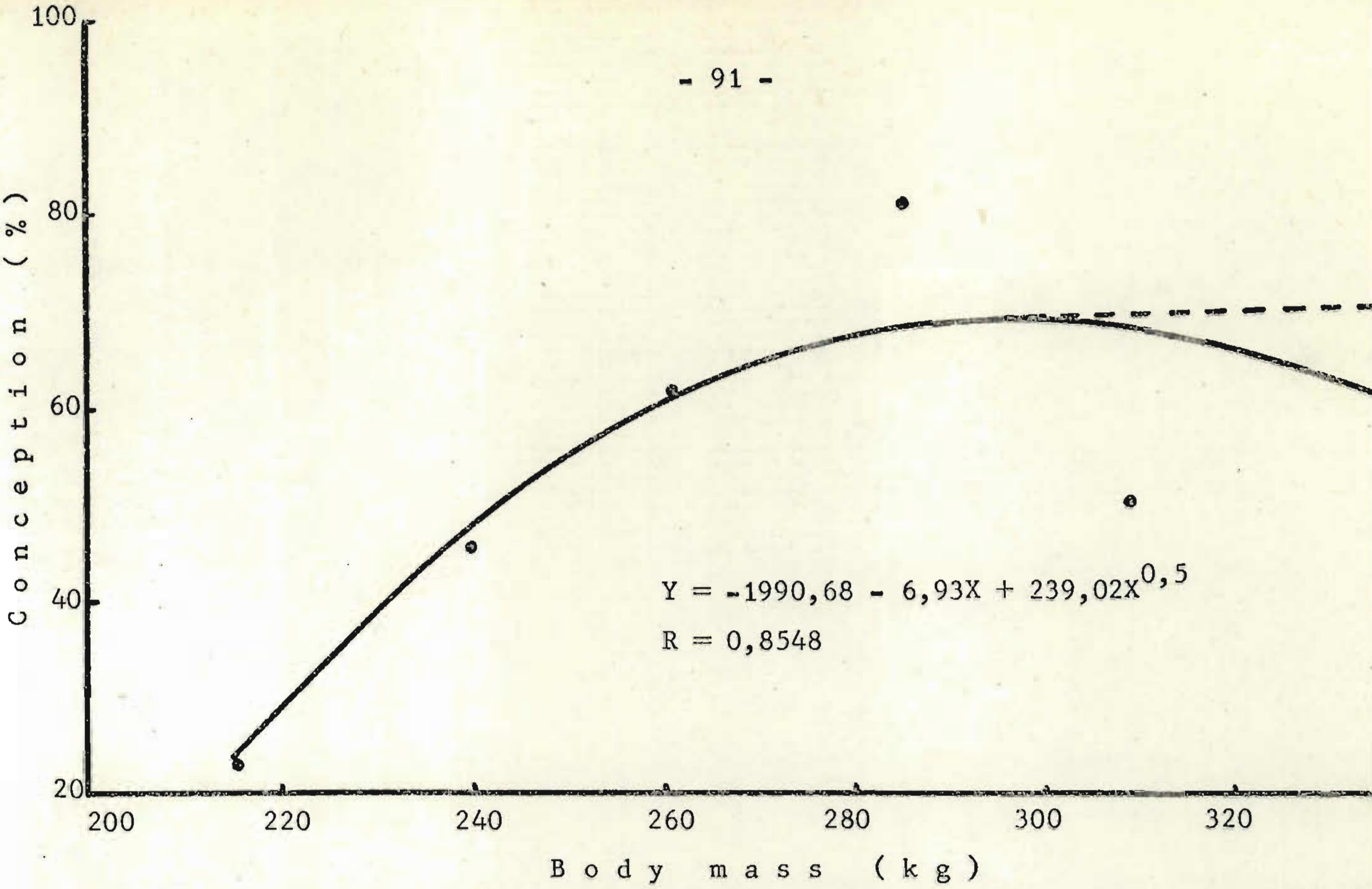

FIG. 3.1 : Relationship between conception and mean body mass of yearling heifers at the start of the mating season

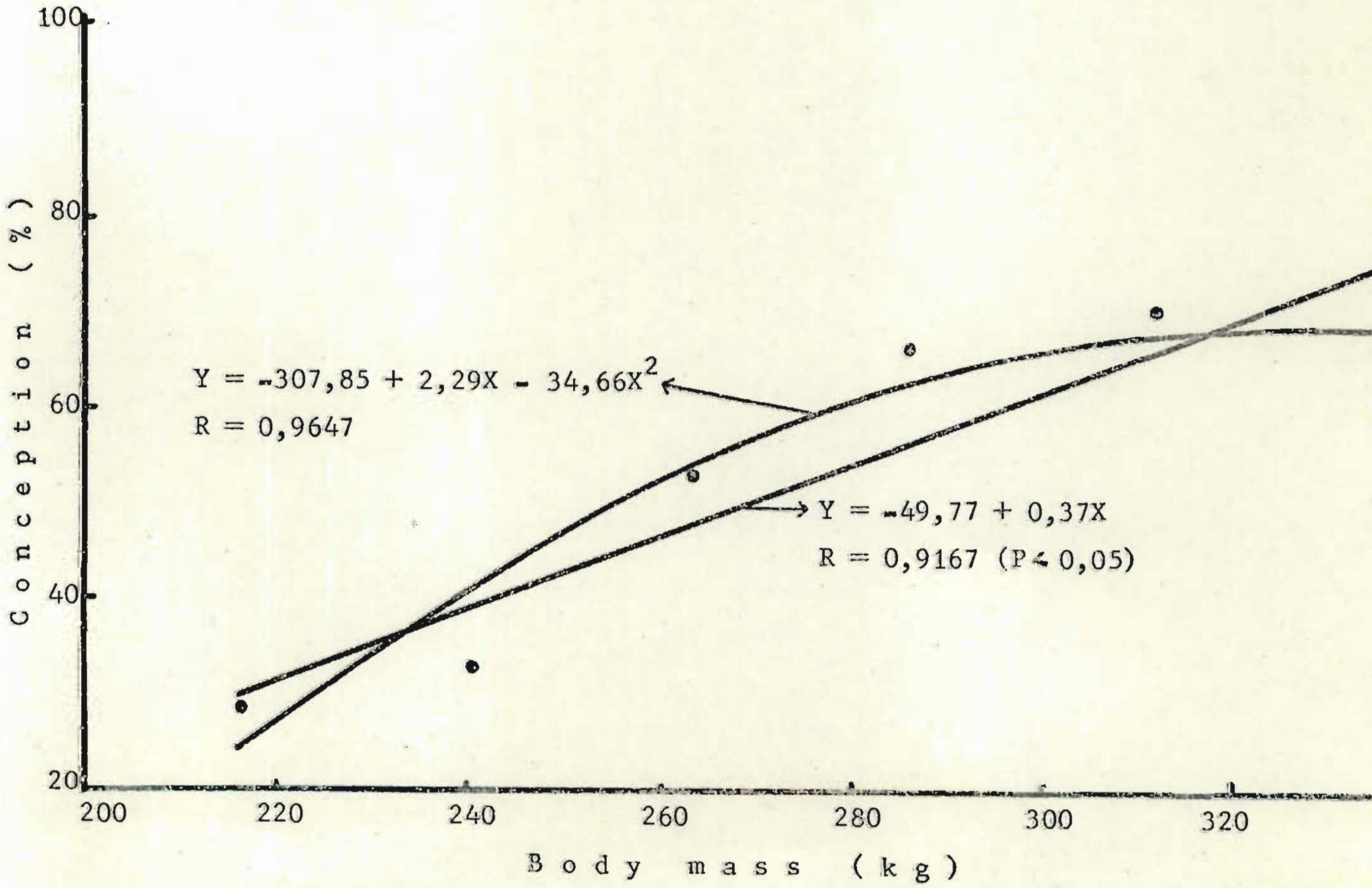

FIG. 3.2 : Relationship between conception and mean body mass of yearling heifers at the end of the mating season

No significant relationship was observed between percentage conception and mean body mass at the start or at the end of the breeding season of two-year-old heifers mated for the first time. Percentage conception did not vary greatly when the mean body mass of the heifers varied between 285 kg and 385 kg at the start of the mating season. These results tend to substantiate the findings of Broster (1973), with the exception that the present findings refer to a specific age group, while Broster studied dairy cows that received moderate to generous planes of nutrition. Harwin, Lamb & Bisschop (1967) found that mass at mating affected the reproductive rate of two-year-old Africander heifers. They recorded a calving rate of 100% when the mass at mating exceeded 318 kg and only 60% when the mass was 250 kg and less. It can be concluded therefore that the mean body mass of the two-year-old heifers used in this study was well above the minimum joining mass required for maximum conception. No definite joining mass for two-year-old heifers mated for the first time, can therefore be recommended. It would appear that the optimum joining mass for two-year-old British beef heifers mated for the first time ranges between 320 kg and 340 kg.

A significant ($P < 0,05$) linear relationship was noted between conception and mean body mass at the start of the mating season of two-year-old cows mated for the second time (Fig. 4.1). Although no decrease in conception was recorded above the maximum at 385 kg, it seemed pointless to feed these animals to above 385 kg as no extra benefit in conception could be expected. From Fig. 4.1 it appears that approximately 390 kg would be the optimum mass for maximum conception to occur. No significant relationship was recorded at the end of the mating season, but it was evident that a tendency existed for conception to occur more readily as the body mass increased (Fig. 4.2).

As with the two-year-old heifers mated for the first time, no relationship was evident between conception and mean body mass at the start or at the end of the breeding season of three-year-old cows mated for the second time. The results indicated (Table 4.1) that high conception rates were attained irrespective of whether the mean body mass at the start of the mating season was 350 kg or 450 kg. It would appear that this response was peculiar to the two- and three-year-old heifers mated for the first time and is in keeping with the findings of Broster (1973). The hypothesis that the animals had attained the minimum mass required

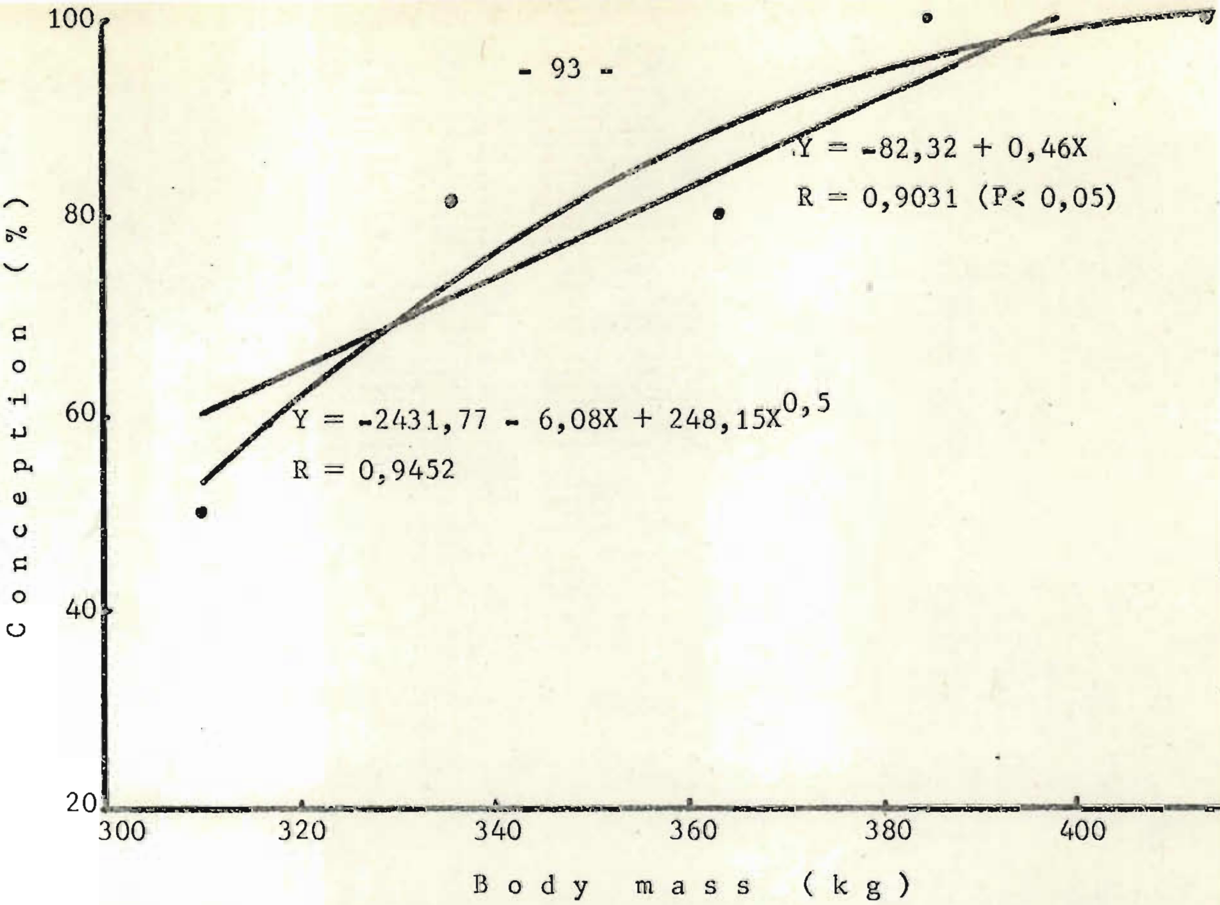

FIG. 4.1 : Relationship between conception and mean body mass at the start of the mating season of two-year-old cows mated for the second time

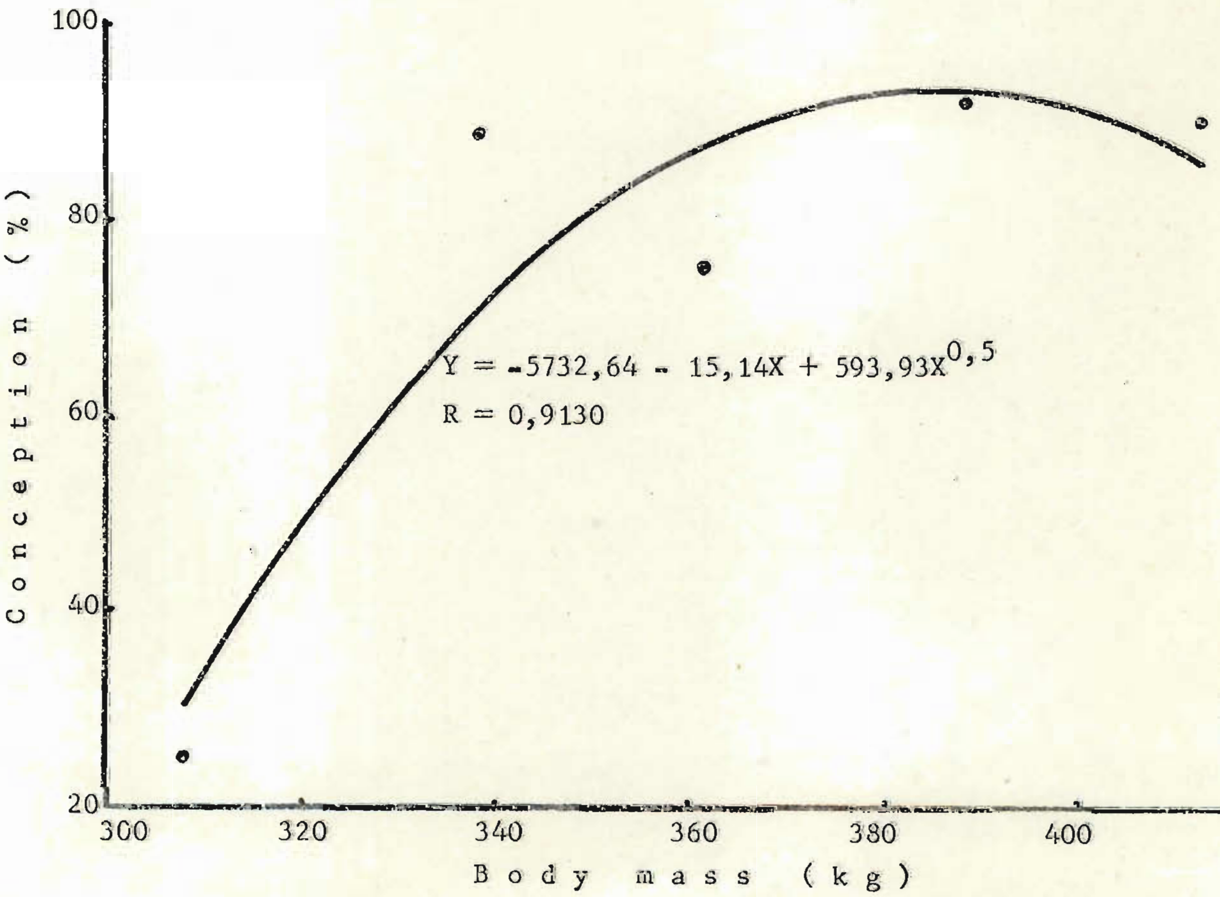

FIG. 4.2 : Relationship between conception and mean body mass at the end of the mating season of two-year-old cows mated for the second time

for maximum conception appears to have been substantiated by the present results. Thus, in this case, body mass had no significant effect on conception. Although animal numbers were limited for this group, the results showed that the optimum mass at mating was approximately 410 kg (Table 4.1).

TABLE 4.1 : Relationship between conception and mean body mass at the start and at the end of the mating season of three-year-old cows mated for the second time

	Body mass categories (kg)			
	340 - 370	371 - 400	401 - 430	431 - 460
Percentage conception according to body mass at:				
Start of mating season %	90	83,3	100	100
End of mating season %	100	70,0	100	100

Although the results of only 36 cows that were three years old and had been mated for the third time were available, significant ($P < 0,05$) relationships were obtained between conception and mean body mass, both at the start and at the end of the breeding season (Figs. 4.3 and 4.4). It is obvious from previous discussions that with the greater animal numbers available these relationships tended to exhibit curvilinear responses. It can therefore be expected that had there been more animals the same curvilinear relationship would apply for the group of three-year-olds. However, the relationship recorded was of the order of a 1,4% increase in conception for every 10 kg increase in body mass at the start of the mating season. Furthermore, according to Fig. 4.3 it appeared that maximum conception occurred when the mean body mass at mating was approximately 440 kg.

Significant ($P < 0,05$) quadratic relationships were recorded between conception and mean body mass at the start and at the end of the mating season of four-year-old cows (Fig. 4.5). It would appear that both functions follow the same trend, except that body mass of the cows at the end of the mating season was approximately 11 kg heavier than at the start. The decrease in conception rate due to overfatness at the onset of breeding is clearly demonstrated in Fig. 4.5. When the mean body

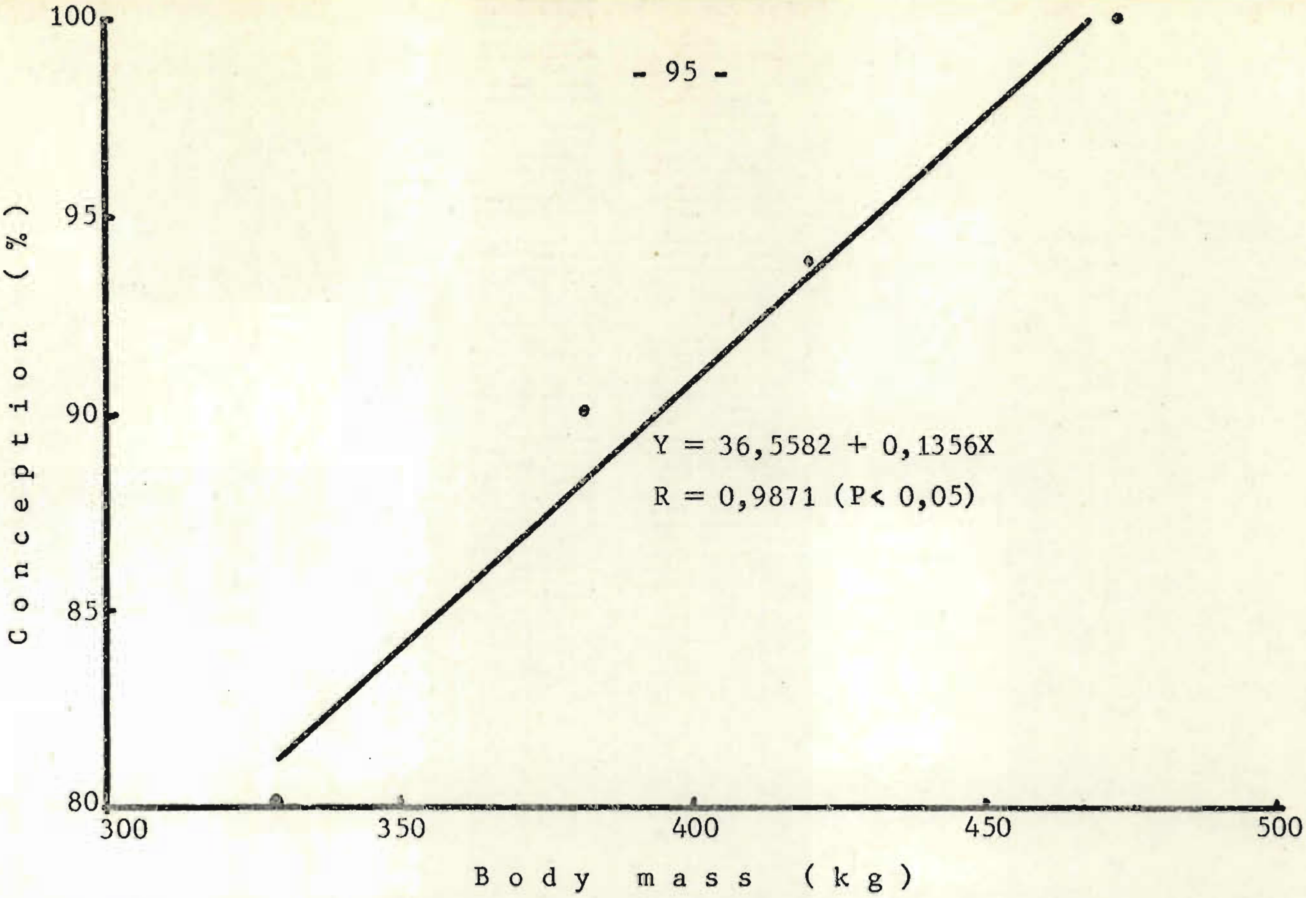

FIG. 4.3 : Relationship between conception and mean body mass at the start of the mating season of three-year-old cows mated for the third time

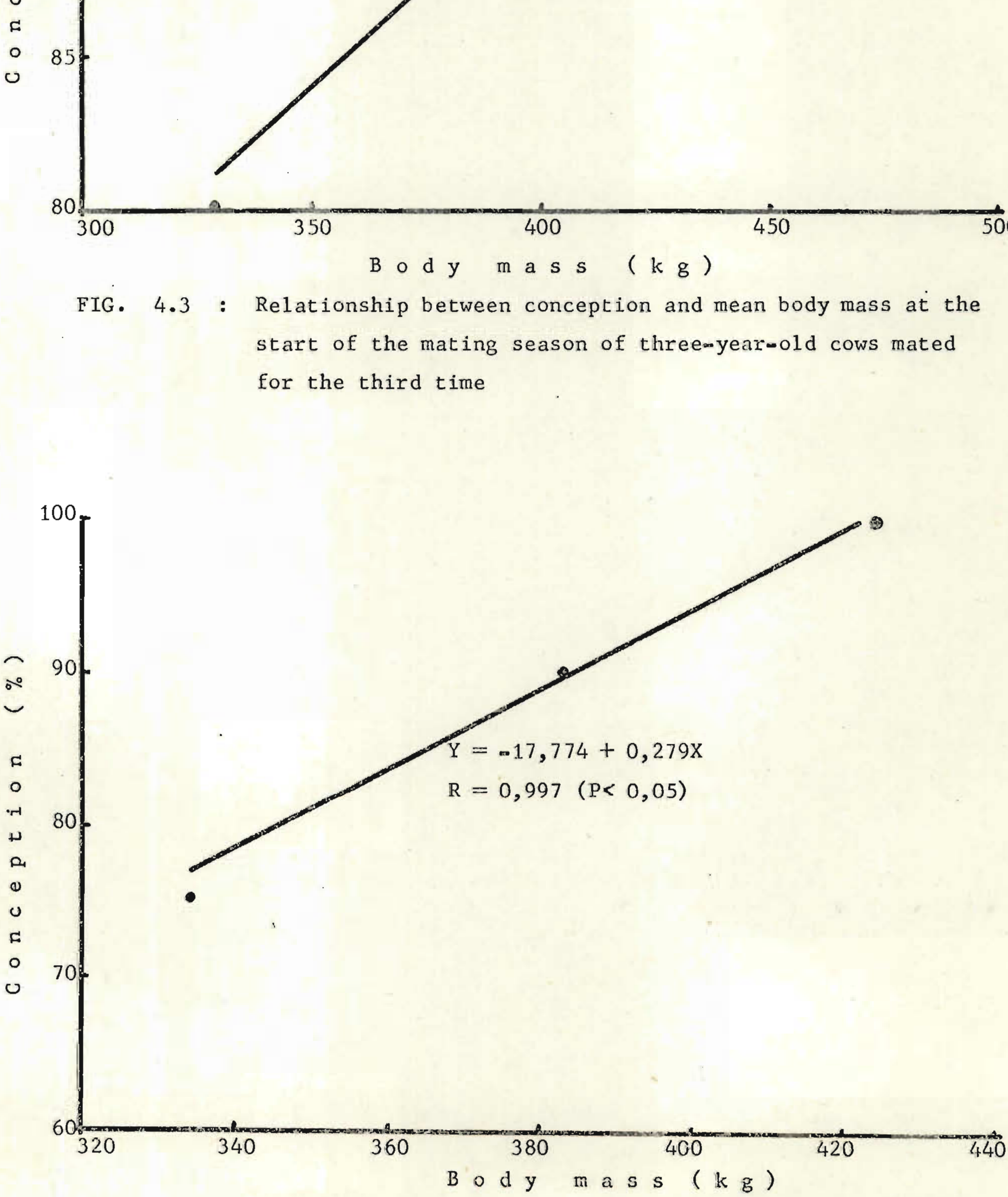

FIG. 4.4 : Relationship between conception and mean body mass at the end of the mating season of three-year-old cows mated for the third time

mass of the cows increased from 460 kg (where maximum conception was recorded) to 510 kg at the start of the breeding season, the percentage conception decreased from 93% to 78% (Fig. 4.5).

As with the four-year-old cows, highly significant ($P < 0,01$) relationships were recorded between percentage conception and mean body mass at the start and at the end of the mating season of adult cows (Fig. 4.6). From the graphs it is evident that the optimum mass at mating, to achieve maximum conception, was approximately 510 kg. Increased body masses thereafter resulted in no extra gain in conception rate. The tendency was rather for conception to decrease with increasing body mass above the optimum mating mass. It was also evident that a gain of say 40 kg in body mass favoured conception rate more in thin cows than that it did in well fleshed cows. For instance, there was an increase of 28% and 12% in conception rates when the body mass of cows at the start of the breeding season increased from 320 kg to 360 kg and from 420 kg to 460 kg, respectively (Fig. 4.6).

The mean peak autumn body mass of adult lactating cows recorded was $469,8 \pm 6,8$ kg ($n = 179$). Richardson et al. (1975) found a relationship between peak autumn mass and body mass recorded at the middle of the following mating season. They concluded that the estimated percentage body mass change from autumn peak to the following mating season, which would be followed by successful conception rates of 50%, 75% and 90%, were -14%, -6% and +1% of autumn body mass, respectively. Using this peak autumn mass hypothesis of Richardson et al. (1975) and the results recorded in Fig. 4.6, body masses calculated as a percentage of peak autumn mass were interpolated for different conception rates. For conception rates of 50%, 75% and 90%, the changes in body mass from the autumn peak to the start of the mating season were -20,6%, -8,7% and +5,9%, respectively. These relationships are in close agreement with those recorded by Richardson et al. (1975) and could be regarded as a refinement of their results, since a far greater number of animals was used in the calculations presented here. Provided cows are not unduly stressed during the summer grazing season, the autumn peak mass can be used to great advantage in determining what gain or loss in body mass is required to attain a conception rate of 90%.

The calculated target masses for maximum conception for the different

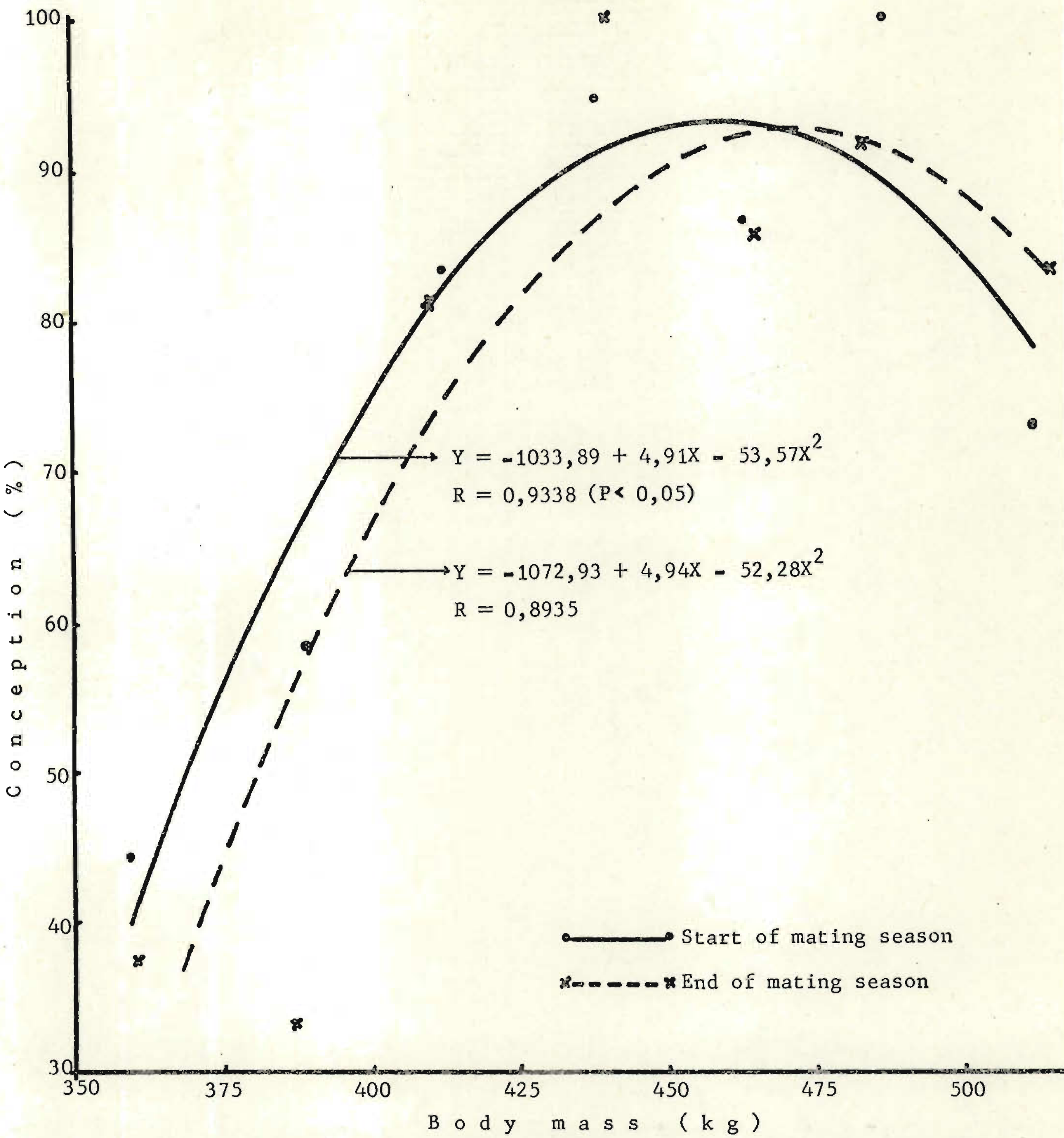

FIG. 4.5 : Relationships between conception and mean body mass at the start and end of the mating season of four-year-old cows, irrespective of the number of matings

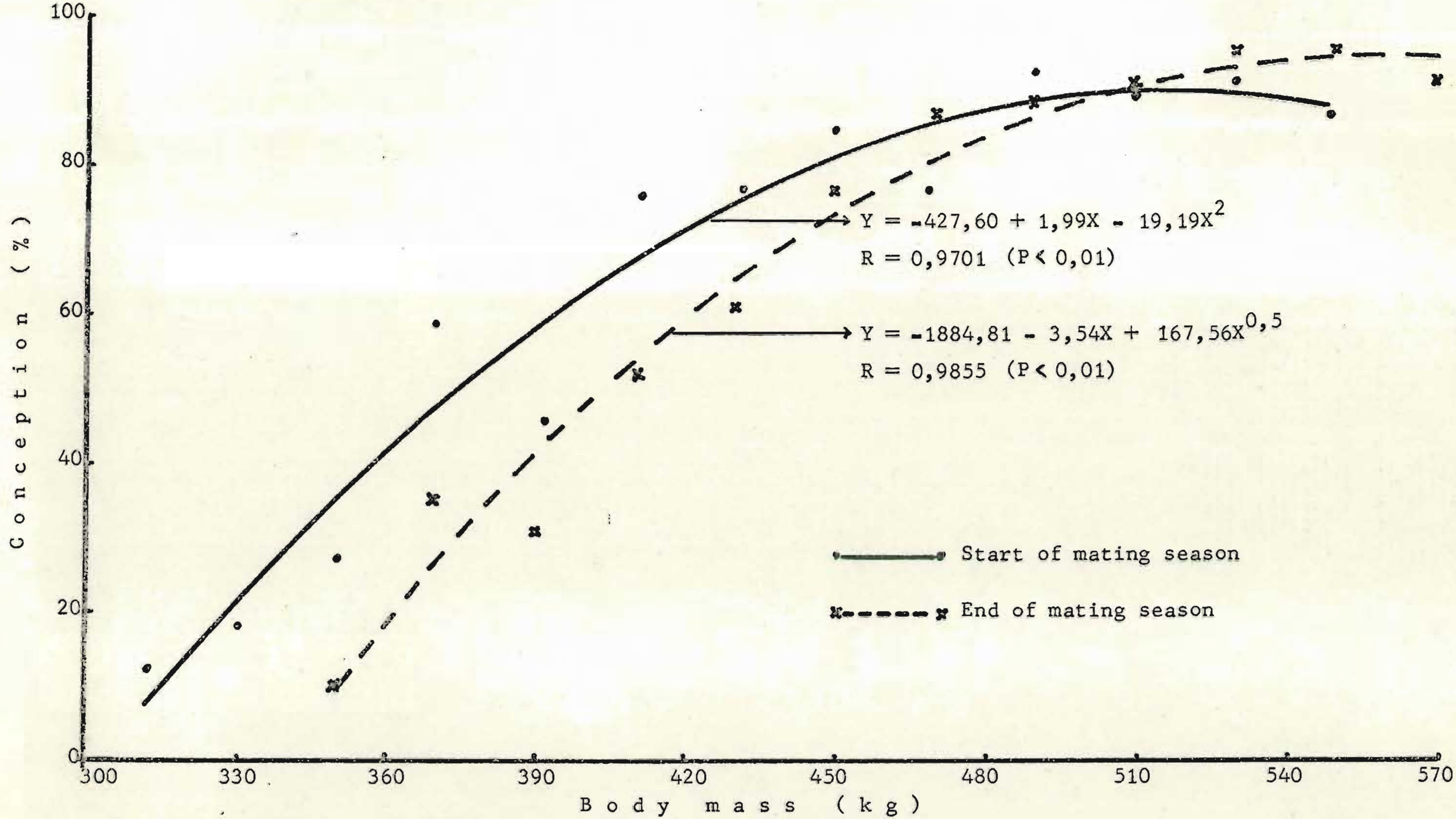

FIG. 4.6 : Relationship between conception and mean body mass at the start and at the end of the mating season of adult cows

aged animals (Figs. 3.1, 4.1, 4.3, 4.5, 4.6) were used to establish a relationship between target mass and age of the cow (Fig. 4.7). This relationship (for cows calving for the first time at two years of age) was linear and significant ($P < 0{,}05$). A highly significant ($R = 0{,}9923$, $P < 0{,}01$) linear relationship was established for cows calving for the first time at three years of age. However, since this function was based on both estimated and calculated target masses (Table 4.2), it was omitted from this presentation. It is obvious from the results that more information is needed on the relationship between body mass and conception of cows mated for the first time as two-year-olds. By using the regression which is illustrated in Fig. 4,7, the stockman would be able to determine what the target mass of any age of Zebu cross British beef type animal should be to ensure maximum conception. Obviously, the accuracy with which the target mass could be determined will depend on the correctness of the calculated or estimated individual target masses of each age group. Since the Zebu cross British beef type animal is very popular in the Republic, these relationships could be of great value to the operator in ensuring high conception rates of his cows.

No relationship could be determined between conception rate and mean body mass at the start of the winter, end of the winter, percentage gain or loss over the winter and percentage gain over the breeding season. The latter results support the findings of Richardson et al. (1975) and Steenkamp et al. (1975) who concluded that the ability to conceive is a function of body mass per se and not of gain during the post partum period.

GENERAL CONCLUSIONS

Having established relationships between conception rate and body mass at the start of the breeding season, it is now possible to recommend target masses at joining for cows differing in age (Table 4.2).

Obviously the suggested target masses will be less accurate if animal numbers are limited and where linear instead of curvilinear functions are fitted. It was evident from the results that animal numbers, and hence the number of categories of body mass that were possible, influenced the significance of the relationships. Furthermore, although

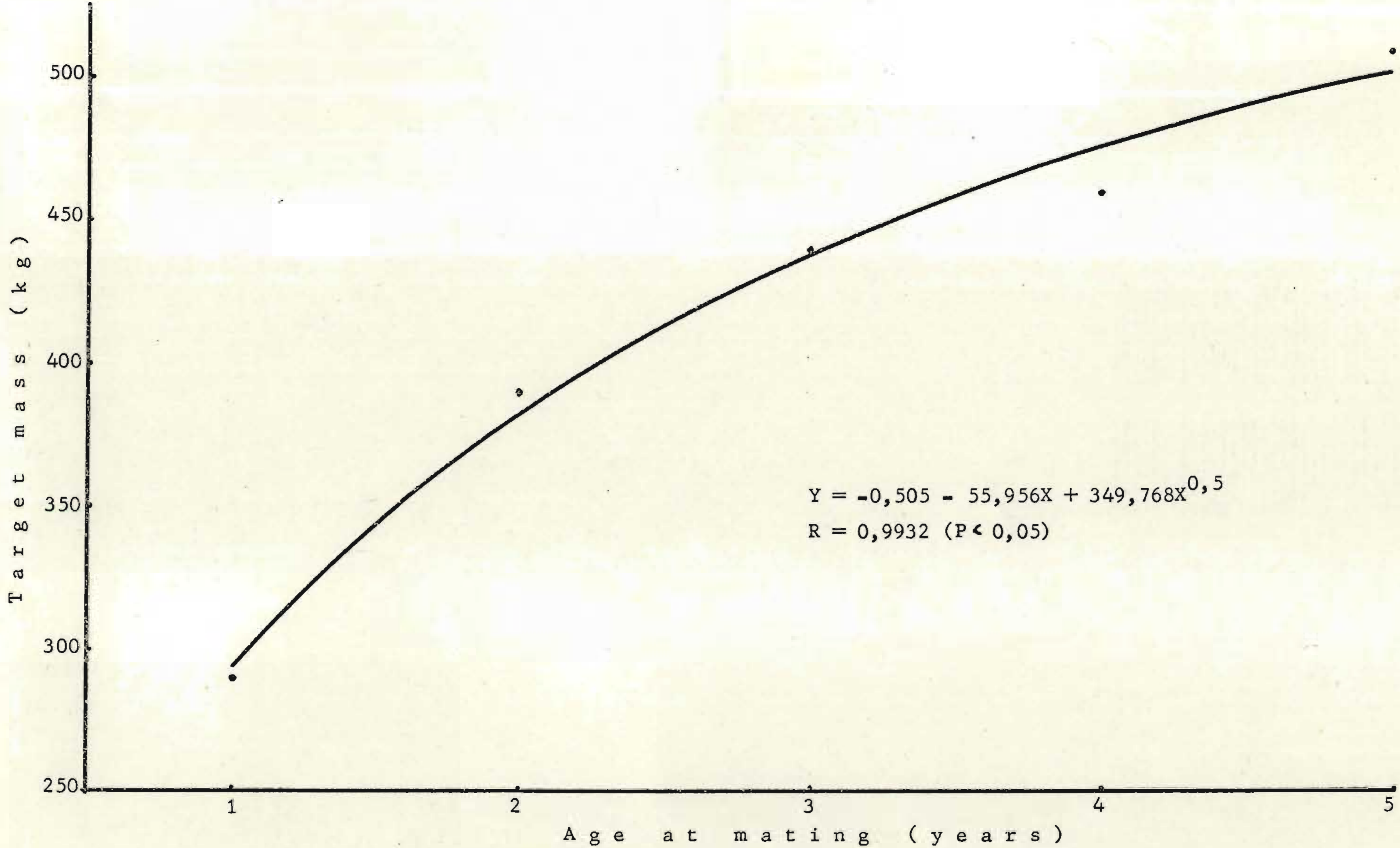

FIG. 4.7 : Relationship between target mass and age at mating of cows calving for the first time at two years of age

101/.

lation could be established for the yearling heifers, no signific that there was a trend for conception rate to increase ig body mass. The results also indicated that conception it was ed when cows became overfat (Figs. 4.5 and 4.6). This is with nt with the findings of Arnett, Holland & Totusek (1971) and 971). It appears, therefore, that the relationships between ion rate and body mass cannot be linear, but should rather fol- curvilinear response curve. When linear functions were fitted, s made the determination of target masses at joining more difficult. nly after greater numbers of animals become available, especially for age groups 1 to 6, and the fitting of curvilinear functions becomes acceptable, will it be possible to establish more accurate target masses at joining for the different aged animals.

TABLE 4.2 : Suggested target masses at joining to ensure maximum conception rates

Age group	Age and number of times mated	Suggested target mass
1	1 year - mated 1st time	290 kg
2	2 years - mated 1st time	330 kg
3	2 years - mated 2nd time	390 kg
4	3 years - mated 2nd time	410 kg
5	3 years - mated 3rd time	440 kg
6	4 years - irrespective of matings	460 kg
7	Adult - irrespective of matings	510 kg

In his review article on the target mass hypothesis, Lamond (1970) refers to age and breed of beef animals as being the limiting factors in the general application of this concept in practice. The results recorded in this study have made it possible to attach a numerical value to the effect of age (Fig. 4.7). The application of this curvilinear function could have a dramatic impact on the national calving rate in that the manager knows well in advance what the target mass of a specific age-group of beef females should be in order to ensure maximum conception. A major limitation, however, is that this response-function is of application only to a Zebu cross British beef type animal.

Although much variation between types of cattle can be expected, i.e. between Zebu, dual purpose and British beef types, the principle of establishing target masses at breeding needs closer attention. This could become the focal point at which the stockman must aim his management in order to achieve high calving rates. From Figs. 3.2, 4.2, 4.4, 4.5 and 4.6 it should be possible to predict the reconception rates of cows of different ages when their average body mass at the end of the breeding season is known.

Having established target masses for Zebu cross British beef type animals of different age groups, it now depends on the ability of the manager to ensure that the cows acquire the predetermined target mass at bulling in order to ensure maximum fertility. According to Lamond (1970), there are two extreme methods of achieving this optimum mass in the animals. One is to let them calve down in moderate body condition and to feed heavily before joining with the bulls. The other is to get as much body condition on the cows prior to calving and then to maintain this body condition until breeding commences. However, Hale (1975) suggests that the concept is not as simple as suggested by Lamond (1970). Hale (1975) undernourished dry cows until sexual activity ceased. For a further three months these cows were undernourished and none of the cows cycled during that period. After the three months these cows were again fed to gain in mass, but did not recommence cycling until the cows had reached a mass which was significantly greater than at which they had stopped cycling. This study indicated that it may be more efficient to maintain animals in a reasonable condition rather than to allow them to lose mass and then to attempt to replenish the lost condition immediately prior to mating.

Another important aspect which emerged from the present results was the failure to show relationships between conception rate and body mass for all the age groups under discussion, viz two-year-old cows mated for the first time and three-year-old cows mated for the second time. These results are not unique since Broster (1975) also failed to show relationships between body mass change and fertility for lactating dairy heifers. Broster (1975) suggested that the cows may have been operating within an optimum range. In more simplistic terms, the heifers used in the trials reported here may have been fed on too high a plane of nutrition. This could have resulted in the mean body mass of the heifers being well above the suggested target mass, but not so high that it lead to obesity and impaired fertility. The necessity for establishing target masses for both the two- and three-year-old heifers and mated for the first time, is clearly illustrated. Unnecessarily high planes of nutrition for both these groups, not only resulted in a wastage of expensive conserved winter feed, but also lead to no improvement in the conception rates.

In practice the objective of the manager should be to determine, first of all, the target mass of his cows, i.e. the optimum mass at joining that will result in maximum conception. Instead of using the different relationships (for each age group), the manager now only needs to refer to the function illustrated in Fig. 4.7 to determine the target mass for his cows. This will naturally vary with type of animal as the relationship established here, applies to a Zebu cross British beef type of animal. Obviously, no set recommendation can be made of how to achieve the target mass, since it will depend greatly on the farm situation. What is apparent, however, is that it is very much an economic question and may mean a compromise between winter feeding of conserved roughages, and supplementation of protein and/or energy during the early part of summer, immediately prior to breeding.

SUMMARY

Chapter 1

Two experiments were conducted to investigate the effects of supplementary feeding of locally produced feeds during winter on the reproductive performance of the beef cow. The experiments commenced in 1971 and 1972 and continued for one and four years respectively. A third experiment started in the early summer of 1973 and continued for three years. In the latter experiment, the effects of supplementation of protein and/or energy to lactating cows during a 100 day period post calving, on the reproductive performance of the beef cow, were studied. The following were the main conclusions:

Experiment 1

1. Rested winter veld, when used to overwinter pregnant and lactating beef cows, was unable to supply the necessary nutrients, despite the fact that the cows received a protein (NPN) lick during the winter. Hence a reconception rate of only 25% was recorded when cows had access to rested winter veld plus the NPN lick.

2. A dramatic increase in reproductive performance was recorded when cows were supplemented during the winter with maize silage and/or *E. curvula* hay. The reconception rates of cows overwintered on either silage *ad lib.*, *E. curvula* hay *ad lib.* or silage and hay *ad lib.* were 87,5%, 68,2% and 79,2% respectively.

3. The voluntary DM intakes of cows in the Silage, Silage-Hay and Hay groups were 3,2%, 2,7% and 1,7% of their body mass, respectively. The increased reconception rates of the cows in the respective groups were in accordance with their voluntary DM intakes.

4. A relationship was observed between change in body mass over the winter period and reconception. With a change in body mass of the cows from the respective groups over the winter period of 5,5%, 2,2%, -2,4% and -22,3%, the resultant reconception rates were 87,5%, 79,2%, 68,2% and 25,0%.

105/.

5. No relationship was evident between body mass gains of cows over the mating season and reconception rate.

6. A relationship was recorded between body mass of cows at the start of the breeding season and rate of reconception. As the body mass of the cows at this time increased from 334,9 kg (Veld group) to 422,2 kg (Silage group) the reconception rate increased from 25,0% to 87,5%.

Experiment 2

1. Problems were encountered in calculating an average calving percentage for the three systems. It would appear, however, that there was no difference between the three systems with regard to calving percentage (estimated average 86%), birth mass of calves - range 32,0 kg (Hay) to 33,0 kg (Silage) and intercalving period - range 378,8 days (Silage) to 375,5 days (Silage-Hay). It was concluded that all three systems were equally effective in overwintering beef cows and maintaining reproductive performance.

2. Over the four year period the average weaning masses of the calves in the Silage, Hay and Silage-Hay systems were 210 kg, 199,7 kg and 213,8 kg respectively.

3. The average total winter feed costs per cow for the Silage, Hay and Silage-Hay systems was R33,92, R32,19 and R33,17, respectively, while the margin above feed costs for the three systems was R38,32, R36,51 and R40,38 per cow. The differences in margins were affected by the differences in the weaning masses of the calves.

4. Although the Silage-Hay system returned the best margin above winter feed costs, this system is not merely recommended. Due to the additional heavy capital investment necessary for the production of both these roughages, it was suggested that either one or the other should be used. Furthermore, it was suggested that the Silage system was likely to be better than the Hay system.

5. Neither of the three systems supplied a balanced diet to the cows. During the pre calving period all three systems supplied amounts of CP and TDN which greatly exceeded the requirements. It was obvious there-

fore that no serious deficiency existed as regards CP and TDN, but rather an excess of nutrients supplied. During the post partum period the three systems more or less satisfied the requirements of the cows. It was suggested that cheaper feeds, such as maize stalks, veld hay, rested winter veld or any other low grade roughage could be used during the pre partum phase of overwintering so as to decrease winter feeding costs. Winter feed cost (roughages only) represented approximately 39% of the total income.

Experiment 3

1. The average recalving percentage over the three seasons for the cows receiving energy-rich-, natural protein-, and non protein nitrogen supplements and for the Control cows was 96,0%, 85,8%, 85,8% and 73,1% respectively.

2. There were no significant differences in the intercalving periods between the four groups. However, 92% of the cows receiving protein and energy supplements had calved within 30 days of the onset of the calving season while only 75,7% and 82,5% had calved during the same period in the Control and NPN supplemented groups, respectively.

3. The average CP content of clipped grass samples at the Dundee Research Station for the summer, autumn, winter and spring periods was 5,88%, 4,20%, 3,80% and 5,67%, respectively. The Ca and the P content of the same samples showed no great variation over the four seasons and averaged 0,17% and 0,11% for Ca and P, respectively.

4. Based on assumptions concerning the average intake of a lactating beef cow and the chemical composition of the grass sward, it was estimated that the veld supplied 90%, 65%, 65% and 42% of the TDN, CP, Ca and P requirements (NRC, 1976) of the lactating beef cow. The fact that forage selected by beef cattle contained approximately 25% more protein than clipped samples was also taken into account. Accordingly it was suggested that lactating beef cows should be able to satisfy the majority of their nutritional requirements, except P, from veld grazing. However, the performance of the cows was not in keeping with this hypothesis since the cows receiving TDN or protein supplements consistently returned better reproductive performances than the Controls.

107/.

5. The cows receiving the energy-rich supplement returned the highest margin above supplementation (R66,99) while the cows that received the natural protein supplement returned the lowest margin (R51,58).

6. The limitations of a field experiment of this nature was clearly borne out. It was impossible to ascribe the results solely to either energy or protein and it was concluded that further studies be carried out in order to establish the mechanisms which control these responses.

Chapter 2

Commencing in the winter of 1977 a 2 x 3 factorial experiment was designed to study the effects of two pre-calving and three post-calving levels of nutrition (calculated on a TDN basis) on the productive and reproductive performance of adult Africander, Africander cross Sussex and Sussex cows. The following were the main conclusions:

1. The reproductive performance of the cows was not affected when they lost 22 kg (4,4%) during the last 93 to 135 days before calving, provided they were well fed after calving.

2. The level of nutrition post calving was not directly related to percentage conception. For the groups receiving the High, Medium and Low levels of nutrition after calving, the percentage reconception was 82,6%, 41,0% and 50,0%, respectively. Possible reasons for the inconsistency in reconception rates were discussed.

3. Post calving nutritional levels influenced the interval to first post partum oestrus while nutritional levels <u>pre partum</u> had no effect. The intervals to first post partum oestrus for the cows in the High, Medium and Low groups were 64,6 days, 73,9 days and 72,3 days, respectively.

4. The incidence of first post partum oestrus, within the first 95 days after calving, for the cows in the High, Medium and Low groups was 78,4%, 36,4% and 54,6%, respectively.

5. There was a tendency for the body mass of the calves from the High group (<u>post partum</u>) to be higher (10,7 kg) than that of the Medium and

the Low groups. Pre-calving nutritional levels had no effect on the growth rate of the calves. It was suggested that the difference in the body mass of the calves at five months, in favour of the High group, was due to the higher milk production of the cows.

6. The average daily milk yield (average for daily milk yields recorded at one, three and at five months) for the cows in the High, Medium and Low groups was 4,85 kg, 4,28 kg and 4,01 kg per cow, respectively.

7. Because of the poor response recorded in terms of gain in body mass by the cows after calving, it was suggested that (i) the energy allowances recommended by NRC (1976) for cows during early lactation were insufficient, and (ii) that the TDN value for the E. curvula (54,4%) was over estimated.

Chapter 3

Commencing in the winter of 1973 and repeated in 1974 and 1975, an experiment was designed to study the effects of age at first calving (two vs three years of age) on the productive and reproductive performance of beef cows. The main observations and conclusions were as follows:

1. The average conception rate over the productive life of five-year-old cows that calved for the first time at either two or three years of age was 81,4% and 62,0%, respectively. The average conception rate of yearlings was 61,3%.

2. The average percentage dystocia recorded with the cows calving for the first time at two or three years of age was 8,1% and 3,2%. This resulted in an average percentage calves born alive for the two groups of 77,9% and 61,2%, respectively.

3. Possible reasons suggested for the increased occurrence of dystocia amongst the two-year-old cows were extremes of nutrition, birth mass of the calf and heifers not well grown.

4. The 205 day corrected weaning mass of calves that were born to cows calving for the first time at two years of age was disappointing and 15,9 kg lighter than those born a year later. This suggested the

introduction of a creep ration which increased the weaning mass of the calves of two-year-olds by 25,1 kg.

5. Weaning mass increased concurrently with age of the cow. The weaning masses for cows that were two, three and four years of age were 129,5 kg, 147,0 kg and 155,1 kg, respectively.

6. Cows calving for the first time as two-year-olds produced 0,7 more calves than those calving for the first time as three-year-olds when calculations were based on a productive life of five years.

7. When heifers were fed a high level of nutrition during winter this increased the mass by 14,7 kg and decreased the age by 13,8 days at puberty when compared with a low plane of nutrition. The average mass and age at puberty for Africander cross Sussex heifers was 236 kg and 342 days, respectively.

8. There was a tendency for conception rate to increase linearly at the rate of 8,3% for every 10 kg increase in body mass, when the mass of yearlings at joining rose from 215 kg to 285 kg.

9. Although the average mass at puberty was 236 kg, the highest conception (81%) was recorded when the average body mass at joining was 285 kg. This implied that higher conception rates were possible if a heifer was bred after several oestrous cycles.

10. Seven skeletal measurements, viz heart girth, body mass, height at withers, height at rump, depth of chest, length of body, width of thurls and width of hips were recorded at yearly intervals until five years of age, for cows that had calved for the first time at two or three years of age. Only body mass at two years and height of withers at three years were significantly affected by early calving. In both these cases the differences had disappeared by the following year. None of the remaining measurements were affected by early calving, indicating that two-year-old calving had no depressing effect on the growth of the cow until five years of age.

11. Significant relationships were calculated for the one and the two-year-olds between body mass and all the other growth variables. For older cattle the relationships varied in significance. Only heart girth

and depth of chest was significantly related to body mass for all the age groups.

12. A significant (R = 0,9404) curvilinear function was fitted to the relationship between circumference of heart girth (X) and body mass (Y).

$$Y = 4\ 715,2 + 4,0X - 270,1X^{0,5}$$

The importance of circumference of heart girth for estimating body mass, irrespective of age at first calving is reflected in this function.

13. Age at first calving did not affect the mean milk production of three- and four-year-old cows. However, age of the cow significantly affected milk production. The average total milk production for two-, three-and four-year-old cows recorded at one, three and at five months, was 8,49 kg, 11,63 kg and 15,20 kg, respectively.

14. The decline in the daily milk production over the first five months of the lactation was more rapid among the two-year-old than the four-year-olds. By the fifth month of lactation the milk production of the two- and the four-year-old cows had declined by 51% and 10% of the daily milk production at one month, respectively.

15. The margin above winter feed costs for the cows calving for the first time at two or three years of age, over four winters, was R16,44 and -R22,64 respectively. Obviously the tremendous difference would narrow if the assessment was made over the entire productive life of a cow. It is doubtful, however, if cows calving for the first time at three years could ever make up the arrears.

Chapter 4

Records on body mass and reproductive performance of 920 Africander, Sussex and Africander cross Sussex cows, ranging in age from yearlings to adults (five years and older) were examined. The data was obtained over a six year period and included: body mass at the start and at the end of the breeding season, percentage gain in mass over the mating season, body mass at the start and at the end of the winter, percentage gain or loss over the winter and peak autumn body mass. The animals were divided into equally spaced body mass categories, within age groups, and the results were then examined for relationships between body mass (X) and reconception (Y). For each age group, the following relations were calculated.

1. Yearlings - start of mating season

$$Y = -1990{,}68 - 6{,}93X + 239{,}02X^{0,5}$$
$$(R = 0{,}8548; \quad P > 0{,}05)$$

Yearlings - end of mating season

$$Y = -49{,}77 + 0{,}37X$$
$$(R = 0{,}9167; \quad P < 0{,}05)$$

2. No significant relationship was observed between percentage conception and mean body mass at the start or at the end of the breeding season for either two-year-old heifers mated for the first time or three-year-old cows mated for the second time. It was suggested that these animals had attained the minimum mass at the start of the mating season which was required for maximum conception.

3. Two-year-old cows mated for the second time:
start of mating season

$$Y = -82{,}32 + 0{,}46X$$
$$(R = 0{,}9031; \quad P < 0{,}05)$$

end of mating season

$$Y = -5732{,}64 - 15{,}14X + 593{,}93X^{0,5}$$
$$(R = 0{,}9130; \quad P > 0{,}05)$$

4. Three-year-old cows mated for the third time:
start of mating season

$$Y = 36{,}56 + 0{,}14X$$
$$(R = 0{,}9871; \quad P < 0{,}05)$$

end of mating season

$$Y = -17,77 + 0,28X$$
$$(R = 0,9970; \quad P < 0,05)$$

5. Four-year-old cows, irrespective of the number of matings:

start of mating season

$$Y = -1033,89 + 4,91X - 53,57X^2$$
$$(R = 0,9338; \quad P < 0,05)$$

end of mating season

$$Y = -1072,93 + 4,94X - 52,28X^2$$
$$(R = 0,8935; \quad P < 0,05)$$

6. Adult cows, irrespective of the number of matings:

start of mating season

$$Y = -427,60 + 1,99X - 19,19X^2$$
$$(R = 0,9701; \quad P < 0,01)$$

end of mating season

$$Y = -1884,81 - 3,54X + 167,56X^{0,5}$$
$$(R = 0,9855; \quad P < 0,01)$$

7. The mean peak autumn mass for adult lactating cows was 469,8 $\pm$ 6,8 kg (n = 179). For conception rates of 50%, 75% and 90%, the changes in body mass from the autumn peak to the start of the mating season were -20,6%, -8,7% and +5,9%, respectively.

8. A significant relationship was established between target mass and age of the cow.

$$Y = -0,51 - 55,96X + 349,77X^{0,5}$$
$$(R = 0,9932; \quad P < 0,05)$$

The practical application of this function viz, how to determine the target mass of different aged Zebu cross British beef type animals, was discussed.

9. No relationship could be determined between conception rate and mean body mass at the start of the winter, end of the winter, percentage gain or loss over the winter and percentage gain over the breeding season.

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