Conception rate of beef cows and growth of suckling calves as influenced by date of calving and supplementary feeding

A.W. Lishman
Department of Animal Science, University of Natal
A.D. Lyle, V.W. Smith and W.A. Botha
Cedara College of Agriculture and Research Institute, Pietermaritzburg

The influence of energy supplementation (2,8 kg maize meal) of beef cows during early lactation and of creepfeeding their suckling calves was investigated in two areas (Thornveld and Transitional Highland Sourveld). The cows were bred in spring to calve during the first (early calvers) or last six weeks (late calvers) of a 90-day calving season.

The gains in bodymass of the cows which calved early were significantly greater than for the late calvers. Energy supplementation had no major effect on the bodymass gains or reconception rates (CR) and intercalving intervals (ICI). In the Thornveld only 14,8 % of the variation in mass gain during early lactation was attributed to supplementation. Variation in the ICI depended largely (70,5 %) on the time of calving. In the Sourveld only 23,9 % of the variation in ICI was due to this factor. Cows which reconceived were heavier at calving and when mating ceased, gained more during the breeding period and had calved earlier than cows which did not reconceive ($P \leqslant 0{,}01$). The CR was closely associated with change in bodymass (Thornveld: $r = 0{,}72$; Sourveld: $r = 0{,}93$) and bodymass at the end of mating (Thornveld : $r = 0{,}87$; Sourveld: $r = 0{,}98$). Early-born calves gained at a faster rate than those born late in the Thornveld, but not in the Sourveld. Creepfeeding was beneficial for late-born calves suckled by cows which received energy supplements in the Thornveld. All creepfed calves benefitted in the Sourveld. In the Thornveld the bodymass at weaning was determined by the season of birth and creepfeeding (31,4 %) while in the Sourveld creepfeeding and bodymass of the dam at calving were significant contributors (23,1 %) to variation in weaning mass.
S. Afr. J. Anim. Sci., 1984, 14: 10 – 19

Die invloed van energiebyvoeding (2,8 kg mieliemeel) van vleisbeeskoeie gedurende vroeë laktasie en van kruipvoeding van hul kalwers is in twee gebiede (Doringveld en Oorgangstipe Hoëlandsuurveld) ondersoek. Die koeie is in die lente gepaar om gedurende die eerste (vroeëkalwing) of laaste ses weke (laatkalwing) van 'n 90-dae seisoen te kalf. Die koeie wat vroeg gekalf het, het 'n betekenisvolle hoër massatoename gehandhaaf as dié wat laat gekalf het. Energiebyvoeding het geen noemenswaardige invloed op massatoenames, of herbesetting en interkalfperiode (IKP) gehad nie. Slegs 14,8 % van die variasie in massatoename gedurende vroeë laktasie in die Doringveld kon aan byvoeding toegeskryf word. Variasie in die IKP was grootliks (70,5 %) aan die kalfdatum te wyte. In die Suurveld kon hierdie faktor slegs 23,9 % van die variasie verklaar. Koeie wat herbeset geraak het was swaarder by kalwing en by beëindiging van paring, het meer in massa toegeneem gedurende die paarseisoen en het vroeër gekalf as koeie wat nie weer beset is nie ($P \leqslant 0{,}01$). Die kalfpersentasie het 'n noue verband met verandering in liggaamsmassa (Doringveld: $r = 0{,}72$; Suurveld: $r = 0{,}93$) en met liggaamsmassa teen die einde van paring (Doringveld: $r = 0{,}87$; Suurveld: $r = 0{,}98$) getoon.

Kalwers wat vroeg gebore is het teen 'n vinniger tempo in massa toegeneem as dié wat laat gebore is in die Doringveld, maar nie in die Suurveld nie. Kruipvoeding was voordelig vir laatgebore kalwers van koeie wat energiebyvoeding ontvang het in die Doringveld. Alle kruipgevoerde kalwers in die Suurveld is bevoordeel. Die liggaamsmassa by speen is bepaal (31,4 %) deur die seisoen van geboorte en deur kruipvoeding in die Doringveld. In die Suurveld was kruipvoeding en liggaamsmassa van die moer by kalwing belangrik (23,1 %) by variasie in speenmassa.
S.-Afr. Tydskr. Veek., 1984, 14: 10 – 19

Keywords: Reproduction, beef cow, supplementary energy, time of calving, creepfeeding, growth of calf

A.W. Lishman*
Department of Animal Science, University of Natal,
Durban, South Africa
A.D. Lyle, V.W. Smith and W.A. Botha
Cedara College of Agriculture and Research Institute,
Private Bag X9059, Pietermaritzburg, South Africa
*To whom correspondence should be addressed
Received 1 March 1983

Introduction

The percentage calf-crop weaned is believed to be the most important single factor determining the profitability of the cow-calf operation (Snapp & Neumann, 1960). The calving rate may not be as important in the extensive ranching areas (Steenkamp, 1977) as in the more intensive, high rainfall areas; nevertheless, low calving rates are far too frequently encountered in such areas (Boulle, 1980).

In the absence of disease, inadequate feeding, particularly during the first few months after calving, is probably the main reason for the low reproductive rate encountered in farming practice (Joubert 1954; Warnick, 1959; Wiltbank, Rowden, Ingalls, Gregory & Koch, 1962; Bishop & Kotze, 1965). An energy deficiency at such times has been identified (Wiltbank *et al.*, 1962; Wiltbank, Rowden, Ingalls & Zimmermann 1964; Davis, Schalles, Kiracofe & Good, 1977).

Owing to the high cost of energy concentrates it is important to limit supplementation. This can be achieved by delaying extra feeding after calving until the reproductive mechanism becomes responsive to improved nutrition (Wiltbank *et al.*, 1964). This practice has the added advantage of increasing the cow's milk production at a time when the calf is most likely to be able to utilize the extra feed.

Inadequacies in milk production after the first three months of lactation can be compensated for by creepfeeding the calves (Heyns, 1960) so that the influence of "season of birth" on preweaning growth rate can be decreased (Marlowe & Gaines, 1958).

For the beef cow which grazes veld it is important to synchronize maximum need (early lactation) with the time when the grazing is at its best. Spring is therefore favoured as a calving time. However, because of the unpredictability of rains the quantity of the grazing is often limited, although the quality is good. Furthermore, when calving occurs four to six weeks prior to the onset of the spring grazing season, the growth of the calf is favoured. However, this situation is detrimental to reconception of the lactating cows (Harwin, Lamb & Bisschop, 1967; Bosman & Harwin, 1969). Where a 90-day mating season is followed, as many farmers do, the early calves commonly arrive at a time which results in the heaviest weaners. However, for several reasons many cows become pregnant towards the end of the mating period. Their calves are then dropped at a time which does not allow the calves to gain the maximum benefit from the early summer grass (Bosman & Harwin, 1966; Bonsma & Skinner, 1969).

Selection of a suitable calving season becomes a matter of optimizing preweaning growth of suckling calves and reconception of the lactating cow. The possible benefit of (i) supplementing the energy supplies of the cow which calves early and of (ii) offering a creepfeed so as to augment the lowered milk supply of the cow which calves late, formed the basis of this study.

Procedure

The effects of time-of-calving within the calving period (*i.e.* early or late), supplementary energy feeding of the lactating cow and creepfeeding of the calf were investigated in a 2^3 factorial experiment conducted at two localities (Thornveld or Transitional Highland Sourveld).

Calving times

At each locality the herd of Afrikander cows was randomly subdivided and the cows were mated to calve either during the first six weeks (early calvers) or last six weeks (late calvers) of a three-month calving season (Table 1). Afrikander bulls were used at the Onverwacht Research Station (Thornveld) while at the Kokstad Research Station (Transitional Highland Sourveld) the sires were Herefords.

The date of onset of the calving seasons in each area was, according to recommendations, based on information available at the time from the National Beef Performance Testing Scheme.

Energy supplementation

The energy concentrate consisted of 2,8 kg maize meal per day which was calculated to be the quantity required to satisfy the daily requirements of a lactating beef cow grazing spring grass. This supplement was supplied 30 days after parturition and continued until 60 days after the onset of the subsequent 90-day mating period. Group-feeding was followed, with each cow and her calf being drafted into the relevant group at the appropriate stage post-partum.

Creepfeeding of calves

The concentrate offered to the calves consisted of 80 parts maize meal and 20 parts peanut oilcake meal. It was fed from four months of age until the calves were weaned at 210 days. The daily allowance did not exceed 0,9 kg per calf per day.

General management

The lactating cows with their calves were grazed on summerveld and at weekly intervals the various treatment groups were interchanged within the available camps to minimize camp effects. Prior to calving the cows received a urea block in addition to the winter Thornveld (May to September). In the Sourveld the pregnant cows were overwintered on a daily ration of 13,5 kg maize silage, 4,5 kg *Eragrostis curvula* hay and a urea block. Normal practices of disease control, castration of male calves at three months of age and provision of calcium-phosphate licks were followed.

Breeding bulls were again joined with the cows for 90 days commencing on a date similar to that used for the early calvers (Table 1). During this breeding period the bulls were rotated weekly between the various subgroups.

The bodymass of each cow and that of her calf were recorded on the day of parturition and at four-week intervals until weaning. Reconception was based on calving data and not on pregnancy tests.

Statistical analyses

Least squares procedures were used to examine the changes in bodymass of cows and the growth of calves. Analyses of covariance were employed to correct for differences in cow mass at calving.

Treatment effects on the calving rate were tested by chi-square tests. Classification of cows into selected categories after pooling data over all treatments, permitted further examination of factors related to reconception. A stepwise regression (stepdown) procedure was applied to such data as well as to the change in bodymass of the cows during lactation and to the growth of the calves during the preweaning period.

Results

Lactating cows

Changes in bodymass according to time of calving

The changes in bodymass which occurred during the period when half the cows received the maize supplement (30 days post-partum to 60 days after initiation of breeding) indicated that the seasonal effects were minor (Table 2, Table 3). The average duration of this period was 84,8 days for the early calvers and 32,8 days for late calvers in the Sourveld, while in the Thornveld the respective periods were 85,2 and 28 days. Contrary to expectation, the average daily gains of the cows over the entire 210-day suckling period suggested that it was the late calvers which were under the greatest stress, both in the Thornveld and in the Sourveld (Table 3).

Supplementary feeding and bodymass change

In the Thornveld, provision of the energy supplement improved ($P \leqslant 0,01$) the average daily gains in bodymass during early

Table 1 Limits of the calving period for early and late calvers and timing of the subsequent mating period in two ecological areas of Natal

Locality	Time of calving within the season	n	Initial breeding period	Calving occurred	Subsequent breeding period
Thornveld	Early	43	16 December to 26 January	2 October to 14 November	20 December to
	Late	28	7 February to 19 March	20 November to 4 January	19 March
Sourveld	Early	33	16 October to 26 November	31 July to 3 September	15 October to
	Late	47	7 December to 17 January	16 September to 10 November	12 January

Table 2 Mean bodymass during the lactation period of beef cows calving at two stages of the season when fed an energy concentrate with suckling calves offered a creepfeed

	Feeding treatment				Average bodymass (kg)			
Locality	cow	calf	Time of calving	n	Parturition	Weaning	Parturition + 30 days	Onset mating + 60 days
Thornveld	Suppl.	Creepfed	Early	12	379,6	447,7	370,7	438,8
			Late	7	373,7	374,7	395,0	416,1
	Suppl.	Control	Early	12	378,7	421,9	363,1	420,8
			Late	10	393,5	399,5	408,7	430,7
	Control	Creepfed	Early	13	378,6	421,3	364,1	410,1
			Late	7	392,2	417,3	417,3	428,4
	Control	Control	Early	8	386,6	439,8	379,1	431,1
			Late	9	402,1	405,6	427,9	434,2
				SD	39,4	43,8	44,9	39,2
Sourveld	Suppl.	Creepfed	Early	9	466,9	482,5	451,8	455,5
			Late	13	405,8	395,4	390,3	393,8
	Suppl.	Control	Early	7	469,1	489,2	450,8	461,0
			Late	12	404,4	409,2	400,8	404,4
	Control	Creepfed	Early	8	433,5	447,3	407,0	414,8
			Late	12	413,2	397,6	392,9	399,4
	Control	Control	Early	9	444,5	461,9	416,7	431,2
			Late	10	417,7	402,5	397,7	407,5
				SD	84,4	68,6	63,2	60,5

Table 3 The effect of time of calving on bodymass changes of lactating cows

			Average daily gain (kg):	
Locality	Time of calving within season	n	Parturition to weaning	Parturition + 30 days to onset mating + 60 days
Thornveld	Early	43	$0{,}21^{a}$	$0{,}65^{c}$
	Late	28	$0{,}05^{b}$	$0{,}75^{c}$
			SE = 0,05	SE = 0,27
Sourveld	Early	33	$0{,}06^{a}$	$0{,}11^{c}$
	Late	47	$-0{,}04^{b}$	$0{,}18^{c}$
			SE = 0,05	SE = 0,27

^{a,b,c}Means in the same column relating to the same locality with different superscripts differ ($P \leqslant 0{,}01$).

Table 4 The effect of supplementary feeding with 2,8 kg maize meal on bodymass changes of lactating cows

			Average daily gain (kg)	
Locality	Treatment of cow	n	Parturition to weaning	Parturition + 30 days to onset mating + 60 days
Thornveld	Supplemented	37	$0{,}15^{a}$	$0{,}81^{b}$
	Control	34	$0{,}15^{a}$	$0{,}48^{c}$
			SE = 0,05	SE = 0,27
Sourveld	Supplemented	41	$-0{,}01^{a}$	$0{,}07^{b}$
	Control	39	$-0{,}07^{a}$	$0{,}22^{b}$
			SE = 0,05	SE = 0,27

^{a,b,c}For each locality, means in the same column with different superscripts differ ($P \leqslant 0{,}05$).

lactation (Table 4). However, this response occurred mainly amongst the late calvers (Table 5). Averaged over the entire suckling period, the effect of the energy concentrate was non-significant (Tables 4 and 5). Surprisingly, during early lactation in the Sourveld, both the early and late calving cows which were supplemented showed poorer gains than the controls (Table 4, Table 5). These trends were not evident over the entire 210-day lactation period.

The ADG during the period of energy supplementation was corrected (covariance) for the bodymass at calving. The overall trend of gains did not change and none of the differences were significant.

Regression analysis

The stepwise regression analysis was used to identify and quantify the effect of those factors which modified the influence of supplemental energy and of time-of-calving. The dependent variables were the average daily change in bodymass of the cows from 30 days after parturition until 30 days before the end of the 90-day mating period (Y_1) and from parturition until weaning of the calf (Y_2). The independent variables considered were those pertaining to the initial status of the cows (*i.e.* bodymass at calving and parity status) and to their experimental treatments (supplementation and time-of-calving). The factors associated with the calves that may have influenced the performance of their dams were creepfeeding and growth rate.

For the cows in the Thornveld the only factor found to contribute significantly to the change in bodymass from 30 days after calving until 30 days before the end of the mating period (Y_1) was "supplementation of the cow" (X_1) and the equation was,

$$Y_1 = 0{,}494 + 0{,}316X_1.$$

Only 14,8 % of the variation in Y_1 was accounted for in terms of X_1. When the change in bodymass of the cows from parturition until weaning of the calf (Y_2) was considered, 31,3 % of the variation was due to "time-of-calving" (X_3) and X_2 (bodymass of the cow at calving) accounted for a further

Table 5 Influence of time-of-calving and supplementary feeding on gain in bodymass of lactating cows

			Average daily gain (kg):				
			Parturition to weaning			Parturition + 30 days to onset mating + 60 days	
Locality	Time of calving	n	Control	n	Suppl.	Control	Suppl.
Thornveld	Early	21	0,20[ad]	22	0,23[ad]	0,54[bd]	0,73[bd]
	Late	13	0,07[ae]	15	0,02[ae]	0,36[bd]	0,95[cd]
	SD			0,05		0,27	
Sourveld	Early	17	0,08[ad]	16	0,07[ad]	0,17[bd]	0,07[bd]
	Late	22	−0,04[ad]	25	−0,02[ad]	0,26[bd]	0,06[cd]
	SD			0,05		0,27	

[a,b,c]Means in the same row with the same superscript do not differ ($P \geqslant 0{,}05$).
[d,e]Means in the same column with different superscripts differ ($P \geqslant 0{,}05$).

12,6 % to yield a total of 43,9 %. The equation was,

$$Y_2 = 0{,}764 - 0{,}0018\ X_2 + 0{,}002\ X_3.$$

The significant relationship established for the results obtained in the Sourveld was;

$$Y_1 = 0{,}403 - 0{,}162X_1 - 0{,}243X_4.$$

The negative coefficients for X_1 and X_4 supported the earlier conclusion that the supplementary energy in fact resulted in poorer gains while first calvers gained more than multiparous cows (X_4). Parity status (X_4) accounted for only 8,7 % of the variation in Y_1 and supplementation a further 5,1 % (total = 13,8 %).

In view of the relatively strong association between "parity status" (X_4) and "bodymass of the cow at calving" (X_2) the former was omitted from the model to determine whether X_2 would contribute significantly as it did in the Thornveld. However, it was found that,

$$Y_1 = 0{,}84 - 0{,}149X_1 - 0{,}004X_6.$$

A total of only 11 % of the variation in Y_1 could be accounted for, with X_6 ("bodymass of the calf at four months of age" *i.e.*, when creepfeeding commenced) being responsible for only 6,7 % of the variability of Y_1.

An examination of the effect of the independent variables on the ADG of the cows from parturition to the end of the lactation period (Y_2) showed that,

$$Y_2 = 0{,}43 + 0{,}004X_3 - 0{,}004X_6.$$

Of the 29,9 % total variation in Y_2 accounted for, 15,4 % was due to "time-of-calving" (X_3) and 14,3 % derived from "bodymass of the calf at onset of the creepfeeding phase" (X_6). Since the latter was correlated ($r = 0{,}508$) with "bodymass of the cow at calving" (X_2), the equation which omitted X_6 and which approached that obtained for the Thornveld was,

$$Y_2 = 0{,}515 - 0{,}0007X_2 + 0{,}002X_3 - 0{,}35X_9.$$

This relationship was only marginally inferior to that using X_2 instead of X_6 (28,1 % of variation in Y_2 accounted for). In this equation X_9 represented the ADG of the calf from birth to weaning.

While confirming and extending the results presented in Tables 4 and 5, the trends indicated by the regression analyses

Table 6 Reconception rates and intercalving intervals (ICI) for cows calving at different stages of the season and fed and an energy concentrate during early lactation

	Nutrition of		Conception rate following				ICI (days) for	
			Early calving		Late calving			
Locality	Cow	Calf	*No.	%	No.	%	Early calving	Late calving
Thornveld	Suppl.	Creepfed	7/11	62,6	6/7	85,7	391,5	354,3
	Suppl.	Control	6/11	54,5	4/7	55,5	397,5	367,2
	Control	Creepfed	6/11	54,5	3/6	50,0	409,5	351,7
	Control	Control	4/8	50,0	4/7	55,5	407,6	356,8
							SD = 29,11	
Sourveld	Suppl.	Creepfed	8/9	88,9	4/13	30,8	398,5	383,3
	Suppl.	Control	5/7	71,4	3/10	30,0	398,5	376,0
	Control	Creepfed	4/8	50,0	3/11	26,4	417,0	388,7
	Control	Control	9/9	100,0	4/9	44,4	404,5	384,2
							SD = 22,95	

* Based on cows remaining in the herd at subsequent calving after subtraction of deaths, lost ear tags *etc.*

also contradict the generally accepted belief that late calving benefits the maintenance of body reserves in the lactating cow. The common finding of a negative association between the growth of the suckling calf and the gain in mass of the lactating cow was also substantiated.

Reconception rates and intercalving intervals (ICI)

The procedure whereby cows were randomly designated to early and late calving times and mated accordingly, could be expected to favour the conception rate of the early calvers when remated under the conditions of this experiment. The 90-day mating period would then cease at a later stage post-partum for the early calvers than for those which calved late and accordingly a greater proportion of the former would be expected to reconceive. However, the ICI would be expected to increase.

Thornveld

Since the provision of maize did not enable the early calvers to maintain bodymass more effectively (Table 5), the failure of extra feeding to increase conception rates (Table 6) was thus not surprising. The reduction of ICI in those cows receiving maize was also non-significant. Amongst the late calvers the improvement in calving rate, where both the cow and the calf were supplemented, followed the same trend as changes in bodymass, but again the difference was non-significant. A similar failure of supplementary feeding to improve either conception rates or ICI was also noted in the Sourveld.

Regression analysis of ICI

The stepwise regression analysis with "bodymass at parturition" (X_1), "change in bodymass during the breeding period" (X_2), "supplementation of the cow" (X_3) and "time-of-calving" (X_4) as measured by the interval (days) from calving to the onset of the subsequent breeding period, suggested that,

$$Y = 361{,}8 + 0{,}675X_4.$$

In this relationship 70,5 % of the variation in Y in the Thornveld was accounted for by variation in X_4. The early calvers thus appeared to be at a disadvantage as regards maintaining an ICI of 365 days. However, their conception rate was likely to benefit since they were exposed to bulls when the last of the early calvers were more than 120 days post-partum. This is contradicted by the failure to observe a difference in the number of days between calving and the onset of the mating period for cows which reconceived as compared to those which did not (Table 7).

There was a negative correlation ($r = -0{,}23$) between ICI and the bodymass at the initial parturition, whereas the association between "change in bodymass during the breeding period" (X_2) and the ICI was positive ($r = 0{,}461$). The implications of this correlation are that cows which gained more during the breeding period had a longer delay to conception than cows which exhibited smaller gains in bodymass.

For the cows in the Sourveld the ICI was dependant on the bodymass of the cows at parturition (X_1) and also on the "time-of-calving" (X_4). The relationship was,

$$Y = 449{,}7 - 0{,}07X_1 + 0{,}51X_4.$$

In contrast to the results obtained in the Thornveld, in this equation only 23,9 % of the variation in Y could be assigned to X_4, while X_1 contributed a further 8,3 %. The negative coefficient for X_1 confirms the trend observed in the Thornveld, although it was non-significant in that area. In the Sourveld, X_1 and X_4 appear to be acting in opposite directions. The cows which reconceived were heavier ($P \leqslant 0{,}001$) at calving then those which did not conceive (Table 6). However, the early calvers, which had the longer ICI, also had a greater bodymass than the late calvers (450 *vs* 410 kg).

Regression analysis of conception rate

From an examination of the factors which influenced conception rate (Table 8) it was evident that in the Thornveld "time-of-calving" did not affect the likelihood of cows reconceiving. Similarly, the bodymass of the cows at parturition was non-significantly associated with conception rate. However, both the change in bodymass during the breeding period and the bodymass of the cows when the mating period ended, significantly influenced the likelikhood of the cows reconceiving (Figure 1A, Figure 2A)

Correlations between any two independent variables in Table 8 were low except for "mass change" and "time-of-calving" ($r = 0{,}46$). Contrary to the effect on ICI, from the regression analysis it was evident that cows which made the greatest gains exhibited the highest conception rate (Figure 1A).

Sourveld

Although all the variables considered had a high correlation with conception rate (Table 8), only those found to be significant in the Thornveld are presented for the Sourveld data in Figures 1B and 2B. As in the Thornveld here too there was a positive association between "mass change" and "time-of-calving" ($r = 0{,}53$). Other correlations between independent

Table 7 Characteristics of cows that reconceived and of those which did not become pregnant during the 90-day breeding period

Locality	Result of subsequent breeding	Bodymass (kg) at: Initial calving	Bodymass (kg) at: End of breeding period	Average change in bodymass (kg) during breeding period	Interval (days) from calving to onset of breeding period
Thornveld	Calf	$393{,}3^{a}$ ± 6,3	$422{,}1^{a}$ ± 6,4	$25{,}1^{a} \pm 2{,}9$	$28{,}5^{a} \pm 3{,}9$
	No calf	$380{,}5^{b}$ ± 5,4	$404{,}9^{b}$ ± 5,0	$21{,}9^{b} \pm 2{,}2$	$27{,}33^{a} \pm 3{,}7$
Sourveld	Calf	$463{,}8^{a}$ ± 7,5	$447{,}8^{a}$ ± 7,8	$15{,}8^{a} \pm 2{,}3$	$44{,}4^{a} \pm 3{,}8$
	No calf	$391{,}4^{b}$ ± 8,1	$382{,}5^{b}$ ± 7,8	$2{,}3^{b} \pm 1{,}6$	$14{,}5^{b} \pm 3{,}3$

[a,b]Means in the same column with different superscripts differ ($P \leqslant 0{,}01$).

Table 8 The relative role of factors which could have influenced the conception rate (CR) of lactating beef cows

Factor	Locality: Thornveld, Association (r) with CR (Y)	Thornveld, % variation in Y due to X	Sourveld, Association (r) with CR (Y)	Sourveld, % variation in Y due to X
Interval (days) from calving to onset of breeding period	−0,07	0,50	0,98	96,3
Mass change (kg) during breeding period	0,72	51,6	0,93	87,1
Bodymass (kg) at previous calving	−0,02	0,03	0,98	95,4
Bodymass (kg) at end of breeding period	0,87	75,1	0,98	95,6

variates were low.

From the data in Tables 7 and 8 it was clear that the cows which gained the most ($P \leqslant 0{,}001$) during the breeding period were the ones that reconceived ($r = 0{,}93$). However, from the regression analysis there was a positive association between "gain during the breeding period" and the ICI ($r = 0{,}243$). Not only did the early calvers have the benefit (as regards conception rate) of exposure to bulls at a later stage of the lactation period, but they also gained more (22,5 *vs* 3,3 kg) during the breeding period than the late calvers.

From the foregoing it would appear that although the early calving resulted in a longer average ICI, the beneficial effect was to increase the conception rate. Similarly, increased bodymass was advantageous in reducing the ICI and increasing the conception rate.

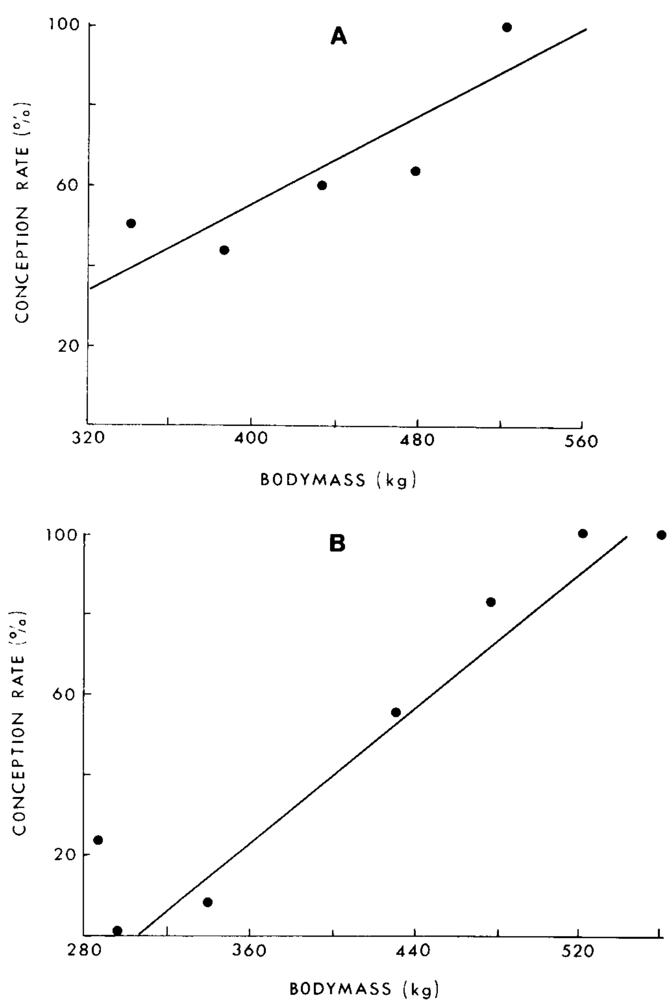

Figure 1 The association between change in bodymass during the mating season and conception rate of lactating cows. A. Thornveld, B. Sourveld.

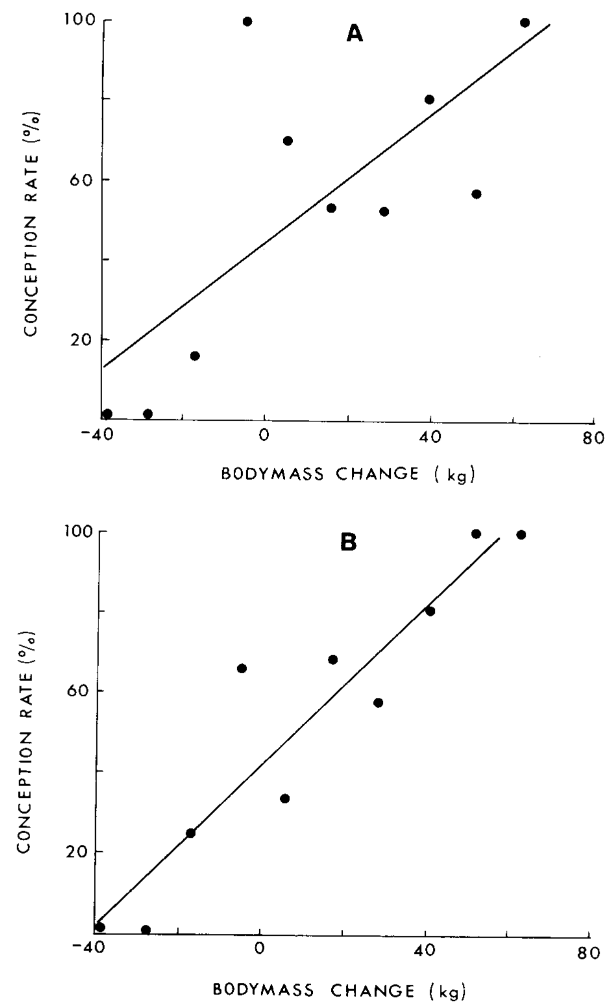

Figure 2 The relationship between bodymass at the end of the mating period and the conception rate of lactating cows. A. Thornveld, B. Sourveld.

Growth of calves during the suckling period

The influence of time-of-birth within the calving period and of creepfeeding is illustrated by the results obtained by least squares analysis of the average daily gains (Tables 9, 10 and 11).

As expected, the early born calves (*i.e.* born 2 October to 14 November) gained at a significantly greater rate ($P \leqslant 0{,}05$) than those born late (20 November to 4 January) in the Thornveld (Table 9). The birthmass had no significant effect on postnatal growth. By constrast, in the Sourveld the early born calves were not at an advantage in spite of the fact that their dams were considerably heavier than those which calved late (Table 2).

When the feeding treatment of the dam was ignored it was evident that although there was a very definite advantage in

Table 9 Influence of season of birth on the preweaning gain in bodymass of suckling beef calves

			Daily gain (kg)	
Locality	Time of birth	n	Birth to weaning	4 months to weaning
Thornveld	Early	45	0,60^{a}	0,52^{a}
	Late	33	0,53^{b}	0,40^{b}
	SD		0,01	0,04
Sourveld	Early	33	0,79^{c}	0,77^{c}
	Late	47	0,80^{c}	0,77^{c}
	SD		0,02	0,02

a,b,c Means within the same column with different superscripts differ ($P \leqslant 0,05$).

the Thornveld in favour of the early born calves this could be reduced, but not eliminated, by creepfeeding (Table 10). However, when the data were reclassified so that the effect of supplementing the lactating cow on the growth of the calf could be examined, it then became evident (Table 11) that creepfeeding of the late born calves was of benefit only where the dams also received an energy supplement during lactation. In these cows, supplementary feeding did reduce the bodymass loss during lactation. Although the growth rate of the calves was almost doubled, the benefit was considerably reduced when the ADG over the entire suckling period was evaluated (Table 10).

Provision of a creepfeed significantly ($P \leqslant 0,01$) improved the growth rate of both the early and the late born calves in the Sourveld. Taken over the entire suckling period of seven months, the benefit was significant ($P \leqslant 0,01$) only for the late born calves (Table 10). Although the difference was of the same order for the early born calves, the smaller number of animals in this group resulted in a non-significant t-test.

When considering the results in terms of the treatment to which the cows were subjected (Table 11), creepfeeding of the calf in the Sourveld was beneficial (early born: $P \leqslant 0,01$; late born: $P \leqslant 0,05$) whether the dam was supplemented or not. For the entire preweaning period the differences were significant, again only for the late born calves, although those recorded for the calves born early approached significance ($P \leqslant 0,10$; $P \geqslant 0,05$).

The growth rate of the calves was examined using the independent variables X_1 — supplementation of calf (creepfeeding), X_2 — bodymass of calf at birth, X_3 — bodymass of calf at four months of age (onset of creepfeeding phase), X_4 — season of birth, X_6 — bodymass of dam at calving, X_7 — bodymass change of dam from calving to wean-

Table 10 The effect of creepfeeding calves born at two stages of the calving period

		Average daily gain (kg) from							
		4 months to weaning				Birth to weaning			
Locality	Nutrition of calf	n	Early born	n	Late born	n	Early born	n	Late born
Thornveld	Creepfed	25	0,59^{ac}	14	0,41^{bc}	25	0,63^{ac}	14	0,53^{bc}
	Control	20	0,59^{ac}	19	0,28^{bd}	20	0,64^{ac}	19	0,46^{bd}
	SD		0,04				0,01		
Sourveld	Creepfed	17	0,84^{ac}	25	0,82^{ac}	17	0,82^{ac}	25	0,84^{ac}
	Control	16	0,71^{ad}	22	0,71^{ad}	16	0,77^{ac}	22	0,76^{ad}
	SD		0,02				0,02		

a,b Means in the same row with different superscripts differ ($P \leqslant 0,05$).
c,d Means in the same column with different superscripts differ ($P \leqslant 0,05$).

Table 11 The effect of supplementary feeding of dams on the preweaning growth of creepfed calves born at two stages of the calving period

	Feeding treatment			Average daily gain (kg) from:							
				4 months to weaning				Birth to weaning			
Locality	Cow	Calf	n	Early born	n	Late born	n	Early born	n	Late born
Thornveld	Suppl.	Creepfed	12	0,55^{ac}	7	0,46^{ac}	12	0,62^{ac}	7	0,55^{ac}
	Control	Creepfed	13	0,61^{ac}	7	0,36^{bce}	13	0,65^{ac}	7	0,52^{bce}
	Suppl.	Control	12	0,60^{ac}	10	0,24^{bdef}	12	0,64^{ac}	10	0,44^{bdef}
	Control	Control	8	0,56^{ac}	9	0,30^{bcef}	8	0,64^{ac}	9	0,49^{bcef}
	SD			0,04				0,01		
Sourveld	Suppl.	Creepfed	9	0,84^{ac}	13	0,82^{ac}	9	0,81^{ac}	13	0,84^{ac}
	Control	Creepfed	8	0,84^{ace}	12	0,82^{ac}	8	0,82^{ac}	12	0,86^{ace}
	Suppl.	Control	7	0,66^{adbg}	12	0,71^{a}	7	0,73^{ac}	12	0,77^{aceg}
	Control	Control	9	0,75^{aceg}	10	0,72^{a}	9	0,80^{ac}	10	0,75^{adfg}
	SD			0,02				0,02		

ab Means in the same row with different superscripts differ ($P \leqslant 0,05$).
cdefg Means in the same column with different superscripts differ ($P \leqslant 0,05$).

ing, X_8 — bodymass change of dam from 30 days after calving to 30 days before end of mating period (period of supplementation), X_9 — supplementation of cow.

In the Thornveld only the "season of birth" (X_4) significantly influenced the ADG from four to seven months of age (Y_1). The equation was,

$$Y_1 = 0{,}335 + 0{,}252\ X_4;$$

X_4 accounted for 44,9 % of the variation in Y_1 and, although non significant, "supplementation of the calf" (X_1) could account for 5,6 % of the variation in ADG when all other variables were omitted.

Although Y_1 was associated with X_2 and also X_7 (X_2:r = 0,356; X_7:r = 0,305), because of their association with "season of birth" (X_4) their influence was accounted for by X_4.

The model used for the Sourveld data also included "parity status of dam" as X_{10}. In agreement with the results in Tables 10 and 11, creepfeeding of the calf (X_1) accounted for 12,6 % of the variation in Y_1. The equation obtained was,

$$Y_1 = 0{,}712 + 0{,}086X_1.$$

The bodymass at birth (X_2) was correlated (r = 0,443) with the bodymass at four months of age, but neither of these variables was closely associated with the rate of growth after four months (Y_1).

When attention was focussed on the ADG of the calves from birth to weaning (Y_2) and X_3 was omitted from the model, then here too the only significant factor in the Thornveld was "season of birth" (X_4). In the equation $Y_2 = 0{,}492 + 0{,}144X_4$ the independent variable accounted for 41,1 % of the variation in Y_2.

In the Sourveld only 16,5 % of the variation could be explained in terms of X_2 and X_7, with the former accounting for 11,6 %. The equation derived was $Y_2 = 1{,}699 + 0{,}125X_1 - 0{,}132X_7$. The nett result was that the final bodymass at weaning in the Thornveld was determined by (in order of importance) "season of birth" (X_4) and "creepfeeding" (X_1). In the equation $Y = 150{,}10 + 11{,}84X_1 + 22{,}96X_4$ only 31,4 % of the variation in Y could be accounted for. Similarly only 23,1 % of the variation in bodymass at weaning for the calves in the Sourveld could be explained in terms of X_1. In this case X_6 ("bodymass of dam at parturition") also contributed significantly. The equation was,

$$Y = 172{,}5 + 18{,}29X_1 + 0{,}05X_6.$$

Although "season of birth" (X_4) and "birth mass of calves" (X_2) were correlated with Y (X_4; r = 0,387; X_2; r = 0,459) these factors were both correlated with the bodymass of the cow at calving. Hence, their individual effects were accounted for by X_6.

When all other factors are held constant a creepfed calf could be expected to show an advantage of almost 12 kg at weaning in the Thornveld (Table 12). Similarly, the advantage of early-season calving was of the order of 23 kg. Accordingly, a calf born early and being creepfed could be expected to show a 35 kg advantage at weaning compared to one born late and not offered creepfeeding (Table 12). A somewhat similar advantage of 18,3 kg due to creepfeeding was noted in the Sourveld (Table 12).

Discussion

There is general agreement amongst research workers that lactating beef cows are likely to benefit (as regards reproductive performance) from supplementary feeding after calving. The question that needs to be answered is why the results reported here are not in accordance with the accepted belief? While bearing in mind that the response may vary from year to year, depending mainly on rainfall distribution, and that only a small number of animals were available, our results demonstrated that:

(1) Contrary to expectation early calvers showed no particular disadvantage as regards ADG during early lactation. Furthermore, over the whole lactation period late calvers were in fact exhibiting the poorest performance.

In the Sourveld, over all treatments, there was a small negative correlation between bodymass at calving and the ADG, both during the period 30 days post-partum to 60 days after onset of mating (r = 0,255) and also the ADG for the entire lactation period (r = 0,114). Furthermore, amongst the early calvers the bodymass at calving for those cows which subsequently received the energy concentrate was 28,6 kg less than for the unsupplemented controls. Perhaps, under certain circumstances the heavier cows lose more bodymass during lactation and the beneficial effects of supplement, if any, could be masked.

Amongst the late calvers the situation was reversed with the non-supplemented cows showing a bodymass advantage of 29 kg over the supplemented cows and yet they gained more than the latter. Bhalaru, Dhillon & Tiwana (1981) suggested that buffalo cows which had the greatest mass at calving also lost most thereafter, when under nutritional stress.

Table 12 Bodymass at weaning of beef calves as influenced by supplementary feeding of dams, creepfeeding of calves and time-of-birth

			Average bodymass (kg)			
	Feeding treatment		Early born		Late born	
Locality	Cow	Calf	Observed	Predicted	Observed	Predicted
Thornveld	Suppl.	Creepfed	179,6	186,1	169,7	160,2
	Control	Creepfed	181,7	183,6	160,4	163,4
	Suppl.	Control	180,9	175,1	144,1	148,9
	Control	Control	177,8	172,8	154,1	153,5
Sourveld	Suppl.	Creepfed	240,0	242,1	235,8	235,4
	Control	Creepfed	239,5	238,4	236,5	236,2
	Suppl.	Control	224,5	224,1	218,3	216,9
	Control	Control	225,0	221,3	213,1	218,4

(2) The benefit of supplemental energy was decidedly questionable as regards ADG and reconception. This confirms the results obtained by Bosman & Harwin (1969), Harwin & Venter, (1970) and by Wells, Hopley & Holness (1980).

In attempting to answer the question posed, besides the possibility of substitution feeding (van Ryssen, Short & Lishman, 1976) and unequal competition at the feed trough (Wells *et al.,* 1980), there is the possibility that the extra energy simply increased milk production without affecting body reserves (Bellows & Short, 1978).

In view of the time-of-calving in relation to the onset of the breeding period late calvers were fed for an average of only four weeks. However, the expectation was that early calvers would benefit from additional feed.

Although Davis, Schalles, Kiracofe & Good (1977) concluded that bodymass changes were associated with reproductive function, they proposed that earlier rebreeding on higher energy rations, but similar cow masses, indicated that mass changes were not necessarily accurate indicators of future reproduction. Meaker (1978) has also observed that changes in bodymass after calving were not related to energy intakes.

From our results it would appear that because energy feeding was advantageous in the Thornveld as regards ADG and because the general conception rate was not much above 50 %, some factor or factors were operating to limit reproductive performance. Grosskopf (1978), Levine, Amezquita & Hohenboken (1980) and Meaker, Coetsee, Smith & Lishman (1980) emphasize the importance of a minimum bodymass that each cow must maintain during the breeding season in order to conceive. Gain or loss prior to breeding was of little consequence provided the bodymass was above a certain minimum (Grosskopf, 1976). This is in accordance with Richardson, Oliver & Clarke (1975) who believe that bodymass *per se* and not gain or loss is important in determining whether a lactating cow will conceive or not. Clearly the apparent contradiction, where changes in bodymass are shown to be important in some studies (Davis *et al.,* 1977) and not in others (Carstairs, Morrow & Emery, 1980; Wells *et al.,* 1980), is due to variation in the physiological status of the animals from experiment to experiment when the studies are initiated.

The data in Figure 1 and 2 and in Table 8 could be said to support both the "target mass', and the "gain during the breeding period" concepts. In both areas, a calving rate of 80 % would appear to be possible provided the cows gained an average of 40 kg during the breeding period, or attained an average mass of 500 kg by the end of the 90-day mating season. The data in Table 7 suggest that the heavier cows also gain the most. Consequently they have a double advantage. The occurrence of first-calvers does however confuse the issue.

In the foregoing, the date of calving has been ignored. Grosskopf (1976) maintained that cows which calved less than 25 days before the start of the 90-day season, did not have a good chance of conceiving. Only the data obtained in the Sourveld confirmed this suggestion.

In attempting to account for the longer ICI amongst the early calvers (Table 6), attention needs to be given to the timing of the subsequent mating period. The data show that the interval between the initial parturition and the onset of the next breeding period was longer ($P \leqslant 0{,}001$) for those cows which conceived than for those which did not (Table 6). Consequently when reconception is considered, the time of calving is important, but to achieve a short ICI early exposure to bulls becomes an advantage. Here it should be noted that the early calvers were already 76 days post-partum when bulls were introduced. In effect there was no "tail" of late conceptions amongst the late calvers since the bulls had already been removed. Amongst the early calvers this was possible.

In order to obtain a clearer understanding of the relative roles of "date of calving" and of bodymass criteria it would be necessary to combine these two factors in a single analysis. To date it has not been possible to select a continuous variate which would yield meaningful results.

When focussing attention on the preweaning growth of the calves the two questions posed were,
(1) Can creepfeeding compensate for the effect of being born late in the season?
(2) Is it more important to feed the lactating cow or the suckling calf?

In the Thornveld there was a clear seasonal effect on the growth rate of the calves. This finding supports the suspicion that some factor or factors were limiting performance of the animals in this area.

Harwin & Venter (1970) were able to increase the growth of late born calves by creepfeeding so as to eliminate the seasonal effect. In the present study however, this effect of time-of-birth could be reduced, but not entirely eliminated, by the creepfeed provided in the Thornveld.

For the results obtained in the Sourveld the least squares analysis revealed only a minor seasonal effect which had to be overcome. In this area, creepfeeding was beneficial to both early and late born calves. Consequently late born calves that received creepfeed achieved a higher weaning mass than early born calves not creepfed.

The foregoing results support the contention (Ochoa, Mangus, Brinks & Denham, 1981) that creepfeeding can decrease the effect of environmental factors on weaning mass. In particular the creepfeed should be of benefit to calves suckling dams with limited milk (Ochoa *et al.,* 1981) as suggested by Harwin (1963) and by Cooper (1965).

The advantage at weaning, due to creepfeeding, of between 12 kg (Thornveld) and 18 kg (Sourveld) agrees with the results obtained by Marlowe, Mast & Schalles, (1965); Cundiff, Willham & Pratt, (1966); Martin, Lemenager, Srinivasan & Alenda (1981) and Ochoa *et al.* (1981), but is of lower magnitude than the 27 – 34 kg reported by Scarth, Miller, Phillips, Sherritt & Ziegler (1968); Harwin & Venter (1970); Ferreira (1975); Martin, Perry, Beeson & Mohler (1977); Stricker, Matches, Thompson, Jacobs, Martz, Wheaton, Currence & Krause (1979). If creepfeeding is to be employed as a means of reducing seasonal effects, then cognizance must be taken of the superior response of males (Martin *et al.,* 1981) and the likelihood of a detrimental effect on the lifetime performance of creepfed heifers (Mangus & Brinks, 1971; Kress & Burfening, 1972; Holloway & Totusek, 1972; Ellicott, Holland & Neumann, 1970; Martin *et al.,* 1981).

From the viewpoint of increased calf growth rate there was little to be gained from providing the dam with an energy supplement. This agrees with the findings of Harwin & Venter (1970).

In considering the cow/calf enterprise as a whole and focussing attention on the need to achieve good conception rates from year to year and good preweaning growth, the practice of providing an energy concentrate during early lactation cannot be recommended. It would appear to be more profitable to focus attention on improving the general nutrition of the breeding herd as a whole rather than attempting to supplement only during periods of peak demand. With creepfeeding the benefit is real, but the cost must be related to the value of the additional return. Limited feeding during periods of stress should be considered.

References

BELLOWS, R.A. & SHORT, R.E., 1978. Effects of precalving feed level on birth weight, calving difficulty and subsequent fertility. *J. Anim. Sci.* 46, 1522.

BHALARU, S.S., DHILLON, J.S. & TIWANA, M.S., 1981. Effect of bodyweight at calving on bodyweight changes during early lactation and post partum reproductive performance in buffaloes. *J. Agric. Sci.* Camb. 97, 595.

BISHOP, E.J.B. & KOTZE, J.J., 1965. Good strategy with beef cows. *Farming S. Afr.* 41, 6.

BONSMA, J.C. & SKINNER, J.D., 1969. Factors influencing birth date, birth weight and preweaning growth rate of Afrikaner, Bonsmara and Hereford cattle in the subtropics. *Proc. S. Afr. Soc. Anim Prod.* 8, 161.

BOSMAN, D.J. & HARWIN, G.O., 1969. The occurrence of post partum oestrus in beef cows under ranching conditions. *Proc. S. Afr. Soc. Anim. Prod.* 8, 165.

BOSMAN, D.J. & HARWIN, G.O., 1966. Genetic and environmental factors affecting pre-weaning traits in beef cattle under extensive ranching conditions. *Proc. S. Afr. Soc. Anim. Prod.* 5, 153.

BOULLE, J.P., 1980. An evaluation of management expertise in Natal beef herds. *20th Annual Congr. S. Afr. Soc. Anim. Prod.* April, 1980.

CARSTAIRS, J.A., MORROW, D.A. & EMERY, R.S., 1980. Post partum reproductive function of dairy cows as influenced by energy and phosphate status. *J. Anim. Sci.* 51, 1122.

COOPER, C.R., 1965. Effects of environmental factors and their two-way interactions in Colorado beef herds. Ph. D. Thesis. Colorado State University.

CUNDIFF, L., WILHAM, R.L. & PRATT, C.A., 1966. Effects of certain factors and their two-way interactions on weaning weight in beef cattle. *J. Anim. Sci.,* 25, 972.

DAVIS, D., SCHALLES, R.R., KIRACOFE, G.H. & GOOD, D.L., 1977. Influence of winter nutrition on beef cow reproduction. *J. Anim. Sci.* 45, 430.

ELLICOTT, G.H., HOLLAND, L.A. & NEUMANN, A.L., 1970. Most probable producing ability of Hereford cows. *Proc. Western Sec. ASAS.* 21, 363.

FERREIRA, I., 1975. Kruipvoeding — Die ware Jakob. *Vleisnywerheid,* Jan. – Maart, 1975, p.14.

GROSSKOPF, J.F.W. 1976. Die herkonsepsie van lakterende vleisraskoeie as beperkende faktor by die praktiese toepassing van ovulasie-sinkronisasie. Ph. D. thesis, Universiteit van Stellenbosch.

HARWIN, G.O., 1963. The effect of inbreeding and environmental factors on the weaning weight and postweaning growth of range Hereford cattle. Ph. D. Thesis, Colorado State University.

HARWIN, G.O., LAMB, R.D. & BISSCHOP, J.H.R., 1967. Some factors affecting reproductive performance in beef females. *Proc. S. Afr. Soc. Anim. Prod.* 6, 171.

HARWIN, G.O. & VENTER, H.A.W., 1970. An investigation of the creep feeding of beef calves in the mixed Bushveld. *Proc. S. Afr. Soc. Anim. Prod.* 9, 161.

HEYNS, H., 1960. The growth of the Afrikaner calf in relation to the production and composition of the milk of its dam. II. The milk production of the dam and growth of the calf. *S. Afr. J. Agric. Sci.* 3, 517.

HOLLOWAY, J.W. & TOTUSEK, R., 1972. Early weaning *vs* normal weaning *vs* creep feeding of replacement heifer calves. *Oklahoma Agric. Exp. Sta. MP.* 87, 18.

JOUBERT, D.M., 1954. The influence of high and low nutritional planes on the oestrous cycle and conception rate of heifers. *J. Agric. Sci.* 45, 164.

KRESS, D.D. & BURFENING, P.J., 1972. Weaning weight related to subsequent most probable producing ability in Hereford cows. *J. Anim. Sci.* 35, 327.

LEVINE, J.M., AMEZQUITA, M.L. & HOHENBOKEN, W.D., 1980. Relationship of liveweight to calving rate of grade Zebu heifers and cows on the eastern planes of Columbia. *J. Anim. Sci.* 50, 1040.

MANGUS, W.L. & BRINKS, J.S., 1971. Relationship between direct and maternal effects on growth in Herefords. I. Environmental factors during pre-weaning growth. *J. Anim. Sci.* 32, 17.

MARLOWE, T.J. & GAINES, J.A., 1958. The influence of age, sex and season of birth of calf and age of dam on pre-weaning growth rate and type score of beef calves. *J. Anim. Sci.* 17, 706.

MARLOWE, T.J., MAST, C.C. & SCHALLES, R.R., 1965. Some non-genetic influences on calf performance. *J. Anim. Sci.* 24, 494.

MARTIN, T.G., LEMENAGER, R.P., SRINIVASAN, G. & ALENDA, R., 1981. Creep feed as a factor influencing performance of cows and calves. *J. Anim. Sci.* 53, 33.

MARTIN, T.G., PERRY, T.W., BEESON, W.M. & MOHLER, H.T., 1977. High urea supplements and pre-weaning creep fed as factors affecting post weaning performance of bulls. *J. Anim. Sci.* 44, 739.

MEAKER, H.J., 1978. The importance of age at first calving, relationship between bodymass and fertility and feeding systems on production in the beef female. Ph. D. Thesis. University of Natal.

MEAKER, H.J., COETSEE, T.P.N., SMITH, M. & LISHMAN, A.W., 1980. The relationship between bodymass and fertility of beef cows of different ages. *S. Afr. J. Anim. Sci.* 10, 83.

OCHOA, P.G., MANGUS, W.L., BRINKS, J.S. & DENHAM, A.H., 1981. Effect of creep feeding bull calves on dam most probable producing ability values. *J. Anim. Sci.* 53, 567.

RICHARDSON, F.D., OLIVER, J. & CLARKE, G.P.Y., 1975. Analyses of some factors which affect the productivity of beef cows and their calves in a marginal rainfall area of Rhodesia. *Anim. Prod.* 21, 41.

SCARTH, R.D., MILLER, R.C., PHILLIPS, P.J., SHERRITT, G.W. & ZIEGLER, J.H., 1968. Effects of creepfeeding and sex on the rate and composition of growth of crossbred calves. *J. Anim. Sci.* 27, 596.

SNAPP, R.R. & NEUMANN, A.L., 1960. Beef cattle. 5th ed. New York. John Wiley & Sons. Inc.

STEENKAMP, J.D.G., 1977. Cost of production of a kilogram of live weaned calf. *Meat Industry* 26, 34.

STRICKER, J.A., MATCHES, A.G., THOMPSON, G.B., JACOBS, V.E., MARTZ, F.A., WHEATON, H.M.N., CURRENCE, H.D. & KRAUSE, G.F., 1979. Cow-calf production on tall fescue-ladino clover pastures with and without nitrogen fertilization or creepfeeding spring calves. *J. Anim. Sci.* 48, 13.

VAN RYSSEN, J.B.J., SHORT, A.M. & LISHMAN, A.W., 1976. Carbohydrate supplementation of lambs on kikuyu pasture. *Agroanimalia* 8, 43.

WARNICK, A.C., 1959. Effect of a protein deficiency on reproduction. Beef cattle. *Fla. Agr. Exp. Sta. Mim. Series* 59 – 10.

WILTBANK, J.N., ROWDEN, W.W., INGALLS, J.E., GREGORY, K.E. & KOCH, R.M., 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. *J. Anim. Sci.* 21, 219.

WILTBANK, J.M., ROWDEN, W.W., INGALLS, J.E. & ZIMMERMAN, D.R., 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. *J. Anim. Sci.* 23, 1049.

WELLS, P.L., HOPLEY, J.D.H. & HOLNESS, D.H., 1980. The influence of concentrate supplementation during the post-partum period on ovarian activity and conception in Afrikaner cows. Zimbabwe Dept. Res. & Spec. Serv. Ann. Rep. Year ending 30 September, 1980, Salisbury, Rhodesia.