

THE EFFECT OF STOCKING RATE ON THE PERFORMANCE
OF BEEF COWS AND THEIR PROGENY IN THE
HIGHLAND SOURVELD AREAS OF NATAL.

A. VAN NIEKERK

DECLARATION

I hereby declare that the results presented
in this thesis have not been previously
submitted by me for a degree
at any other university

A handwritten signature in black ink, appearing to read 'Alvin van Niekerk', is centered on the page.

Alvin van Niekerk

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HIGHLAND SOURVELD AREAS OF NATAL

by

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ABSTRACT

In three separate, but related studies, the performance of weaner/replacement heifers, dry pregnant cows, and first calvers and mature cows and their progeny, at different stocking rates in the Highland Sourveld, was investigated. The study area was located in Bioclimatic region 4e in the Province of Natal, Republic of South Africa.

In the first study, carried out over four seasons, the effect of winter and summer nutritional levels on the performance of replacement heifers, bred at two years of age, was investigated. The results of this study indicated that compensatory growth was a potentially important factor in reducing feed costs, but the degree of compensation was highly dependent upon stocking rate and the condition of the veld. The most economical regime for rearing heifers up to the mating stage was a low growth rate (0 - 0,25 kg/day) during the first winter (post weaning) followed by a low stocking rate (0,75 AU/ha) on summer veld. Treatment did not generally affect the number of heifers attaining puberty, nor their conception rates. Pregnancy rates as high as 96% were achieved. Treatment also had no apparent effect on subsequent calving rates.

In the second series of experiments, the role of condition scoring as a management tool in the Highland Sourveld was studied. The condition score of the cow was shown to be an important factor determining conception rate and time of conception. Only 8% of the cows mated at a condition score of 1,5, conceived, whereas 80% conception rates were achieved when the cows were mated at a condition score of 3,0 - 3,5. The cost of improving a cow's condition from 1,5 to 3,0 was

R108, whereas the cost of improving a cow's condition from 2,0 to 3,0 was R54.

In the third study, carried out over nine consecutive seasons, the effect of stocking rate and lick supplementation on the performance of lactating cows and first calvers was investigated. Four stocking rates were applied - 0,83, 1,0, 1,25 and 1,67 cows plus calves per hectare. The very high stocking rate was terminated after four seasons because of a significant decline in both cow and calf performance, and the severe deterioration of the natural pasture. There was no benefit to either the cows or calves with access to a urea-based lick at the very high stocking rate, but at the low stocking rate (1,0 cow + calf/ha) the cows were in such a condition that the grazing season could have been extended, thereby saving on winter feed costs. First calvers produced weaners as heavy as those of the mature cows and were in similar body condition at the end of the grazing season. The excellent performance of the first calvers was attributed largely to the fact that they calved 3 - 4 weeks prior to the mature cows.

The grazing behaviour of the first calvers and the mature cows, at the different stocking rates, was observed in the fourth study which was carried out over two consecutive seasons. There were no significant differences in the grazing time between the first calvers and the mature cows at any of the stocking rates. In all the treatments, the first calvers appeared to establish the grazing patterns, with the mature cows adopting a followership role. Alloparental behaviour was noted in the early part of both grazing seasons.

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GENERAL INTRODUCTION

It is estimated that the population of the Republic of South Africa will be in the region of 50 million by the year 2000 (HSRC, 1987; per. comm.). This figure usually fails to elicit a response from the man in the street, partly because of its incomprehensibility and, partly because the figure is so often bandied about that it has lost its impact. However, this figure has important implications, not only from an agricultural viewpoint, but also for the country as a whole. If the RSA is to be largely self-sufficient in terms of food production, then large areas of arable land will have to be reserved for agricultural enterprises that can be brought directly into the human food chain. Consequently, beef cattle, and cows in particular, will be required to utilize natural grazing, crop residues and cheap forages grown on marginal lands (Harwin, 1979). A ruminant's ability to convert high cellulose material into digestible protein will ensure its position in the future agricultural scenario. However, the success of future agricultural enterprises is likely to depend on the efficiency of the production system. According to Harwin (1979) there will have to be a significant move away from biological efficiency towards economic efficiency. The striving for economically viable production systems must not take place at the expense of the natural resources. These resources must be maintained in a viable and productive state at all costs.

The interactions between the grazing animal and its environment are complex and not well understood. Despite the many gaps in our knowledge, economically optimum production systems must be based on the latest available scientific and biological information. In this regard, because of the interdependence of the many facets that constitute a viable production enterprise, it is imperative that research aimed at

providing solutions to the many problems, be conducted in an integrated, multidisciplinary way. This is often regarded as a "systems" approach (von Bertalanffy, 1950).

In the Highland Sourveld, van Niekerk (1984) has shown the importance of selecting the right breed-type for breeding herds and the need for a high level of management to ensure high reproductive and weaning rates. The Highland Sourveld is currently an important beef producing area, with considerable potential for increasing the production of the beef herd in general (Bembridge, 1985) and the breeding herd in particular. However, because of the limitations imposed on the beef enterprise by the environment, certain basic problems require attention before the true potential of the sourveld can be realized. These problems are generally related to the effects of stocking rates on the performance of animals, and the impact on the veld. In this context, because of the severity of the of the winter feeding period and the need to supply supplementary feed, the length of the grazing season is of cardinal importance. Stocking rate is probably the most important, and often most controversial factor, influencing beef production on natural grazing. Tainton (1985) has suggested that, from the beginning of research into the management of natural vegetation in South Africa, management procedures, rather than stocking rates, have formed the basis of the research effort. Research into stocking rates for different veld types is a high priority, but should not be investigated in isolation from the grazing management system (Tainton, 1985).

The current series of investigations attempts to address the more important and basic problems relevant to the beef breeding herd in the Highland Sourveld areas of Natal, in relation to stocking rate and the length of the grazing season. Whilst considerable attention has been focussed in this study on the performance of mature lactating cows,

first calvers and dry pregnant cows on Highland Sourveld the importance of correct heifer rearing has also been addressed. If heifers are to make a significant contribution to the breeding herd, they must be adequately fed for good performance during the first and subsequent production cycles (Bond & Wiltbank, 1970; Bellows & Short, 1978). However, whilst nutrition possibly remains the single most important factor affecting animal performance, a clear understanding of the behaviour of animals in general, but grazing animals in particular, should facilitate better management practices, with a concomitant increase in animal production and the efficiency of the enterprise as a whole.

One of the major factors affecting the economic viability of beef enterprises in the Highland Sourveld areas of Natal is the high cost of winter feeding in order to attain high production levels. Alternative sources (to maize silage and Eragrostis curvula hay) must be investigated. The use of foggaged pastures could play an important role in this regard. Better management of the animal also requires further investigation. For instance, whilst the potential of a cow to mobilize body fat as an energy source is sometimes exploited, it is an area that has not been researched in detail in the RSA. In this context the role of condition scoring as a means of identifying different levels of body reserves needs to be placed on a scientific basis. Only then can sound recommendations on the manipulation of body reserves as a means of optimizing feed sources and increasing production levels, be made. Clearly, any management tool that will improve the efficiency of the beef enterprise in the Highland Sourveld areas of Natal deserves investigation.

CHAPTER 1

THE PERFORMANCE OF REPLACEMENT HEIFERS ON HIGHLAND SOURVELD
WHEN BRED AT TWO YEARS OF AGE

INTRODUCTION

Replacement heifers are generally bred for the first time at 24 (or more) months of age because of the extensive nature of the majority of beef enterprises in the Republic of South Africa. Consequently, the emphasis has shifted from the physiological efficiency of the animal to the economic implications of the operation. For instance, age and mass at which puberty is attained are important factors in beef cattle when heifers are bred to calve at two years of age (Ferrell, 1982). It is not only important that these heifers breed and conceive, but also that they should conceive early in the breeding season for maximum efficiency. The emphasis is therefore on production efficiency. A situation in which heifers are mated for the first time at two years, requires these animals to be fed and managed for a minimum period of three years before any return (a calf) is realized. Even then the viability of the product is not guaranteed. This situation is unlikely to change in the Highland Sourveld and it is therefore imperative that the replacement heifers be raised as cheaply as possible without affecting their potential to conceive.

Irrespective of whether heifers are mated at 12 - 14 months or two years of age, an adequate level of feed is necessary for good performance in the first and subsequent production cycles (Bond & Wiltbank, 1970; Kropp, Stephens, Holloway, Whiteman, Knori & Totusek,

1973; Corah, Dunn & Kaltenbach, 1975; Holloway, Stephens, Whiteman & Totusek, 1975). However, the most efficient and economic levels of feeding for heifers under different management systems and environmental situations, remain obscure. The solution to these problems becomes increasingly important when viewed in the light of existing information. Research has shown that undernutrition may result in increased age at puberty (Joubert, 1954; Wiltbank, Kasson & Ingalls, 1969), impaired fertility (Hill, Lamond, Hendricks, Dickey & Niswender, 1970) and the production of less milk during the first lactation (Bond & Wiltbank, 1970). Overfeeding, however, may result in a decline in breeding efficiency (Arnett, Holland & Totusek, 1971), high calf mortality (Bond & Wiltbank, 1970), decreased mammary gland development (Swanson, 1957) and reduced milk production (Swanson, 1957, 1960).

The need to identify the most efficient feeding regime for the rearing of replacement heifers is therefore essential to the beef cow/calf industry. If the current thinking that calves will be produced mainly off veld in future, is accepted, it is likely that in a Natal context, the Highland Sourveld areas (Bioclimatic area 4e and 4f; Phillips, 1973) will be particularly important. The quantification of efficient and economic rearing systems for replacement heifers in the Highland Sourveld is however, far from simple. Realistically, the veld can sustain animal production for a maximum of 270 days a year from spring through to autumn. Consequently, supplementary feeding is necessary during the winter months. Winter feeding is often very expensive, making it imperative that the degree of supplementary feeding is restricted as far as possible. It is axiomatic then that the veld will have to sustain a reasonably high production level to enable replacement heifers to achieve their respective target mating masses. The interactions between winter and summer nutritional levels will have to be clearly understood before reliable recommendations can be made.

The potential role of compensatory growth under sourveld conditions will have to be identified and quantified. It is generally recognised that growing animals exhibit compensatory growth following a period of food restriction (Allden, 1970; O'Donovan, 1984). This has led to the general recommendation that when food supplies are scarce or expensive, temporary food restriction may be practised without any long-term deleterious effect. In fact such an approach may be economically advantageous if compensation can take place when supplies are plentiful and relatively inexpensive ie. summer grazing (Wright, Russell & Hunter, 1986). There is little doubt that compensatory growth on sourveld takes place but the degree of compensation may be modified to a large extent by the stocking rate employed. Very little information is available in the literature in this respect. However, it is essential that the long-term effect of the different feeding regimes on production and specifically reproduction be researched. The objectives of this experiment were: 1) To investigate the interaction between winter and summer nutritional levels and its effect on weaner/replacement heifer growth and reproductive performance on Highland Sourveld; 2) To identify the role of compensatory growth on Highland Sourveld.

The first two years' results (1981/82 and 1982/83 seasons) have been presented (van Niekerk, 1984). The subsequent two seasons' results - 1984/85 and 1985/86 seasons, are presented here, together with the reproduction trends that have become apparent from the four years data thus far obtained.

PROCEDURE

Experimental site

The experiments were carried out at the Thabamhlope Research Station situated at an altitude of 1450 m above sea level, within the Bioclimatic area 4e (Phillips, 1973) in the Province of Natal, Republic of South Africa. The Station falls within 29°02' latitude and 29°39' longitude. The mean annual rainfall is approximately 900 mm per annum with about 70% of the rainfall being recorded between November and March. Mean maximum temperatures are in the region of 22°C and mean minimum temperatures in the region of 6°C.

The area (77,4 ha) assigned to this experiment consists of grass plains and rolling hills. There is a general absence of trees and bushes. The animals are largely unprotected from the elements and in particular, winds which blow throughout the year but are extremely cold during the winter.

Approximately 40 grass species are commonly found at Thabamhlope. However, only five or six species are generally grazed by animals during the summer months. These species include Alloteropsis semialata, Diheteropogon amplexans, Harpechloa falx, Heteropogon contortus, Themeda triandra and Tristachya leucothrix. The veld generally cannot sustain animal performance during the winter months (July - mid-October).

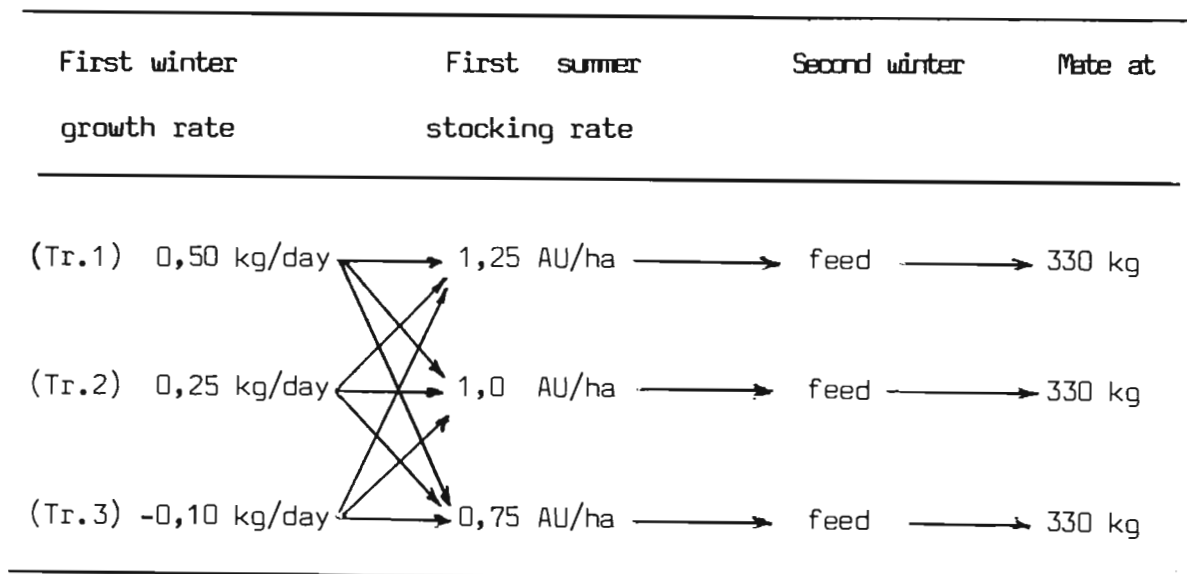
Experimental animals

One hundred and eleven weaner (270 days of age) Simmentaler heifers with a mean mass of $201,38 \pm 28,06$ kg were used during the first season commencing in July 1984. During the second season 93 weaner heifers with a mean mass of $193,29 \pm 20,24$ kg were used. The trial commenced in July 1985. The animals were all born in the spring

of the previous year. Shortly after weaning the animals were randomly allocated to three treatments and fed at three nutritional levels so as to achieve growth rates of 0,5 kg (Tr.1), 0,25 kg (Tr.2) and -0,12 kg (Tr.3) per day.

Experimental design

The winter feeding phase extended for approximately 120 days. At the end of the winter phase the animals were re-allocated to summer grazing treatments so that each summer treatment contained animals from each of the winter treatments. The three stocking rates employed on summer veld were: 1,25 AU/ha, 1,00 AU/ha and 0,75 AU/ha. In this particular situation, an AU is described as a 450 kg non-lactating cow. The target mating mass was 330 kg by mid-October of the second season. The animals would then be 24 - 25 months of age. The mass deficit between the final summer grazing mass and the target mating mass could then be made-up during the second winter feeding phase. The experimental design is shown diagrammatically below.



Experimental rations

The basic rations fed to the heifers during the winter consisted of maize silage and Eragrostis curvula hay. The heifers in Tr.1 received a high protein concentrate (HPC) when their growth rates fell below the required rate. The heifers in Tr.3 received E. curvula hay only; the quantity being constantly adjusted to sustain a sub-maintenance growth rate. The costs allocated to the roughages were derived from figures issued by the Directorate, Agricultural Production Economics. The allocated feed costs were; E. curvula hay - R105,71/ton of dry matter; Maize silage - R85,90/ton DM. The HPC was costed at R300/ton and the urea-based lick at R250/ton.

The heifers were weighed on a fortnightly basis following an 18 hour starvation period. The rations were adjusted every two weeks, depending on the animals' performance. A rumen stimulating lick consisting of 30% salt, 30% dicalcium phosphate, 25% maize meal and 15% urea was freely available to all the animals. Feed intakes were recorded on a daily basis and lick intakes weekly. During the summer grazing period a mineral lick consisting of 50% salt and 50% dicalcium phosphate was available from the beginning of grazing until the 15th of February. Thereafter the animals had access to the rumen stimulating lick.

The heifers were group fed in pens during the winter. Each pen could accommodate eight animals. It was therefore possible to block animals for size within each treatment, so that competition for feed could be reduced to a minimum. The pens were open at the sides, but the feeding area was covered. An uncovered exercise area adjacent to the feeding area was available.

Second winter

Animals below 240 kg at the beginning of the second winter feeding period were culled since these heifers would be required to gain at least 100 kg during the second winter feeding period. Previous research at the Research Station had shown this to be uneconomical under sourveld conditions. The remaining animals were divided into three groups according to their final summer livemasses and fed to reach a mass of 330 kg by mid-October. The basic ration components fed to all the animals during the winter were maize silage and E. curvula hay. A urea-based lick was available at all times. A 60 day breeding season commenced on the 15th of October each year.

Grazing management

The grazing management was based on a modified eight camp system. Unfortunately, because of a shortage of funds, only 18 camps could be fenced. It was therefore possible to allocate only six camps to each treatment. Based on recommendations from the Pasture Specialists it was decided that all 18 camps would be grazed each season, but that all the camps would be rested once every four years. Each camp was grazed for seven days and rested for thirty five days. This effectively simulated an eight camp system with two rest camps per herd. Three stocking rates were employed. These ranged from 1,25 AU/ha. (Tr.1) to 1,0 AU/ha. (Tr.2) to 0,75 AU/ha (Tr.3). The areas allocated to the experiment were relatively uniform (blocks of 26,2 ha, 25,8 ha and 25,4 ha). The number of animals in each treatment was manipulated by the use of additional "grazers" to achieve the desired stocking rates. The performances of the grazers were not monitored and they were not included in the analyses.

Meteorological data

Data relating to daily maximum and minimum temperatures, rainfall and wind velocities were collected by the Natal Agrometeorological Section. Mean monthly data are presented on a seasonal basis.

Statistical analysis

Analysis of variance was used to test the effect of treatment on mass changes. The interactions between winter and summer nutritional levels were analysed by multiple regression analyses. The influence of treatment on conception was tested using the chi-square test.

RESULTS

Meteorological data

Climatological data showing temperature, rainfall and wind conditions during the experimental period are presented in Table 1. It is clear from these data that approximately 70% of the mean annual rainfall was recorded between November and March. June and July were generally the driest and coldest months of the year. Mean monthly minimum temperatures in the region of 6,1°C reflect ambient temperatures. Effective ambient temperatures (EAT's) would have been considerably lower as a result of frost and wind.

First winter: Animal performance and feed intakes

Animal performance

The actual livemass gains of 0,34 kg (Tr.1), 0,14 kg (Tr.2) and -0,18 kg (Tr.3) per day recorded during the first (1984/85) season were lower than the projected daily gains of 0,5 kg, 0,25 kg and -0,12 kg (Table 2). The difference in livemass between the animals in the three

Table 1. Climatic conditions prevailing during the experimental period.

Year	Mean Max. ¹ °C	Mean Min. ² °C	G. Total ³	Rainfall (mm)							Total ⁴	% of Total ⁵	Mean Wind ⁶ Km
				Nov.	Dec.	Jan.	Feb.	Mar.					
1981/82	20,9	5,5	783,5	112,4	120,8	141,8	55,1	150,1	580,2	74,05	148,7		
1982/83	22,3	6,5	736,9	78,6	84,8	100,6	101,2	102,7	467,9	65,50	165,7		
1984/85	21,5	6,0	840,5	45,4	90,2	164,6	184,6	110,4	595,2	70,82	146,3		
1985/86	22,1	6,3	930,0	180,7	145,5	158,2	142,0	84,4	710,8	76,43	146,7		
Mean	21,7	6,1	822,7	104,3	110,3	141,3	120,7	111,9	588,5	71,70	151,9		

1. Mean maximum temperature
2. Mean minimum temperature
3. Total annual rainfall
4. Total rainfall Nov. - March
5. Percentage of total annual rainfall
6. Mean wind/24 hr period

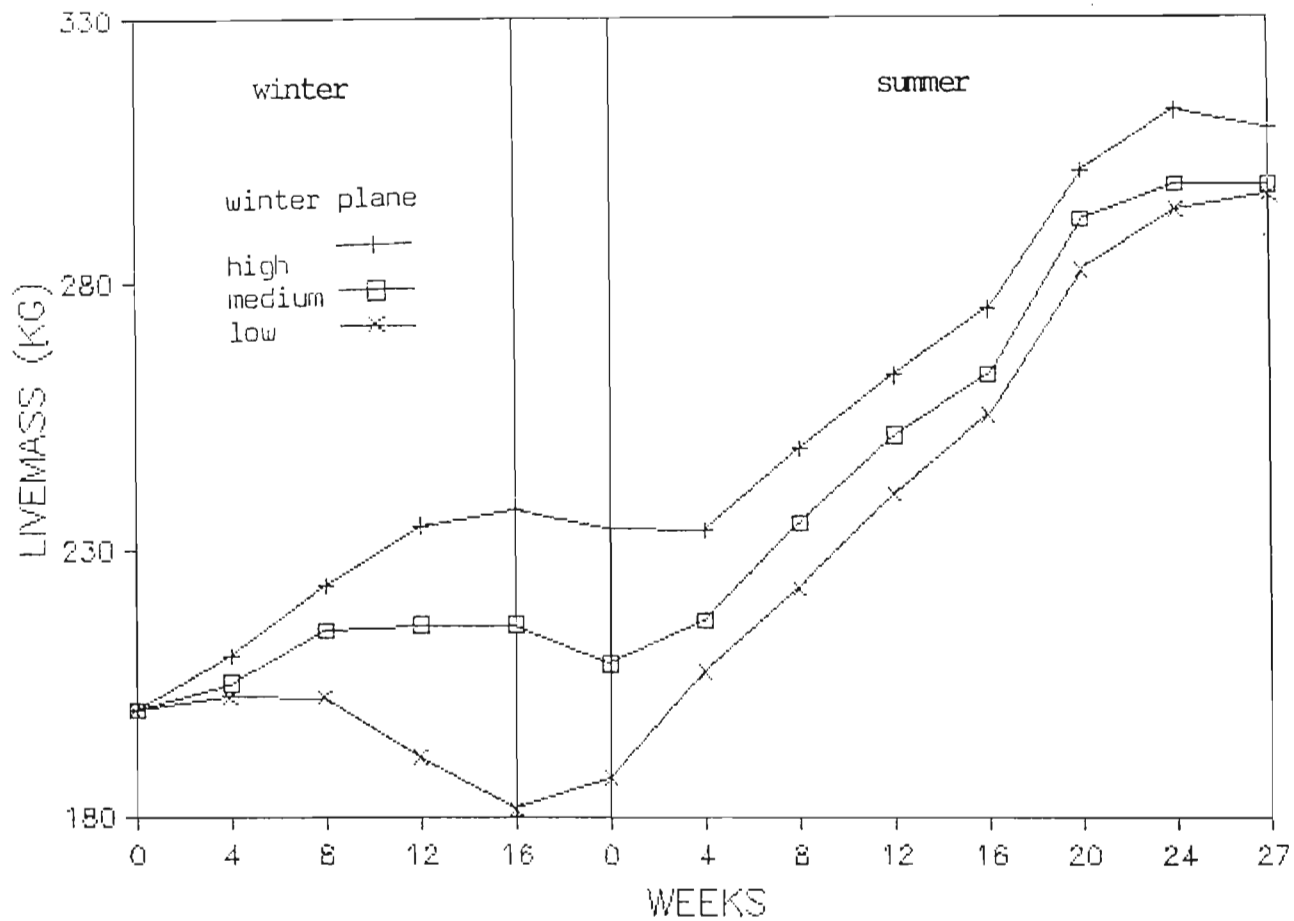


Figure 1. The performance of heifers during winter and subsequent summer when stocked at a low stocking rate on summer veld - 1984/85 season.

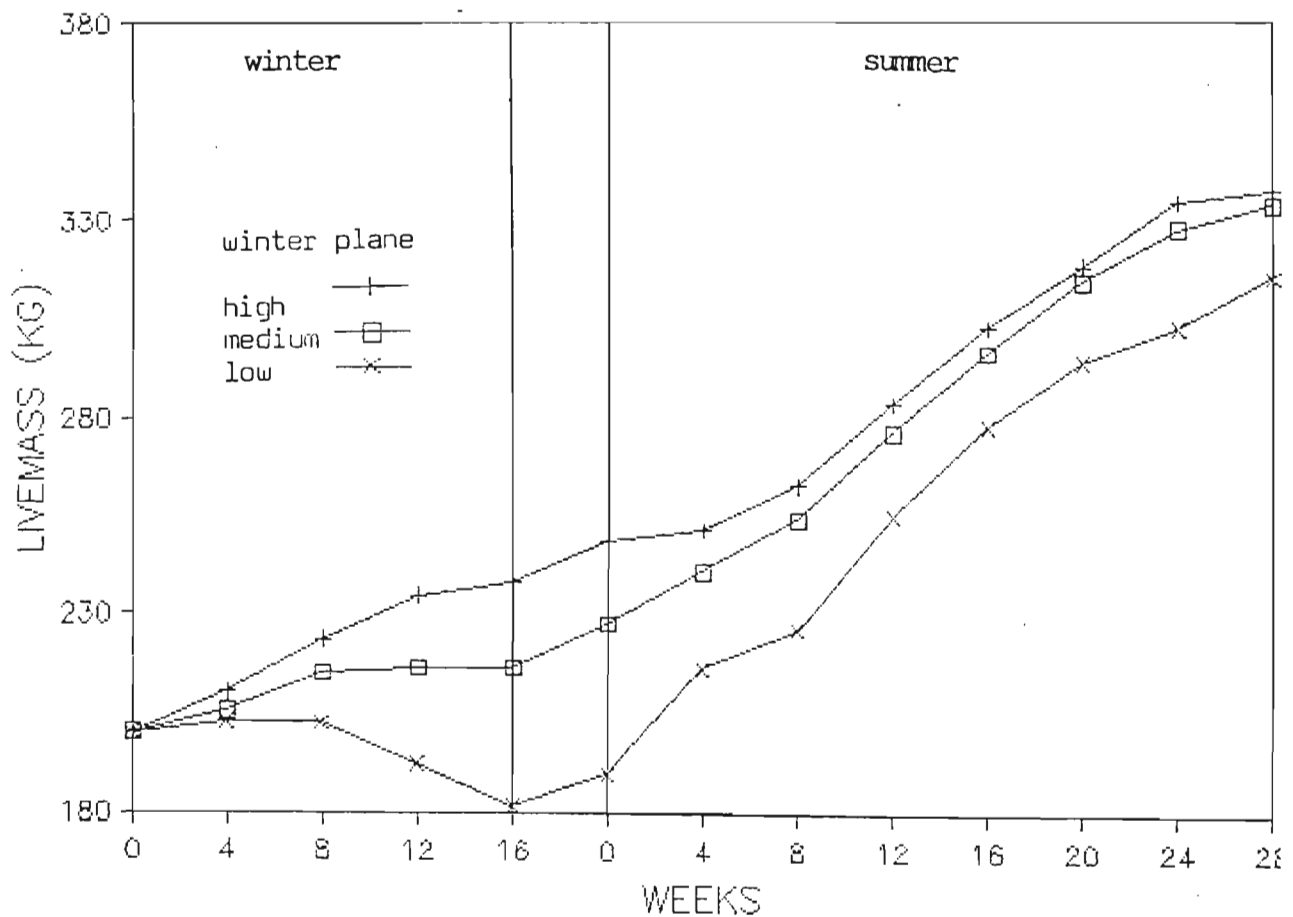


Figure 2. The performance of heifers during winter and subsequent summer when stocked at a medium stocking rate on summer veld - 1984/85 season.

treatments at the end of the winter phase, was however, of sufficient magnitude to enable the winter nutritional effects to be expressed on summer grazing. During the second season (1985/86) the heifers in Tr.1, Tr.2 and Tr.3 had daily growth rates of 0,56 kg, 0,28 kg and -0,06 kg respectively (Table 2). These gains were close to the predicted growth rates.

Feed intakes and costs

The feed intakes and feed costs incurred during the first winter feeding phase are presented in Table 3. During the first season the heifers in Treatments 1, 2 and 3 consumed 4,42 kg, 3,94 kg and 2,75 kg of dry matter (excluding licks) per day, respectively. The daily costs of feed per head were calculated at 45,28 c (Tr.1), 41,6 c (Tr.2) and 32,2 c (Tr.3). In the case of Tr.1 the cost per kilogram of livemass gain was calculated at R1,33. The feed cost per kilogram of livemass gain for the heifers in Tr.1 during the 1985/86 season was also calculated at R1,33. An efficiency cost for the heifers in Tr.2 and Tr.3 has not been calculated since these animals were on restricted diets.

The growth rate of 0,34 kg/day achieved by the heifers in Tr.1 during the first season was below the projected rate, and can be ascribed largely to a shortage of protein in the ration. Consequently, a HPC was fed to the heifers in Tr.1 during the second season. Whilst the addition of a HPC to the ration increased the total cost of the diet, the cost per kg/livemass gain remained at R1,33 and a growth rate of 0,56 kg/day was achieved (Table 3). The growth rates of the heifers in Tr.2 and Tr.3 were maintained at the required rates by restricting the quantity of feed available. For comparative purposes the same feed costs were applied during both seasons.

Table 2. Mass gains of the heifers during the first winter feeding phase.

Nutritional plane Predicted growth rate (kg/day)	Tr.1	Tr.2	Tr.3
	High 0,5	Medium 0,25	Low -0,12
<u>1984/85 season</u>	n=37	n=37	n=37
Initial mass (kg)	202,46 ^{a*}	201,81 ^a	200,13 ^a
Final mass (kg)	237,54 ^a	216,00 ^b	181,44 ^c
Mass gain (kg)	35,08 ^a	14,19 ^b	-18,69 ^c
ADG (104 days) (kg)	0,34 ^a	0,14 ^b	- 0,18 ^c
<u>1985/86 season</u>	n=32	n=32	n=32
Initial mass (kg)	195,28 ^a	193,19 ^a	193,47 ^a
Final mass (kg)	262,80 ^a	226,80 ^b	186,56 ^c
Mass gain (kg)	67,52 ^a	33,61 ^b	- 6,91 ^c
ADG (120 days) (kg)	0,56 ^a	0,28 ^b	- 0,06 ^c

* Figures within rows having different superscripts differ significantly (P < 0,01)

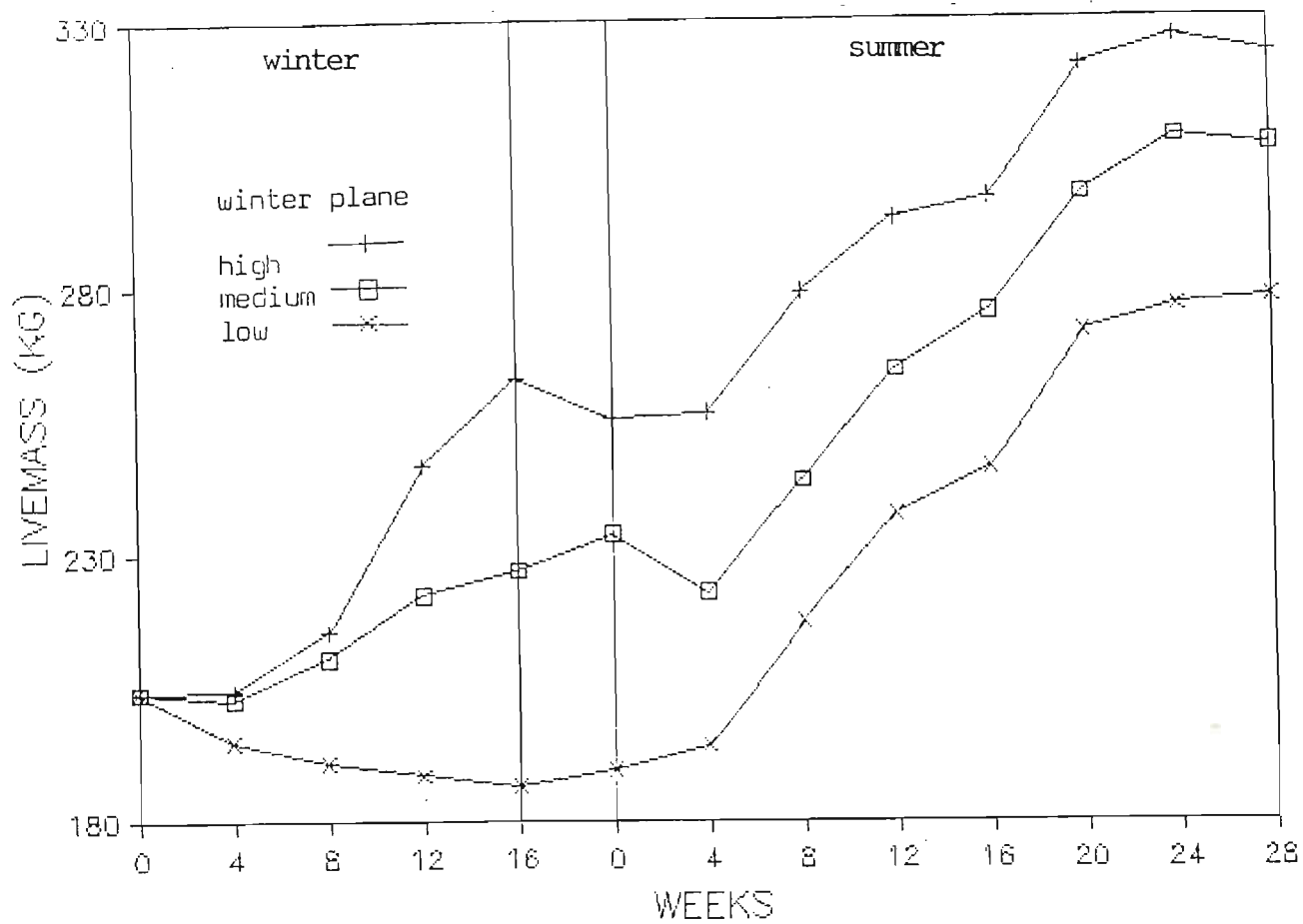


Figure 5. The performance of heifers during winter and subsequent summer when stocked at a medium stocking rate on summer veld - 1985/86 season.

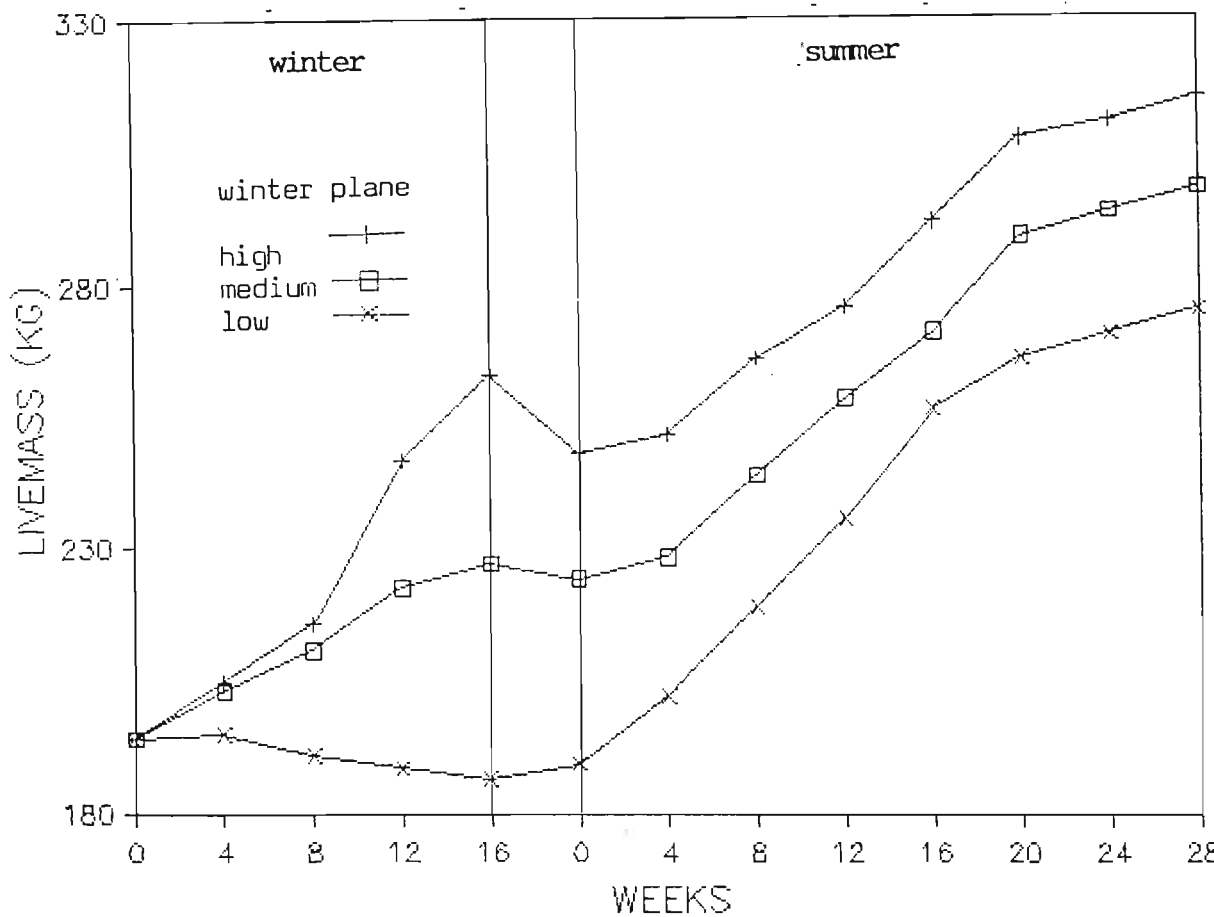


Figure 6. The performance of heifers during winter and subsequent summer when stocked at a high stocking rate on summer veld.

Performance during summer grazing

Effect of stocking rate and season.

Summer grazing, during the first and second season commenced on the 13th of November 1984 and the 15th of November 1985 respectively. The length of the grazing season was 188 days during the first season and 200 days during the second season. The mass gains of the heifers on summer veld, at the three stocking rates, for both seasons, are shown in Table 4. The growth curves of the heifers during the first winter and subsequent summer grazing period are shown in Figures 1 - 6 .

During the 1984/85 season, the heifers stocked at the low stocking rate attained significantly ($P < 0,01$) higher mass gains on summer veld than the heifers stocked at the medium and high stocking rates. The heifers stocked at the medium stocking rate, in turn, had significantly ($P < 0,01$) higher mass gains than the heifers stocked at the high stocking rate (Table 4). The significant effect of stocking rate on summer mass gains was apparent irrespective of the previous winter nutritional level. During the 1985/86 season, animals stocked at the low stocking rate had only slightly higher (NS) summer mass gains than the heifers at the high stocking rate. There was also no significant difference in the summer mass gains between the heifers stocked at the medium and high stocking rates. For each comparable treatment, the heifers had higher summer gains during the first season, than during the second season.

The significant effect of stocking rate on summer mass gains and the higher mass gains achieved during the 1984/85 season was largely a consequence of the grazing management regime employed. The veld utilized during the 1984/85 season had undergone a full seasons rest during the previous season and all the camps burnt at the end of September 1984. In contrast, during the 1985/86 season, the veld was

Table 3. Feed intakes and feed costs incurred during the first winter feeding phase.

Plane of nutrition Predicted daily gain (kg)	Tr.1 High 0,5	Tr.2 Medium 0,25	Tr.3 Low -0,12
<u>1984/85 season</u>	n=37	n=37	n=37
Feed consumed (kg DM/day)			
<u>E. curvula</u> hay	2,00	2,50	2,75
Maize silage	2,42	1,44	nil
<u>Total:</u>	4,42	3,94	2,75
Lick (g/day)	135	114	127
Feed costs (104 days)			
<u>E. curvula</u> hay (R)	21,98	27,48	30,23
Maize silage (R)	21,61	12,86	nil
Lick (R)	3,51	2,97	3,30
<u>Total:</u> (R)	47,10	43,31	33,53
<u>1985/86 season</u>	n=32	n=32	n=32
Feed consumed (kg DM/day)			
<u>E. curvula</u> hay	1,85	2,08	2,49
Maize silage	2,71	1,60	nil
HPC	0,95	nil	nil
<u>Total:</u>	5,51	3,68	2,49
Lick (g/day)	71	109	117
Feed costs (120 days)			
<u>E. curvula</u> hay (R)	23,46	26,38	31,58
Maize silage (R)	27,93	16,49	nil
HPC (R)	36,00		
Lick (R)	2,13	3,27	3,51
<u>Total:</u> (R)	89,52	46,14	35,09

Roughage feed costs based on Agric. Prod. Economics figures - 1986

E. curvula hay - R105,71/ton DM. Maize silage R85,90/ton DM

HPC R300/ton

Lick R250/ton.

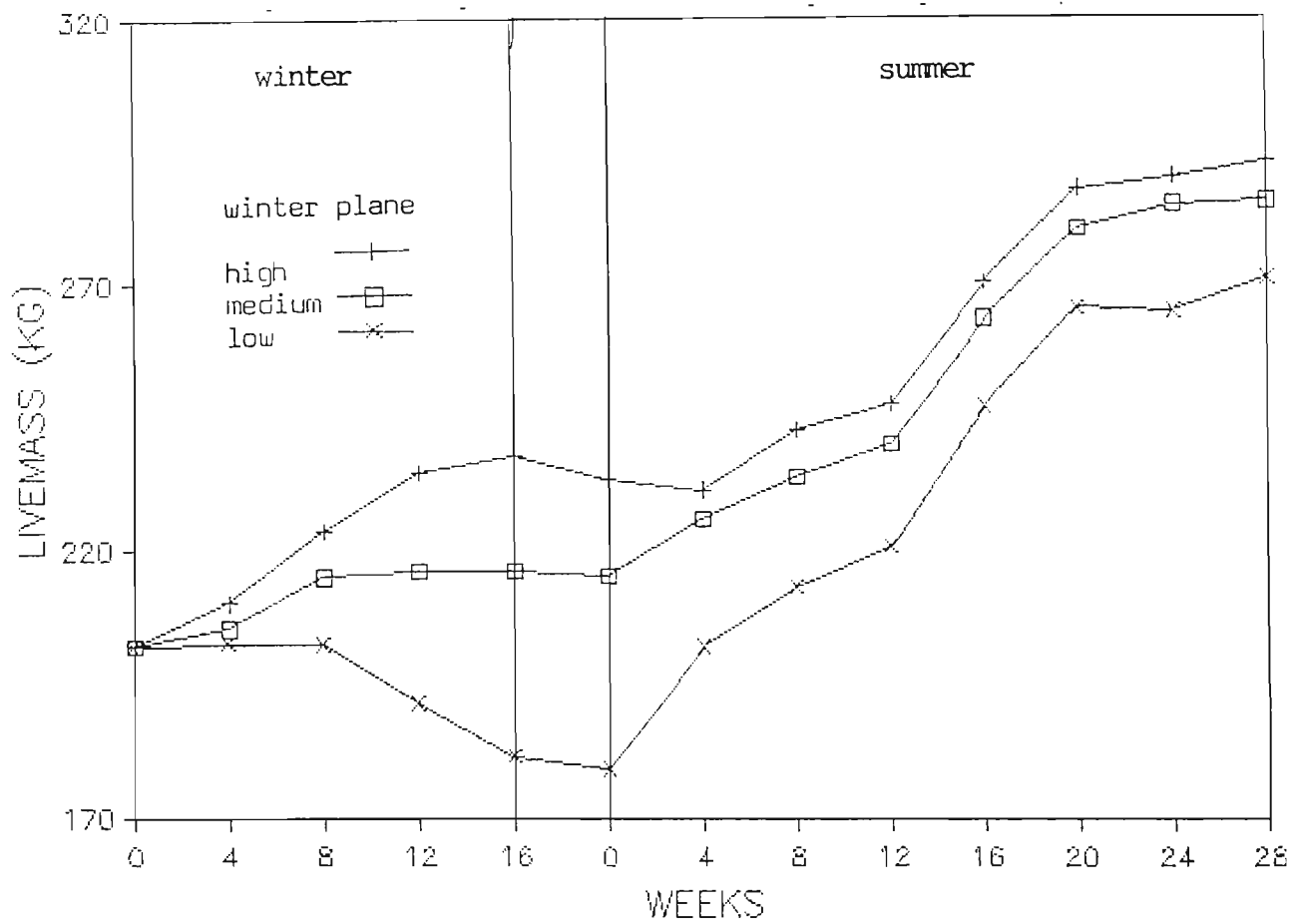


Figure 3. The performance of heifers during winter and subsequent summer when stocked at a high stocking rate on summer veld - 1984/85 season.

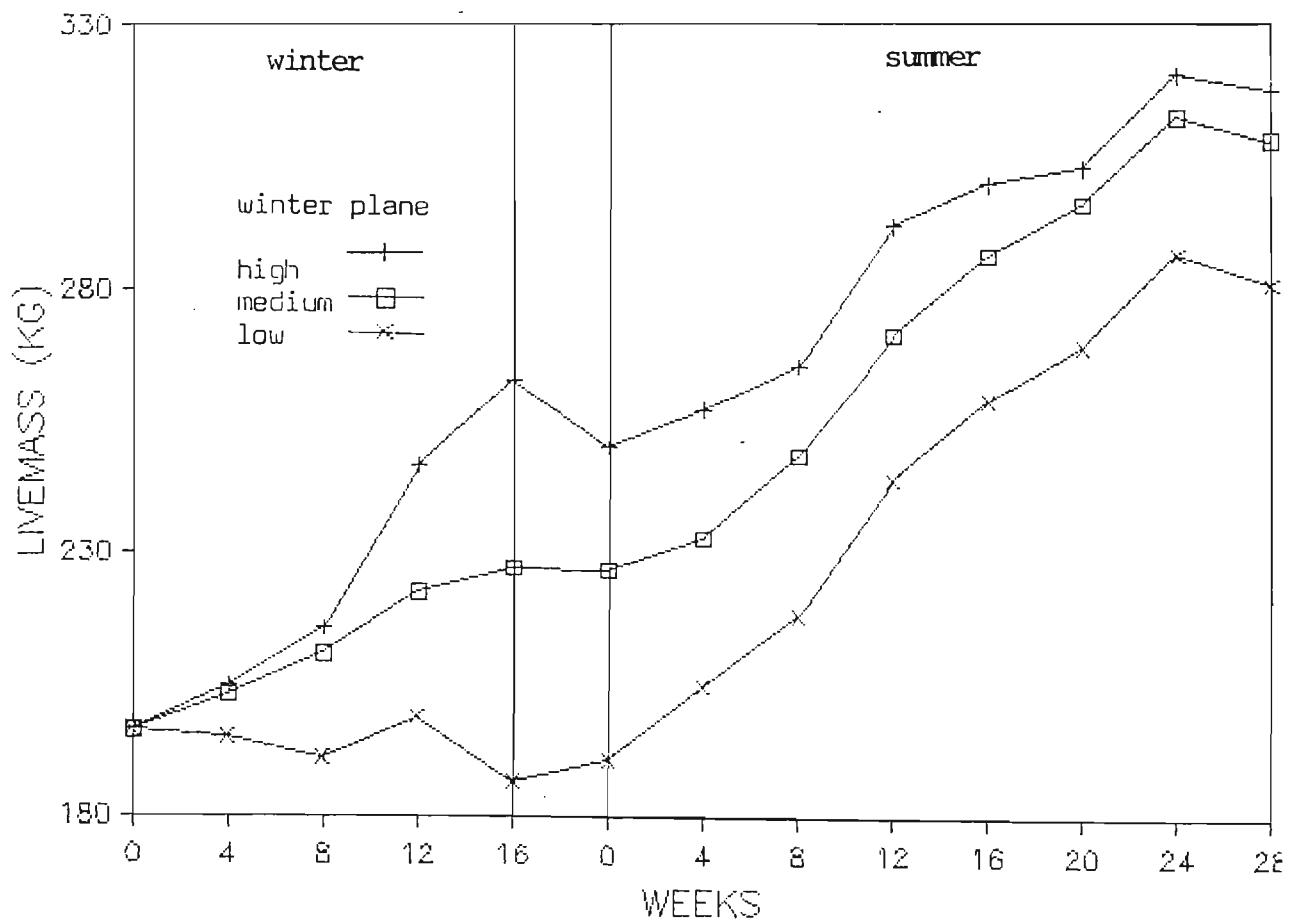


Figure 4. The performance of heifers during winter and subsequent summer when stocked a low stocking rate on summer veld - 1985/86 season.

rested during the previous winter months only and no burning took place. Unfortunately crude protein analyses were not carried out and it is therefore not possible to compare the quality of the herbage available during the two seasons. However, as a consequence of the full seasons rest and the burn there was probably more grass, of better quality, available during the first season.

Compensatory growth

Evidence of compensatory growth on summer veld is apparent from the data shown in Table 4, Table 5 and Figures 1 - 6. During the first season, the heifers wintered on the low plane of nutrition achieved significantly ($P < 0,01$) higher summer gains than the heifers wintered at the medium nutritional level. These heifers (medium winter plane), in turn, achieved significantly ($P < 0,01$) higher mass gains than the heifers wintered on the high plane of nutrition (Table 4). The degree of compensatory growth was modified by stocking rate (Table 4). During the 1985/86 season, the heifers wintered on the low plane of nutrition had significantly ($P < 0,01$) higher summer gains than the heifers wintered at the medium and high levels. This trend was apparent at all three stocking rates (Table 4). In contrast to the 1984/85 season, compensatory growth on veld during the second season, between the medium and high winter nutritional levels was evident at the low stocking rate only (Table 4).

It is important to note that whilst the heifers wintered at the low level had significantly ($P < 0,01$) higher gains on veld than the heifers wintered on the medium plane, the livemasses of the heifers wintered at the higher level were always higher at the end of the summer grazing period than the heifers wintered at the lower level. Consequently the heifers wintered at the higher level during the first winter required less feed during the second winter in order to attain

Table 4. Mass gains (kg) during the summer grazing period and final livemasses (kg) at the end of the summer

Season	Winter nutrition level	Summer stocking rate (AU/ha)					
		0,75		1,0		1,25	
		gain	final	gain	final	gain	final
1984/85	High	84,60 ^{a*}	337,20	75,20 ^b	309,07	58,28 ^c	293,00
	Medium	101,52 ^b	333,50	88,36 ^c	297,78	69,56 ^a	285,15
	Low	120,32 ^c	313,36	105,28 ^a	290,00	90,24 ^b	270,46
1985/86	High	68,40 ^a	317,40	66,50 ^a	323,30	64,60 ^a	315,00
	Medium	79,80 ^b	307,80	68,40 ^a	306,00	72,20 ^{ab}	298,00
	Low	91,20 ^c	280,70	87,40 ^c	277,40	85,50 ^c	275,00

* For each season, figures within columns and rows having different superscripts differ significantly ($P < 0,01$).

the desired mating mass (Table 4).

The final summer livemasses of the heifers wintered at the high and medium levels, and subsequently stocked at the low stocking rate had attained the required mating mass of 330 kg by the end of the summer grazing period. These animals were therefore maintained during the subsequent winter feeding period, whilst the heifers in all the other treatments were fed to achieve the target mating mass by mid-October.

Having established that compensatory growth on sourveld was potentially an important factor, a detailed analysis of the mass gains on summer veld was undertaken to determine at what stage of grazing compensatory growth occurred. These results are presented in Table 5. The summer grazing period was divided into two phases: 1) the first 12 weeks of grazing; 2) from the 13th week until the animals were removed from the veld. During the first 12 weeks of both seasons, the heifers wintered on the low plane of nutrition had significantly ($P < 0,05$) higher mass gains than the heifers wintered at the medium level, however, this trend was not apparent during the subsequent 14,5 weeks. Significant ($P < 0,05$) differences in summer gain between the animals wintered at the medium and high winter nutritional levels were apparent for the first 12 weeks at all three stocking rates in the 1984/85 season, but only at the medium stocking rate in the second season (Table 5). Compensatory growth therefore took place during the first 12 weeks of grazing and not over the whole grazing season.

During the first season, all the heifers wintered on a high plane of nutrition had lower daily gains during the first 84 days on veld than during the subsequent 103 days of grazing, irrespective of stocking rate. However, the growth rates of the heifers wintered at the high level did not differ significantly ($P > 0,05$) during the last 14,5

Table 5. The effect of the interaction between the winter nutritional plane and summer stocking rate on compensatory growth in terms of mass gain (kg) and daily gain (ADG - kg/day) during two different grazing phases.

Season	Winter plane	Summer stocking rate	Day 1 - 84		Day 85 - 188	
			Gain	ADG	Gain	ADG
1984/85	High	Low	34,70 ^{a*}	0,42	53,90 ^a	0,53
	Medium	Low	48,80 ^b	0,58	57,30 ^a	0,56
	Low	Low	65,18 ^c	0,79	60,63 ^a	0,59
	High	Medium	28,54 ^a	0,34	46,84 ^a	0,46
	Medium	Medium	42,49 ^b	0,51	46,58 ^a	0,46
	Low	Medium	62,86 ^c	0,75	49,77 ^a	0,49
	High	High	13,86 ^a	0,17	45,93 ^a	0,45
	Medium	High	24,62 ^b	0,30	45,46 ^a	0,45
	Low	High	41,54 ^c	0,50	49,92 ^a	0,49
1985/86	High	Low	41,51 ^a	0,53	25,80 ^a	0,25
	Medium	Low	44,76 ^a	0,57	36,60 ^b	0,34
	Low	Low	53,40 ^b	0,68	36,90 ^b	0,34
	High	Medium	36,90 ^{ab}	0,47	30,80 ^a	0,28
	Medium	Medium	30,65 ^a	0,39	41,80 ^b	0,38
	Low	Medium	47,58 ^b	0,61	40,40 ^b	0,37
	High	High	27,80 ^a	0,53	25,80 ^a	0,25
	Medium	High	24,29 ^a	0,31	39,80 ^b	0,37
	Low	High	46,03 ^b	0,59	39,70 ^b	0,36

* For each stocking rate treatment and within columns, figures having different superscripts differ significantly ($P < 0,05$)

Table 6 . Relationships between winter nutritional level and summer stocking rate on animal performance. Pooled data - 1984/85 and 1985/86 seasons.

Winter nutrition level	Summer Stocking rate	n	Correlation co-efficient	Significance level	Regression equation y = summer gain x = winter gain
High	High	24	r = -0,130	NS	Y = 59,89 - 0,01 X
High	Medium	23	r = -0,318	NS	Y = 79,62 - 0,14 X
High	Low	20	r = -0,485	*	Y = 104,12 - 0,60 X
Medium	High	23	r = -0,208	NS	Y = 71,16 - 0,14 X
Medium	Medium	23	r = -0,726	**	Y = 96,24 - 0,64 X
Medium	Low	17	r = -0,611	**	Y = 115,28 - 0,84 X
Low	High	23	r = -0,071	NS	Y = 85,08 - 0,16 X
Low	Medium	24	r = -0,342	NS	Y = 97,91 - 0,42 X
Low	Low	20	r = -0,346	NS	Y = 101,55 - 0,97 X

* Significant at the 5% level

** Significant at the 1% level

weeks of grazing from the growth rates of the heifers wintered at the low and medium planes (Table 5).

"Gut-fill" during the early part of the grazing season must have occurred, however, it is not possible to determine how much of the apparent compensatory growth was due to "gut-fill". These data suggest that when grazing was reasonably abundant (low stocking rate), compensatory growth occurred during the first 12 weeks of grazing and not evenly over the entire season.

The pooled data for the two seasons indicating the relationship between winter nutritional level and summer stocking rate on animal performance are summarized in Table 6. The importance of stocking rate is once again demonstrated by the fact that significant negative correlations were obtained for the heifers stocked at the low stocking rate, having previously been subjected to the high ($P < 0,05$) and the medium ($P < 0,01$) planes of nutrition. The heifers wintered on the low plane of nutrition just failed to achieve significance ($P > 0,05$). The correlation coefficients for the heifers wintered at the medium level and stocked at the medium stocking rate were also significant ($P < 0,01$). These figures indicate that the full potential of compensatory growth can only be realized when sufficient herbage is available during the realimentation phase.

Total feed costs

Total feed costs for the first and second winter feeding periods, for both seasons, are presented in Table 7. The livemass gains, for the various treatments, required during the second winter in order for the heifers to reach the target mating mass of 330 kg by mid-October can be calculated from Table 4. A feed cost of R24,60 per heifer during the second winter was allocated to the heifers wintered at the high and

Table 7. Total feed costs incurred in rearing heifers up to the mating stage

Season	Winter nutrition level	1st Winter feed costs	2nd Winter feed costs			Total feed costs		
			SR (AU/ha)			SR (AU/ha)		
			0,75	1,00	1,25	0,75	1,00	1,25
1984/85		R	R	R	R	R	R	R
	High	47,10	24,60	31,40	55,50	71,70	78,50	102,60
	Medium	43,31	24,60	48,33	67,28	67,91	91,64	110,59
	Low	33,53	24,96	60,00	89,31	58,49	93,53	122,84
1985/86	High	89,52	24,60	24,60	24,60	114,12	114,12	114,12
	Medium	46,14	33,30	36,00	48,00	79,44	82,14	94,14
	Low	35,09	73,95	78,90	82,50	109,04	113,99	117,59

medium levels and subsequently stocked at the light stocking rate (1984/85 season) because these heifers were required to only maintain their final summer livemasses during the second winter. All the heifers wintered at the high level were required to achieve daily growth rates of less than 0,2 kg during the second winter in order to reach the required mating mass. These heifers were therefore also allocated a winter feed cost of R24,60 per head (Table 7). The heifers in the remaining treatments were fed at a cost of R1,50 per kilogram livemass gain.

During the first season, the heifers wintered on the low plane of nutrition and subsequently stocked at the low stocking rate on summer veld realized the lowest feed costs (Table 7). The highest feed costs were realized by the heifers wintered at the low level and subsequently stocked at the high stocking rate (Table 7). The restricted intakes resulting from the high stocking rates clearly prevented the heifers wintered at the low level from attaining maximum compensatory growth on summer veld. Consequently, considerable winter feed was required during the second winter in order for these heifers to achieve the target mating mass of 330 kg by mid-October.

The lowest feed costs during the second winter were realized by the heifers wintered on the medium plane of nutrition and subsequently stocked at the low stocking rate (Table 7). The highest feed cost were attributed to the heifers wintered at the low level and subsequently stocked at the high stocking rate on summer veld. The highest feed costs were therefore realized by the same treatment in both seasons.

Whilst stocking rate appeared to be the dominant factor affecting total winter feed costs during the first season, plane of nutrition during the first winter appeared to be the dominant factor in the 1985/86 season. These results not only highlight the complexity of the interactions between winter nutritional level and summer stocking rate

in the Highland Sourveld, but they reaffirm the need for the farmer to have a clear understanding of the condition of his veld and the requirements of the different classes of animals.

Reproduction trends

Replacement heifers born 1981 - calved 1984

The performances of these animals up to the mating stage have previously been described (Van Niekerk, 1985).

The number of heifers involved in the experiment, culled, diagnosed pregnant, calved and the calving rate are summarized in Table 8. Animals were culled at the end of the summer grazing period if they had not yet reached a livemass of 240 kg by this stage. It was considered uneconomical and therefore impractical to feed these animals during the winter feeding phase.

Twenty of the original ninety four animals were culled of which 11 (55%) had been wintered on the low plane of nutrition and 9 (45%) on the medium plane during the first winter. None of the heifers wintered on the high plane of nutrition were culled (Table 8).

Heifers were mated over a 60 day period and three weeks before the main herd. Seventy four heifers were mated of which forty four calved (59,46%). There were, however, considerable differences in calving rate, both between and within treatments. No clear relationship between calving rate and winter plane of nutrition or between calving rate and summer stocking rate was apparent.

In an attempt to pin-point the reasons for the poor conception rates in some of the groups, the livemasses of the pregnant and non-pregnant heifers at the start of the mating season were analysed (Table 9). It is apparent from these data that the differences in mass

between the heifers that conceived and those that failed to conceive were relatively small. The pooled data of the pregnant and the non-pregnant heifers indicated that there were no statistically significant differences in mass at the beginning of the mating season (Table 9).

The overall poor conception rate (59,46%) of the heifers can probably be ascribed to a bull effect. The heifers were run as one group during the breeding season (60 days) together with three bulls, giving an effective bull to cow ratio of 1:25. Whilst the bulls were fertility tested, they were young and lacked experience, particularly with heifers.

The calving data of the 44 heifers that did calve are summarized in Table 10. Based on the mean calving date, it is evident that, with the exception of the heifers wintered at the low level and subsequently stocked at the high stocking rate, the mean conception date was within 30 days of the commencement of breeding. The low winter/high stocking rate heifers had a mean conception date 42 days after the initiation of the breeding season.

There was also no discernible effect of treatment on calf birth mass (Table 10). Calf birth mass was however, significantly correlated ($P < 0,05$) with the mass of the dam at mating. The correlation coefficient was $r = 0,346$ and the regression equation $Y = 3,264 + 0,079$ ($Y = \text{birth mass; } n = 44$).

Subsequent calving performance

The number of calves born over the last three seasons to heifers that calved for the first time in 1984 is summarized in Table 11. Thirty (68%) of the 44 heifers produced three calves in three years, thirteen (30%) heifers produced two calves in three years and only one heifer produced one calf in three years. Whilst a detailed statistical

Table 8 . Number of heifers culled, diagnosed pregnant or non-pregnant, and the calving rate for replacement heifers born during the 1981 season.

Winter nutrition level	Summer stocking rate	No. of animals	No. of animals culled	No. of animals pregnant	No. of animals not pregnant	No. of animals calved	Calving rate %
High	High	9	0	8	1	8	88,89
High	Medium	9	0	8	1	9	100,00
High	Low	5	0	3	2	2	40,00
Medium	High	14	4	7	3	3	30,00
Medium	Medium	15	1	8	6	3	21,43
Medium	Low	15	4	9	2	7	63,64
Low	High	9	5	3	1	3	75,00
Low	Medium	9	4	4	1	5	100,00
Low	Low	9	2	5	2	4	57,10

Table 9 . Livemasses (kg) of pregnant and non-pregnant heifers at the beginning of the mating season. Replacement heifers born 1981.

Winter nutrition level	Summer stocking rate	Livemass at beginning of mating season	
		Pregnant	Non-pregnant
High	High	348,75 ± 29,70	340,00 ± 0
High	Medium	342,75 ± 16,83	340,00 ± 0
High	Low	324,00 ± 10,39	348,00 ± 11,31
Medium	High	330,29 ± 17,41	329,33 ± 10,07
Medium	Medium	336,57 ± 18,43	340,00 ± 29,61
Medium	Low	349,56 ± 16,99	328,00 ± 17,44
Low	High	324,00 ± 17,09	324,00 ± 0
Low	Medium	332,00 ± 9,93	348,00 ± 0
Low	Low	353,20 ± 29,58	347,00 ± 7,07
	Mean	337,90 ± 11,14	338,26 ± 9,11

analysis of the data was not possible due to the small number of animals involved, no long-term effects of treatment on subsequent calving performance were apparent.

. Since the interval between calvings is of economic significance to the farmer and the beef industry as a whole, the effect of treatment on calving interval was studied. The pooled data from all the treatments indicated that the mean calving interval between the first and second calf was 399 days (Table 12). Whilst this figure appears high, it should be noted that the replacement heifers were mated 30 days prior to the main breeding herd. The mean calving interval between the second and third calves was 373 days (Table 12) which meant that as first-calf heifers, these animals conceived within the first 20 - 30 days of the start of the breeding season. Previous treatments apparently did not affect the calving interval between either the first and second calf or the second and third calf.

Replacement heifers born 1983 - calved 1986

The performance of these heifers up to the mating stage are described in Table 2 and Table 4 (1984/85 season).

A summary of the number of animals involved in the analysis, the number culled, animals diagnosed pregnant or non-pregnant and the calving rates of the heifers in the various treatments, are presented in Table 13. In contrast to the previous season's results, only two animals were culled at the end of the 1985 summer grazing period whereas 20 animals were culled at the end of the 1983 summer grazing period.

Calving rates were consistently high with a mean calving rate, for all the treatments, of 94,83%. The high calving rate can be partially ascribed to the fact that bull performance was monitored; any bull that appeared not to be working was replaced. The breeding season was

Table 10. Calving date, mass at breeding and birth mass of progeny born to heifers. Progeny born 1984.

Winter nutrition level	Summer stocking rate	n	Date of Calving	Heifers mass at breeding (kg)	Calf birth mass (kg)
High	High	8	22.08.84 ± 10	346,75 ± 31,91	29,13 ± 4,32
High	Medium	9	20.08.84 ± 10	343,56 ± 15,93	30,44 ± 6,27
High	Low	2	19.08.84 ± 6	318,00 ± 0	26,00 ± 2,83
Medium	High	3	24.08.84 ± 8	338,67 ± 8,08	34,00 ± 2,00
Medium	Medium	3	16.08.84 ± 4	340,67 ± 11,37	30,33 ± 3,79
Medium	Low	7	21.08.84 ± 11	348,86 ± 16,41	30,00 ± 5,83
Low	High	3	04.09.84 ± 74	315,33 ± 10,07	29,33 ± 4,16
Low	Medium	5	18.08.84 ± 10	329,20 ± 21,34	29,20 ± 7,69
Low	Low	4	18.08.84 ± 15	349,30 ± 35,60	31,00 ± 8,08

Table 11. The effect of Treatment on the number of calves produced by replacement heifers.

Winter nutrition level	Summer stocking rate	n	No. of calves born in 3 years		
			3	2	1
High	High	n = 8	7 (87,5%)	1 (12,5%)	nil
High	Medium	n = 9	6 (66,7%)	2 (22,2%)	1 (11,1%)
High	Low	n = 2	nil	2 (100,0%)	nil
Medium	High	n = 3	2 (66,7%)	1 (33,3%)	nil
Medium	Medium	n = 3	2 (66,7%)	1 (33,3%)	nil
Medium	Low	n = 7	5 (71,4%)	2 (28,6%)	nil
Low	High	n = 3	2 (66,7%)	1 (33,3%)	nil
Low	Medium	n = 5	4 (80,0%)	1 (20,0%)	nil
Low	Low	n = 4	2 (50,0%)	2 (50,0%)	nil

restricted to sixty days. The heifers were run as one group with a bull to cow ratio of 1:25.

The livemasses at the beginning of the mating season of the five heifers that did not conceive were compared with their pregnant counterparts (Table 14). Subsequent analysis showed that in all but one treatment, the heifers that failed to conceive were slightly heavier than the animals that did conceive. The difference in mass at the beginning of the mating season between the heifers that did conceive and those that did not was therefore unlikely to have affected conception rate.

The reproductive performances of the heifers that calved are summarized in Table 15. All the heifers conceived within 20 days of the initiation of the breeding season. The heifers wintered on the low plane of nutrition and subsequently stocked at the low stocking rate conceived within seven days of being put to the bulls. Treatment exerted no significant effect on calf birth mass (Table 15). Calf birth mass was significantly ($P < 0,05$) correlated with the mass of the dam at conception. The correlation coefficient was $r = 0,376$ and the regression equation $Y = 11,22 + 0,054X$ ($Y =$ birth mass; $n = 94$).

DISCUSSION

The results presented in this study have been obtained by simulating an eight camp rotational grazing system. Whether similar results could be obtained from a four camp, or continuous grazing system, is open to speculation. This is an area that is at present being researched at the Thabamhlope Research Station. However, the grazing management aspect must be taken into consideration when attempting to apply the recommendations made in this thesis. The veld

Table 12. The effect of Treatment on the calving interval in replacement heifers.

Winter nutrition level	Summer stocking rate	Interval between calvings (days)		
		1st calf - 2nd calf 1984 - 1985	2nd calf - 3rd calf 1985 - 1986	1st calf - 2nd calf 1984 - 1986
High	High	392,14 ± 10,7	361,17 ± 9,9	-
High	Medium	388,67 ± 11,10	373,67 ± 17,9	766,00 ± 28,28
High	Low	437,00 ± 0	-	762,00 ± 0
Medium	High	386,00 ± 6,25	383,00 ± 5,20	-
Medium	Medium	399,33 ± 12,90	265,00 ± 4,90	-
Medium	Low	391,60 ± 10,43	365,00 ± 2,91	749,00 ± 0
Low	High	406,50 ± 81,32	387,50 ± 3,54	-
Low	Medium	390,60 ± 10,16	366,75 ± 6,07	-
Low	Low	401,50 ± 7,78	381,00 ± 16,97	770,00 ± 7,07
	Mean	399,26 ± 15,63	372,95 ± 9,81	761,75 ± 9,11

Table 13. Number of heifers culled, diagnosed pregnant or non-pregnant and the calving rate for replacement heifers born during the 1983 season.

Winter nutrition level	Summer stocking rate	No. of animals	No. of animals culled	No. of animals pregnant	No. of animals not pregnant	No. of animals calved	Calving rate %
High	High	13	2	10 ^a	1	9	81,82
High	Medium	13	0	13	0	13	100,00
High	Low	9	0	9	0	9	100,00
Medium	High	12	0	11	1	11	91,67
Medium	Medium	14	1 ^b	13	0	13	100,00
Medium	Low	10	1 ^c	9	0	9	100,00
Low	High	11	1 ^d	9	1	9	90,00
Low	Medium	13	0	13	0	13	100,00
Low	Low	11	0	10	1	9	90,00

a = 10 cows pregnant - calf born dead - excluded from analysis

b, c = cows died - lightning strikes

d = cow died

Table 14. Livemasses (kg) of pregnant and non-pregnant heifers at the beginning of the mating season. Replacement heifers born 1983.

Winter nutrition level	Summer stocking rate	Livemass at beginning of mating season	
		Pregnant	Non-pregnant
High	High	346,64 ± 31,09	336,00 ± 0
High	Medium	361,31 ± 40,28	-
High	Low	379,60 ± 27,19	-
Medium	High	340,91 ± 31,14	347,00 ± 0
Medium	Medium	354,36 ± 37,55	-
Medium	Low	366,40 ± 28,01	-
Low	High	338,30 ± 34,84	346,00 ± 0
Low	Medium	357,85 ± 35,25	-
Low	Low	363,44 ± 23,45	394,00 ± 0
	Mean	356,53 ± 13,14	355,75 ± 25,98

Table 15. Calving date, mass at breeding and birth mass of progeny born to heifers. Progeny born 1986.

Winter nutrition level	Summer stocking rate	n	Date of calving	Heifer mass at breeding (kg)	Calf birth mass (kg)
High	High	9	15.08.86 ± 30	351,67 ± 27,61	30,22 ± 7,1
High	Medium	13	12.08.86 ± 18	361,31 ± 40,28	32,62 ± 2,31
High	Low	9	15.08.86 ± 23	376,86 ± 29,79	30,79 ± 4,68
Medium	High	11	12.08.86 ± 13	338,45 ± 29,53	29,27 ± 4,86
Medium	Medium	13	11.08.86 ± 13	351,92 ± 37,83	29,92 ± 5,78
Medium	Low	9	12.08.86 ± 13	369,56 ± 27,76	32,00 ± 2,83
Low	High	9	06.08.86 ± 12	339,89 ± 36,90	30,44 ± 4,48
Low	Medium	13	09.08.86 ± 16	357,85 ± 35,25	31,00 ± 5,63
Low	Low	9	28.07.86 ± 11	363,79 ± 23,33	28,44 ± 3,25

utilized during the 1984/85 season had previously undergone a full season's rest with a burn at the end of September. The animals commenced grazing on the 13th of November 1984.

. During the first four weeks on veld, the animals wintered on the low plane of nutrition gained at rates of 0,94 kg, 1,06 kg and 0,82 kg per day on summer veld in the low, medium and high stocking rate treatments respectively (Fig. 1 - 3). A large proportion of these gains can be ascribed to "gut-fill". This view is supported by the fact that the animals previously wintered on the medium and high planes of nutrition achieved significantly ($P < 0,01$) lower mass gains for the first four weeks on veld than their low winter plane counterparts (Figures 1, 2 and 3). The problem of "gut-fill" has been recognised for a long time (Palsson & Verges, 1952a and 1952b; Joubert, 1954; Wilson & Osbourn, 1960). It was therefore inevitable that in the 1960's the use of livemass fluctuations as the evaluation criterion of compensatory growth changed, with increasing attention being devoted to carcass masses (Lawrence & Pearce, 1964a and 1964b). More recently, information on the dynamic variations in the distribution and composition of various body components has increased the understanding of mass loss/mass gain relationships (O'Donovan, 1984).

During the second season (1985/86) the veld was rested only during the winter months (June to October). No burning took place. Consequently, the quality of grazing available would probably have been lower than during the previous season (Mes, 1958; Tainton, Groves & Nash, 1977). The quantity of herbage available may also have been reduced due to the short rest period, during which very little growth would have taken place. The mass gains of the heifers for the first four weeks on veld during the second season support these viewpoints. The heifers wintered on the low plane of nutrition had subsequent summer gains of 0,58 kg, 0,20 kg and 0,52 kg per day (Fig. 4 - 6) for

the low, medium and high stocking rate treatments respectively. Although a large proportion of these gains would have been due to "gut-fill", the mass gains were nevertheless lower than those achieved during the previous season.

The inverse relationship between level of winter feeding and subsequent performance on summer veld (Table 6) indicates the ability of the heifers to exhibit compensatory growth. The precise mechanisms contributing to compensatory growth are not fully understood. The subject has been comprehensively reviewed by Wilson & Osbourn (1960), Allden (1970) and O'Donovan (1984). According to Gleeson (1972), the degree of compensation depends on the nature of the under-nutrition, the severity of under-nutrition, the duration of the under-nutrition period, the stage of development at the start of under-nutrition, the relative rate of maturity of the animals and the pattern of realimentation. In the present study the degree of under-nutrition could not be described as severe and by the end of the second winter feeding period complete compensation had occurred. Sixty to eighty percent of the compensation had taken place by the end of the summer grazing phase (Figures 1 - 6). Most of the compensation took place during the first 12 weeks of the grazing season. The results from this study are in general agreement with those of Gleeson (1972), Wanyoike & Holmes (1981) and O'Donovan (1984).

The mass compensation realized on veld varied between 52% at the high stocking rate and 82% at the low stocking rate. McCarrick, Harrington & Conway (1963) and Lawrence & Pearce (1964a) recorded mean compensation values of 75 - 80% which were close to the figures recorded at the low stocking rate in this study. However, the majority of workers (Hull, Meyer, Bonillan & Weitkamp, 1965; Broadbent, Ball & Dodsworth, 1969; O'Donovan, 1972 and Horton & Holmes, 1978) found degrees of compensation on pasture ranging from 32 to 55% which are

similar to the compensation values achieved in this study at the high stocking rate. These figures suggest that stocking rate, by affecting the amount of herbage available, may modify the degree of compensatory growth severely.

The significant inverse correlations in mass gain shown in Table 6 are slightly lower than those obtained by other workers. Lawrence & Pearce (1964a) obtained figures of -0,78 compared with those of -0,75 to -0,80 recorded by McCarrick et al. (1963) and -0,81 measured by Wanyoike & Holmes (1981). Within each stocking rate treatment, the compensation on summer veld was considerable but never complete. For instance, the difference in mass gain between the different treatments at the beginning of the summer grazing period was always reduced (the degree depending on the stocking rate) but never totally eliminated by the end of the summer grazing period (Figures 1 - 6). The data does however provide sufficient evidence to support the idea of exploiting compensatory growth on Highland Sourveld as part of a management decision aimed at reducing the cost of rearing replacement heifers.

Effect of stocking rate

Increasing stocking rate effectively reduces the amount of herbage available to the animal and consequently performance declines. During the first season stocking rate significantly ($P < 0,01$) modified the degree of compensatory growth on summer veld (Table 6). This was not the case during the second season. Whilst significant ($P < 0,01$) levels of compensatory growth were attained during the second season (Table 4), stocking rate had no apparent effect on modifying the degree of compensatory growth.

Several researchers (Meyer, Hull, Weitkamp & Bonilla, 1965; O'Donovan, 1972; Horton & Holmes, 1978; Baker, Young & Laws, 1982) have recorded higher feed intakes in cattle during periods of

realimentation. It is axiomatic that if the stocking rate is too high during the realimentation phase, then complete compensation is not possible. There was no shortage of grazing available to the heifers in the low stocking rate treatment during the second season and consequently herbage intake was probably not affected. Although the difference in mass gains between the heiferes stocked at the low and high stocking rates did not differ significantly (Table 4), the heifers stocked at the high stocking rate had the benefit of constantly grazing fresh (regrowth) material which invariably is of higher quality (Tainton, 1981). Whilst these animals probably had insufficient feed intakes to record high mass gains, the quality of the feed consumed was high. There is little doubt that the performance of the heifers during both seasons was affected by the production of the veld which, in turn, was affected by the veld management. These data highlight the need to interpret data of this nature in the proper perspective. In other words significant interactions between winter nutritional levels and subsequent summer performance may exist and the performance of the grazing animal may be significantly affected by the way the veld is managed.

The feed cost data presented in Table 7 are largely a reflection of the production of the veld during the two seasons. During the first season, when the grass was plentiful and of a relatively high quality (consequence of a burn), compensatory growth was an important factor in reducing the feed costs during the second winter and therefore the total feed costs. It is significant that the lowest feed costs were recorded for the treatments stocked at the low (0,75 AU/ha) stocking rate. The heifers wintered on the low plane of nutrition and subsequently stocked at the low stocking rate recorded the lowest feed costs of all the treatments.

During the second season, when stocking rate had a relatively

small effect on animal performance, feed costs during the first winter exerted the greatest influence on total feed costs (Table 7). The animals wintered on the high and low planes of nutrition had similar total feed costs (Table 7), but for different reasons. The heifers wintered on the low plane recorded a low first winter feed cost (R35,09) but high second winter costs mainly due to the fact that the animals performed relatively poorly on summer veld. The animals wintered on the high plane of nutrition had high first winter feed costs (R89,52) but low second winter costs, due to the fact that the mass requirements during the second winter were relatively low.

Reproduction

Conclusions on reproductive performances of the heifers studied in this experiment must be considered as tentative due to the small number of heifers involved (175). Nevertheless the trends that have evolved from these trials provide important indications which might enable farmers to manage their heifers more efficiently in the Highland Sourveld.

The primary reason for poor conception in replacement heifers is a failure to attain sexual maturity. Puberty in heifers is dependent upon age and livemass at breeding (Allden, 1970; Lamond, 1970; Short & Bellows, 1971; Burfening, 1974). The target mating mass is related to the mature size of the heifer, which is primarily a function of the breed (Bowden, 1977; Gregory, Laster, Cundiff, Smith & Koch, 1979; Nelsen, Long & Cartwright, 1982). Dual-purpose animals such as Simmentalers, are sexually later maturing than British breeds and therefore are mated at 320 - 340 kg livemass (Wiltbank, 1977). The condition scoring system advocated by van Niekerk & Louw (1980) is not intended for use on heifers. Theoretically, a heifer could attain the necessary condition for optimum conception, as recommended for cows, at

10 months of age. However, heifers are generally not mated at such young ages. The interaction between mass and age remain the dominant factors affecting puberty (Allden, 1970).

The heifers mated during the first season generally fell within this range (Table 11). The differences in mass at mating between the heifers that conceived and those that failed to conceive was not statistically significant. The relatively low calving rates of these heifers is ascribed largely to poor bull performances. The livemasses of the heifers at breeding during the second season (Table 14) were slightly heavier than during the first season (mean 356,53 kg vs. 337,90 kg). Significant correlations ($P < 0,05$) were established between the mass of the dam at mating and calf birth mass. This correlation could prove useful in practice in predicting possible dystocia. The effect of increased birth mass on the incidence of calving difficulty is well established (Bellows, Short, Anderson, Knapp & Pahnish, 1971; Dickerson, Kunze, Cundiff, Koch, Arthaud & Gregory, 1974; Burfening, Kress, Friedrich & Vaniman, 1978). The economic implications of calving difficulty make it essential that detailed attention should be given to this facet of management.

The calving performance of the 1983 heifers was excellent with a mean calving rate of 94,83% (Table 13). As in the first season, there was no significant difference in the livemasses at the beginning of the breeding season between heifers that did not conceive and heifers that did conceive (Table 14). The reproductive performances of the heifers at second breeding is largely dependent on the time of first calving (Lesmeister, Burfening & Blackwell, 1973). In the current experiment, all the heifers calved within 30 days of the start of their first calving season (Table 10) and within the first 20 days during the second season (Table 15). This is a highly desirable situation because it is axiomatic that the calves born earlier in the season will be the

heaviest at weaning when the weaning time is fixed. Furthermore lifetime production of heifers born early in the season is significantly increased (Lesmeister et al., 1973; Roberts, Le Fever & Wiltbank, 1970).

The subsequent calving performances of the 1981 replacement heifers (calved for the first time in 1984) indicates that 30 of the 44 heifers studied produced the maximum of three calves in three years. Thirteen (29,55%) of the heifers produced two calves in three years (Table 11). These results were achieved despite the fact that the heifers were subjected to various experimental treatments subsequent to their first calving.

The fact that the heifers were mated for the first time three to four weeks before the main herd allowed heifers sufficient time to recover before being mated for the second time. As first-calvers, these animals were then able to compete with the mature herd during the breeding season. This aspect is discussed in more detail in Chapter 3.

Conclusions

These data suggest that when herbage is plentiful and of reasonably high quality, the optimum feeding regime on Highland Sourveld would be: low to medium plane of nutrition during the first winter so as to gain 0 to 0,25 kg per day followed by a stocking rate of not more than 1,0 AU/ha. If, on the other hand, grazing is not plentiful and appears to be of relatively poor quality, then the nutritional level during the first winter should be adjusted so as to achieve a growth rate of between 0,25 to 0,35 kg per day. The subsequent stocking rate on summer veld would need to be in the region of 0,75 AU/ha.

The hypothesis that heifer rearing in the Highland Sourveld is largely an economic issue has been substantiated. However, attention

must be paid to stocking rate and veld management. The results show conclusively that compensatory growth is only possible if grazing is freely available (low stocking rate) and that most of the stocking rate occurs during the first 12 weeks of grazing.

This experiment has identified the need to reduce either the total feed input during the winter or to reduce the length of the winter feeding period. The length of the winter feeding period can be reduced by extending the summer grazing period. Maize silage and E. curvula hay have formed the basis of the rations used at the Research Station. However, the use of other forages such as foggaged kikuyu and maize residue during the winter months must be considered in an attempt to reduce feed costs. Maize stalks are used extensively in many areas for the wintering of dry pregnant cows (Creighton & van Schalkwyk, 1986). These researchers attach a figure of R40/ha/month to maize residues which works out at approximately 19c/cow/day.

The viability of any beef enterprise in the Highland Sourveld appears to be highly dependent upon the ability of the operation to maximize summer grazing and reduce winter inputs. This aspect is considered in Chapter 2.

CHAPTER 2

THE ROLE OF CONDITION SCORING AS A MANAGEMENT TOOL
IN THE HIGHLAND SOURVELD

INTRODUCTION

The Highland Sourveld regions of Natal (Bioclimate areas 4e and 4f; Phillips, 1973) are important beef producing areas. The cow/calf enterprise in particular is well suited to these semi-extensive conditions.

A major factor influencing the profitability of beef production in the Highland Sourveld is the fact that the veld can, on average, provide only 210 to 240 days of grazing. During the rest of the year the animals require some form of supplementary feeding, which can often be an expensive operation. If the summer grazing period can be extended, the winter feeding period will be reduced and the economic viability of the enterprise will obviously be improved. Unfortunately, the solution is not quite so simple. One of the problems facing a farmer attempting to extend the summer grazing period is that the management of the breeding herd, particularly post-weaning and during the winter feeding period, is reasonably complex. The longer the cow remains on Highland Sourveld during the winter, the more her condition will deteriorate. This will necessitate the feeding of high quality feed in order for her to calve down in a reasonable condition. Any management decision must ensure that: 1) The reproductive performance of the cow is not affected; 2) The veld is not damaged; 3) Optimum utilization of the available feed resources is realized. Economically

optimum cow and veld production returns would be improved if a simple management tool could be devised that allows for the reliable and easy assessment of the physiological state of a breeding cow. Such a tool should allow accurate rationing of the winter feed supply, and promote increased reproductive performance, whilst simultaneously sustaining the vigour of the veld.

Condition scoring as a means of assessing the body condition of beef and dairy cows and sheep has gained widespread acceptance over the last 20 years (Jefferies, 1961; Russel, Doney & Gunn, 1969; Lowman, Scott & Somerville, 1976, Kilkenny, 1978; van Niekerk, 1982a; 1982b). Body condition was defined by Murray (1919) as 'the ratio of the amount of fat to the amount of non-fatty matter in the body of the living animal'. Whilst farmers have always visually assessed their cattle and sheep and described them as "thin", "fat" or "trim" these terms have been open to interpretation. The first objective system for describing body condition was devised by Jefferies (1961) for sheep. The system was based on a six-point scale with each point being described in terms of the amount of tissue cover over the lumbar region of the spine. Russel et al. (1969) quantified body condition scores on sheep by showing that body condition was closely related to the proportion of chemical fat in the body. Condition score has been shown to be a better indicator of the degree of fatness than has livemass, although, if animals are of similar body size, livemass and condition score afford similar levels of body fat (Guerra, Thwaites & Edey, 1972). The system described by van Niekerk & Louw (1980) and used extensively in Natal and other parts of South Africa was based on the method described by Lowman et al. (1976), but modified by research carried out at the Thabamhlope Research Station.

Ideally a breeding cow should produce and raise a viable calf each and every year of her breeding life. However, this objective is seldom

achieved. The national calving rate in South Africa has been estimated to be in the region of 55%. One of the main reasons for this situation is an inadequate level of nutrition during strategic stages of the cow's production cycle. Several researchers have suggested that the breeding cow should be on a rising plane of nutrition and gaining mass during the mating season to ensure a large calf crop (Wiltbank, Rowden, Ingalls & Zimmerman, 1964; McClure, 1965; Preston & Willis, 1974). However, a study by Richardson, Oliver & Clarke (1976) concluded that the ability of an animal to conceive was a function of body mass per se and not rate of gain during the breeding season. This view is supported by Lamond (1970); Topps (1977) and Froid & Croxton (1978) who go further and describe the condition of the cow at mating as being one of the most significant factors likely to affect a cow's ability to conceive.

If target condition scores at strategic stages of the production cycle could be identified, then the available feed could be rationed to achieve the desired score. The objectives of this research were therefore to: 1) Establish the relationship between condition score and reproductive performance; 2) Gain reliable estimates of feed intakes and time-spans required to move from one condition score to the next; It was envisaged that the data emanating from these studies would enable target condition scores at parturition, breeding and weaning to be set.

PROCEDURE

Animals and treatments

The data relating to condition score at mating and conception rate

were obtained from an analysis of two years of breeding records at the Thabamhlope Research Station. A total of 550 records were reviewed. Condition score at mating for the cows that calved and the mean condition score during the breeding season for cows that failed to conceive were analysed. The time of conception in relation to the start of the breeding season was also analysed.

A series of feeding experiments were designed to supplement the data obtained from the breeding records. A total of 175 cows were involved in two separate experiments aimed at assessing the amount of feed required and the time-span taken to improve from one condition score to the next. The animals were fed to achieve a final condition score of 3,0. In the first experiment seventy five pregnant and sixty three non-pregnant Simmentaler cows were involved. Non-pregnant animals were included in the trial to establish whether dry, pregnant cows required similar feed intakes and time periods to pregnant animals in order to achieve the desired condition scores. The age of the cows varied between four and seven years. Seventeen mature cows and twenty first-calf heifers were compared in the second experiment. The animals were scored according to the procedure set out by van Niekerk & Louw (1980). The system involves assessing the amount of fatty tissue over the transverse processes and the pin-bones and tail-head areas. A five-point scale is used with half-point increments. A score of one represents an emaciated animal and a score of five an obese animal.

To reduce competition for feed, particularly amongst the very thin cows, animals were fed in groups each having the same score. Once the next highest score was attained the cow was transferred to that particular group. Thus a cow in group one with an initial condition score of 1,5 was transferred to group two, on attaining a condition score of 2,0. During the first experiment the cows were weighed and condition scored fortnightly. The mature cows and the first-calvers in

the second experiment were fed separately. The animals were condition scored three times a week and weighed weekly.

The birth masses of the calves born to cows with different condition scores at the onset of winter were analysed to establish whether the degree of winter feeding necessary to improve the various condition scores had any effect on calf birth mass.

Rations and feed intakes

The basic diet in both feeding experiments was E. curvula hay and maize silage fed ad libitum. In the first trial, the animals in Group 1 (condition score 1,5) received 3,5 kg per head of a high protein concentrate in addition to the basic diet. Each condition score group was allocated a separate feeding pen that allowed adequate feeding space. Feed intakes were recorded daily.

RESULTS

Relationship between body condition at mating and conception rate

The relationship between body condition at mating and reproductive performance is illustrated diagrammatically in Figure 7. The highest calving rates were achieved when the condition of the cow at mating was 3,0. Cows with condition scores of 1,5 and 2,0 at mating had significantly lower conception rates than cows with a condition score of 3,0. It is also clear from the data in Figure 7 that the cows in poor condition at mating conceived later in the mating season than cows in better (CS 3,0) condition. Cows with condition scores of 3,0 to 3,5 at mating conceived within the first 21 days of the start of the mating season, whilst cows with a condition score of 1,5 to 2,0 conceived approximately 20 days later.

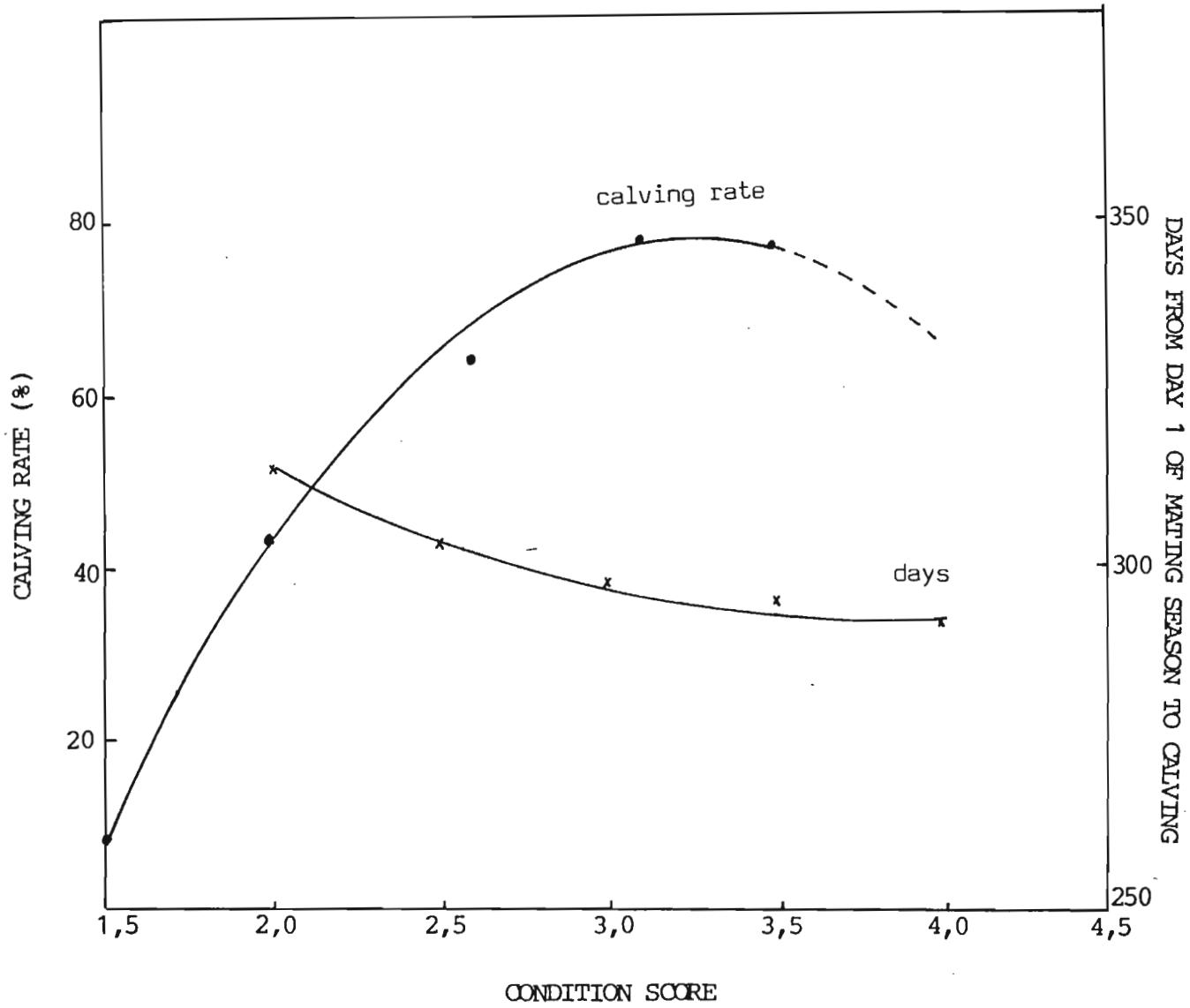


Figure 7. Relationships between condition score at mating and subsequent calving rates and time of calving.

The drop in mass immediately post-partum because of the birth of the foetus and loss of associated fluids corresponded with a decline in body condition of the cow. The loss in body condition immediately after calving was not quantified, however, whilst there was variation between cows, the condition score loss was generally observed to be half a condition score point. Cows calving at a condition score of 3,0 generally lost half a score within two to three weeks of calving. The implications when the condition of the cow at parturition is less than 3,0 are therefore obvious (Figure 7), particularly if the breeding season commences within 60 - 80 days of parturition. Experience gained at the Research Station from feeding cows in early lactation has shown that sufficient good quality feed is necessary to merely maintain body condition and that it is extremely difficult to improve a cow's condition during the early post-partum period.

First experiment

Mass and condition score changes

At the start of the experiment the pregnant cows were six to seven months pregnant. The pregnant cows were significantly ($P < 0,01$) heavier than the non-pregnant cows at an initial condition score of 1,5 (Table 16). The difference in mass between the pregnant and non-pregnant cows was probably due to the mass of the foetus and associated fluids. The pregnant cows required 32 days to attain a condition score of 2,0 and the non pregnant cows 29 days. The difference in mass gained was not statistically significant (Table 16). Pregnant cows required 34 days to improve their condition from 2,0 to 2,5 during which time they gained 49,7 kg. In comparison, the non-pregnant cows achieved a condition score of 2,5 after 35 days during which time they gained 22,4 kg (Table 16). The difference in mass gain was statistically significant

($P < 0,01$). A total of 85 days were required by both the pregnant and non-pregnant cows to achieve a condition score of 3,0. The pregnant cows gained 85 kg and the non-pregnant cows 74,3 kg over this period.

The mass gains of both the pregnant and non-pregnant cows with an initial condition score of 2,0 are summarised in Table 17. The pregnant cows required 26 days and gained 27,4 kg in attaining a condition score of 2,5, whilst the non-pregnant cows required only 21 days to achieve a condition score of 2,5 but gained significantly ($P < 0,01$) less mass (18,0 kg) than the pregnant cows during this period. A condition score of 3,0 was attained after 23 days by the pregnant cows and after 28 days by the non-pregnant cows. During this period, the pregnant cows gained 21,7 kg and the non-pregnant cows 20,9 kg (NS). The total time taken to improve the condition score of both the pregnant and the non-pregnant cows from 2,0 to 3,0 was 49 days. During this time however, the pregnant cows gained 49,1 kg compared to a 38,9 kg gain by the non-pregnant cows (Table 17). This difference was highly significant ($P < 0,01$).

The mass gains and condition score changes of cows with an initial condition score of 2,5 are reflected in Table 18. The mass gains and number of days required to achieve a condition score of 3,0 were similar for both the pregnant and non-pregnant cows. These time-spans and mass gains correspond well with those of cows with an initial condition score of 2,0 (Table 17).

Non-pregnant cows with an initial condition score of 1,5 required 35 days to improve their condition from 2,0 to 2,5. During this time they gained 22,4 kg. In contrast, non-pregnant cows with an initial condition score of 2,0 required only 21 days to achieve a score of 2,5 and gained 18,0 kg in the process (Table 17). The cows with an initial condition score of 1,5 therefore required 14 days longer to improve their score from 2,0 to 2,5 than the cows with an initial score of 2,0.

Table 16. Mass and condition score (CS) changes for cows with an initial condition score of 1,5.

	Cows	
	Pregnant	Non-pregnant
Initial mass (kg)	407,9 ^{a*}	377,7 ^b
Mass at CS 2,0 (kg)	422,3 ^a	404,9 ^b
Mass gain (kg)	14,4 ^a	27,2 ^a
No. days CS 1,5-2,0	32	29
Mass at CS 2,5 (kg)	472,0 ^a	427,3 ^b
Mass gain (kg)	49,7 ^a	22,4 ^b
No. days CS 2,0-2,5	34	35
Mass at CS 3,0 (kg)	492,9 ^a	452,0 ^b
Mass gain (kg)	20,9 ^a	24,7 ^a
No. days CS 2,5-3,0	19	21
Total mass gain 1,5-3,0 (kg)	85,0 ^a	74,3 ^a
No. days	85	85

* Figures within rows having different superscripts differ significantly ($P < 0,01$).

Table 17. Mass and condition score (CS) changes of cows with an initial condition score of 2,0.

	Cows	
	Pregnant	Non-pregnant
Initial mass	445,7 ^{a*}	404,4 ^b
Mass at CS 2,5	473,1 ^a	422,4 ^b
Mass gain	27,4 ^a	18,0 ^b
No. days CS 2,0-2,5	26	21
Mass at CS 3,0	494,8 ^a	443,3 ^b
Mass gain	21,7 ^a	20,9 ^a
No. days CS 2,5-3,0	23	28
Total mass gain 2,0-3,0	49,1	38,9
No. days	49	49

* Figures within rows having different superscripts differ significantly ($P < 0,01$)

The difference in mass gain between the two groups was however very small (4,9 kg). These data indicate that the cows with an initial condition score of 1,5 required considerably longer to improve their body condition, than cows that were in better condition initially, despite recording similar mass gains. This factor is economically significant as the additional 14 days represents a considerable cost in terms of feed inputs.

Feed costs

The feed intakes for both the pregnant and non-pregnant cows are summarised in Table 19. The cost of the rations for the cows with an initial condition score of 1,5, 2,0 and 2,5 was 14,42c, 13,29c and 12,28c per kg DM respectively. The difference in costs between the rations is due to the increased level of concentrates fed to the animals in poorer condition. There was no significant difference in dry matter intake between the pregnant and non-pregnant cows. Pregnant cows with an initial condition score of 1,5 consumed 8,85 kg of dry matter per day for 85 days whilst the cows with an initial condition score of 2,0 and 2,5 consumed 8,25 kg DM/day and 8,69 kg DM/day respectively. The differences in intake between the groups was non-significant. However, because of the extended feeding period the cost of improving a cow's condition from 1,5 to 3,0 was R108,01 or R1,27 per day, whilst the cost of feeding a cow from a condition score of 2,0 to 3,0 was R53,77 or R1,10 per day. Cows with an initial condition score of 2,5 attained a score of 3,0 after only 26 days at a cost of R27,74 or R1,07 per cow per day. These figures provide considerable evidence to substantiate the contention that too poor a condition in breeding cows prior to the winter feeding period will increase feed costs and reduce the economic viability of the enterprise in the Highland Sourveld.

Table 18. Mass (kg) and condition score (CS) changes of cows with an initial condition score of 2,5.

	Cows	
	Pregnant	Non-pregnant
Initial mass (kg)	438,9 ^{a*}	428,0 ^a
Mass at CS 3,0 (kg)	468,3 ^a	452,1 ^a
Mass gain (kg)	29,4 ^a	24,1 ^a
No. days CS 2,5-3,0	26	30

* Figures within rows having different superscripts differ significantly ($P < 0,01$).

Second experiment

Mass and condition score changes

The mass and condition score changes of both the mature cows and first-calf heifers are shown in Table 20. Although the performances of the cows with an initial condition score of 1,5 are also presented in Table 20, they have been excluded from any further analyses because of the small number of animals involved ($n=6$). The difference in initial mass between those mature cows and first-calvers with an initial condition score of 2,0, was 33,78 kg ($P<0,05$). However, in achieving a condition score of 2,5, the mature cows gained 40,40 kg in 26,18 days whilst the first-calvers gained 37,45 kg in 33,82 days (Table 20). This trend persisted over the entire experimental period. The mature cows achieved a condition score of 3,0 after 46,18 days during which time they gained 55,32 kg of livemass, whilst the first-calvers required 53,22 days and gained 38,18 kg to reach a condition score of 3,0 (Table 20). These results suggest that the mature cows were more efficient in replacing lost body reserves than the first-calvers. These results are not surprising since the first-calvers were not fully mature and were therefore still in a growing phase.

The 46 days required by the mature cows to improve their condition score from 2,0 to 3,0 compares favourably with the 49 days required by the cows in the first experiment (Table 17).

Feed intakes

Daily feed intakes for mature cows and first-calf heifers are reflected in Table 21. The mature cows consumed 500,31 kg of dry matter per head during the 61,85 days required to achieve a condition score of 3,0 (an average of 8,10 kg of dry matter per head per day). The first-calvers, on the other hand, consumed 600,96 kg of dry matter per

Table 19. Daily feed intakes (kg) for pregnant and non-pregnant cows in varying body condition, fed to achieve a condition score of 3,0.

	Pregnant cows					Non-pregnant cows				
	Days	Hay (kg)	Silage (kg)	HPC (kg)	DM (kg)	Days	Hay (kg)	Silage (kg)	HPC (kg)	DM (kg)
<u>Initial CS 1,5</u>										
CS 1,5-2,0	32	3,99	11,05	3,22	9,64	29	3,52	11,08	2,97	8,73
CS 2,0-2,5	34	4,72	9,99	2,01	8,95	35	4,07	10,20	1,90	8,35
CS 2,5-3,0	19	3,67	10,24	0,94	7,18	21	4,40	10,26	0,95	7,86
CS 1,5-3,0	85	357,89	887,24	189,24	749,20	85	336,93	864,78	172,58	710,19
Feed costs R		34,05	22,86	51,10	108,01					
Cost/kg/DM c					14,42					
<u>Initial CS 2,0</u>										
CS 2,0-2,5	26	4,39	10,52	2,08	8,87	21	4,44	10,87	2,19	9,12
CS 2,5-3,0	23	4,62	8,54	0,98	7,56	28	4,86	9,62	0,95	8,07
CS 2,0-3,0	49	220,40	469,94	76,62	404,50	49	229,32	497,63	72,59	417,48
Feed costs R		20,97	12,11	20,69	53,77					
Cost/kg/DM c					13,29					
<u>Initial CS 2,5</u>										
CS 2,5-3,0	26	5,62	9,66	1,05	8,69	30	5,18	8,43	0,83	7,90
Total		146,12	251,16	27,30	225,94		155,40	252,90	24,90	237,00
Feed costs R		13,90	6,47	7,37	27,74					
Cost/kg/DM c					12,28					

Feed costs: E. curvula hay R105,71/ton DM

Maize silage R 85,90/ton DM

HPC R300,00/ton DM

head in order to achieve a condition score of 3,0. The feed was consumed over a period of 72,55 days at an average of 8,28 kg of dry matter per head per day. The mature cows therefore consumed less (NS) dry matter per head per day than the first-calvers. Dry matter intake based on a percentage of live bodymass for the mature cows was 1,74% and 1,95% for the first-calvers. Despite the fact that the cows were fed the rations ad libitum and that adequate feed space was available, these percentage intake figures are slightly lower than NRC (1984) standards for a 450 kg dry, pregnant cow during the middle third of pregnancy. The reasons for this situation are obscure. There is, however, little doubt that the utilization of the feed and the deposition of subcutaneous (visible) fat was quite different for the two classes of animals.

The fact that the first-calvers were not fully mature meant that they had a relatively higher protein requirement than the mature cows (NRC, 1976). Crude protein analyses indicated that the diet provided a maximum of 480 g of crude protein per head per day. The maintenance protein requirement for a 450 kg cow in the middle third of pregnancy is 590 g per day (NRC, 1984). The first-calvers were therefore clearly short of protein. Apparently the mature cows were able to satisfy their maintenance requirements and still convert available feed into body reserves.

Effect of winter nutrition on calf birth mass

It was important in this study to establish to what extent calf birth mass was affected by poor dam condition at the beginning of winter and the plane of nutrition required to improve the condition of the cow. A summary of the birth masses of calves born to cows with varying condition scores at the start of the winter feeding period in

Table 20. Mass (kg) and condition score changes for mature cows and first-calvers

		Cows	
		Mature cows	First-calvers
Initial mass CS 1,5	(kg)	390,67 ± 22,03	370,67 ± 58,05
Mass at CS 2,0	(kg)	415,33 ± 31,26	391,33 ± 64,79
No. days		15,67 ± 4,04	19,33 ± 2,31
Initial mass CS 2,0	(kg)	437,60 ± 40,04 ^a	403,82 ± 33,48 ^b
Mass at CS 2,5	(kg)	478,00 ± 34,76 ^a	441,27 ± 38,21 ^b
No. days		26,18 ± 7,24 ^a	33,82 ± 8,46 ^a
Initial mass CS 2,5	(kg)	478,92 ± 38,92 ^a	443,20 ± 41,24 ^b
Mass at CS 3,0	(kg)	492,92 ± 42,60 ^a	442,00 ± 36,88 ^b
No. days		20,00 ± 5,12 ^a	19,40 ± 9,58 ^a
Mass at CS 2,0	(kg)	437,60 ± 40,04 ^a	403,82 ± 33,48 ^b
Mass at CS 3,0	(kg)	492,92 ± 42,60 ^a	442,00 ± 36,88 ^b
Mass gain	(kg)	55,32 ^a	38,18 ^a
No. days CS 2,0-3,0		46,18	53,22

Figures within rows having different superscripts differ significantly ($P < 0,05$).

the first and second experiments is shown in Table 22. In the first experiment, cows with initial condition scores of 1,5 and 2,0 produced calves that averaged 3,5 kg more than those from cows with an initial condition score of 2,5. This trend was not evident in the second experiment. No definite conclusions can be drawn from the data for cows with an initial condition score of 1,5 during the second experiment because of the small number of calves involved (n=6). However, the data does suggest that cows with initial condition scores of 1,5 did recover sufficiently for the foetus not to be detrimentally affected.

DISCUSSION

The results from this study have highlighted the importance of the body condition of the breeding cow at mating on subsequent reproductive performance. Body condition is essentially a reflection of the nutritional regime being applied. These results are therefore in general agreement with other research, which suggests that reproductive performance is largely dependent upon the nutritional state of the cow (Wiltbank, Rowden, Ingalls, Gregory & Koch, 1962; Croxton & Stollard, 1976; Topps, 1977; Dunn & Kaltenbach, 1980; Haresign, 1980; Rutter & Randel, 1984). The winter feeding programme at the Research Station is based on maize silage and E. curvula hay. In a research situation, where specific objectives must be met, a reliable source of good quality feed is essential. However, whilst many farmers in the Highland Sourveld do make use of maize silage and hay, alternative, cheaper sources of winter feed must be investigated. The possible use of foggaged pastures and maize residues were discussed in Chapter 1. The use of spared winter veld together with a rumen stimulating lick has not been successful at the Station. However, this aspect is receiving further attention at the Thabamhlope Research Station at present.

Table 21. Daily feed intakes (kg) for mature cows and first-calf heifers in varying body condition, fed to achieve a condition score of 3,0.

	Mature cows				First-calvers			
	Days	Hay (kg)	Silage (kg)	DM (kg)	Days	Hay (kg)	Silage (kg)	DM (kg)
CS 1,5-2,0	15,67	4,45	15,00	8,51	19,33	4,76	12,52	8,04
CS 2,0-2,5	26,18	4,06	13,78	7,89	33,82	4,58	13,95	8,31
CS 2,5-3,0	20,00	4,04	14,79	8,07	19,40	4,45	14,90	8,48
CS 1,5-3,0	61,85	256,82	891,61	501,31	72,55	333,24	1002,86	600,96

Table 22. Birth masses of calves (kg) born to cows with different initial condition scores at the onset of winter

	Cow initial condition score		
	1,5	2,0	2,5
<u>First experiment</u>			
Mature cows	36,3 ± 1,2	36,3 ± 1,2	32,8 ± 1,2
<u>Second experiment</u>			
Mature cows	30,0 ± 4,4	36,3 ± 5,8	33,4 ± 4,1
First-calvers	30,0 ± 3,5	32,0 ± 3,4	33,8 ± 4,5

The highest conception rates were achieved when the condition of the cow at mating was in the region of 3,0 - 3,5, which is consistent with results from similar research (Mulvaney, 1978; Meaker, 1984; Selk, Wettemann, Lusby & Rasby, 1986). Whilst calving rates of 80% may appear to be slightly low, it should be noted that, in this study, the breeding season was restricted to 90 days and the bulls used were either "home-grown" or purchased on local sales and probably not of superior quality or ability. The conception rate declined concomitantly with the condition of the cow, to such an extent, that only 8% of the cows with a condition score of 1,5, conceived. Reproductive responses at the upper and lower ends of the condition scoring scale appear to be fairly variable. Mulvaney (1978) recorded conception rates in the region of 40% when cows were mated at a condition score of 1,5. Generally, conception rates do not exceed 10% when cows are mated at a condition score of 1,5 (Meaker, 1984; Selk et al., 1986). Very little information is available in the literature regarding the conception ability of fat cows (condition score 4,0 and 5,0). The results from this study however, suggest that conception is reduced at this level. It is likely that the excessive fat surrounding the uterus and ovaries in these animals reduces their reproductive ability. A target condition score of 3,0 at mating would therefore appear to be the optimum for successful conception.

Whilst condition of the cow at mating has been stressed in this particular study, the question is often posed whether cows should be on a rising plane of nutrition and gaining mass during the breeding season. Grosskopf (1976), in a study of 1204 Bonsmara cows found that ADG before calving, ADG during the breeding season, ADG from parturition to the end of the breeding season and ADG during lactation all affected reconception rate significantly ($P < 0,01$). However, the most striking difference between the lactating cows that reconceived

and those that failed was that those that conceived maintained a livemass of at least 450 kg during the breeding season. Those that did not conceive failed to reach an average mass of 450 kg at any stage during the breeding season. The observation applied to both winter and summer breeding seasons and despite the fact that both groups lost mass rapidly during the winter season. Unfortunately, no reference is made to the condition of the cows during the breeding season, but the data suggests that mass at breeding was the most important factor affecting conception in the Bonsmara study. These results are therefore in agreement with those of Richardson et al. (1976), Lamond (1970) and Topps (1977).

The observation in the sourveld study that the condition of the cow at mating was highly dependent upon the condition of the cow at parturition if breeding commenced within 60 days of parturition, is of particular importance. Experience has shown that cows often lose up to half a condition score at parturition (Van Niekerk, 1982). It is very difficult to improve a cow's condition between parturition and mating, because of the effects of post-partum lactational stress (Rutter & Randel, 1984). A high level of post-partum nutrition is necessary merely to maintain a cow in a reasonable condition. A cow should therefore be at a condition score of 3,0 - 3,5 at calving if a condition score of 3,0 is to be attained at mating.

Cows with a condition score of 3,5 at mating, had mean conception dates 18 to 20 days earlier than cows with a condition score of 2,0 at mating. These results are consistent with other research (Hancock, Kropp, Lusby, Wettemann, Buchanan & Worthington, 1985; Rakestraw, Lusby, Wettemann & Wagner, 1986; Richards, Spitzer & Warner, 1986). In a study by Kilkenny (1978) the calving interval was reduced from 383 days, for cows with a condition score of 2,0 at mating, to 363 days, for cows with a condition score of 3,5 at mating. Cows, which calve

early in the season will have a longer interval from calving to breeding and will therefore have more time to recover from the stresses of parturition. However, the inter-calving interval (ICI) will increase. This factor has significant economic implications from the point of view of the weaner as well. Studies have generally shown (Zimmerman, Pope, Stephens & Walker, 1957; Lesmeister *et al.*, 1973) that cows that calve late in the season tend to be late calvers for the rest of their productive lives. Furthermore, in areas (such as the Highland Sourveld) where weaning takes place at a fixed time, it is obvious that calves born early in the season will be older and therefore heavier at weaning than calves born later in the season. Unfortunately, the tendency amongst farmers is to calve too early in the season in an effort to increase the weaning mass of their calf crop, but the supplementary feeding period for the cows is thereby extended, reducing the economic viability of such an exercise.

This study has concentrated on the practical implications of condition scoring as a tool for managing the breeding herd in the Highland Sourveld. Unfortunately, even the basic relationships between body condition of cows and hormone symptoms and/or hormone secretion are unclear (Rasby, Wagner, Wettemann, Geisert & Lusby, 1986). Indeed the whole issue of the nutritional effects on the endocrine patterns of the post-partum female are often poorly understood (Rutter & Randel, 1984). Pituitary activity appears to be the limiting factor affecting follicular activity post-partum (Rasby *et al.*, 1986). However, much of the evidence is contradictory. For instance, energy balance during the first 20 days of lactation is important in determining the initiation of ovarian activity (Butler, Everett & Coppock, 1981). However, measurements of blood glucose levels have been reported to be either positively (Patil & Deshpande, 1979) or inversely (Kellogg & Miller, 1977) correlated with post-partum interval. Several researchers have

shown a positive effect of increased levels of nutrition on reproductive potential, including enhanced pituitary function (Beal, Short, Staigmiller, Bellows, Kaltenbach & Dunn, 1978; Lishman, Allison, Fogwell, Butcher & Inskeep, 1979; Moss, Parfet, Diekman, Lemenager & Hendrix, 1982) as well as increased ovarian activity (Wiltbank et al., 1962; Wiltbank et al., 1964). Other researchers however, have found no consistent relationships between calculated dietary nutrient intake and ovarian activity (Lishman et al., 1979; Carstairs, Morrow & Emery, 1980) or pituitary activity (Hill et al., 1970; Dunn, Rone, Kaltenbach, van der Walt, Riley & Akbar, 1974; Haresign, 1981).

The importance of an adequate supply of energy immediately postpartum is well established (Wiltbank et al., 1962, 1964; Dunn, Ingalls, Zimmerman & Wiltbank, 1969; Holness, Hopley & Hale, 1978). However the energy requirements are difficult to meet in early spring-calving cows. Frequently, cows cannot eat enough to supply the energy needed for lactation (Garmendia, Wettemann, Lusby, Baker & Geisert, 1986). It is at such times that body reserves are mobilized to supply the deficit.

Pre-partum nutrition is of vital importance to the whole cow/calf enterprise in the Highland Sourveld. The necessary level of winter nutrition will depend upon the condition of the cow at the beginning of the winter supplementary feeding period. It is therefore imperative that a target condition score for the beginning of the winter period should be established.

This study has shown that cows with an initial condition score of 1,5 at the start of the winter feeding period achieved a score of 3,0 after 85 days (Table 16). Cows with an initial score of 2,0 required 49 days to achieve the same condition score (Table 17). The heifers with an initial condition score of 2,0 therefore achieved the target condition score by parturition in 57,6% of the time taken by the cows

with an initial score of 1,5, but more importantly, at exactly half the cost (R54 vs. R108). This finding has important managerial and economic implications. Taken a step further, the cows with an initial score of 2,5 required only 26 days to achieve the target condition score of 3,0 at a cost of R27,74 per head. This probably represents the ideal, although largely unattainable, situation in the Highland Sourveld. In a spring-calving situation, weaning usually occurs during April and May. These results emphasise the need to wean the calf before the condition of the cow drops too low (2,0 - 2,5). The condition of the cow at weaning and at the beginning of the winter feeding period will therefore be similar for the spring-calving cow. The ideal condition score at weaning/beginning of winter would be 2,3 - 2,5.

The point has been stressed that by extending the summer grazing season in the Highland Sourveld, the winter supplementary feeding period will be reduced. Consequently, the economic viability of the enterprise should improve. However, when winter feed is in short supply, or of very poor quality, the tendency amongst many farmers is to extend the grazing season too far. In severe cases, cows may be undernourished to the extent that reproductive performance is affected. Several researchers have shown that ovarian activity may be affected when cows suffer severe mass losses (Hale, 1975; Richards, Wettemann & Schoenemann, 1986; Louw, Lishman & Thomas, 1988). In a study using *Bos taurus* cows, Louw et al. (1988) found that cows were between 35 and 57 kg heavier at the resumption than at the cessation of ovarian activity. These results support the principle, demonstrated in the current study, that excessive mass and condition losses may severely hamper the performance of a breeding cow.

Mature cows required significantly ($P < 0,05$) less time to improve their condition scores from 2,0 to 3,0 than the first-calvers. During this time the mature cows gained significantly ($P < 0,05$) more mass

(55,32 kg vs. 38,18 kg). These results are not surprising since the growing first-calvers would have a relatively higher maintenance requirement, in relation to production, than the mature cows (NRC, 1984). These results do, however, have significant practical implications from a nutritional/management point of view. The first-calvers required significantly ($P < 0,01$) more dry matter to improve their condition from 1,5 to 3,0 (Table 21). If a cost of 10c per kg of dry matter is used as a basis for evaluation, then it is clear that the cost of improving a cow's condition score from 1,5 to 3,0 was in the region of R50, and R60 for the first-calvers. In a group feeding situation where trough space may be limited, the smaller, less dominant, first-calver may not receive sufficient nutrition for adequate growth and reproductive performance.

The time-spans required by the cows in the first and second experiments to improve their condition scores from 2,0 to 3,0 were very consistent (Tables 24 and 27). It is interesting to note that in neither experiment did condition score at the beginning of the winter feeding period have a significant effect on calf birth mass. The cows in the first experiment generally produced slightly heavier calves than the cows in the second experiment. In the second experiment, the difference in birth mass between calves born to mature cows and those of first-calvers was also statistically non-significant.

Conclusions

The results obtained from these series of studies have highlighted the importance of body condition in the breeding cow at various stages of her production cycle if she is to be an asset to the breeding herd. Based on these results, target condition score at weaning, parturition and mating of 2,5, 3,0 - 3,5 and 3,0 respectively, are suggested. These condition scores are not independent of one another. In the Highland

Sourveld it is therefore important that the calf should be weaned from the cow and the cow removed from the veld before her condition declines to a stage where it is both difficult and uneconomical to improve her condition score prior to calving. The value of cows conceiving early in the breeding season is often stressed. In this context, the cows in better condition at mating conceived earlier in the season than cows in poorer condition and therefore had bigger calves at weaning.

Despite the fact that condition scoring is a subjective measure of body condition, results from this study have shown it to be an inexpensive, reliable management tool. As an indicator for such strategies as weaning, the removal of breeding cows from the veld and the rationing of winter feed supplies with a consequent improvement in reproductive performance, condition scoring is potentially an important tool. The application of these principles on different classes of beef cows and their progeny, at different stocking rates, are discussed in detail in Chapter 3.

CHAPTER 3

THE EFFECT OF STOCKING RATE AND LICK SUPPLEMENTATION
ON THE PERFORMANCE OF LACTATING COWS
IN THE HIGHLAND SOURVELD

INTRODUCTION

In 1957 Bonsma and Joubert suggested that beef production could be more efficient were beef enterprises to be regionalized. They argued that certain bioclimatic areas are better suited to breeding animals whilst other areas, closer to supplementary feed sources and markets, could probably be better utilized for the growing-out and the "finishing" of beef animals. Although the implications of such an approach are complex and far-reaching, at least one study has provided a biological justification for such systems. In a study by van Niekerk (1984) it was evident that cows (Simmentaler and Afrikaner) in the Highland Sourveld had significantly higher calving rates than cows, of similar genetic background, in the Valley Thornveld areas of Natal. However, Afrikaner and Simmentaler heifers consumed 36% and 25% more dry matter per kg livemass gain respectively, in the Sourveld than in the Thornveld. These data suggest that the breeding herd performed better in the Sourveld and the growing animal better in the Thornveld. Clearly, animals well adapted to a particular environment are more likely to be economically viable within that environment than poorly adapted animals.

Traditionally the Highland Sourveld has been an important area for the cow/calf enterprise. The Highland Sourveld carries 28,4% of Natal's

cows, 33% of Natal's calves and 31% of the beef animals between one and two years of age (Agriquest, 1980). This situation is unlikely to change drastically in the foreseeable future, although the use of intensive pastures is expected to increase (Harwin & Theron, 1975; Louw, 1984). A possible future scenario is one where the calf will be bred and raised until weaning on veld, grown-out under intensive pasture conditions and then either "finished" on grass, or more likely, in a feedlot.

One of the major factors affecting cow and calf performance, in terms of both animal production and economics, in the Highland Sourveld is the length of the grazing season. In Chapter 2 attention was drawn to the fact that the degree of winter feeding is largely dependent on the length of the grazing season. In order for cow/calf enterprises to remain viable in the Highland Sourveld, the grazing season must be extended to 270 days and ultimately be as long as possible (300+ days). Communication with study and liaison farmer groups suggests that the current average grazing season on most farms is in the region of 180 to 210 days. The single most important factor affecting the length of the grazing season is stocking rate. There is no "best" stocking rate since stocking rate affects individual animal performances by amounts which may vary from year to year and from one season of the year to another (Morley, 1981). However, increasing stocking rate decreases pasture growth, decreases herbage availability, affects botanical composition, increases exposure of the soil, increases stress on the animal and decreases the production per animal (Morley, 1981). It is therefore evident that the optimum stocking rate will fall within a range of acceptable stocking rates and will vary from season to season. The determination of an optimum stocking rate is further complicated by the fact that in any enterprise, the optimum stocking rate is dependent upon several criteria, some of which may conflict. These may include

maximum production per hectare; maximum stability of the pasture; minimum stress on the livestock; soil conservation; appearance of the animals (Morley, 1981). Inevitably the choice of an optimum stocking rate is a compromise between some of these factors, but the stability and condition of the veld should never be compromised.

In the Highland Sourveld, significant problems may arise when a farmer attempts to maximize production per hectare in a cow/calf enterprise. Increasing stocking rate will normally increase production per hectare (up to a point) whilst at the same time reducing production per head. Unfortunately, increasing stocking rate in the Sourveld also increases the supplementary feeding period. The result is that the economic advantage of selling more weaners per hectare is far outweighed by the cost of feeding the dams of those weaners during an extended winter period. An optimum economic stocking rate in the Highland Sourveld areas of Natal will therefore exact a high performance level from both the cow and the calf, whilst at the same time require that the summer grazing period be extended.

According to Venter & Drewes (1969), less than 5% of farmers implemented any system of veld management in Natal in the late 1960's. Whilst no accurate figures are currently available, it is probable that, almost 20 years later, the situation is not significantly different. Venter and Drewes (1969) suggested that the reason why veld management systems have not been more readily accepted by the farmer is the degree of inflexibility that surrounds the advocated systems. Another possible reason for the poor acceptance of current veld management systems is that, to date, eight camp systems have generally been advocated. Whilst the benefits of eight camp rotational systems have been described in theory (Booyesen, Klug & York, 1974), in practice farmers generally do not apply such systems (Tainton, 1985).

The current economic climate dictates that herds should be

combined wherever possible whilst still maintaining production objectives. The mature cow and first-calf heifer groups are possible candidates for such a combination approach. The first-calver has generally been recognised as a "problem" animal on the farm, largely as a result of poor reproductive performances in this class of beef cow (Harwin, Lamb & Bisschop, 1967). Lindly, Easley, Whatley & Chambers (1958) found a curvilinear effect of age of cow on reproduction. Performance improved up to 10 years of age and declined thereafter. These results have been supported by similar results from several researchers (Lasley & Bogart, 1943; Stonaker, 1958; Warnick, Meade & Koger, 1960). The effect of age and size of the dam on weaning mass has also received considerable attention. Most of the studies suggest that maximum weaning mass is obtained when the age of the dam exceeds six years. However, other workers (Jamison, Christian, Temple & Butts, 1965; Cundiff, Willham & Pratt, 1966; Smith & Fitzhugh, 1968) have emphasized that age is more important in the first four years. The management of the first-calver and mature cow in a single herd on veld must therefore ensure high levels of reproduction and weaning masses, both factors of economic importance.

There is a wide seasonal fluctuation in both the quantity and quality of herbage available to the animal under natural grazing conditions. Shortages of protein, in particular, and energy to a lesser extent, are the main restrictions on the performance of grazing animals (Crampton, 1957; Skinner, 1964; Van Schalkwyk & Lesch, 1970). Under severe conditions, supplementary feeding is often carried out in an effort to promote lactation, increase reproduction and ensure satisfactory growth in young animals (Alden, 1981). Supplementary feeding of animals on veld during the winter periods may take the form of either additional roughage, such as hay, together with chicken litter, or alternatively, a protein/energy lick. Whilst the responses

are biological, the measure of success is financial and depends upon the economic framework in which the farmer operates (Allden, 1981). Unfortunately, the results of controlled experiments designed to determine the effects of supplementary feeding have often been variable. It is generally accepted that urea can be converted into protein by the ruminant. The efficiency of this conversion depends on the amount and type of crude protein in the diet as well as the quantity of carbohydrate (Satter & Slyter, 1974; Rush & Totusek, 1976). Urea and molasses are relatively cheap sources of protein and energy respectively, and have been widely used in lick supplements with varying degrees of success (Skinner, 1964; van Schalkwyk & Lesch, 1970; Rush & Totusek, 1976; Kartchner, 1981).

The interaction between stocking rate and urea-based licks on the performance of beef cows and their progeny in the Highland Sourveld areas of Natal has not previously been well studied. Their use in extending the summer grazing season as well as in improving both cow and calf performance is therefore not clear at present. Research carried out at the Kokstad Research Station (drier phase of Highland Sourveld) indicated that molasses supplementation on summer veld did not improve either steer or sheep mass gains. However, protein supplementation at a level of 41 g of digestible crude protein per day did improve summer gains (Bredon & Lyle, 1971). Lishman & Smith (1968) found in the Thornveld that urea blocks in the early summer period significantly ($P < 0,01$) improved mass gains of all lactating cows, but late calvers in particular. In Natal, research in this area has therefore concentrated on improving animal performance with the result that, as a means of lengthening the summer grazing period, the use of licks has largely been ignored. The general recommendation in the Highland Sourveld is that protein supplementation should take place from mid-February onwards, when it is assumed that the quality of the

grazing begins to decline (Bransby, 1981). The provision of a urea lick from the beginning of the grazing season as opposed to the period from mid-February onwards is also not clear at present.

The main factors restricting the viability of the cow/calf enterprise in the Highland Sourveld areas have been outlined. This experiment therefore has as its main objectives: 1. The determination of an optimum stocking rate or range of stocking rates that will support high cow and calf performances, whilst at the same time maintain vigorous and productive veld; 2. The integration of the first-calf heifer into the mature cow herd so as to sustain high production levels from both classes of animals; 3. To determine the role of a urea/energy lick at different stocking rates.

PROCEDURE

The performance of spring-calving beef cows, first-calf heifers, dry cows and replacement heifers on Highland Sourveld was examined over nine consecutive seasons. The experiment commenced in 1978.

Experimental location

The investigation was conducted at the Thabamhlope Research Station. The location of the station was described in Chapter 1. The actual sites allocated to the experiment consisted of gently rolling hills with a general absence of trees. These animals therefore had very little protection from the prevailing climatic conditions.

Experimental animals

The cows used in the experiment were originally of a Sussex X Simmentaler type, although the type used during the last five seasons has been at least three quarters to seven eighths Simmentaler. Only Simmentaler bulls have been used at the station for the past 15 years. The mating season extended from the 15th of November to the 15th of January each year. The trial was designed to accommodate 30 cows and calves in each treatment. Unfortunately, a shortage of lactating cows necessitated the use of some dry cows and heifers. During the period from 1978/79 to 1983/84 the age of the lactating cows varied between four and ten years. First-calf heifers were introduced into the experiment at the beginning of the 1984/85 season.

Experimental treatments

Following parturition and prior to the initiation of the summer grazing season, cows were grouped according to their age, calving date and condition score. As far as was possible, treatments were also blocked for the sex of the calf. The cows within each group were randomly allocated to one of six treatments. Four stocking rates were applied, viz. 0,83, 1,0, 1,25 and 1,67 cows plus calves per hectare or 1,20, 1,0, 0,80 and 0,59 ha/cow plus calf. Stocking rates have also been expressed in terms of fodder units per hectare (FU/ha). The calculation of the FU's was based on the mass of the cows at the start of the grazing season, since, particularly during the second phase of the experiment, the masses of the cows at the end of the grazing season were generally lower than the livemasses at the start of the grazing.

Animals in each of these treatments had free access to a mineral lick consisting of 50% salt and 50% dicalcium phosphate from the start of the grazing season until the 15th of February each season, whereafter the animals received a winter lick until they were removed

from the veld. The 1,0 and 1,67 cow + calf/ha treatments were duplicated, one group at each stocking rate being supplied with a rumen stimulatory lick for the full duration of the grazing season. The winter lick consisted of 32% salt, 23% dicalcium phosphate, 30% maize meal and 15% urea. The experimental treatments indicating the lick allocation and the number of cows of each class, for the first four years on veld, are shown in Table 23. The experimental treatments for the subsequent five seasons are shown in Table 24.

Veld management

Prior to the 1980/81 season a six camp grazing system was employed. It was intended that all the camps would be rested every fifth year. The period of stay in a camp was one week and the period of absence five weeks. However, during the 1980 winter the treatments were subdivided to incorporate eight camps in each treatment, with two camps being rested each year. As a result of the subdivisions the size of the camps within each treatment varied. There were four small camps and four large camps in each treatment. The size of the small and large camps at the light stocking rate varied between 3 ha and 7 ha respectively, whilst at the high stocking rate the size of the camps varied between 1,5 and 3 ha. The period of occupation in the small camps, for all treatments was 3,5 days with a period of absence of 21-35 days. The period of stay in the large camps was 7 days with the period of absence varying between 21 and 28 days. The period of absence varied because of the different camp sizes and the grazing management programme.

The allocation of camps was made on a logistical basis. It was essential that the camps, in which the urea-based lick was to be compared with the mineral lick, should adjoin one another. In the case of Tr.2 and Tr.3 a total of 60 hectares were required. A block of 36

hectares was required for Tr.5 and Tr.6. A plan of the camps is shown in Appendix 12. It can be seen from the plan that Tr.1 was not part of the block in which the other treatments were located. Tr.1 is in effect approximately three kilometers from the other treatments. Whilst it was appreciated that this was not ideal, the importance of including the low stocking rate treatment was greater than the location disadvantages.

Eight camps were allocated to each treatment. Two camps within each eight camp system were rested in rotation for the duration of the season each year, whilst the remaining six were rotationally grazed. The two rest camps were grazed for between seven to ten days during mid-January. The rested camps were burnt before the following grazing season and always grazed first in the grazing cycle. Grazing was initiated each season when, according to a Pasture Specialist, the minimum height of the palatable species in the burnt camps was above 10 cm. Grazing commenced between the 30th of October and the 15th of November each year. Towards the end of the first phase of the experiment (1981/82) and during the second phase, grazing was terminated on the basis of the mean body condition of the cows in each treatment. When the mean condition score of the cows in a particular group fell to below 2,0 that treatment was terminated. Each treatment was terminated individually.

Animal management

Winter feeding

It was important that the cows in the various treatments went onto the veld in similar body conditions. Considerable attention was therefore focussed on this aspect during the winter.

At the onset of the winter feeding period, cows were grouped

according to their condition scores and fed in pens to achieve a condition score of 3,0 to 3,5 at parturition. The cows were fed diets consisting of E. curvula hay and maize silage. The winter lick described previously, was available at all times. Cows in very poor condition were fed 0,5 kg of HPC (33% CP) per head, in addition to the basic ration. After parturition cows were maintained on a ration of E. curvula hay and maize silage until the commencement of the grazing season.

Cow management

A comprehensive dosing, dipping and inoculation programme was followed. Cows were dipped fortnightly during the summer months and at monthly intervals during the winter period. Heifers were inoculated against Brucellosis at approximately 18 to 20 months of age. Heifers and cows were inoculated against Leptospirosis in March each year, and against Vibriosis and Chlamydia eight weeks before the start of each breeding season. All pregnant cows were inoculated with an E. coli vaccine in late pregnancy (July).

The breeding season for the mature cows commenced on the 15th of November and was terminated on the 15th of January each year. The replacement heifers were mated 4 weeks before the main herd for a period of 60 days. Bulls were rotated every two weeks between the treatments.

Calf management

All calves were inoculated with Paratyphoid vaccine within one week of birth. All animals were inoculated annually against Anthrax and annually (until three years of age) against Quarter Evil (Blackquarter). At weaning, the calves were inoculated against Lumpy skin. Calves were inoculated against Gall Sickness (Anaplasmosis) and

Redwater in December each year.

A strict dosing programme for tapeworms and roundworms was adhered to. The calves were dipped together with their dams.

Measurements obtained

Climatic data

Climatic data were collected on a daily basis by the Natal Agrometeorological Section.

Bodymass and body condition

Dams and their calves were weighed within 24 hours of birth. The calves were then identified with ear notches and a numbered ear-tag. Cows and calves were weighed fortnightly for the full duration of each season. Cows were also condition scored fortnightly.

Herbage quality and quantity

Herbage samples were collected on a weekly basis for the full duration of the trial and analysed for crude protein (CP) and crude fibre (CF). Samples were selected at random by throwing a ring (diameter 40cm) into the grass and cutting the grass within the ring. Eight samples were cut to form one composite sample for each treatment. Herbage production was assessed in the rest camps of each treatment at the end of the first phase of the experiment (1981/82). During the 1985/86 and 1986/87 seasons, one camp in each of the treatments was selected at random and used to estimate herbage production and utilization for that particular treatment. In each of these two seasons, four 10 X 1,2m plots were cut from each selected camp just prior to the animals entering it and again, directly after the animals

had been removed from the camp.

Veld condition assessments

Veld condition assessments were carried out in two camps in each treatment in February/March 1978, 1980, 1982 and 1984 using the method proposed by Foran, Tainton & Booysen (1978). The assessments were carried out by several Pasture Specialists during the 1978 and 1980 seasons, but by a single observer thereafter.

RESULTS

Results from two specific phases of the experiment are presented. The first phase involved six treatments with four stocking rates (Table 23) and was carried out over four seasons. Phase two was carried out over the following five seasons and involved four treatments with three stocking rates (Table 24).

Climatic data

A summary of the climatic conditions prevailing during the experimental period is shown in Table 25. Between 66% and 82% of the total annual rainfall recorded at the Station fell between November and March. This period corresponds with the most productive phase of the veld. The total rainfall figures provide an indication of the variability between the seasons.

Wind data have been included since previous research at the Thabamhlope Research Station has shown the effect of wind-chill on animal performance to be a significant factor in the Highland Sourveld. The figures indicated in Table 25 represent the mean wind recorded during a 24-hour period. Calculations based on these data indicate that

Table 23. Experimental treatments employed during the first phase of the of the experiment.

	Tr. 1	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6
Cows + calves/ha	0,83	1,00	1,00	1,25	1,67	1,67
Hectares/cow + calf	1,20	1,00	1,00	0,80	0,59	0,59
Hectares/FU*	1,02	0,81	0,81	0,64	0,48	0,48
Lick	M	M	U	M	M	U
<u>1978/79</u>						
Lactating cows	20	20	20	20	20	20
Calves	20	20	20	20	20	20
Repl. heifers	10	10	10	10	10	10
<u>1979/80</u>						
Lactating cows	13	13	13	13	13	13
Calves	13	13	13	13	13	13
Dry cows	13	13	13	13	13	13
Repl. heifers	4	4	4	4	4	4
<u>1980/81</u>						
Lactating cows	19	19	19	19	19	19
Calves	19	19	19	19	19	19
Repl. heifers	11	11	11	11	11	11
<u>1981/82</u>						
Lactating cows	15	15	15	15	15	15
Calves	15	15	15	15	15	15
Dry cows	15	15	15	15	15	15

M = mineral lick = urea-based lick

* FU = Fodder unit (Lesch, Louw, Jones & Whitehead, 1980)

= animal that requires 10 kg DM/day with not more than 65% TDN.

464 kg day cow = 1 FU

464 kg lactating cow = 1.2 FU

Table 24. Experimental treatments employed during the second phase of the experiment.

	Tr. 1	Tr. 2	Tr. 3	Tr. 4
Cows + calves/ha	0,83	1,00	1,00	1,25
Hectares/cow + calf	1,20	1,00	1,00	0,80
Hectares/FU*	0,85	0,71	0,71	0,42
Supplement	M	M	U	M
<u>1982/83</u>				
Lact. cows	20	20	20	20
Calves	20	20	20	20
Dry cows	10	10	10	10
<u>1983/84</u>				
Lact. cows	20	20	20	20
Calves	20	20	20	20
Dry cows	10	10	10	10
<u>1984/85</u>				
Lact. cows	18	19	19	20
Calves	18	19	19	20
First calvers	12	11	11	10
Calves	12	11	11	10
<u>1985/86</u>				
Lact. cows	14	14	14	14
Calves	14	14	14	14
First calvers	7	7	7	7
Calves	7	7	7	7
Second calvers	9	9	9	9
Calves	9	9	9	9
<u>1986/87</u>				
Lact. cows	7	7	7	7
Calves	7	7	7	7
First calvers	18	18	18	18
Calves	18	18	18	18
Second calvers	5	5	5	5
Calves	5	5	5	

M = mineral lick

U = urea-based lick

* FU = Fodder unit.

the mean daily wind-speed during daylight hours varied between 11,5 and 13,8 km per hour. Whilst the highest wind-speeds are generally recorded between August and January, particularly strong winds are sometimes experienced during the winter months, thereby significantly increasing the animals' energy requirements.

Mean maximum temperatures varied by less than 1,5°C and mean minimum temperatures by less than 1°C between seasons (Table 25). The monthly mean minimum temperatures and mean maximum temperatures over the experimental period showed considerable variation (Figures 8 and 9). The monthly mean minimum temperatures are of particular interest (Figure 8). Sub-zero mean minimum temperatures were recorded during June and July every year of the experiment. Mean minimum temperatures during May and August were just above zero with several seasons recording sub-zero temperatures. The mean maximum temperatures during June and July were in the region of 16,9°C.

Phase I (1978/79 - 1981/82)

Metabolic mass per hectare

Cow and calf livemasses at the start and end of the summer grazing season were converted to metabolic mass ($W^{0,73}$) in order to gain a more accurate reflection of the effective stocking rate. The total metabolic mass per hectare for each of the four stocking rate treatments is shown in Figures 10a (1978/79 season), 10b (1979/80 season), 10c (1980/81 season) and 10d (1981/82 season).

Within a specific treatment, the total metabolic mass per hectare at the start of the grazing period varied by less than 6 kg between seasons. The stocking rates applied were therefore consistent each year. By the end of the fourth season however, the total metabolic mass

Table 25. A summary of climatic conditions prevailing during the experimental period.

Season	Mean max. Temp °C	Mean min. temp. °C	Mean wind km/24 hr.	Tot. rain mm	% rain Nov - Mar.
1978/79	21,7	6,5	141,5	1071,5	66,06
1979/80	21,1	5,7	147,6	818,8	72,87
1980/81	21,2	5,8	138,2	1204,7	82,56
1981/82	20,9	5,5	148,7	783,5	74,05
1982/83	22,3	6,5	165,7	736,9	63,50
1983/84	20,9	6,2	153,9	928,5	73,22
1984/85	21,5	6,0	146,3	840,5	70,82
1985/86	22,1	6,3	146,7	930,0	76,43
1986/87	22,0	6,1	139,9	936,9	76,07
Mean	21,52	6,1	147,6	916,8	72,9
	± 0,53	±0,35	± 8,3	± 147,1	± 5,7

Table 26. Monthly rainfall figures (mm) recorded at Thabamhlope together with the mean (10 years) monthly rainfall. The total rainfall for each year and the long-term (23 years) mean annual rainfall are also presented.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1978	239,4	96,1	146,5	74,3	11,4	0,0	0,0	21,7	67,7	129,7	79,7	332,0	1198,0
1979	80,2	118,7	97,2	44,5	99,8	0,8	24,2	85,1	27,5	40,8	51,8	137,0	807,6
1980	137,9	141,3	128,8	36,5	7,9	0,0	0,0	19,8	97,3	32,7	131,7	228,7	962,6
1981	234,1	344,2	55,4	30,7	7,7	22,4	0,0	87,0	24,6	35,7	112,4	120,8	1075,0
1982	141,8	55,1	150,1	52,4	0,0	3,6	3,1	2,0	58,3	134,5	78,6	84,8	764,3
1983	100,6	101,2	102,7	31,9	37,8	1,4	33,2	25,4	8,2	95,2	212,6	115,0	865,2
1984	94,3	105,1	152,9	67,0	3,8	15,8	5,0	62,8	31,2	117,3	45,4	90,2	790,8
1985	164,6	184,6	110,4	10,0	4,4	14,6	0,0	0,0	17,9	110,1	180,7	145,5	942,80
1986	158,2	142,0	84,4	64,8	0,4	26,0	0,0	52,0	10,5	133,2	94,4	173,0	938,90
1987	150,5	115,2	179,6	10,5	0,0	18,0	4,0						
Mean	150,2	140,4	120,8	42,3	19,2	10,3	6,9	39,5	38,1	92,0	10,1	158,6	928,0
Mean annual 1088													

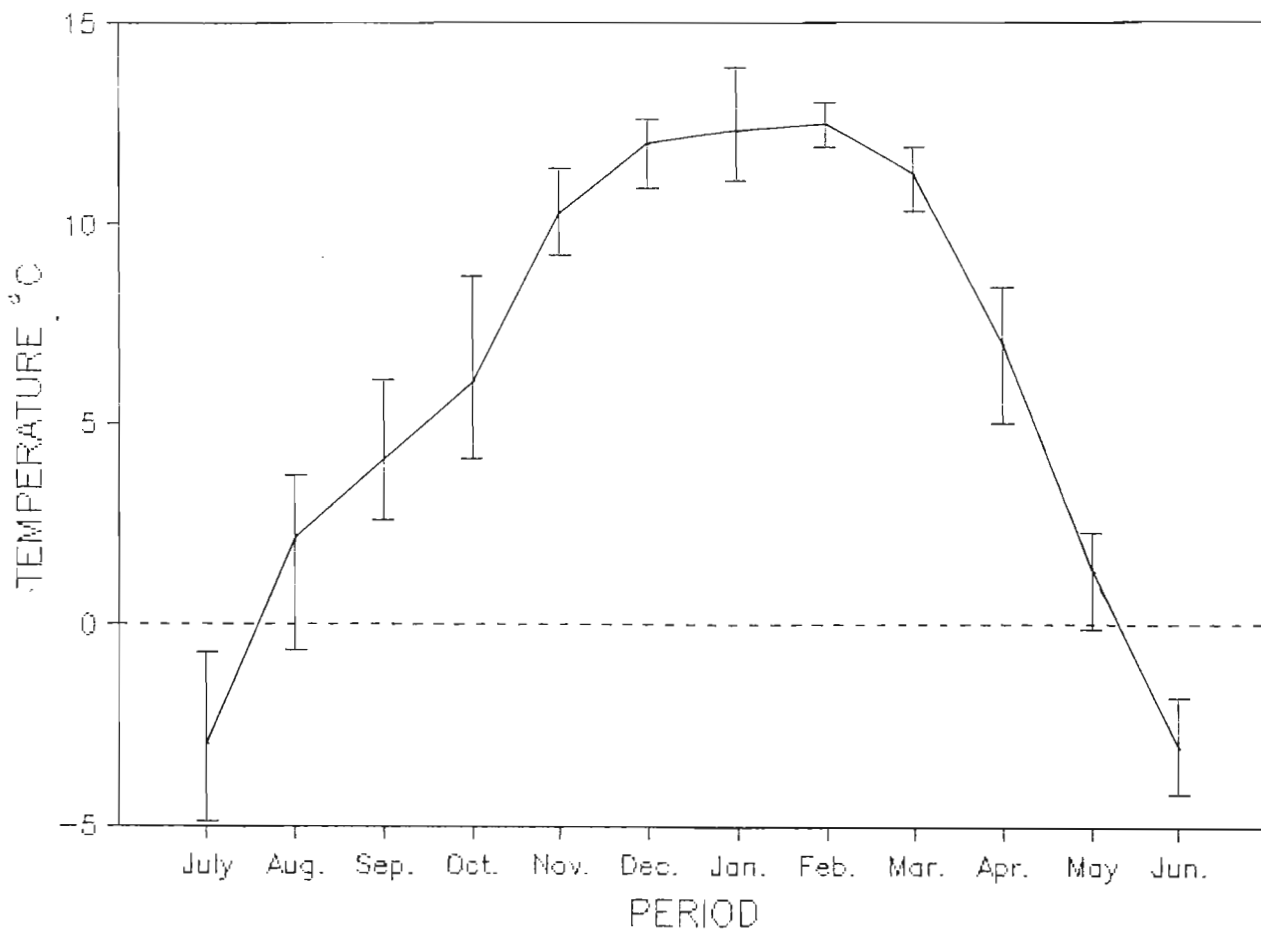


Figure 8. Monthly mean minimum temperatures and the ranges recorded during the period from 1978 to 1987.

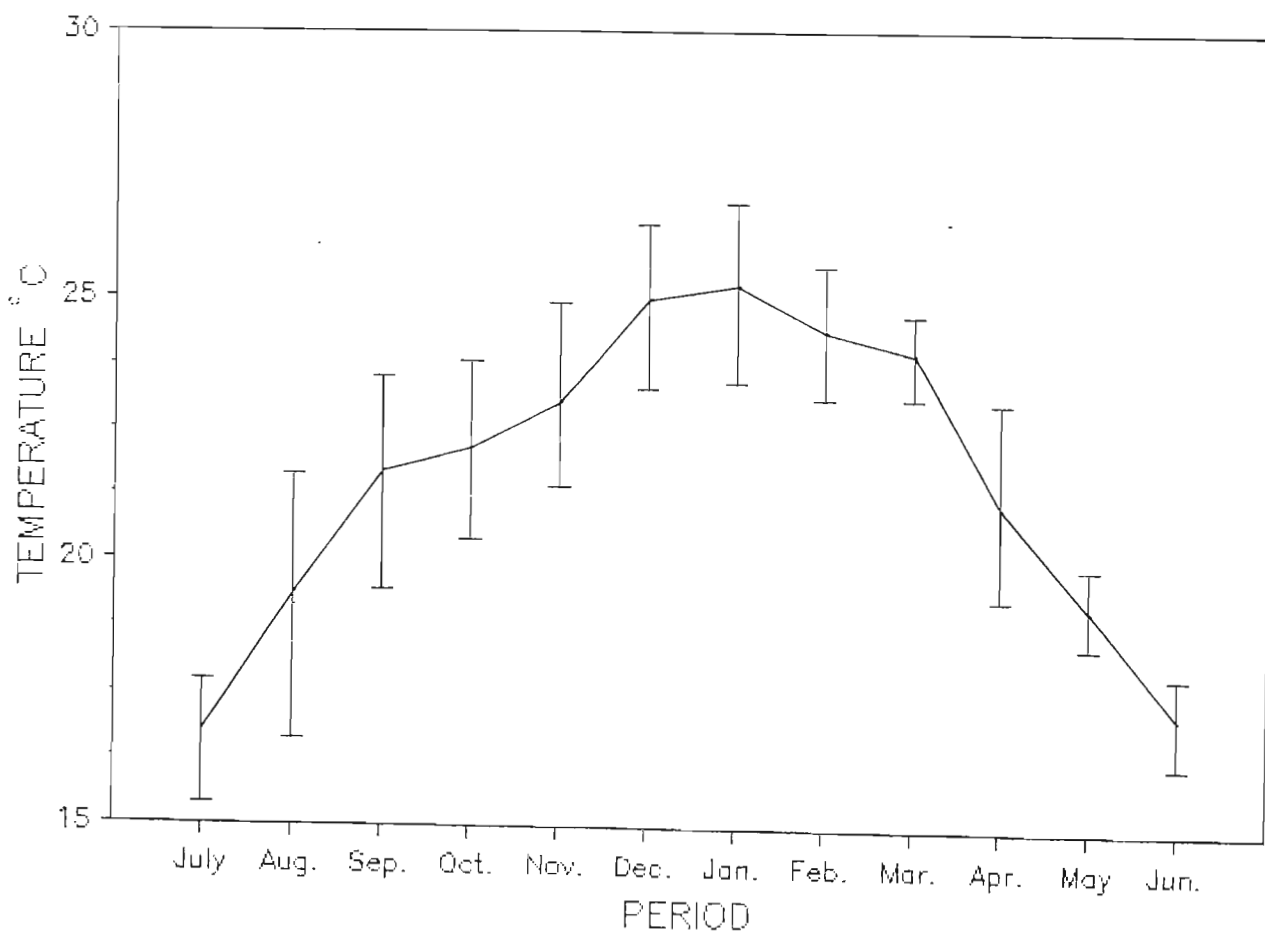


Figure 9. Monthly mean maximum temperatures and the ranges recorded during the period from 1978 to 1987.

per hectare in Tr.5 (1,67 cows + calves /ha - Figure 10d) was 14,82 kg lower than the total metabolic mass recorded during the 1978/79 season in the corresponding treatment (Figure 10a). There was, in fact, a progressive decline in the total metabolic mass per hectare over the four seasons in both Tr.4 and Tr.5. In contrast, the total metabolic mass produced per hectare in Tr.1 and Tr.2 remained relatively constant over the four seasons.

The percentage metabolic mass that could be allocated to the lactating cows and their calves, varied in each treatment because of the varying numbers of these classes of animals available. However, at the onset of grazing each season, the proportion of metabolic mass that could be allocated to the lactating cows and the calves varied by less than two percent between the four treatments. The correlation between the increase in calf metabolic mass and stocking rate was curvilinear (Figure 11). The length of the grazing season sometimes varied between treatments, particularly at the low and very high stocking rates. There was considerable variation in metabolic mass change between the seasons, the same trend held true for all four seasons (Figure 11).

As expected, the calves stocked at the high stocking rate did not perform as well as those stocked at the lower stocking rates. On average (4 seasons), the calves at the low stocking rate (0,83 cows + calves per hectare) increased their metabolic mass by $127,14 \pm 14,8\%$, whilst the calves in Tr.5 (1,67 cows + calves per hectare) increased their metabolic mass by only $85,56 \pm 20,47\%$. The changes in the metabolic mass of the lactating cows are shown in Figure 12. The response to stocking rate was similar to that shown by the calves. The lactating cows in Treatments 1 and 2 increased their metabolic mass by less than 14% during the grazing season, whilst the cows in Treatment 5 lost mass in all four seasons.

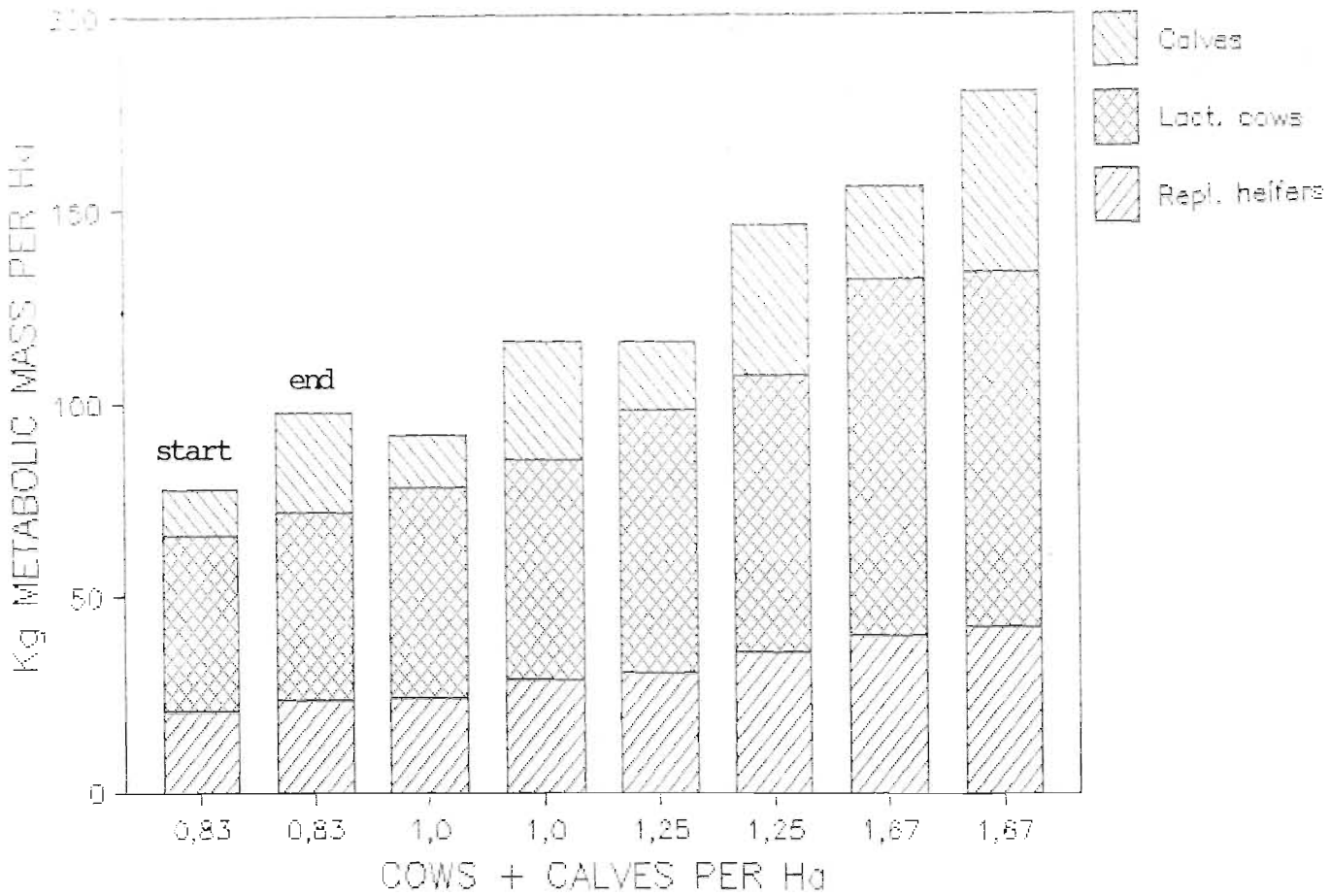


Figure 10a. Total metabolic mass per hectare for the various classes of animals for the 1978/79 season.

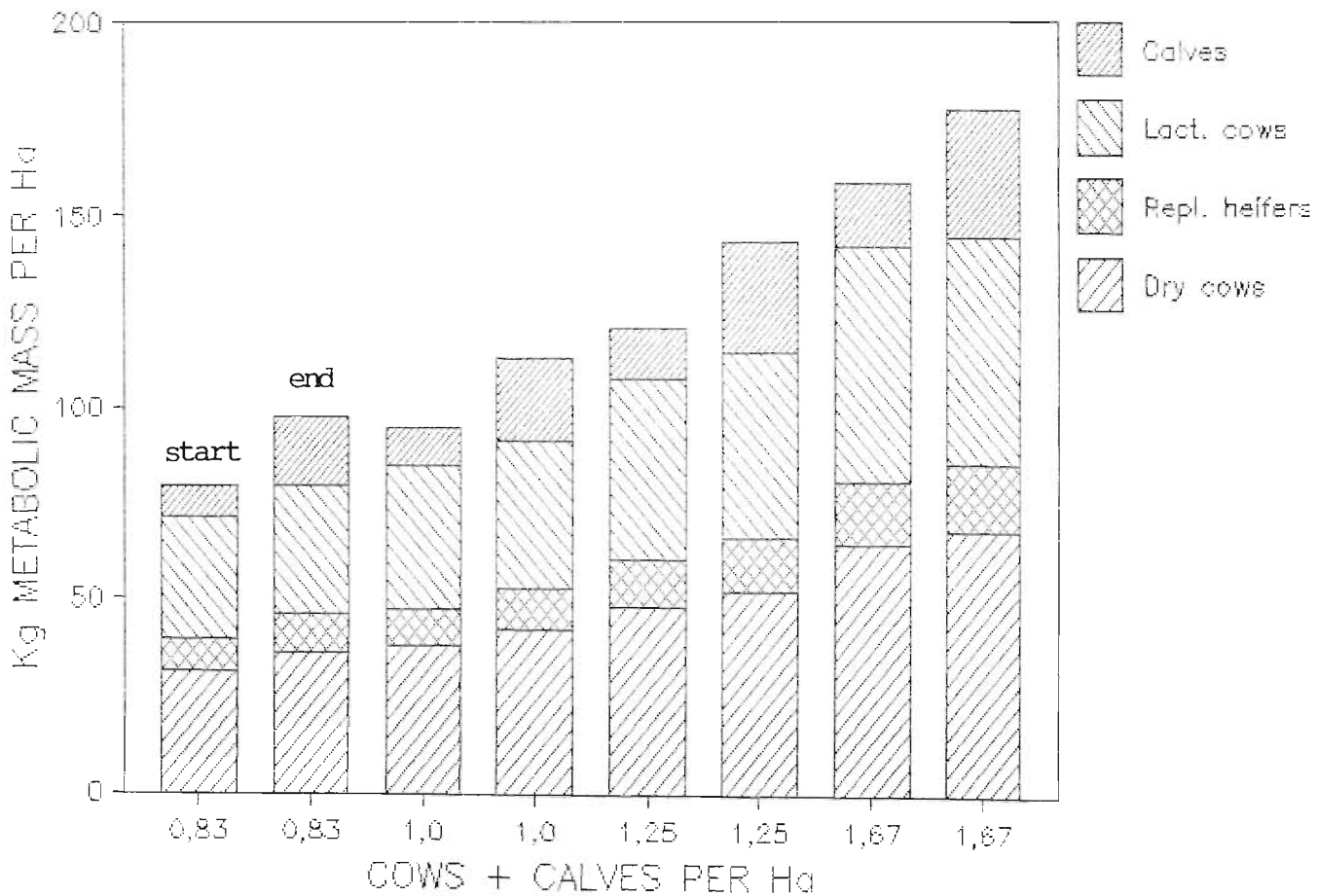


Figure 10b. Total metabolic mass per hectare for the various classes

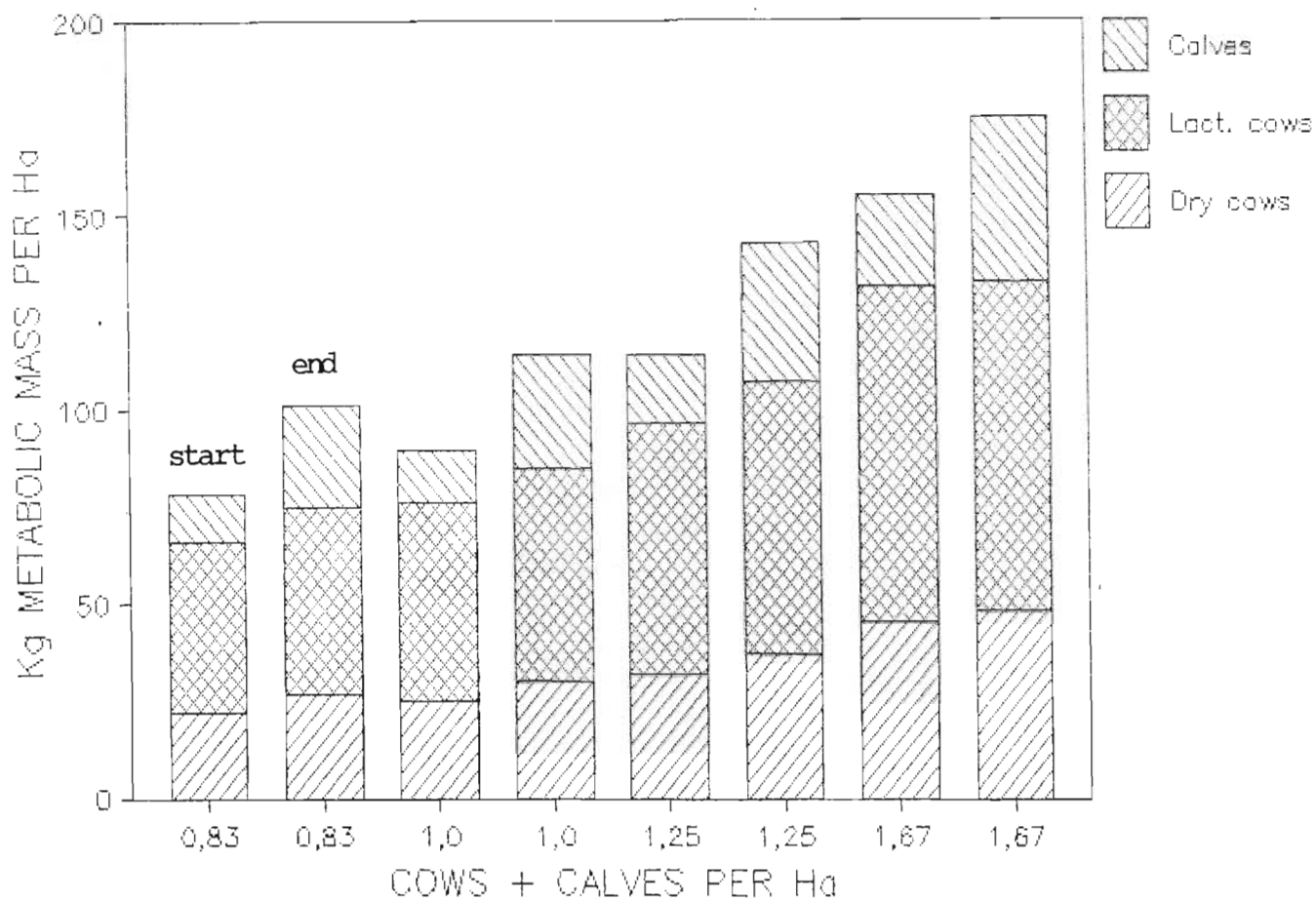


Figure 10c. Total metabolic mass per hectare for the various classes of animals for the 1980/81 season.

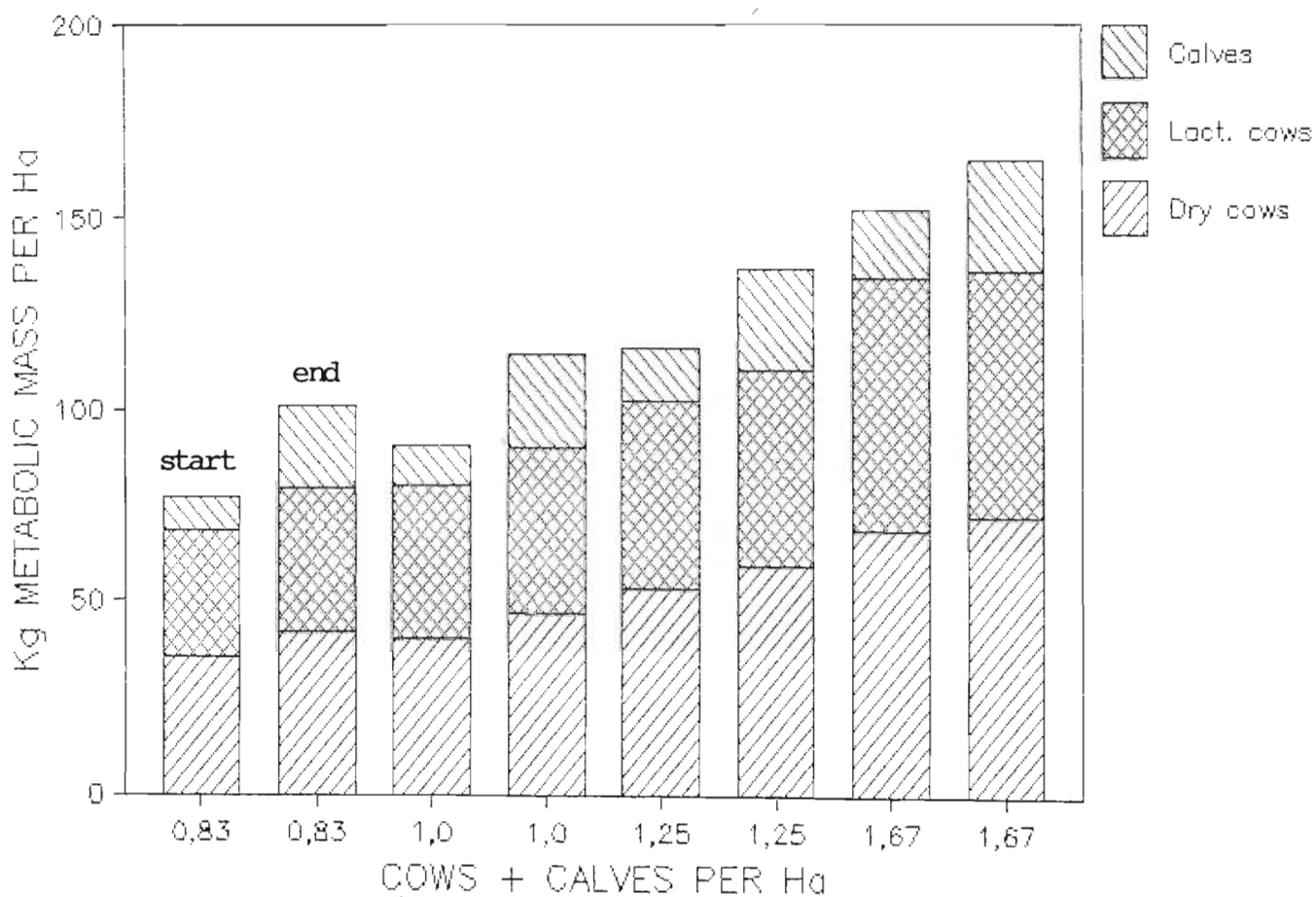


Figure 10d. Total metabolic mass per hectare for the various classes of animals for the 1981/82 season.

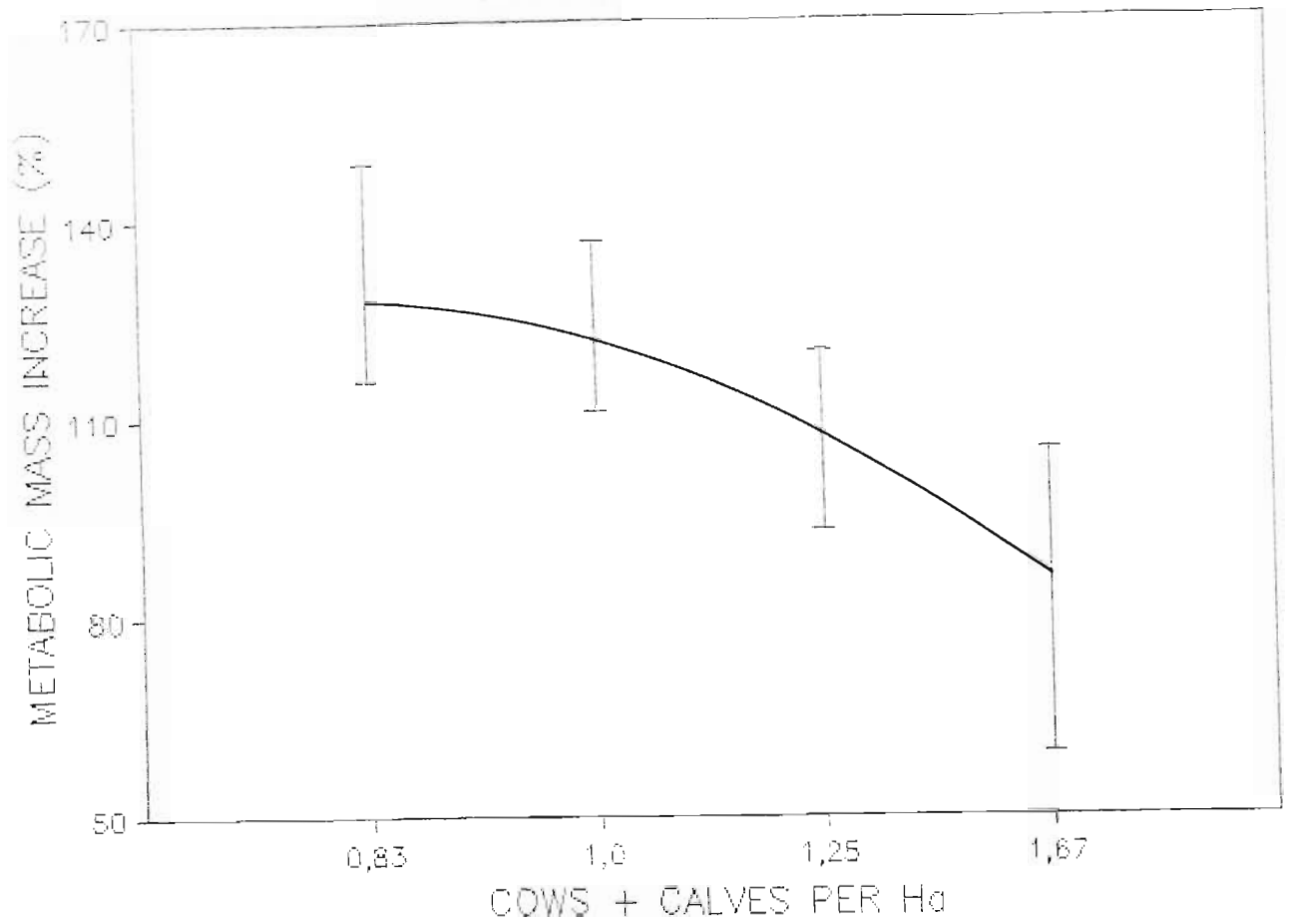


Figure 11. The percentage mean metabolic mass increase for the calves on veld at the different stocking rates during the 1978/79 - 1981/82 seasons.

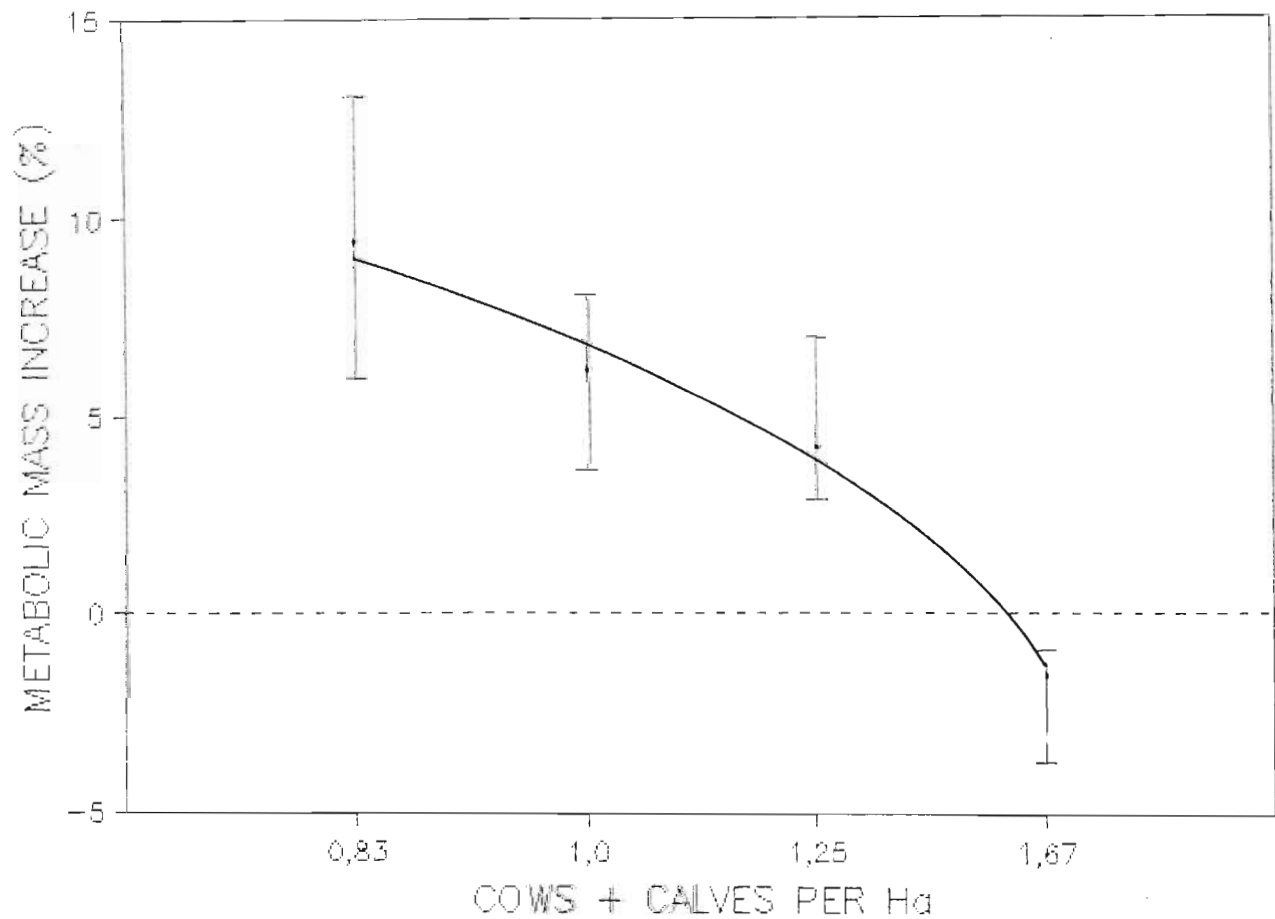


Figure 12. The percentage mean metabolic mass increase for the lactating cows on veld at the different stocking rates during the 1978/79 - 1981/82 seasons.

Mass changes - lactating cows

The changes in body mass of the cows for each of the four seasons are shown in Figure 13a (1978/79), Figure 13b (1979/80), Figure 13c (1980/81) and Figure 13d (1981/82). The curves were derived from the quartic equations presented in Appendix 1. The cows in Tr.1 (0,83 cows + calves /ha) had significantly ($P < 0,01$) higher mass gains to maximum mass than the cows in Tr.2. The time required to attain maximum mass was similar for both treatments. Maximum or peak mass was considered to be an important variable in indicating the potential gain possible under the prevailing conditions. Rapid losses generally occurred in all the treatments after maximum mass was reached. Grazing was normally terminated within 30 days of maximum mass being attained.

The performance of the cows in Tr.2 (1,0 cows + calves/ha) and Tr.4 (1,25 cows + calves /ha) varied little for the first three seasons (Figures 13a, 13b and 13c), but stocking rate clearly exerted a significant effect during the fourth season (Figure 13d). A comparison of the two treatments over the four seasons reveals that the cows in Tr.2 and Tr.4 had mass gains of 39,77 kg and 35,86 kg to maximum mass respectively. However, whilst the time taken to reach maximum mass differed between the two treatments, the mean ADG's were similar (Table 27). Two notable differences between treatments two and four became apparent during the 1981/82 season. Firstly, the cows in Tr.4 achieved a maximum mass of 429,06 kg after 150 days, whilst the cows in Tr.2 attained their maximum mass of 451,56 kg after 218 days. However, the cows in Tr.2 were still gaining in mass when they were removed from the veld (Figure 10d). It can therefore be assumed that the grazing period for the cows in Tr.2 could have been extended. In contrast, the cows in Tr.4 were removed from grazing after only 180 days due to their extremely poor body condition (mean condition score 1,83).

During the 1978/79 and 1980/81 seasons the mean maximum mass of

Table 27. The mean maximum mass, days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for lactating cows.

Treatment		Tr. 1	Tr. 2	Tr. 4	Tr. 5
Cows + calves/ha		0,83	1,0	1,25	1,67
<u>Maximum mass</u>					
1978/79	(kg)	457,69	442,28	452,94	426,40
1979/80	(kg)	493,97	447,18	477,57	442,41
1980/81	(kg)	484,39	457,62	463,59	442,66
1981/82	(kg)	473,19	451,56	429,06	398,48
		477,31	457,16	455,79	422,49
		±15,60	±14,72	±20,48	±18,16
<u>Days to maximum mass</u>					
1978/79		175	171	164	150
1979/80		178	174	176	9
1980/81		165	160	162	151
1981/82		188	218	150	0
		176,50	180,75	163,00	77,50
		± 9,47	±25,56	±10,65	±84,58
<u>ADG to maximum mass</u>					
1978/79	(kg)	0,25	0,19	0,26	0,03
1979/80	(kg)	0,22	0,15	0,12	0,08
1980/81	(kg)	0,34	0,30	0,28	0,05
1981/82	(kg)	0,40	0,22	0,18	0,00
		0,31	0,22	0,22	0,05
		±0,07	±0,01	±0,08	±0,04
<u>No. of grazing days</u>					
1978/79		196	196	196	196
1979/80		197	197	197	197
1980/81		189	189	189	189
1981/82		218	281	180	124
		200,00	200,00	190,50	176,50
		±12,5	±12,5	± 7,86	±35,18

Table 28. Daily growth rates (kg/day) of lactating cows during different grazing stages.

Treatment		Tr. 1	Tr. 2	Tr. 4	Tr. 5
Cows + calves/ha		0,83	1,0	1,25	1,67
<u>1978/79 Season</u>					
15.11.78 - 15.01.79	61 days	0,163	0,133	0,129	-0,033
15.02.79 - 15.05.79	89 days	0,133	0,098	0,017	-0,129
01.11.78 - 15.05.79	195 days	0,198	0,144	0,134	-0,050
<u>1979/80 Season</u>					
07.11.79 - 16.01.80	70 days	0,122	-0,075	-0,080	-0,173
13.02.80 - 22.05.80	99 days	0,226	0,187	0,179	-0,175
07.11.79 - 22.05.80	197 days	0,180	0,089	0,092	-0,157
<u>1980/81 Season</u>					
15.11.80 - 15.01.81	61 days	0,402	0,129	0,190	-0,189
15.02.81 - 14.05.81	88 days	0,102	0,058	0,070	-0,187
06.11.80 - 14.05.81	189 days	0,264	0,151	0,169	-0,121
<u>1981/82 Season</u>					
29.10.81 - 19.01.82	82 days	0,533	0,174	0,057	-0,224
16.02.81 - *End grazing		0,270	0,280	0,070	0,030
29.01.81 - *End grazing		0,312	0,221	0,070	-0,085

* End of grazing : Tr. 1 11/6/82 = 218 days
 Tr. 2 4/6/82 = 218 days
 Tr. 4 27/4/82 = 180 days
 Tr. 5 2/3/82 = 124 days

the cows in Tr.5 was reached after 150 days at an average growth rate of 0,037 kg/day and 0,051 kg/day respectively (Table 27). The mean maximum mass was therefore only marginally higher than the mean livemass at the start of the summer grazing. During the 1979/80 and 1981/82 seasons, the cows lost mass right from the start of the grazing season. Grazing, during the 1981/82 season, was terminated after only 124 days. The mean condition score of the cows at the end of the 1981/82 grazing season was 1,73.

The daily growth rates during various grazing stages are shown in Table 28. The first stage (from the initiation of grazing up to mid-January) includes the breeding season. The second stage covers the period from mid-February to the termination of grazing. As a decline in veld quality and availability generally occurs from mid-February, a urea-based lick was supplied to the animals in all the treatments during this stage. The third stage incorporates the entire grazing season.

The cows in Tr.5 lost mass during the breeding season each year (mean 0,16 kg/day) and continued to lose mass until being removed from the veld despite having access to the urea lick from mid-February. Although the cows in Tr.2 and Tr.4 also lost mass during the 1979/80 breeding season (Table 28), both these groups gained mass during the period when a urea-based lick was made available. As a result, a positive growth rate was recorded for these two treatments when analysed over the entire grazing period (Table 28).

In an effort to identify the factors influencing the mass changes of the lactating cows on veld over the four seasons, the data were subjected to a stepwise regression analysis (Genstat V). The following independent variables were included in the analysis:

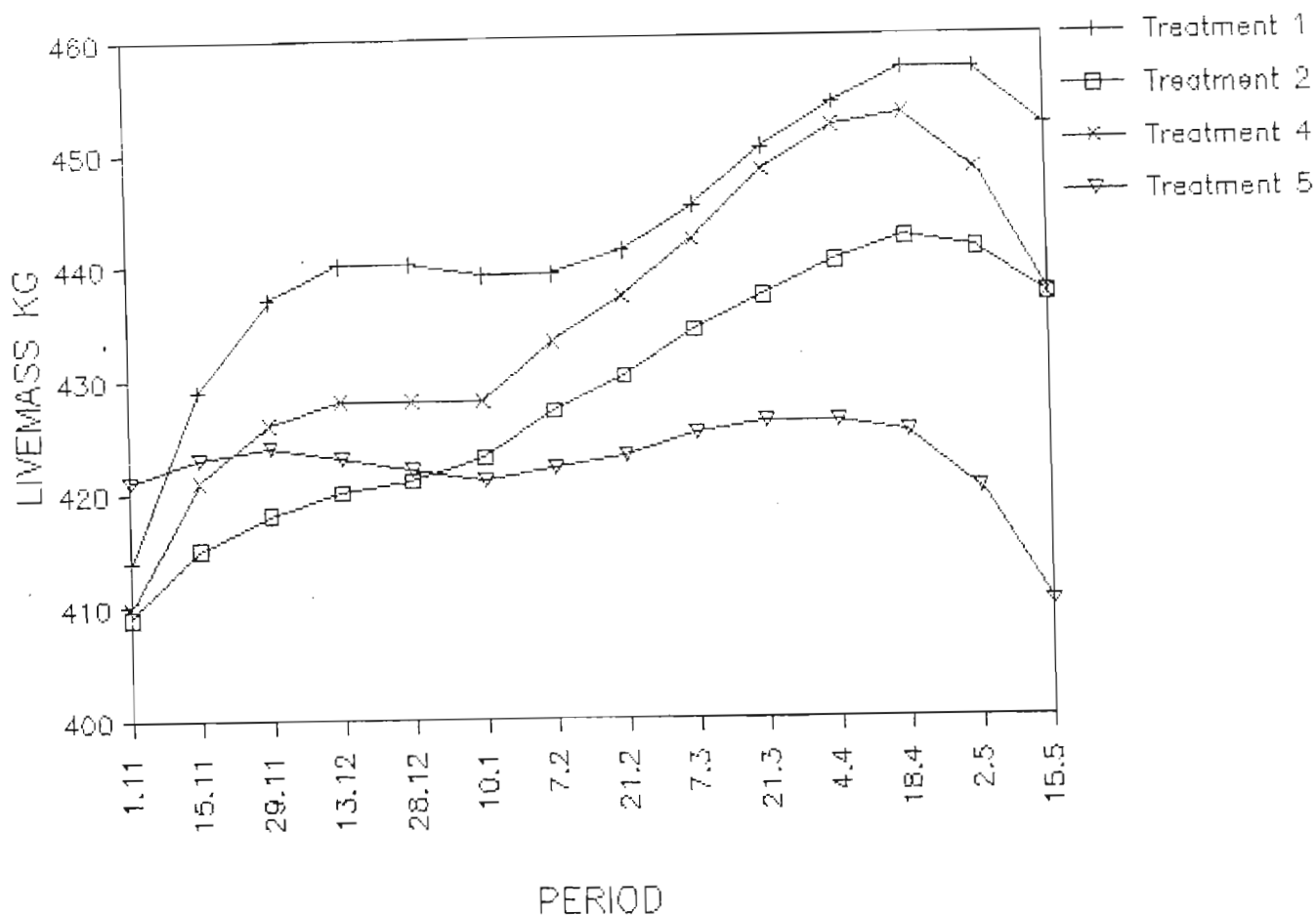


Figure 13a. The mean mass changes on veld for the lactating cows, during the 1978/79 season.

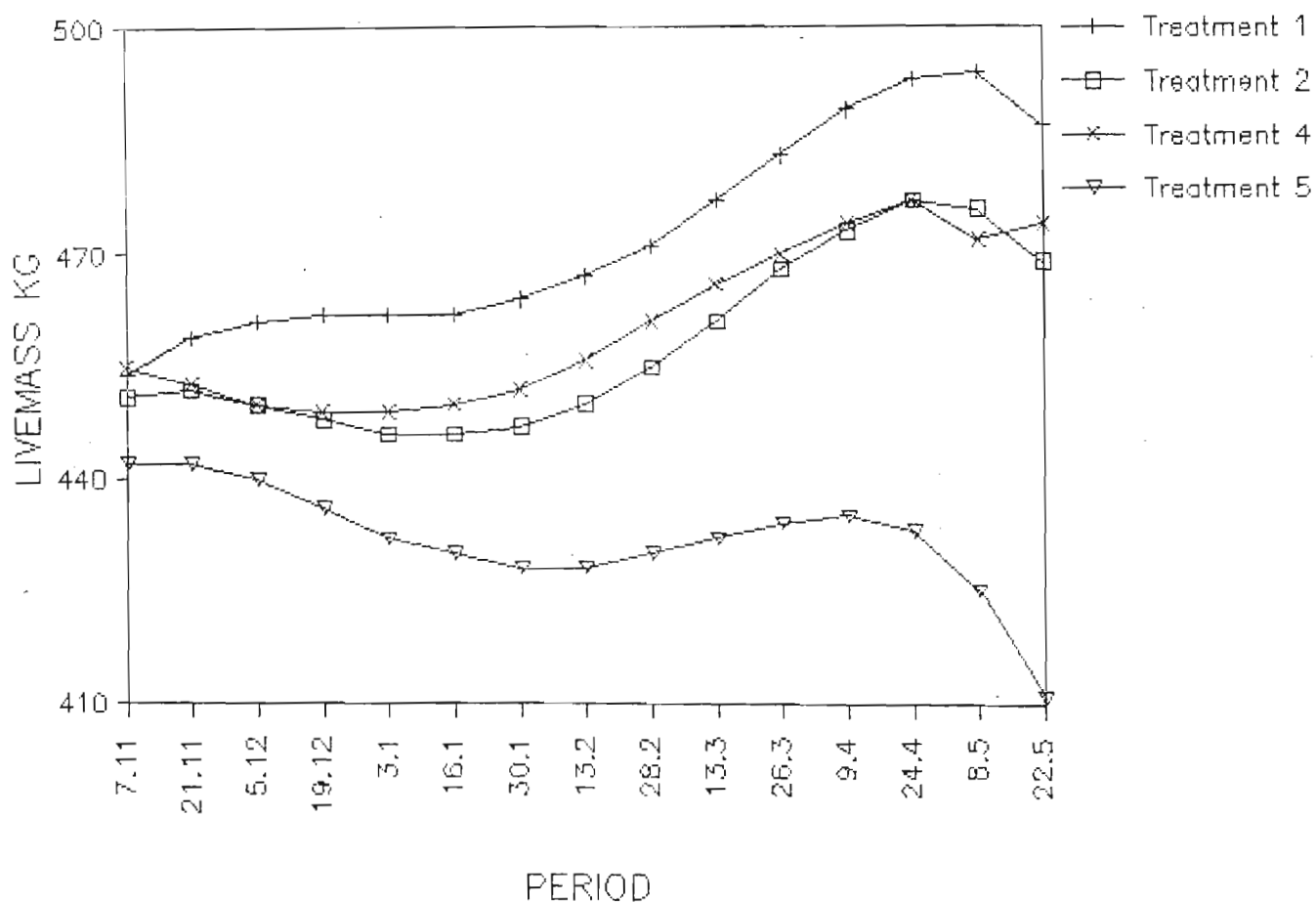


Figure 13b. The mean mass changes on veld for the lactating cows during the 1979/80 season.

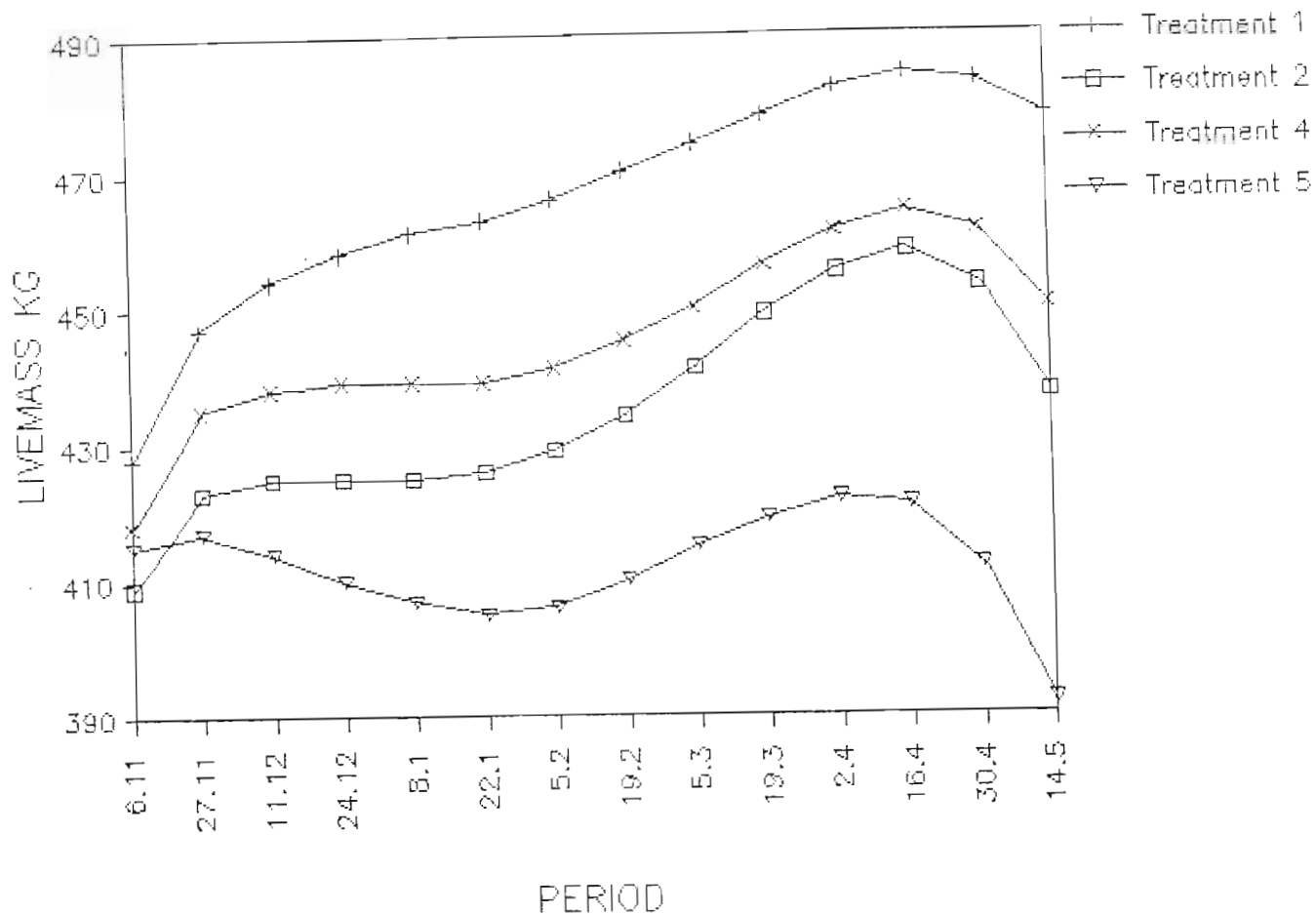


Figure 13c. The mean mass changes on veld for the lactating cows during the 1980/81 season.

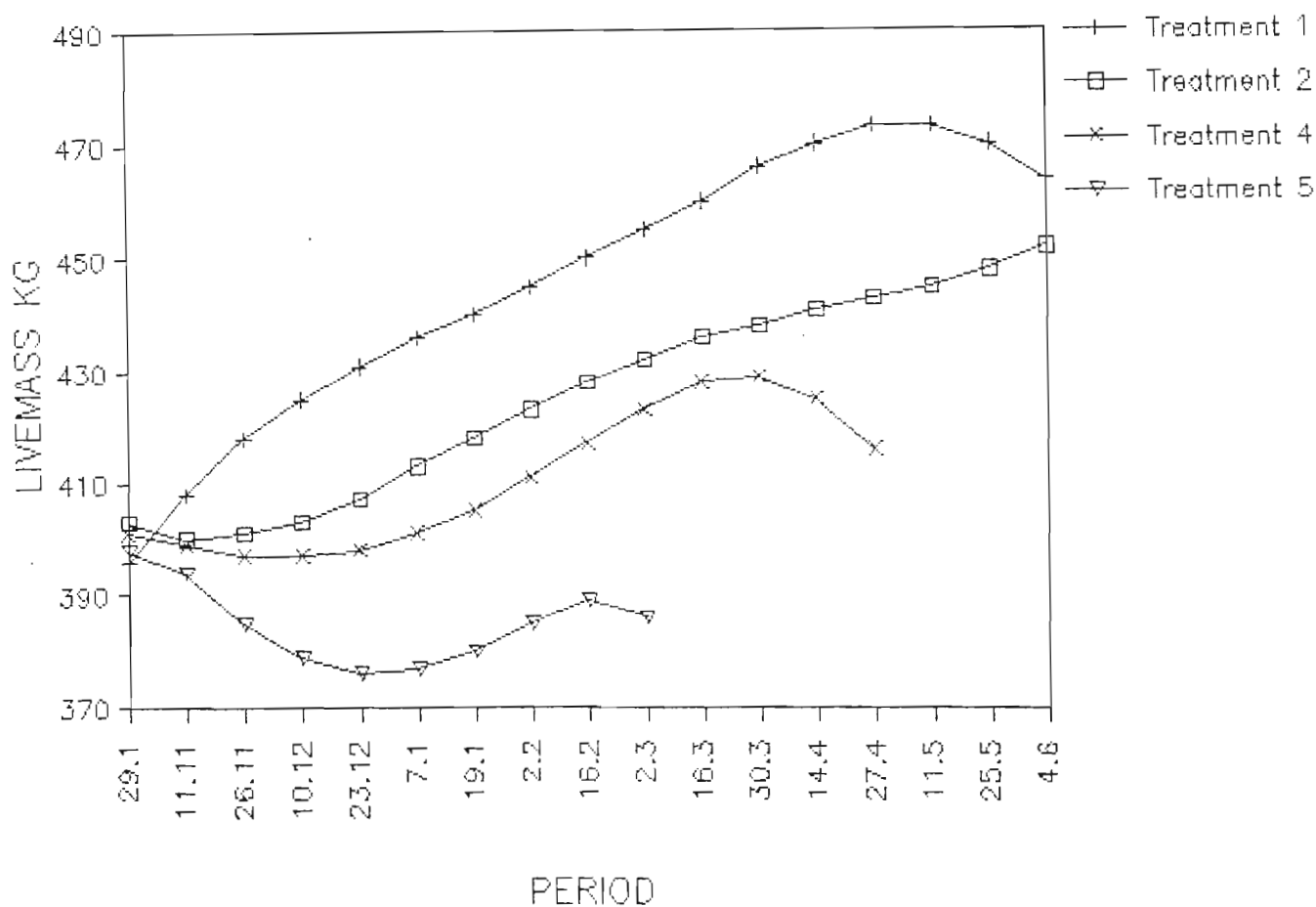


Figure 13d. The mean mass changes on veld for the lactating cows during the 1981/82 season.

Stocking rate	X1
Initial mass (mass at start of grazing)	X2
Season	X3
Calf gain	X4
No. of days postpartum	X5

All the cows were fed to achieve a similar condition (CS 3,0) at calving. Condition score was therefore not included as an independent variable. Mass changes (Y) were recorded between the onset of the grazing season and removal from the veld. Those factors that affected cow mass changes significantly are summarised in Table 29. Stocking rate was by far the most important factor affecting cow performance, accounting for 45,5% of the total variation. Initial mass (X2) accounted for an additional 9,8% of the variation. In total, 56,8% of the variation was accounted for. Season, calf gain and the number of days post-partum accounted for less than 1,5% of the total variation. Their contribution was not statistically significant. Season had no significant effect on cow performance. Whilst this finding is surprising, it is supported by the data in Figures 10a - 10d where the differences in metabolic mass changes between seasons, on a per hectare basis, were relatively small.

Changes in condition score - lactating cows

The concept of condition scoring as a means of assessing the physiological state of a breeding cow was used in this experiment for the first time in 1979/80. The changes in condition score of the lactating cows during the 1979/80, 1980/81 and 1981/82 seasons are shown in Figures 14a, 14b and 14c respectively. The means presented in these figures were derived from the quartic equations presented in Appendix 2. Weaning on the basis of the dam's condition was also first

Table 29. Factors influencing cow mass changes on veld over four seasons, as determined by stepwise regression analysis.

Dependant variable Y	Independent variable	Contribution of variable(s) to total variation R ² X 100	Significance of added independent variable
Cow mass change from initiation of grazing to weaning	Stocking rate (X 1)	45,5	P < 0,001
	Stocking rate (X 1) + initial mass (X 2)	55,3	P < 0,001
	+ Season (X 3)	56,3	NS
	+ Initial mass (X 4)	56,5	NS
	Y = 200,7 - 76,9 (X 1) - 0,206 (X 2)	R = 0,744	

attempted during the 1979/80 season. The criterion for weaning was theoretically defined as that time when the mean condition score of all the lactating cows in any one treatment, fell below a condition score of 2,0. All the treatments were then terminated for that particular season. Whilst an attempt was made to apply the weaning criterion strictly, in practice, treatments were often terminated when the mean condition score was either just above or below 2,0. During the 1979/80 season the calves were weaned, and all the animals were removed from summer grazing when the mean condition score of the cows in Tr.5 (1,67 cows + calves /ha) was just above a 2,0. All the animals were removed from veld after 197 days of grazing (Table 27). Although the condition scores of the cows in Tr.1, Tr.2 and Tr.4 were declining at weaning, the grazing period could have been extended had the criterion for weaning on the basis of condition score been strictly applied.

During the 1980/81 season the cows in Tr.1 increased their condition scores during the first two weeks on veld and thereafter maintained condition until the end of the grazing period (Figure 14a). The grazing season was terminated after 189 days when the mean condition score of the cows in Tr.5 was 1,73 (Figure 14a). The cows in Tr.1, Tr.2 and Tr.4 had mean condition scores at the end of the grazing season of 3,06, 2,17 and 2,76 respectively. The grazing season could therefore have been extended for these three treatments. The changes in condition score during the 1981/82 season (Figure 14c) varied considerably from the trends reflected in the two previous seasons (Figures 14a and 14b). The cows in Tr.1 gained condition and reached a condition score of 3,57 after 150 days on veld. Their condition declined slightly thereafter, with the mean condition score at weaning (218 days) being 3,47. The cows in Tr.2 showed a steady decline in condition during the first 30 days on veld. They then recovered slightly to realize a mean condition score of 2,67 at the cessation of

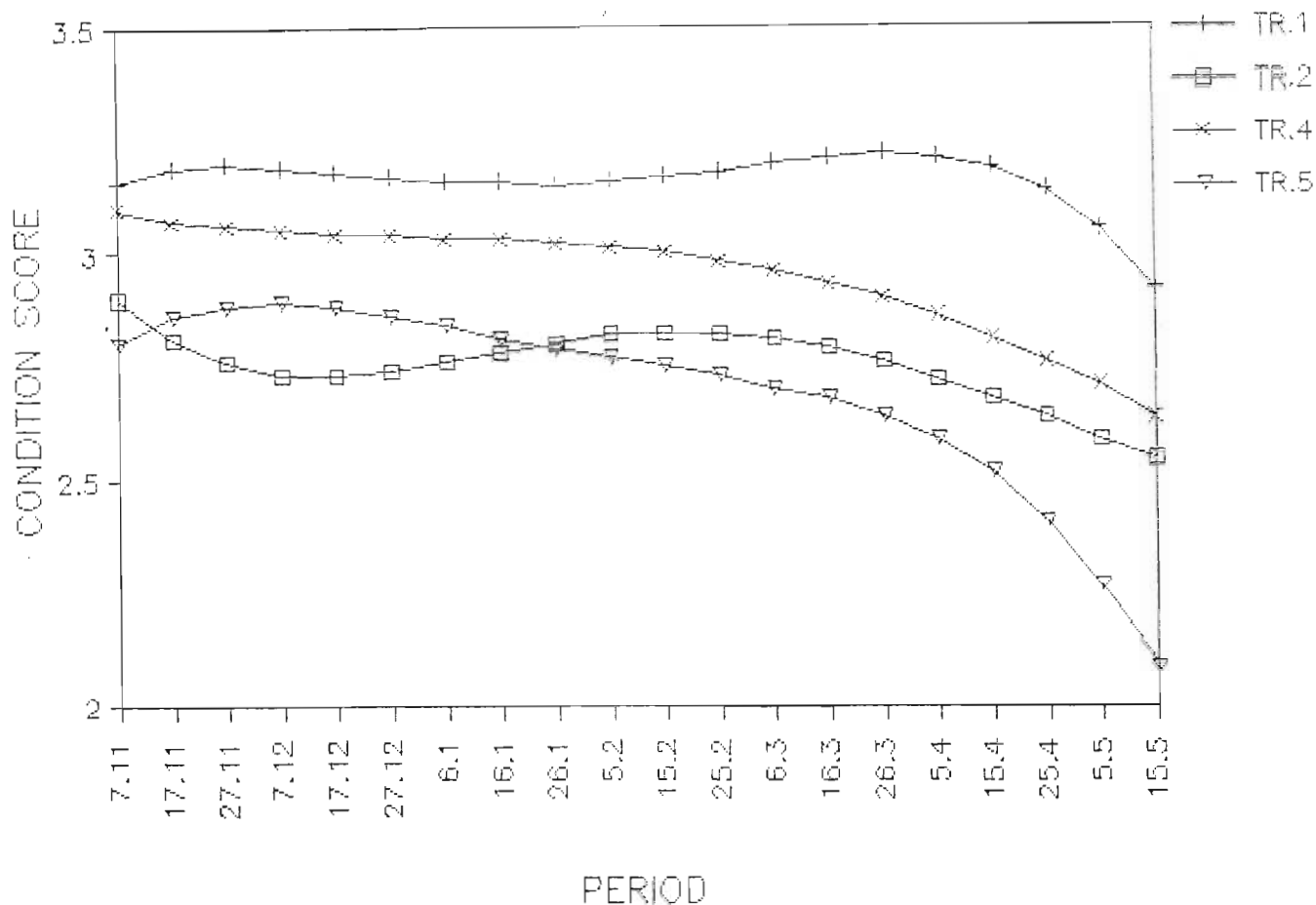


Figure 14a. The mean condition score changes for the lactating cows during the 1979/80 season.

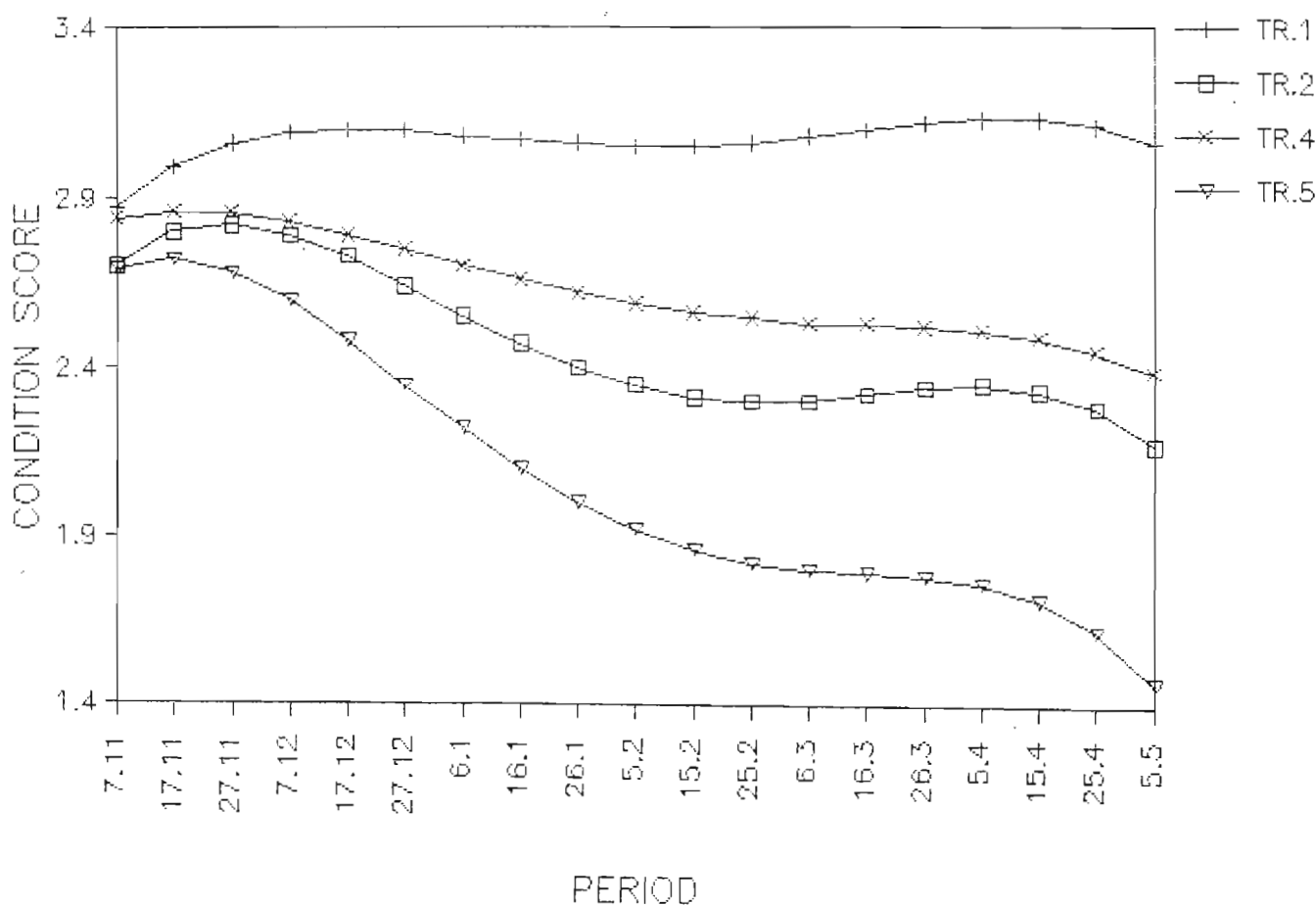


Figure 14b. The mean condition score changes for the lactating cows during the 1980/81 season.

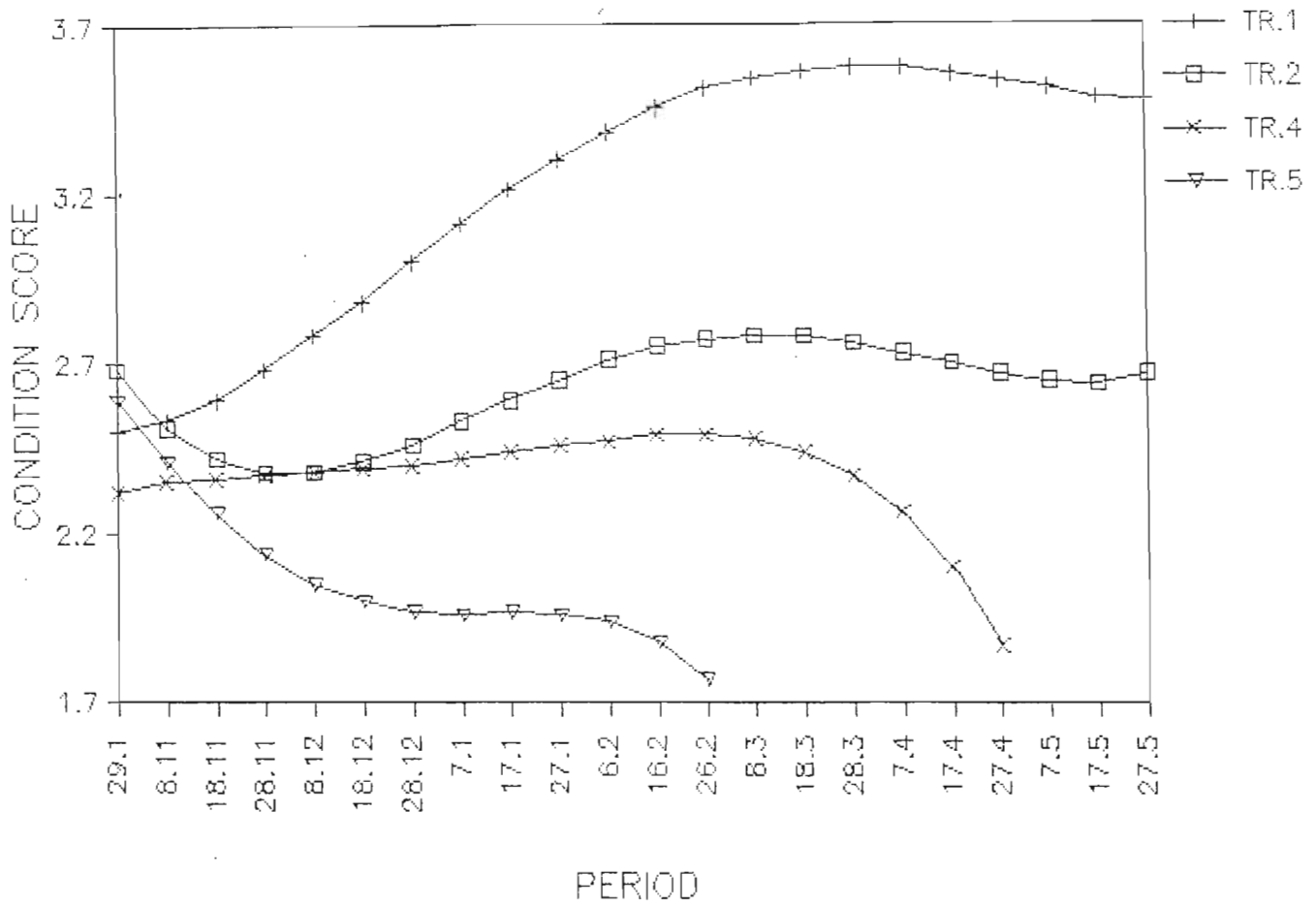


Figure 14c. The mean condition score changes for the lactating cows during the 1981/82 season.

grazing. The grazing period for the cows in Tr.4 was terminated after 180 days when the mean condition scores of the cows was 1,87. These cows showed a rapid decline in condition score during the last 50 days on veld. The cows in Tr.5 had a mean condition score of 1,77 after only 124 days on veld.

Mass changes - non-lactating cows

Insufficient lactating cows were available for the experiment during the 1979/80 and 1981/82 seasons. Dry cows were therefore included in each treatment in order to maintain the desired stocking rates. Whilst the experiment was designed to carry 30 cows plus calves per treatment, the inclusion of dry cows during two of the seasons provided the opportunity to assess the performance of dry pregnant cows, relative to lactating cows, at different stocking rates.

Mass changes for dry pregnant cows during the 1979/80 and 1981/82 grazing season are shown in Figures 15a and 15b respectively. The curves shown in Figure 15a indicate that whilst the dry cows in Tr.5 did not perform as well initially as the cows in Tr.2 and Tr.4, the mass changes for the first 165 days, on veld were similar for all three treatments. In particular, the cows in Tr.5 lost mass rapidly after 165 days on veld. The cows in Tr.1 achieved their mean maximum mass after 186 days on veld at an average growth rate of 0,525 kg/day (Table 30). The cows in Tr.2 and Tr.4 attained similar mean maximum livemasses but at slightly different ADG's (0,25 vs. 0,32) because of the difference in the number of days taken to reach peak livemasses for the season. The cows in Tr.2 recorded a mean daily growth rate to maximum mass of 0,352 kg/day, whilst the cows in Tr.4 gained at a rate of 0,327 kg/day (Table 30).

The performance of lactating cows and dry cows within the same stocking rate treatments and the same seasons (1979/80 and 1981/82)

Table 30. The mean maximum mass, days to maximum mass, mass gained to maximum mass, average daily gain (ADG) to maximum mass for dry cows on summer veld.

Treatment Cows + calves/ha	Tr. 1 0,83	Tr. 2 1,0	Tr. 3 1,25	Tr. 5 1,67
<u>Maximum mass</u>				
1979/80	555,79	524,38	519,40	511,88
1981/82	561,51	505,35	520,84	449,44
	558,65	514,87	520,12	480,66
	± 4,05	±13,46	± 1,02	±44,16
<u>Days to max. mass</u>				
1979/80	186	193	179	165
1981/82	198	218	160	124
	192,0	205,5	169,5	144,5
	± 8,49	±17,68	±13,44	±29,0
<u>Mass gained to max. mass</u>				
1979/80	97,65	69,34	64,42	52,40
1981/82	120,38	98,98	91,98	30,26
	109,02	84,16	78,20	41,33
	±16,08	±20,96	±19,49	±15,66
<u>ADG to max. mass</u>				
1979/80	0,52	0,35	0,32	0,26
1981/82	0,60	0,45	0,51	0,24
	0,57	0,41	0,42	0,26
	± 0,06	±0,08	± 0,13	±0,02
<u>No. of grazing days</u>				
1979/80	197	197	197	197
1981/82	218	281	180	124
	207,5	207,5	188,5	160,5
	±14,85	±14,85	±12,02	±51,62

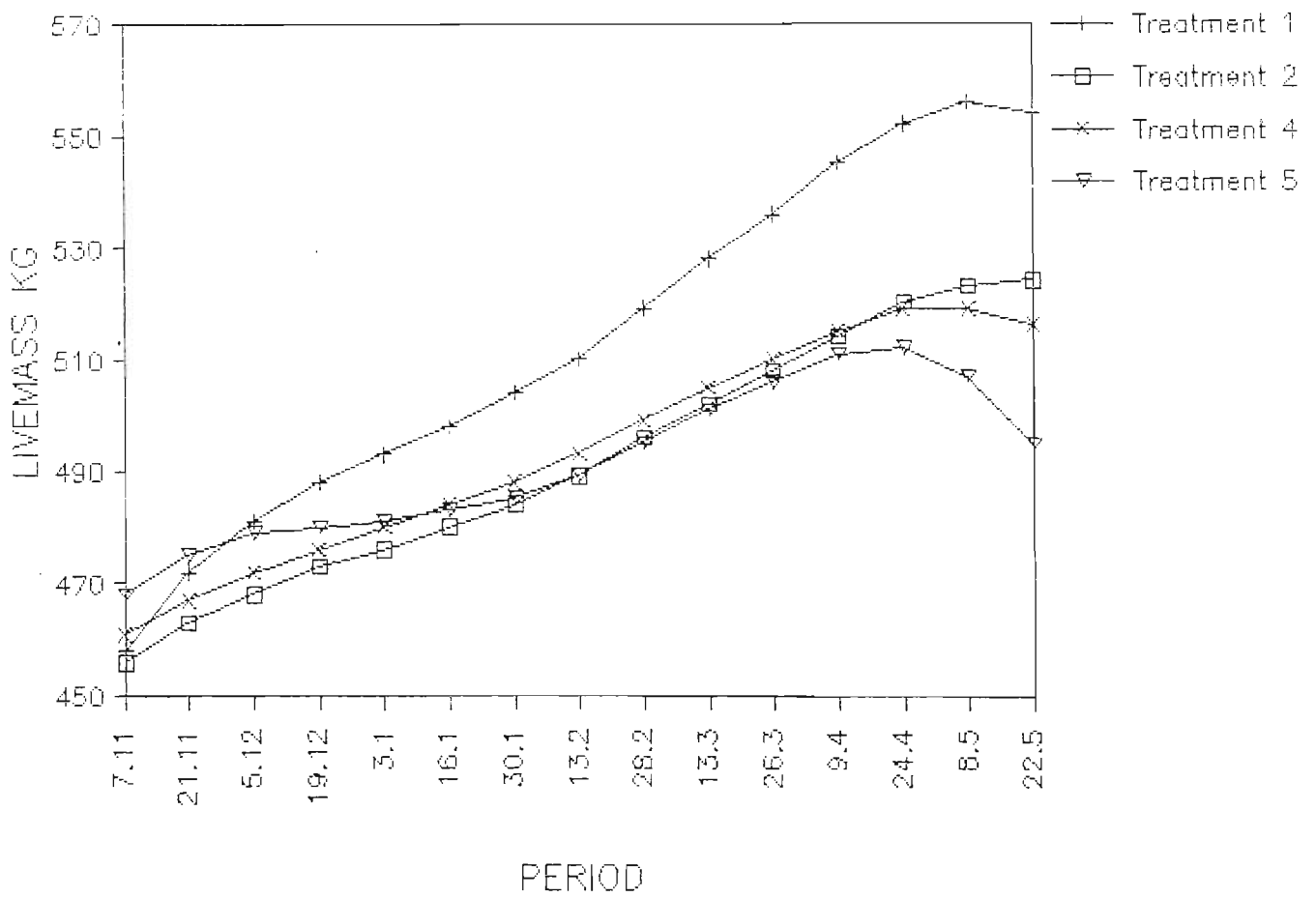


Figure 15a. The mean mass changes on veld for the dry pregnant cows during the 1979/80 season.

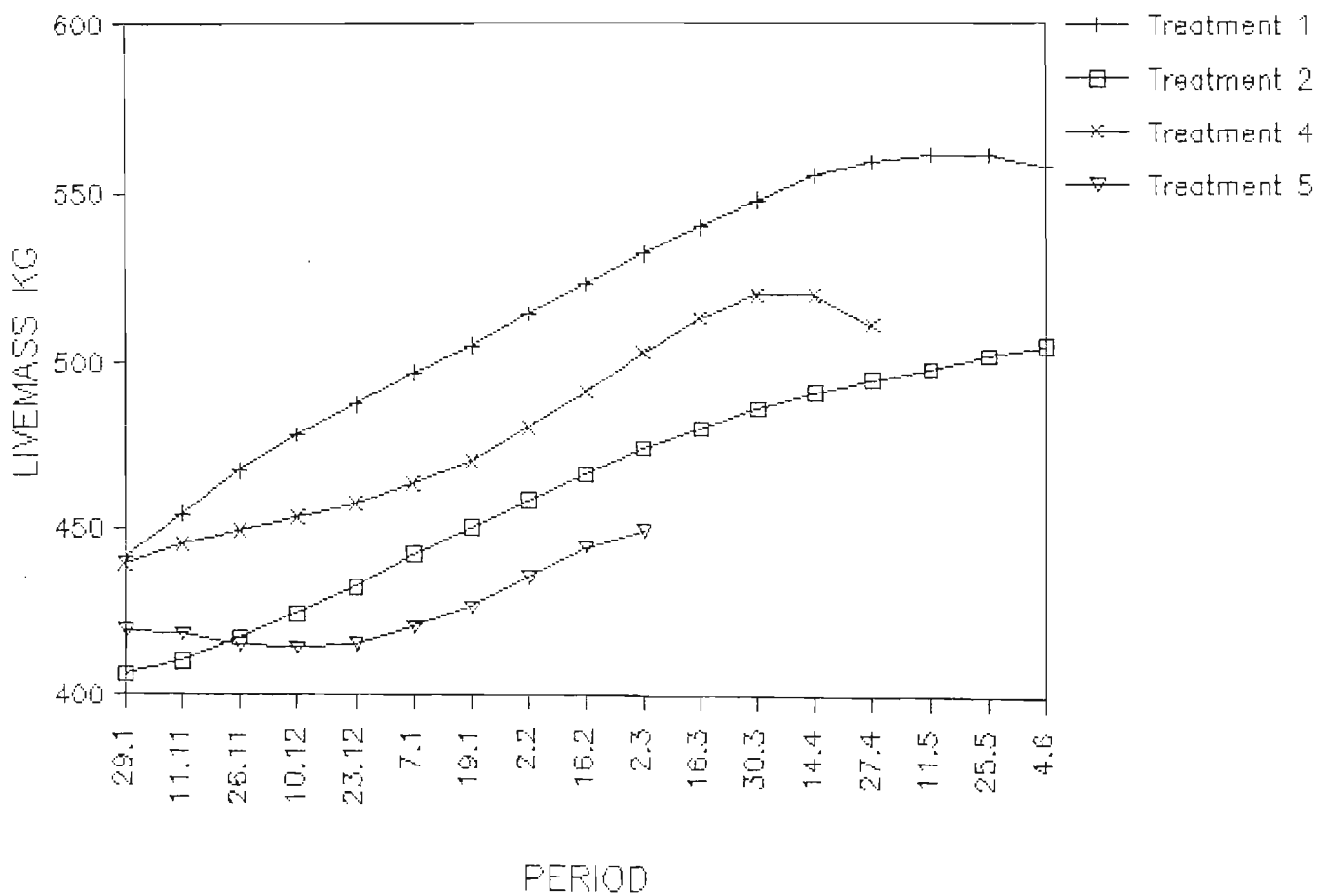


Figure 15b. The mean mass changes on veld for the dry pregnant cows during the 1981/82 season.

were compared. The lactating cows in Tr.1, Tr.2, Tr.4 and Tr.5 achieved their mean maximum livemasses after 183, 196, 163 and 75 days (mean for two seasons) respectively (Table 27). In contrast, the dry cows reached their mean maximum livemasses after 192, 206, 170 and 144 days (mean two seasons) in Tr.1, Tr.2, Tr.4 and Tr.5 respectively (Table 30). The main differences between the two classes of animal are reflected in the mass gained in achieving maximum mass. Mass gained by the lactating cows was 58,56 kg (Tr.1), 37,24 kg (Tr.2), 26,08 kg (Tr.4) and 3,0 kg (Tr.5), whilst the dry cows showed mass gains of 109,44 kg, 82,20 kg, 71,19 kg and 36,0 kg in Tr.1, Tr.2, Tr.4 and Tr.5 respectively. The dry cows therefore had 86,89%, 120,73%, 172,97% and 1200,00% greater livemass gains than the lactating cows in Tr.1, Tr.2, Tr.4 and Tr.5 respectively.

Whilst these figures are predictable in the sense that dry cows would be expected to show greater livemass gains than lactating cows under similar conditions, these data indicate that the lactating cows were infinitely more susceptible to increasing stocking rate than dry, pregnant cows.

Condition score changes - non-lactating cows

The condition score changes for dry cows during the 1979/80 and 1981/82 seasons are shown in Figures 16a and 16b respectively. The dry cows generally maintained or gained condition slightly during the 1979/80 grazing season. The condition fluctuations recorded by the cows in Tr.4 were not as dramatic as they appear in Figure 16a as a result of the scale of the graph. The cows in Tr.4 gained an average of 0,36 condition score points during the first 80 days on veld, but lost this condition during the following 90 days. The mean condition score of these cows at the termination of grazing was the same as their condition score at the onset of grazing. A similar trend held true for

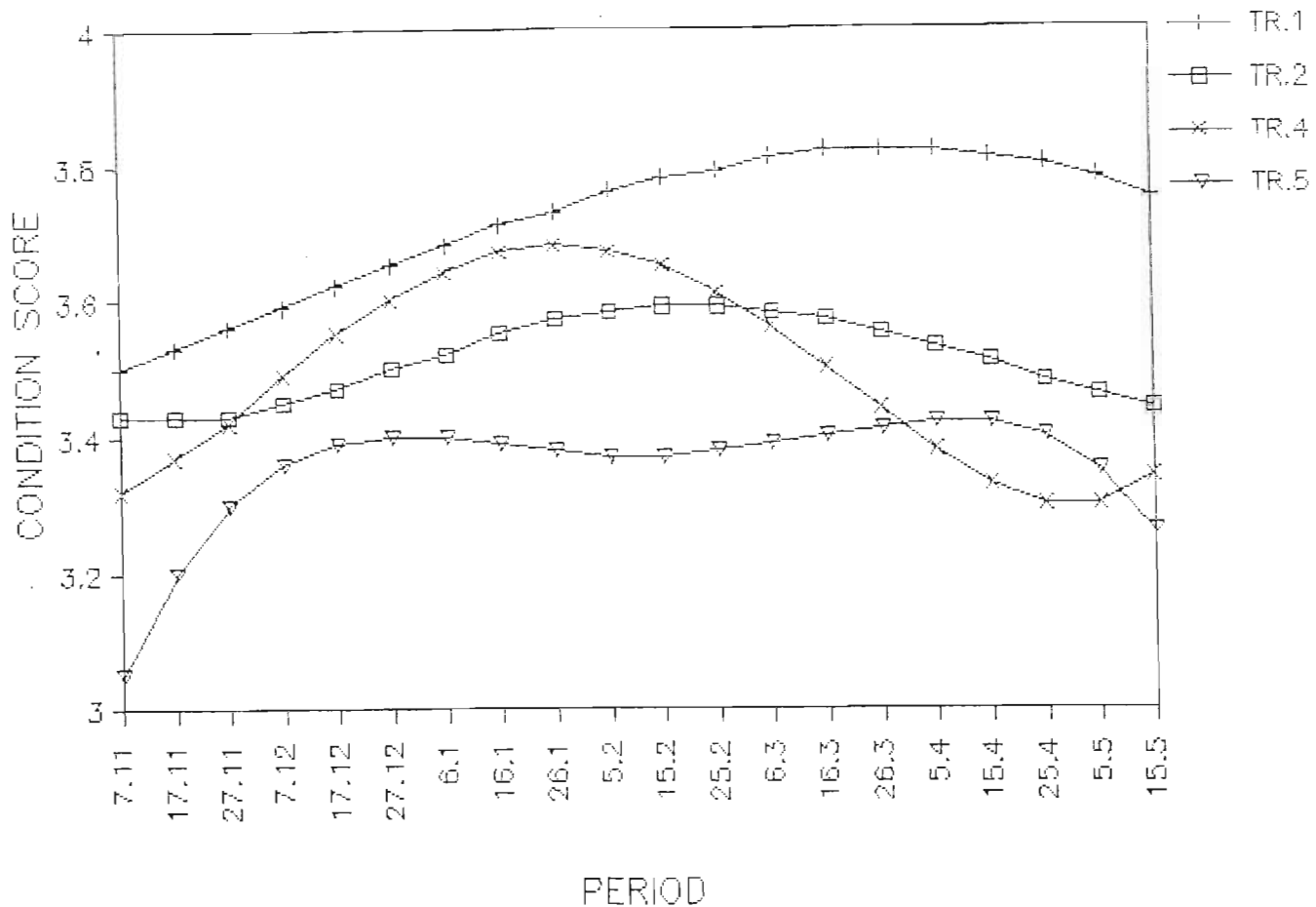


Figure 16a. The mean condition score changes for the dry pregnant cows during the 1979/80 season.

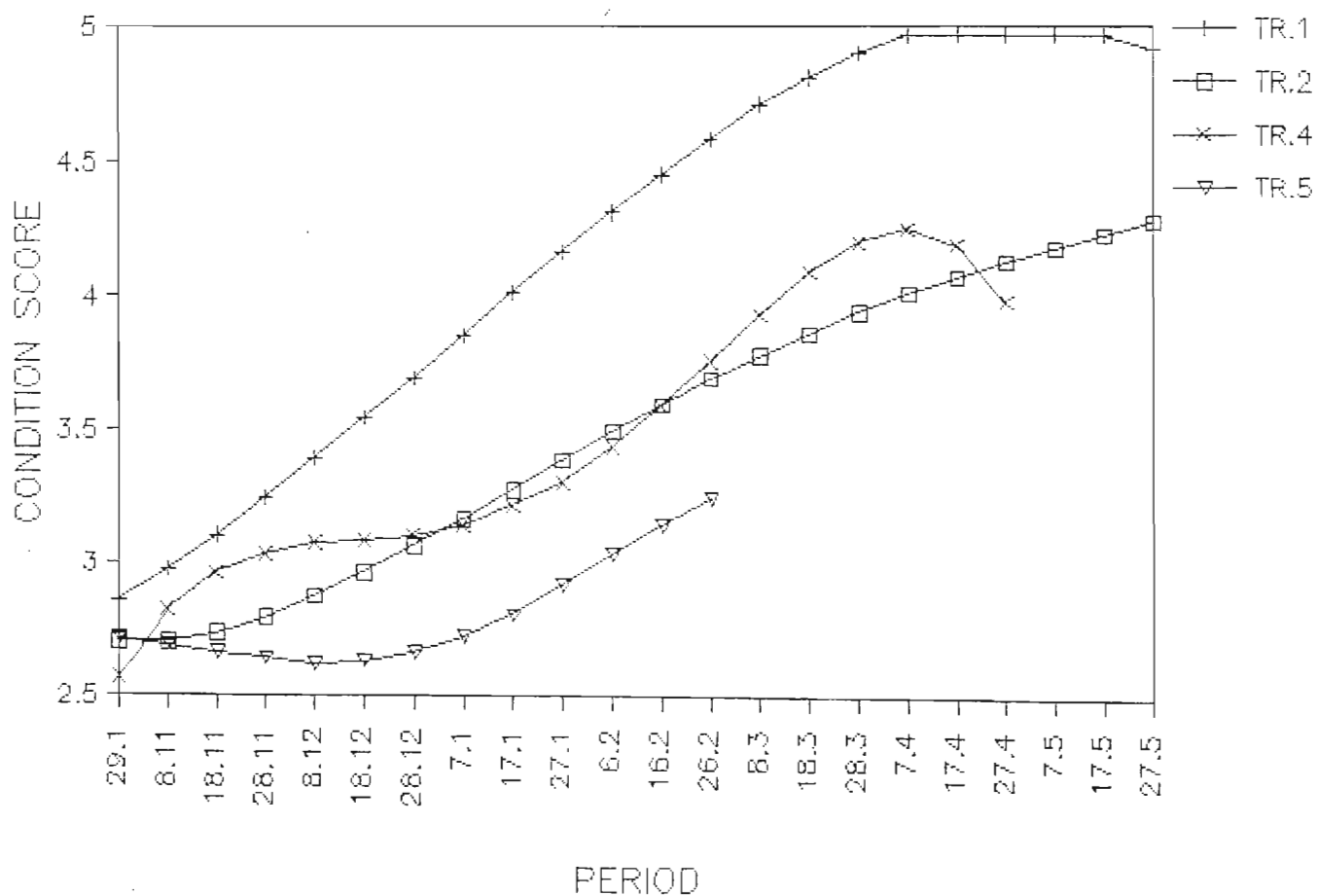


Figure 16b. The mean condition score changes for the dry pregnant cows during the 1981/82 season.

the cows in Tr.2. The cows in Tr.1 showed a marginal condition score improvement (0,25 condition points) during the grazing season (Figure 16a).

Condition score changes during the 1981/82 season (Figure 16b) were substantially different from those recorded during the 1979/80 season. The cows in all four treatments improved their condition and those in Tr.1, Tr.2 and Tr.4, in particular, showed significant gains. The cows in Tr.1 had a mean condition score of 5,0 after 180 days on veld. The cows in Tr.4 had a mean condition score of 4,25 after 160 days on veld (Figure 16b). However, their condition scores declined during the last 20 days on veld. Grazing was terminated after 180 days, at which stage the mean condition score of these cows (Tr.4) was 3,98. The mean condition score of the cows in Tr.2 at the end of the grazing season was 4,28 (Figure 16b). These cows were, however, still gaining in condition at this stage. Clearly, the cows in both Tr.2 and Tr.4 were fat at the onset of the winter feeding period and would be required to lose half a condition score point before calving. The cows in Tr.5 showed no condition score gain during the first 50 days on veld, but thereafter improved their condition score to 3,24 before being removed from the veld together with the lactating cows.

Calves

Growth rates

The growth curves for the calves during the four seasons are presented in Figures 17a, 17b, 17c and 17d respectively. The curves were based on fitted means which were derived from the quartic equations presented in Appendix 3. The calves in Tr.5 (1,67 cows + calves /ha) were weaned after 124 days on veld in the 1981/82 season because of the poor body condition of their dams. The mean weaning mass

Table 31. Mean maximum mass (kg), days to maximum mass, average daily gain (ADG) to maximum mass (kg/day) and the number of grazing days recorded by calves during the summer grazing season.

Treatment	Tr. 1	Tr. 2	Tr. 4	Tr. 5
Cows + calves/ha	0,83	1,0	1,25	1,67
<u>Maximum mass</u>				
1978/79	193,88	187,04	192,67	167,77
1979/80	216,51	211,30	231,30	186,39
1980/81	215,63	189,60	188,47	156,54
1981/82	226,65	215,29	168,89	130,62
	213,17	200,81	195,34	160,33
	$\pm 13,80$	$\pm 14,55$	$\pm 26,13$	$\pm 23,32$
<u>Days to max. mass</u>				
1978/79	196	196	194	190
1979/80	197	192	197	189
1980/81	189	189	189	182
1981/82	218	218	180	124
	200,00	198,75	190,00	171,25
	$\pm 12,52$	$\pm 13,15$	$\pm 7,44$	$\pm 31,70$
<u>ADG to max. mass</u>				
1978/79	0,66	0,63	0,65	0,53
1979/80	0,73	0,71	0,75	0,61
1980/81	0,74	0,64	0,63	0,47
1981/82	0,74	0,68	0,55	0,50
	0,73	0,67	0,66	0,54
	$\pm 0,04$	$\pm 0,04$	$\pm 0,09$	$\pm 0,07$
<u>No. of grazing days</u>				
1978/79	196	196	196	196
1979/80	197	197	197	197
1980/81	189	189	189	189
1981/82	218	218	180	124
	200,00	200,00	190,50	176,50
	$\pm 12,52$	$\pm 12,52$	$\pm 17,86$	$\pm 35,18$

of the calves in Tr.5 was 130,62 kg which was achieved at a growth rate of 0,508 kg/day (Table 31). The data in Figures 17a, 17b and 17c indicate that the calves in Tr.5 tended to gain mass at a slower rate during the last 42 days of grazing, than was the case during the earlier part of the season. The calves in Tr.5 generally attained their mean maximum masses about seven days before they were removed from the grazing (Table 31). This trend was contrary to that seen in the other three treatments. In general, the number of days required to reach maximum mass and the number of grazing days did not differ for the calves in Tr.1, Tr.2 and Tr.4. It is evident from these data that the very high stocking rate (1,67 cows + calves /ha) reduced both the cows' and the calves' performances significantly. The data in Table 31 also show that the calves in Tr.4 (1,25 cows + calves /ha) were suppressed by the high stocking rate, as the mean maximum masses (weaning masses) and the ADG's declined progressively during the 1979/80, 1980/81 and 1981/82 seasons. The calves in Tr.1 (0,83 cow + calf /ha) realized 6,16% (mean four years) higher weaning masses than the calves in Tr.2 (1,0 cow + calf /ha). However, apart from the 1980/81 season ($P < 0,01$), there were no statistically significant differences in the growth rates on summer veld between the calves in these two treatments.

The factors affecting calf gain (Y) on veld between the onset of grazing and removal from the veld were analysed by a stepwise regression analysis (Genstat V). The independent variables included in the analysis were:

Stocking rate	X1
Season	X2
Initial mass (at start of grazing)	X3
Cow mass change (over grazing season)	X4
Age of calf at start of grazing	X5

A summary of the factors affecting calf gains is presented in Table 32. Stocking rate had the most significant ($P < 0,01$) effect on calf gain, accounting for 39,2% of the variation. Season contributed a further 3,6% to the total variation. Initial mass, cow mass change and age of calf at the start of grazing contributed only a further 0,8% to the variation. In total, 44,4% of the variation was accounted for. It is interesting to note that season had a small, but significant ($P < 0,001$) effect on calf performance - in contrast to cow performance. Once again these figures confirm the trends in metabolic mass changes shown in Figures 10a - 10d where metabolic mass changes per hectare varied between seasons.

Mineral vs. urea/mineral supplement

Lactating cows

The mass changes for the lactating cows in Tr.2 (1,0 cow + calf/ha - mineral lick), Tr.3 (1,0 cow + calf/ha - urea lick), Tr.5 (1,67 cows + calves/ha - mineral lick) and Tr.6 (1,67 cows + calves/ha - urea lick) during the four seasons are presented in Figures 18a, 18b, 18c and 18d. All the animals received a urea-based lick from the 15th of February each year. However, only Tr.3 and Tr.6 received the urea lick from the beginning of the grazing season. The animals in the other four treatments had free access to a mineral lick.

Lick intakes were monitored during the 1978/79 and 1979/80

Table 32. Factors influencing calf gain on veld over four seasons, as determined by stepwise regression analysis

Dependent variable Y	Independent variable(s)	Contribution of variable(s) to total variation R ² x 100	Significance of added independent variable
Calf gain from initiation of grazing until removal from veld	Stocking rate (X 1)	39,2	P < 0,001
	Stocking rate (X 1) + Season (X 2)	43,6	P < 0,001
	+ Initial mass (X 3)	44,1	NS
	+ Cow mass gain (X 4)	44,4	NS
	Y = 196,57 - 59,98 (X 1) - 7,1 (X2)	R = 0,66	

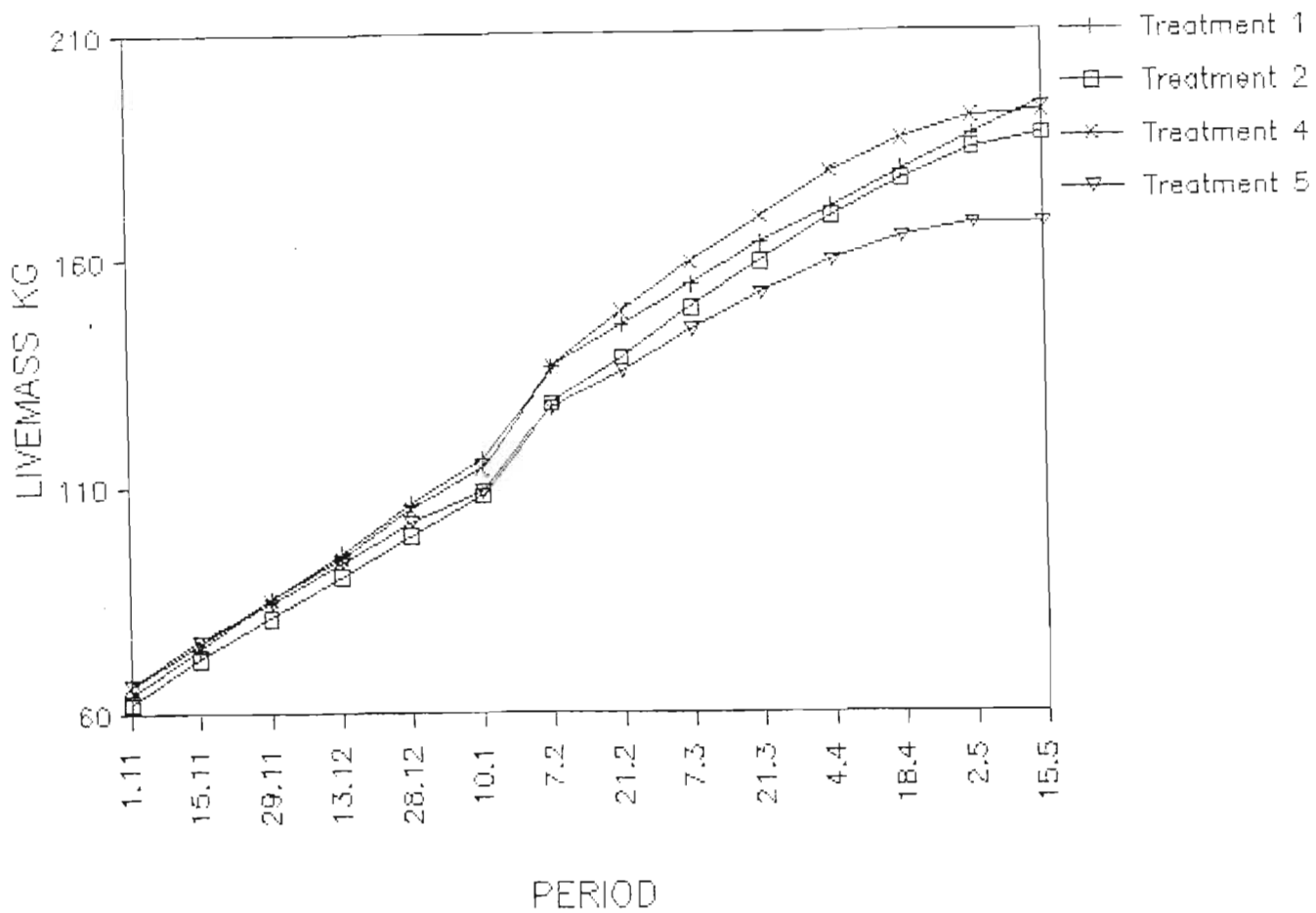


Figure 17a. The mean mass changes on veld for the calves during the 1978/79 season.

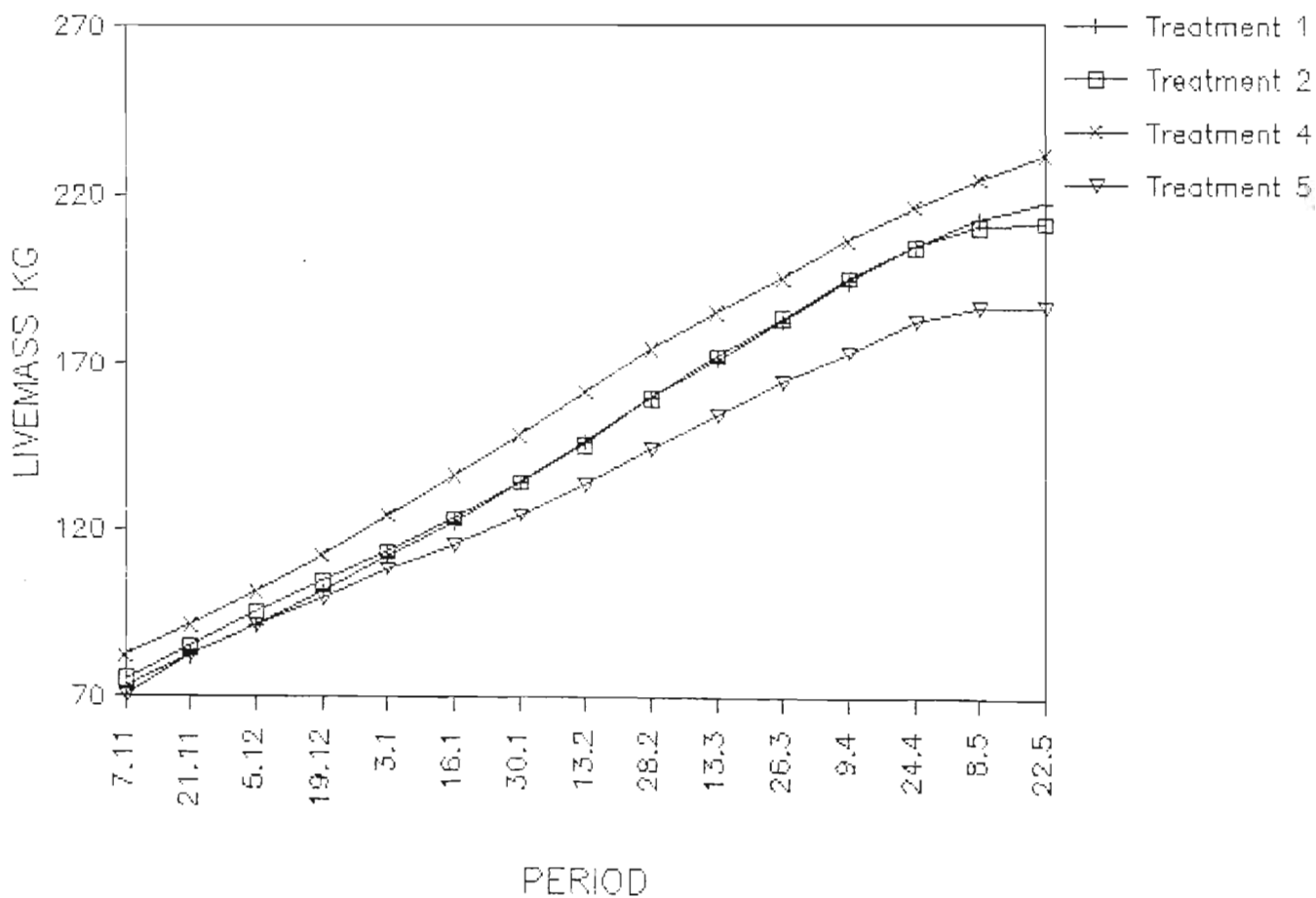


Figure 17b. The mean mass changes on veld for the calves during the 1979/80 season.

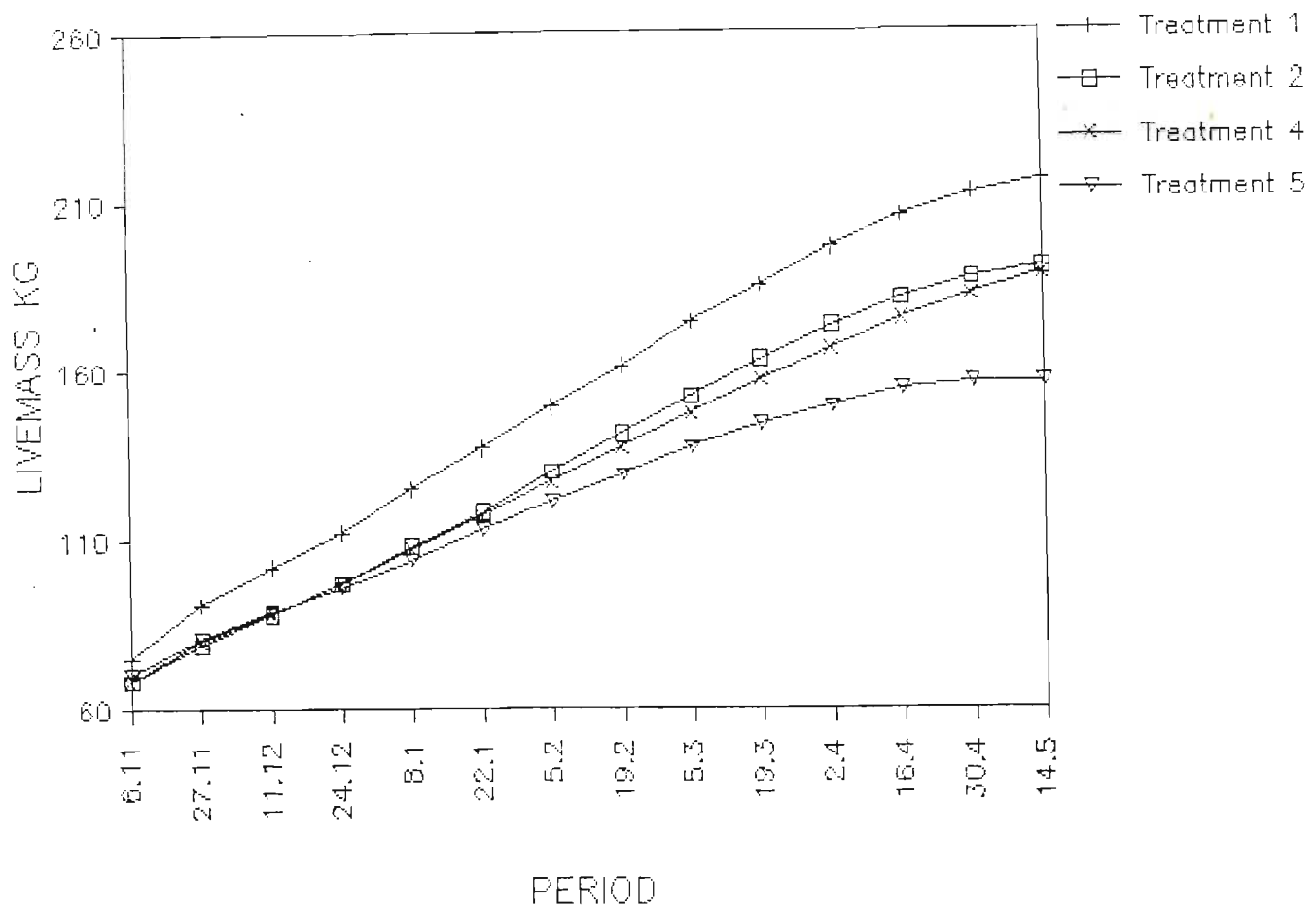


Figure 17c. The mean mass changes on veld for the calves during the 1980/81 season.

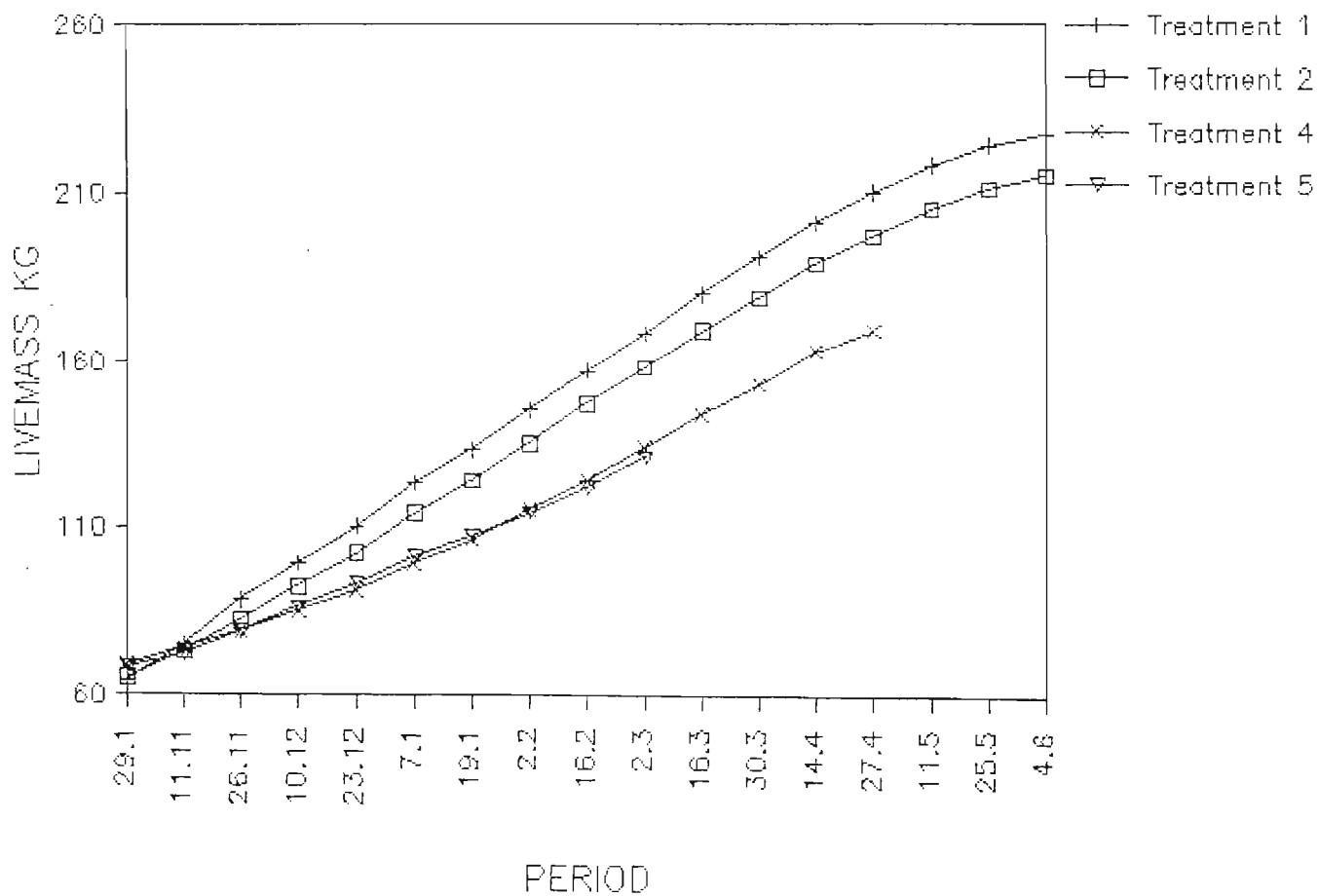


Figure 17d. The mean mass changes on veld for the calves during the 1981/82 season.

seasons. Intakes in excess of 1000g per head per day were frequently recorded, which was considered high for the type of lick being provided. However, towards the end of the second season it was discovered that lick was being stolen out of the feed troughs. Unfortunately, this meant that the intakes recorded during the first two seasons were unreliable. These data have therefore not been presented. A policy of providing 450 g of winter lick per head/day was adopted at the beginning of the 1981/82 season. The lick was supplied three times a week. This policy remained in force until the termination of the trial.

The benefit of a urea lick to the cows stocked at 1,0 cow + calf/ha (Tr.3) is evident from the trends in Figures 18a, 18b, 18c and 18d. The mean ADG's of the cows in Tr. 3 were significantly ($P < 0,01$) higher than those of the cows in Tr.2 (Table 33) in each of the four seasons. Whilst the number of days required to achieve maximum mass varied very little between the two treatments, the average daily gains achieved by the cows in Tr.3 were significantly ($P < 0,01$) higher than the ADG's achieved by the cows in Tr.2.

There was no difference in body condition between the cows in Tr.2 and Tr.3 at the end of the 1979/80 grazing season. However, during the 1980/81 and 1981/82 seasons, the cows that had access to the urea lick (Tr.3) during the first 120 days on veld, were in better ($P < 0,05$) condition at the termination of grazing. Consequently, the grazing season could have been extended for the cows in Tr.3, thereby reducing the winter feeding period.

A more detailed analysis of the performance of the lactating cows until the 15th of February (Table 34) reveals that the cows in Tr.3 achieved significantly higher ($P < 0,01$) ADG's during the first 60 days of the grazing season than the cows in Tr.2. Daily gains by the cows in Tr.3 were significantly ($P < 0,01$) lower during the second 60 days of

Table 33. Mean maximum mass (kg), days to maximum mass, average daily gain (ADG - kg/day) and the number of grazing days for lactating cows receiving either a mineral (M) or urea (U) lick.

Treatment	Tr. 2	Tr. 3	Tr. 5	Tr. 6
Cows + calves/ha	1,0	1,0	1,67	1,67
Supplement	M	U	M	U
<u>Maximum mass</u>				
1978/79	442,28	463,52	426,40	421,42
1979/80	477,18	491,81	442,41	453,41
1980/81	457,62	466,43	422,66	423,38
1981/82	451,56	473,01	398,48	399,48
	457,16 ±14,77	473,70 ±12,72	422,49 ±18,16	424,43 ±22,16
<u>Days to max. mass</u>				
1978/79	171	178	150	31
1979/80	174	172	9	6
1980/81	160	165	151	150
1981/82	218	208	0	0
	180,75 ±25,56	180,75 ±18,93	77,50 ±84,38	46,75 ±70,13
<u>ADG to max. mass</u>				
1978/79	0,19	0,34	0,03	0,34
1979/80	0,15	0,35	0,08	0,07
1980/81	0,30	0,37	0,05	0,00
1981/82	0,22	0,42	0,00	0,00
	0,22 ±0,07	0,38 ±0,04	0,05 ±0,04	0,11 ±0,17
<u>No. of grazing days</u>				
1978/79	196	196	196	196
1979/80	197	197	197	197
1980/81	189	189	189	189
1981/82	218	218	124	124
	200,00 ±12,52	200,00 ±12,52	176,50 ± 7,86	176,50 ± 7,86
<u>*Mean condition score</u>				
1978/79	-	-	-	-
1979/80	2,58	2,58	1,58	1,88
1980/81	2,03	2,74	1,21	1,26
1981/82	2,63	3,17	1,73	1,73
	2,42 ±0,34	2,83 ±0,31	1,60 ±0,34	1,63 ±0,33

* Mean condition score at the termination of grazing.

Table 34. The average daily gains (ADG's - kg/day) of lactating cows on summer grazing when fed either a mineral (M) or urea (U) supplement.

Treatment	Tr. 2	Tr. 3	Tr. 5	Tr. 6
Cows & calves/ha	1,0	1,0	1,67	1,67
Supplement	M	U	M	U
<u>Day 0 - 60</u>				
1978/79	0,209	0,576	0,015	0,119
1979/80	-0,083	0,412	-0,102	-0,226
1980/81	0,292	0,608	-0,122	-0,352
1981/82	0,123	0,750	-0,359	-0,354
	0,140	0,590	-0,150	-0,120
	$\pm 0,170$	$\pm 0,140$	$\pm 0,16$	$\pm 0,23$
<u>Day 61 - 120</u>				
1978/79	0,171	0,195	0,037	-0,030
1979/80	0,152	0,281	-0,050	-0,059
1980/81	0,229	0,254	0,076	0,181
1981/82	0,362	0,316	0,189	0,277
	0,230	0,270	0,070	0,100
	$\pm 0,10$	$\pm 0,06$	$\pm 0,10$	$\pm 0,170$
<u>Initial - Final Mass</u>				
1978/79	0,141	0,293	-0,054	-0,068
1979/80	0,089	0,255	-0,157	-0,160
1980/81	0,151	0,288	-0,121	-0,149
1981/82	0,221	0,404	-0,098	-0,047
	0,150	0,310	-0,110	-0,110
	$\pm 0,06$	$\pm 0,07$	$\pm 0,05$	$\pm 0,06$

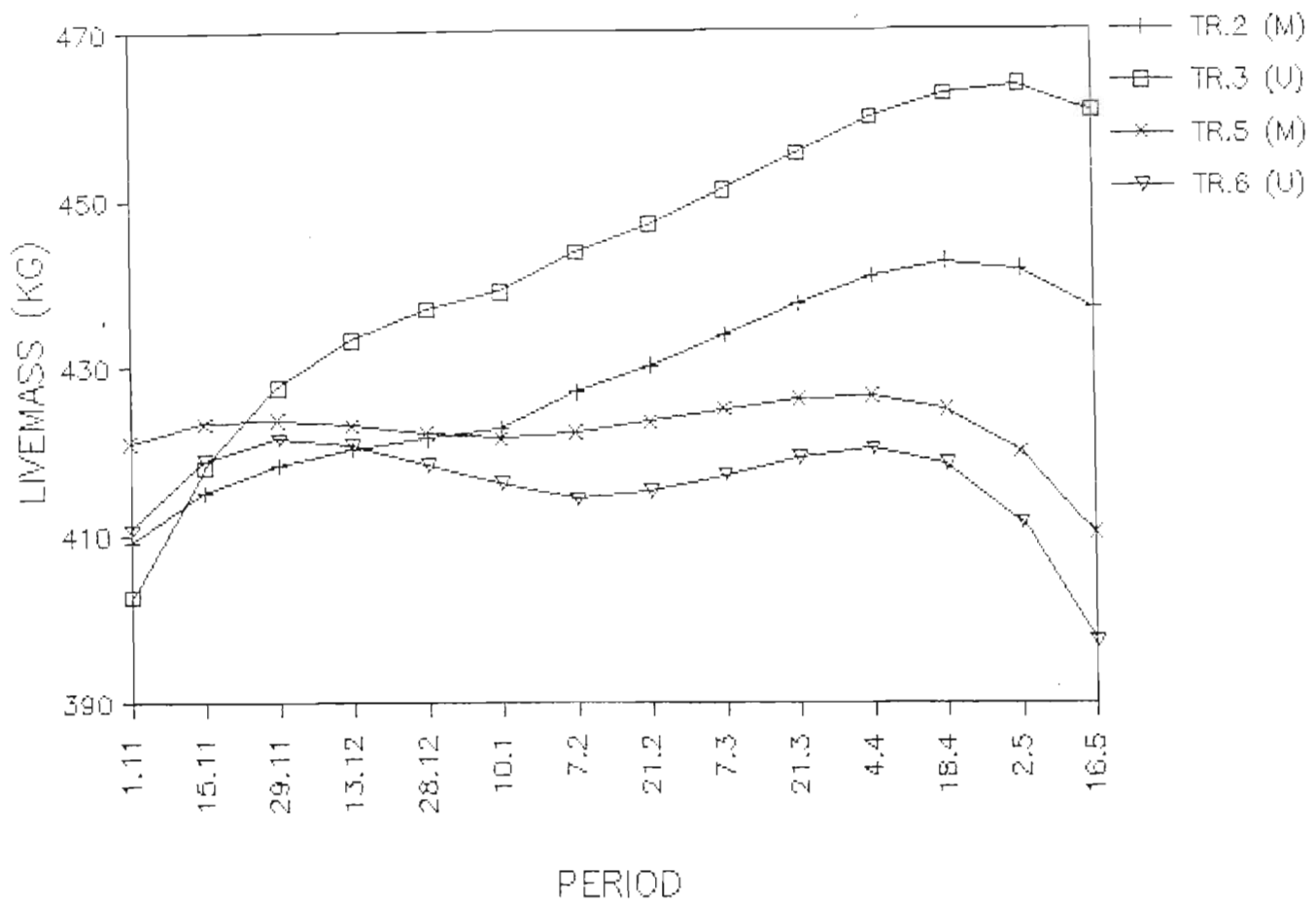


Figure 18a. The mean mass changes of the lactating cows with access to either a mineral or urea lick - 1978/79 season.

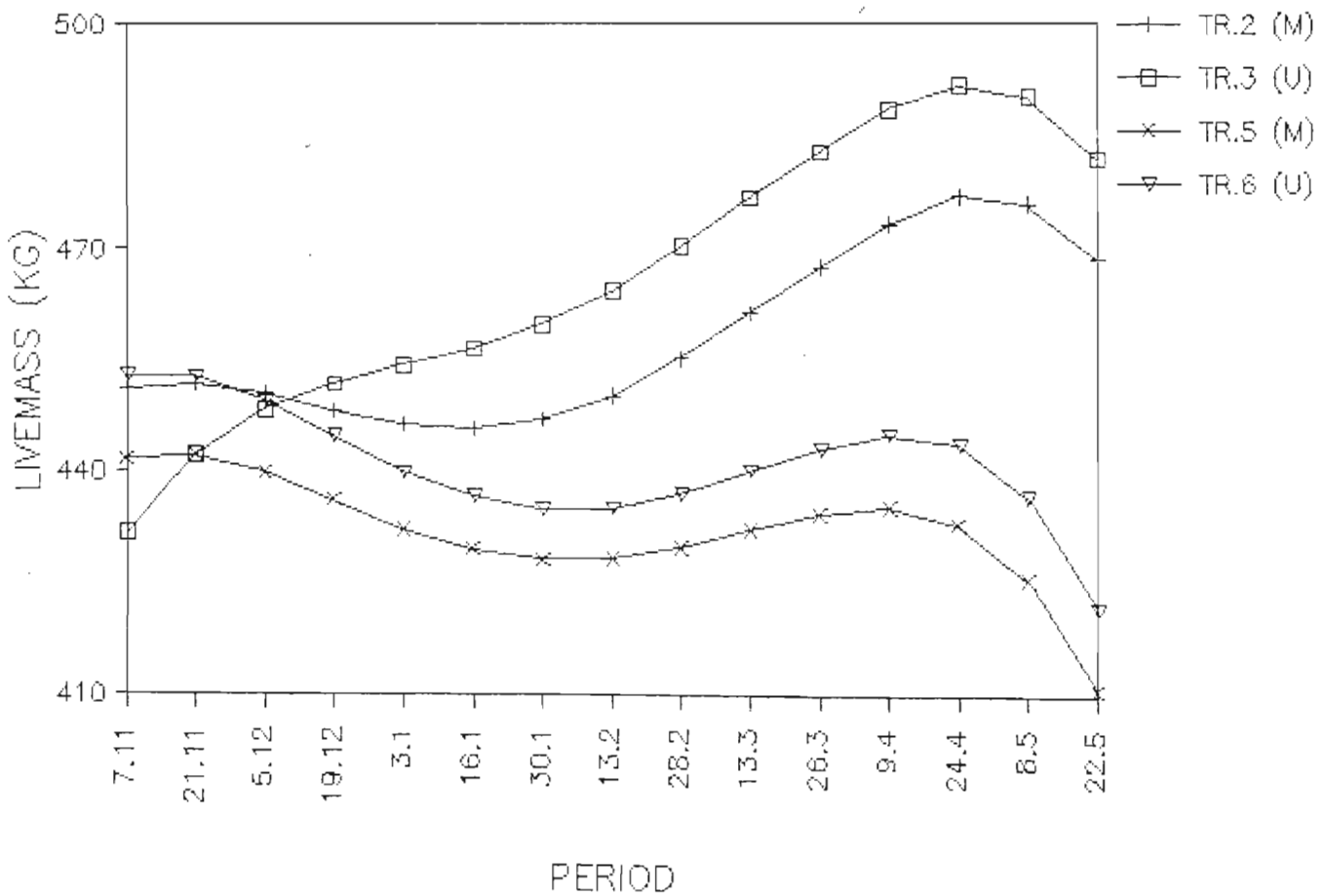


Figure 18b. The mean mass changes of the lactating cows with access to either a mineral or urea lick - 1979/80 season.

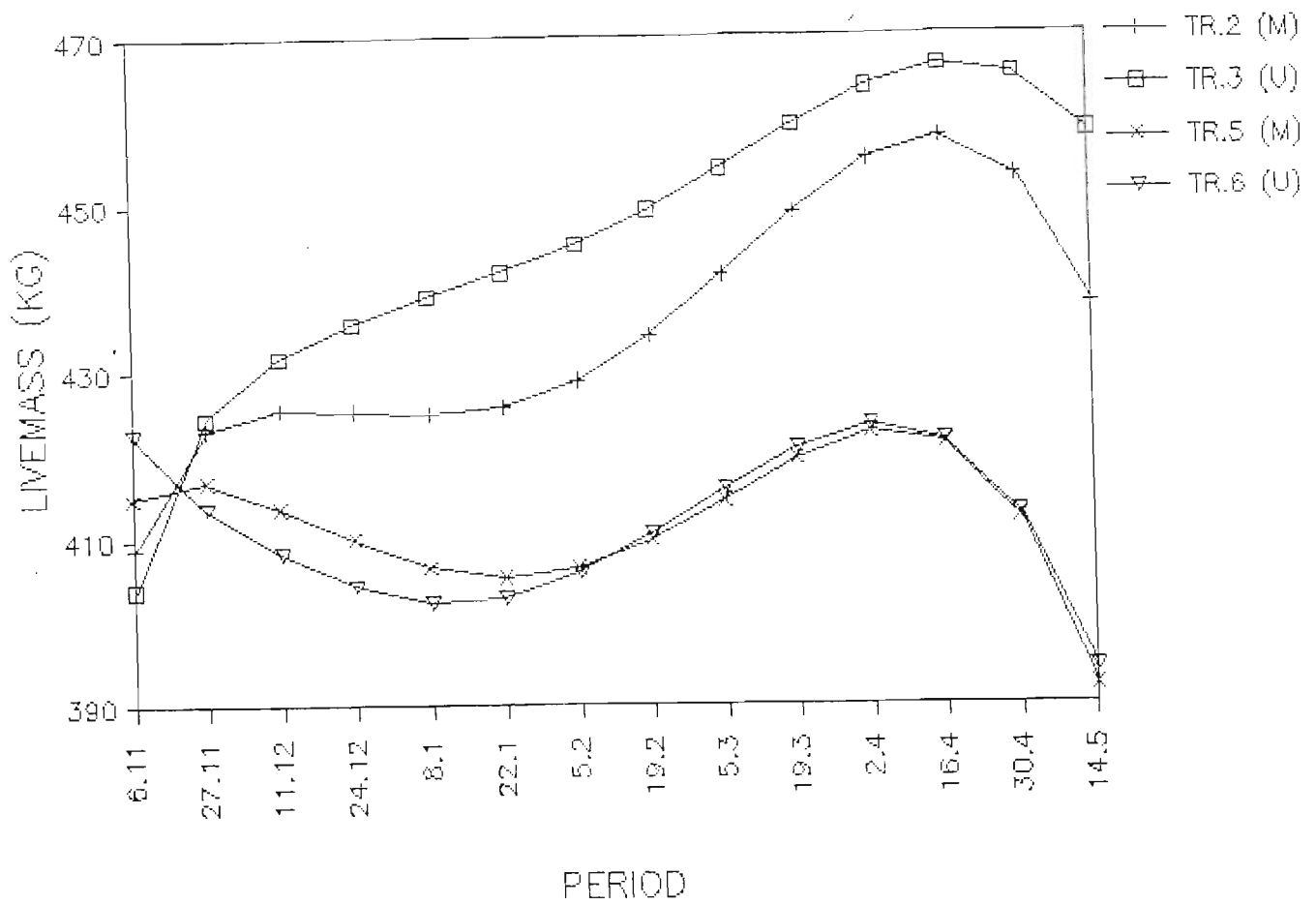


Figure 18c. The mean mass changes of the lactating cows with access to either a mineral or urea lick - 1980/81 season.

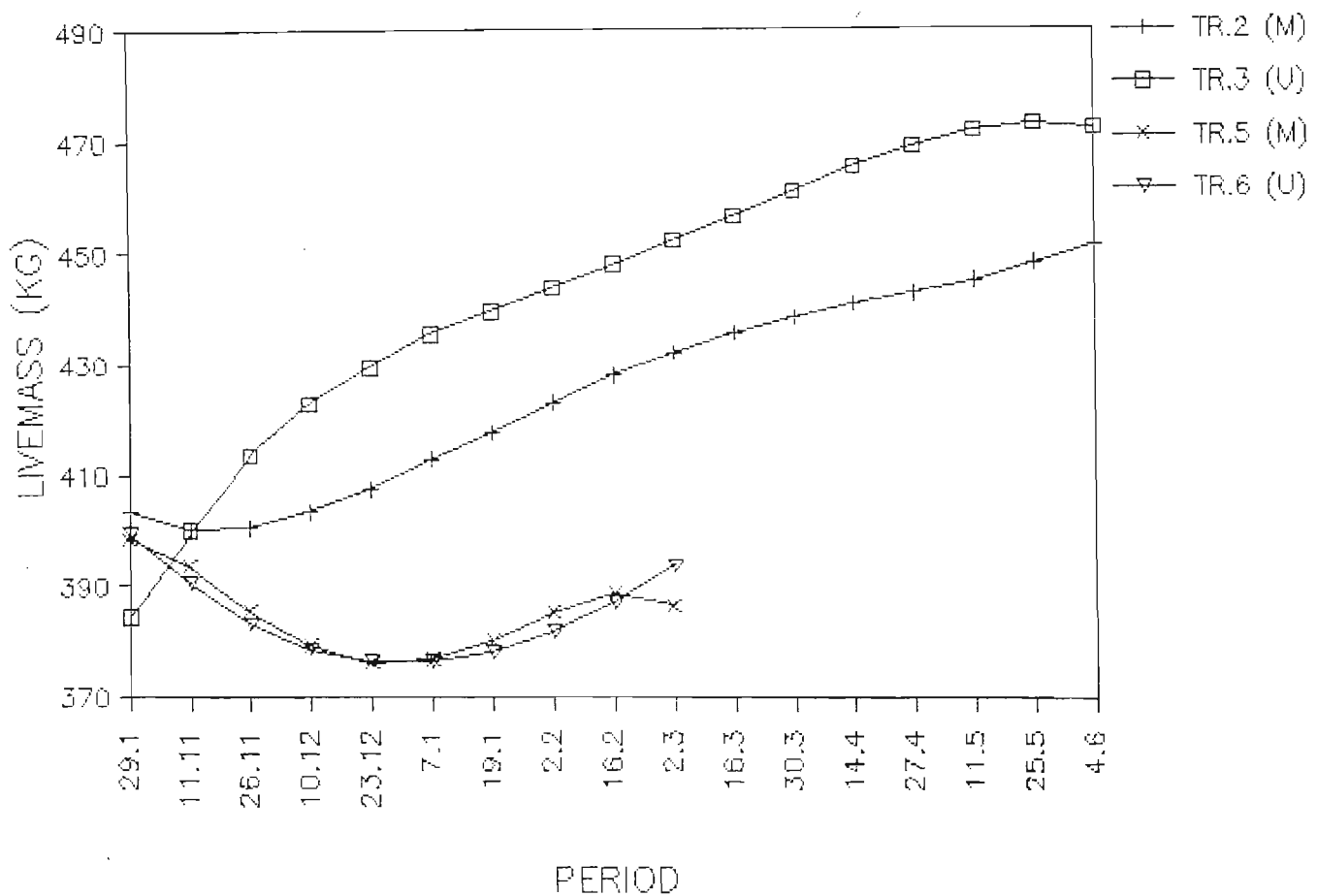


Figure 18d. The mean mass changes of the lactating cows with access to either a mineral or urea lick - 1981/82 season.

respectively. The urea-based lick resulted in small (NS) additional mass gains at the low stocking rate (1,0 cow + calf/ha) but no apparent improvement in mass gain at the high stocking rate (1,67 cows + calves/ha).

The data presented in Tables 42 and 43 validate this statement. In three of the four seasons (1978/79 - 1980/81), the calves in Tr.3 recorded mean maximum masses approximately 10kg higher (NS) than the calves in Tr.2. In terms of ADG to maximum mass (weaning mass), the calves in Tr.3 also had slightly higher growth rates than the calves in Tr.2, but the difference was not statistically significant (Table 35). In contrast, the calves in Tr.6 showed mean maximum masses approximately 10 kg lower than the masses attained by the calves in Tr.5, in three of the four seasons. The ADG's recorded by the calves in Tr.6 were also lower (NS) than the ADG's recorded by the calves in Tr.5.

A detailed analysis of the performance of the calves during the first and second 60 days on veld as well as the ADG's from initial to final mass, are presented in Table 36. During the 1978/79 and 1980/81 seasons, the calves in Tr.3 recorded significantly ($P < 0,01$) higher ADG's over the first 60 days on veld than the calves in Tr.2. This trend did not persist during the second 60 days on veld (Table 36). During the 1981/82 season the calves in Tr.2 recorded slightly higher (NS) ADG's during the first 60 days on veld, than the calves in Tr.3. This trend was, however, reversed during the second 60 days. From day 61 to day 120 the calves in Tr.3 consistently outperformed the calves in Tr.2 (Table 36).

At the high stocking rate (1,67 cows + calves/ha) there was no benefit from the urea lick during the first 120 days on veld. In the first 60 days of the 1979/80 and 1981/82 seasons, the calves in Tr.5 had higher (NS) ADG's than the calves in Tr.6. This trend persisted

Table 35. Mean maximum mass (kg), days to maximum mass, average daily gains (ADG's - kg/day) and the number of grazing days for calves having access to either a mineral (M) or urea (U) lick.

Treatment	Tr. 2	Tr. 3	Tr. 5	Tr. 6
Cows + calves/ha	1,0	1,0	1,67	1,67
Supplement	M	U	M	U
<u>Maximum mass</u>				
1978/79	187,04	197,47	167,77	158,83
1979/80	211,30	220,25	186,39	176,31
1980/81	189,60	204,95	156,54	157,98
1981/82	215,29	216,18	130,62	120,38
	200,81	209,72	160,33	153,38
	$\pm 14,55$	$\pm 10,42$	$\pm 23,32$	$\pm 23,57$
<u>Days to max. mass</u>				
1978/79	196	196	190	182
1979/80	192	197	189	190
1980/81	189	189	182	186
1981/82	218	218	124	124
	198,75	200,00	171,25	170,50
	$\pm 13,15$	$\pm 12,52$	$\pm 31,70$	$\pm 31,18$
<u>ADG to max. mass</u>				
1978/79	0,63	0,69	0,53	0,55
1979/80	0,71	0,75	0,61	0,58
1980/81	0,64	0,72	0,47	0,48
1981/82	0,68	0,68	0,50	0,43
	0,67	0,72	0,54	0,52
	$\pm 0,04$	$\pm 0,03$	$\pm 0,07$	$\pm 0,07$
<u>No. of grazing days</u>				
1978/79	196	196	196	196
1979/80	197	197	197	197
1980/81	189	189	189	189
1981/82	218	218	124	124
	200,00	200,00	176,50	176,50
	$\pm 12,52$	$\pm 12,52$	$\pm 7,86$	$\pm 7,86$

Table 36. The average daily gains (ADG's - kg/day) of calves on summer grazing having access to either a mineral (M) or urea (U) lick.

Treatment	Tr. 2	Tr. 3	Tr. 5	Tr. 6
Cows + calves/ha	1,0	1,0	1,67	1,67
Supplement	M	U	M	U
<u>Day 0 - 60</u>				
1978/79	0,655	0,748	0,621	0,667
1979/80	0,678	0,729	0,674	0,648
1980/81	0,617	0,756	0,538	0,546
1981/82	0,687	0,659	0,477	0,448
	0,660	0,730	0,580	0,580
	$\pm 0,04$	$\pm 0,05$	$\pm 0,09$	$\pm 0,11$
<u>Day 61 - 120</u>				
1978/79	0,719	0,736	0,615	0,599
1979/80	0,804	0,878	0,642	0,662
1980/81	0,792	0,827	0,577	0,619
1981/82	0,813	0,842	0,542	0,418
	0,790	0,820	0,600	0,580
	$\pm 0,05$	$\pm 0,06$	$\pm 0,05$	$\pm 0,11$
<u>Initial - Final Mass</u>				
1978/79	0,638	0,693	0,517	0,499
1979/80	0,691	0,754	0,588	0,559
1980/81	0,644	0,726	0,454	0,474
1981/82	0,688	0,689	0,508	0,434
	0,670	0,720	0,520	0,500
	$\pm 0,03$	$\pm 0,03$	$\pm 0,06$	$\pm 0,06$

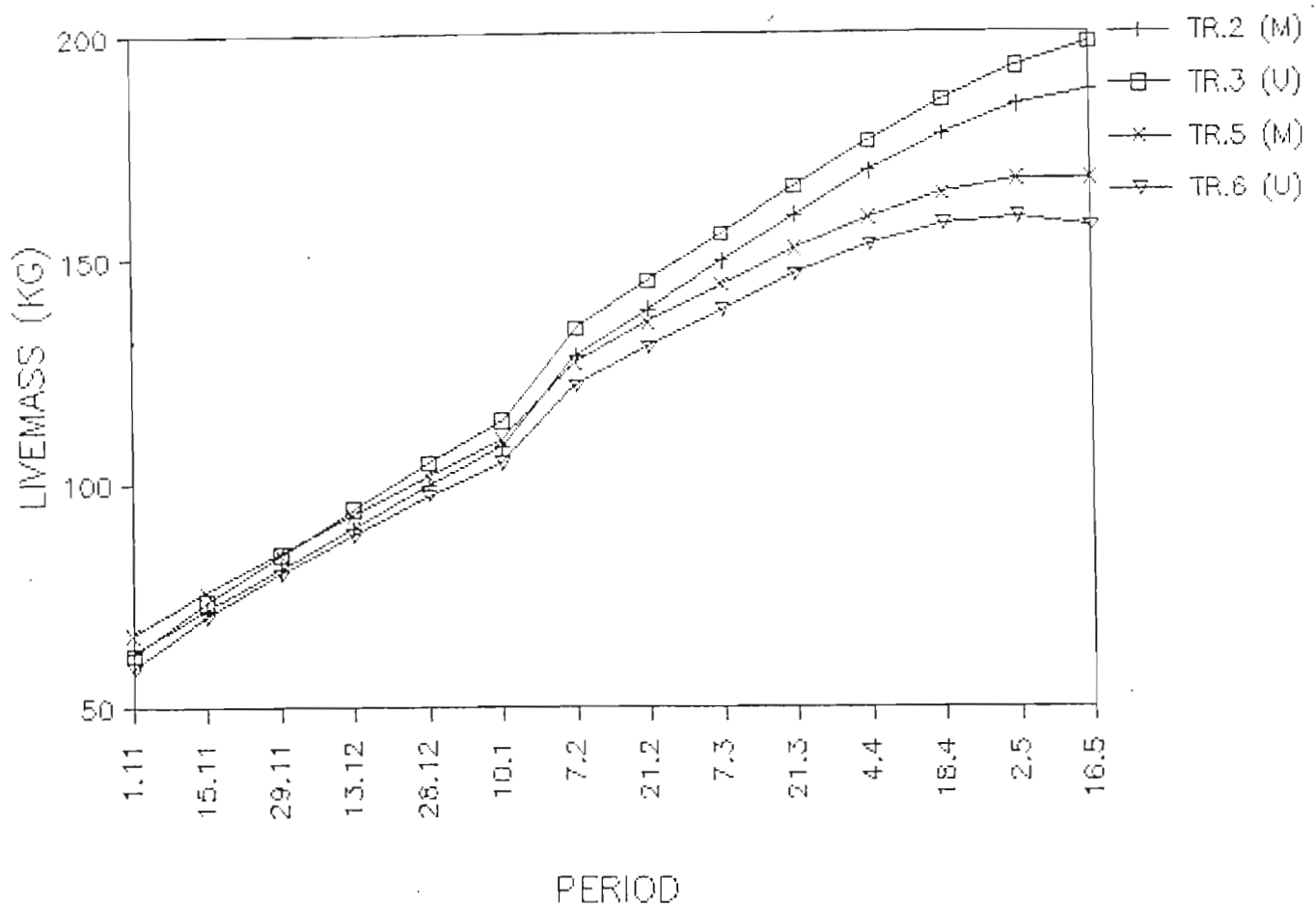


Figure 19a. The mean mass changes of the calves on veld with access to either a mineral or urea lick - 1978/79 season.

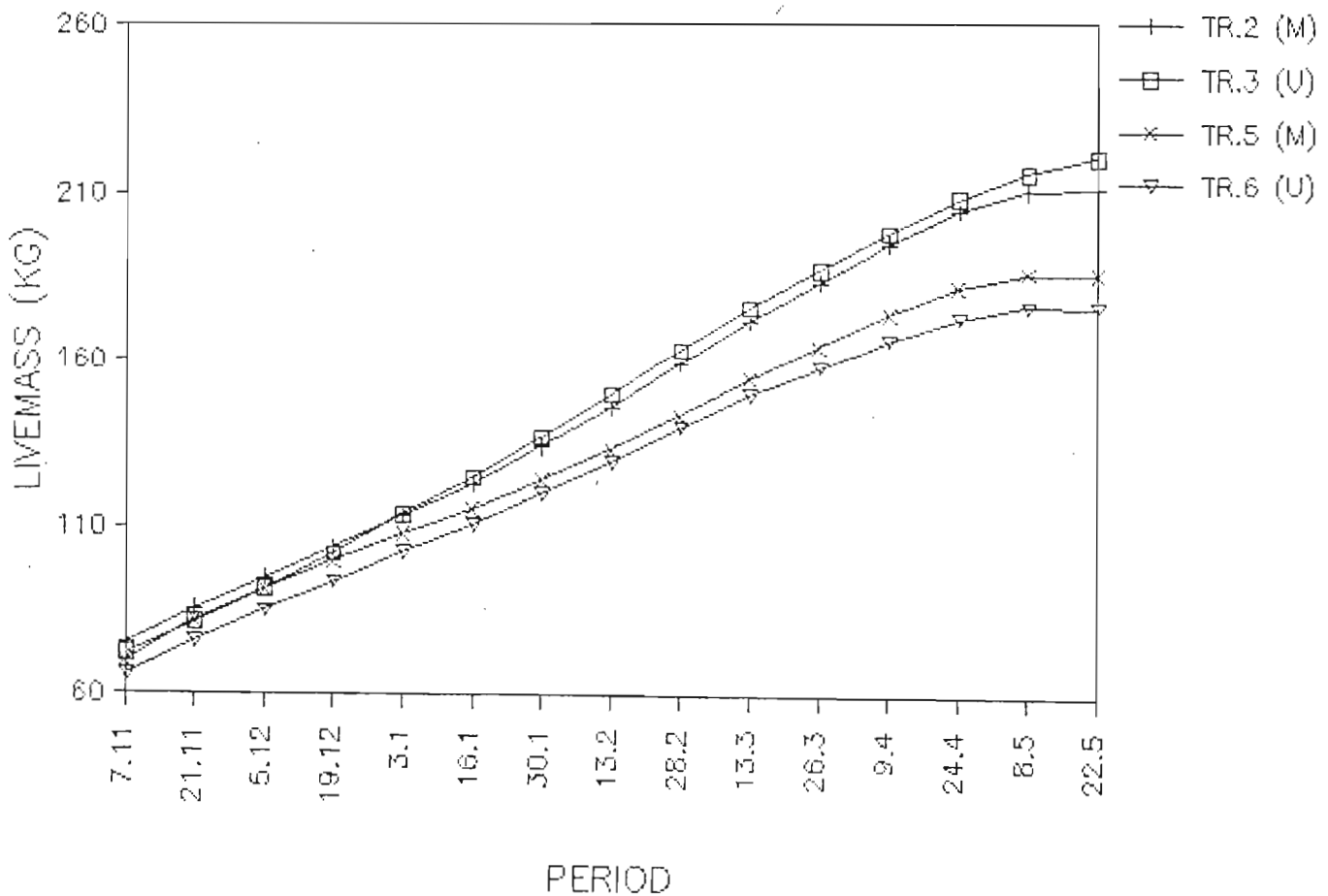


Figure 19b. The mean mass changes of the calves on veld with access to either a mineral or urea lick - 1979/80 season.

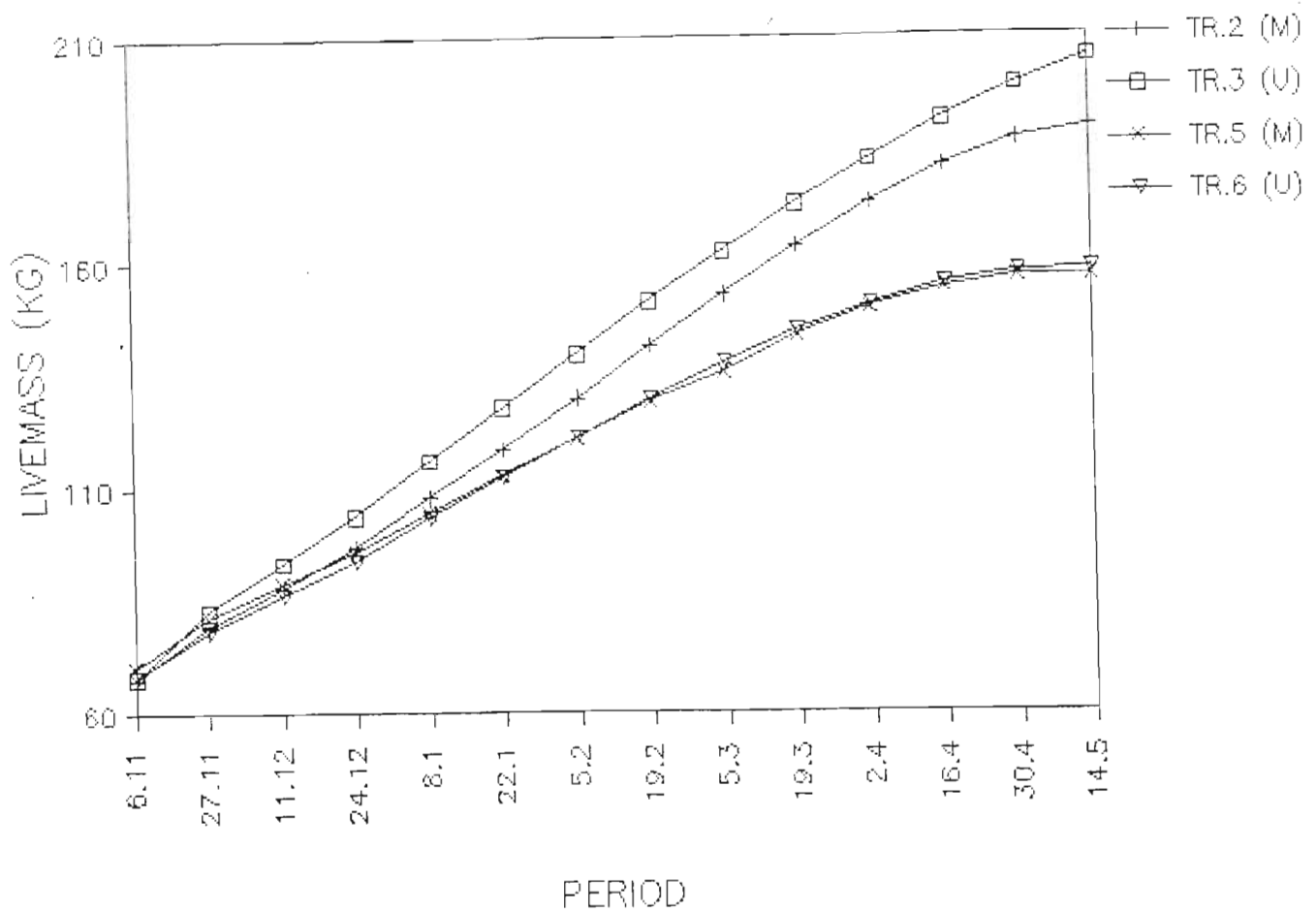


Figure 19c. The mean mass changes of the calves on veld with access to either a mineral or urea lick - 1980/81 season.

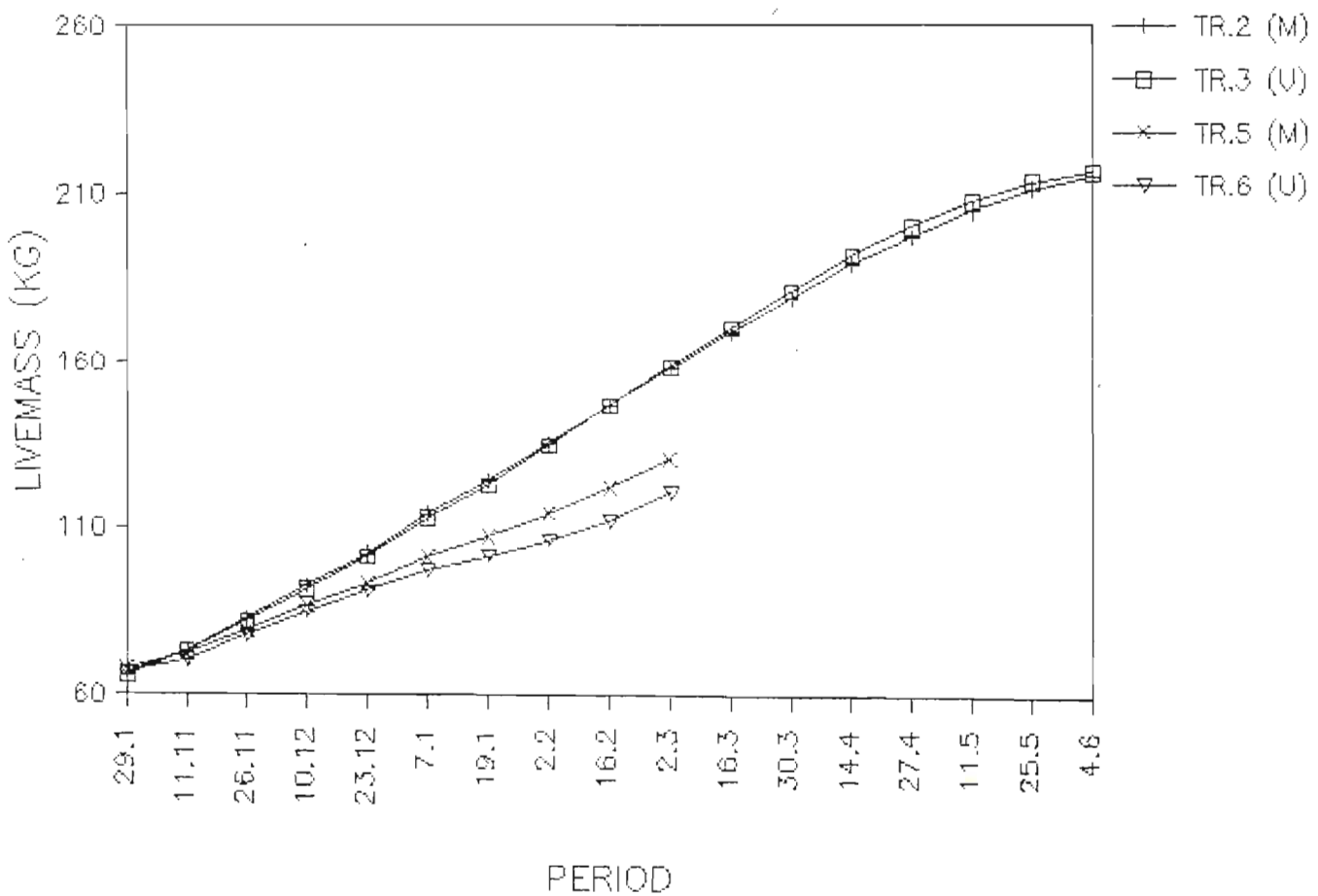


Figure 19d. The mean mass changes of the calves on veld with access to either a mineral or urea lick - 1981/82 season.

during the second 60 days on veld.

The ADG's reflecting the overall performance on veld indicate that, in three of the four seasons, the calves in Tr.5 had higher (NS) growth rates than the calves in Tr.6. There was therefore no benefit from supplying a urea-based lick to the calves at the high stocking rate.

Veld quality and composition

Crude protein

The mean crude protein (CP) content of the veld for each of the four seasons is presented in Figures 20a, 20b, 20c and 20d. A summary of the trend in CP quality over the four seasons is shown in Figure 21. Unfortunately, sampling problems were experienced during the 1980/81 season. As a result, CP changes during certain periods only, were recorded. These stages included the mating season, the period from the start of the grazing season to mid-February, and that from mid-February to the end of the grazing season. These data are nevertheless presented in Figure 19c.

The change in monthly CP values within each treatment, over the four seasons, is of considerable interest. The data shown in Figure 20a indicate the relatively small difference (approximately 1%) in crude protein between the different treatments for the first six months of grazing. The quality of the grass declined sharply during the last month of grazing in Tr.1 and Tr.2. It should be noted that, prior to the commencement of the experiment, the camps allocated to each treatment had not been subjected to any experimental regime.

The relatively low CP values recorded at the beginning of the 1979/80 season probably result from the poor rainfall recorded during September, October and November (Table 26). However, the quality of the

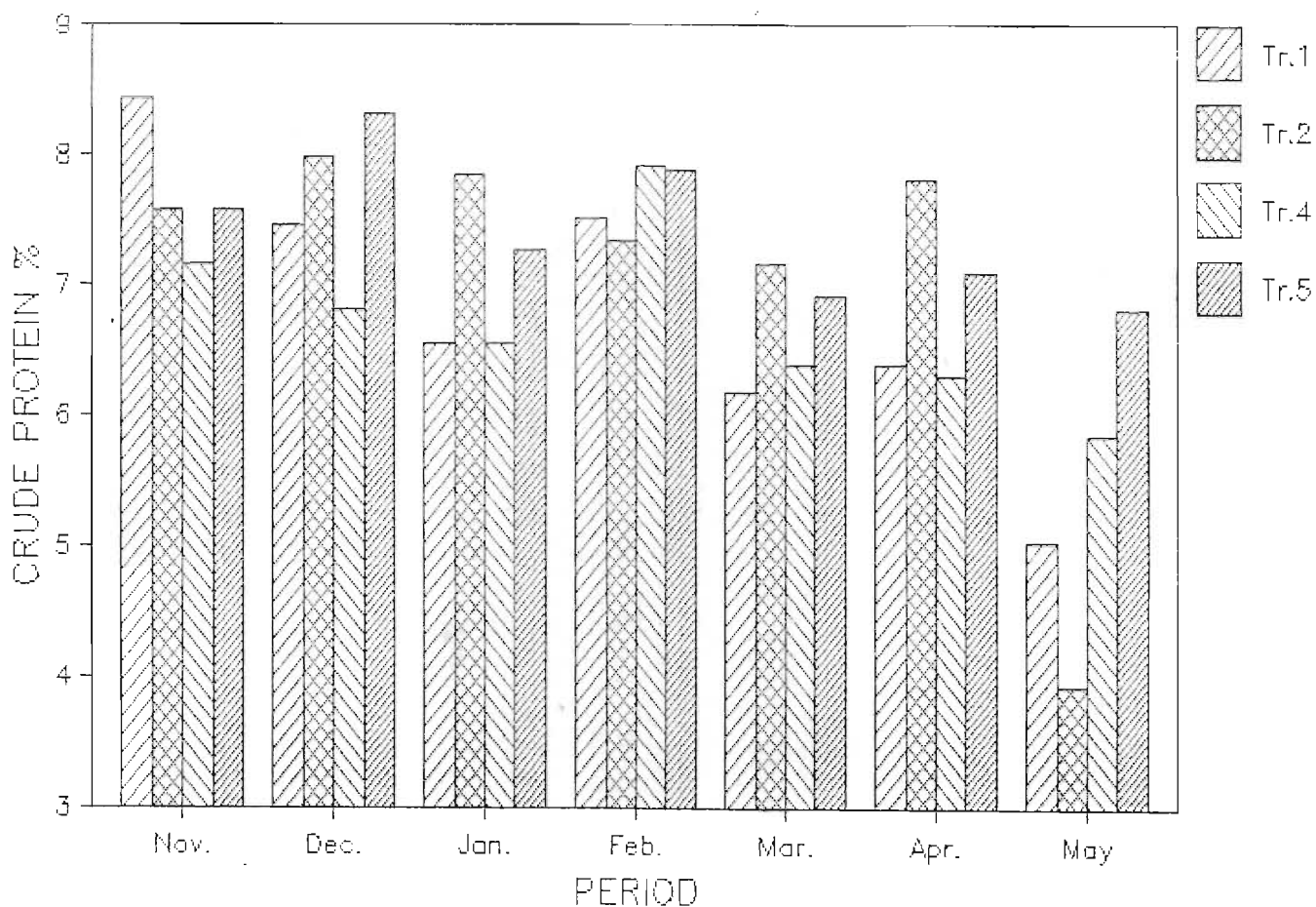


Figure 20a. The seasonal crude protein changes at the four stocking rates recorded during the 1978/79 season.

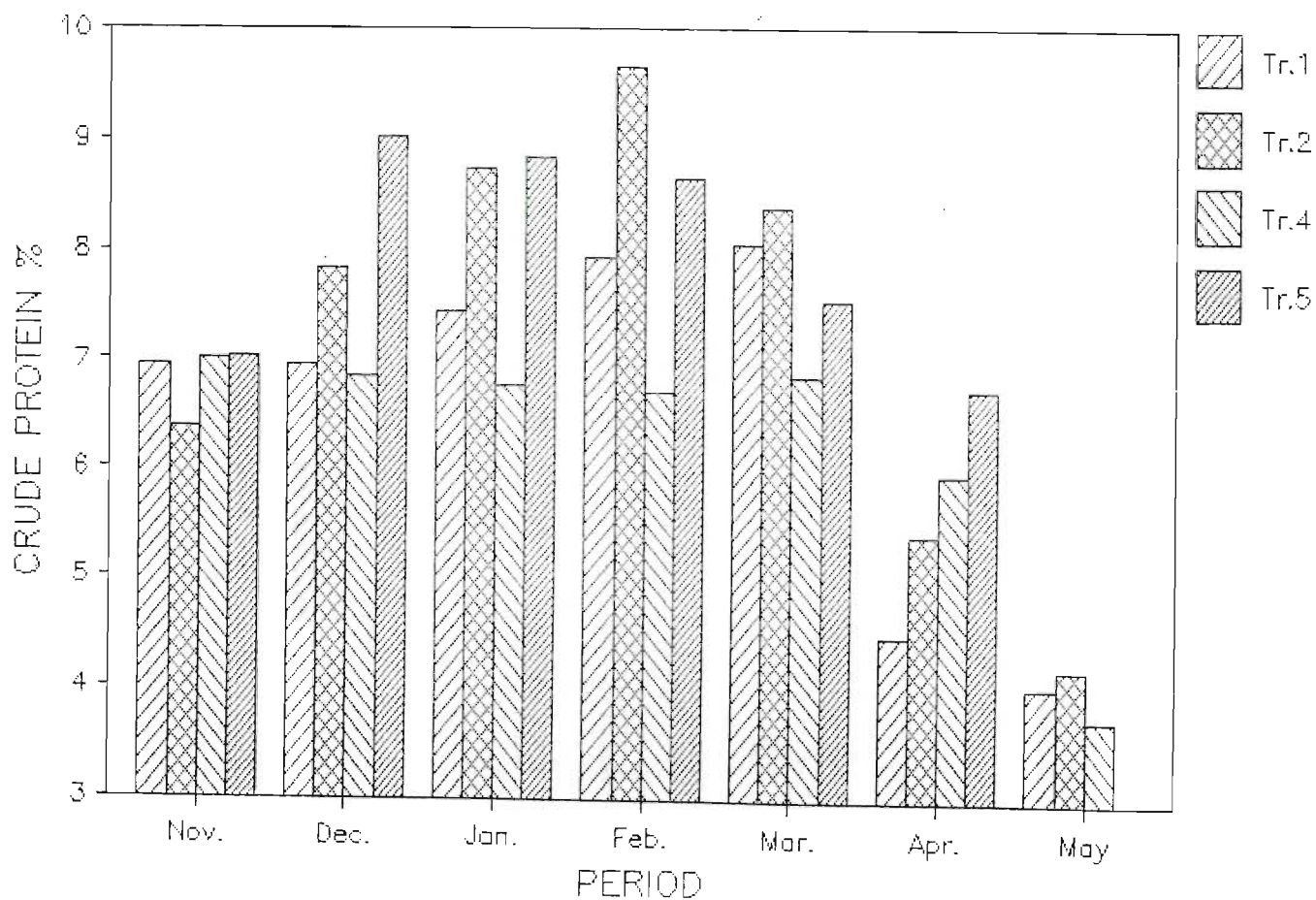


Figure 20b. The seasonal crude protein changes at the four stocking rates recorded during the 1980/81 season.

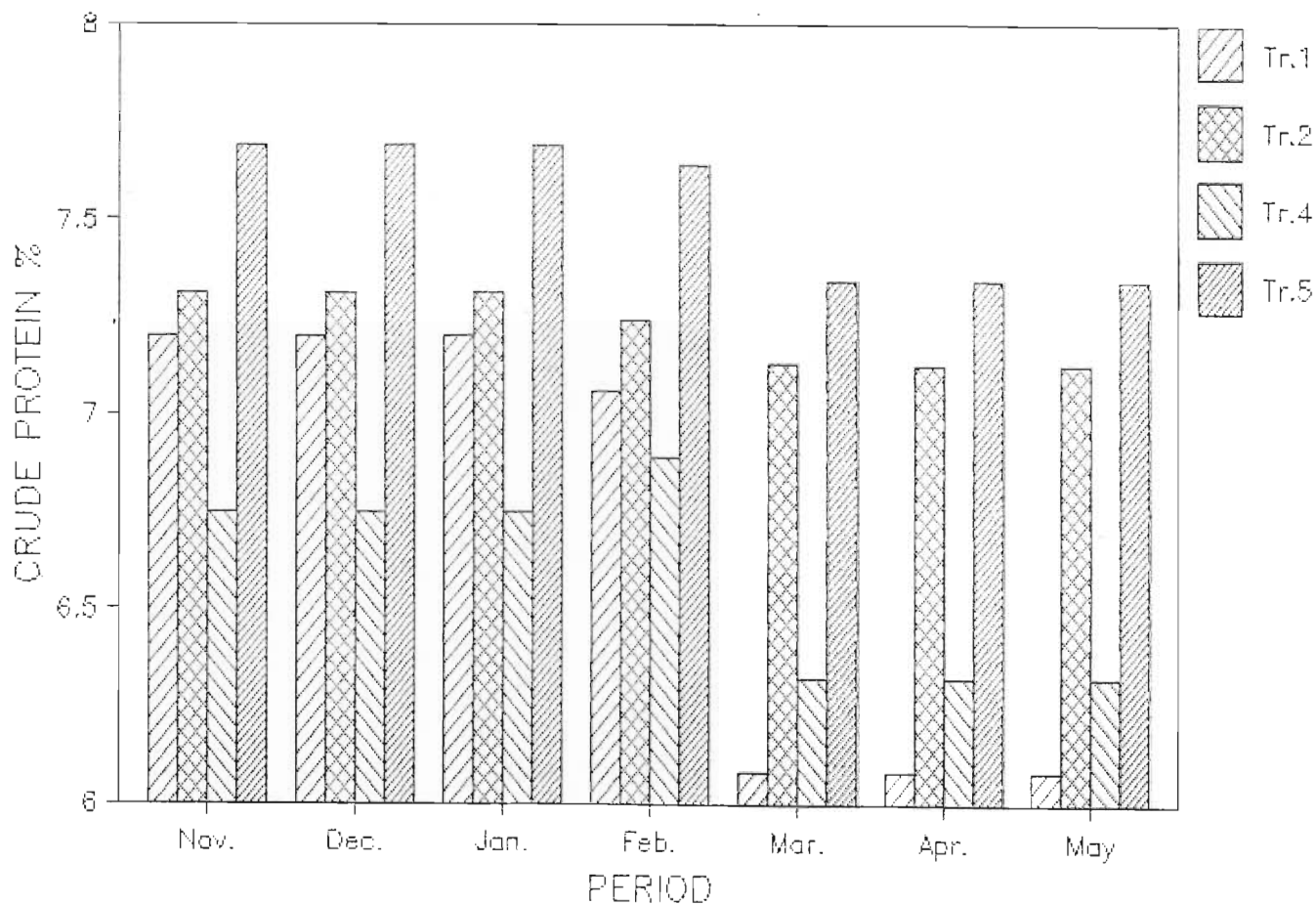


Figure 20c. The seasonal crude protein changes at the four stocking rates recorded during the 1981/82 season.

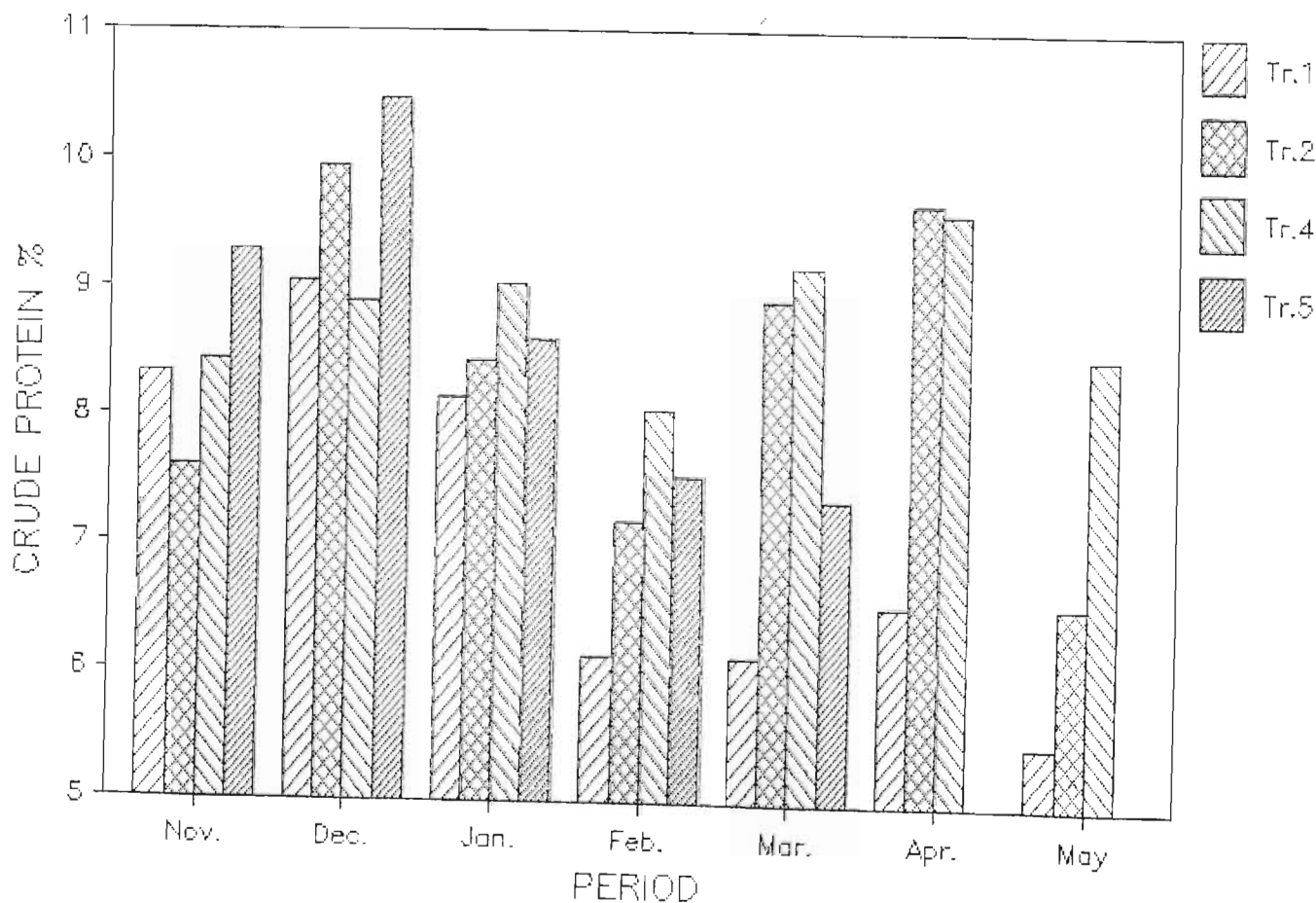


Figure 20d. The seasonal crude protein changes at the four stocking rates recorded during the 1981/82 season.

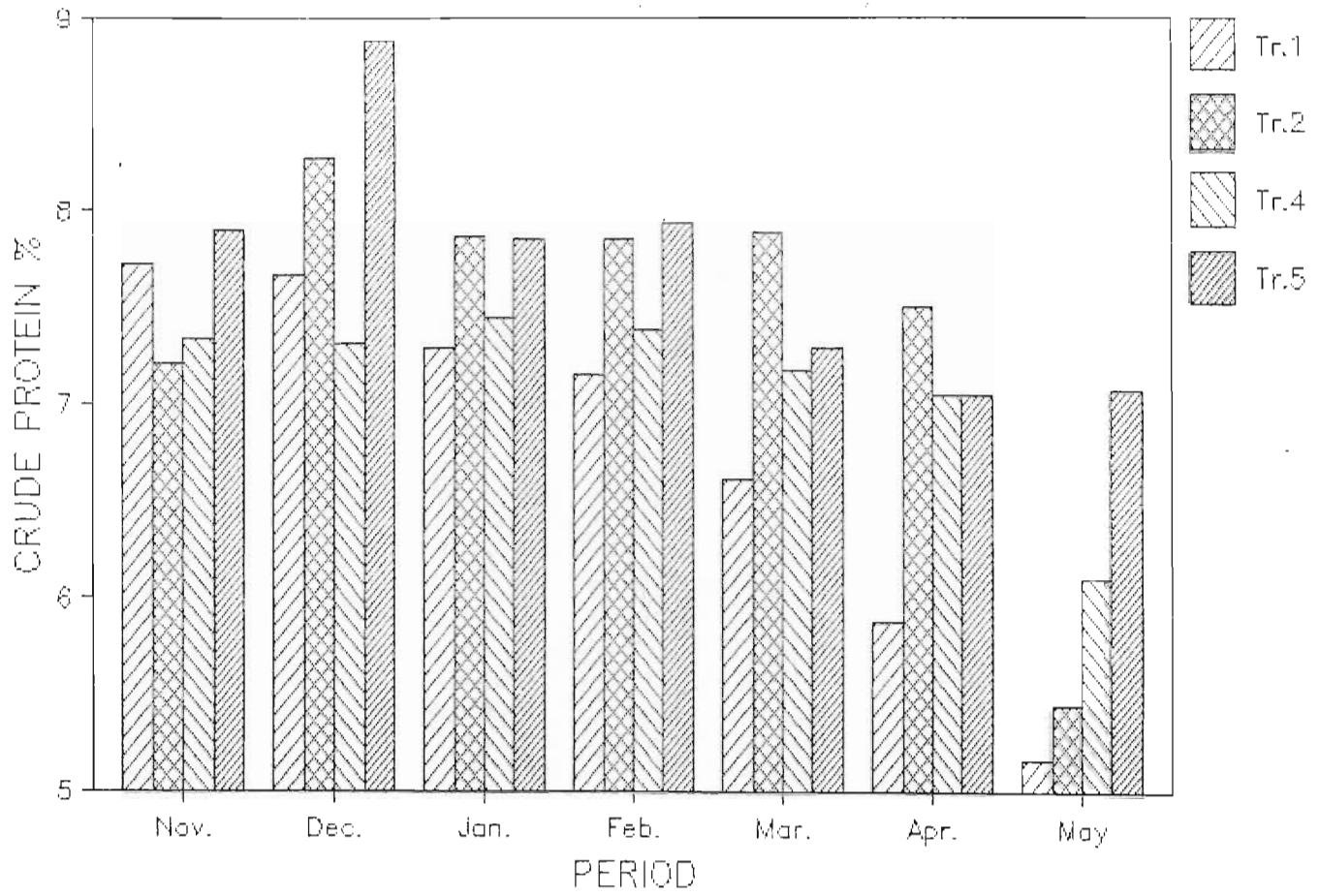


Figure 21. The mean seasonal crude protein content of the veld for the periods 1978/79 to 1981/82.

veld recovered slightly after good rainfall in December.

By the end of the fourth season, differences in CP between the low and high stocking rates were clearly evident (Figure 20d). During the first three months of grazing in the 1981/82 season, the differences between the treatments in terms of CP were relatively small. However, from February onwards, the CP values recorded in Tr.1 were consistently lower than the values recorded between November and January. In contrast, the figures recorded in Tr.2, to some extent, and Tr.4 and Tr.5 in particular, were considerably higher than the CP values recorded in Tr.1. The mean CP figures, over the four seasons, reflected in Figure 21 indicate a steady decline in quality in Tr.1 from March onwards. Generally, all the treatments, except Tr.1, maintained a reasonably high CP content through to April.

Veld composition

The results of the veld composition assessments are shown in Table 37. The composition of the veld in the low to moderately stocked treatments (Tr.1, Tr.2 and Tr.3) changed relatively little over the period from 1978/79 to 1981/82. The 50% reduction in the proportion of Decreasers in Tr.1 (within two years) is regarded as unrealistic. No sound explanation can be offered for this trend. It is possible that the observers differed in their interpretation of the species category between the 1978 and 1980 seasons. However, this option would appear to be unlikely. A second possibility is that the camps used to assess the species composition were not only leniently defoliated, but also had a full season's rest between 1978 and 1980, resulting in the increase in the proportion of Increaser I's. However, the proportion of Decreasers in Tr.1 remained stable during the following two seasons. The consistent proportion of Decreasers with a slight increase in the proportion of Increaser II's and concomitant decrease of Increaser I's

in Tr.2 and Tr.3 indicates over-utilization of the veld during the 1978/79 - 1981/82 grazing cycle.

Data from only two seasons were collected for Tr.4 (1,25 cows + calves/ha). The reduction in the proportion of Decreasers and Increaser III's and the increase in the proportion of Increaser II's indicate over-utilization.

The veld in Tr.5 and Tr.6 (1,67 cows + calves/ha) showed a rapid decline in composition score. The proportion of Increaser II's increased by approximately 100%, whilst the proportion of Increaser I's, Increaser III's and Decreasers declined by about 70%. These figures indicate marked over-utilization of the veld.

The results of herbage production estimates for the 1981/82 grazing season, for each treatment, are presented in Table 38. The differences in herbage production between the low (0,83 cows + calves/ha) and moderate (1,0 cow + calf/ha), and high (1,25 cows + calves/ha) and very high (1,67 cows + calves/ha) stocking rates for the 1981/82 season were highly significant ($P < 0,01$). These data indicate that even though a recognised management system was applied, stocking rates in excess of 1,0 cow + calf/ha resulted in a reduction of herbage in a relatively short time. The composition of the veld in Tr.4 remained much the same as that in Tr.1 and Tr.2, but dry matter production was about 1000 kg/ha lower from these treatments during the 1981/82 season. This suggests that the lower herbage production was due to reduced plant vigour.

In Tr.5 and Tr.6, both herbage yield and veld composition were affected to such an extent that, by the end of the four-year cycle, the grazing season was reduced to four months. During the same period, grazing continued for another three months in Tr.1, Tr.2 and Tr.3.

Poor animal performance and the deterioration in veld condition

Table 37. Veld composition changes during the 1978, 1980 and 1982 seasons,

Treatment	Year	Percentage contribution of each species category to veld composition				Composition %
		Decreaser*	Increaser I*	Increaser II*	Increaser III*	
[†] Bench		53	28	12	7	100
Tr. 1	1978	27	37	18	18	65
0,83 LSU/ha	1980	12	48	18	22	53
	1982	14	46	23	17	56
Tr. 2	1978	27	42	12	18	67
1,0 LSU/ha	1980	19	45	13	22	59
	1982	21	38	20	21	64
Tr. 3	1978	16	28	47	8	51
1,0 LSU/ha	1980	16	34	38	12	48
+ urea	1982	17	23	53	7	47
Tr. 4	1978	-	-	-	-	-
1,25 LSU/ha	1980	29	40	15	15	65
	1982	18	44	27	10	59
Tr. 5	1978	19	23	45	13	59
1,67 LSU/ha	1980	7	21	66	6	37
	1982	8	8	81	3	25
Tr. 6	1978	26	25	42	8	64
1,67 LSU/ha	1980	6	13	76	5	29
+ urea	1982	7	7	83	3	23

* As defined by Tainton, Edwards & Mentis (1980)

[†]Composition of benchmark site is that established by Foran *et al.* (1978)

1 LSU = cow + calf

Table 38. Herbage production recorded in the rest camps at the end of the first four-year grazing cycle.

Treatment	Tr. 1	Tr. 2	Tr. 3	Tr. 4	Tr. 5	Tr. 6
Cows + calves/ha	0,83	1,0	1,0	1,25	1,67	1,67
Lick	M	M	U	M	M	U
Herbage production (kg DM/ha)	2500 ^{a*}	2918 ^a	2348 ^a	1691 ^b	515 ^c	666 ^c

* Treatments having different superscripts differ significantly ($P < 0,01$)

resulted in the termination of Tr.5 and Tr.6 during the 1981/82 season.

Second phase (1982/83 - 1986/87)

During the second phase of the experiment only three stocking rates were applied, viz. 0,83 cows + calves/ha (Tr.1), 1,0 cow + calf/ha (Tr. 2) and 1,25 cows + calves/ha (Tr.4). As in the first phase of the experiment, the 1,0 cow + calf/ha treatment was duplicated to compare urea and mineral licks (Table 24).

Animal performance

Mass changes - lactating cows

The mass changes of the lactating mature cows during the five seasons are presented in Figures 22a, 22b, 22c, 22d and 22e respectively. The fitted means were derived from the quartic equations shown in Appendix 4.

The mean (five seasons) maximum mass attained by the cows in Tr.1, Tr.2 and Tr.4 varied according to stocking rate and by approximately 10 kg per treatment (Table 39). During the first 60 days of the 1984/85 season and, in particular, the 1986/87 season, growth rates were lower (Figures 22a - 22e), than during the other three seasons. This poor cow performance can largely be attributed to environmental factors. The quality (CP) of the grass in all four treatments during December 1984 and January 1985 was lower than the mean CP's recorded during November 1984 and February 1985 (Figure 34c). Whilst CP analyses of the herbage samples ranged between 8% (Tr.2) and 10,5% (Tr.4), herbage yield samples indicated that the quantity of grass available was not as abundant as that observed in previous seasons. The reduction in herbage

was largely a reflection of the poor rainfall recorded during November and December, 1984 (Table 26).

In contrast, the performance of the cows during the 1986/87 season might have been affected by below average effective ambient temperatures resulting from the above average wind and rainfall recorded during December 1986. Whilst these data might illustrate the effect of climatic influences on animal performance, they were apparently of little economic consequence. Neither the length of the grazing season, nor the performance of the calves were significantly affected by these apparently adverse conditions. It is likely that a certain degree of compensatory growth followed these periods of mass loss, thereby resulting in reasonable animal performance when viewed over the entire season.

After attaining maximum mass, the cows, irrespective of season or treatment, lost mass until the termination of the treatment. Treatments were terminated on the basis of body condition. Consequently at the cessation of grazing, cows were either at a mass similar to, or lower than, their mass at the start of the grazing season (Figures 22a - 22e). As the majority of the cows were six to seven months pregnant at the end of the grazing season, the actual body mass losses were greater than those indicated in Figures 22a - 22e. The cows were therefore under considerable stress by the end of the grazing season.

Condition score changes - lactating cows

The condition score changes for the lactating cows during the five seasons are shown in Figures 23a - 23e respectively. The means were derived from the quartic equations presented in Appendix 5.

The cows generally maintained condition for the first 170 - 190 days on veld. The condition scores then declined to a point where it was necessary to wean the calves (Figures 23a - 23e). The cows in Tr. 4

Table 39. Mean maximum mass, days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for mature lactating cows.

Treatment		Tr. 1	Tr. 2	Tr. 4
Cows + calves/ha		0,83	1,0	1,25
<u>Maximum mass</u>				
1982/83	(kg)	474,58	448,81	439,29
1983/84	(kg)	506,07	490,73	476,09
1984/85	(kg)	469,99	500,21	471,63
1985/86	(kg)	499,00	489,96	482,98
1986/87	(kg)	503,71	476,39	487,79
		490,67 ± 17,05	481,22 ± 20,01	471,56 ± 19,08
<u>Days to max. mass</u>				
1982/83		169	149	105
1983/84		129	157	133
1984/85		149	163	147
1985/86		143	132	131
1986/87		155	0	0
		149,0 ± 14,76	120,20 ± 68,19	103,20 ± 59,65
<u>ADG to max. mass</u>				
1982/83	(kg)	0,29	0,18	0,14
1983/84	(kg)	0,37	0,31	0,15
1984/85	(kg)	0,11	0,13	0,05
1985/86	(kg)	0,29	0,30	0,11
1986/87	(kg)	0,07	0	0
		0,23 ± 0,13	0,18 ± 0,13	0,09 ± 0,06
<u>No. of grazing days</u>				
1982/83		236	196	179
1983/84		231	224	196
1984/85		237	223	188
1985/86		237	237	216
1986/87		237	211	204
		235,6 ± 2,61	217,6 ± 16,55	196,6 ± 14,28

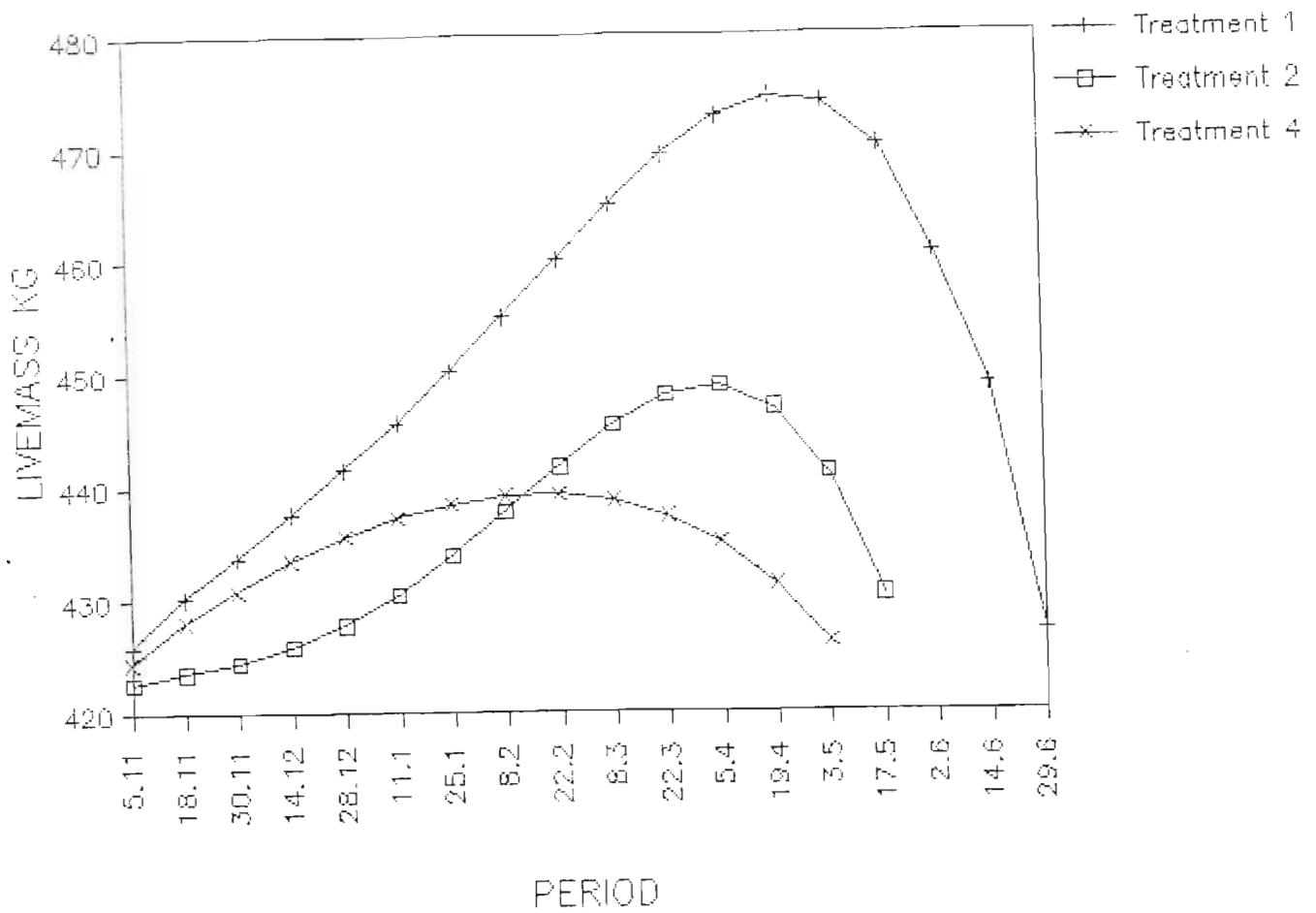


Figure 22a. The mean mass changes on veld for the lactating cows during the 1982/83 season.

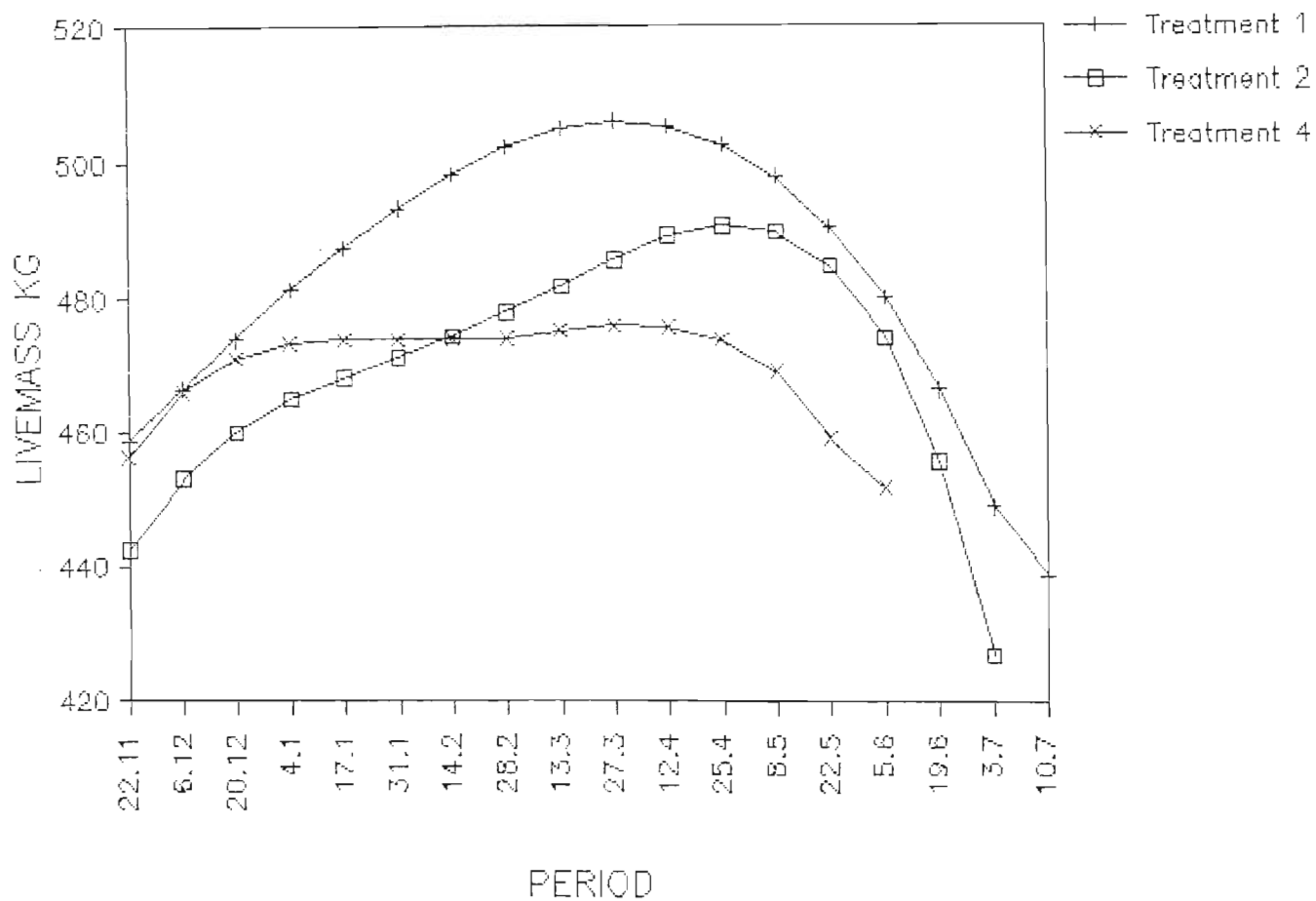


Figure 22b. The mean mass changes on veld for the lactating cows during the 1983/84 season.

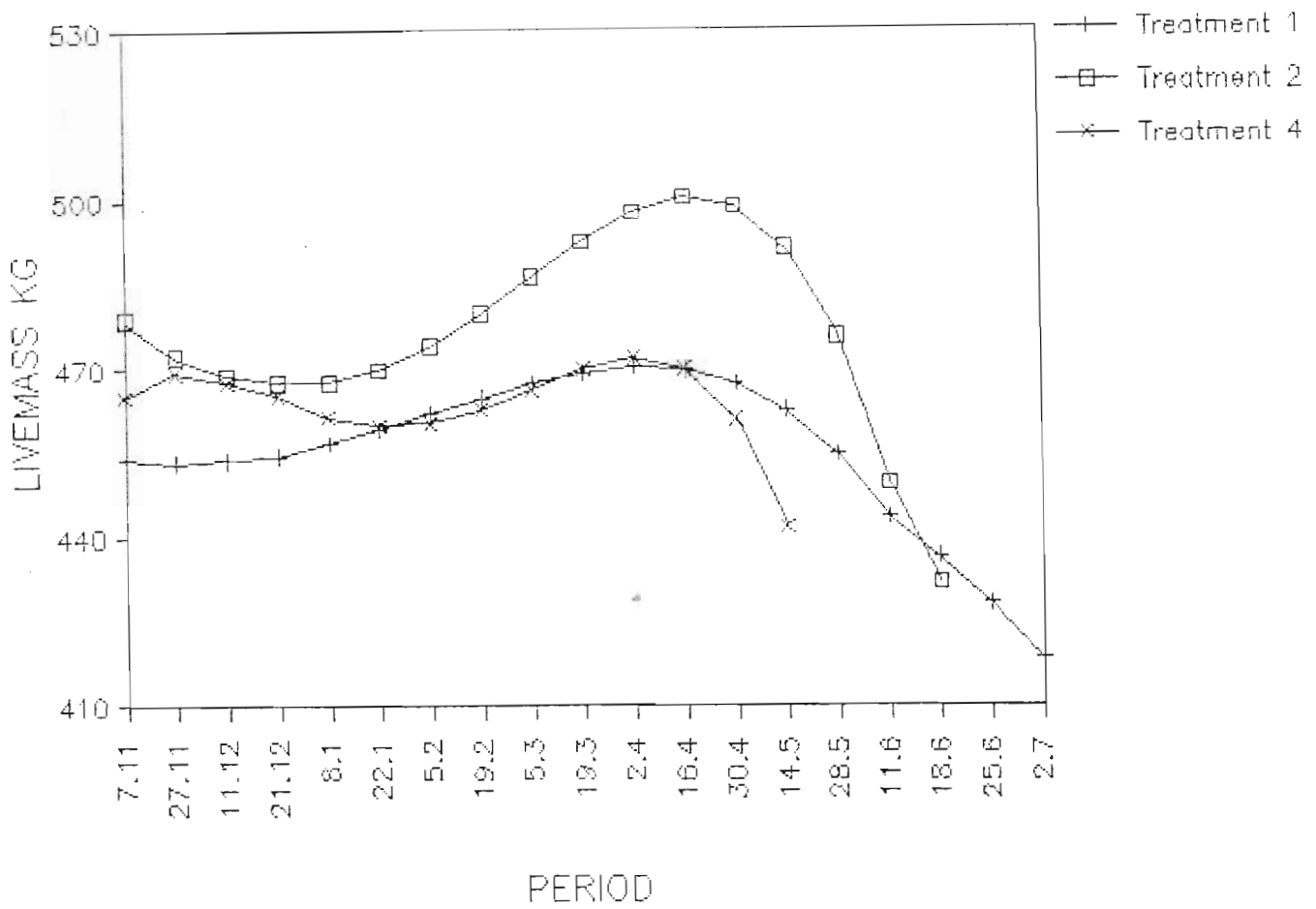


Figure 22c. The mean mass changes on veld for the lactating cows during the 1984/85 season.

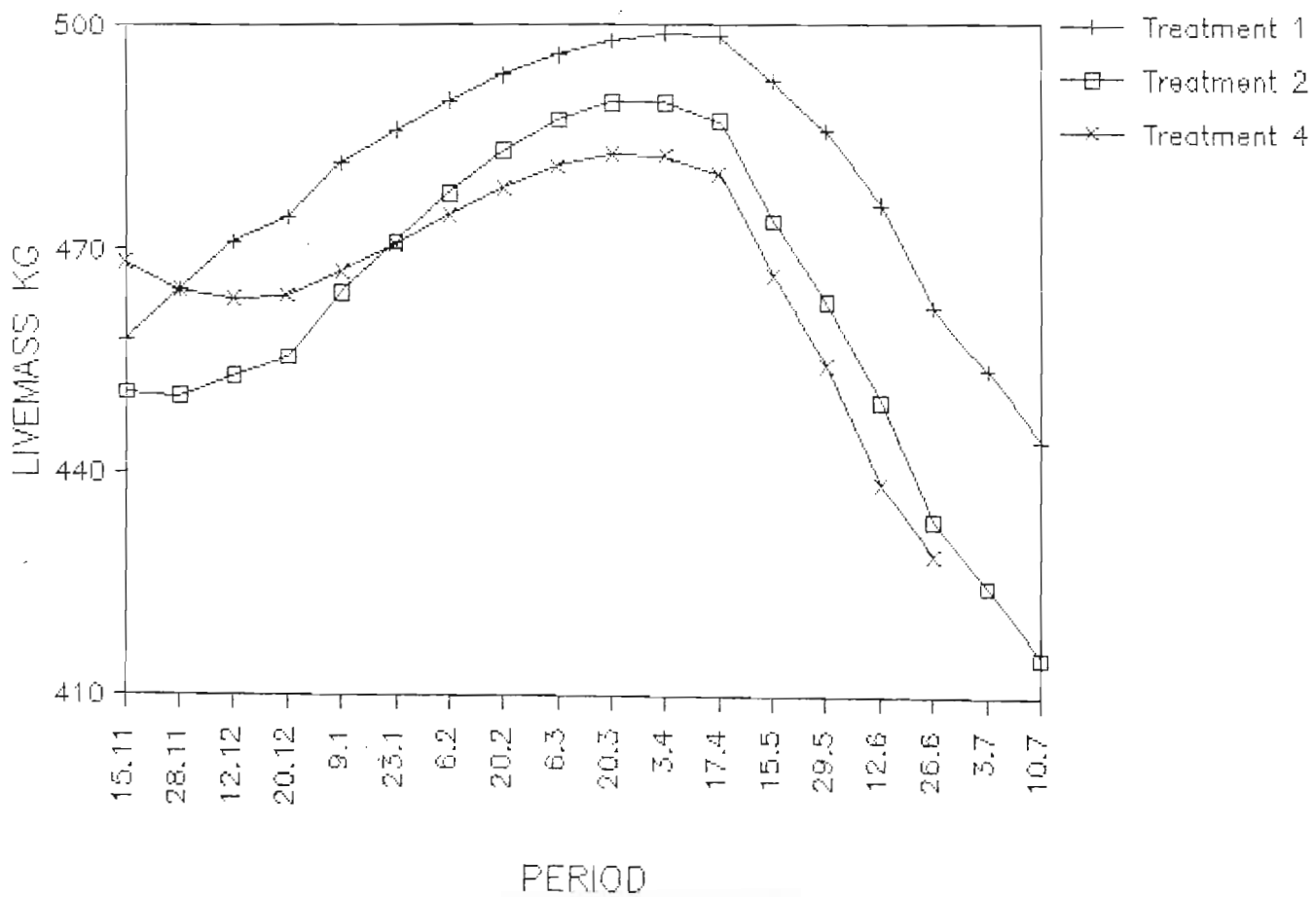


Figure 22d. The mean mass changes on veld for the lactating cows during the 1985/86 season.

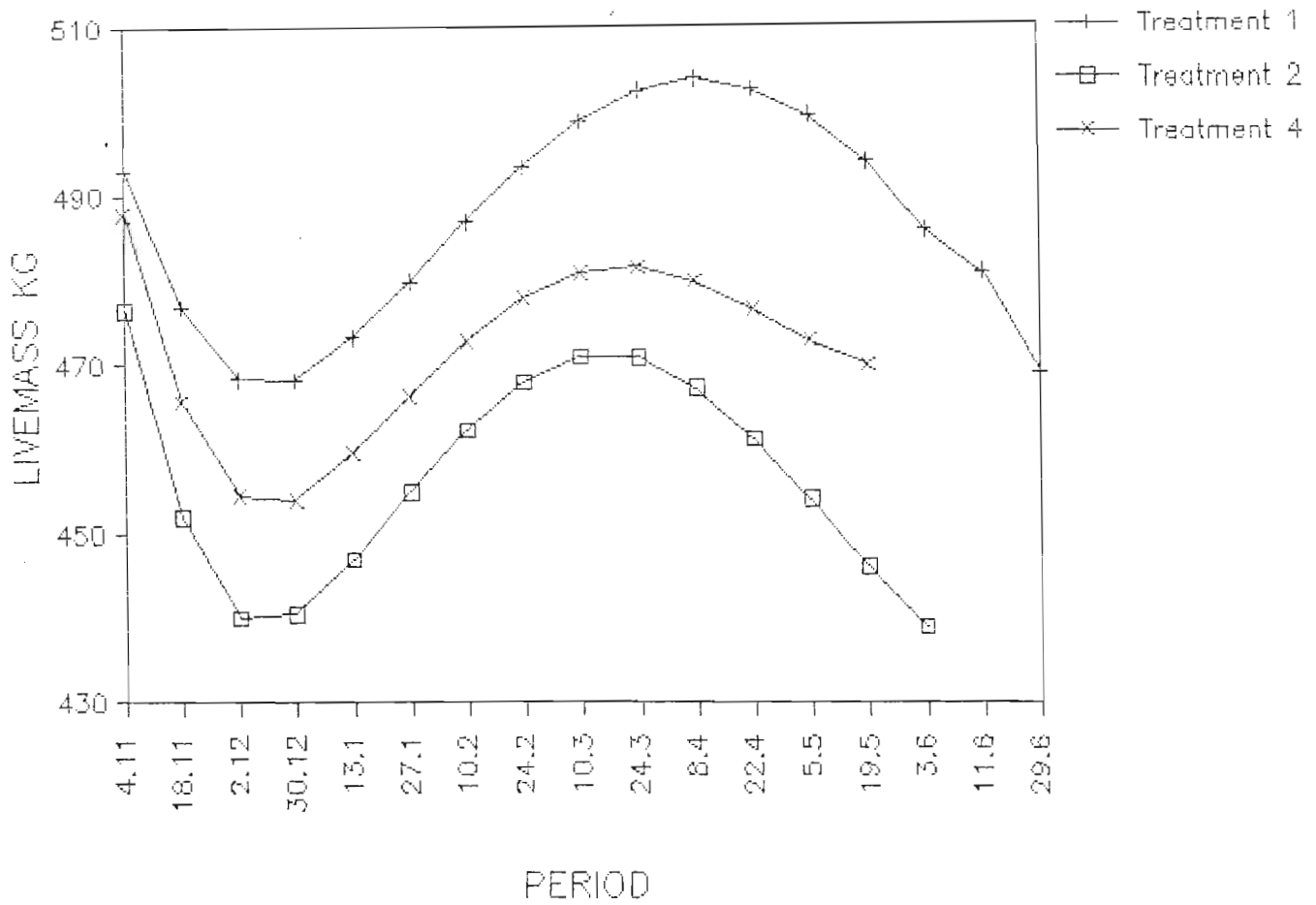


Figure 22e. The mean mass changes on veld for the lactating cows during the 1986/87 season.

were obviously stressed as their condition scores declined from the start of the season (Figure 23a - 23e). The sharp decline in condition score in Tr.1 and Tr.2 was generally recorded 7 - 14 days after a decline in mass (Figures 22a - 22e). The increase in cow mass recorded by the cows in all three treatments during the early part of the season was not associated with significant increases in condition score.

The trends in condition score of the cows in all three treatments during the 1982/83 season were atypical, in comparison with the trends evident in the other four seasons. The condition scores of all the cows declined during the first 60 days of the 1982/83 season. This decline was then followed by a period of stable condition scores with the expected loss of body condition occurring towards the end of the season (Figure 23a). Loss in body condition at the beginning of the season was associated with small increases in body mass. These results appear to be contradictory and are difficult to explain. It is possible that, although sufficient herbage was available to satisfy the animal's dry matter requirements, this herbage was of relatively poor quality. This theory is supported by the results of the crude protein analyses (Figure 34a) which indicate that the quality (CP) of the grass during November and December 1982 was 1,5 - 2% lower than the mean figures recorded during the same period in subsequent seasons. The lower CP figures were probably a consequence of the low rainfall recorded during November and December (Table 26). Whilst the animals could possibly satisfy their total dry matter intake requirements, they were not able to meet their nutrient requirements for lactation and were therefore forced to mobilize significant amounts of body fat as an energy source.

The results indicate that the cows were placed under considerable pressure when weaning was based on a mean condition score of 2,0 for the dams. However, this was the intention as it provided the opportunity to select an optimum weaning time based on a full range of

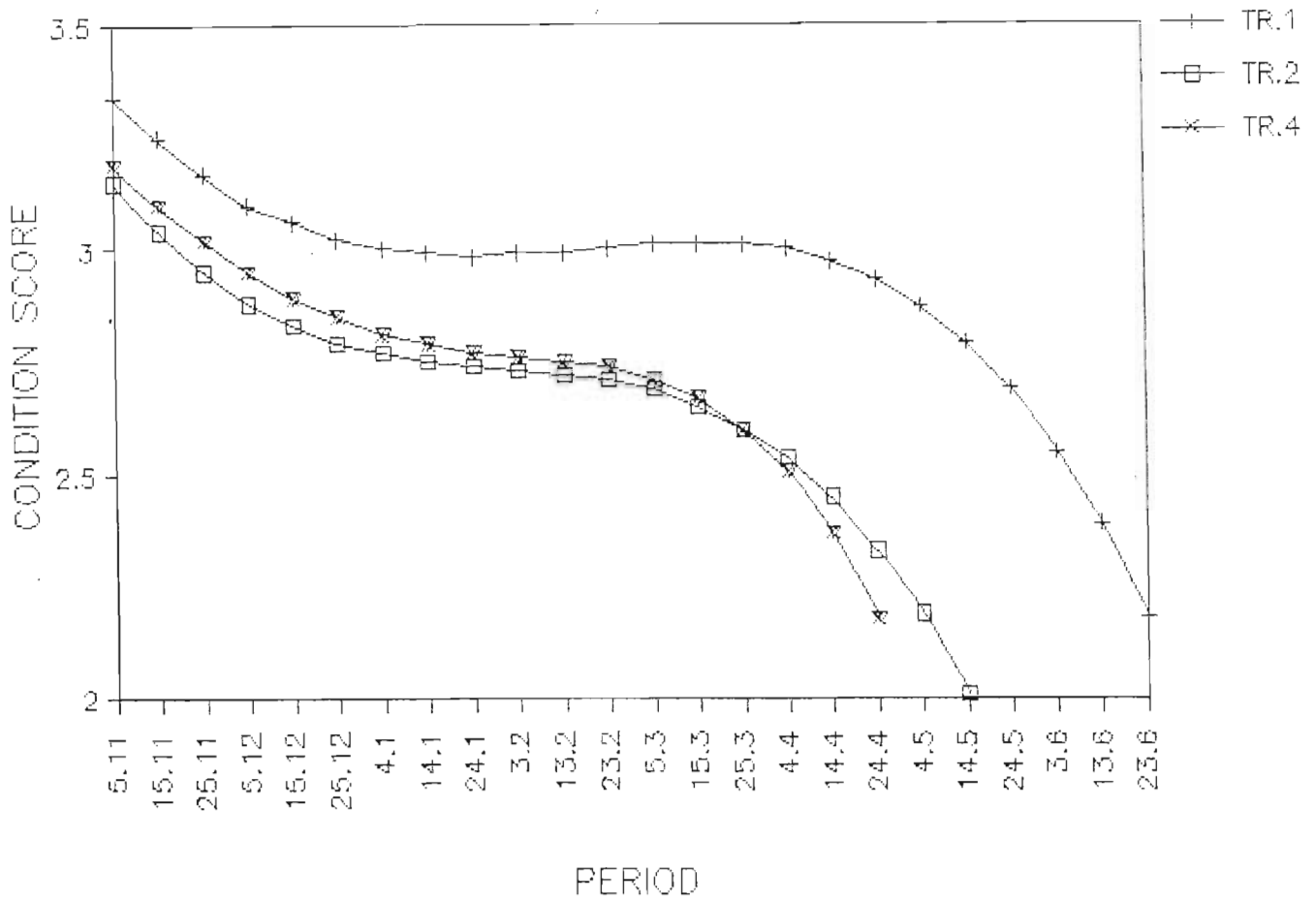


Figure 23a. The mean condition score changes for the lactating cows during the 1982/83 season.

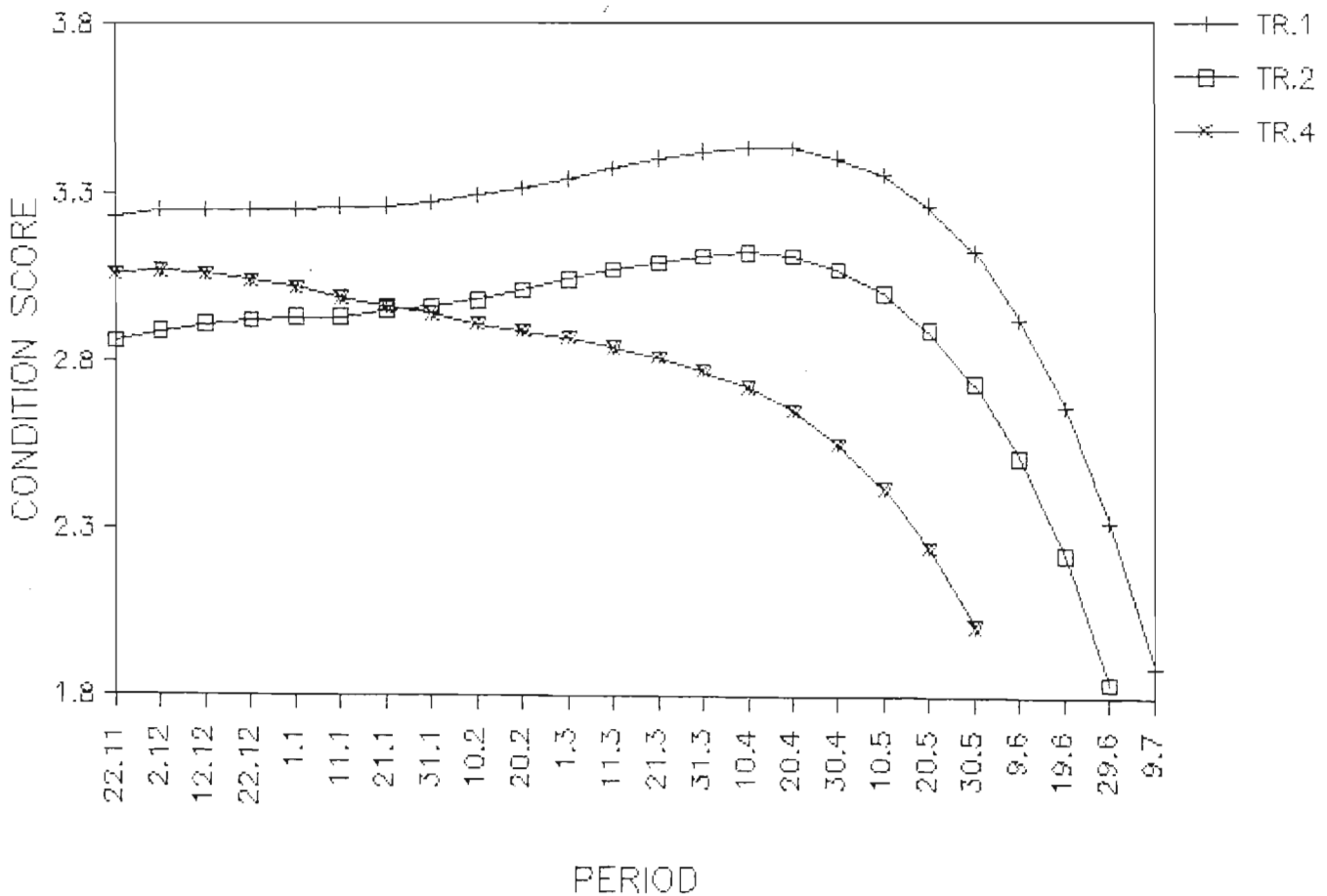


Figure 23b. The mean condition score changes for the lactating cows during the 1983/84 season.

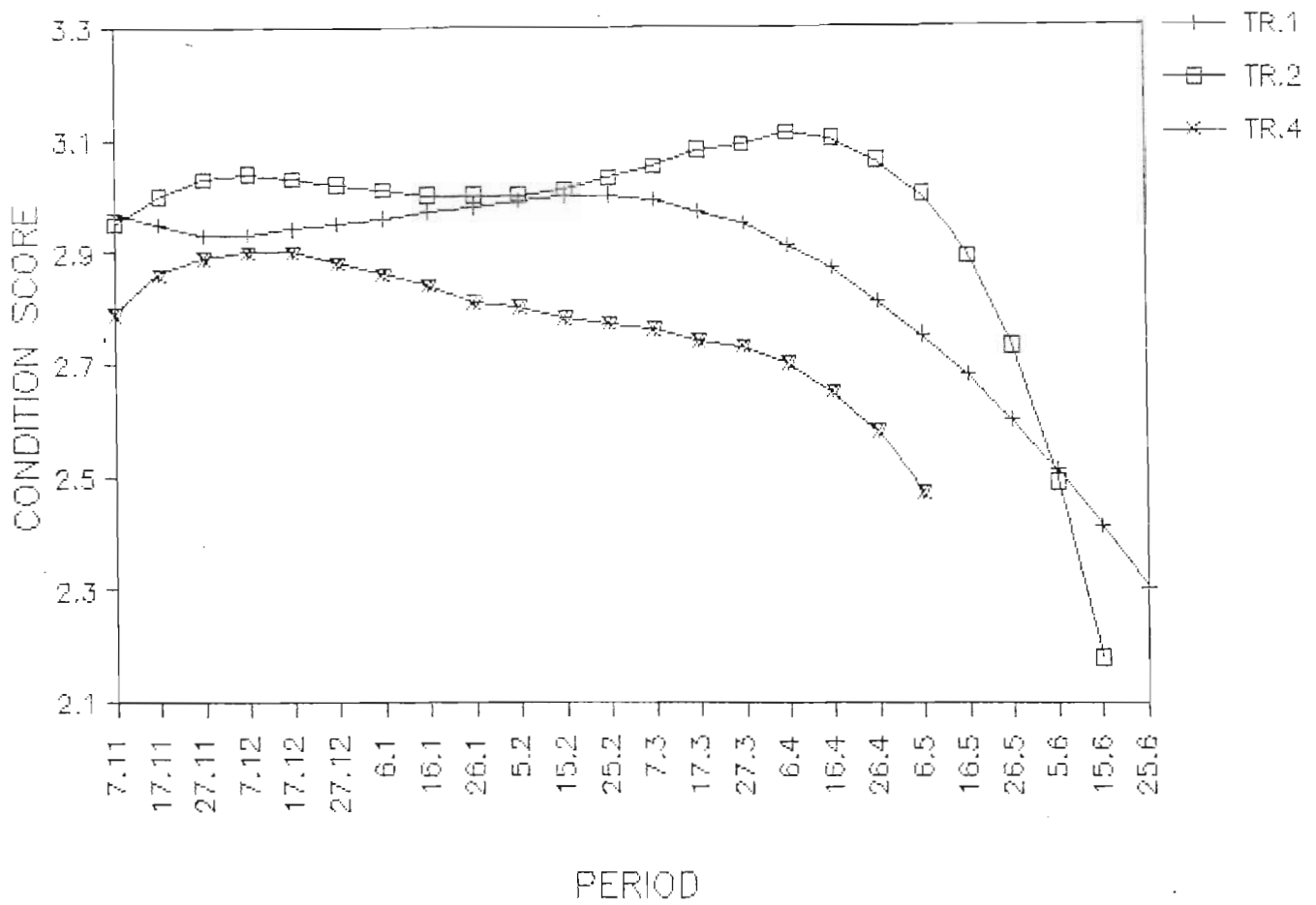


Figure 23c. The mean condition score changes for the lactating cows during the 1984/85 season.

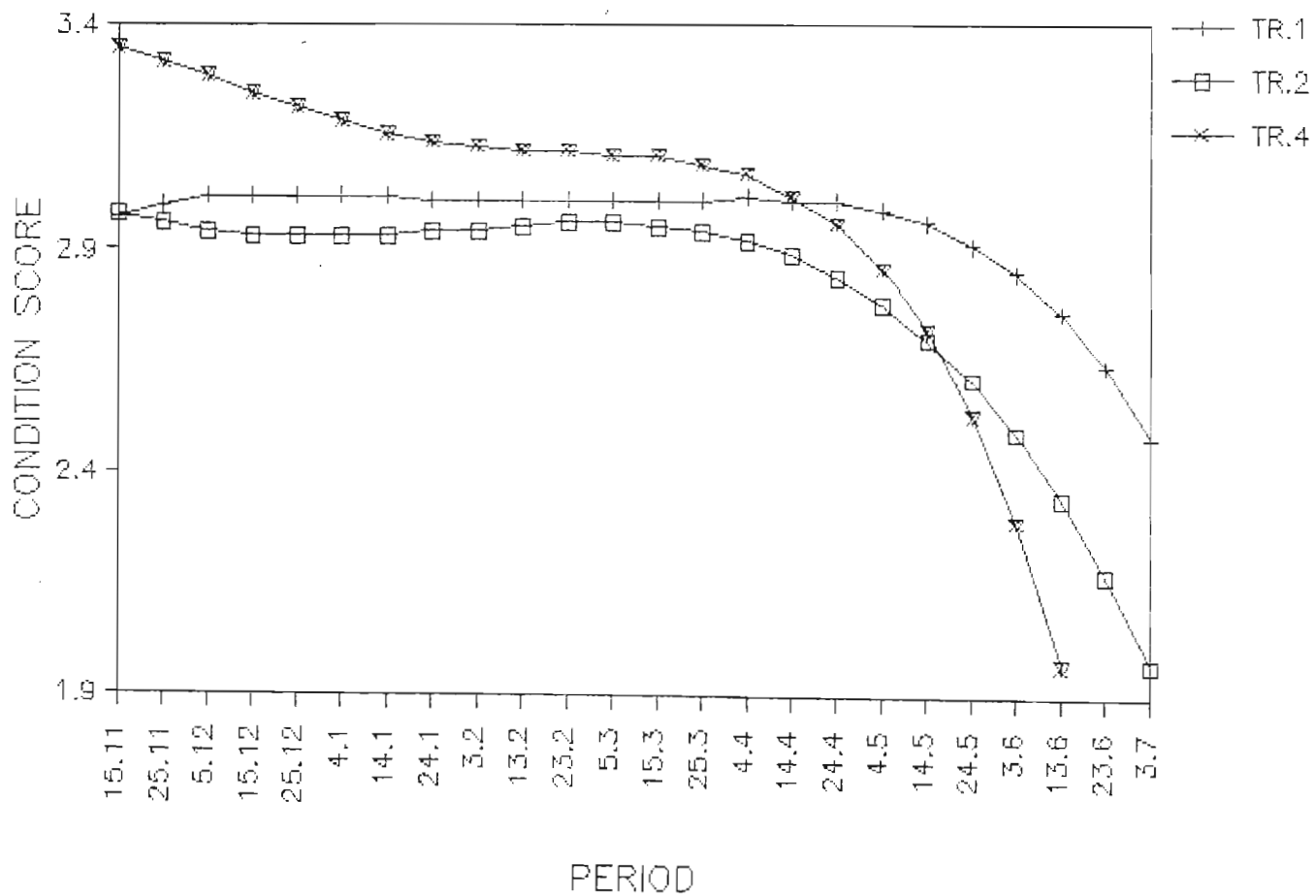


Figure 23d. The mean condition score changes for the lactating cows during the 1985/86 season.

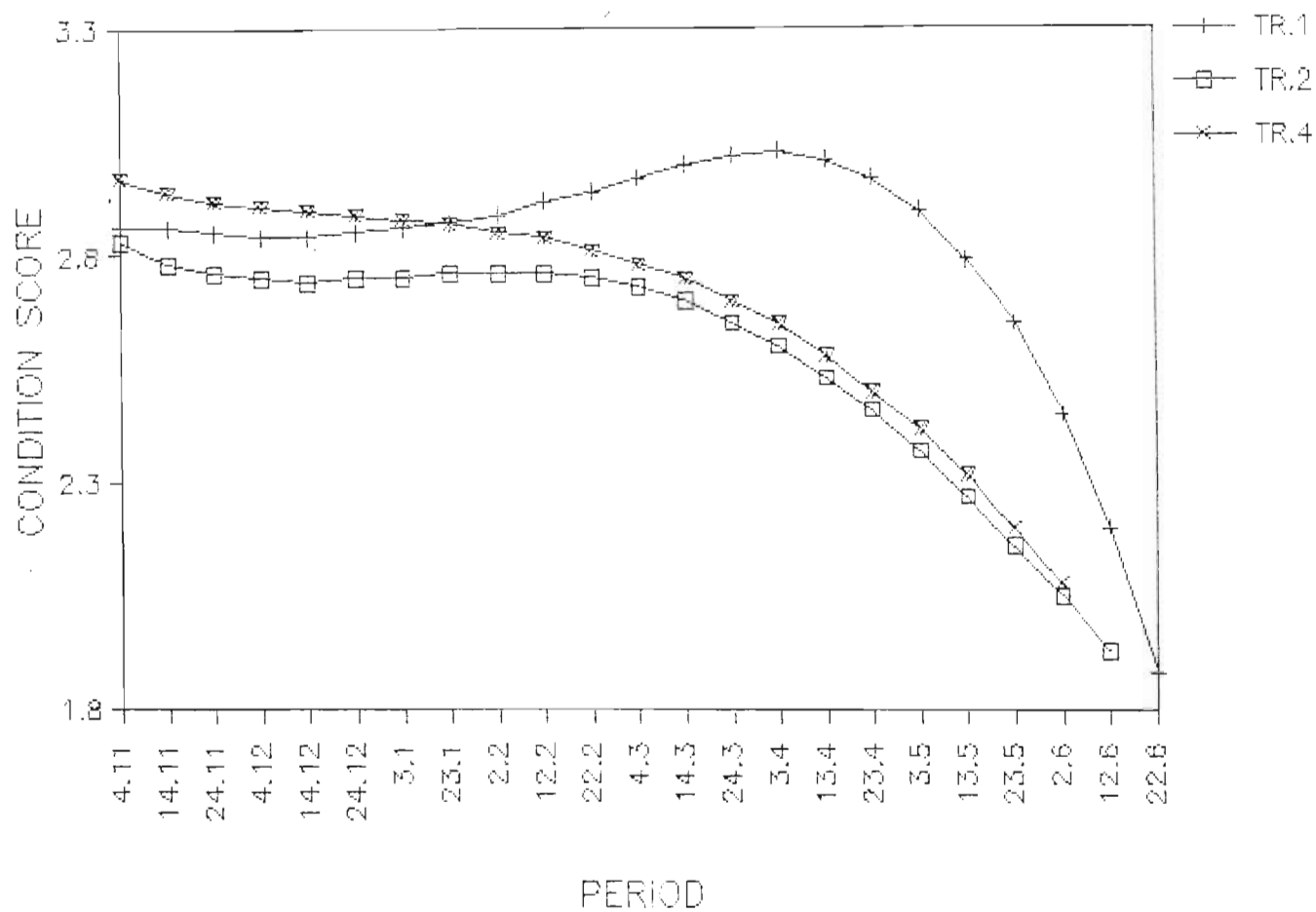


Figure 23e. The mean condition score changes for the lactating cows during the 1986/87 season.

performance data.

Growth curves - first calvers

The growth curves for the first calvers during the 1984/85, 1985/86 and 1986/87 seasons are shown in Figures 24a - 24c respectively. The fitted means were derived from the quartic equations presented in Appendix 6. Stocking rate had no significant effect on the gains to maximum mass for the cows in Tr.1 and Tr.2. The growth curves for the first calvers were similar to those of the mature cows in that the curves peaked in autumn, and declined rapidly thereafter. However, the first calvers attained maximum mass approximately 20 days (Tr.1) and 38 days (Tr.2) later than the mature cows in the corresponding treatments. Daily growth rates for the two classes of cows in the same treatments were also similar (Tables 46 and 47).

As was the case with the mature cows, the livemasses of the first calvers were lower at the end of the grazing season than at its start, in all three grazing treatments. This factor undoubtedly placed severe stress on the first calvers, particularly as they were not yet mature.

Condition score changes - first calvers

The changes in condition score for the first calvers during the 1984/85, 1985/86 and 1986/87 seasons are presented in Figures 25a, 25b and 25c respectively. The means were derived from the quartic equations shown in Appendix 7. The trends in condition score of the first calvers were similar to those of the mature lactating cows in the corresponding treatments. In both cases, the condition scores remained relatively constant for the first 180 days on veld and then declined sharply. The responses of the first calvers in Tr.4 varied according to season (Figures 25a - 25e). As was the case with the mature cows, the condition score of the first calvers generally declined seven to ten

Table 40. Mean maximum mass, number of days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for first-calf heifers.

Treatment		Tr. 1	Tr. 2	Tr. 4
Cows + calves/ha		0,83	1,0	1,25
<u>Maximum mass</u>				
1984/85	(kg)	425,91	411,22	384,84
1985/86	(kg)	423,59	448,29	419,02
1986/87	(kg)	435,34	420,78	401,80
		428,28 ± 6,23	426,77 ± 19,25	401,89 ± 17,09
<u>No. of days to max. mass</u>				
1984/85		174	171	153
1985/86		160	155	144
1986/87		173	150	0
		169,0 ± 7,81	158,6 ± 10,97	99,0 ± 85,85
<u>ADG to max mass</u>				
1984/85	(kg)	0,18	0,14	0,04
1985/86	(kg)	0,21	0,24	0,11
1986/87	(kg)	0,09	0,09	0
		0,16 ± 0,07	0,16 ± 0,08	0,05 ± 0,06
<u>No. grazing days</u>				
1984/85		237	223	188
1985/86		237	237	216
1986/87		237	211	204
		237,0 ± 0	223,67 ± 13,02	202,67 ± 14,05

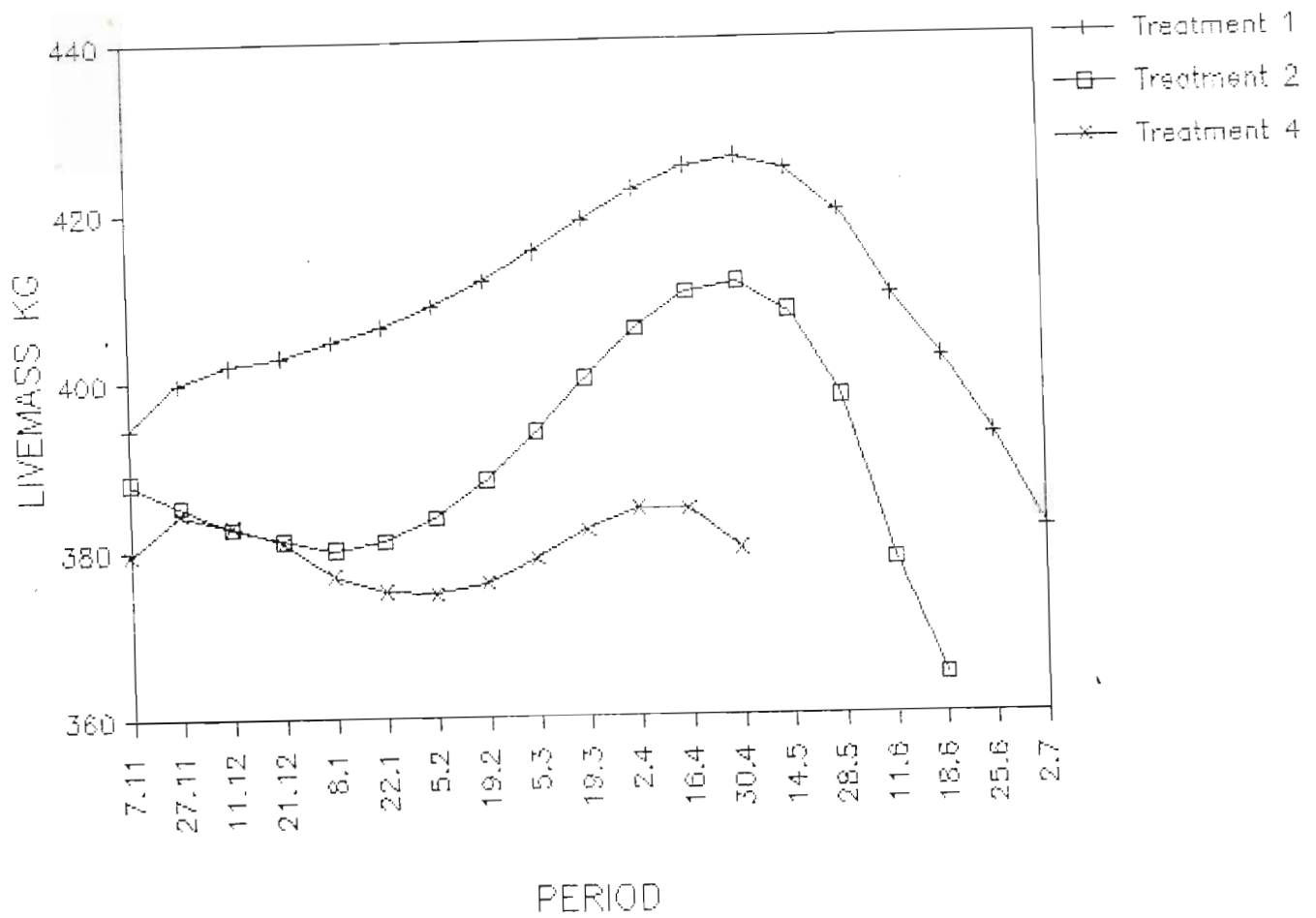


Figure 24a. The mean mass changes for the first calvers on veld during the 1984/85 season.

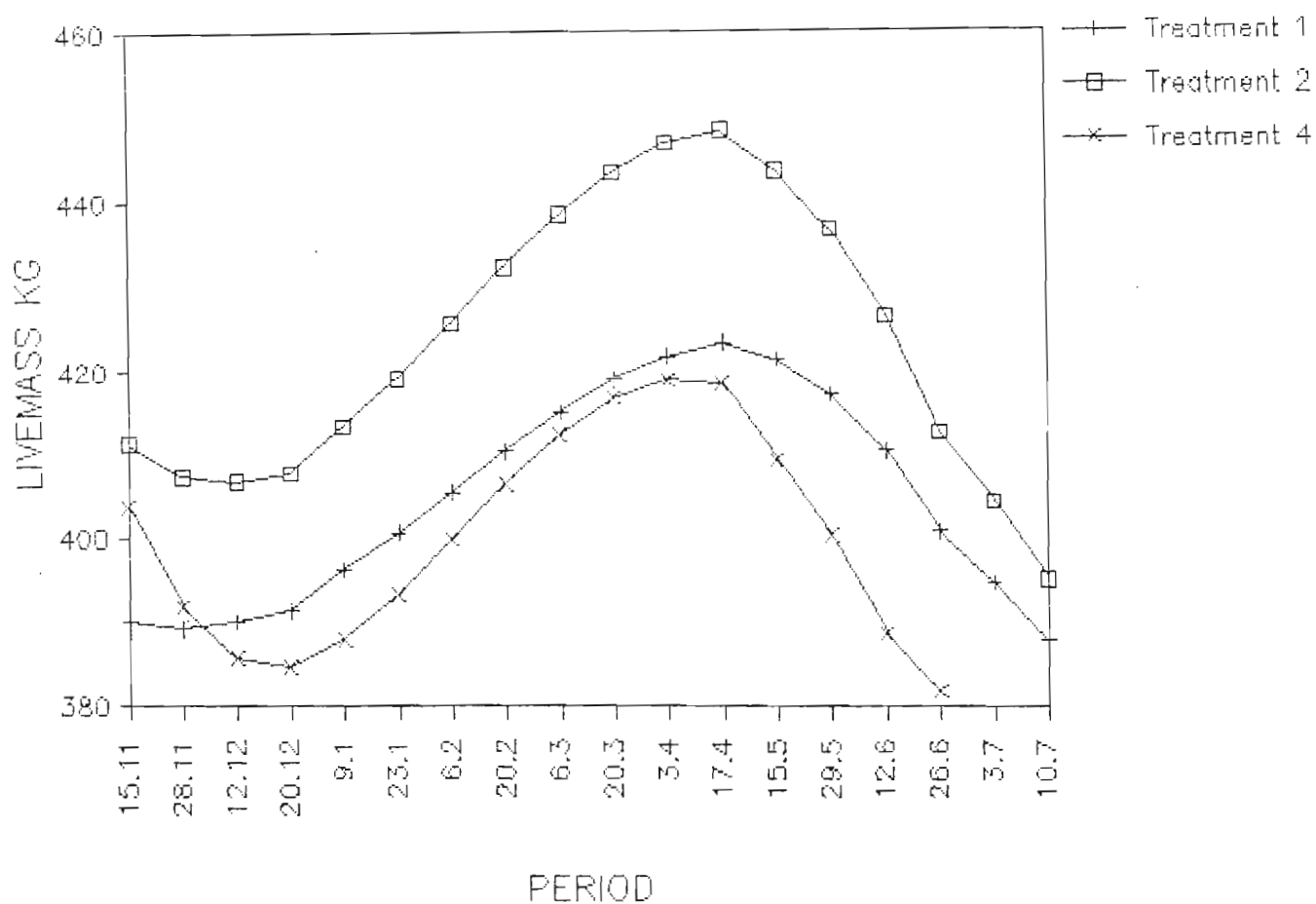


Figure 24b. The mean mass changes for the first calvers on veld during the 1985/86 season.

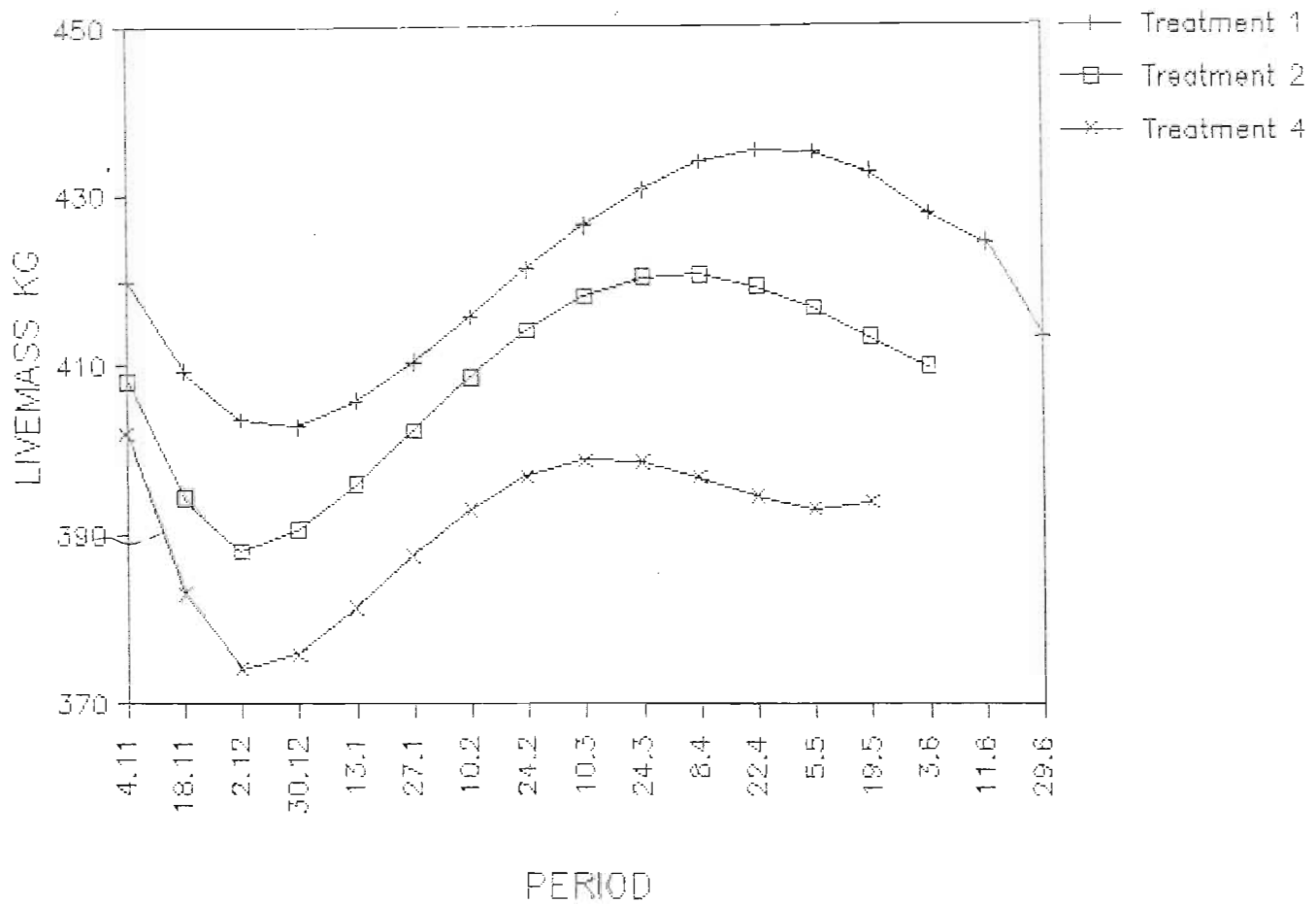


Figure 24c. The mean mass changes for the first calvers on veld during the 1986/87 season.

days after significant declines in body mass were noted. Increases in body mass were not associated with increases in body condition. It would appear that these animals were depositing significant amounts of body protein rather than external body fat.

In all three treatments, the final livemasses of the first calvers were lower than at the start of the grazing season. These animals were therefore under severe stress towards the end of the grazing season. The provision of an adequate high quality feed during the winter period was therefore a prerequisite to maintaining the animal in a productive state.

Mass changes - non-lactating cows

Mass changes for the dry, pregnant cows during the 1984/85 and 1985/86 seasons are presented in Figures 26a and 26b respectively. The fitted means were derived from the quartic equations shown in Appendix 8. As expected, mass gains to maximum mass were higher for the dry cows than that attained by either the lactating cows or the lactating first-calf heifers. The mean mass gains of the dry cows in Tr.1, Tr.2 and Tr.4 from the start of the season until peak mass was attained, were 103 kg, 87 kg and 63 kg respectively. In contrast, the lactating cows gained 49 kg, 38 kg and 20 kg respectively, over the corresponding period (Table 39). The effect of stocking rate on both classes of cows is evident from Figures 22a - 22e; 26a and 26b. The data indicates that the lactating cows were apparently more susceptible to changes in stocking rate than the dry cows.

Table 41. Mean maximum mass, days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for dry pregnant cows.

Treatment		Tr. 1	Tr. 2	Tr. 4
Cows + calves/ha		0,83	1,0	1,25
<hr/>				
<u>Maximum mass</u>				
1982/83	(kg)	552,72	520,11	518,67
1983/84	(kg)	554,56	552,10	477,06
<hr/>				
		553,64 ± 1,31	536,11 ± 22,62	497,87 ± 29,43
<hr/>				
<u>Days to max. mass</u>				
1982/83	(kg)	186	164	179
1983/84	(kg)	159	162	158
<hr/>				
		172,50 ± 19,10	163,00 ± 1,42	168,50 ± 14,85
<hr/>				
<u>ADG to max mass</u>				
1982/83	(kg)	0,62	0,60	0,38
1983/84	(kg)	0,57	0,46	0,35
<hr/>				
		0,60 ± 0,04	0,54 ± 0,10	0,37 ± 0,02
<hr/>				
<u>No. of grazing days</u>				
1982/83	(kg)	236	193	179
1983/84	(kg)	231	224	196
<hr/>				
		233,50 ± 3,54	208,50 ± 21,92	187,50 ± 12,02

Condition score changes - non-lactating cows

The condition score changes for the dry pregnant cows during the 1982/83 and 1983/84 seasons are presented in Figures 27a and 27b respectively. The fitted means were derived from the quartic equations shown in Appendix 9.

The loss in the body condition of the dry cows in Tr.2 and Tr.4 during the first 60 days of the 1982/83 season was similar to the responses of the lactating cows in the corresponding treatments (Figures 23a and 23b). However, the lactating cows maintained body condition for the following 90 days, whereas the dry cows gained significant amounts of body condition during this period (Figures 27a and 27b). Despite losing body condition during the last few weeks of grazing, the animals were still in extremely good condition when each treatment was terminated. The grazing season could therefore have been extended particularly in Tr.1 and Tr.2.

Length of the grazing season and condition score

The length of the grazing season was determined by the condition scores of the cows of a particular class, within a specific treatment. The number of grazing days and the mean condition scores at weaning, for each treatment are shown in Table 42. These figures indicate that an increase in stocking rate was concomitant with a decrease in the length of the grazing season, and hence an increase in the length of the winter feeding period. Although stocking rate and the length of the grazing season were negatively correlated, the response was not linear. An increase in stocking rate from 0,83 cows + calves/ha to 1,0 cow + calf/ha (15%) decreased the number of grazing days by 7% whereas an increase in stocking rate from 1,0 cow + calf/ha to 1,25 cows + calves/ha (25%) reduced the length of the grazing season by 11%. The potential length of the grazing season was highly dependent upon

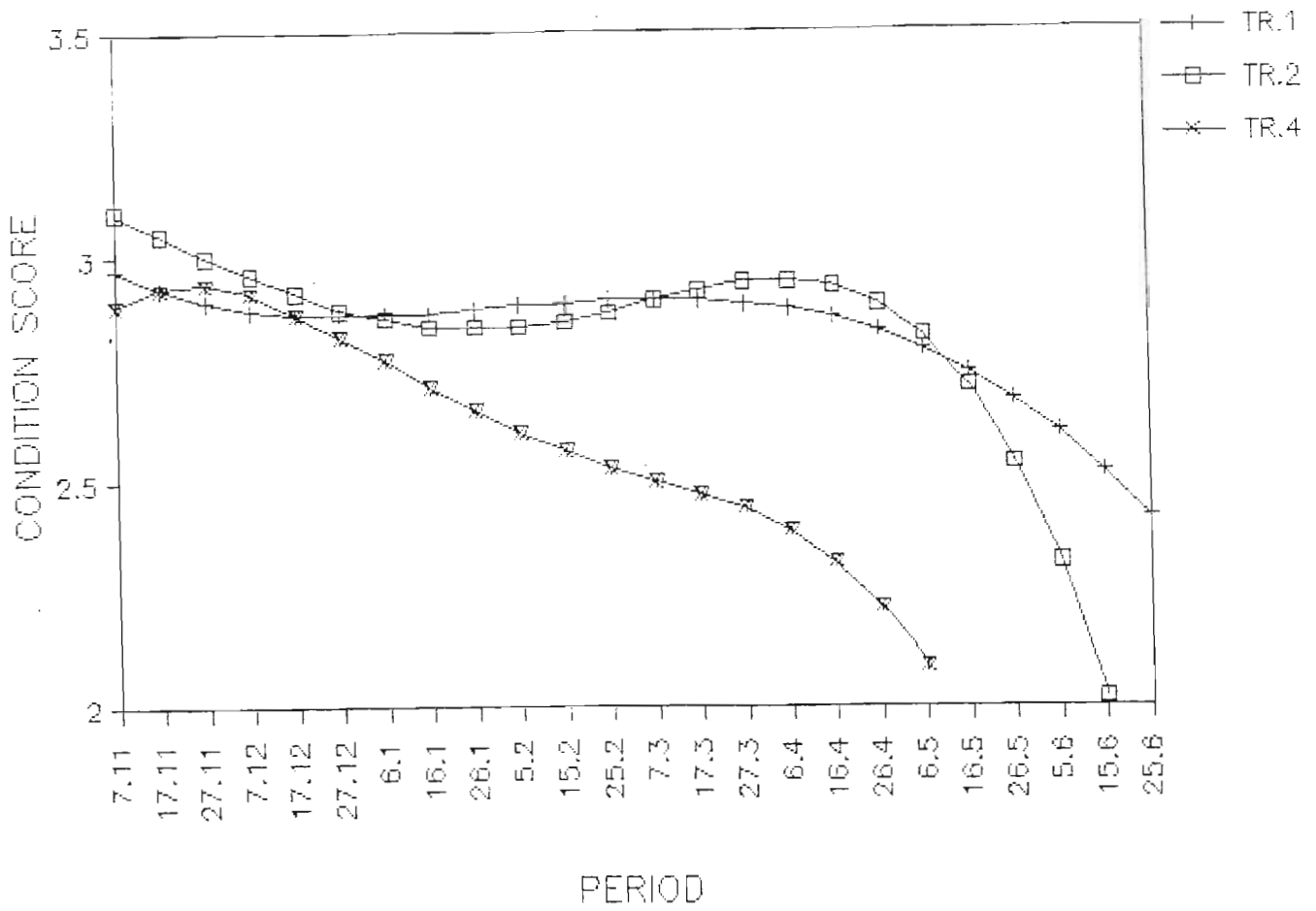


Figure 25a. The mean condition score changes for the first calvers during the 1984/85 season.

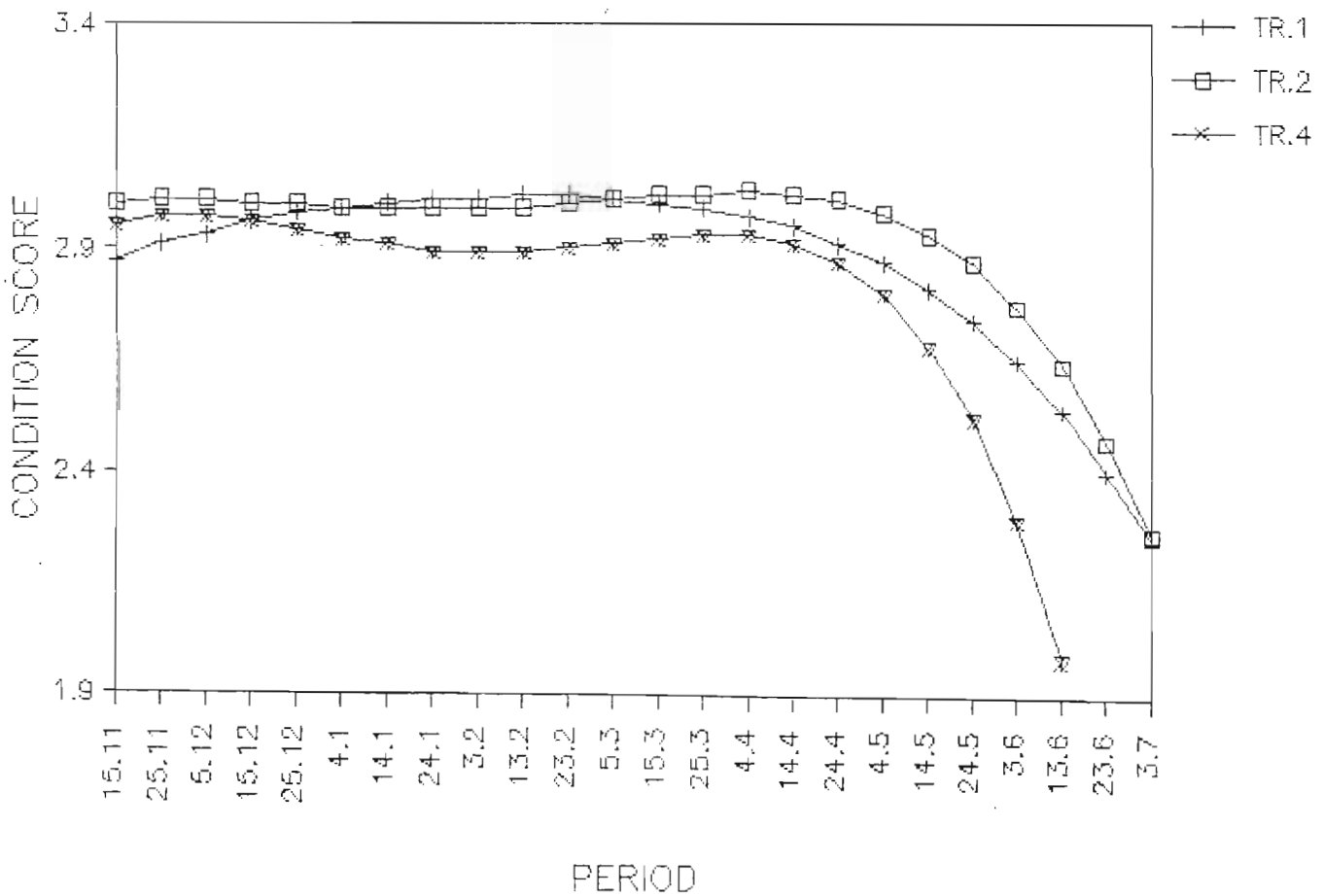


Figure 25b. The mean condition score changes for the first calvers during the 1985/86 season.

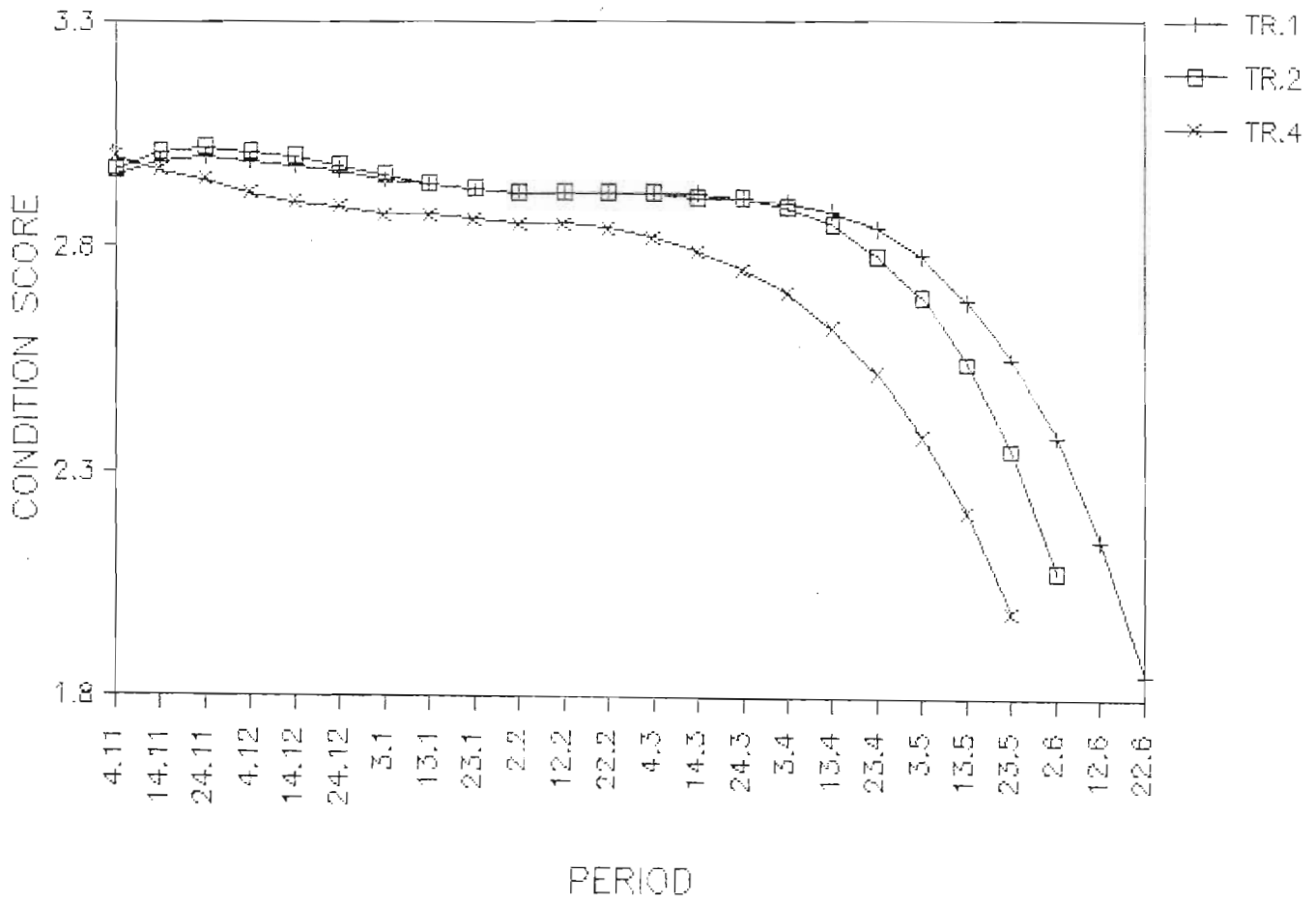


Figure 25c. The mean condition score changes for the first calvers during the 1986/87 season.

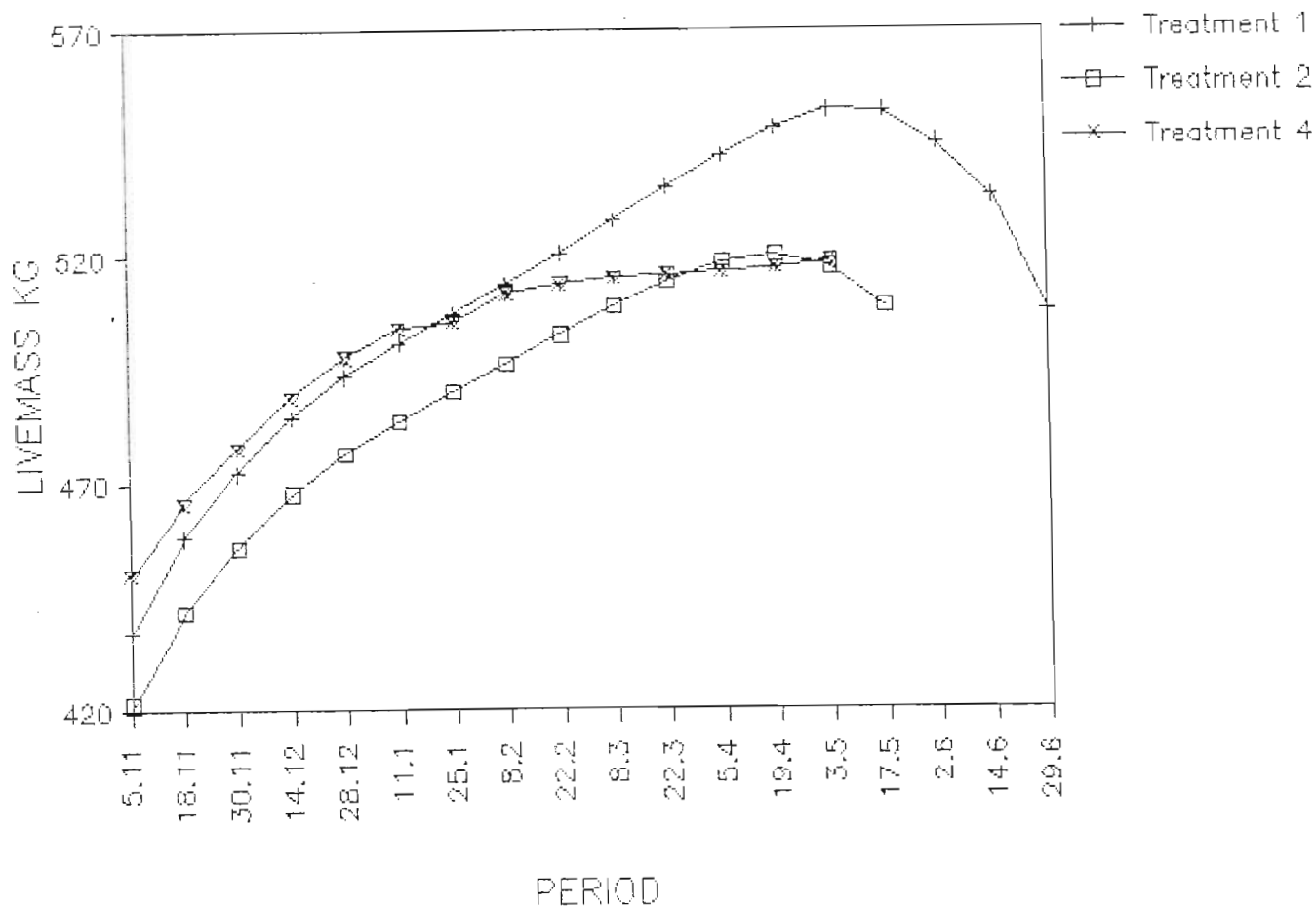


Figure 26a. The mean mass changes on veld for the dry pregnant cows during the 1982/83 season.

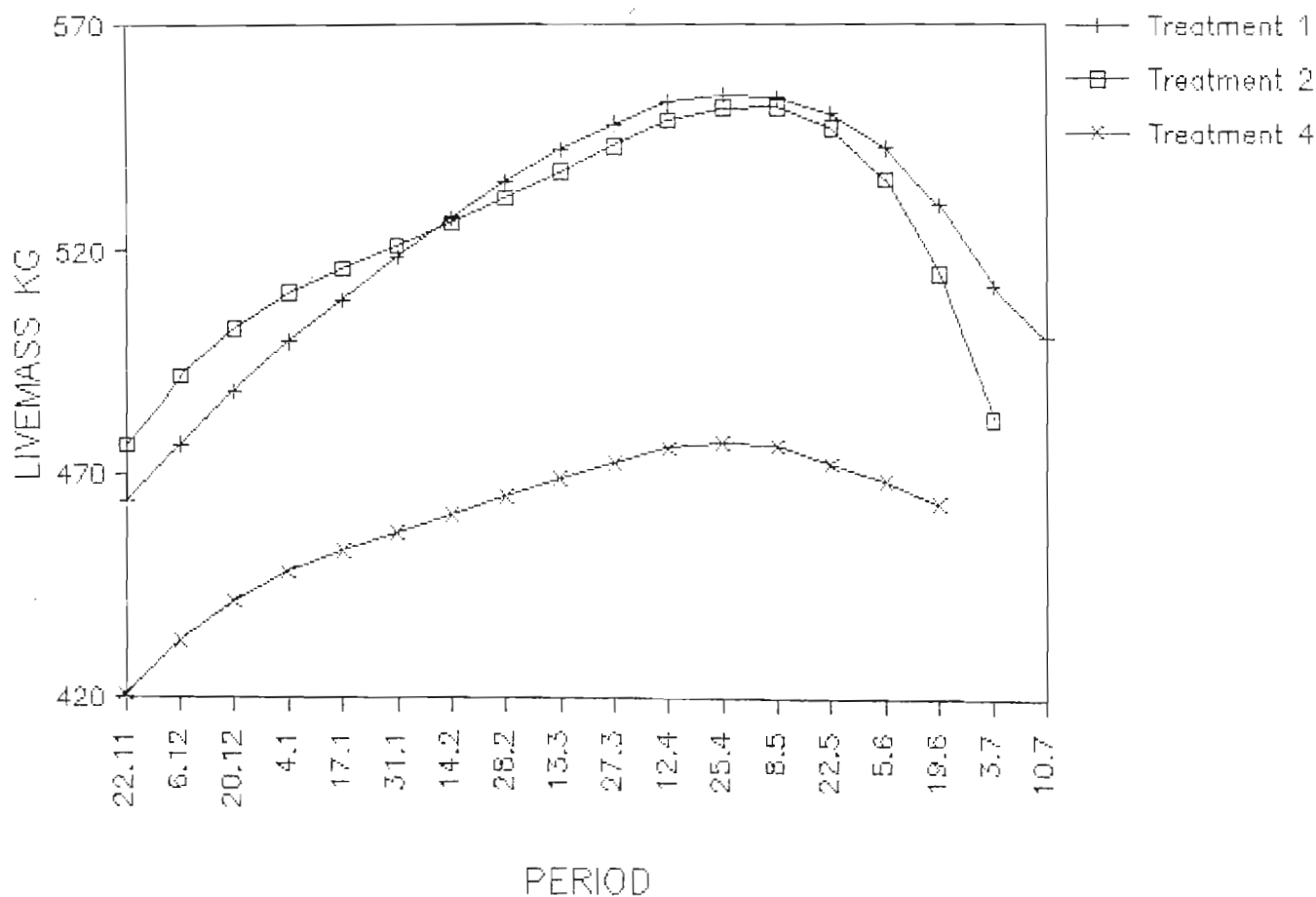


Figure 26b. The mean mass changes on veld for the dry pregnant cows during the 1983/84 season.

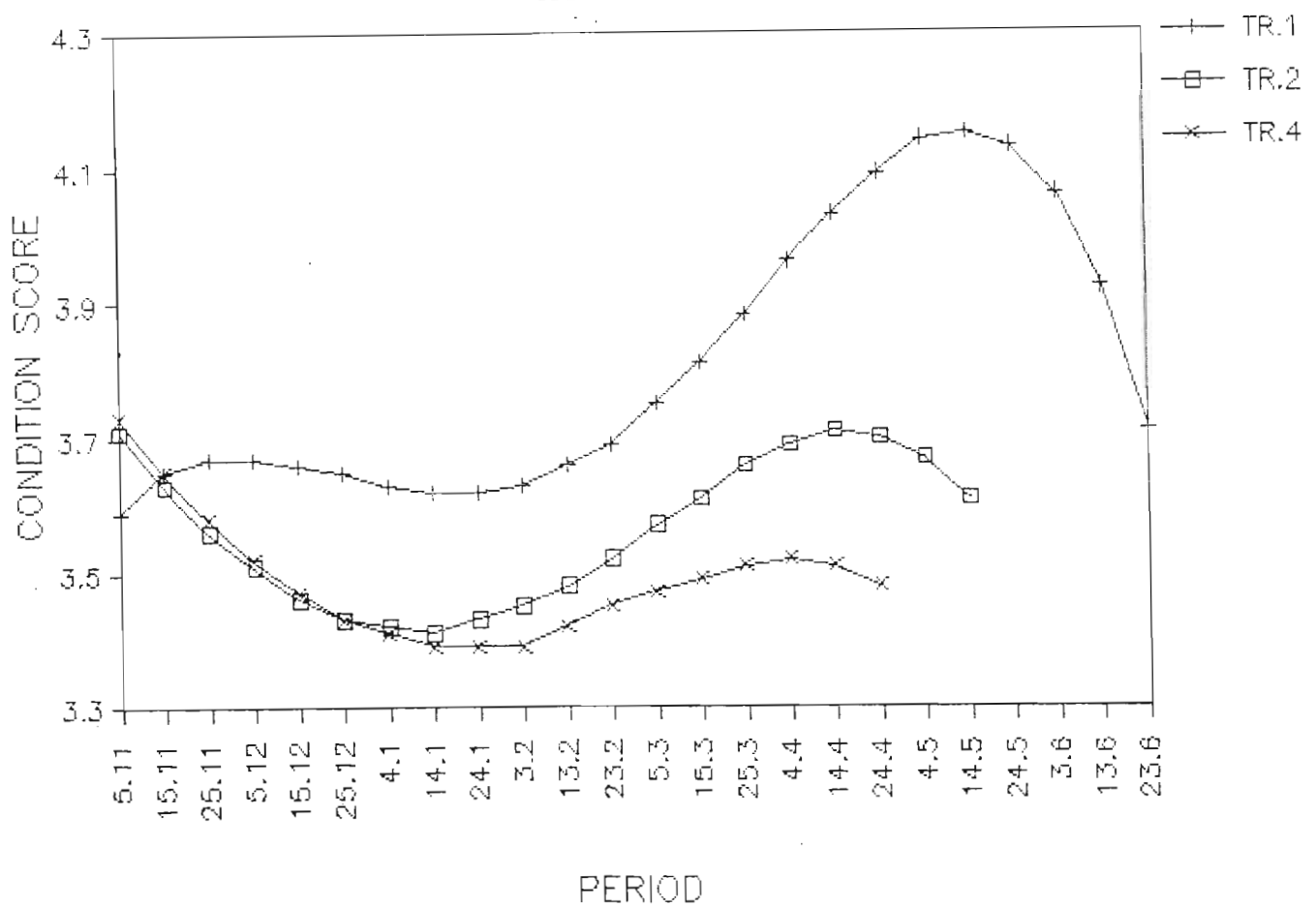


Figure 27a. The mean condition score changes for the dry pregnant cows during the 1982/83 season.

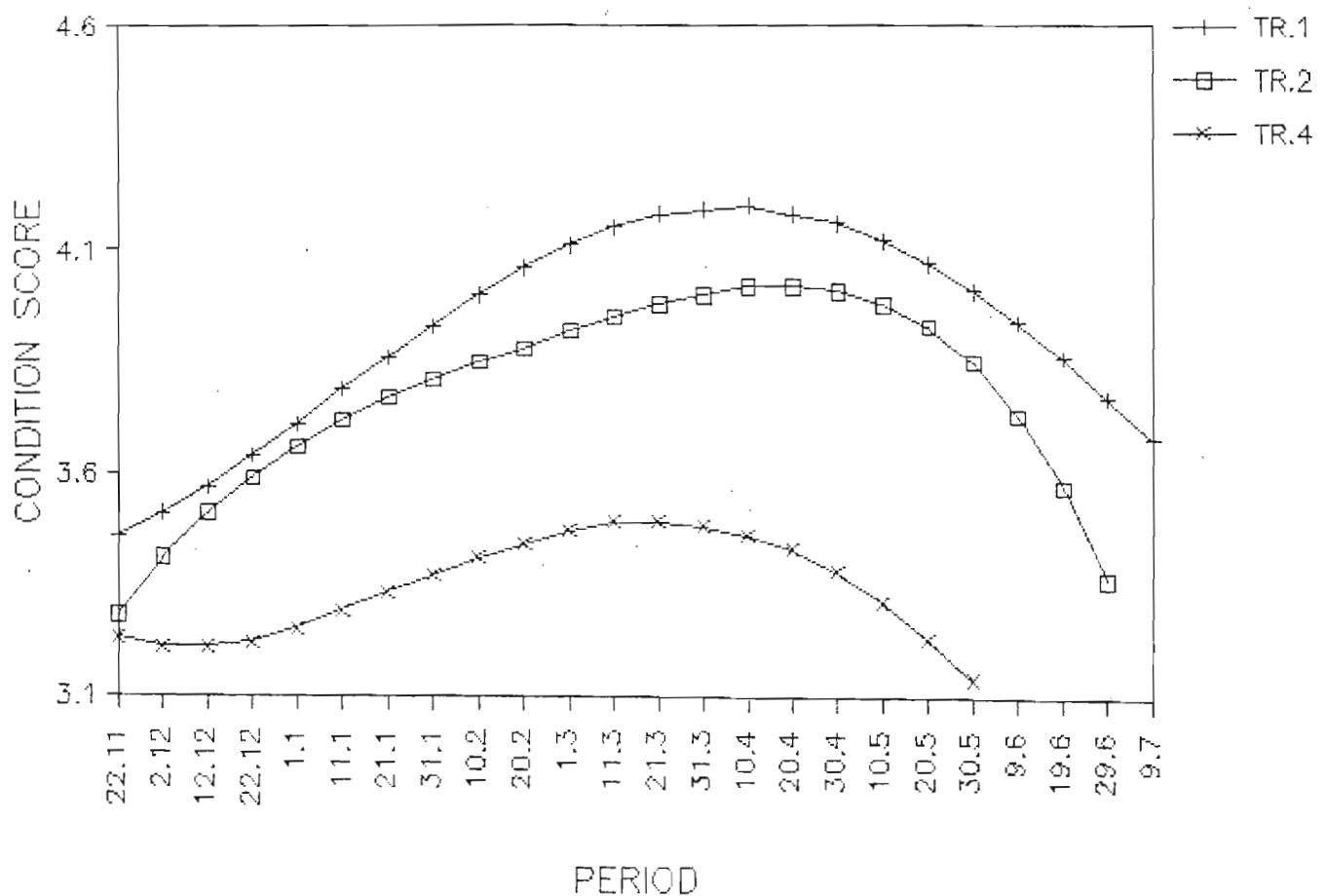


Figure 27b. The mean condition score changes for the dry pregnant cows during the 1983/84 season.

season. The observed length of the grazing season in Tr.1 was remarkably constant ($235,6 \pm 2,61$ days). The final condition scores, however, varied considerably (Figures 23a - 23e). The mean length of the grazing season recorded for Tr.2 was $217,6 \pm 16,55$ days and $196,6 \pm 14,28$ days in Tr.4. If animals were weaned individually, or in groups with similar body conditions, as would be possible on a farm, the length of the grazing season in all these stocking rates, could be extended considerably. After attaining maximum condition score the lactating cows generally lost condition at the rate of 0,01 (mean) condition score points per day. This figure has been used in subsequent analyses to predict the potential length of the grazing season.

At weaning, the final condition scores of the first calvers were not consistently lower than those of the mature cows in the corresponding treatments (Table 42). In fact, in five of the nine situations, the first calvers had higher mean condition scores at the end of the grazing season than the mature cows. These figures suggest that the first calver was able to compete successfully with the mature cow for grazing over a range of stocking rates.

Growth curves

Calves - born to mature cows

Growth curves for calves born to mature cows are presented in Figures 28a - 28e. The fitted means were derived from the quartic equations presented in Appendix 10. The performance data of the calves born to the second calvers have not been included in the analyses, since they would bias the data of the calves born to the mature animals.

Growth rates were linear for the first 150 - 180 days for all the treatments, thereafter the mass gains declined slightly before weaning.

Table 42. The mean number of grazing days and final condition scores of cows under different stocking rate conditions.

Treatment cows + calves/ha		Treatment 1 0,83			Treatment 2 1,0			Treatment 4 1,25				
Season	Grazing days	Lact. cows CS	First calvers CS	Dry cows CS	Grazing days	Lact. cows CS	First calvers CS	Dry cows CS	Grazing days	Lact. cows CS	First calvers CS	Dry cows cs
1982/83	236	2,18		3,71	196	2,01		3,61	179	2,18		3,48
1983/84	231	1,89		3,68	224	1,84		3,36	196	2,01		3,14
1984/85	237	2,30	2,42		223	2,18	2,02		188	2,47	2,09	
1985/86	237	2,48	2,25		237	1,97	2,26		216	1,97	1,98	
1986/87	237	1,85	1,88		211	1,93	2,08		204	2,08	1,99	
	235,60 ± 2,61	2,44 ±0,27	2,19 ±0,28	3,70 ±0,03	271,60 ± 16,50	1,99 ±0,13	2,12 ±0,13	3,49 ±0,18	196,6 ± 14,28	2,15 ±0,20	2,02 ±0,06	3,31 ±0,24

Table 43. Mean maximum mass, days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for calves born to mature cows.

Treatment		Tr. 1	Tr. 2	Tr. 4
Cows + calves/ha		0,83	1,0	1,25
<hr/>				
<u>Maximum mass</u>				
1982/83	(kg)	193,62	194,68	183,89
1983/84	(kg)	221,41	202,32	202,21
1984/85	(kg)	210,31	220,68	187,45
1985/86	(kg)	218,84	213,28	187,80
1986/87	(kg)	208,34	203,63	185,92
		<hr/>		
		210,50 ± 10,93	206,92 ± 10,14	189,45 ± 7,29
<hr/>				
<u>Days to max. mass</u>				
1982/83	(kg)	205	193	179
1983/84	(kg)	190	192	185
1984/85	(kg)	197	195	178
1985/86	(kg)	200	197	184
1986/87	(kg)	204	202	194
		<hr/>		
		199,20 ± 6,06	195,80 ± 3,96	183,60 ± 5,59
<hr/>				
<u>ADG to max. mass</u>				
1982/83	(kg)	0,67	0,66	0,66
1983/84	(kg)	0,75	0,68	0,66
1984/85	(kg)	0,68	0,71	0,63
1985/86	(kg)	0,72	0,70	0,63
1986/87	(kg)	0,70	0,71	0,66
		<hr/>		
		0,70 ± 0,04	0,69 ± 0,02	0,65 ± 0,02
<hr/>				
<u>No. of grazing days</u>				
1982/83		236	193	179
1983/84		231	224	196
1984/85		237	223	188
1985/86		237	237	216
1986/87		237	211	204

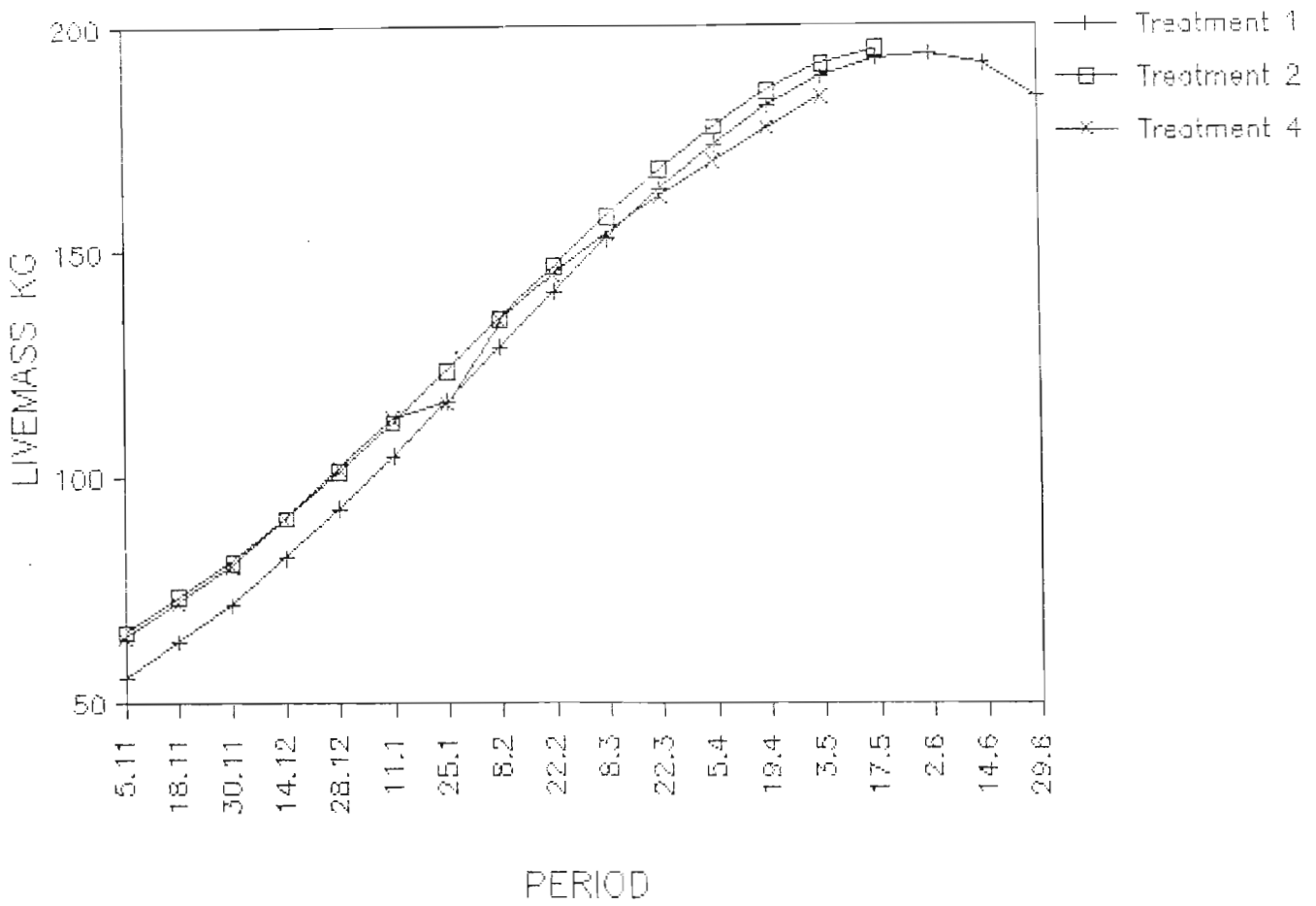


Figure 28a. Mass changes on veld of calves born to mature cows during the 1982/83 season.

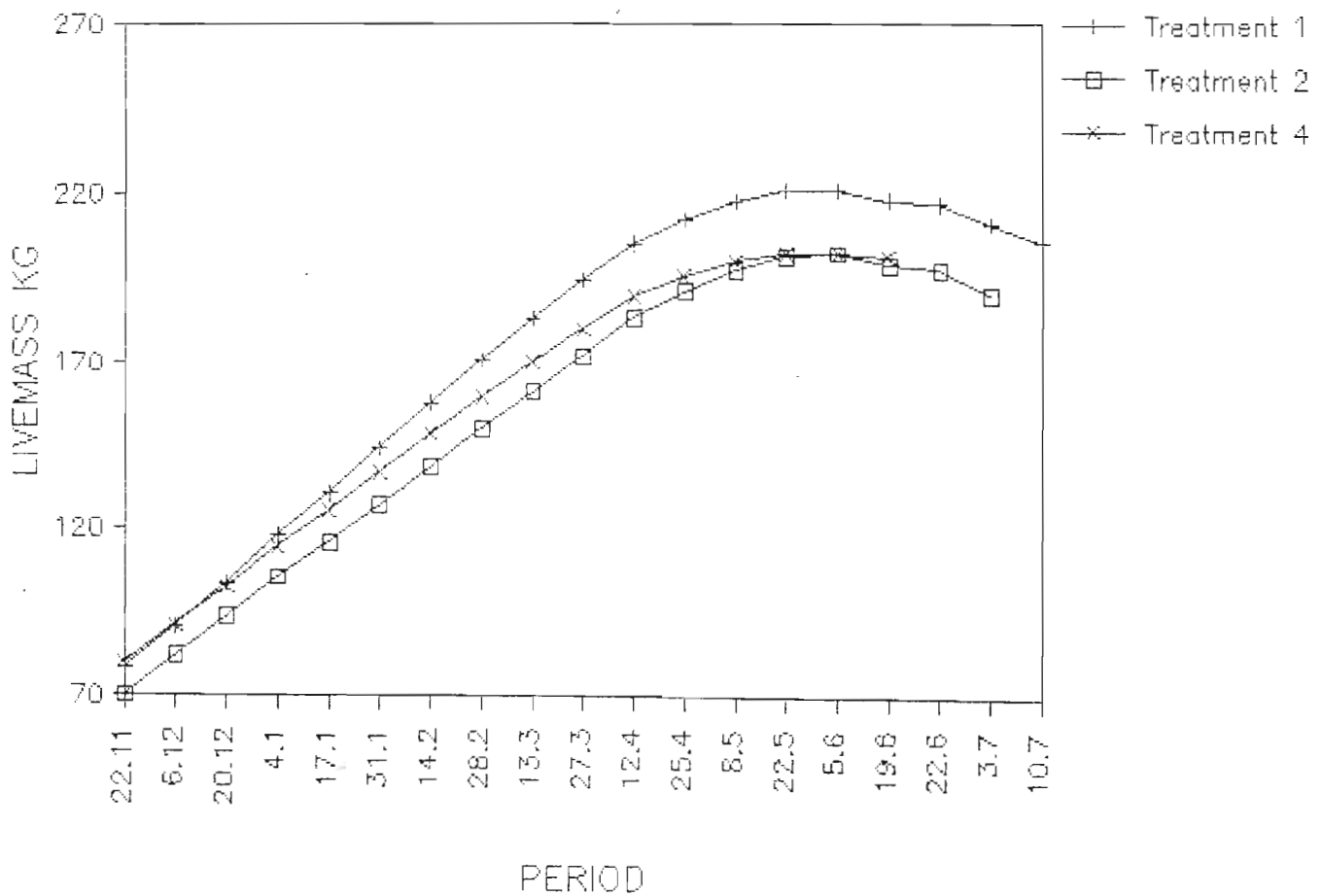


Figure 28b. Mass changes on veld of calves born to mature cows during the 1983/84 season.

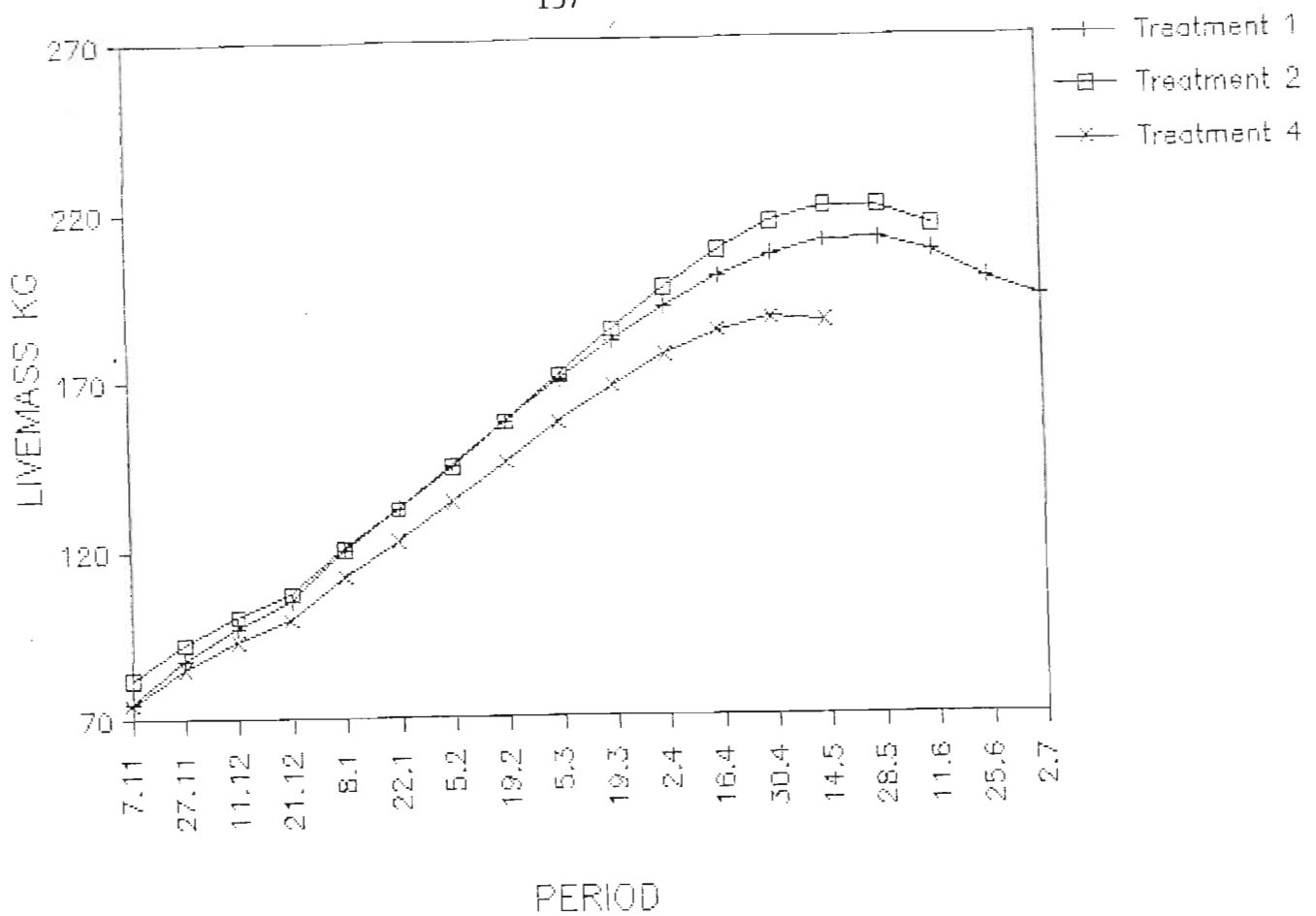


Figure 28c. Mass changes on veld of calves born to mature cows during the 1984/85 season.

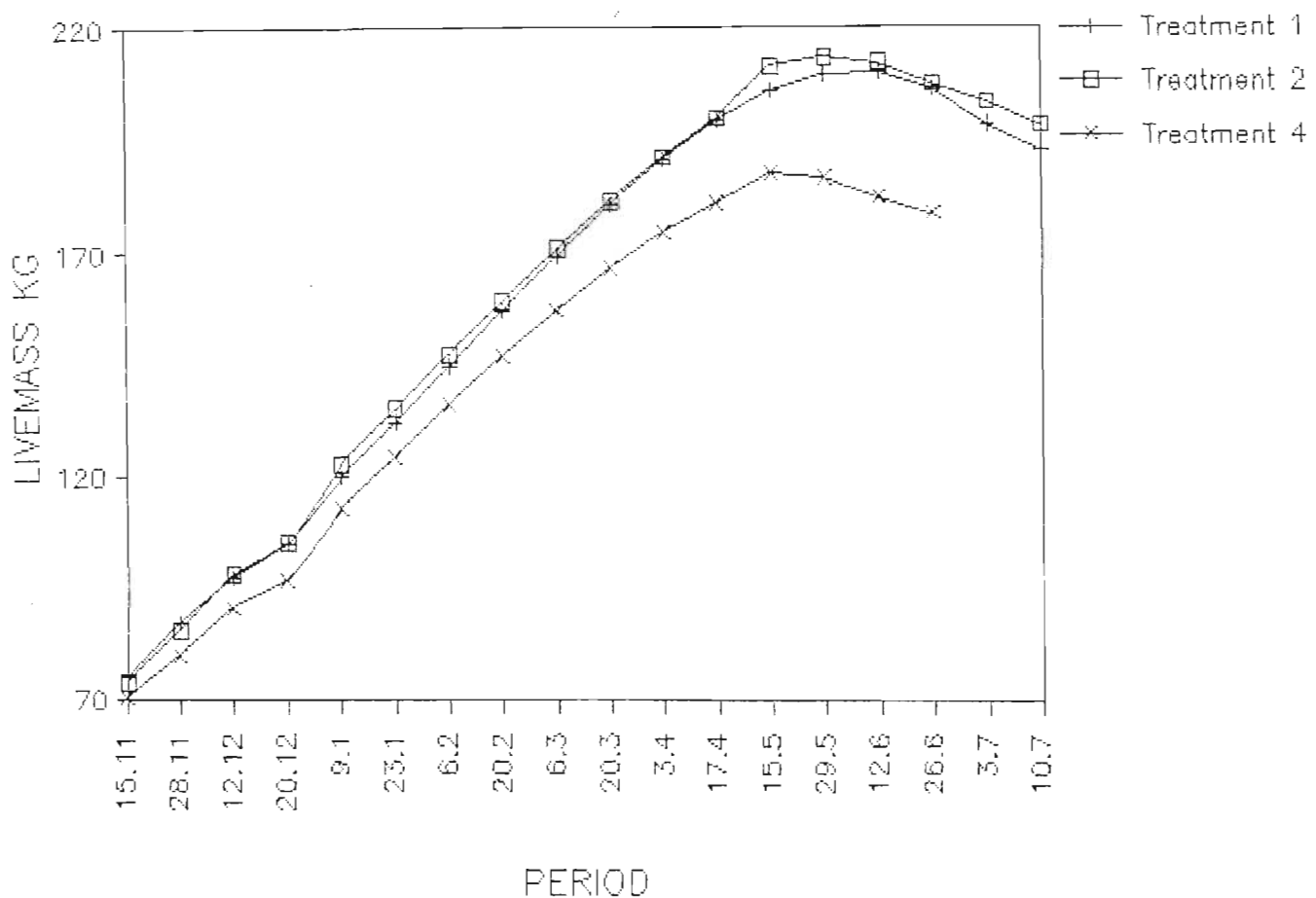


Figure 28d. Mass changes on veld of calves born to mature cows during the 1985/86 season.

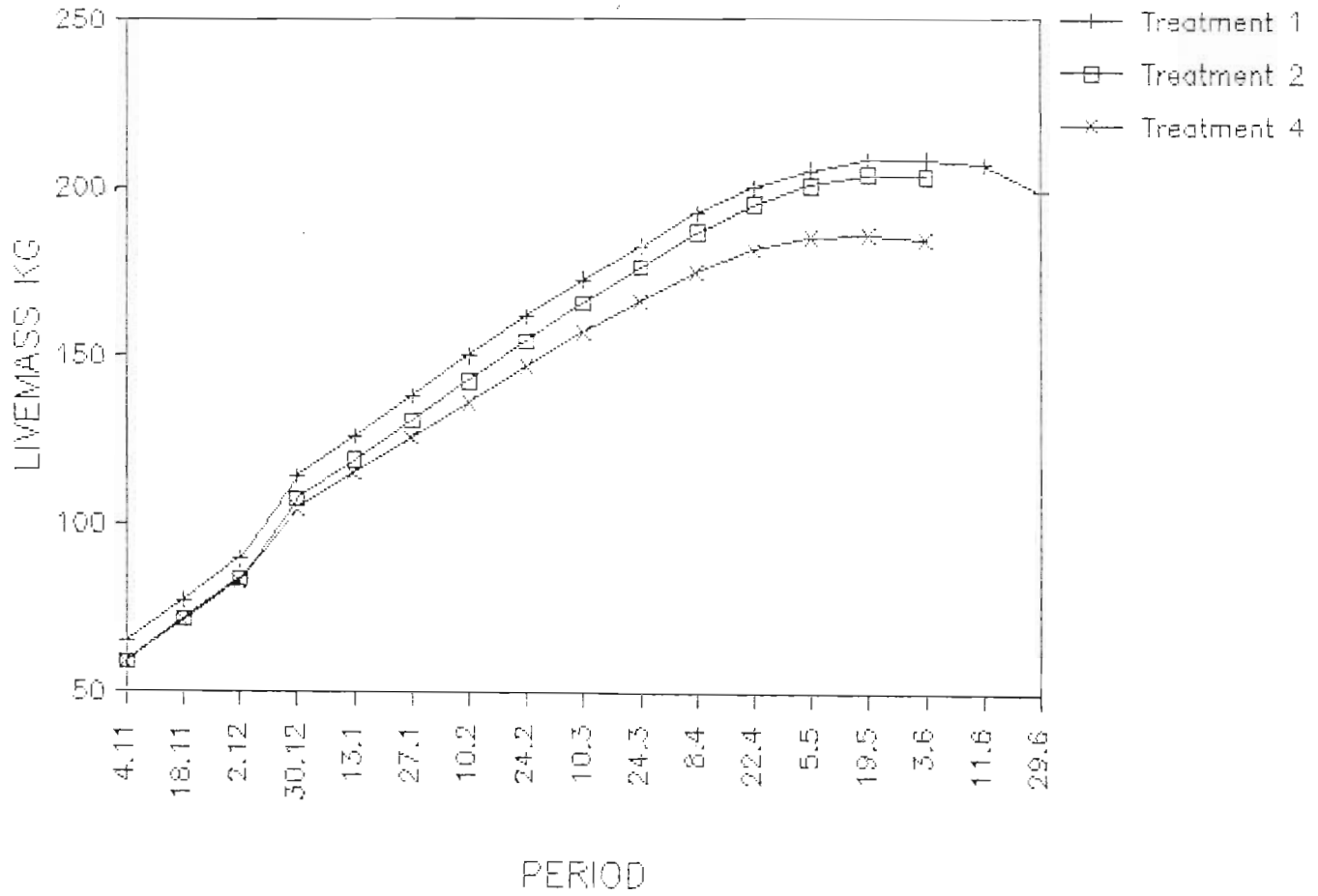


Figure 28e. Mass changes on veld of calves born to mature cows during the 1986/87 season.

The number of days required to achieve maximum mass was consistent between seasons for any particular treatment (Table 43). The difference between Tr.1 and Tr.2, in terms of the number of days required to achieve maximum mass, was relatively small ($199,20 \pm 6,06$ vs. $195,80 \pm 3,96$). The calves in Tr.4 attained a mean maximum mass of $189,45 \pm 7,29$ kg after $183,6 \pm 5,59$ days. The difference in the mean ADG's between the calves in Tr.2 and Tr.4 increased towards the end of the experimental period (1984/85 onwards). It is possible that the productivity of the herbage, and therefore the amount of grass available, was beginning to decline. This would support visual observations at the time.

The mean condition scores (1982/83 - 1986/87) of the dams in Tr.1, Tr.2 and Tr.4, when their calves achieved maximum mass was 2,78, 2,40 and 2,36 respectively. Had the calves been weaned at peak mass, and the cows maintained in their respective treatments on veld, the grazing season could have been extended beyond the periods indicated in Table 43. These data suggest that the optimum weaning time for a stocking rate of one cow plus calf/ha would be attained after approximately 200 days of grazing when the mean condition score of the cows was in the region of 2,3 - 2,4.

Calves - born to first calvers

Growth curves for the calves born to the first calvers are presented in Figures 29a, 29b and 29c respectively. The fitted means were derived from the quartic equations presented in Appendix 11. It is significant that the mean maximum masses were, on average, similar irrespective of whether they were born to the first calvers (Table 44), or to the corresponding mature cows (Table 43). In fact, in two of the three treatments the peak masses of the first calvers' calves were slightly (NS) higher than those of the mature cows' calves. However,

Table 44. Mean maximum mass, number of days to maximum mass, average daily gain (ADG) to maximum mass and the number of grazing days for calves born to first-calf heifers.

Treatment		Tr. 1	Tr. 2	Tr. 4
Cows + calves/ha		0,83	1,0	1,25
<u>Maximum mass</u>				
1984/85	(kg)	200,35	203,47	178,93
1985/86	(kg)	219,40	234,16	214,19
1986/87	(kg)	212,24	212,49	189,08
		210,67 ± 9,63	216,71 ± 15,78	191,74 ± 19,52
<u>No. of days to max mass</u>				
1984/85		197	191	180
1985/86		193	191	175
1986/87		203	199	189
		197,67 ± 5,04	193,67 ± 4,62	181,34 ± 7,10
<u>ADG to max. mass</u>				
1984/85	(kg)	0,61	0,62	0,55
1985/86	(kg)	0,67	0,73	0,66
1986/87	(kg)	0,63	0,65	0,54
		0,63 ± 0,03	0,67 ± 0,06	0,58 ± 0,07
<u>No. of grazing days</u>				
1984/85		237	223	188
1985/86		237	237	216
1986/87		237	211	204
		237,00 ± 0	223,66 ± 13,01	202,66 ± 14,04

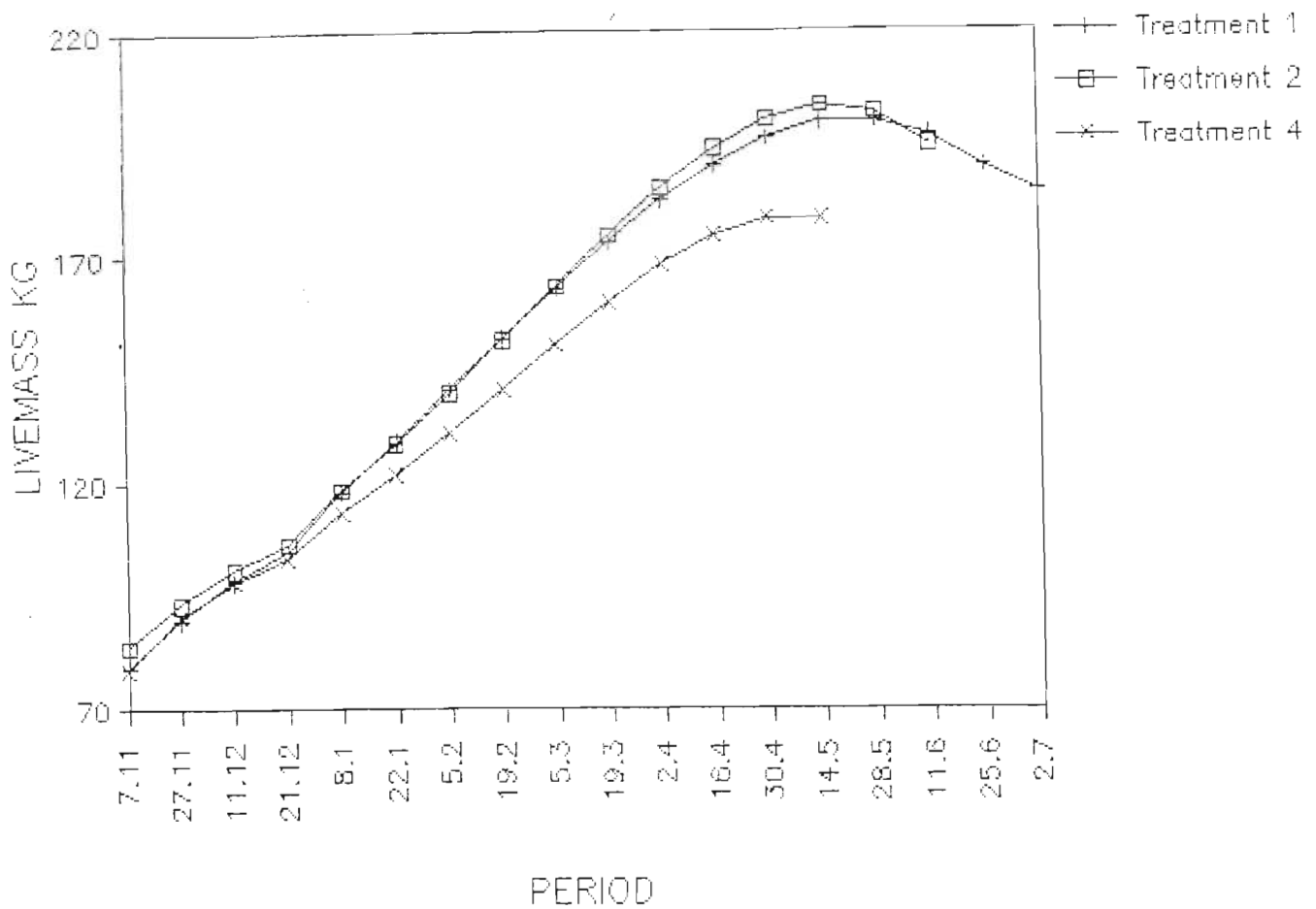


Figure 29a. Mass changes on veld of calves born to first calvers during the 1984/85 season.

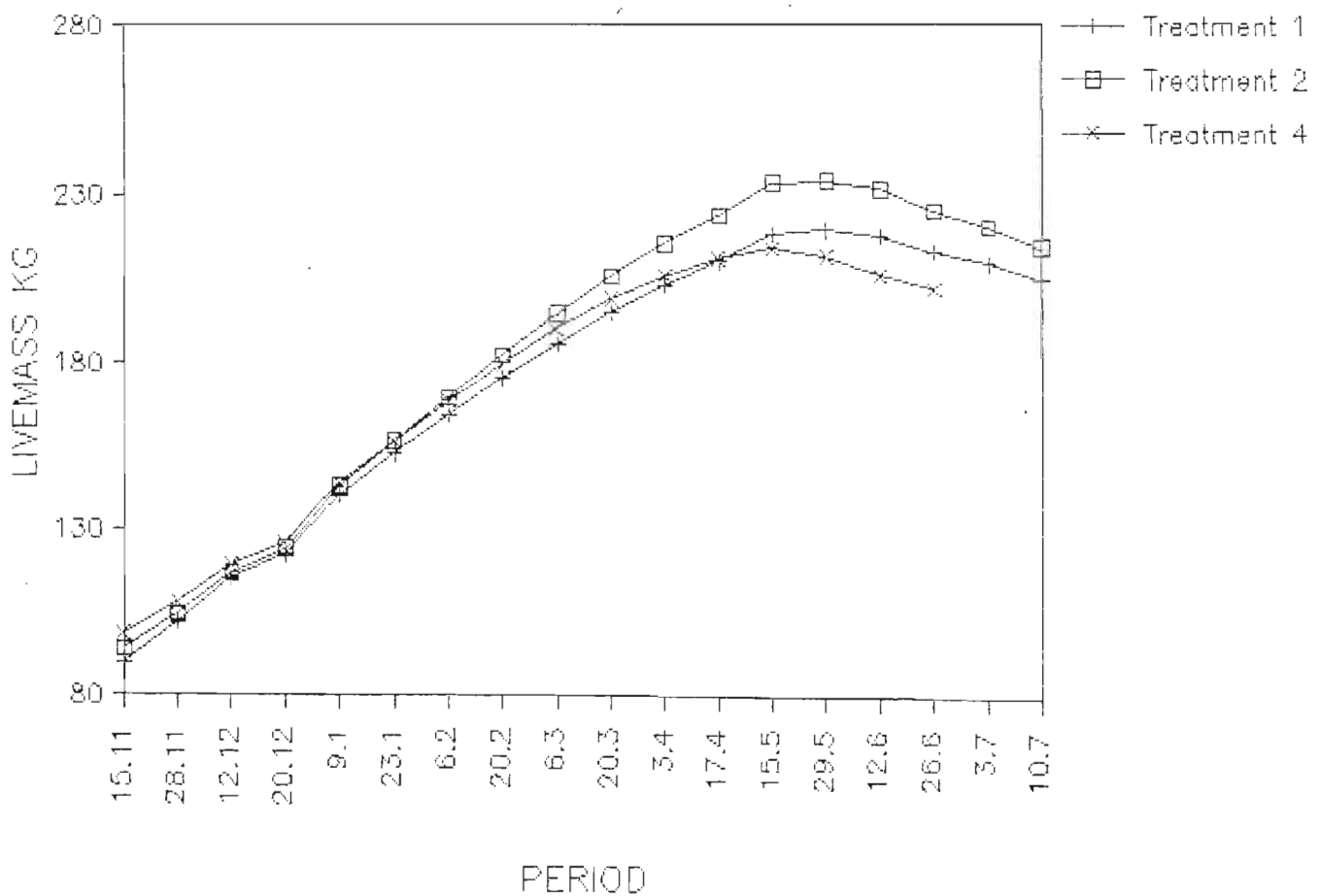


Figure 29b. Mass changes on veld of calves born to first calvers during the 1985/86 season.

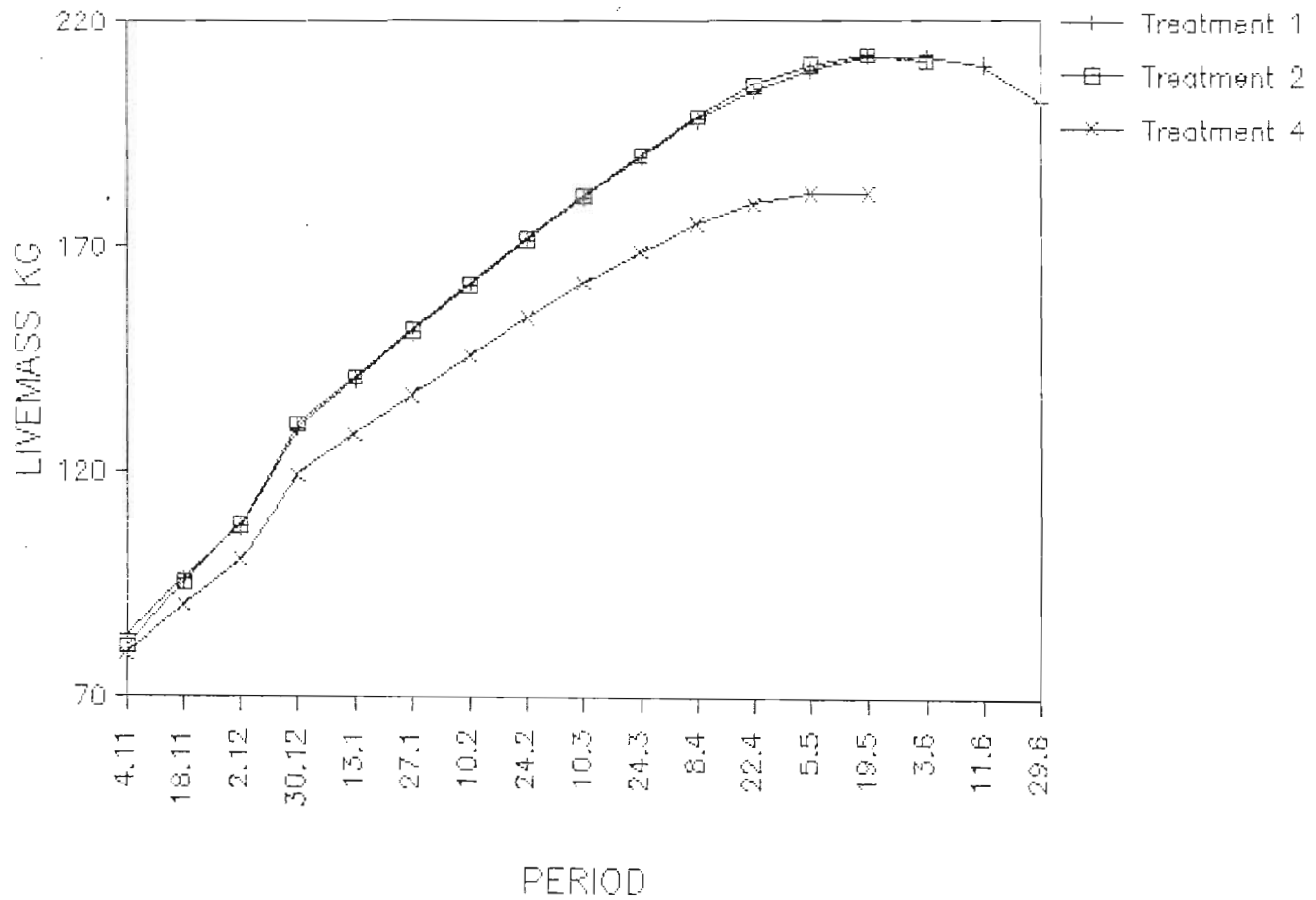


Figure 29c. Mass changes on veld of calves born to first calvers during the 1986/87 season.

the first calvers' calves were born three to four weeks earlier, on average, than those of the mature cows. This explains why the mature cows' calves had ADG's 10,8% (Tr.1), 3,4% (Tr.2) and 11,1% (Tr.4) higher than the calves born to the first-calf heifers, despite the similarity between the mean maximum masses of both groups of calves. This highlights the value of calving early in the season for first calvers. The reason for the sustained high level of production is probably due to two factors. Firstly, the heifers calved down at a time when good quality food was freely available, which enabled the animals' early lactational nutrient requirements to be met. Consequently, relatively high levels of milk production could be established which promoted calf growth. Adequate nutrition immediately post-partum also enabled the younger cows to maintain body condition thereby facilitating early cycling and successful conception. Secondly, by the time the grazing season commenced, the calves were approximately one month older than the calves suckled by the mature cows and therefore able to utilize the available herbage to a greater extent.

Mineral vs. urea/mineral lick supplementation

Lactating mature cows

The mass changes of the lactating mature cows in Tr.2 (1,0 cow + calf/ha - mineral lick) and Tr.3 (1,0 cow + calf/ha - urea lick) during phase 2 are presented in Figures 30a - 30e respectively. These figures indicate that the performance of the cows provided with a urea-based lick during the first 100 days on veld was not significantly better than that of the cows that received a mineral lick during the corresponding period. Whilst the cows in Tr.3 generally recorded slightly higher (NS) ADG's during the period of supplementation, the difference between the mean ADG's over the whole grazing season was

Table 45. Mean maximum mass (kg) average daily gains (ADG's - kg/day), number of grazing days and final condition scores for lactating mature cows receiving either a mineral (M) or urea (U) lick.

Treatment Cows + calves/ha Supplement	Tr. 2 1,0 M	Tr. 3 1,0 U
<u>Maximum mass</u>		
1982/83	448,81	454,70
1983/84	490,73	487,20
1984/85	500,21	489,00
1985/86	489,96	473,65
1986/87	476,39	506,50
	481,22 ± 20,0	482,21 ± 19,30
<u>ADG Day 0-100</u>		
1982/83	0,16	0,16
1983/84	0,37	0,53
1984/85	-0,01	0,06
1985/86	0,33	0,34
1986/87	-0,13	-0,12
	0,14 ± 0,21	0,19 ± 0,25
<u>ADG Initial - final mass</u>		
1982/83	0,04	0,02
1983/84	-0,07	0,01
1984/85	-0,21	-0,11
1985/86	-0,15	-0,06
1986/87	-0,17	-0,21
	-0,09 ± 0,10	-0,07 ± 0,09
<u>Final condition score</u>		
1982/83	2,01	2,13
1983/84	1,84	1,99
1984/85	2,18	2,24
1985/86	1,97	2,34
1986/87	1,93	2,33
	1,98 ± 0,12	2,20 ± 0,14
<u>No. of grazing days</u>		
1982/83	193	193
1983/84	224	224
1984/85	223	223
1985/86	237	237
1986/87	211	211
	217,60 ± 16,54	217,60 ± 16,54

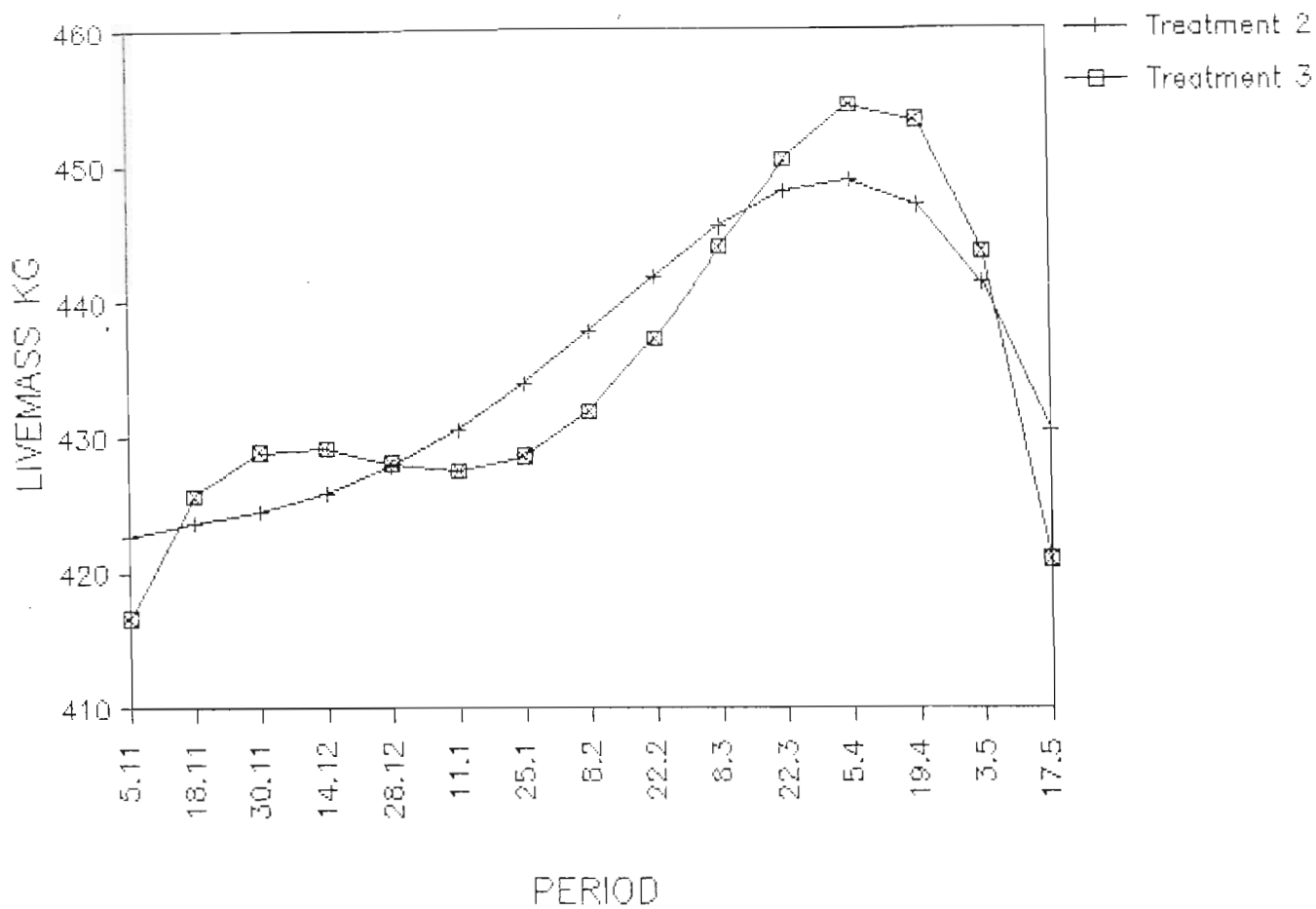


Figure 30a. Mean mass changes of lactating cows with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1982/83 season.

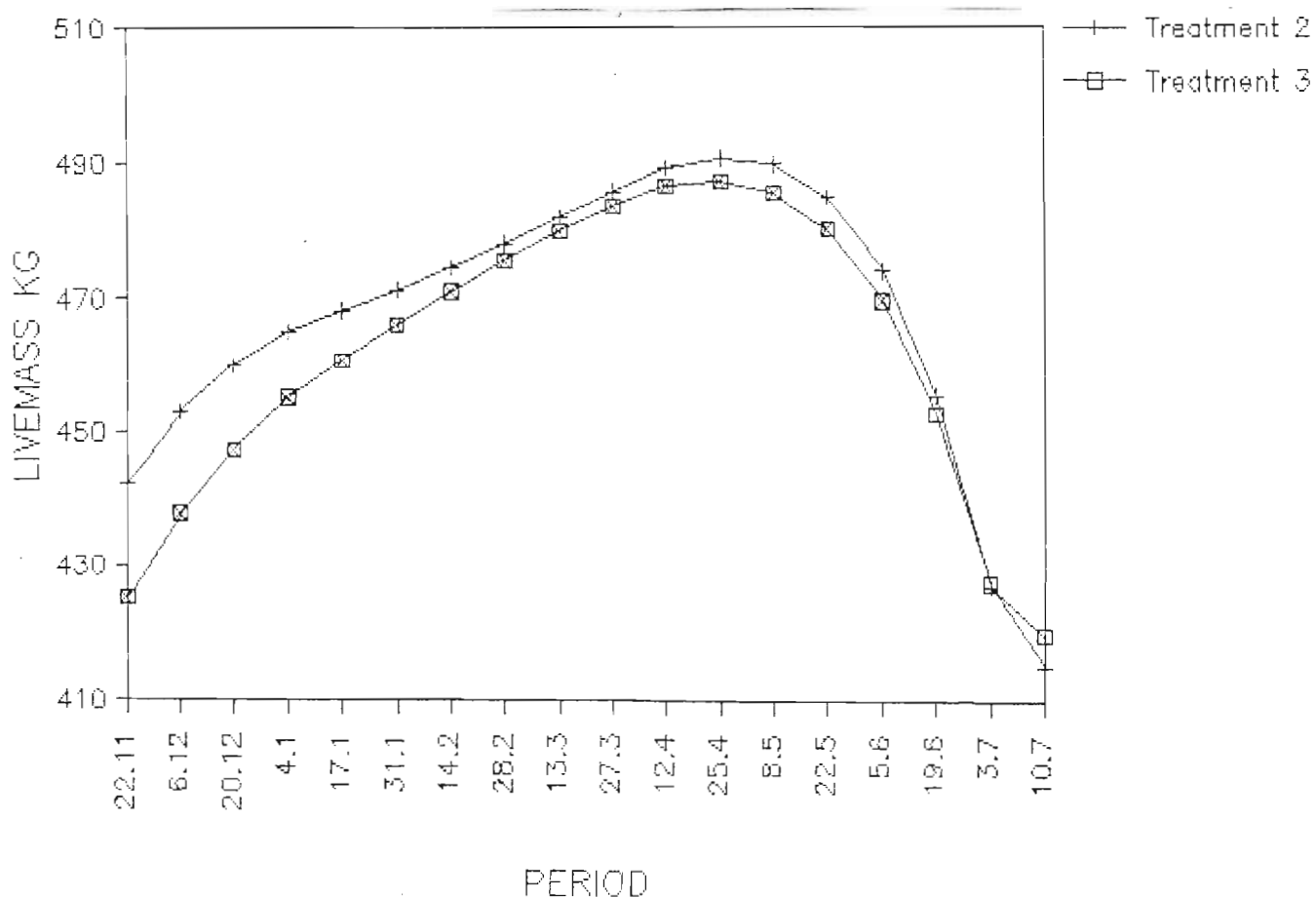


Figure 30b. Mean mass changes of lactating cows with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1983/84 season.

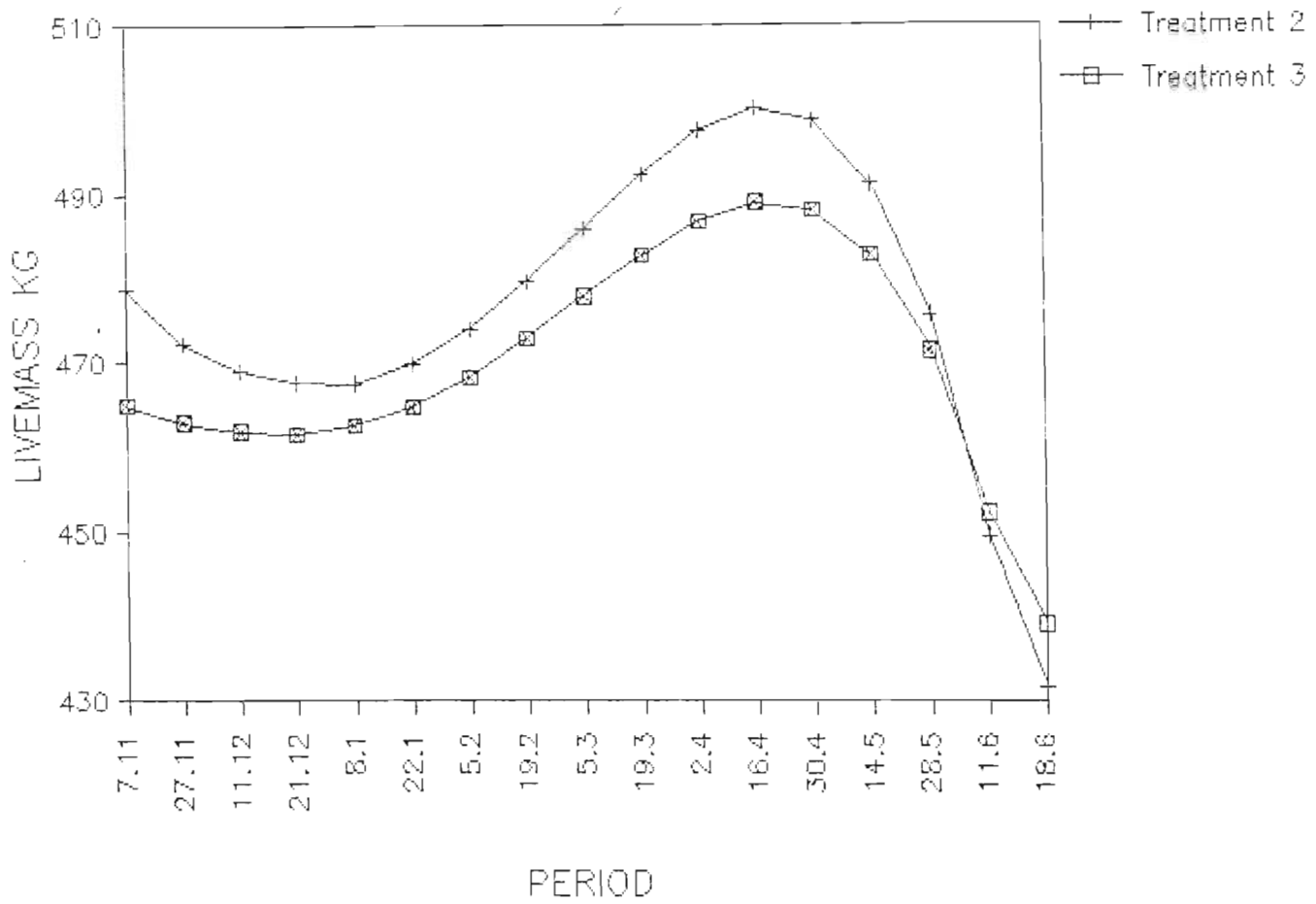


Figure 30c. Mean mass changes of lactating cows with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1984/85 season.

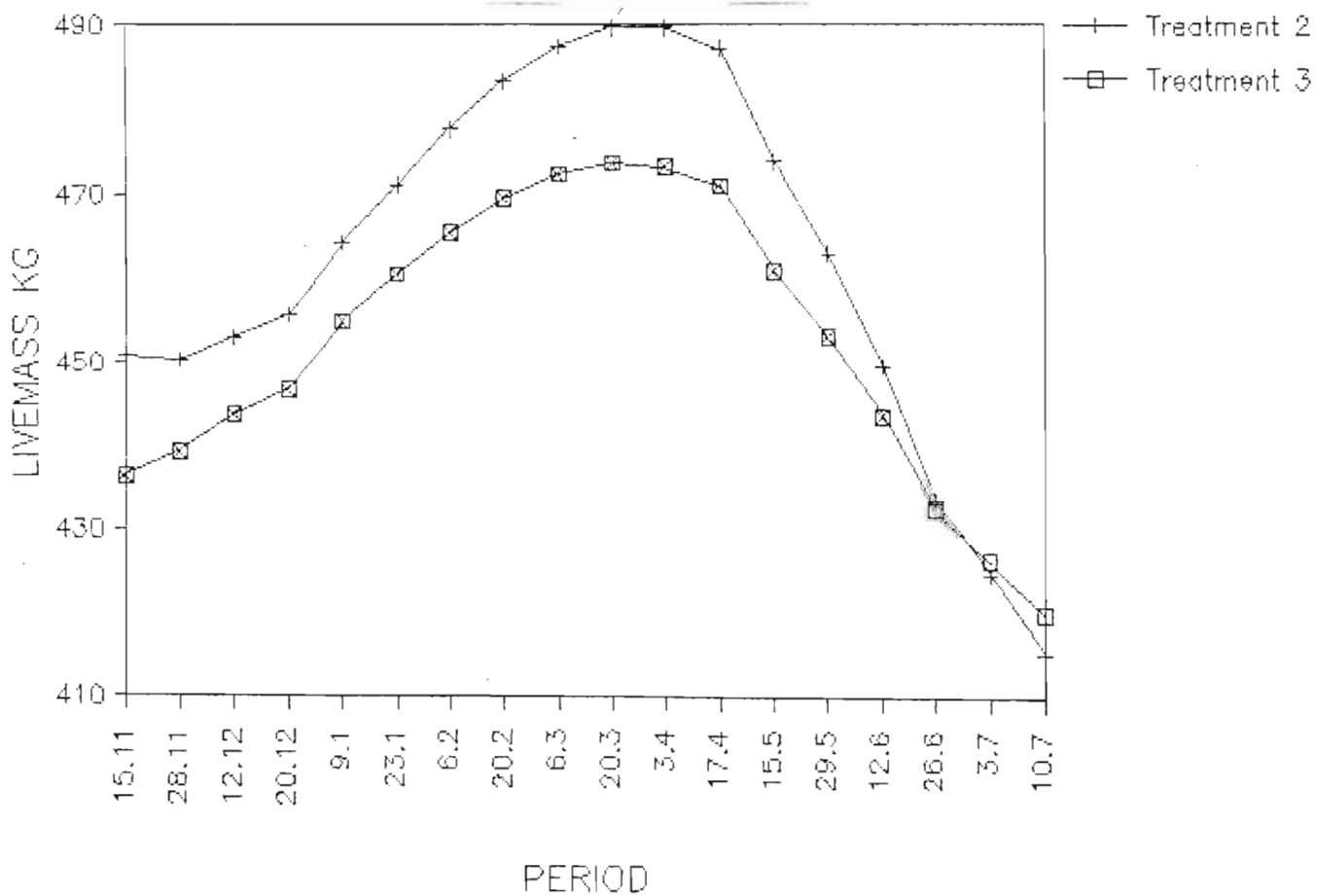


Figure 30d. Mean mass changes of lactating cows with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1984/85 season.

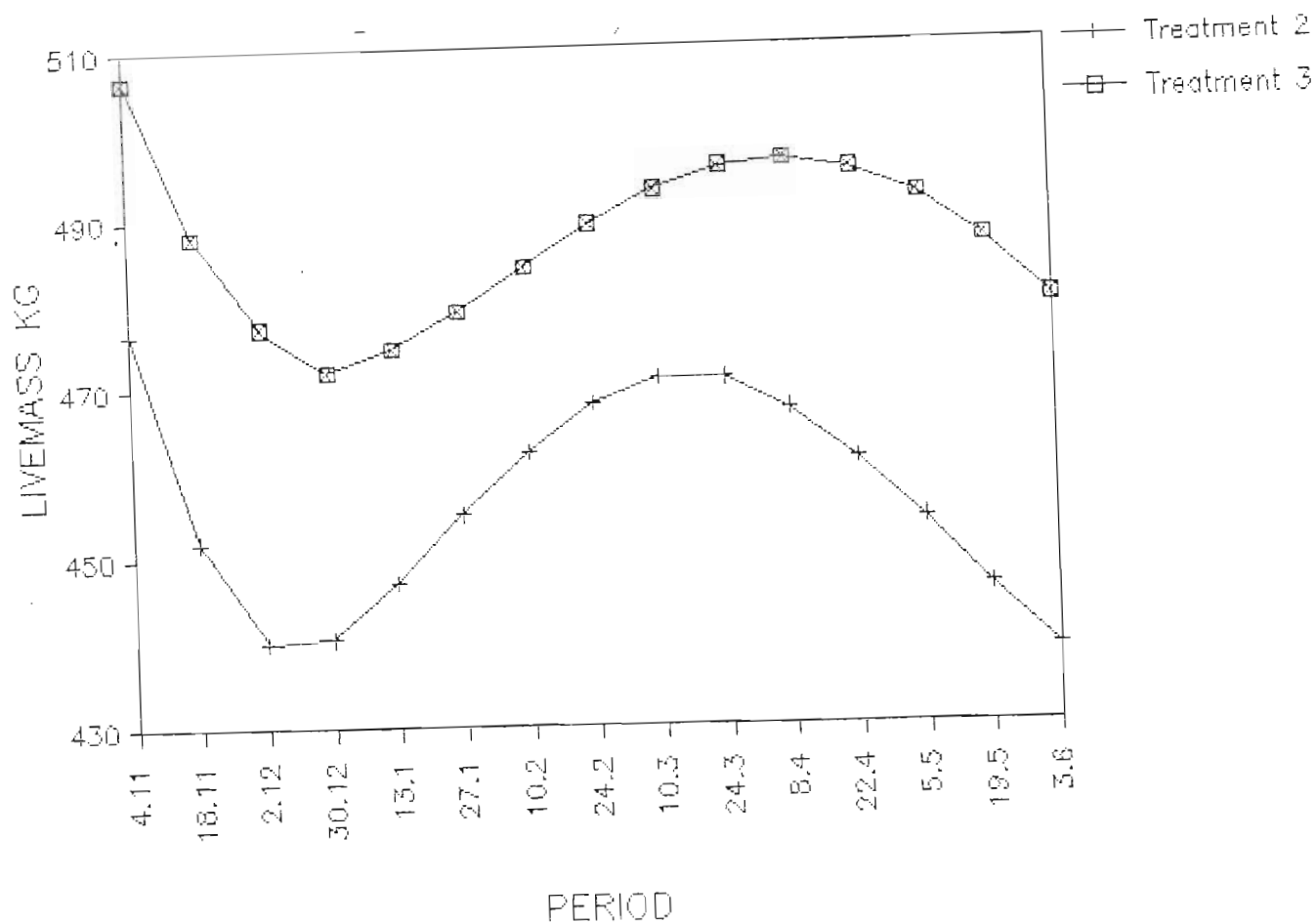


Figure 30e. Mean mass changes of lactating cows with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1986/87 season.

small and not statistically significant (Table 45). The cows in Tr.3 had 11,12% higher condition scores at the end of the grazing season than the cows in Tr.2. The difference in condition represents an additional 22 days of grazing for the cows with access to the urea lick from the start of the grazing season (Table 45).

First-calf heifers

The growth curves of the first calvers during the 1984/85, 1985/86 and 1986/87 seasons are shown in Figures 31a, 31b and 31c respectively. As was the case with the mature cows, there was no significant improvement in growth rates, during either the supplementation period or the entire season, between those first calvers provided with a urea lick and those that had access to a mineral lick (Table 45).

The first calvers in Tr.3 were not in better condition at weaning than the first calvers in Tr.2. In this case the cost of the lick outweighed the saving in winter feed. The first calvers therefore did not benefit from the urea-based lick to the same extent as the mature cows.

Calves - born to mature cows

The growth curves of these calves during the second phase of the experiment are shown in Figures 32a - 32e respectively. With the exception of the 1983/84 season, the difference in performance (Table 47) between the two groups of calves was small (NS). This result is not surprising as it is unlikely that the calves in Tr.3 would benefit directly from the urea lick. The consumption of lick during the early part of the grazing season would be very low as the calves would be largely reliant on their dams for their nutrient requirements.

Although the calves in Tr.3 showed slightly higher (NS) ADG's to maximum mass, both during the supplementation period, and over the

Table 46. Mean maximum mass (kg), average daily gains (ADG's - kg/day), number of grazing days and final condition score for lacting first calf heifers receiving either a mineral (M) or urea (U) lick.

Treatment Cows + calves /ha Supplement	Tr. 2 1,0 M	Tr. 3 1,0 U
<u>Maximum mass</u>		
1984/85	411,22	406,63
1985/86	448,29	449,10
1986/87	420,78	411,58
	426,76 ± 19,24	422,43 ± 23,22
<u>ADG Day 0 - 100</u>		
1984/85	-0,01	0,08
1985/86	0,19	0,15
1986/87	0,01	-0,07
	0,06 ± 0,11	0,05 ± 0,11
<u>ADG Initial - final mass</u>		
1984/85	-0,10	-0,08
1985/86	-0,06	-0,04
1986/87	0,01	-0,12
	-0,05 ± 0,05	-0,08 ± 0,03
<u>Final Condition Score</u>		
1984/85	2,02	2,16
1985/86	2,26	2,29
1986/87	2,08	1,93
	2,12 ± 0,12	2,12 ± 0,18
<u>No. of grazing days</u>		
1984/86	223	223
1985/86	237	237
1986/87	211	211
	223,66 ± 13,01	223,66 ± 13,01

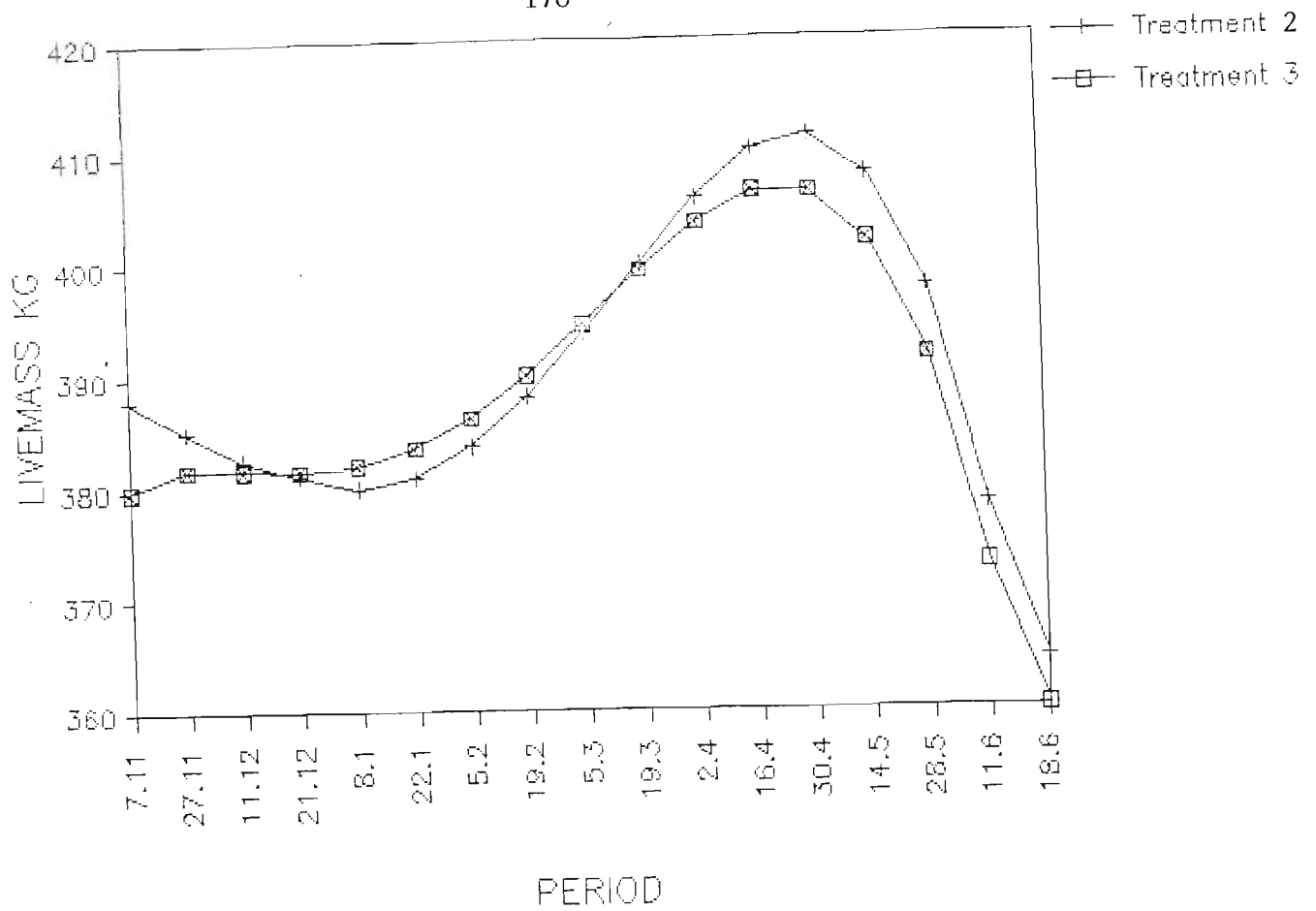


Figure 31a. Mean mass changes of first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1984/85 season.

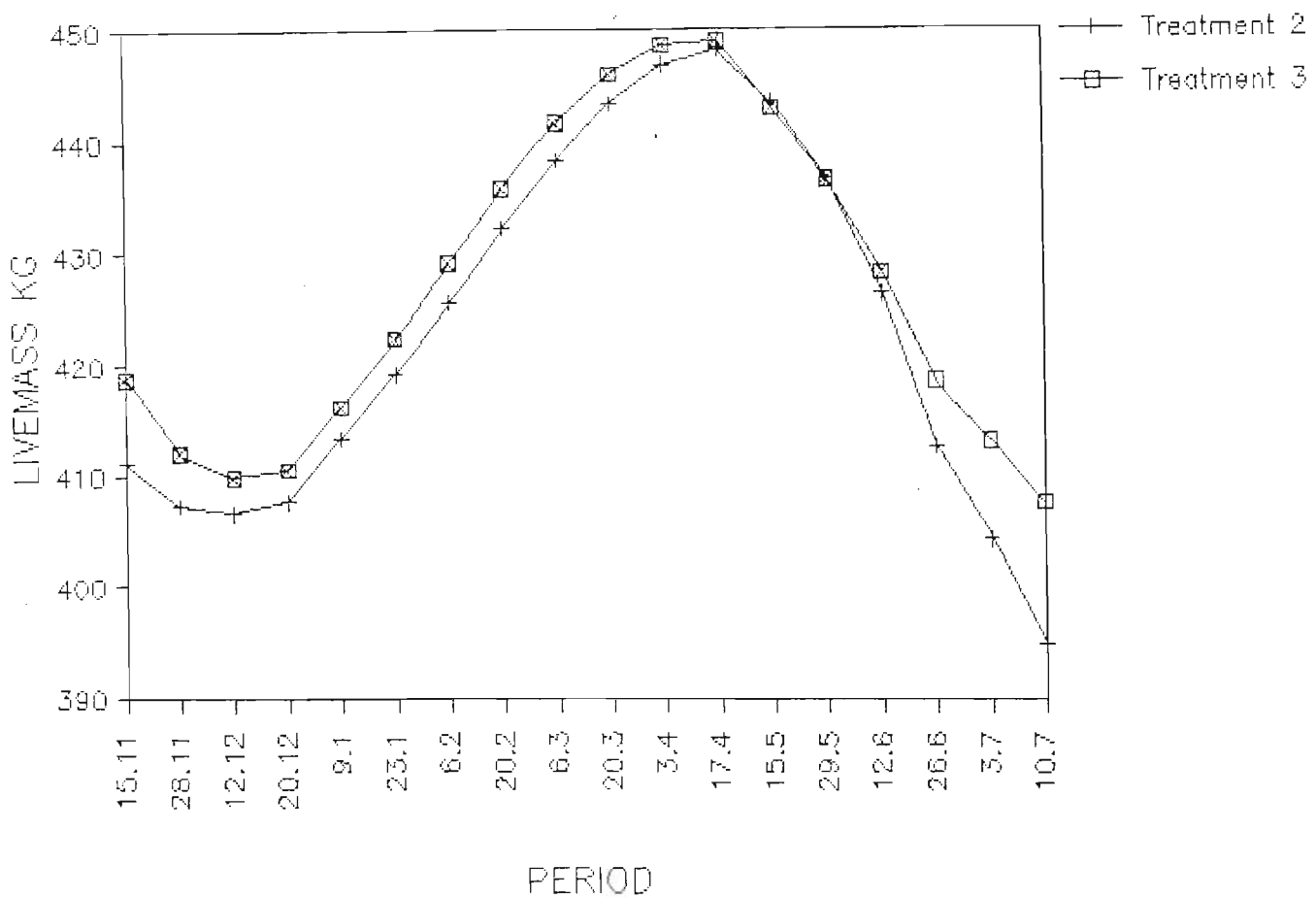


Figure 31b. Mean mass changes of first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1987/88 season.

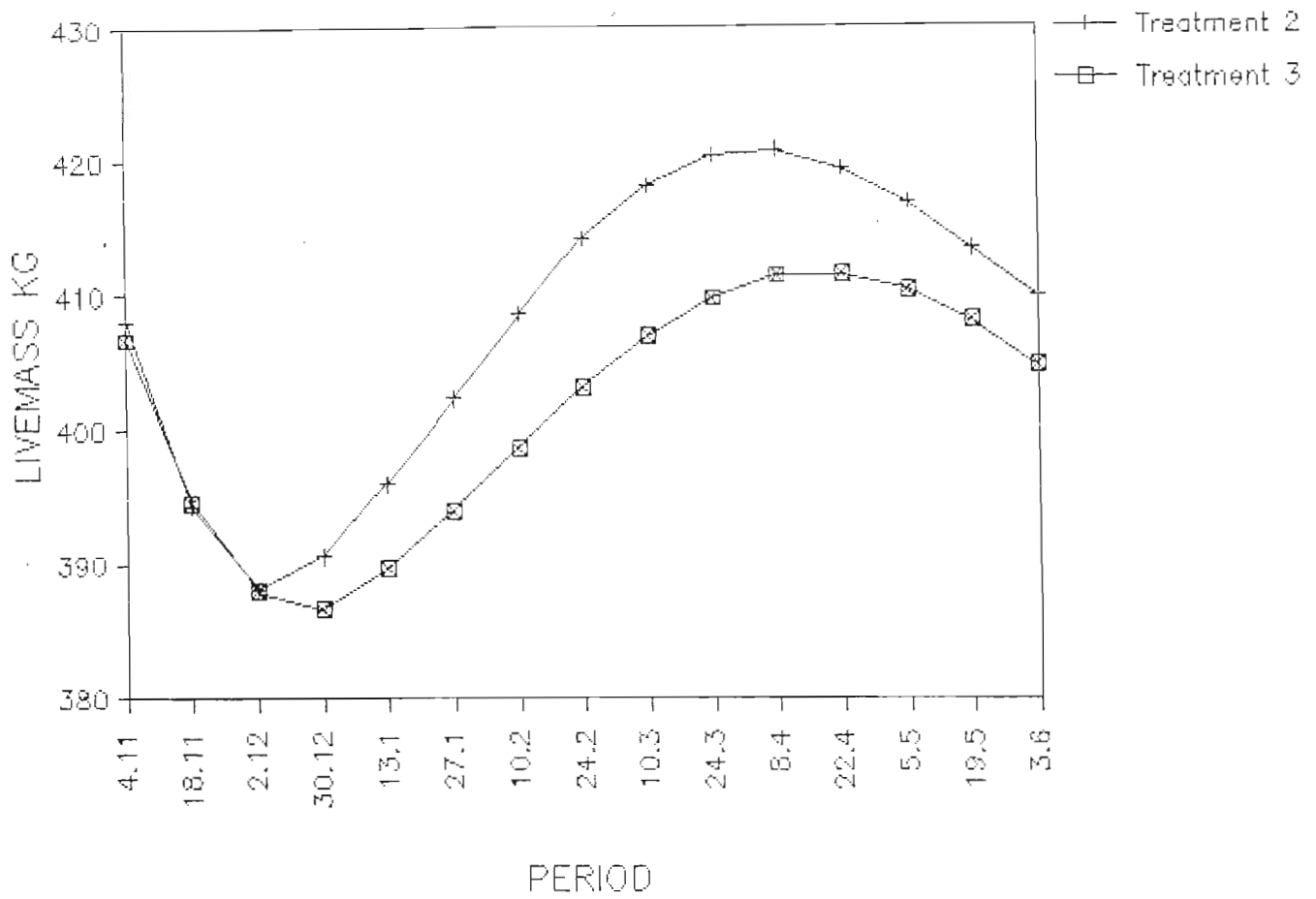


Figure 31c. Mean mass changes of first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick during the 1986/87 season.

whole season, than their counterparts in Tr.2, their weaning masses were not significantly higher. Whereas the benefit of a urea lick to the mature cows was evident from the lengthening of the grazing season, this did not apply to their offspring. Ideally, calves would be weaned at their peak mass.

Calves - born to first calvers

The growth curves for the calves born to the first calvers during the 1984/85, 1985/86 and 1986/87 seasons are presented in Figures 33a, 33b and 33c respectively. A comparison of the maximum masses attained by the calves in Treatments 2 and 3 (Table 48) indicates that no benefits were derived from the urea lick, either during the period of supplementation, or over the entire grazing period (Table 48). The performance of these calves largely reflects that of their dams, as the first calvers showed only minor responses to the urea lick.

Reproductive performance

The reproductive performances of the mature cows and the first calvers are presented in Table 49. Only two years data are presented. The various disease problems experienced rendered much of the earlier data unreliable, consequently only two years data are presented. Whilst no definite conclusions can be drawn, the trends in cow performance are however, of considerable interest.

As expected, the mature cows were significantly heavier ($P < 0.01$) than the first calvers at parturition, but the first calvers were in similar or better (NS) condition at calving than the mature cows. Body condition did not reflect the summer grazing treatments as all cows were fed according to their particular nutritional requirements during the winter feeding period. This resulted in all the cows having a

Table 47. Mean maximum mass (kg), average daily gains (ADG's - kg/day) and the number of grazing days for calves (born to mature cows) having access to either a mineral (M) or ureal (U) lick.

Treatment Cows + calves/ha Supplement	Tr. 2 1,0 M	Tr. 3 1,0 U
<u>Maximum mass</u>		
1982/83	194,68	194,53
1983/84	202,32	220,75
1984/85	220,68	210,47
1985/86	213,28	209,27
1986/87	203,63	201,87
	206,9 ± 10,4	207,37 ± 9,84
<u>ADG to max. mass</u>		
1982/83	0,66	0,68
1983/84	0,68	0,74
1984/85	0,71	0,67
1985/86	0,70	0,70
1986/87	0,71	0,68
	0,69 ± 0,07	0,69 ± 0,02
<u>ADG Day 0 - 100</u>		
1982/83	0,73	0,73
1983/84	0,81	0,86
1984/85	0,71	0,70
1985/86	0,88	0,91
1986/87	0,85	0,81
	0,79 ± 0,07	0,80 ± 0,08
<u>ADG Initial - final mass</u>		
1982/83	0,66	0,68
1983/84	0,53	0,59
1984/85	0,56	0,57
1985/86	0,52	0,52
1986/87	0,68	0,65
	0,59 ± 0,07	0,59 ± 0,06
<u>No. of grazing days</u>		
1982/83	193	193
1983/84	224	224
1984/85	223	223
1985/86	237	237
1986/87	211	211
	217,6 ± 16,54	217,6 ± 16,5

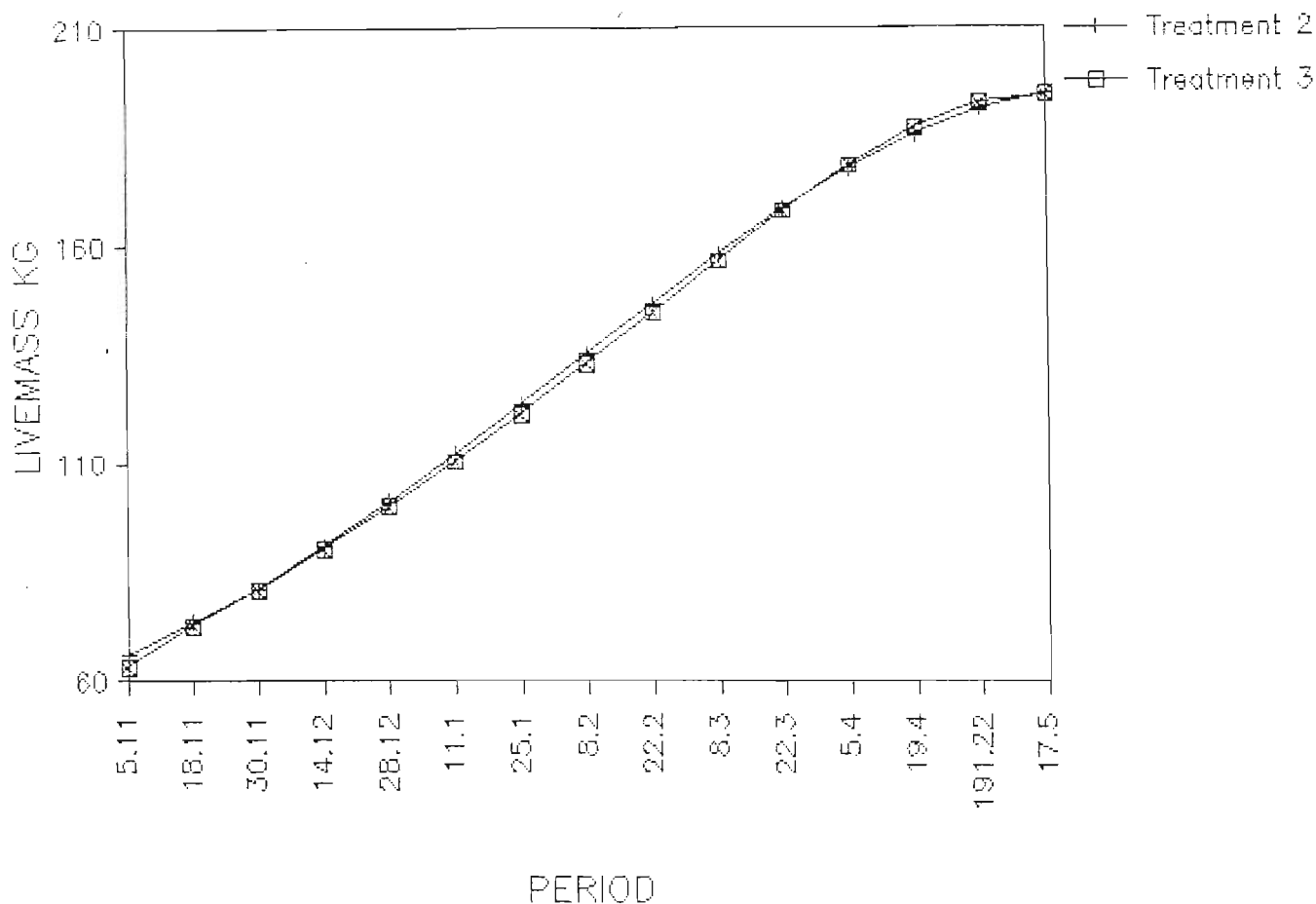


Figure 32a. Mass changes of calves born to mature cows with access to either a mineral (Tr.2) or urea (Tr.3) lick - 1982/83 season.

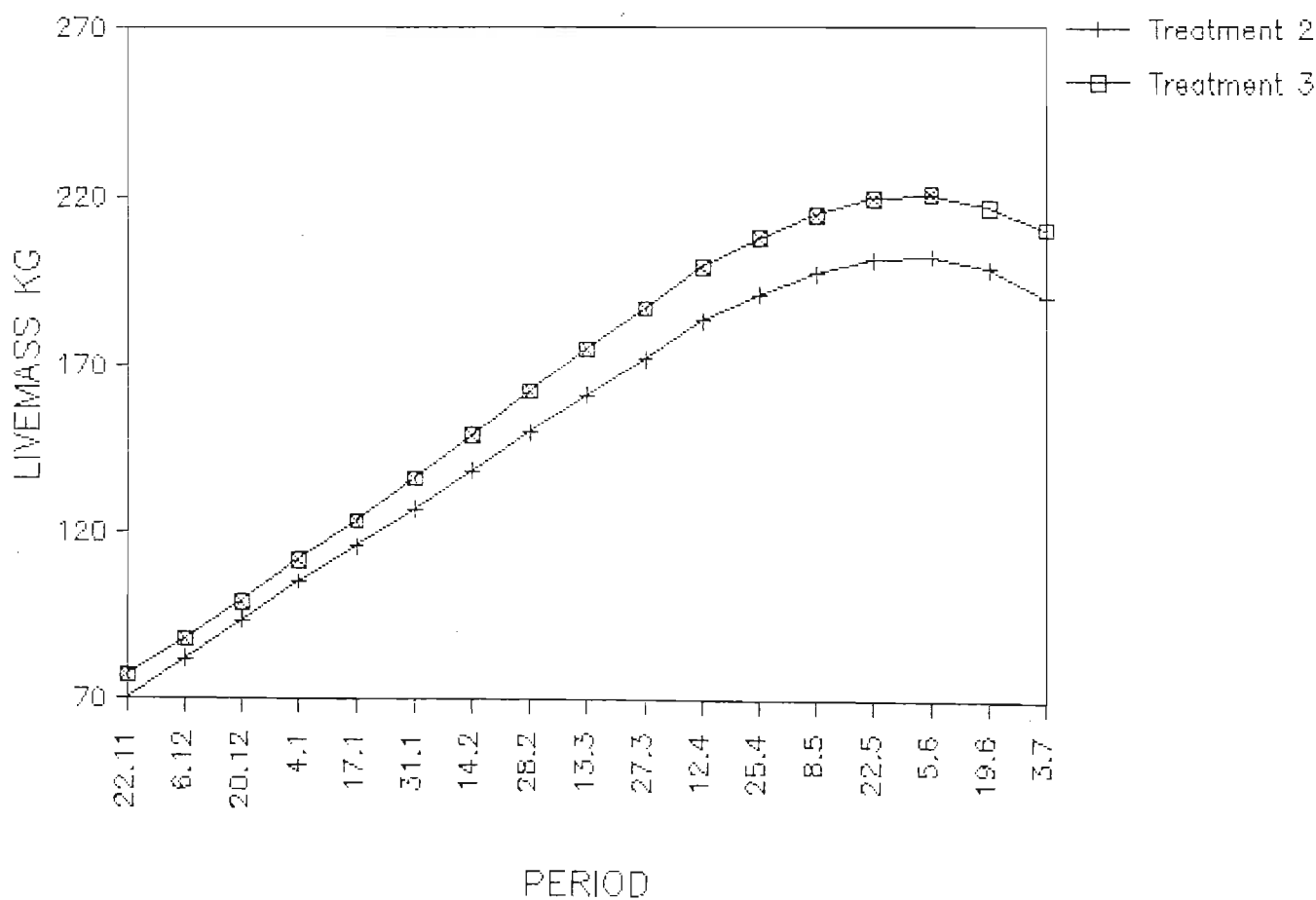


Figure 32b. Mass changes of calves born to mature cows with access to either a mineral (Tr.2) or urea (Tr.3) lick

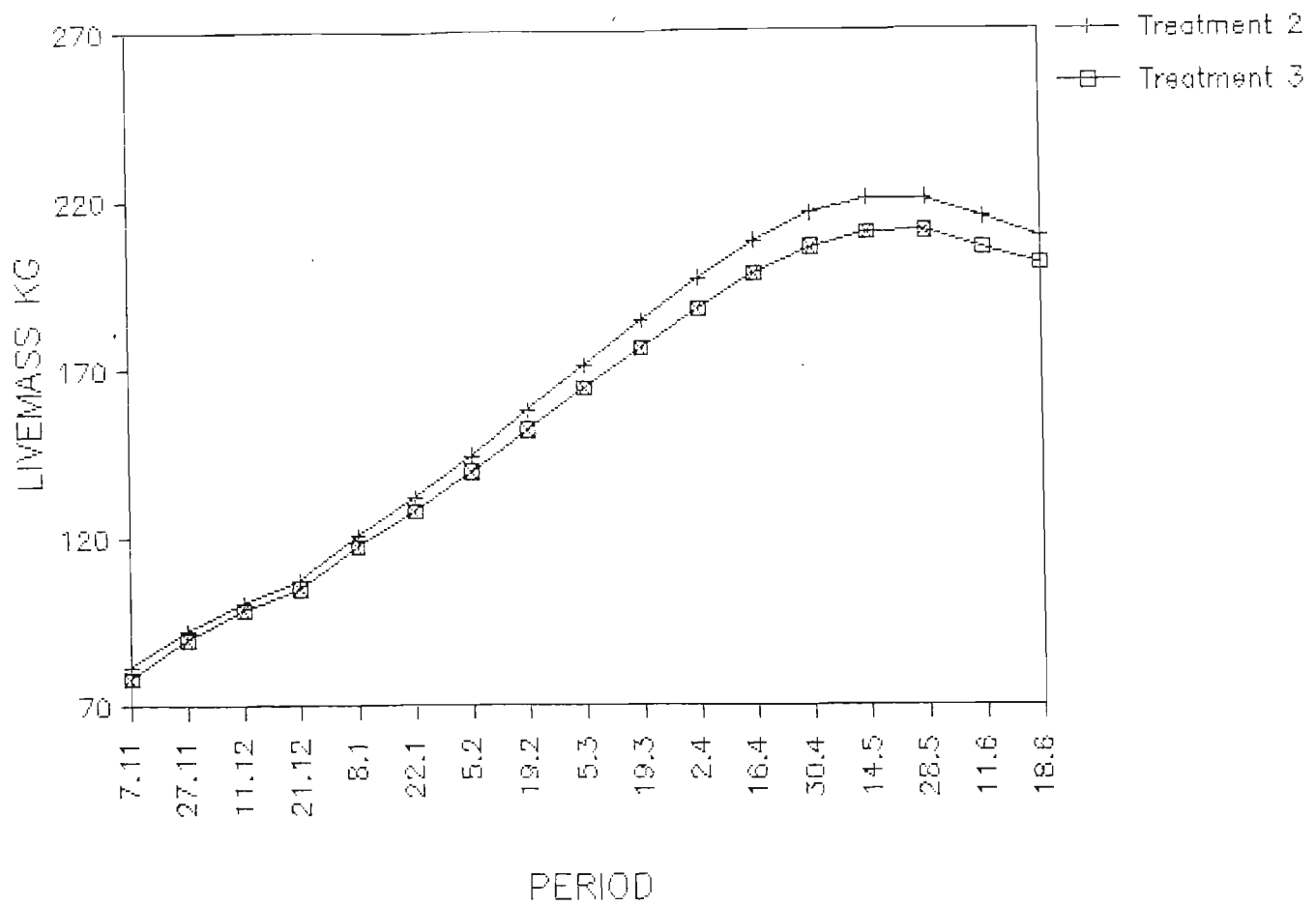


Figure 32c. Mass changes of calves born to mature cows with access to either a mineral (Tr.2) or urea (Tr.3) lick - 1984/85 season.

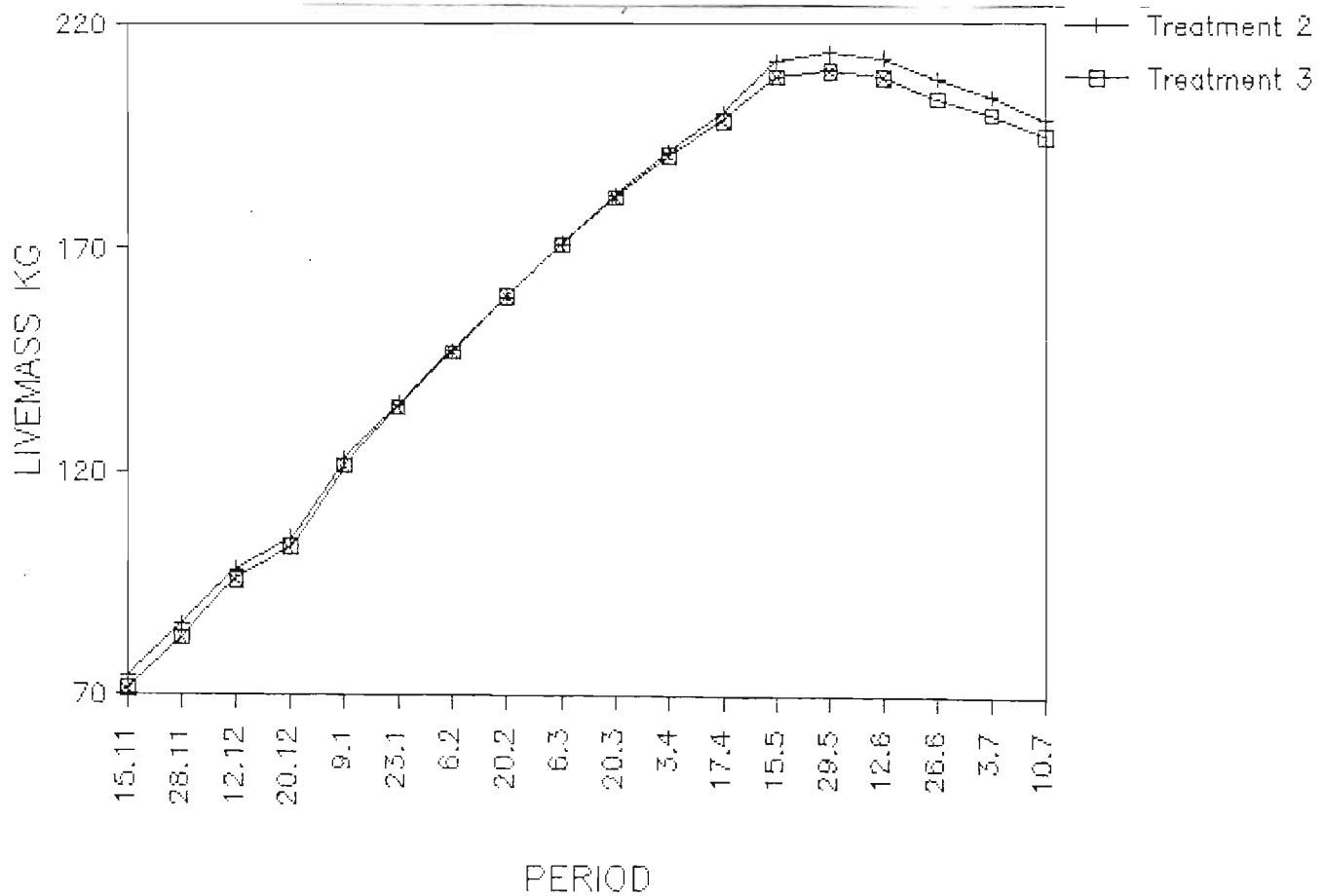


Figure 32d. Mass changes of calves born to mature cows with access to either a mineral lick (Tr.2) or urea (Tr.3) lick - 1984/85 season.

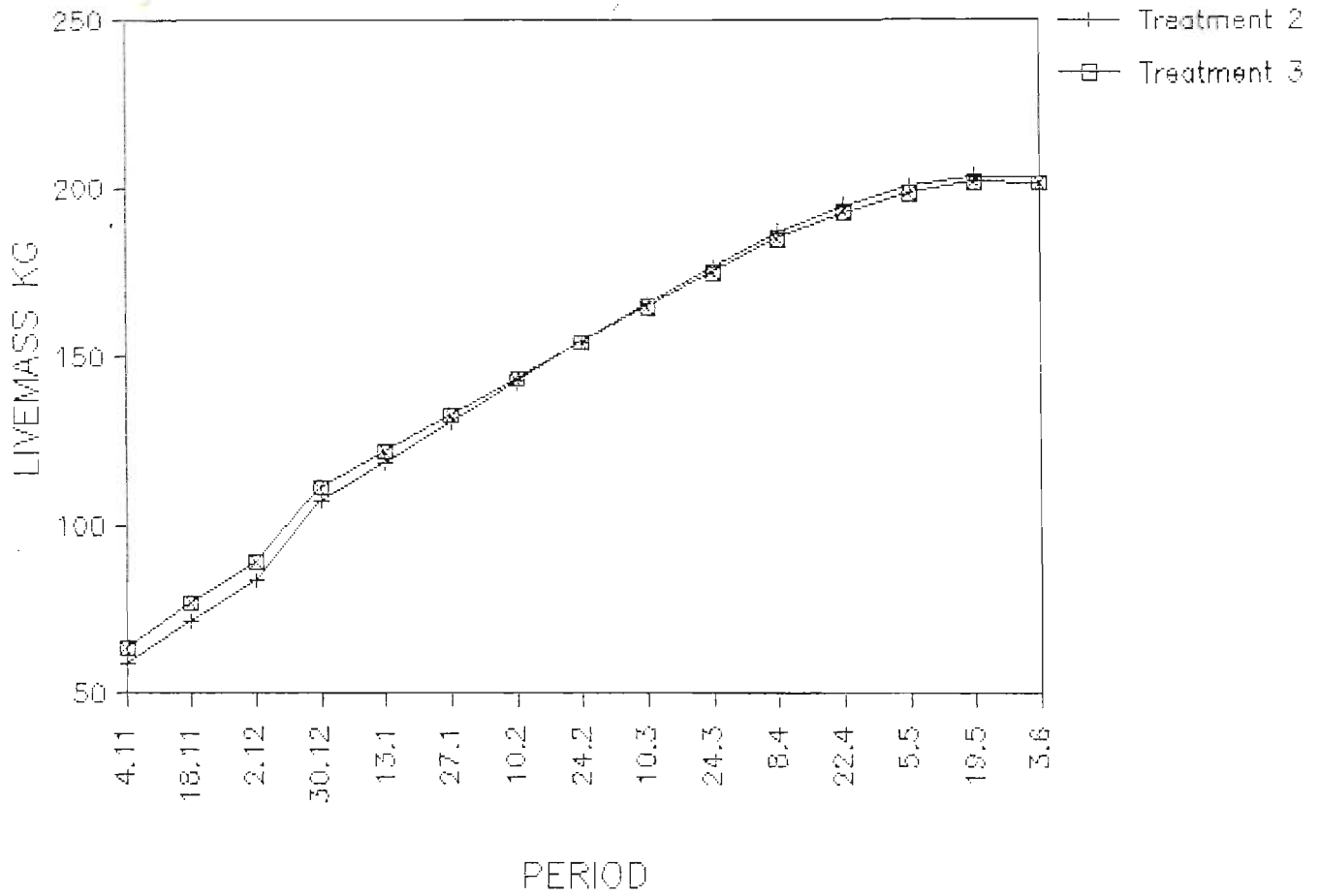


Figure 32e. Mass changes of calves born to mature cows with access to either a mineral (Tr.2) or urea (Tr.3) lick - 1986/87 season.

Table 48. Mean maximum mass (kg), average daily gains (ADG's - kg/day) and the number of grazing days for calves (born to first calvers) having access to either a mineral (M) or urea (U) lick.

Treatment Cows + calves/ha Supplement	Tr. 2 1,0 M	Tr. 3 1,0 U
<u>Maximum mass</u>		
1984/85	203,47	200,84
1985/86	234,16	222,07
1986/87	212,49	204,56
	216,70 ± 15,77	209,15 ± 11,33
<u>ADG to max. mass</u>		
1984/85	0,62	0,62
1985/86	0,73	0,70
1986/87	0,65	0,65
	0,67 ± 0,05	0,66 ± 0,04
<u>ADG Day 0-100</u>		
1984/85	0,64	0,64
1985/86	0,91	0,92
1986/87	0,81	0,78
	0,79 ± 0,13	0,78 ± 0,13
<u>ADG Initial - final mass</u>		
1984/85	0,47	0,51
1985/86	0,51	0,50
1986/87	0,61	0,58
	0,53 ± 0,07	0,53 ± 0,04
<u>No. of grazing days</u>		
1984/85	223	223
1985/86	237	237
1986/87	211	211
	223,66 ± 13,01	223,66 ± 13,01

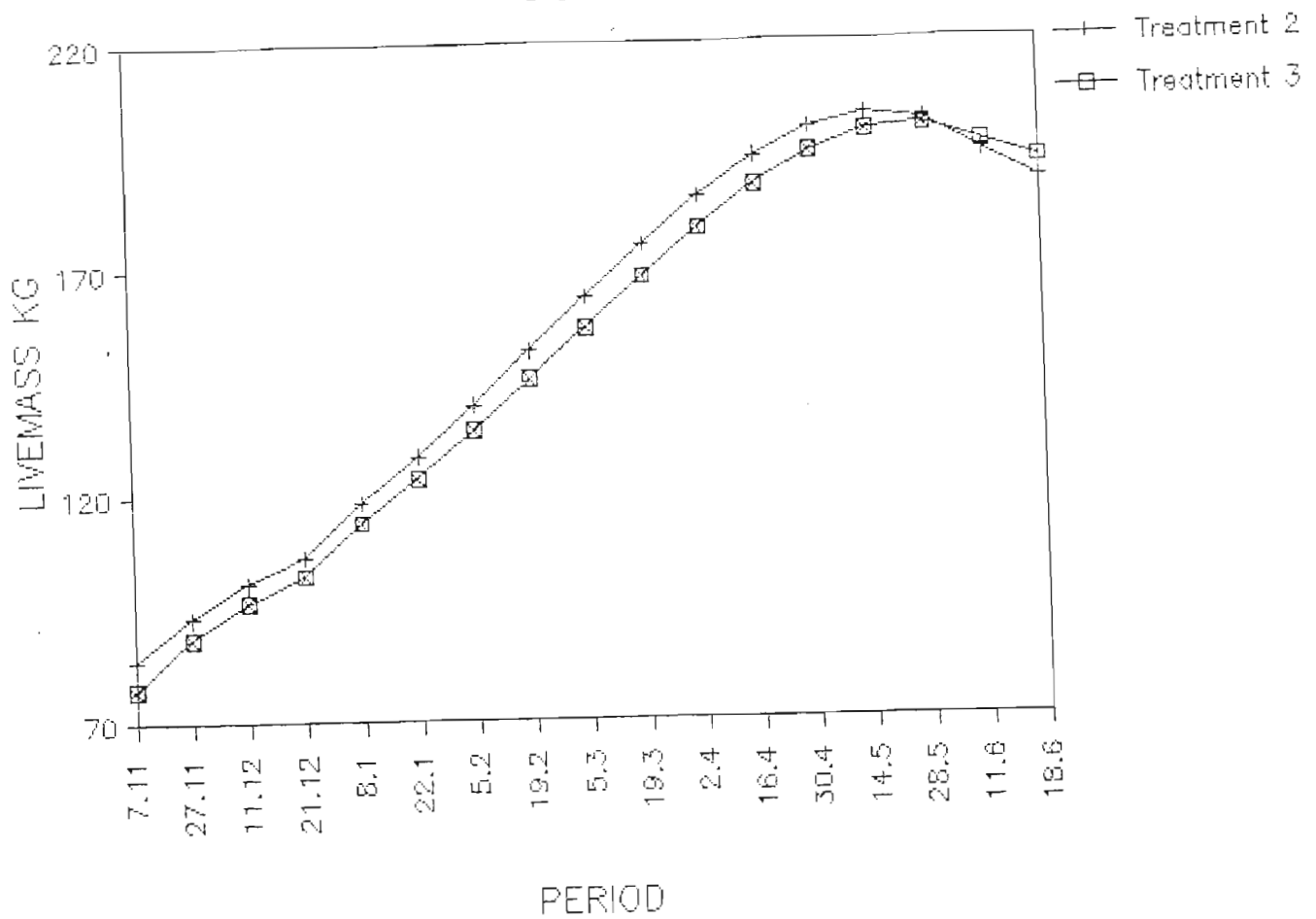


Figure 33a. Mass changes of calves born to first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick - 1984/85 season.

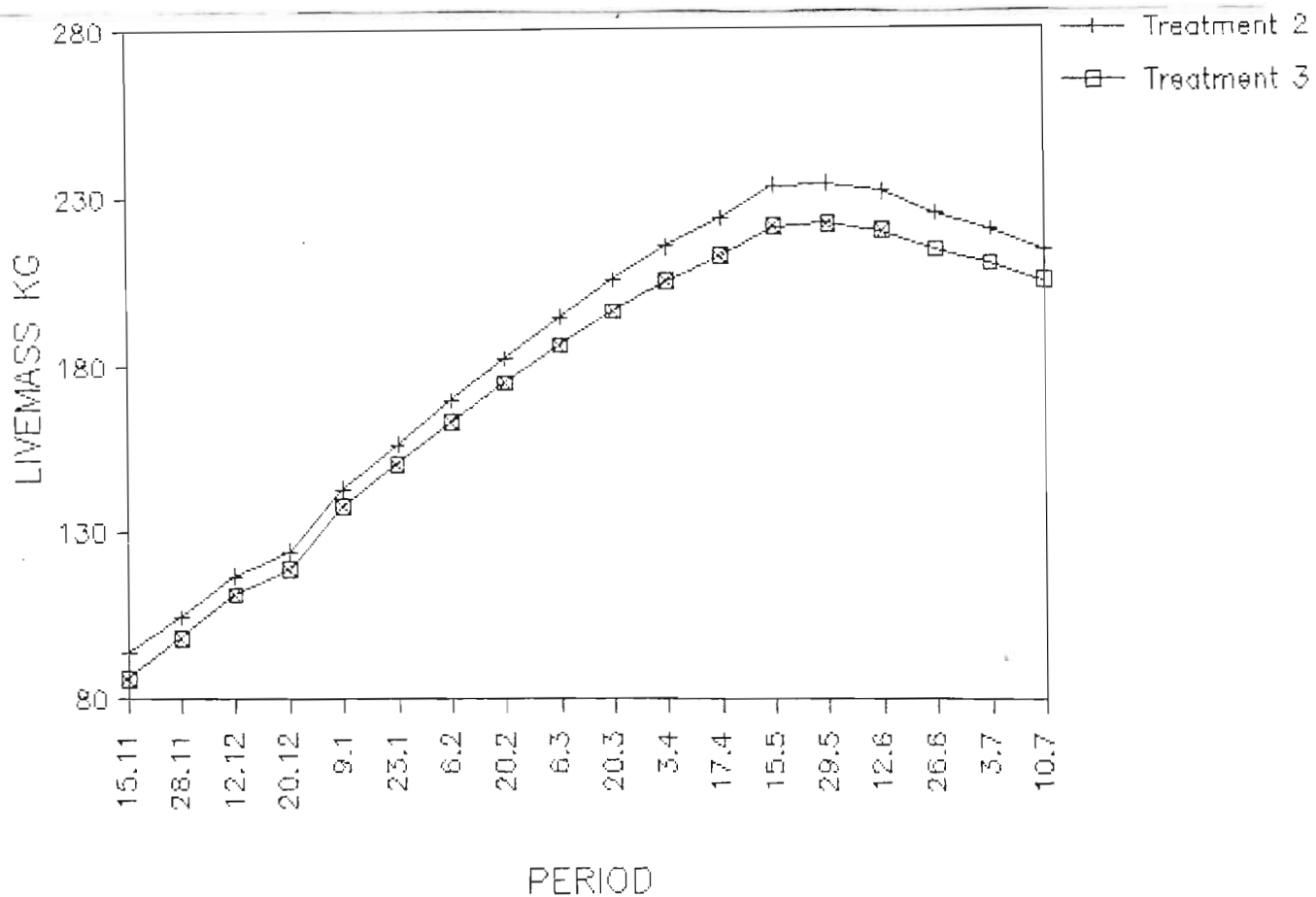


Figure 33b. Mass changes of calves born to first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick.

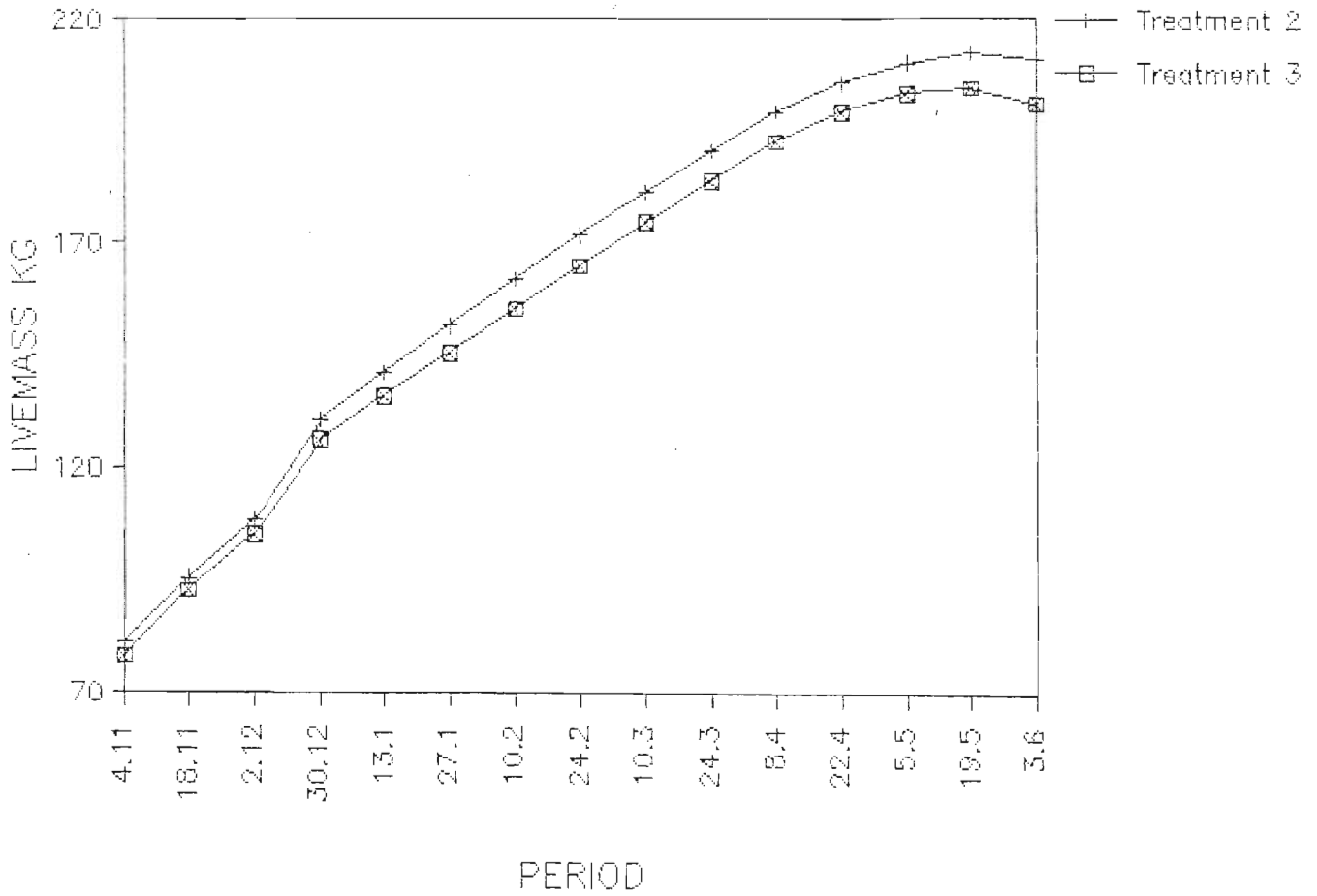


Figure 33c. Mass changes of calves born to first calvers with access to either a mineral (Tr.2) or urea (Tr.3) lick - 1986/87 season.

similar body condition at the onset of grazing (Figures 23a - 23e; 25a - 25c). It is therefore unlikely that the summer grazing strategy would have affected reconception rates significantly. The data in Table 49 validate this supposition. There was no significant correlation between stocking rate and pregnancy rates in either the mature cows or the first calvers. Furthermore, stocking rate did not seem to affect the time of conception (Table 49). The cows in Tr.4, despite being under pressure from the start of the grazing period, conceived relatively early in both seasons. During the 1985/86 season, the mature cows in Tr.1 and the mature cows and first calvers in Tr.2 conceived later in the season relative to the cows in the other treatments. The reason for this remains obscure but was not due to a "bull effect" as the bulls were rotated between treatments. The large standard errors recorded during both seasons indicates the high degree of variation within the data (Table 49).

Stocking rate did not affect the birth masses of the calves significantly (Table 49). Birth mass, expressed as a percentage of cow mass within 24 hours of parturition, was $7,65 \pm 0,50\%$ for the first calvers and $7,02 \pm 0,53\%$ ($P < 0,05$) for the mature cows. During the 1984/85 season, the mature cows generally produced significantly heavier calves than the first calvers. This trend was not repeated during the 1985/86 season.

Approximately 10% and 30% of the first calvers which had been diagnosed pregnant during the 1984/85 and 1985/86 seasons respectively, failed to produce a calf. It is assumed that they either aborted or reabsorbed their fetuses. These figures appear high, but the pregnancy diagnoses were carried out by experienced veterinarians. Although all the cows (and the first calvers in particular) were under considerable pressure at the high stocking rate, the high foetal mortality cannot be ascribed conclusively to the grazing regime.

Table 49. Reproductive performance of mature cows and first calvers during the 1984/85 and 1985/86 seasons.

Treatment	Tr. 1		Tr. 2		Tr. 3		Tr. 4	
Stocking rate	0,83 cows + calves/ha		1,0 cow + calf/ha		1,0 cow + calf/ha		1,25 cow + calf/ha	
Class of cow	Mature	1st Calver	Mature	1st Calver	Mature	1st Calver	Mature	1st Calver
<u>Season 1984/85</u>								
Cow mass at calving (kg)	454,73	426,75	486,41	402,27	477,50	411,57	512,21	440,86
CS at calving	2,83 ± 0,49	3,07 ± 0,27	3,06 ± 0,43	2,82 ± 0,25	2,86 ± 0,53	3,07 ± 0,19	3,11 ± 0,21	3,07 ± 0,19
Calf birth mass (kg)	31,33 ± 3,29	32,89 ± 4,89	31,00 ± 4,39	28,18 ± 4,92	34,57 ± 6,73	30,29 ± 3,14	31,71 ± 4,21	30,57 ± 3,99
Mean calving date	20,24 ± 12,76	24,10 ± 17,95	33,47 ± 16,09	25,09 ± 7,19	24,00 ± 9,69	25,29 ± 7,27	18,62 ± 5,16	24,57 ± 6,63
% Pregnant	94,4	100,0	89,5	100,0	89,5	63,6	75,0	80,0
% Calved	94,4	83,3	89,5	100,0	89,5	63,6	75,0	70,0
Calved within 1st 20 days (%)	64,5	50,0	23,53	27,27	37,5	0	69,23	42,86
<u>Season 1985/86</u>								
Cow mass at calving (kg)	457,69	398,46	466,18	417,43	445,45	423,43	455,45	400,00
CS at calving	2,65 ± 0,52	2,75 ± 0,38	2,64 ± 0,45	2,71 ± 0,43	2,82 ± 0,75	2,82 ± 0,25	2,59 ± 0,44	2,38 ± 0,48
Calf birth mass (kg)	31,54 ± 4,81	31,21 ± 3,09	34,45 ± 5,57	34,36 ± 4,72	33,28 ± 5,31	34,43 ± 5,63	31,45 ± 7,33	32,00 ± 5,03
Mean calving date	35,15 ± 20,48	28,86 ± 8,65	45,36 ± 13,34	37,93 ± 10,10	29,55 ± 16,05	21,29 ± 7,39	24,64 ± 7,65	22,83 ± 13,29
% Pregnant	92,9	93,8	78,6	100,0	84,6	88,2	84,6	100,0
% Calved	92,9	87,5	78,6	93,8	84,6	82,4	76,9	70,6
Calved within 1st 20 days (%)	38,46	7,14	0	0	36,36	50,0	36,36	33,33

* Days after day 1 of calving season.

* P < 0,05

** P < 0,01

*** P < 0,001

The provision of a urea-based lick during the early part of the grazing season did not improve reconception rates significantly, but it is evident that the cows in Tr.3 conceived, on average, 14 days earlier than the cows in Tr.2.

Herbage quality and availability

Crude protein

The quality of the natural grazing, as measured by crude protein analyses, for the 1982/83, 1983/84, 1984/85 and 1986/87 seasons, is shown diagrammatically in Figures 34a - 34d respectively.

Higher CP values were recorded more frequently in the camps allocated to Tr.2 and Tr.4 than in the Tr.1 and Tr.3 camps. The lowest CP values during all the seasons were consistently recorded in Tr.1. This could have resulted from the build-up of material often associated with low stocking rates. The relatively high CP values recorded in Tr.4 is probably because of the association between regrowth material and a high stocking rate. The difference in CP values between Tr.2 and Tr.3 cannot be ascribed to the effects of stocking rate since the stocking rate was theoretically identical for the two treatments. Although these two sets of camps adjoined one another, the aspect varied slightly, and this was possibly sufficient to affect herbage quality.

There was considerable inter-seasonal variation in veld quality. A large proportion of this variation can be ascribed to poor rainfall during October, November and December. The relatively poor quality of the grass in November and December 1982 and December and January 1984/85 coincided with poor rainfall during November and December in each of those seasons (Table 26). Sufficient rainfall, at critical times, is apparently a vital factor in influencing veld quality in the Highland Sourveld.

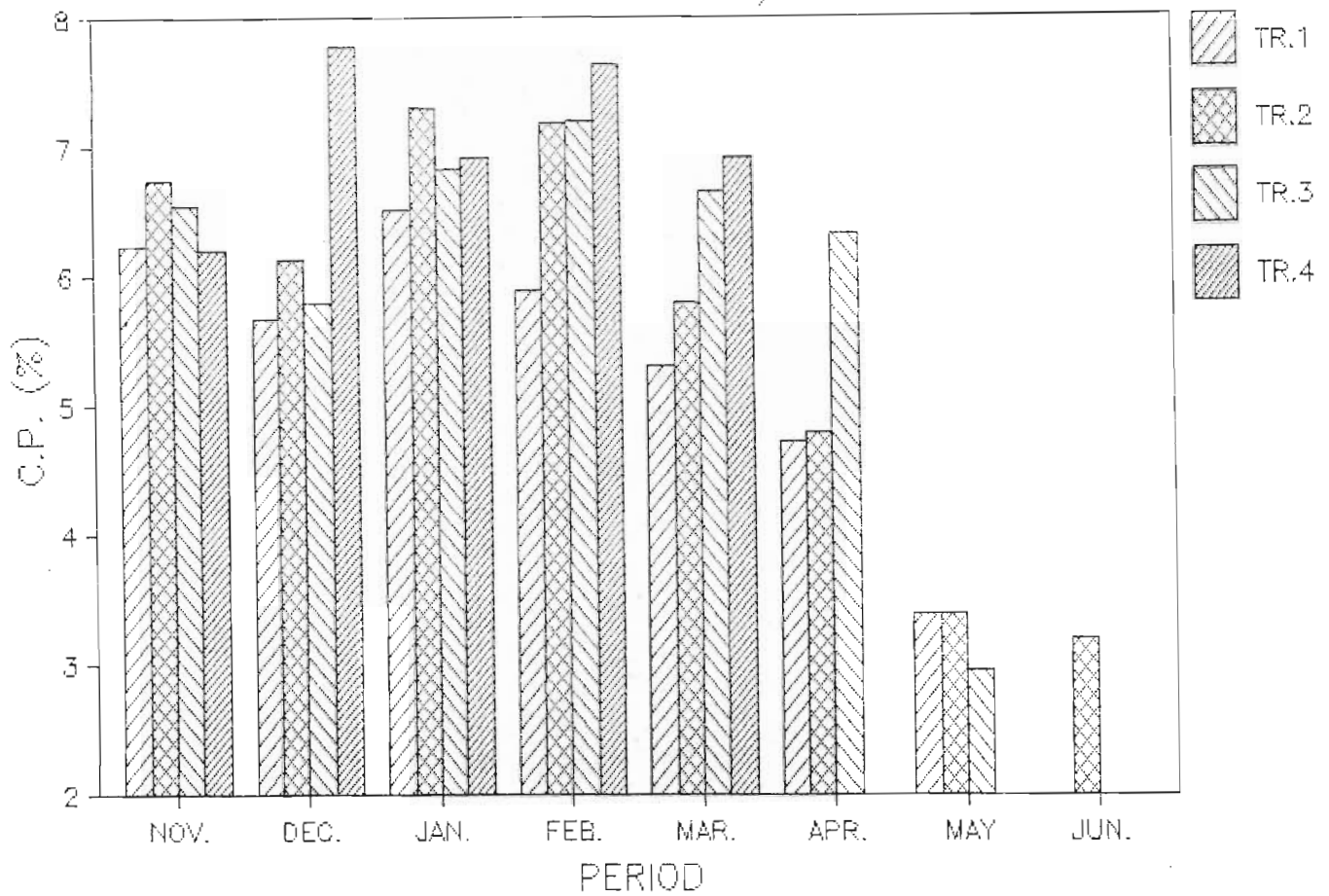


Figure 34a. Seasonal changes in the crude protein content of the veld during the 1982/83 season.

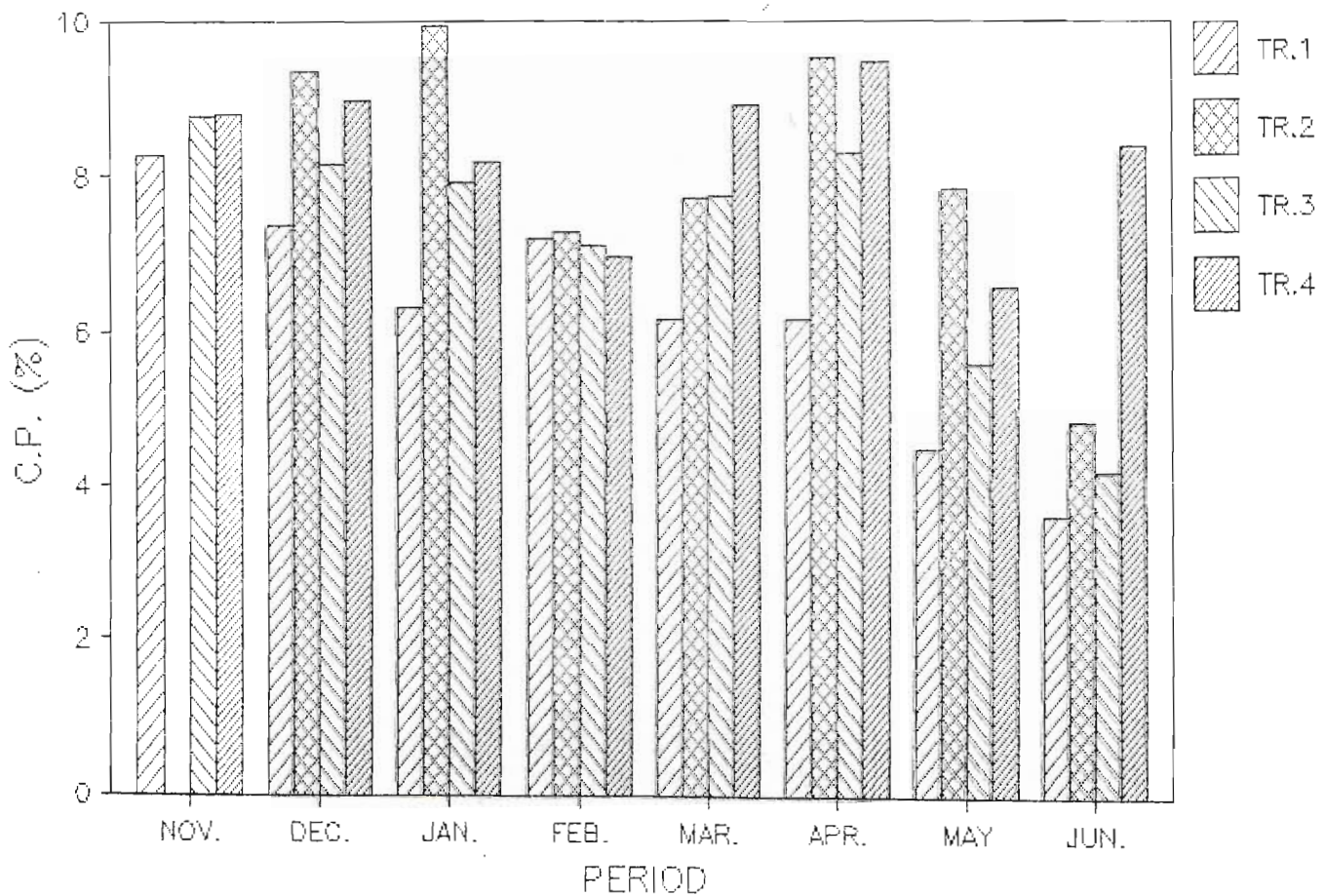


Figure 34b. Seasonal changes in the crude protein content of the veld during the 1983/84 season.

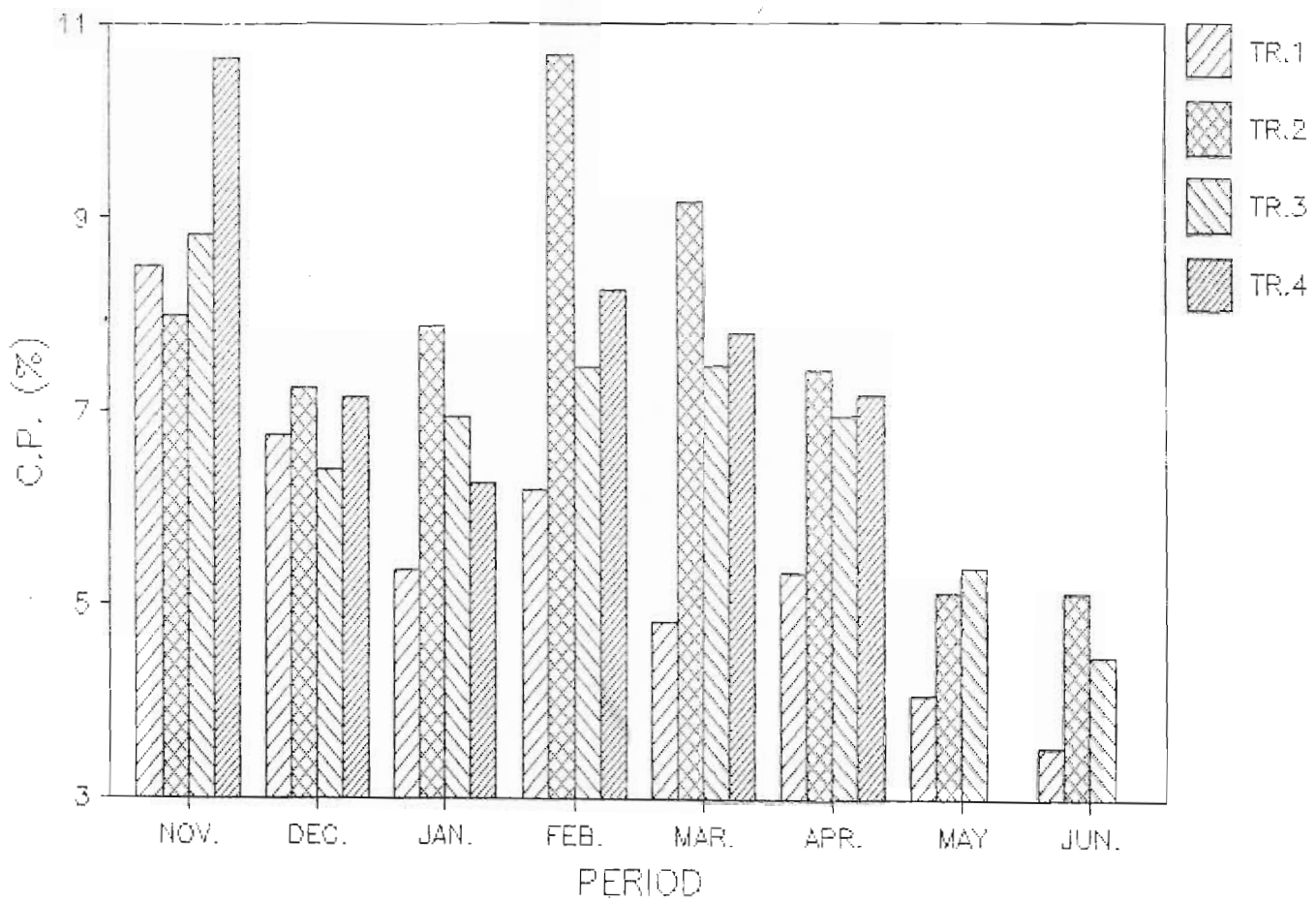


Figure 34c. Seasonal changes in the crude protein content of the veld during the 1984/85 season.

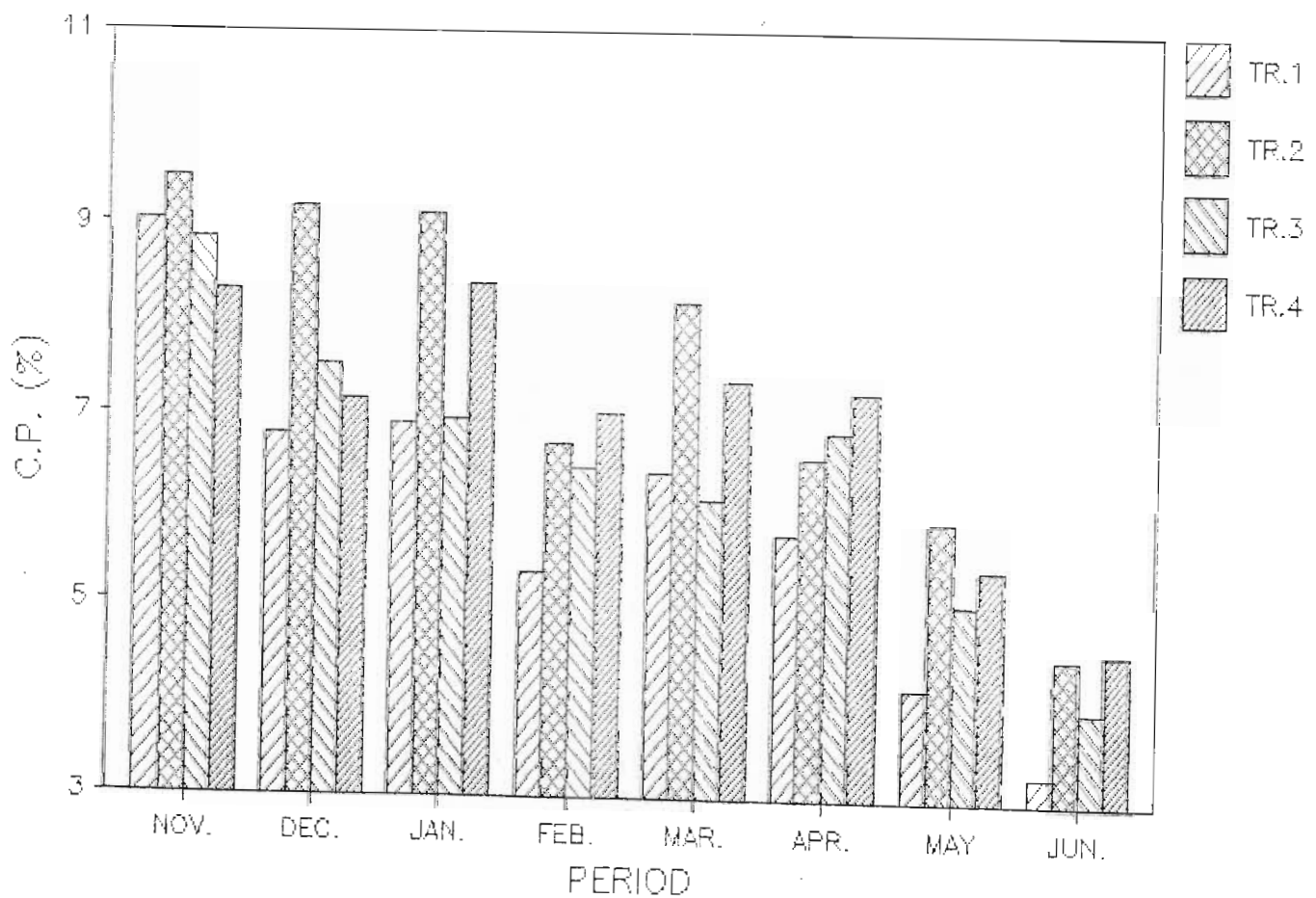


Figure 34d. Seasonal changes in the crude protein content of the veld during the 1985/86 season.

Herbage yield

Herbage yield samples were collected from the beginning of the 1982 season. During the 1982/83, 1983/84 and 1984/85 seasons the samples were harvested with a mower which, because of the height of the cut, did not provide a representative sample of the grass available to the animal. Unfortunately, the relationship between the cut sample and the probable amount of grass available was extremely variable and regressions could not be calculated. These data were therefore considered unreliable and have not been included for discussion.

The results from the herbage yield analyses for the 1985/86 and 1986/87 seasons are presented diagrammatically in Figures 35a and 35b respectively. A significant feature of these results is the increase in herbage production from the camps allocated to Tr. 1. These results verify visual observations which indicated that the grass in Tr.1 was becoming increasingly rank with progressing seasons. The increase in production was associated with a decrease in crude protein in these camps (Figures 34b, 34c and 34d). Clearly, the veld management programme of the camps stocked at the light stocking rate (0,83 cows + calves/ha) should be modified if a high production level of good quality were to be maintained. It is evident from Figures 35a and 35b that the amount of herbage available at the end of the 1985/86 and the beginning of the 1986/87 season was similar in Tr.1, but higher in Tr.2, Tr.3 and Tr.4. Herbage yield within Tr.2, Tr.3 and Tr.4 during February, March and April of the 1985/86 season, remained relatively constant. This suggests that herbage growth was equivalent to the animals' intake. During the 1986/87 season, herbage production in Tr.3 and Tr.4 remained relatively constant, but production in Tr.1 and Tr.2 showed a typical seasonal curve with an increase in herbage yield up to the end of March, and a decline during April, May and June. Treatment 2

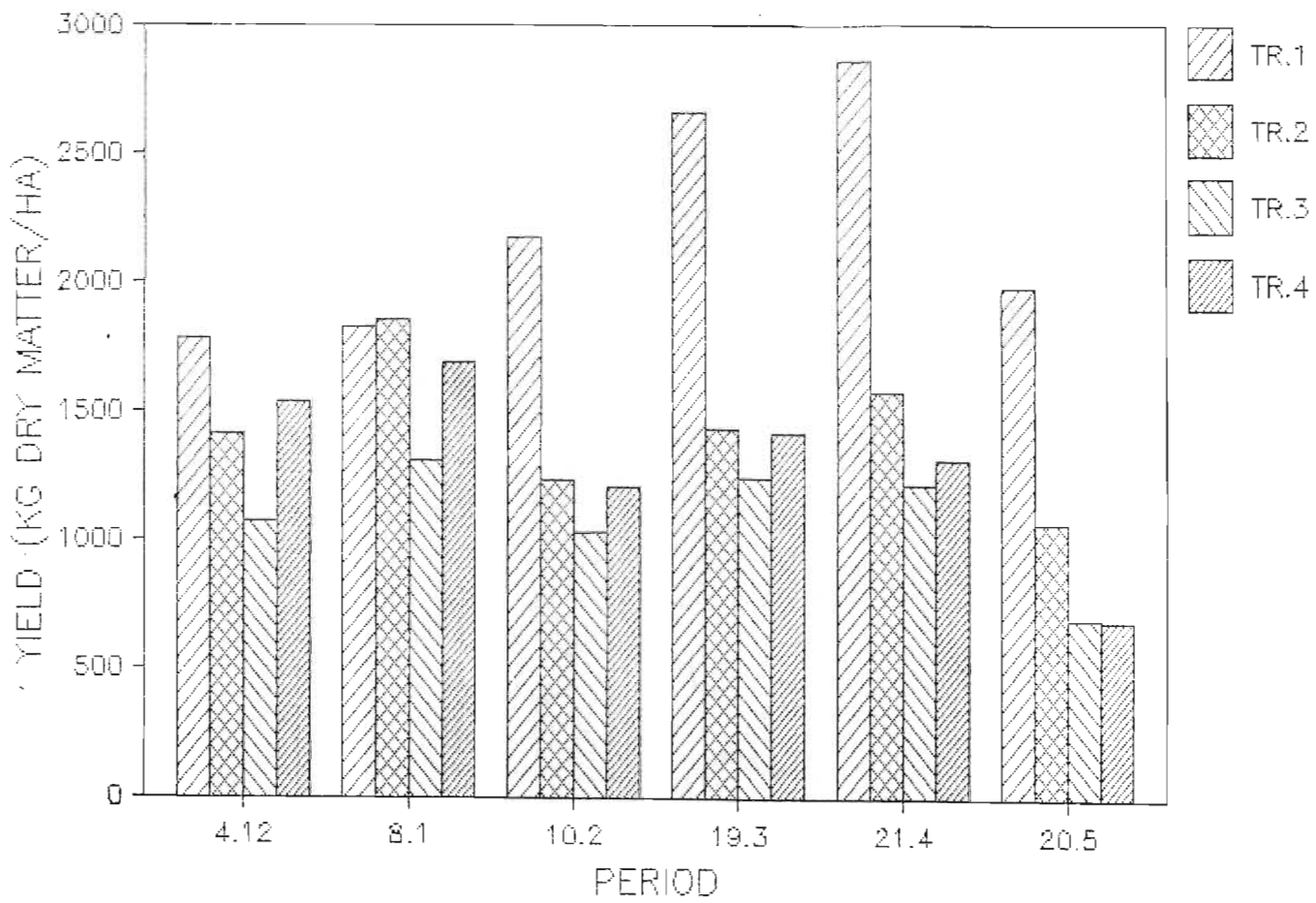


Figure 35a. Herbage yield of the veld during the 1985/86 season.

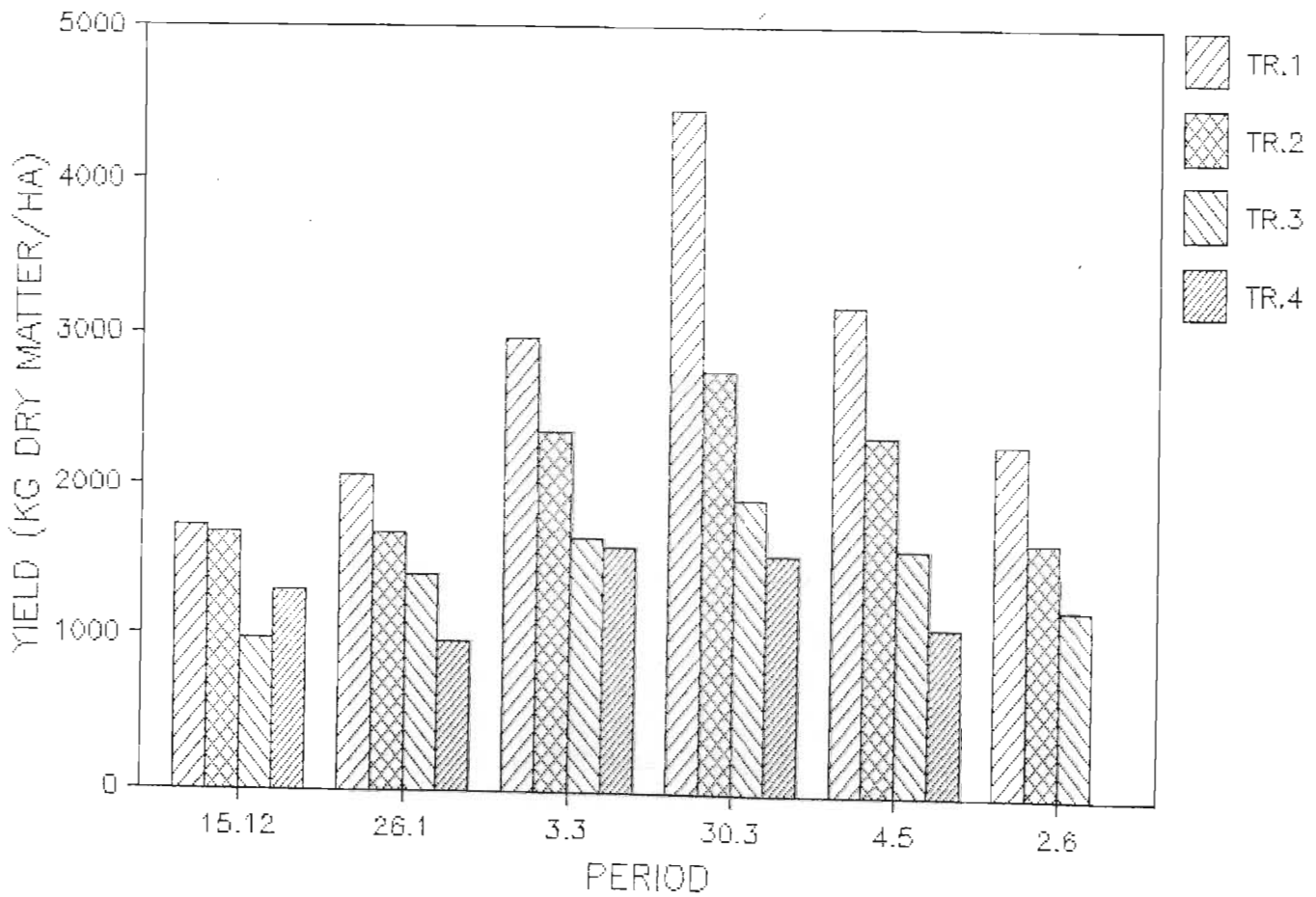


Figure 35b. Herbage yield of the veld during the 1986/87 season.

consistently recorded higher herbage yields than Tr.3. These trends were more pronounced during 1986/87 season.

Veld composition

A summary of the 1984 assessment, together with those of the 1978, 1980 and 1982 seasons, are presented in Table 50. The differences in camp size and the differences in the veld composition score (VCS) at the start of the experiment make the interpretation of the botanical data difficult. However, certain trends are evident. After an initial decline in the percentage of Decreaser species in Tr.1, Tr.2 and Tr.4, these species have generally stabilized, although they remain well below the benchmark. Although the proportion of Increaser I species together with the stable Decreaser species in Tr.1 appear to have stabilized, the 28% increase in Increaser II's indicates overutilization in the camps monitored. In Tr.2, the trend during the last two seasons has indicated a continuing increase in Increaser II's which signifies over-utilization of the veld during the last three to four seasons. This would suggest that with progressing seasons, the camps allocated to Tr.2 were increasingly stressed and overutilized.

A definite downward trend in VCS is apparent in Tr.3. The provision of a urea-based lick may have stimulated a greater utilization of available herbage, accounting for the continuing decrease in Decreaser and Increaser I species and the increase of Increaser II's. However, a more likely reason for the difference in the decline in VCS between Tr.2 and Tr.3 is due to the difference in the size of the camps in which the VCS was monitored in these two treatments. In Tr.3 the camps monitored varied between 2,21 ha and 3,35 ha (mean $2,7 \pm 0,63$ ha), whilst in Tr.2 the size of the camps monitored varied between 1,88 ha and 5,03 ha (mean $3,31 \pm 1,60$ ha), indicating that the stocking pressure was far higher in the camps monitored in

Table 50. Veld composition score (VCS) and variation in species for the period 1978 - 1984.

	Year	% contribution of each species category to veld composition				Veld composition score
		Dec.*	Inc. I*	Inc. II*	Inc. III*	%
Bench Mark		53	28	12	7	100
Treatment						
1	1978	27	37	18	18	65
0,83	1980	12	48	18	22	53
cows + calves	1982	14	46	23	17	56
per hectare	1984	16	47	23	15	57
2	1978	27	42	12	18	67
1,0	1980	19	45	13	22	59
cows + calves	1982	21	38	20	21	64
per hectare	1984	19	36	25	20	60
3	1978	16	28	47	8	51
1,0	1980	16	34	38	12	48
cows + calves	1982	17	23	53	7	47
per hectare	1984	12	23	60	5	39
+ urea lick						
4	1978	-	-	-	-	-
1,25	1980	29	40	15	15	65
cows + calves	1982	18	44	27	10	59
per hectare	1984	23	38	29	10	61

* As defined by Tainton, Edwards & Mentis (1980).

Tr.3 than in Tr.2.

The 21% decrease in Decreaser species and the 93% increase in Increaser II's in Tr.4 indicates severe overutilization of the veld. The decline in VCS was associated with a decline in the vigour of the veld as well as an increase in soil erosion in Tr.4 as a whole. All the treatments showed a tendency towards overutilization; the higher the stocking rate, the higher the rate of change.

DISCUSSION

The basic philosophy underlying this experiment was that the rate at which a pasture (either natural or cultivated) is stocked is possibly the most important single factor in grazing management affecting animal performance (Edwards, 1981). Unfortunately, research in South Africa into the management of the natural vegetation has concentrated on managerial procedures rather than stocking rates (Tainton, 1985). Consequently, optimum stocking rates for different vegetation types have not been clearly identified. Such a situation existed in the Highland Sourveld at the initiation of this experiment. One of the main objectives of this study was therefore to identify the range of stocking rates that would sustain high levels of animal and veld production. The stocking rates initially selected for the experiment were based on previous experience. The range of stocking rates selected included very high stocking rates in an attempt to quantify the effects of these excessively high stocking rates on animal performance and the composition of the veld. Whilst the Agriquest (1980) survey has subsequently indicated that very few farmers stock at such high stocking rates, the impact on the veld has been of considerable interest to farmers, study groups and visiting

researchers.

The effect of stocking rate on animal production can be expressed in terms of production per individual animal, production per unit area of land, or gross margin per unit area of land. In the first situation, research evidence indicates that livemass changes relatively little at "light" stocking rates. However, as the stocking rate increases through "moderate" to "heavy" the yield per animal declines in a linear fashion (Jones & Sandland, 1974; Malechek, 1984). Animal production per unit area of land follows a quadratic function. Production per hectare increases with an increase in stocking rate to a maximum at a stage beyond that at which maximum production per head occurs and then declines (Gammon, 1983). Production is maximized at a stocking rate about half of that which is able to maintain animal mass (Tainton, 1985). The most economic stocking rates are usually lower than those which provide for maximum production off a unit area of land (Darkwerts & King, 1984).

Maximum gross margins, or profits, should be the criteria for evaluation of the success of the enterprise. In practice however, the class of animal often plays an important role in determining which approach should be adopted. In the case of young growing animals which are marketed either directly off grass or following a short "finishing" period after being removed from grass, the emphasis is usually towards maximizing production per unit area of land. However, in the case of the cow/calf enterprise and in particular where expensive winter feed is necessary, maximising production per unit area of land would not be desirable economically. Such an approach would be to the detriment of the cow with the result that the cost of maintaining her in good breeding condition would be higher than the returns generated from the sale of the weaners.

The collection of detailed and accurate climatic data was of prime

importance in this study as it has been shown that the environment may affect animal performance significantly in the Highland Sourveld (van Niekerk, 1984, 1986). In only two of the nine seasons during which the experiment was conducted, did the mean annual rainfall exceed the long-term (29 years) mean. The inter-seasonal rainfall figures varied considerably (Table 26). The mean annual rainfall varied between 70% of the long-term mean in 1982 to 110% of the long-term mean in 1978. Mean annual rainfall over the nine seasons was 927 mm which was 85,22% of the long-term mean. Between 65,5% (1982/83) and 82,65% (1980/81) of the mean annual rainfall fell between November and March which are considered to be the important growing months. Poor rainfall during November and December may lead to a significant decrease in the crude protein (CP) of the veld early in the season (Figure 34a).

The mean maximum and mean minimum temperatures varied little between seasons. The mean maximum temperature (nine seasons) was $21,46 \pm 0,53^{\circ}\text{C}$ and the mean minimum temperature was $6,06 \pm 0,37^{\circ}\text{C}$. This was 100% and 90% of the long-term (13 years) mean respectively. The windrun over a 24 hour period was of particular significance because of the wind-chill factor in the region. The mean windrun over a 24 hour period was $148,57 \pm 8,36$ km which was 101,14% of the long-term (11 years) average.

Surprisingly, season did not affect the performance of the lactating cows between the initiation of grazing and weaning significantly (Table 29). Season accounted for only 1% of the total variation in cow mass gain. Season did, however, have a highly significant ($P < 0,001$) effect on calf performance accounting for 3,6% of the total variation in calf gain between the initiation of grazing and weaning. These results are supported by the metabolic mass gains on a per hectare basis (Figures 10a - 10d). Relatively small between-season variations in the metabolic mass changes of cows were recorded, but the

change in metabolic mass between seasons for the calves varied by between 25 and 30%, depending on stocking rate. The 3,6% variation in calf gain that could be accounted for by season was lower than other reported figures. Brown (1960) noted that year effects were responsible for approximately seven percent of the variation in weaning masses whilst Louw (1984) ascribed approximately 10% of the variation in calf gain between the initiation of grazing and weaning, to season. However, in the same study, Louw (1984) found that less than 1,5% of the variation in cow gain could be ascribed to season, which is similar to the result obtained in this study.

Stocking rate was by far the most significant factor affecting cow and calf performance. Stocking rate accounted for 45,5% (Table 29) of the total variation in cow gain between the onset of grazing and weaning. It is difficult to establish whether these trends are consistent for all veld types (Acocks, 1953). Whilst a considerable amount of research involving cows and calves on natural pastures has been done in South Africa (Carstens, 1970; Eloff, 1971; Ludemann, 1971; Cilliers, 1986; Marincowitz, 1986), the impact on the veld has largely been ignored. The complexity of the various veld situations suggests that comparisons of results should ideally be made within the same veld type, but at least within the same bioclimatic regions.

Relatively sophisticated veld and animal management procedures have been employed in this study. It is probable therefore, that the cow and calf performance data recorded represents the potential for the Highland Sourveld. Hence the emphasis has been on factors related to maximum mass.

The results from this study have shown conclusively that the cows (of all classes) stocked at the lighter stocking rates (Tr.1 and Tr.2) achieved higher maximum masses than the cows stocked at the higher stocking rates (Tr.4 and Tr.5). Consequently the cows at the lighter

stocking rates were able to mobilize more body reserves in the latter part of the grazing season and therefore recorded longer grazing periods than the cows stocked at the high stocking rates.

Stocking rate effectively regulates the amount of herbage available to the animal. Since animal performance is dependent upon feed intake, the factors affecting feed intake are clearly important. Whilst there is a wealth of information on the intakes of penned animals, this is not the case with the grazing animal, mainly because of the complexity of the grazing situation (Cordova, Wallace & Pieper, 1978).

This study has shown a significant decrease in the amount of herbage available with increasing stocking rate (Figures 35a and 35b). This result is in general agreement with local research under both natural pasture conditions (Fourie, Opperman & Roberts, 1985; Fourie, Engels & Roberts, 1986) and cultivated pastures (Louw, 1984).

An interesting observation from the cow and calf performance data in this experiment was that the cows were influenced by stocking rate to a far greater extent than their calves. Stocking rate accounted for 45,5% of the total variation in cow gain but only 39,2% ($P < 0,001$) of the variation in calf gain. Whilst there were significant differences ($P < 0,01$) in livemass gain between the calves stocked at the high (Tr.4 and Tr.5) and low (Tr.1 and Tr.2) stocking rates (Tables 41, 59 and 61), it is likely that the milk intake buffered the effects of low herbage intake. Similar responses have been detected under intensive pasture conditions (Baker, Alvarez & Le Du, 1981; Louw, 1984). Consequently the lactating cows were under considerably more stress than the dry cows in the corresponding treatments. This aspect is further demonstrated by the fact that the cows in Tr.1, Tr.2, Tr.4 and Tr.5 recorded mean (4 years, Tr.5 - two years) ADG's to maximum mass of 0,323, 0,214, 0,151 and 0,043 kg/head/day in contrast to the growth

rates of 0,581, 0,469, 0,395 and 0,255 kg/day recorded by the dry cows for the corresponding periods and treatments. These figures represent a 79,9%, 119,2%, 161,6% and 493,0% mass gain advantage by the dry cows over the lactating cows in Tr.1, Tr.2, Tr.4 and Tr.5 respectively. Similarly, the dry cows were in considerably better condition than their lactating counterparts at the end of the grazing season. Whilst stocking rate affected the degree of condition score loss in both classes of animal, the response by both classes was similar. The dry cows in Tr.1, Tr.2, Tr.4 and Tr.5 had 153,4%, 161,7%, 160,1% and 168,4% higher condition scores at the end of the grazing season than the lactating cows. These results are supported by the literature. According to Neville & McCullough (1969) the metabolizable energy (ME) requirements for maintenance and gain were 31% and 29% higher for lactating than dry Hereford cows respectively. In a subsequent study, Neville (1974) indicated that the maintenance requirements for lactating cows were 41% higher than those for dry cows. The NRC (1971) suggests coefficients of 77 kcal/kg net energy (NE) for maintenance of dry cows and 85 kcal/kg NE for maintenance of lactating cows.

A particularly significant trend that emerged from this experiment was the ability of the lactating first-calf heifer to produce and reproduce at a high level under the prevailing conditions. A number of studies have shown that weaning masses increase as the age of the dam increases. Maximum weaning mass has been achieved when cows were between six and nine years of age (Cundiff et al., 1966; Anderson & Willham, 1978; Nelsen & Kress, 1981). However, Jamison et al. (1965) and Smith & Fitzhugh (1968) have emphasized that age is of particular importance within the first four years. It is likely that the general recommendation that first-calf heifers should receive preferential grazing and management in order to ensure a long, productive life, has emanated from such research. The trends in animal performance resulting

from this experiment, are therefore particularly significant and serve as an indication of the potential performance of the first calver under sourveld conditions. However, it must be stressed that these results were obtained under good nutritional conditions and where management was of a high standard. It is unlikely that similar results could be obtained where any one of these factors were absent.

There was very little difference in final condition score between the first calvers and mature cows (Table 42). The mature cows in Tr.4 had a mean (five seasons) final condition score 8,1% higher than the mean score of the first calvers (Figures 23a - 23e; 25a - 25c). These data suggest that, at the lower stocking rates the first calver can compete successfully with the mature cow for grazing. However, as the stocking pressure increases and herbage availability decreases, the first calver is increasingly stressed with a concomitant decrease in performance. This aspect deserves further investigation and clarification. The results of a study in which the grazing behaviour of first calvers and mature cows, at different stocking rates, was investigated are discussed in Chapter 4.

The calf performance data indicates that there was very little difference in terms of maximum mass (theoretical weaning mass) between the calves born to the mature cows and those born to the first calvers. The calves born to the mature cows, however, showed slightly higher (NS) ADG's on veld than the calves born to the first calvers. The reason for the good performance of the first calvers and their progeny can probably be ascribed to the fact that they calved three to four weeks before the mature cows. Post-partum nutrition in both classes of cows was excellent, but was of particular benefit to the younger cows. Consequently, both classes of cow were able to establish relatively high levels of milk production (Baker, Ball, Kilkenny & Walsh, 1972) before being stressed by environmental factors associated with veld

grazing. The performance of the calves during the early part of the season in all the treatments, suggests that milk was not a limiting factor. Louw (1984) found that cow age did not influence milk production under intensive pasture conditions. This finding is of particular significance as the cows used in the intensive pasture study were derived from the same herd as that used in the sourveld, and were therefore of similar genetic background. Furthermore, similar winter feeding regimes were employed in both investigations. The results from this study and that of Louw (1984) are in general agreement with other research (Lamond, Holmes & Haydock, 1969; Wilson, Gillooly, Rugh, Thompson & Purdy, 1969; Somerville, Lowman Edwards & Jolly, 1983).

The calves born to the first calvers were three to four weeks older than the mature cows' calves, at any comparable stage of grazing. Consequently the calves born to the younger cows were able to utilize the available grass more effectively than the younger calves. This factor, coupled with the relatively high levels of milk production, enabled the calves born to the younger cows to perform well on veld. These data suggest that the calving of heifers three to four weeks before the main herd should be a priority if the first calvers are expected to compete successfully on veld with mature cows. Clearly, an adequate level of early postpartum nutrition is essential if these animals are to realize their milk production potential.

The lactating cows stocked at the low to medium stocking rates showed small mass gains during the first 140 - 180 days on veld (Figures 22a, 22b and 22d). The condition scores of these cows, however, remained relatively constant during the corresponding period. It would appear therefore that very little of the livemass gain was transformed into visible fat, which suggests that a large proportion of the fat gain was deposited internally. Fat and protein account for approximately 50% and 10% of the livemass gain respectively (Chigaru &

Topps, 1981; Thompson, Meiske, Goodrich, Rust & Byers, 1983). The lactating cows stocked at the high and very high stocking rates (Tr.4 and Tr.5) generally lost mass and condition right from the start of the grazing season. The dry cows in all the treatments gained condition (with the exception of the 1982/83 season) during the first 150 days on veld (Figure 23a). The actual condition score gain was related to stocking rate with the cows stocked lightly recording the highest gain. During the 1979/80 and 1980/81 seasons, the calves in all six treatments were weaned when the mean condition scores of the lactating cows in Tr.5 and Tr.6 reached 2,0. Consequently, the cows in Tr.1, Tr.2 and Tr.3 were still in excellent condition at weaning and the grazing season could therefore have been extended for these cows. From the 1980/81 season onwards, each treatment was weaned separately. The procedure for weaning has been described. However, it is important to note that from the 1982/83 season onwards the calves were losing mass at weaning (Figures 28a - 28e). The mean maximum mass varied according to stocking rate. The calves in Tr.2, Tr.4 and Tr.5 attained mean peak masses that were 96,3%, 89,8% and 73,5% of those of the calves in Tr.1. The mean number of days to reach maximum mass varied from about 200 days for the lighter stocking rates (Tr.1 and Tr.2) to 165 days for the very high stocking rates (Tr.5). When the calves attained maximum mass, the mean condition score of the cows in Tr.2, Tr.4 and Tr.5, relative to those in Tr.1, was 88,3%, 83,3% and 62,8% respectively.

These data indicate that the criterion for weaning needs to be adapted according to stocking rate. There are obvious marketing implications involved in weaning at different times, but from an optimum performance viewpoint, the data indicate that, at the low and medium stocking rates, calf masses peak after about 200 days on veld. There would therefore appear to be little point in keeping calves on sourveld after this stage since they would be losing mass (Figures 28a

- 28e). However, the cows are still in excellent condition at 200 days. Weaning at this stage would reduce the stress on these cows with the result that the grazing season could be extended until six to eight weeks before calving. As shown in Chapter 2, a 60 day reduction in the winter feeding period could affect the economic viability of the enterprise significantly.

The condition scores of the cows should not be allowed to fall below 2,3 at any stage. In the case of the heavier stocking rates - 1,25 cows + calves/ha (Tr.4) and 1,67 cows + calves/ha (Tr.5) - the condition of the cow should form the criterion for weaning. Calf weaning masses peaked after 180 days in Tr.4 and only 165 days in Tr.5. Weaning at 200 days would therefore be detrimental to both the cow and the calf. The ability of energy-deficient lactating beef cows to mobilize body reserves for milk production is well documented (Ball, Broadbent & Dodsworth, 1971; Economides, Miller, Topps, Gelman & Keith, 1973; Somerville, et al., 1983). Weaning must therefore occur before severe depletion of body reserves results. These data suggest weaning should ideally occur when the mean condition scores of the dams range between 2,3 and 2,4. The cows should improve their body condition slightly after weaning with a concomitant increase in the length of the grazing season.

The mean (for a group of cows) target condition score of 2,3 as a basis for removal from grazing is an important concept from a winter nutritional viewpoint. Removing the cows at a mean condition score of 2,0 has resulted in the masses of the cows, at the end of grazing, often being considerably lower than their mass at the start of the grazing season. Consequently, the mass lost during the summer period has to be gained during the winter at considerable cost. Weaning the calves at a higher dam condition score should reduce the stress on the cows earlier and thereby increase the grazing season considerably. The

cows would then be heavier and in better condition at the start of the winter period and consequently require lower nutritional levels to achieve the target condition score at calving.

The relationship between stocking rate and the length of the grazing season is of cardinal economic importance in the Highland Sourveld. As stocking rate increases, so the length of the grazing season decreases and consequently the length of the winter feeding period increases. The mean (nine years) length of the grazing season for treatments 1, 2, 4 and 5 was $219,67 \pm 20,25$, $209,67 \pm 16,78$, $193,78 \pm 11,53$ and $176,50 \pm 35,18$ days respectively. The high standard error in Tr.4 is a result of the sharp decline in the length of the grazing period (124 days) during the 1981/82 season. These data are however, biased in favour of the high stocking rates because the cows in Tr.1 and Tr.2 were still in excellent condition at weaning in the 1978/79, 1979/80 and 1980/81 seasons. However, when the cows were all removed from grazing on the basis of condition score (CS 2,0) the mean (six years) length of the grazing season for the cows in Tr.1 was $232,50 \pm 7,45$ days, Tr.2 - $217,50 \pm 14,90$ and Tr.4 - $193,67 \pm 14,32$ days.

By incorporating the animal performance data and the grazing season data obtained from this study, into a theoretical model, it is possible to demonstrate the effect of stocking rate and the importance of a reduced winter feeding period. The grazing area used in the model is set at 500 ha. The theoretical stocking rates are based on those used in the study. The calves are sold in April - May at prices existing in May 1987. Winter feed costs are based on a ration of E. curvula hay and maize silage. One rand per head per day as an allocated feed cost is a conservative figure. However, some farmers maintain that their winter feed costs do not exceed this figure.

Stocking rate	Cows + calves/ha			
	Very high	High	Med.	Low
Area (ha)	500	500	500	500
No. of cows	835	625	500	415
No. of calves	835	625	500	415
Income from calves				
Weaning mass	160	190	210	210
Selling price c/kg	200	220	230	230
Total	R 267200	261250	241500	200445
Variable costs				
Feed costs - cows				
Winter				
No. grazing days	175	190	220	250
No. feed days	190	175	145	115
Cost/day	R 1,00	1,00	1,00	1,00
Total	R 158650	109375	72500	47725
Lick ¹ 16c/day	R 24048	18000	14400	11952
Summer				
Lick 3,5c/day	R 5260	3937	3150	2614

Other costs

Veterinary R6/head R	5010	3750	3000	2490
Bull costs ² R	16700	12500	10000	8500

Interest on cows

Invest R1300/cow R	1085500	812500	650000	539500
Interest @14%/pa. R	151970	113750	91000	75530

Net return

Sale of weaners R	267200	261250	241500	200445
Total variable costs R -	209668	147562	138450	73281
Total R	57532	113688	103050	127164
Less interest R	151970	113750	91000	75530
Total R	- 94438	- 62	47450	51634

Return/ha R	- 189	000	95	103
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1. Winter lick: intake 500g/day/180 days

2. Bull costs: R3000/bull prorated over 6 years; 25 cows/bull

The following conclusions can be drawn from this exercise.

1. The highest income from the calves was obtained at the very high and high stocking rates. The high income was achieved as a result of the large number of calves, despite a lower weaning mass and lower price per kilogram livemass.

2. The inverse relationship between the length of the grazing season and the length of the winter feeding period is clearly a function of

stocking rate.

3. The increases in winter feed costs as stocking rate increases, are a reflection of both the number of cows and the extended winter feeding period.

4. Not only did the animals stocked at the very high stocking rate realize the lowest margins, but the veld grazing was also subjected to severe stress and degradation. This degradation is evident in the significant decline of the desirable grass species, an increase in undesirable grass species, the decline of vigour and the significant decline in herbage production.

5. The animals stocked at the high stocking rate (1,25 cows + calves/ha) realized the second lowest returns per hectare. After nine seasons, it is obvious that the veld allocated to these treatments is showing signs of severe stress. Coupled with the change in species composition, there has been a reduction in herbage production and vigour. Soil erosion has become a potentially serious problem in these camps.

The current high beef prices (in the region of 220 -250 c/kg livemass - 21st May, 1987 - for weaners/yearlings) unfortunately make the high stocking rate option economically attractive in the short term. However, there is no doubt that this will be to the long-term detriment of the natural grazing.

6. The "best" returns depended on whether money was borrowed to purchase the cows and interest charged on the investment, or not. The economic analysis shows that if money is not borrowed then the return per hectare at the medium stocking rate appears to be the highest.

However, the decline in veld composition at this stocking rate indicates that this stocking rate was too high and therefore should not be considered a viable, long-term option.

7. Based on this analysis, stocking rates of not higher than 83 cows plus calves per 100 hectares should be recommended for the Highland Sourveld providing for a 250 day grazing season. However, it is important to stress that the data on which this analysis was based was obtained under good managerial and nutritional conditions. The low stocking rate applied in this study might still be regarded as being too high, and indeed this would be the case where a less sophisticated veld management system is applied.

The benefit of providing a urea-based lick for the first 100 days on veld was apparent in terms of increased weaner masses and superior cow condition at the end of the grazing season, at a stocking rate of 1,0 cow and calf per hectare, but not at a stocking rate of 1,67 cows and calves/ha.

During the first phase of the experiment (1978/79 - 1982/83), the cows in Tr.3 had consistently higher mean maximum masses and significantly ($P < 0,01$) higher daily growth rates to maximum mass than the cows in Tr.2. These results are similar to those recorded by other researchers (Beames, 1959; Skinner, 1964; van Schalkwyk & Lesch, 1970; Rush & Totusek, 1976; Capper, Pratchett, Rennie, Light, Rutherford, Miller, Buck & Trail, 1977). However, as noted by Skinner (1964) and Capper et al. (1977), the provision of an energy/protein lick cannot always be justified economically. In the current study, the benefit of providing a urea/energy lick was apparent from the improved body condition of the cows in Tr.3 at the cessation of grazing, relative to the cows in Tr.2. The supplemented cows had a 15,85% higher condition

score, on the basis of which the grazing season could theoretically be extended. During the second phase of the experiment the cost of providing the urea-based lick was calculated at 16c/head/day, and the cost of the mineral lick at 3,5c/head/day. The costs per head during the 100 day supplementation period were therefore R16 and R3,50 for the cows in Tr.3 and Tr.2 respectively. On the basis of cow performance, the cost of providing the urea lick would therefore not appear to be justified. The data in Table 45 indicate that the cows in Tr.3 were in better body condition at weaning than the cows in Tr.2. The mean (five seasons) difference in condition score represents a theoretical, additional 22 days of grazing for the cows in Tr.3. Depending on the cost of the winter feed supplied, the provision of a urea lick during the early part of the season might be justified by the concomitant reduction in winter feed requirements. In much of the Highland Sourveld, where winter feed costs are conservatively estimated to be in the region of R1/cow/day, the 22 days saving in winter feed represents a saving of R22/cow at a lick cost of R12,50.

At the very high stocking rate (1,67 cows + calves/ha) there was no improvement in either growth rate or condition score from those cows with access to the urea-based lick. There would therefore be no justification in supplying a urea/energy lick at such high stocking rates. This finding should be of considerable interest to the farming community, since the average farmer believes that, when grazing is of poor quality and in short supply, the provision of a urea lick will improve animal performance dramatically. The results from this study are at variance with the findings of Heitschmidt, Kothman & Rawlins (1982) in which supplementation on natural grazing significantly increased production in heavily stocked treatments, but not at moderately stocked treatments. The supplement fed by Heitschmidt et al. (1982) was however, in the form of a natural protein: viz. cottonseed

meal (41% CP). Several workers (Rush & Totusek, 1976; Clanton, 1978; Owens, Lusby, Mizwicki & Ferero, 1980) have found that cattle grazing natural pastures and receiving supplements containing NPN have not performed as well as cattle receiving soybean meal protein.

The poor response of the cows to the urea-based lick at the very high stocking rate was probably directly related to low dry matter intakes. As a result of low herbage consumption, protein and energy intakes were insufficient to meet the daily requirements, even for maintenance. A shortage of energy is of particular significance in this situation, since readily available carbohydrates are essential for the efficient utilization of urea (Skinner, 1964; Satter & Slyter, 1974; Rush & Totusek, 1976). The amount of maize meal in the ration was clearly insufficient to initiate a response from the urea. A supplement of natural protein at very high stocking rates may well be of greater benefit than a NPN-based lick.

The performance of the younger cows was similar to that of the older cows, in that the differences in performance between the supplemented and unsupplemented groups was small and not statistically significant. However, as with the mature cows, the condition of the supplemented first calvers was better at weaning than the condition of the first calvers that did not have access to the urea lick during the early part of the season. In contrast to the mature cows, the provision of a urea lick to the first calvers could not be economically justified. No reason for the difference in performance between the two classes of cows, with regard to the urea-based lick, can be advanced. The possibility that the first calvers would derive greater benefit from a natural protein-based supplement, as opposed to a NPN-based supplement, cannot be discounted and possibly deserves investigation.

Crude protein analyses were carried out to measure the changes in veld quality over the season. It is not clear how wisely animals are

able to select their food, although Arnold (1985) has suggested that ruminants are hedyphagic, ie. food is selected to minimize unpleasant and/or maximize pleasant olfactory and other sensations. However, there is little doubt that animals prefer young to older material, leaf to stem and living to dead material (Arnold, 1985). Bredon (1976) showed that cattle grazing sourveld grasses selected herbage of higher CP values than cut samples, but only with mature grass (>12 weeks). The performances of both the cows and the calves in Tr.1 suggests that the animals selected herbage of a higher quality than that shown in Figures 34a - 34d. Based on an intake of 10 kg DM/head/day the animals could have consumed between 600 g and 900 g of CP per day in the beginning of the grazing season, depending on season and treatment, and 300 g - 500 g/day towards the end of the season. According to NRC (1984), a 450 kg dry, pregnant cow, during the middle third of pregnancy, requires an average of 590 g of CP for maintenance. The results from this study indicate that the mature cows may well have been short of protein towards the end of the grazing season. At the high stocking rates in particular, dry matter intake was limited, and the crude protein intake would have been below maintenance levels. It is therefore not surprising that the livemasses of these cows declined dramatically towards the end of the grazing season.

High reproductive rates of beef cows under sourveld conditions are of vital importance if beef enterprises are to be viable in these areas. It was therefore unfortunate that disease problems prevented a detailed analysis of the reproductive data emanating from this experiment, from being carried out. Both Leptospirosis and Trichomoniasis were encountered at different stages of the experiment, which resulted in a significant number of abortions. The incidence of Trichomoniasis necessitated the culling of a large number of cows and bulls. Nevertheless, the data presented, although representative of

only two seasons, are of considerable interest.

The finding, that grazing treatment had little apparent effect on reconception rates, is not surprising. As a result of the winter nutritional programme, the cows were all in good condition at the start of the grazing season. Consequently, stocking rate exerted a relatively minor effect on cow and calf performance during the 90 day breeding season. Under these favourable conditions, it is encouraging to find that the first-calf heifers performed as well as the mature cows during the breeding season. Whilst this result is at variance with the generally accepted finding that the first calvers have lower reconception rates than older cows (Harwin, Lamb & Bisschop, 1967) it is interesting to note that Louw (1984) obtained similar results under cultivated pastures, with a winter feeding regime similar to that used in this experiment. It would appear therefore, that, providing the animal's post-partum nutritional requirements are met, and she is in good condition at the time of calving and mating, good reconception rates can be obtained from first calvers.

Thirty eight percent of the mature cows calved within the first 20 days of the calving season compared to 26% of the first calvers. Probably of more significance, however, was the fact that 86% of the mature cows were diagnosed pregnant and 85% calved whereas 91% of the younger cows were diagnosed pregnant but only 81% calved. The highest foetal losses were recorded in the high stocking rate treatment each year. These figures suggest that the effect of a high grazing pressure and the ensuing low nutritional supply, on foetus mortality may well be significant and should not be discounted.

However, the first calvers were generally as productive as the mature cows in terms of producing large weaners, maintaining body condition on veld and realizing high conception rates. The possibility that the younger cows modified their grazing behaviour in order to

achieve high production levels could not be discounted and required investigation. The results of a two-year study on the grazing behaviour of the first calvers and the mature cows are discussed in Chapter 4.

CHAPTER 4

SOME OBSERVATIONS ON THE GRAZING BEHAVIOUR
OF FIRST-CALF HEIFERS AND MATURE COWS
ON NATURAL VELD AT DIFFERENT
STOCKING RATES

INTRODUCTION

The simplification of current recommended grazing management practices will lead to a greater awareness and acceptance of these grazing strategies by farmers. A better understanding of the grazing behaviour of free-ranging cattle may stimulate the development of improved grazing strategies which ultimately would lead to an increase in the efficiency of animal production. Cattle grazing natural pastures usually depend entirely upon that pasture to satisfy their nutritional requirements. This underlines the importance of the close association between the animal's grazing environment and animal performance (Kropp, Holloway, Stephens, Knori, Morrison & Totusek, 1973).

Results emanating from the research conducted in the Highland Sourveld have shown that lactating mature cows and first-calf heifers can graze together successfully under a range of stocking rates. However, whilst a number of grazing studies have been carried out and comprehensively reviewed (Hafez & Schein, 1962; Fraser, 1968; Arnold & Dudzinski, 1978; Syme & Syme, 1979; Reinhardt & Reinhardt, 1981; Curtis & Houpt, 1983; Stricklin & Krautz-Scanavy, 1984; Arnold, 1985), there is relatively little information on the behaviour of beef cattle as influenced by stocking rate. More specifically, no literature could be found on the effects of stocking rate on the social interactions and

spatial relationships between different classes of beef animals. This aspect, rather than grazing behaviour per se, is the focus of this study.

According to NRC (1984), the nutritional requirements of first calvers are significantly different to those of mature cows at the same stage of lactation. The degree to which the first calver will modify its grazing behaviour in order to satisfy its nutritional and lactational requirements, when grazing with mature cows, is poorly understood at present. The benefits of grazing the two classes of cows together, particularly from a grazing management point of view, are evident from the results reported in the previous chapter. The social interactions between the two classes of cows are therefore of importance in explaining the performances of these animals.

Several studies with beef and dairy cows have noted a high correlation between social rank and performance where there is competition for feed (Wagon, 1963; Friend & Polan, 1974). Most of the studies have, however, observed differences in performance where some form of supplementary feeding was involved and do not relate specifically to grazing situations. Spacing behaviour has also been measured as an indication of social dominance in cattle (Syme & Syme, 1979). As these studies have generally involved penned animals, it is not clear whether the behavioural responses would extend to grazing situations.

The overall objective of this study was therefore to find possible explanations for the excellent performance of the first calvers and their progeny, relative to the mature cows. Specific attention was focused on grazing patterns and social interactions under a range of stocking rates.

PROCEDURE

The studies were conducted during the 1985/86 and 1986/87 seasons. A total of six observations during the first season and nine observations during the second season were carried out in each of the three stocking rates. During the first season, observations commenced on the 21st of March 1986. This was considered to be the time when the quality and quantity of the herbage available was declining, with the result that the animals were beginning to be stressed from a grazing point of view. This approach changed during the second season, and observations commenced at the beginning of the grazing season. During both seasons, the last observations took place shortly before weaning.

Observations commenced at 08h00 and ended at 16h00. This time-span was selected because the spatial relationships between the first calvers and the mature cows, as well as their grazing behaviour, were under observation. The major periods of grazing in beef animals are generally concentrated in the early morning and again in the late afternoon, under most conditions. It was therefore felt that the period from 08h00 to 16h00 would coincide with periods of both low and high grazing activity and that social interactions were more likely to occur during these periods.

Experimental animals

A representative sample of 20% of the animals in each treatment was selected at random. This amounted to six animals per treatment, comprising four first calvers and two mature cows. It was possible to monitor only a small percentage of the population because of the nature of the terrain and the limited number of observers. The three treatments in which the observations took place were: Tr.1 (0,83 cows plus calves/ha), Tr.2 (1,0 cow plus calf/ha) and Tr.4 (1,25 cows plus

calves/ha). The animals were clearly marked by painting large numbers on their flanks. All the cows were lactating.

Experimental terrain

The location and topography of the experimental sites were described in Chapter 3. Two camps in each treatment were selected for the behavioural studies. The size and configuration of the camps varied considerably (Appendices 13 - 24). Within each treatment, the animals were rotated between large and small camps. Observations were carried out on the second day of occupation of the specified camps to allow the animals to adjust to the particular camp. Drinking water was freely available in each camp, usually from small dams. A mineral lick was provided for the first (approximately) 100 days on veld, whereafter the animals had access to a urea-based lick.

Experimental observations

The assessments were carried out by three teams each comprising three people. The activities noted were:

1. Grazing
2. Standing
3. Walking
4. Lying down
5. Ruminating
6. Drinking water
7. Eating lick
8. Suckling calf

Combinations of activities were often recorded viz. 2/5 or 4/5 represented a cow standing and ruminating or lying down and ruminating respectively. 3 Represented an animal either walking between grazing

areas, or walking to water or lick troughs. Every tenth minute, the position of the animal in the camp relative to the marker posts, was recorded using a grid map. Agonistic or unusual behaviour at any stage was noted by the observers.

Statistical analyses

Differences between the treatments in terms of the time spent grazing, resting/ruminating, and suckling were analysed by analysis of variance. Tests for interactions between the age of the dam and treatment were also made.

The data on the social facilitation trends were analysed by Chi-square analyses. The hypothesis tested was that the animals were randomly distributed, relative to one another, throughout the camp at any particular time.

RESULTS

Time spent grazing

The percentage of time that the two groups of animals, at each of the three stocking rates, spent grazing during the eight-hour observation periods, is shown diagrammatically in Figures 36a, 36b and 36c (1985/86 season) and 37a, 37b and 37c (1986/87 season). During the first season (21/3/86 - 3/6/86) the mean time spent grazing by the first calvers in Tr.1, Tr.2 and Tr.4 was 308,31 (64,23%), 269,04 (56,05%) and 294,53 (61,36%) minutes respectively. For the mature cows in the corresponding treatments, mean grazing times of 292,32 (60,90%), 299,76 (62,45%) and 308,45 (64,26%) minutes in Tr.1, Tr.2 and Tr.4 were recorded. Amongst neither the mature cows, nor the first calvers, were

Table 51. Percentage of time spent grazing by the first calvers and mature cows in the small and large camps.

	First calvers						Mature cows					
	small camps			large camps			small camps			large camps		
	start %	end %	diff. %	start %	end %	diff. %	start %	end %	diff. %	start %	end %	diff. %
<u>1985/86 season</u>												
Tr. 1	57,98	67,64	+9,66 ^a	60,94	76,02	+15,08 ^{a*}	47,88	62,77	+14,89 ^a	56,25	73,47	+17,22 ^a
	±8,22	±10,67		±3,56	±1,02		±1,51	±16,56		±2,95	±8,66	
Tr. 2	48,96	54,76	+5,80 ^a	54,50	64,47	+ 9,97 ^a	57,30	58,34	+ 1,04 ^a	59,0	62,77	+ 3,77 ^a
	±13,24	±3,37		±5,98	±13,66		±4,42	±8,43		±15,56	±13,55	
Tr. 4	56,25	67,98	+11,73 ^a	56,92	67,19	+10,27 ^a	56,25	72,62	+16,37 ^a	50,0	71,88	+21,88 ^a
	±11,91	±15,85		±5,32	±9,98		±8,84	±5,05		±4,52	±7,36	
<u>1986/87 season</u>												
Tr. 1	46,0	62,0	+16,0 ^a	47,97	61,71	+13,74 ^a	41,0	56,0	+15,0 ^a	55,34	69,15	+13,81 ^a
	±15,24	±12,65		±3,54	±5,50		±15,56	±11,32		±0,32	±4,52	
Tr. 2	40,69	59,70	+19,01 ^a	49,02	63,05	+14,03 ^a	46,08	61,23	+15,15 ^a	45,10	75,01	+29,91 ^a
	±0,98	±4,21		±2,27	±6,40		±4,16	±8,66		±2,78	±1,54	
Tr. 4	43,37	60,21	+16,84 ^a	58,17	57,62	-0,55 ^b	40,82	61,23	+20,41 ^a	64,29	58,70	-5,59 ^b
	±3,87	±3,91		±7,55	±5,75		±0,0	±5,71		±1,45	±3,07	

* Figures within rows having different superscripts differ significantly (P < 0,05)

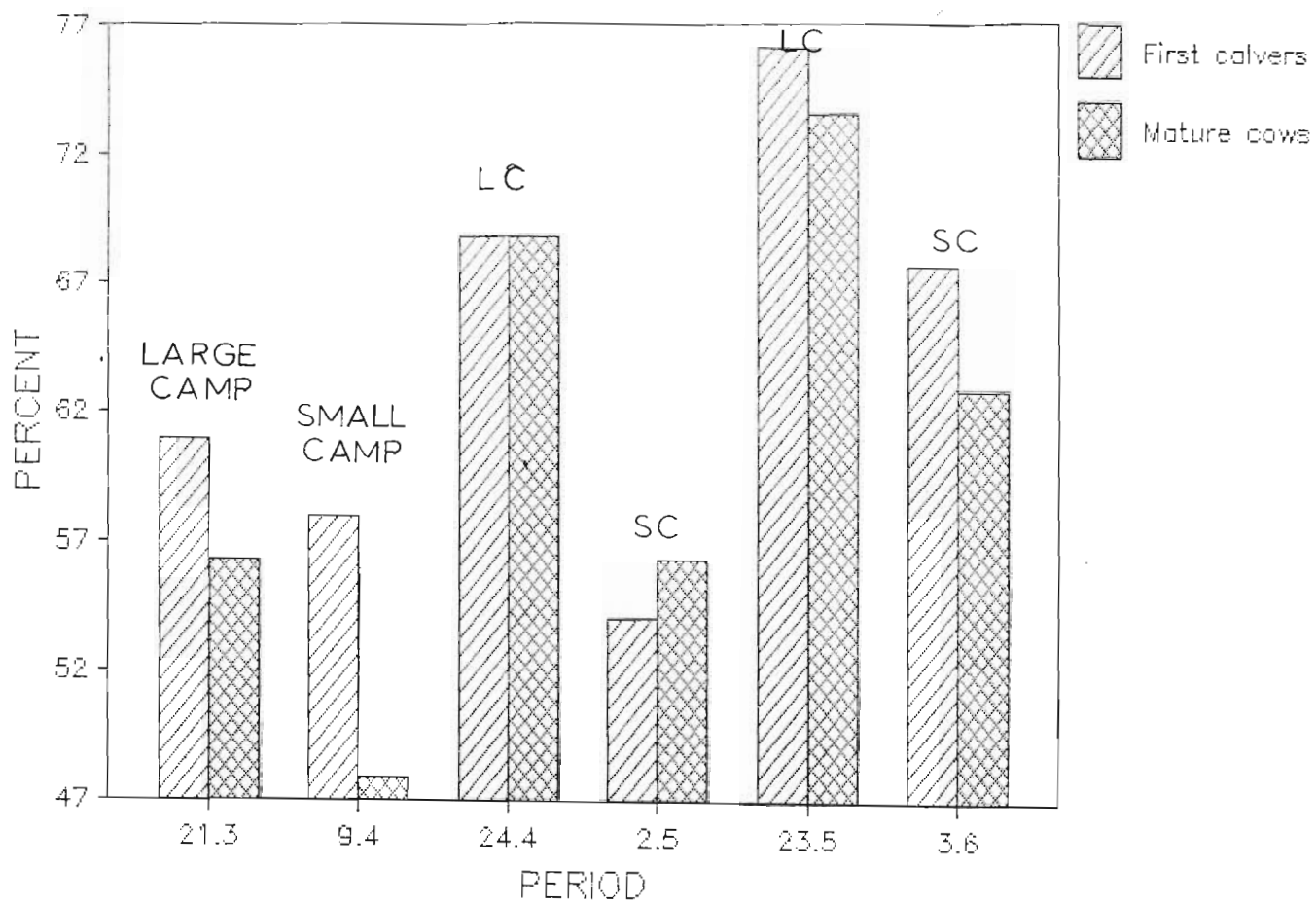


Figure 36a. The percentage of time spent grazing by the mature cows and first calvers in Tr.1 - 1985/86 season.

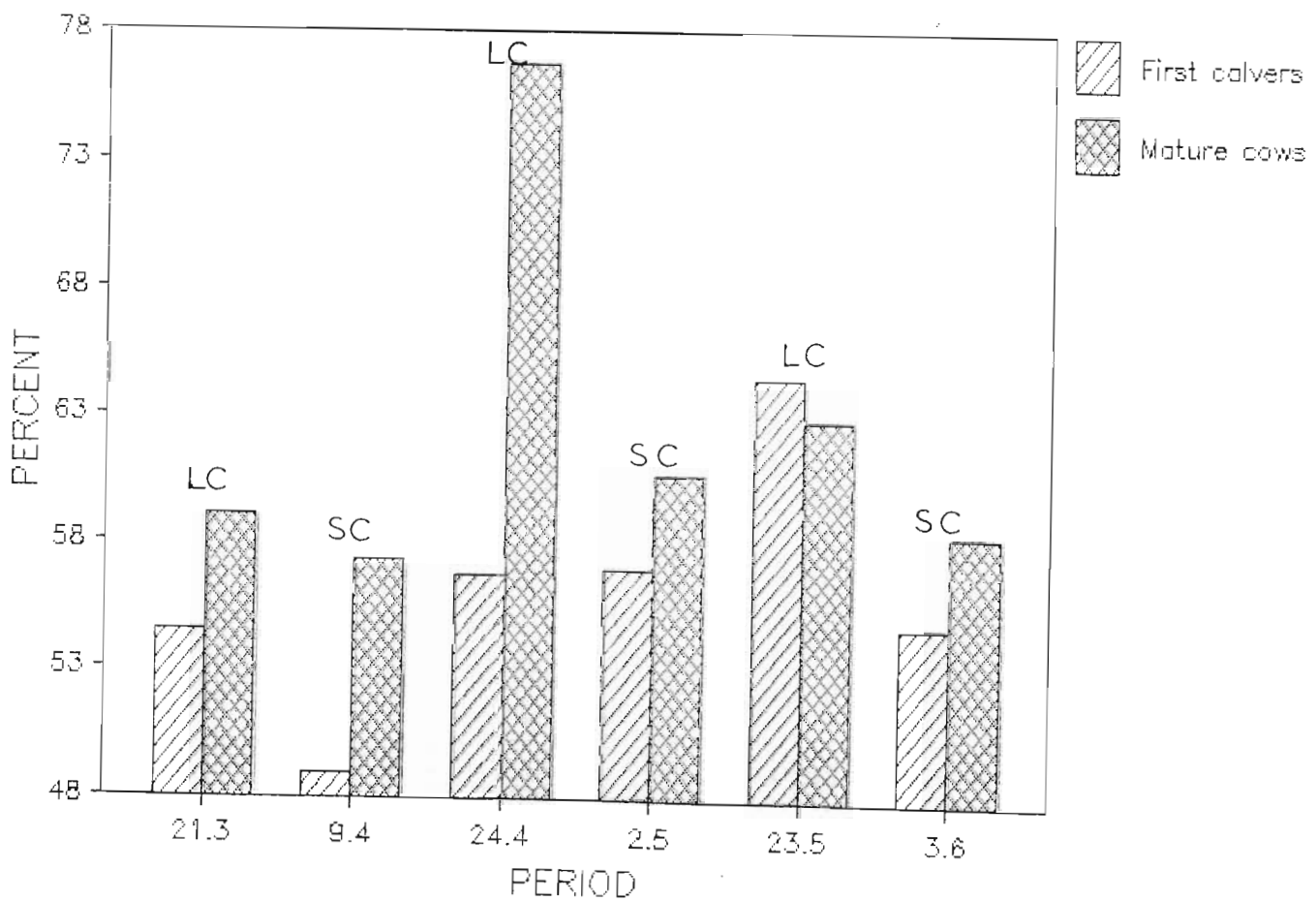


Figure 36b. The percentage of time spent grazing by the mature cows and first calvers in Tr.2 - 1985/86 season.

the differences in grazing time between the treatments statistically significant. No clear pattern emerged from these data in terms of any particular class of cow grazing for longer times during the periods under observation. The largest difference was recorded in Tr.2 where the mature cows spent 60,9% of their time grazing as opposed to the 56,05% minutes recorded for the first calvers (Figure 36b): a difference of 23,28 minutes (NS).

During the second season (18/11/86 - 20/5/87), a mean grazing time of 274,32 minutes (57,15%) was recorded for the first calvers in Tr.1, as opposed to 279,08 minutes (58,14%) for the mature cows (Figure 37a). In Tr.2, grazing accounted for 57,71% (277,01 minutes) and 59,08% (283,59 minutes) of the 480 minutes possible for the first calvers and mature cows respectively (Figure 37b). The time spent grazing by the first calvers and mature cows in Tr.4 amounted to 259,78 minutes (54,12%) and 270,68 minutes (56,39%) respectively (Figure 37c). In contrast to the first season, the mean grazing times recorded were consistently longer for the mature cows. The differences were, however, very small (largest = 11 minutes) and not statistically significant. A significant feature of these results is the similarity in actual time spent grazing by all the animals during the two seasons. The largest difference (38 minutes) was recorded in Tr.4.

Increase in time spent grazing over season

The increase in time spent grazing during the two seasons for Tr.1, Tr.2 and Tr.4 are presented diagrammatically in Figures 36a - 37c and have been summarized in Table 51 to show the effect of camp size. During the first season, the first calvers stocked at the low, medium and high stocking rates increased their mean grazing time between the first and last observations by 6,7%, 0,26% and 11,06% respectively. In contrast, the increase in time spent grazing over the season by the

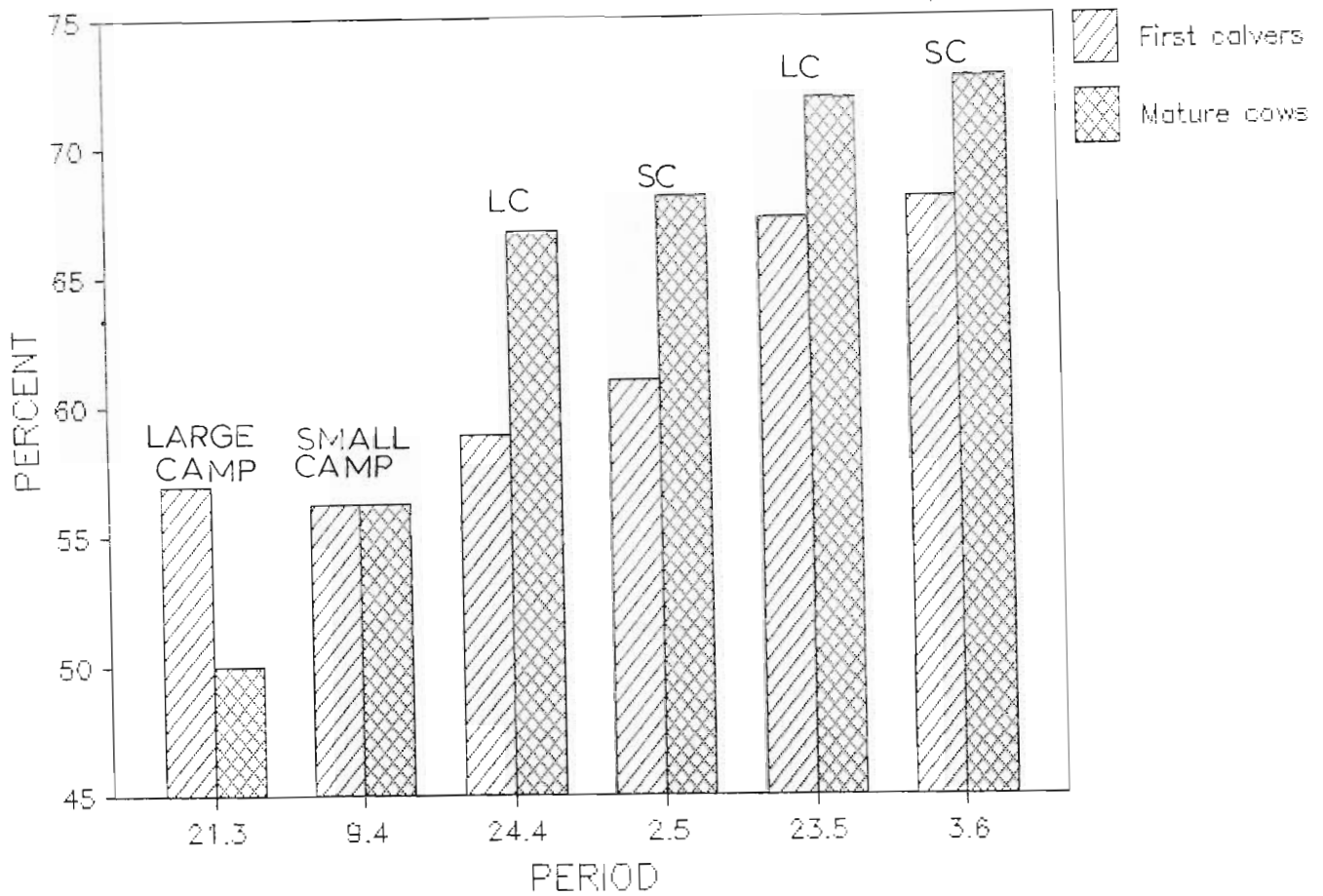


Figure 36c. The percentage of time spent grazing by the mature cows and first calvers in Tr.4 - 1985/86 season.

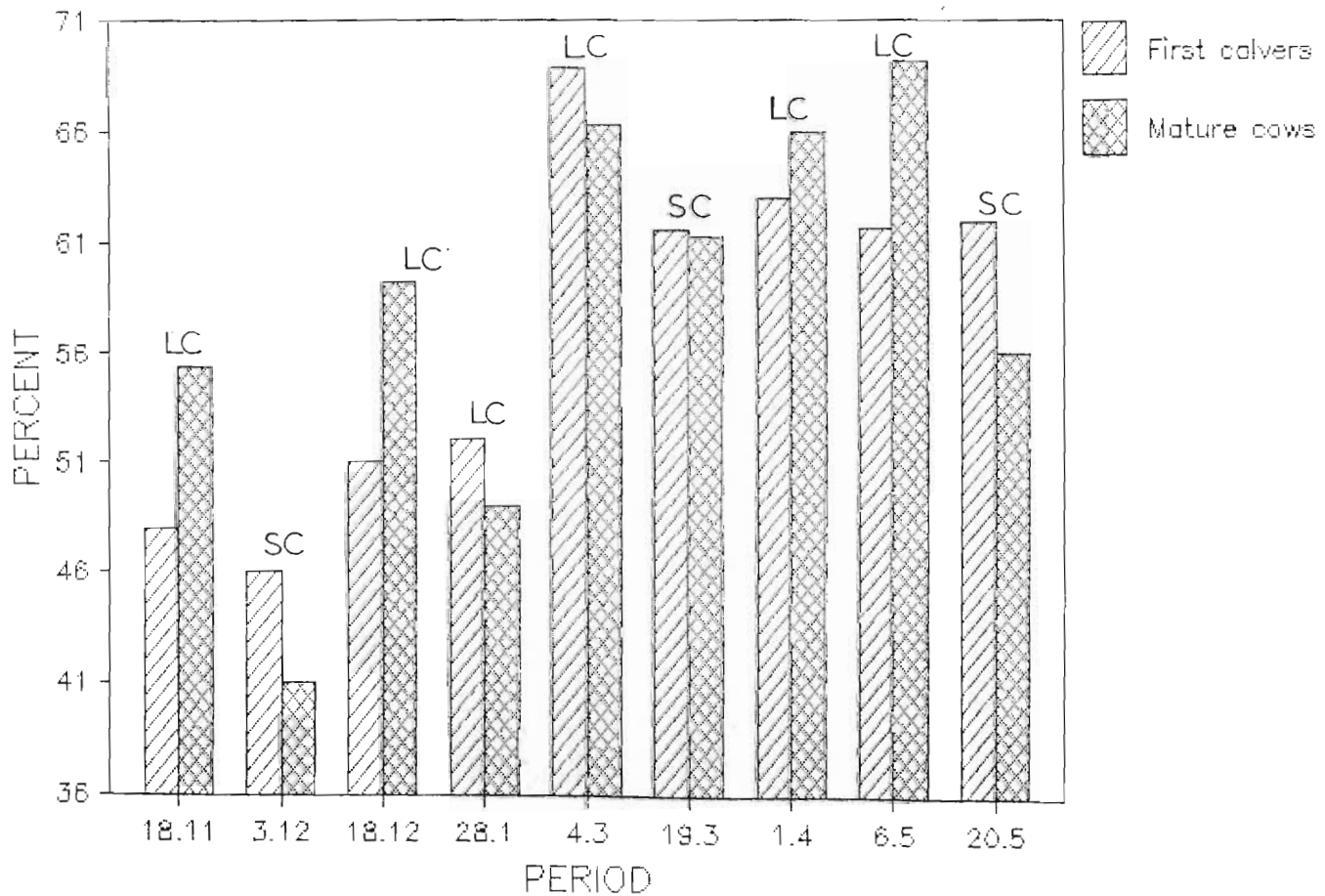


Figure 37a. The percentage of time spent grazing by the mature cows and first calvers in Tr.1 - 1986/87.

mature cows was 6,52%, -0,66% and 22,62% in Tr. 1, Tr. 2 and Tr. 4 respectively. It is clear from these data that there was considerable variation in the time spent grazing between observations. These variations can largely be attributed to camp size. When the grazing times within camps were analysed, it was apparent that the first calvers in Tr. 1, Tr. 2 and Tr. 4 increased their grazing times in the small camps by 9,66%, 5,8% and 11,73%, and in the large camps by 15,08%, 9,97% and 10,27% respectively. The mature cows stocked at the low, medium and high stocking rates increased their times spent grazing in the small camps by 14,89%, 1,04% and 16,37%, and in the large camps by 17,22%, 3,77% and 21,88% respectively.

The pooled data (all three treatments) indicates that the first calvers increased their grazing time over the season by 9,06% (44 minutes) in the small camps, compared to an increase of 10,76% (52 minutes) by the mature cows (Table 57). In the large camps, the first calvers increased their grazing time over the season by 11,77% (56 minutes) and the mature cows by 14,29% (69 minutes). In neither the small, nor the large camps, were the differences in grazing time between the two classes of cows, statistically significant.

The most notable differences in the time spent grazing during the first season were, however, between treatments. The lowest ($P < 0,01$) increase in grazing time over the season was recorded for the mature cows in Tr.2. A similar, but statistically non significant, increase in grazing time, was shown by the first calvers in comparison to the other treatments. Similar trends with respect to treatment differences were not noted during the second season.

The differences in the time spent grazing between the first calvers and the mature cows in the small and large camps during the second season are shown in Table 51. The most dramatic differences were

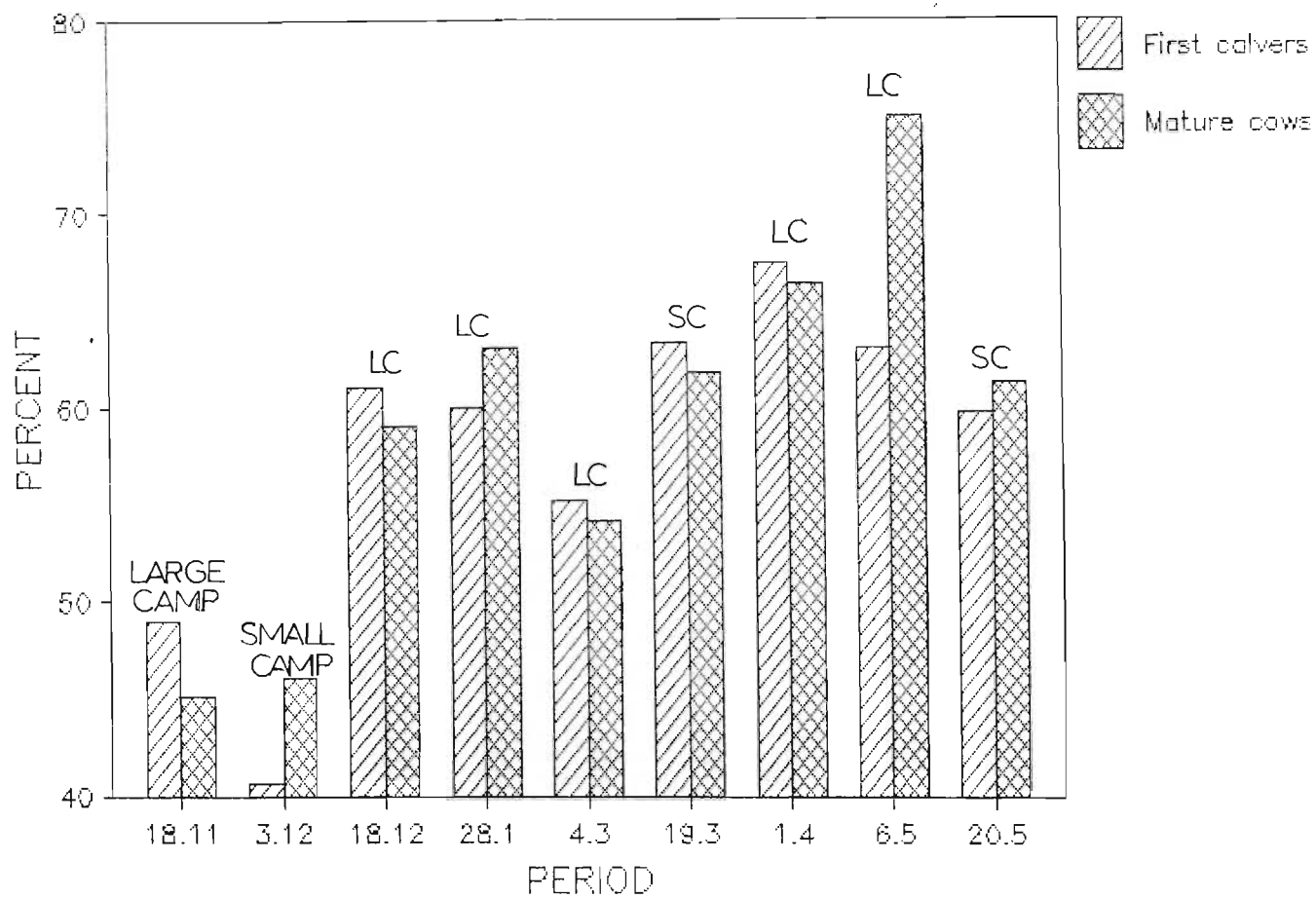


Figure 37b. The percentage of time spent grazing by the mature cows and first calvers in Tr.2 - 1986/87 season.

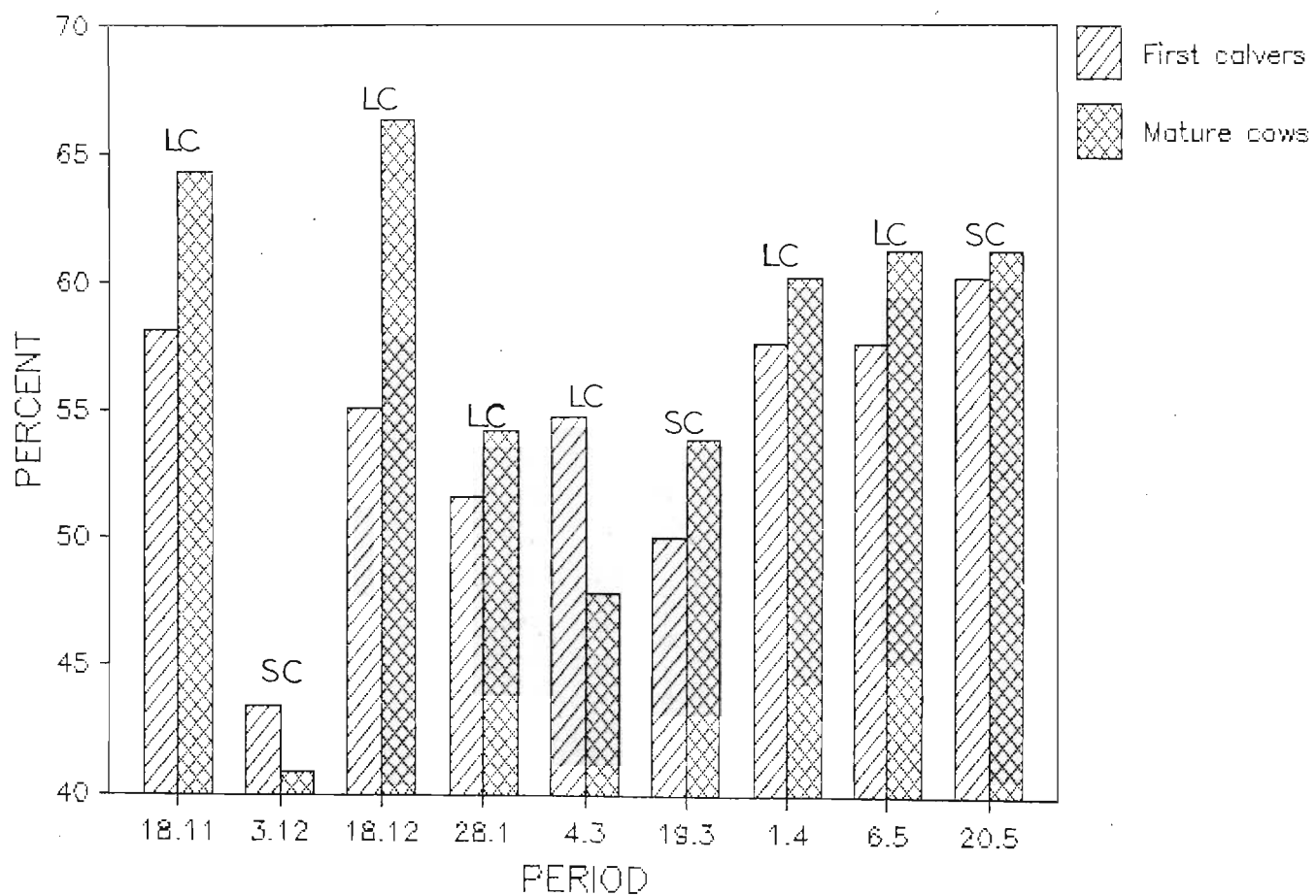


Figure 37c. The percentage of time spent grazing by the mature cows and first calvers in Tr.4 - 1986/87 season.

recorded in Tr.4. Both the first calvers and the mature cows reduced the time spent grazing in the large camps by 0,55% and 5,59% respectively. However, in the small camps, the first calvers increased the time spent grazing by 16,84% and the mature cows by 20,41% (Table 51). It is apparent from Figure 37c that the grazing time recorded during the observations on the 18/11/86 and 18/12/86 appear to be atypical, relative to the time spent grazing in the other observations. The general trend is certainly towards a reduction in the time spent resting and an increase in the time spent grazing as the season progressed.

Social facilitation

The actual grazing patterns of the mature cows (No's 5 and 6) and two of the first calvers (No's 1 and 2) during the first and second season are presented diagrammatically in Appendices 13 - 24 respectively. The grazing patterns of only two of the first calvers in each treatment are shown in an attempt to provide a clearer representation of the grazing movements. The positions of the animals are shown at hourly intervals although their positions were actually noted every tenth minute. The grazing patterns reflected in Appendices 13 - 24 indicate the "marker" animal number followed by the hour of observation. An association between animals was assumed if a "marker" first calver and mature cow were within a 25m radius of one another. Associations at 30 minute intervals were analysed. A total of 16 associations between any two animals were possible during any 480 minute observation period.

During the first observation of the 1985/86 season (21/3/86), the first calvers and mature cows in Tr.4 were generally randomly distributed ($P < 0,20$) relative to each other. It is, however, evident from Appendix 15 that cow No. 6 had a reasonably strong association

(NS) with cows 1 and 2. The associations between the cows in Tr.1 and Tr.2 were not random ($P < 0,50$ - Tr.1; $P < 0,95$ - Tr.2). This viewpoint is substantiated by the grazing patterns in Appendices 13 and 13. The associations between the mature cows and the first calvers at any particular time was very strong. It is noticeable in Appendices 13, 14 and 15 that the full dimension of the camps was not utilized in any of the treatments.

The interactions between the two classes of cows at the end of the first season (3/6/86) are to some extent apparent from Appendices 16, 17 and 18. This observation is reinforced by the chi-square analyses which indicate that the animals were not randomly distributed ($P < ,70$ - Tr.1; $P < 0,98$ - Tr.2 and $P < 0,70$ - Tr.4). The associations between cows 6 and 3 and 6 and 4, and between cows 5 and 3 and 5 and 4 in Tr.1 were particularly strong, but, due to the simplification of the grazing patterns, are not shown in Appendix 16. In contrast to the observations made in the beginning of the season, the last observations (3/6/86) indicated that the animals in Tr.2 and Tr.4 tended to utilize a larger proportion of their camps. This was possibly because the last observations were made in the smaller camps. Another possible contributing factor may have been that the grazing was of poorer quality (Figure 34d) and not as abundant at this stage which meant that the animals had to forage wider to satisfy their feed intakes. During the second season, observations commenced at the initiation of the grazing period. The second observation (3/12/86) has been used in the analysis, at which stage the animals should have become familiar with the veld conditions. The hypothesis applied during the first season was also applied during the second season. The distribution of the first calvers and the mature cows relative to one another, at the beginning of the season, was not random ($P < 0,80$ - Tr.1; $P < 0,70$ - Tr.2; $P < 0,90$ - Tr.4). The strong associations between the two classes of cows are

clearly apparent from Appendix 19 - Tr.1, Appendix 20 - Tr.2 and Appendix 21 - Tr.4. The animals in Tr.1 and Tr.2 clearly did not utilize the full extent of their respective camps (Appendices 19 and 20). The cows in Tr.4, however, ranged far wider and utilized their camp better. This was probably a consequence of the high stocking rate.

The distribution of the two classes of cows, relative to one another in Tr.4, at the end of the grazing season was apparently random ($P < 0,20$). Whilst there were reasonably strong associations between cows 5 and 1, and 5 and 2, associations between the other animals under observation were very poor (Appendix 24). The two classes of cows in Tr.1 and Tr.2 were not randomly distributed ($P < 0,80$ - Tr.1 & Tr.2). This trend is similar to that observed during the first season in the corresponding treatments. These trends appear to indicate that, with the advancing season, the animals in the high stocking rate treatment became increasingly stressed from a foraging point of view. The animals therefore grazed further apart in an effort to satisfy their intake requirements.

A number of interesting observations were made with regard to differences in grazing behaviour between the two classes of cows. The observers were unanimous in their observations that the first calvers appeared to set the grazing pattern for the whole herd. Even in situations where the mature cows commenced grazing first, they followed the first calvers as soon as the latter started to graze. This trend is apparent in Appendices 13 - 24 if the grazing positions and directions of the first calvers, relative to the mature cows, are compared. No agonistic behaviour between the two classes of cows was noted at any stage of grazing. Agonistic behaviour was, however, frequently observed at the lick troughs where feeding space was limited. A few cases of

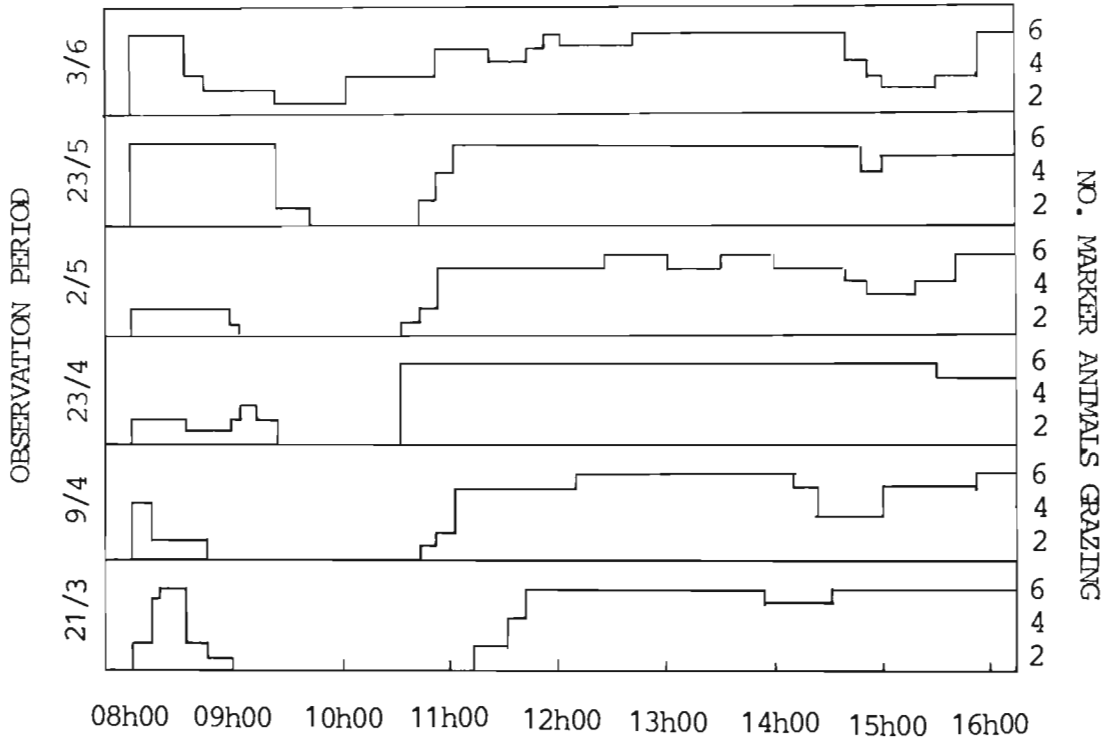


Figure 38a. Daily grazing activity during the periods of observation for the cows in Tr.1 - 1985/86 season.

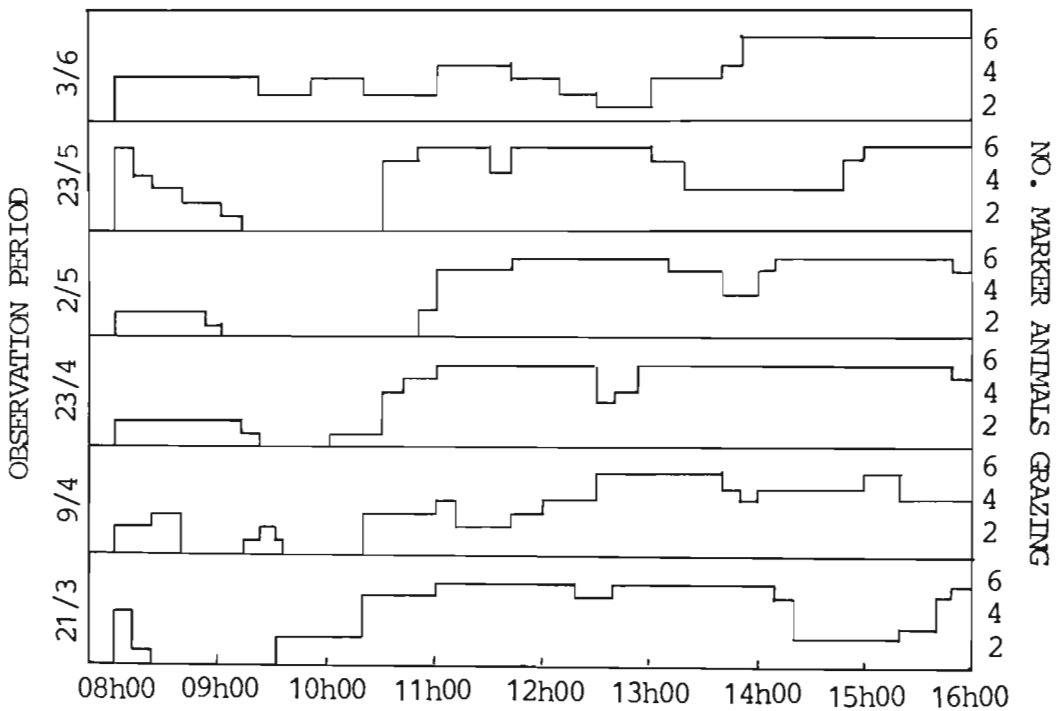


Figure 38b. Daily grazing activity during the periods of observation for the cows in Tr.2 - 1985/86 season.

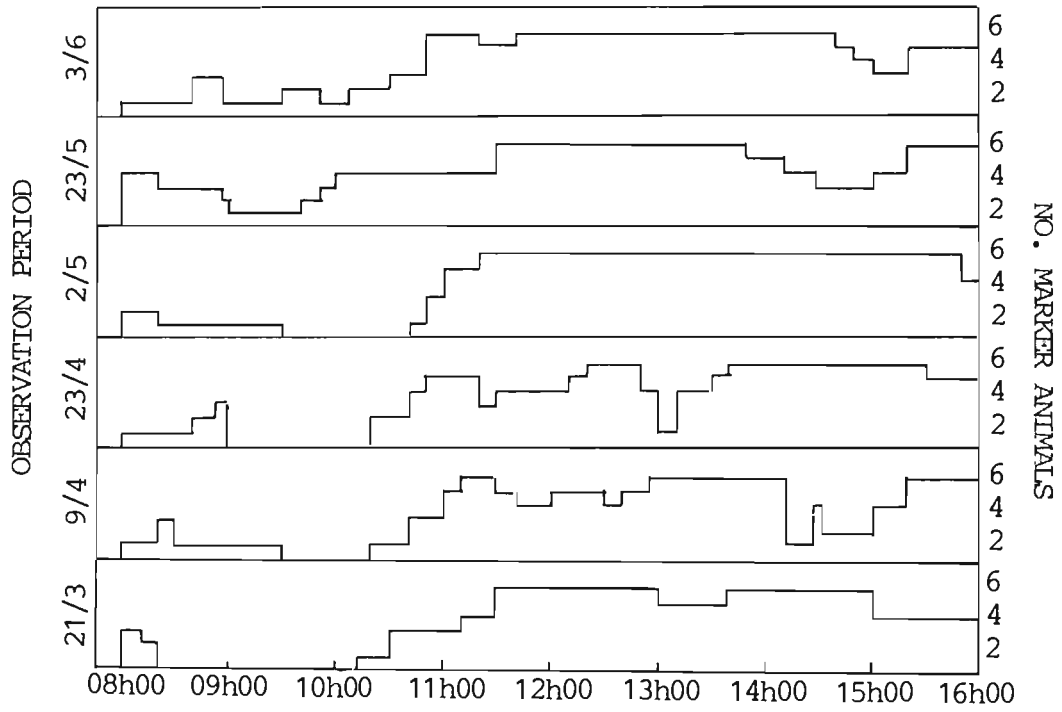


Figure 38c. Daily grazing activity during the periods of observation for the cows in Tr.4 - 1985/86 season.

agonistic behaviour at water troughs were recorded. In all the situations where agonistic behaviour was noted, the bigger mature cows dominated the first calvers. There was therefore a clear distinction between leadership (first calvers) and dominance (mature cows).

Time of grazing

The actual times spent grazing during the periods of observation in the first season, in Tr.1, Tr.2 and Tr.4 are shown diagrammatically in Figures 38a, 38b and 38c respectively. The figures are characterized by two distinct grazing periods. The first period, during which one to six of the observation animals grazed, was of relatively short duration and was probably the tail-end of the early morning grazing session. After a period of between one and two hours, grazing was reinitiated with at least five of the six animals grazing by 11h30. Grazing after 11h30 was maintained until 16h00 by at least four of the six animals in all three treatments. As the season progressed the rest periods decreased until on the 3/6/86 a varying degree of continuous grazing was evident in all three treatments. In Tr.4, continuous grazing was already apparent as early as the 23/5/86. This grazing situation was probably a consequence of a shortage of available herbage brought about by the high stocking rate.

The times spent grazing by the "marker" cows during the second season in Tr.1, Tr.2 and Tr.4 are shown in Figures 39a, 39b and 39c respectively. The grazing patterns during November and December in all three treatments were characterized by the relatively late start in grazing activity (09h00 - 10h00) and the short periods of intense grazing activity, particularly in Tr.2 and Tr.4 (Figures 39b and 39c). The relatively late start to grazing within the period of observation is probably a consequence of the first intensive grazing period around

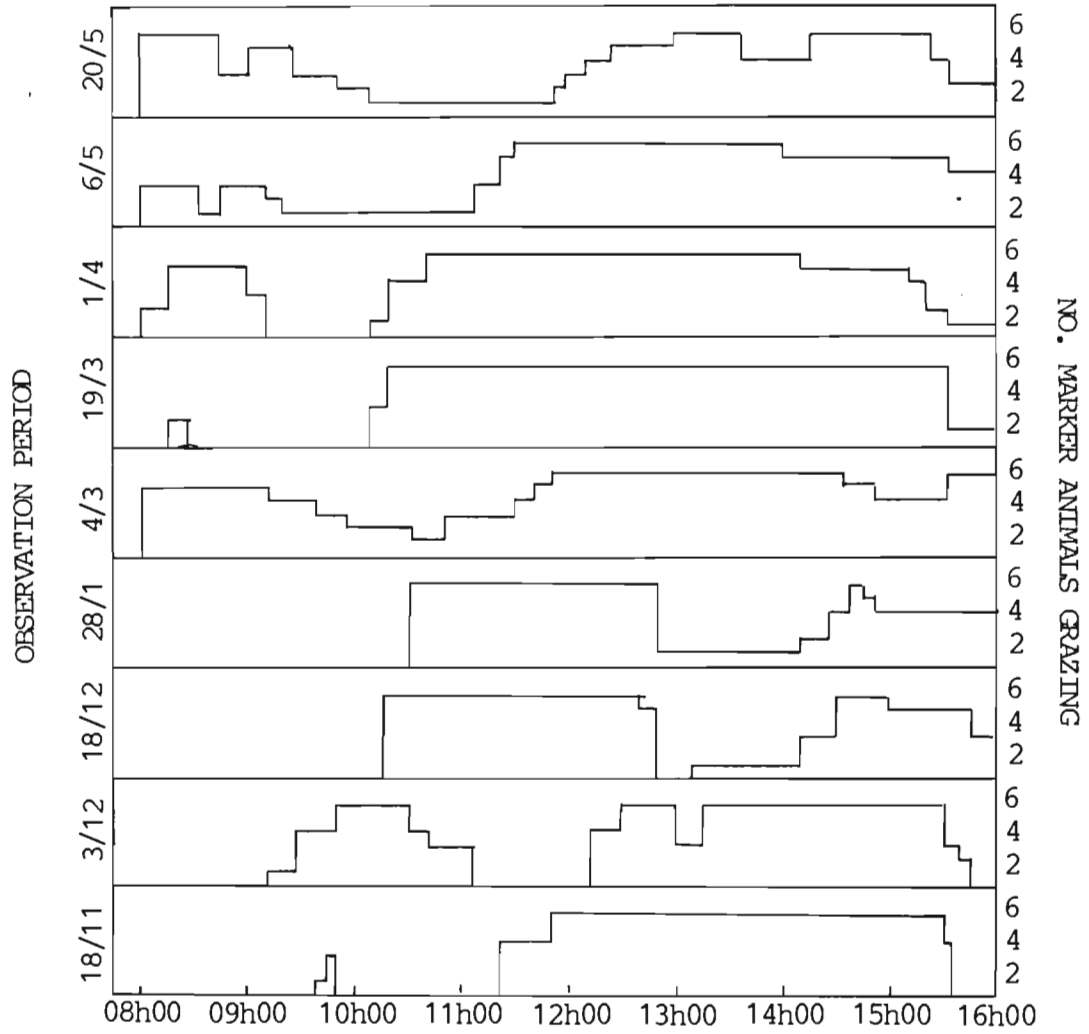


Figure 39a. Daily grazing activity during the periods of observation for the cows in Tr.1 - 1986/87 season.

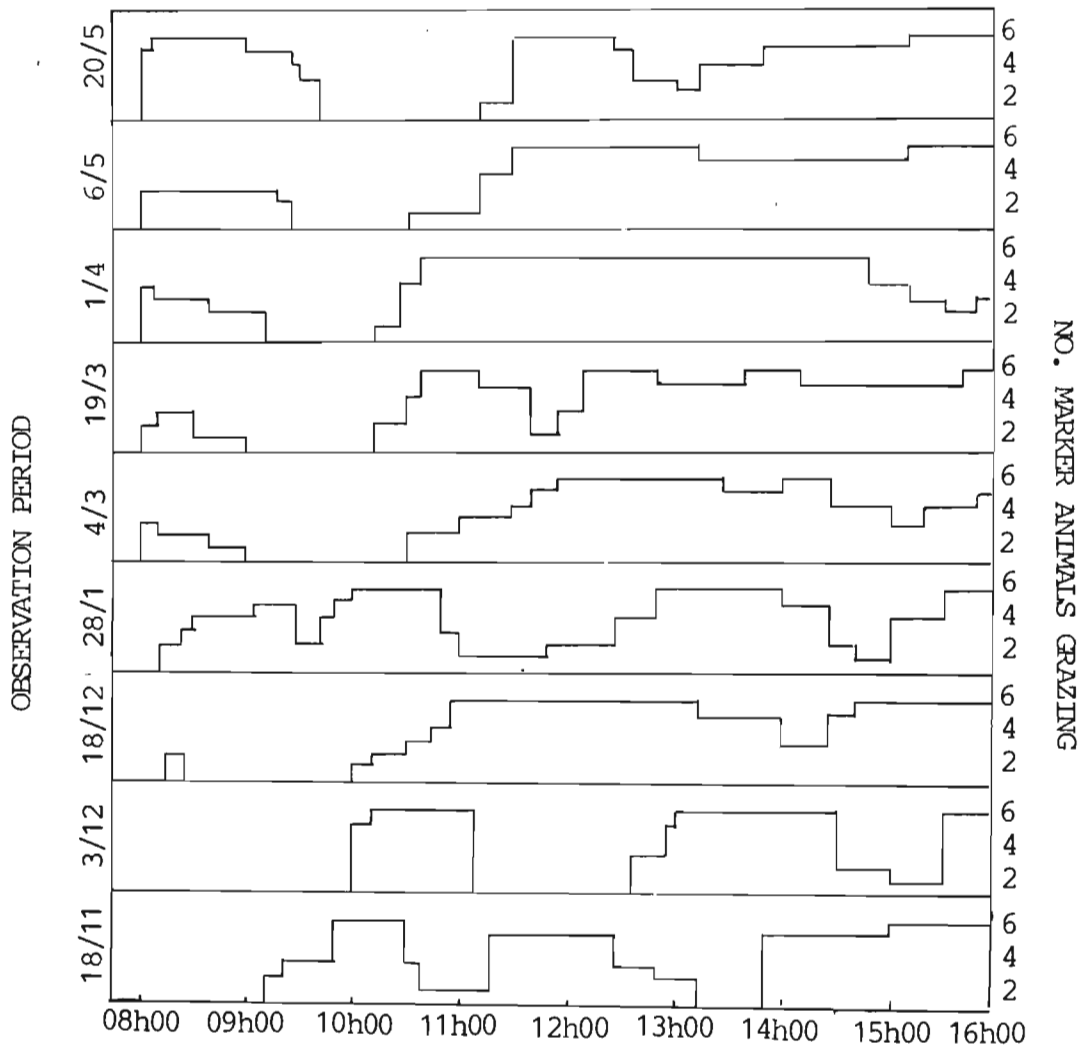


Figure 39b. Daily grazing activity during the periods of observation for the cows in Tr.2 - 1986/87 season.

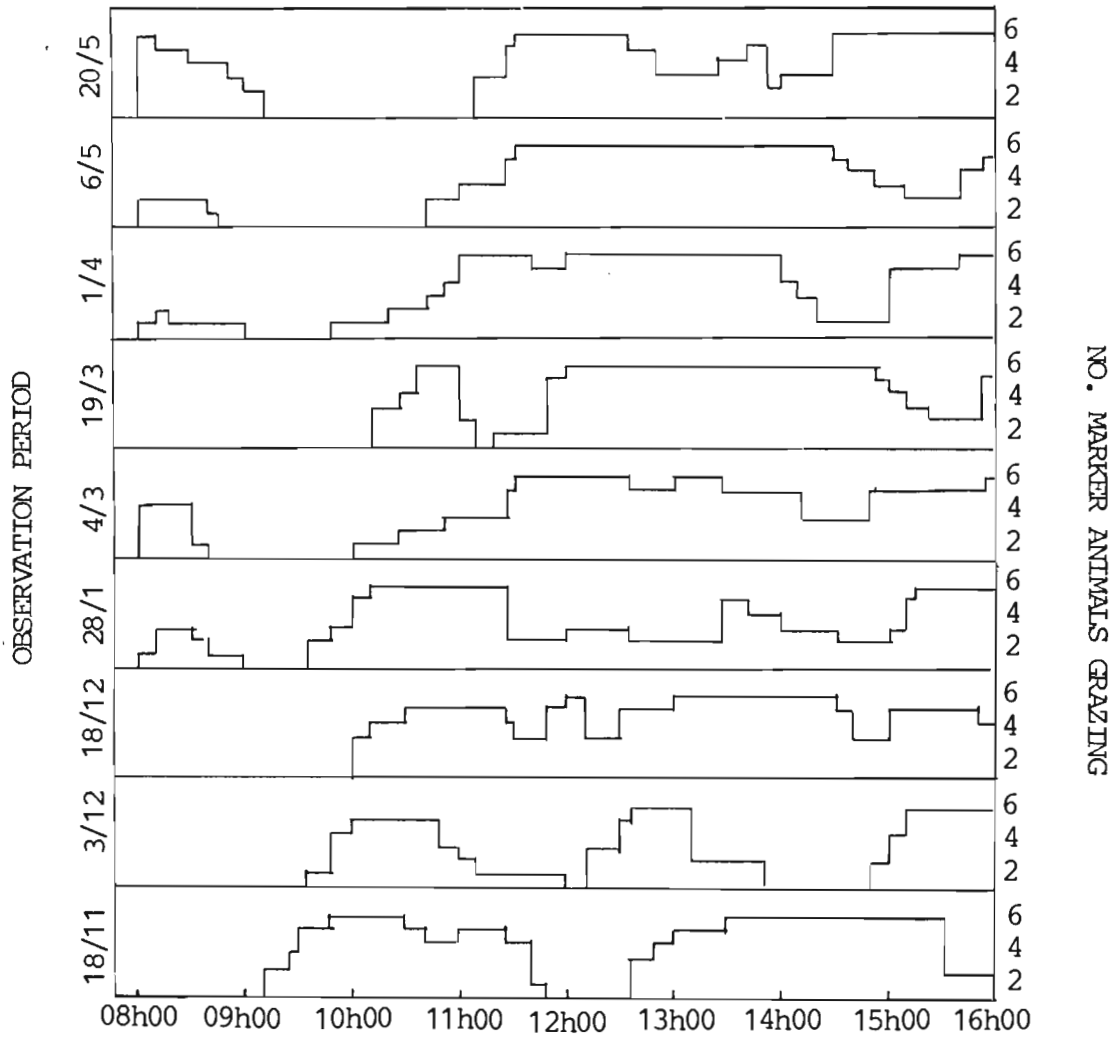


Figure 39c. Daily grazing activity during the periods of observation for the cows in Tr.4 - 1986/87 season.

dawn, followed by the first significant rest period. The observed grazing period commencing between 09h00 and 10h00, is the start of the second grazing session. From late January/early February onwards, low level grazing activity was apparent at 08h00 which was probably the tail-end of the first grazing session which commenced later as a result of the longer hours of darkness associated with the advancing season. The grazing activity between 08h00 and 09h00 increased in all three treatments as the season progressed. From March onwards, the patterns of grazing intensity were similar to those recorded during the first season (Figures 38a, 38b and 38c). The major difference between the two seasons however, was that the continuous grazing activity exhibited by at least some of the cows in Tr.2 and Tr.4 during the first season was not apparent during the second season. However, in Tr.1, the two seasons showed similar trends (Figures 38a and 39a).

Resting and ruminating

The times spent resting and ruminating have been combined and are presented for the different treatments in Table 52. As expected, the non-grazing time decreased over the season. An exception to this trend was noted in Tr.2 over the first season, where, in the small camps, both the first calvers and the mature cows increased the time spent resting over the season by 1,69% (8,12 min) and 5,29% (25,40 min) respectively. No logical explanation for these deviations from the apparently normal trends can be offered.

During the second season, the first calvers decreased the time spent resting in the small camps by 11,87% (56,97 min), 12,88% (61,83 min) and 11,23% (53,90 min) in Tr.1, Tr.2 and Tr.4 respectively. However, camp size apparently had a non-significant effect on the change in resting time, over the season, for any particular treatment.

In contrast, the mature cows decreased their resting time over the season, in the small camps, by 11,0% (52,80 min), 14,52 min (69,70 min) and 20,41 % (97,92 min) in Tr.1, Tr.2 and Tr.4 respectively. Once again, camp size did not significantly affect the time spent resting for any particular treatment, except at the high stocking rate. Stocking rate apparently had little effect on the time spent resting by the first calvers, but a significant ($P < 0,05$) effect on the mature cows. The high standard errors recorded for both classes of cows indicate that a considerable amount of variation between the animals was evident. This is however, not surprising because of the small numbers of animals involved in the actual observations.

With the exception of the cows in Tr.2, the mean time spent resting and ruminating, by both the mature cows and the first calvers during the second season, was generally similar to that recorded during the first season.

Suckling activity

The mean percentage time that the cows spent suckling their calves during the periods of observation, in the first season, are shown in Figures 40a, 40b and 40c. As expected, suckling activity was highest in the beginning of the season, and declined as the season progressed.

During the first season, the mature cows in Tr.1 generally spent a greater percentage of their time suckling their calves than their first calver counterparts. Similar trends were not apparent in the other two treatments. A feature of the data presented in Figure 40b and Figure 40c was the fact that from the end of April onwards, in two of the three observations in Tr.2 and three of the four observations in Tr. 4, the mature cows did not suckle their calves at all during the periods

Table 52. Percentage of time spent ruminating and resting by first calves and mature cows in the small and large camps.

1985/86 season	Large camp			Small camp		
	21.03.86	23.05.86	Difference	09.04.86	03.06.86	Difference
First Calvers						
0,83 cows/calves/ha	33,34 ± 1,71	19,90 ± 1,03	- 13,44 ^{ab*}	32,98 ± 6,14	22,89 ± 8,92	- 10,09 ^{ac}
1,0 cows/calves/ha	37,00 ± 6,22	28,63 ± 8,04	- 8,37 ^a	41,16 ± 16,0	38,69 ± 7,38	- 2,47 ^{bc}
1,25 cows/calves/ha	36,71 ± 5,32	30,60 ± 8,43	- 6,11 ^a	40,11 ± 11,08	27,78 ± 12,34	- 12,33 ^a
Mature cows						
0,83 cows/calves/ha	38,54 ± 1,48	31,63 ± 15,88	- 6,91 ^a	36,18 ± 6,03	27,66 ± 9,03	- 8,52 ^a
1,0 cows/calves/ha	34,0 ± 8,49	31,91 ± 18,05	- 2,09 ^a	33,34 ± 11,79	39,29 ± 8,41	+ 5,95 ^b
1,25 cows/calves/ha	44,69 ± 3,02	23,96 ± 7,37	-20,73 ^b	37,51 ± 5,89	24,99 ± 8,47	- 12,52 ^a
1986/87 season						
	18.11.86	06.05.87	Difference	03.12.86	20.05.87	Difference
First Calvers						
0,83 cows/calves/ha	45,94 ± 5,41	34,06 ± 5,22	-11,88 ^a	45,00 ± 12,81	33,13 ± 9,69	- 11,87 ^a
1,0 cows/calves/ha	39,72 ± 2,47	32,63 ± 5,89	- 7,09 ^a	47,08 ± 3,20	34,20 ± 4,22	- 12,88 ^a
1,25 cows/calves/ha	35,73 ± 5,15	39,15 ± 6,40	- 3,42 ^{ac}	44,41 ± 1,96	33,18 ± 4,53	- 11,23 ^a
Mature cows						
0,83 cows/calves/ha	37,78 ± 1,44	26,60 ± 4,52	-11,18 ^a	48,00 ± 11,32	37,00 ± 9,90	- 11,00 ^a
1,0 cows/calves/ha	43,15 ± 2,79	21,76 ± 6,15	-21,39 ^b	44,13 ± 6,93	29,61 ± 7,22	- 14,52 ^a
1,25 cows/calves/ha	27,57 ± 7,22	33,72 ± 4,62	+ 6,15 ^c	53,08 ± 2,89	32,67 ± 2,90	- 20,41 ^a

* Figures within columns having different superscripts differ significantly (P<0,05)

of observation.

During the second season, suckling activity continued right through to the end of the grazing season in all three treatments (Figures 41a, 41b and 41c). As expected, suckling activity generally declined over the season. However, both the mature cows, and the first calvers in Tr.2 maintained a high level of suckling activity until the end of the grazing season. At the end of the season, the first calvers spent 2,55% of the observed 480 minutes suckling, compared with 3,07% recorded by the mature cows (Figure 41b). This represents 1,25 and 1,5 suckling periods respectively. The first calvers in Tr.1, Tr.2 and Tr.4 recorded mean suckling times (total time spent suckling during the 480 minutes) at the beginning of the season of 21,60, 25,92 and 29,48 minutes respectively. By the end of the season this was reduced to 4,80, 12,24 and 4,90 minutes respectively. In contrast, the mature cows in Tr.1, Tr.2 and Tr.4 recorded mean total suckling times of 19,20, 23,56 and 24,53 minutes at the beginning of the season respectively. These times were reduced to 4,80 minutes (Tr.1), 14,74 minutes (Tr.2) and 4,90 minutes (Tr.4) by the end of the grazing season. It is interesting to note that both the mature cows and the first calvers in Tr. 2 spent significantly more time suckling than the cows in the other two treatments. No explanation can be offered for this situation but it is clear that both classes of cows maintained a high level of suckling activity right through to the end of the season. Whilst these figures cannot be regarded as absolute, because observations were only made at 10 minute intervals, the trends nevertheless remain meaningful. These trends suggest that generally there were no significant differences in the time spent suckling between the mature cows and the first calvers in any of the treatments.

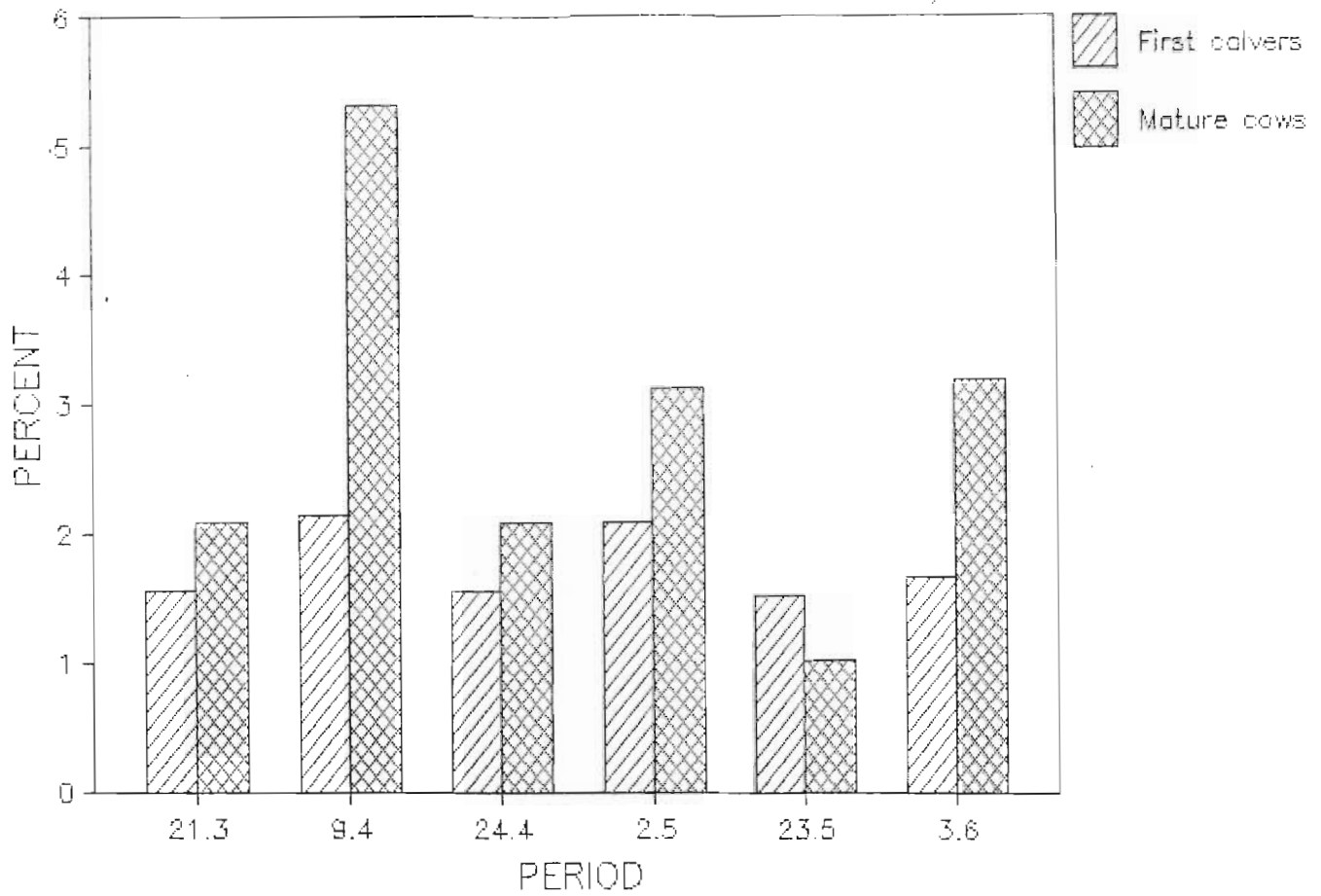


Figure 40a. The percentage of time spent suckling by the mature cows and first calvers in Tr.1 - 1985/86 season.

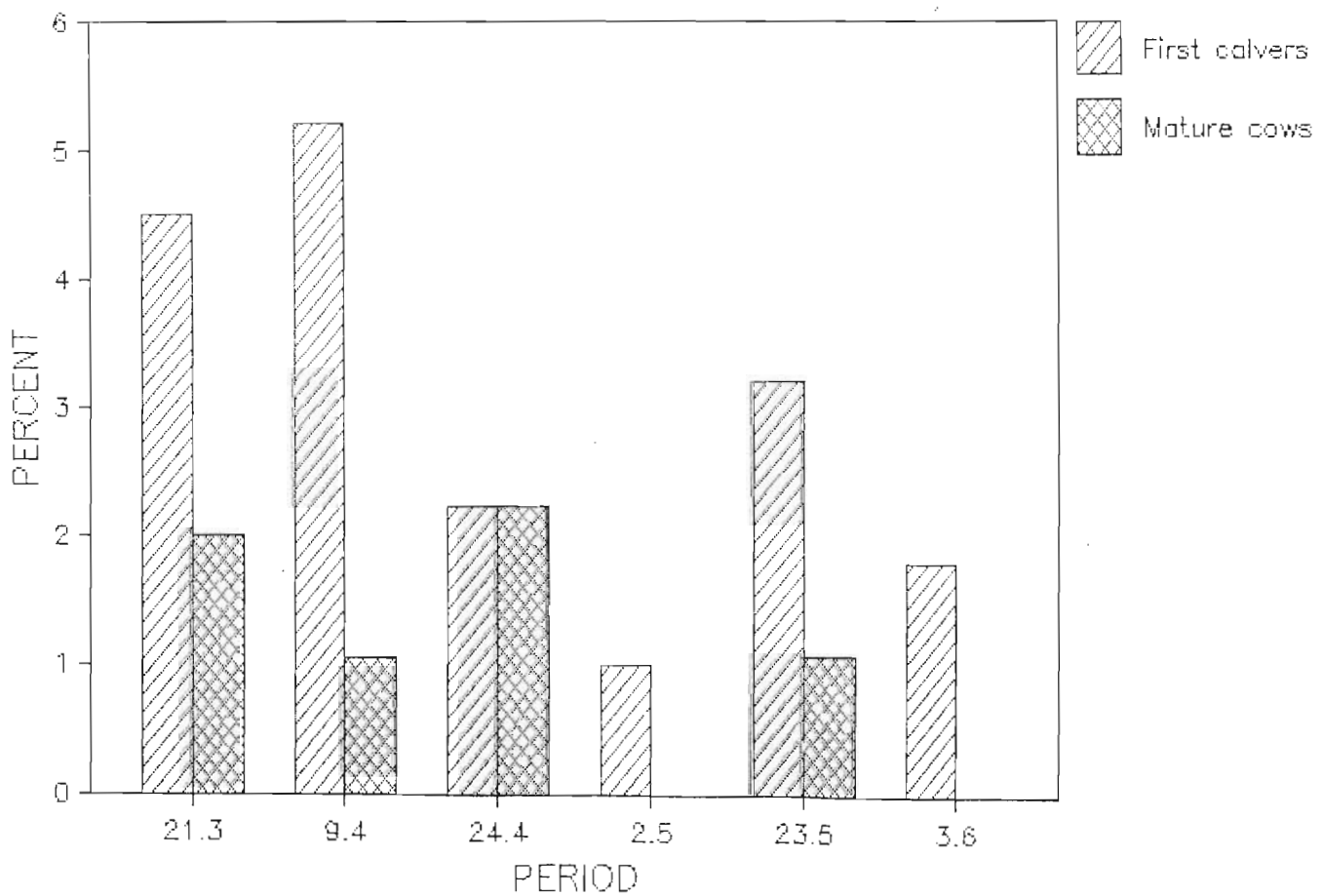


Figure 40b. The percentage of time spent suckling by the mature cows and first calvers in Tr.2 - 1985/86 season.

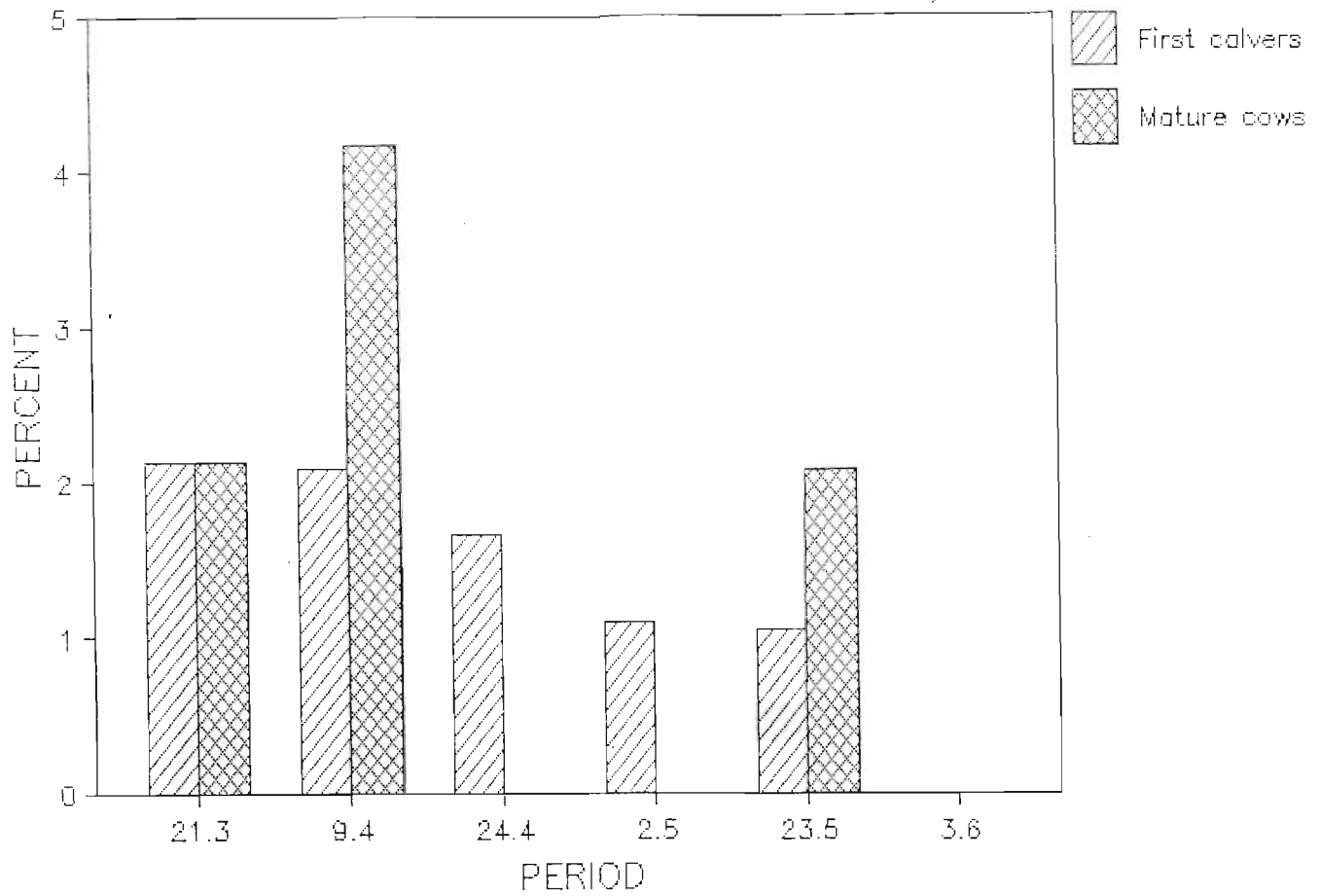


Figure 40c. The percentage of time spent suckling by the mature cows and first calvers in Tr.4 - 1985/86 season.

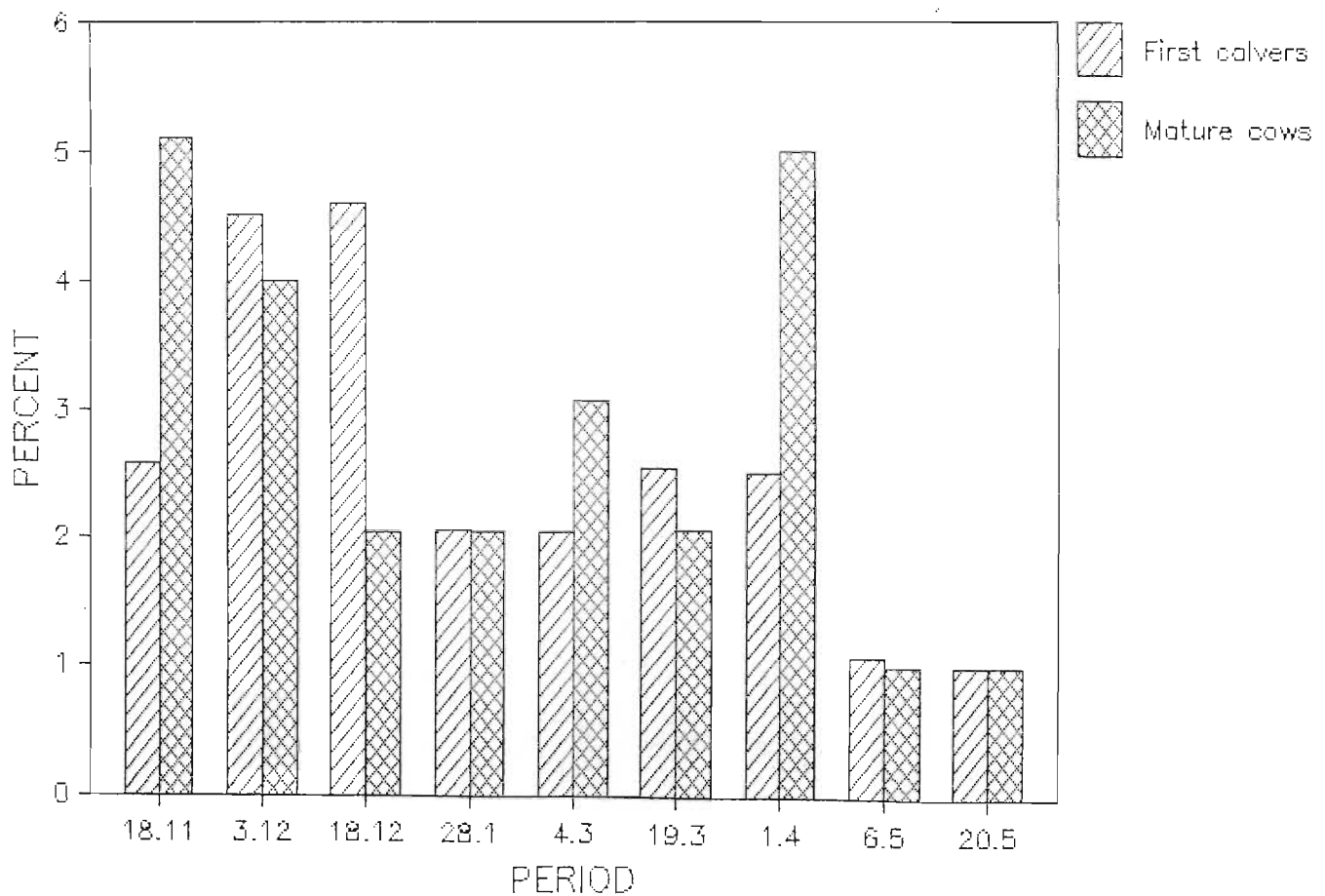


Figure 41a. The percentage of time spent suckling by the mature cows and first calvers in Tr.1 - 1986/87 season.

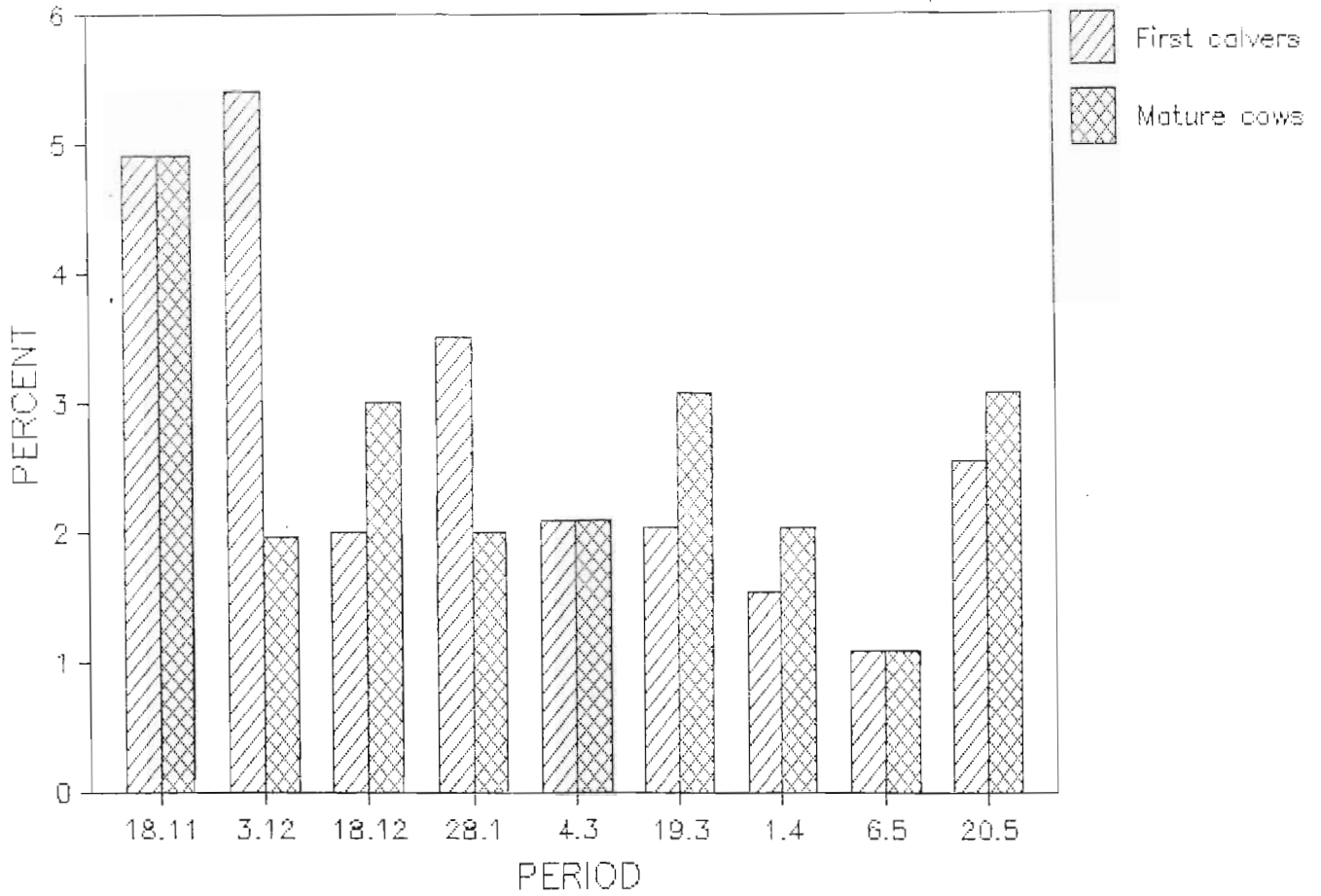


Figure 41b. The percentage of time spent suckling by the mature cows and first calvers in Tr.2 - 1986/87 season.

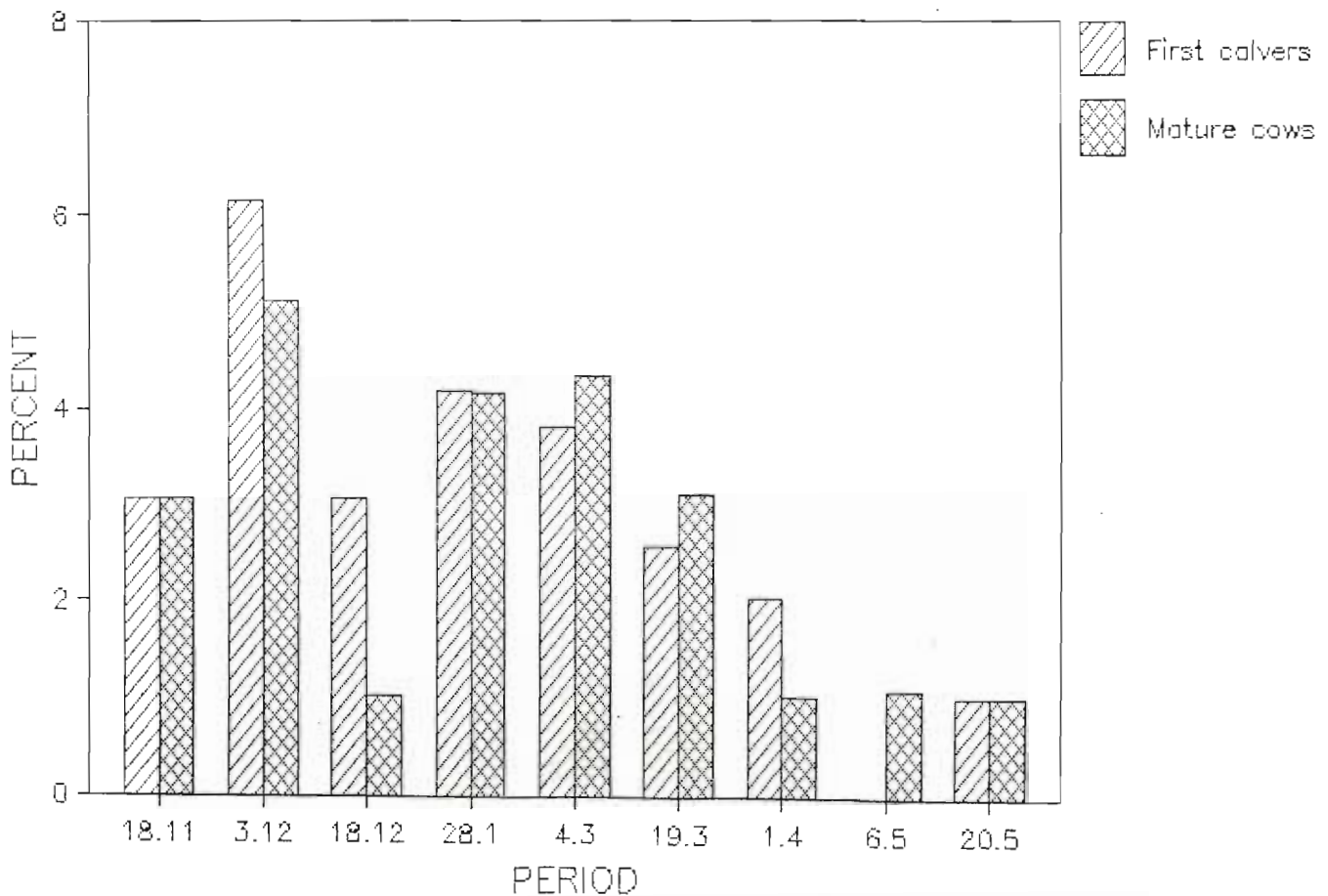


Figure 41c. The percentage of time spent suckling by the mature cows and first calvers in Tr.4 - 1986/87 season.

Miscellaneous observations

On four occasions, in various stocking rate treatments, all the calves in that treatment were seen to lie down in close proximity to one another with two, or three cows in close attendance. This usually occurred mid-morning and while all the other cows were grazing. The cows in attendance usually grazed without intent, or alternatively lay down with the calves. This pattern of behaviour seldom persisted for more than 90 minutes. The cows in attendance were sometimes relieved by other cows during this period.

DISCUSSION

In neither of the two seasons did any one class of animal graze for significantly longer periods than the other. Whilst one might have expected the lighter first calf heifers to graze for shorter periods than the mature cows on the basis that intake is a function of body mass (Hodgson & Wilkinson, 1967), this clearly did not occur (Figures 36a - 37c). The main reason for this is probably the fact that the first calvers have higher nutritional requirements, relative to mature cows, at the same stage of lactation (NRC, 1976). The first calvers would therefore have had to either increase their grazing time, increase their bite rate, or have been more selective in order to satisfy their nutritional requirements.

During both seasons, the increase in grazing time over the season was lower in the small camps than the large camps (Figures 36a - 37c), particularly for treatments 1 and 2. Camp size apparently played a minor role in affecting grazing time at the high stocking rate (Figure 36c), with a linear increase in grazing time over the season

irrespective of camp size. The camp-related increases in grazing time during the second season were generally higher than those recorded during the first season. In contrast to the trends recorded during the first season, the mean increase in grazing time in Tr. 4 during the second season, varied considerably between camp sizes and age of animal, but was nevertheless apparent (Figure 37c).

The effect of camp size on animal behaviour and performance has not been well studied. Research in this area has concentrated mainly on the effects of camp size on walking and drinking activities. Under extreme conditions, when drinking water is freely available, animals range further for food, but do not travel far for water, but when watering points are limited, walking to and from water accounts for most of the distance travelled (Arnold & Dudzinski, 1978). In this particular study, drinking water was freely available from a single source in each camp. Even the large camps were not of such a size (5 - 8 ha) that the single water source would have significantly affected their grazing behaviour. The animals were seldom seen to drink and it must therefore be assumed that drinking occurred outside the periods of observation. On average, the animals were seen to drink only once every two to three observation periods. Generally, a drinking session was initiated by one or two animals with the rest of the herd following soon afterwards. On several occasions the entire herd was seen suddenly to cease grazing and gallop to the water with much frolicking and kicking of hind legs. Both the cows and the calves exhibited this behaviour.

The social interactions, including social facilitation and spatial relationships, between the first calvers and the mature cows were of particular interest in this study. Social facilitation has been described as the modification of the grazing times of groups of animals

with different potential grazing times, due to the social interaction of grazing together (Arnold & Dudzinski, 1978). The chi-square analyses indicated strong associations between the first calvers and the mature cows, at the beginning of the first season. In Tr.4 however, grazing appeared to be random. At the end of the first season the trends had remained the same in Tr.1 and Tr.2, but strong associations between the first calvers and the mature cows were also observed in Tr.4. During the second season, there were strong associations between the first calvers and the mature cows in all three treatments at the beginning of the season. As the season progressed, the associations between the two classes of cows remained strong in Tr.1 and Tr.2, but the cows in Tr.4 appeared to graze randomly. These figures suggest that when grazing is limited towards the end of the season, as in the case of high stocking rates (Tr.4), social interactions declined in importance. The animals were then forced to graze wider and more independently in order to try and meet their nutritional needs. This observation is similar to that noted by Rutter (1968) using time lapse photography with grazing heifers. In general, where there is a shortage of feed, grazing time and the number of bites per minute will increase, but total intake will decrease (Arnold, 1985).

At the lower stocking rates (Tr.1 and Tr.2), leadership/followership patterns were noted by all the observers. In all three treatments, the first calvers were seen to establish the grazing patterns. Whilst this observation was subjective, it is to some extent supported by the grazing patterns shown in Appendices 13 - 24, which indicate that the mature cows generally arrived at a particular point at various intervals after the first calvers. According to Hafez & Schein (1962), leadership in cattle is a passive response, rather than an active one, with animals with less cohesive tendencies moving

away from their neighbours, which then follow. Syme & Syme (1979) noted that the spatial behaviour of subordinate heifers appears to be affected by attempts to maintain suitable distances between themselves and dominant animals. These authors suggest that the higher the social ranking, the more likely cows are to be found near other members of the herd.

At the high stocking rate, where grazing was in short supply, it was clearly not in any animal's interest to adopt a follower position which would mean that they then only had access to the herbage not selected by the leaders. Consequently, spatial relationships were extended in an effort to meet the nutritional demands by grazing "wider". At the low stocking rates, where grazing was more abundant, leadership/followership patterns were more apparent because the animals were able to satisfy their nutritional requirements within a more cohesive grazing unit. This finding is again similar to that noted by Rutter (1968).

There is no definitive evidence to suggest that animals have the ability to select herbage which will correct deficiencies in their diet. Hancock (1954) has, however, postulated that some animals are more selective and graze herbage of better quality than less discriminating animals. Hafez & Schein (1962) have suggested that selective grazing is inversely related to the age of the animal. If this is indeed the case, and the first calvers were more selective in their grazing habits, it may explain why the first calvers managed to perform at a level at least as high, and often higher, than the mature cows whilst grazing for similar lengths of time. The grazing times of herds containing animals of different ages (such as first calvers and mature cows), may differ considerably from homogeneous herds

(Arnold & Dudzinski, 1978). Whilst the effects of social facilitation have been noted more often in sheep (Tribe, 1950; Holder, 1962; Arnold & Dudzinski, 1978), some effects have been observed in cattle (Bailey, Bishop & Boord, 1974). In almost all cases, the grazing time was longer for groups of animals grazing separately. In the sourveld investigation, the first calvers did increase their grazing time relative to their requirements on a body mass basis. It is also possible that, in this particular study, the first calvers increased their bite rate, but because of a smaller bite size, this modification to the situation was largely nullified. Furthermore, the possibility that the first calvers were also more selective cannot be overlooked.

The finding that, as the days shortened, the intervals between grazing periods decreased until the latter part of May/beginning of June, when grazing activity was often continuous (Figures 38a - 39c), is similar to that observed by Arnold (1985).

During the first season there were no significant differences in grazing patterns between the three stocking rate treatments except that continuous grazing was noted in Tr.4 approximately 10 days before it was noted in the other two treatments. This was clearly a response to the high stocking rate and shortage of available herbage. Towards the end of the season, there still seemed to be sufficient herbage available in Tr.1 to satisfy the animals' dry matter requirements. However, as this material was of relatively poor quality (Figures 34a - 34d) the animals had to adjust their grazing behaviour in order to satisfy their nutritional requirements. The rest periods generally occurred within the periods 09h00 to 11h00, with a period of low level grazing activity often noted around 15h00.

During the second season, when observations were started at the beginning of the grazing season, there was no grazing activity in any of the treatments until after 09h00. The grazing patterns were then characterized by several periods of high (>50% of marker animals grazing) and low (<50% of marker animals grazing) grazing activity until approximately 15h00, when grazing activity once again commenced in earnest. The lack of grazing activity prior to 09h00 almost certainly coincides with the first significant rest period of the day following intense grazing activity which usually commences around dawn. From February/March onwards, as the days become shorter, so the first rest period shifts to late in the morning (Figures 34a - 34d). In all the treatments, grazing was almost continuous, during the observation periods, from March onwards, with varying degrees of activity through to 16h00 (Figures 38a - 39c).

These data suggest that stocking rate played a minor role in affecting the diurnal patterns of grazing. This response is similar to that observed by Arnold & Dudzinski (1978) who suggested that the amount of herbage available does not affect diurnal patterns of grazing. Rutter (1968) noted that, when feed was in short supply, there was less conformity between heifers in a herd of individuals. According to Craig (1986), limited resources are usually not prorated according to dominance ranks. He suggested that the relationship is probably one where the dominant animals benefit at the expense of the others. When resources are available in moderate quantities, more animals benefit, but a few will still be excluded.

The inverse relationship between the time spent grazing and, resting and ruminating found in this study, is not surprising and is in general agreement with other studies (Arnold & Dudzinski, 1978). These

authors also found no distinct diurnal pattern in rumination as is often found during periods of grazing. Lofgreen, Meyer & Hull (1957) have suggested that the ratio of ruminating time to grazing time is related to the total digestible nutrients (TDN) of the forage grazed. Hancock (1954) found that the ruminating time of cows on ryegrass-white clover pastures increased as the pasture changed from vegetative to full flowering. Small seasonal changes in ruminating time often occur because coarse, mature herbage is less digestible than succulent herbage, and therefore less of it is eaten (Herbel & Nelson, 1966; Kropp, Stephens, Holloway, Whiteman, Knori & Totusek, 1973). In five separate studies, Arnold & Dudzinski (1978) found that between 64% and 71% of rumination occurs between 18h00 and 06h00. Between 62% and 83% of the ruminating is done when the cows are lying down.

In general, suckling behaviour in cattle is not as well documented as that in sheep. The decrease in the total time spent suckling per day and the decrease in suckling activity over the season noted in this study, is in general agreement with the results of Nicol & Sharafeldin (1975). The finding that the first calvers generally did not spend a significantly greater time suckling their calves than the mature cows suggests that the younger cows had similar milk productions to the older cows. This observation supports the conclusions regarding the age of the dam and milk production proposed in the previous chapter. The weaning masses of the calves born to the first calvers were consistently as high and sometimes higher than the calves born to the mature cows. The failure of the mature cows to suckle their calves, during the periods of observation, from April onwards (Figures 40b and 40c) is surprising. One must therefore assume that as herbage availability and quality declined milk production was reduced to the extent that the calves were largely independent of their dam's milk as

the major source of nutrients towards the end of the season. Why such a situation should be peculiar to the mature cows is not clear.

Behaviour, in which group members other than the parent care for offspring, is termed "alloparental care" and is not unique to beef cows (Stricklin, Wilson & Graves, 1976). Similar behaviour to that noted in this experiment has been reported by Wagnon (1963). In this study, alloparental behaviour was noted only in the beginning of the season when sufficient herbage was available and the cows were not nutritionally stressed.

Conclusions

The fact that the length of the grazing periods did not differ between the first calvers and the mature cows suggests that the younger cows had to graze relatively longer in order to satisfy their high nutritional requirements. Furthermore the first calvers appeared to establish the grazing pattern with the mature cows adopting a "follower" position. It would be logical to assume that the first calvers, by adopting leadership positions were better able to select herbage of higher quality and thereby meet their nutritional requirements. It is interesting to note that no agonistic behaviour was observed during grazing periods.

Stocking rate and advancing season affected the grazing behaviour in the sense that as the days shortened, the interval between grazing periods decreased until the end of May when grazing became continuous within the periods of observation. These data suggest that the increased grazing time was a response to the declining quality and quantity of herbage. The response of the two classes of cows to each other at the high stocking rate was interesting. At the start of the second season, when grazing was reasonably abundant, there were strong

associations between the first calvers and the mature cows in all three treatments. However, at the end of the season the two classes of cows grazed further apart at the high stocking rate. It was therefore concluded that as the grazing pressure increased, social interactions became less important. The trend was not consistent between the two seasons. During the second season, there were strong associations between both classes of cows, in all three treatments, at the end of the grazing season. No logical explanation can be offered for the difference between the two seasons.

GENERAL DISCUSSION

"Modern science is characterized by its ever increasing specialization necessitated by the enormous amount of data, the complexity of techniques and of theoretical structures within every field. Thus science is split into innumerable disciplines continually generating new sub-disciplines. In consequence the physicist, the biologist, the physiologist and the social scientist are, so to speak, encapsulated in their private universes and it is difficult to get word from one cocoon to the other" (von Bertalanffy, 1979).

The discipline of Agriculture, as one of the applied sciences, is no less complex than any of the other sciences and consists of countless sub-disciplines. In the field of Agriculture it is vital that the basic and applied aspects of the discipline should be viewed in their proper, and not isolated perspective. Such an approach is necessary if the research and extension inputs, which aim at improving the viability and efficiency of agricultural systems, are to be successful. It is for this reason that a multidisciplinary or "systems" approach to the research effort at the Thabamhlope Research Station has been adopted unequivocally.

Agriculture is practised in the form of production systems, enterprises or farming systems (Spedding, 1975). Economic considerations are generally of prime importance, often dictating the viability of a particular enterprise or production system. However, the manipulation of such systems can be successful only when the underlying scientific principles, and the impact that management could have on such systems, are clearly understood. The understanding of agricultural systems thus requires a synthesis of biological principles, management and economics.

Heifer rearing

The rearing of replacement heifers forms a sub-system of the greater breeding herd, which in turn, is an integral part of the whole beef enterprise. The success of a breeding herd is largely dependent upon an adequate supply of selected heifers each year. Strict selection and judicious management of replacement heifers provide the producer with the opportunity for improving the production efficiency of his whole breeding herd. Age at calving and the time of calving within the calving season (early or late) are important in determining the heifer's lifetime production potential (Zimmerman et al., 1957; Lesmeister et al., 1973). The experiments described in this thesis were conducted with Simmentaler heifers, which, according to Wiltbank (1976), are relatively late in attaining sexual maturity. Whilst several workers have shown large differences between breeds or breed crosses in the age of heifers at puberty (Wiltbank, Gregory, Swiger, Ingalls, Rothlisberger & Koch, 1966; Laster, Glimp & Gregory, 1972; Laster, Smith, Cundiff & Gregory, 1979; Gregory, Laster, Cundiff, Koch & Smith, 1978; Reynolds, DeRouen & Bellows, 1978), the majority of these studies have been concerned with mating of heifers at 14 - 15 months of age so that they calve down at two years of age. In the Highland Sourveld, where heifers are usually mated at two years of age and calve down as three year-olds, the attainment of puberty generally poses few problems. Body mass is also an important factor affecting sexual maturity (Allden, 1970, Lamond, 1970; Short & Bellows, 1971; Burfening, 1974). In the present study, the target mating mass of 330 kg was achieved with relative ease under a range of management options, and should therefore present no problem to the producer.

The heifer-rearing aspect of the breeding enterprise is placed under severe financial stress if the heifers have to be fed for three years before producing a calf whose viability is not guaranteed. The

results from this study have indicated quite clearly that the number of management options available within a relatively rigid system are considerable and that the economic returns between each option vary greatly (Table 7). A rigid system is defined as a situation where, as for example in the Highland Sourveld, the beef enterprise is based largely on veld, but some form of supplementary or substitute feeding is necessary during the winter months. The options within such a fixed system with regard to winter nutritional levels and summer stocking rates are however, infinite.

Several researchers have drawn attention to the fact that undernutrition may result in increased age at puberty (Joubert, 1954; Wiltbank et al., 1969), subnormal conception rates and impaired fertility (Hill et al., 1970; Short & Bellows, 1971). Overfeeding on the other hand, may result in decreased breeding efficiency (Arnett et al., 1971), high calf mortality (Bond & Wiltbank, 1970), decreased mammary gland development (Swanson, 1957) and decreased milk production (Swanson, 1957, 1960). Thus, incorrect nutritional levels during the development period may have both short and long-term effects on heifer productivity. It has been suggested that a negative relationship between the early growth rates of heifers and subsequent calf-rearing ability may be significant under natural pasture conditions (Mangus & Brinks, 1971; Koch, 1972). However, the extent of production differences associated with different growth rates during rearing, are variable (Johnson & Obst, 1984).

Underfeeding of one group of heifers was incorporated into this study to test the potential benefit of compensatory growth on sourveld. Explanations for compensatory growth that have been advanced include decreased maintenance requirements (Saubidet & Verde, 1976), alteration of the composition of tissue gains (Thompson, Bickel & Schurch, 1982; Baker, Young & Laws, 1985), increased food intake (Meyer et al., 1965)

and increased efficiency of utilization of energy and protein (Fox, Johnson, Preston, Dockerty & Klosterman, 1972). In this study, the biggest single factor affecting compensatory growth was stocking rate. Cattle generally record higher feed intakes during periods of realimentation (Meyer et al., 1965; Horton & Holmes, 1978; O'Donovan, 1984). It is therefore axiomatic that complete compensation is not possible, or takes longer to achieve, if herbage intake is restricted during the realimentation period. In the present study, whilst the degree of undernutrition could not be described as severe, up to eighty percent of the compensation, as measured by mass, had taken place by the end of the summer grazing phase, relative to the heifers wintered on the high plane of nutrition, and complete compensation by the end of the second winter.

The degree of compensatory growth achieved in this experiment varied between seasons (Table 5) and was probably a function of both the quality and the quantity of herbage available. All the camps were burnt during the 1983/84 season. Unfortunately no herbage analyses were carried out, but it is likely that the burn affected the quality of grass available during the 1984/85 season.

The effect of season on the production of summer veld clearly affected the economics of rearing heifers at the Thabamhlope Research Station. The significant role of compensatory growth in reducing the second winter feed costs (therefore the total feed costs) during the first season, was not repeated during the second season (Table 7). These data serve to emphasize the fact that management decisions aimed at optimizing summer and winter nutritional interactions are possible for the producer with a clear understanding of his animals' requirements and the factors determining veld production even though season is impossible to predict accurately.

Reproduction

Sixty eight percent of the heifers that calved for the first time in 1984, produced three calves in three years and thirty percent of the heifers produced two calves in three years. These reproductive performances were achieved despite the fact that the heifers were subjected to various experimental treatments following the birth of their first calves. Whilst it is not possible to make any predictions with regard to the lifetime production of these heifers, the effect of poor nutrition during the post-weaner stages does not appear to have had any detrimental effect thus far. The fact that all the heifers calved within the first 30 days of the calving season during both years (Tables 10 & 15) is also highly desirable in terms of lifetime production (Roberts et al., 1970; Lesmeister et al., 1973) and is furthermore a clear indication that the animals had achieved puberty and were cycling (Allden, 1970; Lamond, 1970; Short & Bellows, 1971). There was therefore no apparent effect of compensatory, or continuous growth rates, on the oestrous cycle and conception rate. This is in general agreement with the results obtained by Bond and Wiltbank (1970). The birth masses of the calves born to heifers reared at different growth rates did not differ significantly, which is in agreement with the findings of Clanton, Jones & England (1983).

The high costs of winter feed realized in this study has highlighted the need to adopt management strategies aimed at reducing winter inputs as far as possible. A major objective of any livestock producer in the Highland Sourveld must be, not only to increase animal production off summer veld, but also to extend the length of the summer grazing season without detrimentally affecting either the veld or the animal. The time of weaning and the post-weaning management of the breeding heifer are therefore critical for the economic survival of the beef breeding enterprise.

Body condition and performance

The ability of lactating beef cows, receiving a diet deficient in energy, to mobilize body reserves for milk production has been noted by several researchers (Ball et al., 1971; Economides et al., 1973) as has its significance on the economic efficiency of beef production (Somerville et al., 1983). Chestnutt (1984) found that the energy requirements of lactating cows could be reduced by up to one third, where energy reserves were built up on grass and mobilized during winter. Condition score has been shown to be a better predictor of body reserves than live mass, although if animals are of similar body size, live mass and body condition provide similar levels of prediction of body fat (Guerra et al., 1972).

In investigating the role of condition scoring of beef cows as a possible management tool, the objective in this study was to improve the overall efficiency of the breeding operation. Particular attention was focused on the effect of body condition on reproduction in the context of the economic rationing of winter feed.

The concept of a "target mating mass" based on the principle that there is an optimum body mass for successful conception, has been supported by a number of researchers (Lamond, 1970; Steenkamp, van der Horst & Andrew, 1975; Ward & Tiffin, 1975). According to Richardson et al. (1976) the ability of a beef cow to conceive is a function of body mass per se and not rate of gain between parturition and breeding. The target mass concept is dependant upon animals being weighed at regular intervals. However, under semi-extensive and extensive conditions cows are seldom weighed. This renders a visual appraisal of a cow's physiological state particularly useful in such situations, providing the method of appraisal is repeatable and reliable.

A number of methods of estimating the body composition of live animals have been investigated. These include the following: (i)

Potassium - 40 (^{40}K) liquid scintillation detection (Bennink, Ward, Johnson & Cramer, 1968; Lohman, Ball & Norton, 1970; Belyea, Frost, Martz, Clark & Forkner, 1978). (ii) Body water, on the basis that total body water is highly negatively correlated with body fat (Panaretto, 1963) by means of tritiated water (TOH) infusion (Carnegie & Tulloh, 1968; Little & Morris, 1972; Little & McLean, 1981), and deuterium oxide (D_2O) dilution (Crabtree, Houseman & Kay, 1974). (iii) Urea space which is defined as the amount of water with which urea equilibrates (Kock & Preston, 1979; Meisner, van Staden & Pretorius, 1980). (iv) Fat probes (Miller, Mersmann, Ferrell & Tatum, 1982; Daley, Tatum & Taylor, 1983). (v) Ultrasonics (Gillis, Burgess, Osborne, Greiger & Talbot, 1973) and linear measurements (Klosterman, Sanford & Parker, 1968). All these methods, except the last mentioned, require the use of some type of specialized equipment which renders them unsuitable for use on the farm.

Condition scoring, although based on a visual subjective appraisal (Klosterman, et al., 1968; Lowman et al., 1976) has been shown in this study to be a highly effective management tool. The technique is both reliable and repeatable (Croxtton & Stollard, 1976). The significant relationship between body condition score at mating and reconception rates obtained in this study are of particular importance since it provides the opportunity to promote "target" condition scores at mating. Similar results to those obtained in this study with regard to body condition and successful conception have been recorded by a number of other researchers (Kilkenny, 1978; Mulvaney, 1978; Meaker, 1984). The finding in this investigation that the cows in good body condition at mating (condition score 3,0 - 4,0) conceived early in the season is also of economic and managerial significance. In this context, several researchers have noted that body condition at calving has a significant effect on post-partum anoestrous intervals (Wiltbank et al., 1962;

Croxton & Stollard, 1976; Graham, 1982).

Whilst a cow's physical body condition is largely influenced by plane of nutrition, the physiological basis for the relationship between body condition and fertility in breeding cows is not well understood. It has been established that if an animal is sufficiently undernourished, cyclic activity may be severely retarded (Hale, 1975; Louw et al., 1988). In both these studies sexual activity recommenced at a mass which was significantly higher than the mass at which cyclic activity ceased. Symington (1969) has noted that in situations where undernutrition is chronic, the lowered reproductive state is attributable primarily to depressed gonadotropic function of the pituitary. The depressed gonadotropic function is probably due to reduced pituitary size rather than the lowered concentrations of gonadotropins. In cows where undernutrition is less severe, the exact mechanisms that may affect reproductive performance are less clear. Wiltbank et al. (1964) and Lamond (1970) have related follicular development to nutrient intake. Hill et al. (1970) found that short-term undernutrition reduced follicle numbers and plasma progesterone levels in beef heifers. A less pronounced manifestation of infertility is silent heat. In such situations, it appears that the pre-ovulatory surge of oestrogen is sufficient to stimulate the normal release of luteinizing hormone (LH), but is not sufficient to stimulate the production of pheromone and normal oestrus behaviour (Topps, 1977). Hale (1975) found that, in dry cows, as many as 35% of anticipated oestrous periods were silent and that in the postpartum period of lactating cows, there were two silent heats for every three full heats.

The severe effects of undernutrition on the cyclic activity of beef cows as noted by Hale (1975) and Louw et al. (1988) have been mentioned above. However, the economic consequences of attempting to

improve a cow's body condition significantly during the winter months on expensive, conserved forages may be equally serious (Table 19). Whilst the importance of an adequate supply of energy immediately post-partum is well established (Wiltbank et al., 1962, 1964; Dunn et al., 1969; Holness et al., 1978), the results from this study clearly show that a cow in poor condition at parturition, and therefore also at breeding, is less likely to conceive than a cow in good condition. Body condition at calving, and consequently mating, thus remains one of the most important factors influencing successful conception. According to Selk et al. (1986), if nutrient intake after calving is equal, cows with extra body reserves will meet their caloric needs for parturition, lactation, uterus involution and re-breeding more easily than thin cows. It has also been suggested that cows maintaining good body condition after parturition have enhanced pituitary and reproductive potential regardless of calculated nutrient requirements. The overriding factor which dictates the winter feeding regime in the Highland Sourveld is the condition of the breeding cow at the end of the summer grazing period and at the onset of the winter feeding stage. This, in turn, is determined by the management of the animal on summer veld, an aspect that was considered in detail in this investigation.

Effect of stocking rate on animal performance

The main emphasis has centered around the relationship between stocking rate and animal performance. The data obtained show unequivocally that both cow and calf performance decline with increasing stocking rate. This is in general agreement with the stocking rate/animal performance model proposed by Jones & Sandland (1974). This model has been widely used in South Africa to determine the optimum economic stocking rate for different situations (Booyesen, Tainton & Foran, 1975; Dankwerts & van Rooyen, 1980; Edwards, 1981).

Stocking rate is defined as the area of land allotted to each specified animal with the length of the grazing season also being specified (Edwards, 1981). Stocking density on the other hand, is defined as the ratio between the number of specified animal units and area of land (ha) at any instant in time (Edwards, 1981). The specification of the length of the grazing season in the Highland Sourveld is essential because of the strong relationship between the number of grazing days and the economic viability of the enterprise due to the high cost of feeding during winter.

Stocking rate is, however, not independent of the grazing management procedure, and both aspects should be viewed simultaneously (Tainton, 1985). The veld in this investigation was managed according to a modified Venter & Drewes (1969) flexicamp system recommended for the sourveld areas of Natal. However, this system of veld management is regarded as sophisticated by the farmers, because of the number of camps per herd (eight). In general, effective rotational grazing programmes are not widely used (Tainton, 1985). The animal performance data obtained from this study must therefore be regarded as being close to the optimum for the breed-type used, when viewed in the context of the reasonably sophisticated veld management system and the feeding regime employed during the winter period.

Whilst the Department of Agriculture and Water Supply's official recommendation with regard to veld management in the sourveld areas of Natal is based on rotational grazing using between four and eight camps (preferably eight), there still appears to be divergent views on the number of camps required to optimize animal and veld production. Undoubtedly, the Department's approach has been based largely on the work of Scott (1947), Acocks (1966) and Booysen (1966, 1969). The multicamp/rotational grazing veld management approach has been largely supported by Edwards (1981) and Tainton (1981, 1985). However, the

conclusion to be drawn from the research of Denny & Barnes (1977) and Denny & Steyn (1977) is that individual animal performance declines as the number of camps increases. In a review of experiments comparing systems of grazing management on natural pastures, Gammon (1978), found that fewer than half the rotational grazing systems resulted in pasture improvements relative to continuous grazing and that animal performance was either similar to or poorer than results achieved under continuous grazing.

Stocking rate remains the most important single factor in grazing management affecting animal production from grass (Edwards, 1981). The criteria for choice of stocking rate are both diverse and complex. In the beginning of the season, when herbage may be plentiful, the pasture might be understocked, although the same stocking rate mid-way through the season and at the end of the grazing season, may impose severe demands on the animal as well as the pasture (Morley, 1981). There is therefore no "best" stocking rate, but a range of stocking rates that will be economically optimum in terms of animal performance and herbage production. Although dry matter intake, digestible energy and digestible protein are the major factors affecting the production of grazing animals (Raleigh, 1970), the complexity of the grazing situation prevents the simple calculation of stocking rate based on dry matter available from a particular pasture. The methods of estimating dry matter production from veld and the dry matter intakes of grazing animals have been researched for many decades, and, as yet, no method has been shown to provide complete, reliable answers to this highly complex situation (Fontenot & Blaser, 1965; Freer, 1981; Waldo, 1986).

Forage organic matter intake (OMI) or dry matter intake (DMI) are often expressed relative to body mass (Langlands, 1968), or as a percentage of body mass (Engels & Malan, 1973; Cordova et al., 1978). Intake by grazing animals varies with some function of body mass

(Cordova, et al., 1978), and when differences in live mass result from age, breed or previous level of nutrition, no single relationship may be generally acceptable (Langlands, 1968). It is largely because of such discrepancies that many researchers have expressed intake per unit of metabolic body mass. However, the exponent which provides the best fit to experimental results varies from 0,43 (Holmes, Jones & Drake-Brockman, 1961) to 1,0 (Weston, 1959; Hadji pieris, Jones & Holmes, 1965). The literature suggests that the most commonly used exponents are 0,73 - 0,75 (Cordova et al., 1978) Because of the different classes of animals within each treatment in this study, metabolic mass has been used to compare differences in mass between treatments. Total metabolic mass declined over the seasons at the high stocking rates (1,25 and 1,67 cows and calves/ha), but remained relatively constant over the seasons at the lighter stocking rates (0,83 and 1,0 cows and calves/ha). The correlation between stocking rate and the increase in calf metabolic mass over a season was curvilinear (Figure 11). The trend in metabolic mass gain for the cows was similar to that recorded for the calves (Figure 12).

The very high stocking rate (1,67 cows + calves/ha) produced the greatest quantity of weaned beef per hectare, but, after four years the mean weaning mass had declined to 130 kg and the grazing season had been reduced to 124 days. The cows were also in very poor condition (condition score - 1,73) at the end of the grazing season. This was clearly a highly undesirable and uneconomical situation. Furthermore, the condition of the veld declined to such an extent that the treatment was terminated after four years. The rapid change in veld composition towards a less desirable situation, occurred despite a recommended veld management programme being applied which emphasizes the importance of stocking rate. The cows were in good condition at the start of the grazing season, a factor which indicates the degree of stress the cows,

calves and the veld were subjected to. According to extension personnel, there are relatively few farmers operating at these excessively high stocking rates. Unfortunately, it is sometimes believed that high stocking rates can be employed successfully if a urea-based lick is freely available to the animals. The data obtained in this study show conclusively that the provision of a urea-containing lick failed to increase either cow or calf performance at a very high stocking rate. In all four seasons the cows with access to the urea-based lick produced weaners on average 7 kg lighter (NS) than the cows that had access to the urea lick only after the 15 th of February. Dry matter intakes were clearly insufficient to meet even the cows' maintenance requirements at the very high stocking rates.

Gains of cattle on low quality forages have generally been improved with urea-molasses licks, but not with molasses alone. It would appear therefore, that protein is the first limiting factor (Beames, 1959). This viewpoint is supported by Capper et al. (1977), who concluded that in southern Africa, crude protein, and not energy, is the major limiting factor. Protein supplementation has been shown to improve performance of beef cows consuming low-quality roughages (Clanton & Zimmerman, 1970; Clanton, 1978). Supplementation in the form of NPN has not supported livemass gains equal to that of natural protein supplements (Rush & Totusek, 1976; Clanton, 1978; Owens et al., 1980). The cost of NPN licks has, however, generally made them attractive, although the cost per unit of protein is probably not cheaper than natural proteins. The efficient utilization of urea is dependent upon a readily available source of carbohydrates (Skinner, 1964; Satter & Slyter, 1974; Rush & Totusek, 1976), which will increase the costs of urea licks further unless, the herbage source is high in energy.

At the low stocking rate (1,0 cow + calf/ha) the provision of a

urea lick did not improve calf performance, but could be economically justified under the conditions prevailing at the Research Station; viz. lower winter feed costs due to improved cow condition (Table 33). There is little doubt that, because of the lower stocking rate, the cows in Tr.2 and Tr.3 (1,0 cow + calf/ha) were better able to satisfy their dry matter intakes than the cows in Tr.5 and Tr.6 (1,67 cows + calves/ha). Whilst urea utilization at both stocking rates may have been equally poor, it is possible that it was sufficient to cause an increase in appetite which could be satisfied at the lower, but not at the higher, stocking rate.

The method of weaning calves on the basis of their dam's condition proved to be useful under sourveld conditions, particularly at the higher stocking rates. As the calves at the low stocking rate tended to lose mass after 200 days on veld, there would appear to be no reason to maintain them on veld after this period irrespective of the condition of their dams. The decline in mass after 200 days can be ascribed to the low milk production of the cow at this stage (6 - 8 months) and the decline in the quality of the veld after April. In a study in which the milk production from cows of the same genetic background as those used in the sourveld study, was determined, Louw (1984) found that on intensive pastures, Simmentaler cows produced between 2,8 and 5,8 l of milk per day, depending on stocking rate, after 200 days on pasture. These cows were then at the same stage of lactation as the cows in the Sourveld study. The masses of the calves on intensive pastures also declined at the high stocking rates after 200 days on pastures, as in the veld situation. The requirements for maintenance for a 100 kg calf is 5,5 l per day (Roy, 1980). It is therefore not surprising that the calves lost mass after 200 days on veld.

The inflexibility of the experimental design prevented the calves from being weaned separately, or in batches. Under practical farming

conditions, particularly at high stocking rates where peak masses are likely to occur before 200 days on veld, weaning on the basis of the dams' condition score (between 2,25 and 2,5) is recommended. The importance of stocking rate on calf performance is emphasized by the fact that 40% of the total variation in calf gain was ascribed to stocking rate (Table 32). In the case of the cows, stocking rate accounted for 45,5% of the total variation in cow gain between the initiation of grazing and weaning. These figures become more significant when viewed in the light of the simple economic model analysed in this investigation. There was a R292 difference in return per hectare between the very high stocking rate and the low stocking rate treatments.

The current high beef prices make overstocking attractive, in the short-term. If cheap sources of winter feed are available, then high stocking rates become even more economically viable. There is little doubt that this will be achieved at the expense of the veld. It should be noted that such situations are likely to occur even when accepted and recommended veld management principles are applied.

The finding in this investigation that lactating first calvers produced weaners, at least as heavy, and on average heavier (and older), than the weaners raised by the mature cows, was noteworthy. Of equal importance however, was the fact that the first calvers produced weaners in excess of 200 kg and yet were in similar body condition to the mature cows at the termination of grazing (Table 42). The first calvers therefore did not require significantly more winter feed because of a poorer body condition. These data have important implications from an animal production and veld management viewpoint. The possibility of combining first calvers and mature cows successfully in a single herd on veld, will reduce the total number of camps required to conduct an effective veld management system. However, it is

important that the factors contributing to the good performances of the first calvers are clearly understood.

In this study the first calvers were mated 3 - 4 weeks prior to the main breeding herd. At parturition, the heifers were in good body condition and a high level of nutrition was maintained during the early postpartum period. These cows were therefore probably able to realize their potential milk production levels. At the start of the grazing season, the calves born to the first calvers were on average 3 - 4 weeks older than the calves born to the mature cows. The calves born to the first calvers were, on average, 70 to 80 days old at the start of the grazing season. These calves therefore had access to a milk supply that was not influenced by plane of nutrition during the first 2,5 to 3 months, and were able to start grazing at a stage when the veld was relatively succulent and at its most nutritious. The early calves were therefore clearly able to adapt to the veld conditions better than the calves born later. It could be argued that the cost of feeding the heifers during the late winter period could not be justified economically. However, the relatively small number of animals involved (20% of the breeding herd), and the improved chances of early reconception should outweigh the additional feed costs.

According to Holness et al. (1978), postpartum anoestrus is lengthened by a thin body condition and poor nutrition. Harwin, Lamb & Bisschop (1967) have suggested that the postpartum anoestrus, or lactational anoestrus, period is particularly evident in the case of three year-old cows with their first calves at foot. The data obtained in this study indicate that the longer postpartum period prior to the mating season for the first calvers allowed sufficient time for the cows to recover physiologically before going to the bull for the second time. The first calvers achieved reconception rates as high as those attained by the mature cows (Table 49). Topps (1977) has suggested that

first calvers are a problem in terms of reconception mainly because the requirements for growth and lactation place two demands on the animal which limit reconception. Furthermore, the data obtained from this study indicate that the first calver, because it is still not mature, should not be unduly stressed on veld, and that weaning should occur before the cow suffers significant mass losses.

Whilst the factors discussed above certainly contributed to the high productivity of the first calvers, the question was posed whether any other factors were involved. The possibility of the heifers being genetically superior was discounted on the basis that no artificial insemination was carried out, and that, because of the conditions prevailing at the Research Station, the breeding herd was, to a large extent, closed. Bulls bred on the farm have been used for the past four seasons and the majority of the "imported" bulls were between 7 and 11 years of age and not considered to be genetically superior to any of the other bulls on the farm. Furthermore, the cows used during the second phase of the experiment were almost pure Simmentaler (three quarters to seven eighths). The progeny of these cows (first calvers) therefore did not contain significantly more Simmentaler genes than the mature cows. The possibility that the younger cows were more efficient grazers was considered and two behavioural studies were subsequently initiated to investigate the grazing behaviour of the two classes of cows at different stocking rates.

Behaviour of the cows on summer veld

The finding that there was no significant difference in the time spent grazing (within the periods of observation) between the first calvers and the mature cows is of considerable interest. These results are at variance with those of Hodgson & Wilkinson (1967) who found that the time spent grazing was inversely related to the age of the animal.

Intake relative to body mass would be higher for the younger animals than the older cows, if the animals all had the same bite size and bite rate. Bite rate was not measured in this investigation, but it can be assumed that the smaller first calvers had smaller bite sizes and that intake per unit of time was, therefore, lower for the first calvers. It was not possible to ascertain whether the relative increase in time spent grazing was offset by the smaller bite size. The fact that the first calvers were apparently able to meet their nutritional requirements for high production (as reflected in > 200 kg weaners), suggests that these animals utilized the available feed resources effectively.

The question of nutritional wisdom in animals is often debated (Arnold, 1985). There is however, little doubt that grazing animals have preferences for certain grass species and will select young material as opposed to old, and leaf as opposed to stem. Hafez & Schein (1962) have suggested that the degree of selective grazing is negatively correlated with the age of the animal. An important finding in the sourveld study was that, at the low stocking rate, where grazing was plentiful, the animals were more randomly distributed throughout the camps, than at the high stocking rates, or when grazing was limited. A shortage of available herbage resulted in all the animals grazing in a smaller, more uniform unit. It was particularly under the more stressful grazing conditions that clear patterns of leadership/followership emerged. A trend in which the first calvers established the grazing patterns in all three treatments was consistently noted by all the observers. One might assume that animals in front of the herd would have had the opportunity to select the more desirable grass species and therefore attain higher levels of production.

Whilst the bigger mature cows were dominant at the lick troughs and where drinking space was limited, the first calvers showed apparent leadership tendencies during the grazing phases. No agonistic behaviour between the two classes of cows was noted during any of the observations. Hafez & Schein (1962) have suggested that under grazing conditions, animals with lower cohesive tendencies move away from their neighbours, who, if having high cohesive tendencies, will follow. According to Bennett & Holmes (1987), animals ranked low socially maintain more distance between themselves and the closest animal whilst grazing. In a study by Wagon, Loy, Rollins & Carroll, (1966) subordinate animals generally remained on the periphery, whereas the dominant animals made up the nucleus. It is possible that, in the study carried out at the Thabamhlope Research Station, the first calvers were in effect attempting to establish "space" between themselves and the more dominant animals and that this behavioural pattern was interpreted by the observers to be a leadership situation. However, a genuine leadership/followership situation appears more likely since no attempt to create a minimum distance during resting periods was observed.

This study has highlighted both the interaction between the grazing animal and its environment and the impact of the grazing environment on the productivity of the animal. A clear understanding of these interactions is necessary to promote the optimal utilization of the natural resources whilst simultaneously improving the economic viability of the enterprise.

This series of investigations will have been futile if the results are not passed on to the farmer. According to Joubert (1983) the advantages of research cannot be realized unless the accompanying new technology is acceptable and can be applied. He concludes that research must take into account the farmers' requirements and situations as well

as the well-being of the population as a whole. In South Africa a large mass of agricultural research is never put into practice (Bembridge, 1985). In this context, it has been estimated that, based on existing knowledge, the potential increase in gross margin per LSU for beef production in Natal, is in the region of 75% (Bembridge, 1985). The problem is universal. Indeed, agriculture holds a unique position in being the area of human endeavour with the greatest gap between readily available knowledge and that which is actually being used (Al-Sudeary, 1982). The problem lies in effective communication: how knowledge can best be conveyed from the researcher to the farmer. This is the main challenge facing extension people, however, extension workers and advisers interested in effecting change, should be prepared not only to keep up with changes, but also be willing to change themselves (Bembridge, 1985).

The National Grazing Strategy (NGS), formulated by the Department of Agriculture and Water Supply, has increased the need for closer cooperation between research and extension workers. The credibility of the research/extension segment of agriculture, in the eyes of the farmer, is to a large extent dependent upon researchers and extension personnel presenting a common extension message. A structured, unified approach is necessary if large programmes, such as the NGS, are to be successful. The Natal Region in particular has undertaken a number of "liaison/information" days where the identification of grass species and their role in veld management are discussed. However, a systems approach is once again essential. For example, although the identification of grasses is necessary and important, this aspect is only part of the production system, and it is therefore important that the broader implications and benefits are clearly outlined. The emphasis must be placed on the economics of the system in conjunction with conservation aspects rather than on conservation alone. Efficiency

of production is likely to be the key to the future.

SUMMARY

Chapter 1

The effect of three winter nutritional levels on subsequent summer performance of weaner/replacement Simmentaler heifers when stocked at three stocking rates over four seasons was investigated. The results from the 1984/85 and 1985/86 seasons are presented in this thesis. The results from the two previous seasons have already been presented (van Niekerk, 1984). The three winter nutritional levels were constantly adjusted to achieve growth rates of -0,1 kg/day, +0,25 kg/day and +0,5 kg/day. The three summer stocking rates were 0,75, 1,0 and 1,25 AU per hectare. Summer grazing generally commenced in November and was terminated in May each year. The heifers were fed during the second winter so as to achieve a target mating mass of 340 kg by mid-October. The study was carried out at the Thabamhlope Research Station which is situated at an altitude of 1450 m above sea level, within Bioclimate 4e in the Province of Natal, RSA.

The main findings and conclusions were:

1. The mean annual rainfall over the four year experimental period was 822,7 mm which was 75,6% of the long-term mean. Approximately 72% of the mean annual rainfall was recorded between November and March. The mean maximum temperature was 21,7°C and the mean minimum temperature 6,1°C. Season did not significantly affect mean maximum and mean minimum temperatures.
2. During the 1984/85 season, both the winter nutritional level and

stocking rate affected the performance of the heifers on summer veld. The heifers wintered at the low level had significantly ($P < 0,01$) higher ADG's at all three summer stocking rates, than the heifers wintered at the medium level, which in turn had significantly ($P < 0,01$) higher ADG's than the heifers wintered at the high level.

3. During the first season, the heifers at the low stocking rate attained significantly ($P < 0,01$) higher ADG's than the heifers stocked at the high stocking rate, irrespective of the winter nutritional level.

4 The heifers wintered at the low level during the second winter, achieved significantly higher ($P < 0,01$) growth rates on summer veld than the heifers wintered at the medium and high levels. There was generally no difference in summer growth rates between the latter two groups, except at the light stocking rate.

5. There were generally no stocking rate related differences in performance between the various treatments, during the second season.

6. It was concluded that full compensatory growth was possible during the first season because the camps had benefitted from a full season's rest. During the second season, the camps were only rested during the winter months, prior to the onset of the grazing season, and consequently there was less herbage available during the 1985/86 season, a factor which affected the performance of the heifers.

7. During the first season, the heifers wintered at the low level and subsequently stocked at a low stocking rate, realized the lowest total

feed costs - R58,13. The highest feed costs were attributed to the heifers wintered at a low level and subsequently stocked at a high stocking rate - R122,84.

8. The heifers wintered at a medium level and subsequently stocked at a low stocking rate, during the second season, realized the lowest feed costs - R79,44, whereas the heifers wintered at the low level and subsequently stocked at a high stocking rate, incurred the highest feed costs - R117,59.

9. It was concluded that heifer rearing in the Highland Sourveld is predominantly an economic issue and that a conservative approach should be adopted ie. mass gains in the region of 0 - 0,25 kg/day during the first winter, followed by a low stocking rate (0,75 AU/ha) on summer veld.

10. A total of 106 heifers were utilized in the experiment during the 1984/85 season. Of these, two were culled and three died of natural causes; one hundred and one were mated; 97 (96%) were diagnosed pregnant and 95 (94%) calved.

11. All the heifers calved within the first 30 days and 20 days of the first and second calving seasons respectively. This implies that the time of conception was not affected by treatment.

12. Thirty of the 44 heifers that calved for the first time in 1984, produced three calves in three years. Thirteen heifers (30%) produced two calves in three years. The data suggests that there was no effect of prepartum treatment on subsequent calving performance.

Chapter 2

The role of condition scoring as a management tool in the Highland Sourveld was investigated using both mature cows and first-calf heifers. The study examined the role of condition scoring in improving the reproductive performance of beef cows whilst simultaneously optimizing the use of available feed during both winter and summer.

The following data are highlighted:

1. The study underlined the importance of the body condition of the breeding cow at both parturition and mating with respect to subsequent reproductive performance.
2. The highest conception rates were achieved when the condition of the cow at mating was between 3,0 and 3,5. Only 8% of the cows conceived with a condition score of 1,5 at mating. A target condition score of 3,0 - 3,5 at mating is therefore recommended.
3. Cows, with a condition score of 3,5 at mating, had mean conception dates 18 to 20 days earlier than cows mated at a condition score of 2,0.
4. The condition score of the cow at the beginning of winter did not affect the birth mass of the calf.
5. Cows, with a mean condition score of 1,5 at the start of the winter feeding period, achieved a condition score of 3,0 after 85 days,

whereas, a cow with an initial condition score of 2,0 required an average of 49 days to reach a condition score of 3,0. The cows with an initial condition score of 1,5 incurred feed costs of R108 as opposed to the cost of R54 realized by the cows with an initial condition score of 2,0. There was no difference in feed intakes or feed costs between pregnant and non-pregnant cows.

6. Mature cows required significantly ($P < 0,05$) less time to improve their condition score from 2,0 to 3,0 than the first calvers. During this time the mature cows gained significantly ($P < 0,05$) more mass (55,32 kg vs. 38,18 kg).

7. In improving their condition from 1,5 to 3,0, the first calvers consumed significantly ($P < 0,01$) more dry matter at a higher cost (R10/head) than the mature cows.

8. Condition scoring was shown to be an effective management tool for improving conception by the efficient utilization of the available feed.

Chapter 3

In this study, the effect of stocking rate and lick supplementation on the performance of various classes of beef cows and their progeny was investigated. The experiment commenced in 1978 and was terminated in 1987. The study was conducted in two phases. During the first four year phase, four stocking rates were applied. A total of 180 cows and calves were involved each year. During the second five year phase, 120

cows and calves were used and three stocking rates were applied. The stocking rates were: 0,83 cows + calves/ha (Tr.1), 1,0 cow + calf/ha (Tr.2), 1,25 cows + calves/ha (Tr.4) and 1,67 cows + calves/ha (Tr.5). The very high stocking rate was terminated after the first phase of the trial. Two stocking rates were duplicated to test the effect of a urea-based lick. From the onset of grazing until the 15th of February, the animals in Tr.1, Tr.2, Tr.4 and Tr.5 had access to a mineral lick and the cows in Tr.3 and Tr.6 received the urea based lick. All the animals received the urea lick from the 15th of February until they were removed from the veld. Grazing was terminated when the mean condition scores of the dams declined to 2,0. Each treatment was terminated separately.

The main findings and conclusions were:

1. Mean minimum temperatures varied by less than 1°C and mean maximum temperatures by less than 1,5°C between seasons. Sub-zero mean minimum temperatures were recorded during June and July every year of the experiment. It was concluded that the wind-chill factor would have reduced the effective ambient temperatures during May, June, July and August to a level where they would have significantly affected animal performance. The mean annual rainfall during the study period was 928 mm, which was 85,3% of the long-term mean. Between 66% and 82% of the total annual rainfall was recorded between November and March each year.

2. In any particular treatment, the total metabolic mass per hectare varied by less than 6 kg between seasons which indicates the consistency of the stocking rates applied. Total metabolic mass per hectare increased over the first four seasons at the low stocking

rates, but declined at the high stocking rates. The increase in calf metabolic mass was curvilinear.

3. Stocking rate was by far the most important factor affecting cow performance, accounting for 45,5% of the total variation ($P < 0,001$). Initial mass accounted for an additional 9,8% of the variation ($P < 0,001$). A total of 56,8% of the total variation was accounted for. Season, calf gain and the number of days post-partum accounted for less than 1,5% of the total variation.

4. Thirty nine percent ($P < 0,001$) of the variation in calf gain on summer veld was attributed to stocking rate. Season contributed a further 3,6% of the total variation. Initial mass, cow mass change and age of the calf at the start of the grazing season contributed only 0,8% of the total variation. A total of 44,4% of the total variation was accounted for.

5. During the first phase of the experiment, the cows that had access to the urea lick during the first 100 days on veld (Tr.3) had 15,85% higher condition scores than the cows that had access to the mineral lick (Tr.2). Theoretically, this improved condition score represented an additional 43 days of grazing. During the second phase of the experiment, the difference in condition score between the cows in Tr.2 and Tr.3 represented a theoretical, additional 24,4 days of grazing. In economic terms, the saving in winter feed costs for the urea-supplemented cows amounted to R11,50 per head.

6. At the very high stocking rate (Tr.5 and Tr.6), there was no improvement in either the growth rate or condition score for those cows

with access to the urea- based lick. The provision of a urea-based lick at such high stocking rates was therefore economically disastrous.

7. The responses of the first calvers, with access to the urea-based lick, was similar to that of the mature cows in terms of improved mass gains and higher condition scores. However, the advantages of providing the urea lick to the younger cows were not sufficient to be economically justifiable.

8. At the light stocking rates, there was no apparent justification for maintaining calves on veld for longer than 200 days. However, at the high stocking rates, weaning on the basis of the dam's condition was preferable. It is suggested that weaning should occur when the mean, or individual, cow condition is between 2,3 and 2,5. Cow condition should not be allowed to fall below 2,0.

9. There was very little difference in maximum mass (theoretical weaning mass) between the calves born to the mature cows and those born to the first calvers. The calves born to the mature cows, however, had slightly higher ADG's until weaning.

10. The good performances of the calves born to the first calvers is ascribed to the fact that they were born 3 - 4 weeks earlier than the calves born to the mature cows and consequently were able to utilize the veld more efficiently at any comparable stage of grazing. Secondly, because the first calvers calved earlier, when good quality feed was freely available, they were able to realize their milk production potential.

11. The mean length of the grazing season for Tr.1, Tr.2, Tr.4 and Tr.5 was 220, 210, 194 and 177 days respectively. The very high stocking rate treatment was terminated after four years because of a decline in the composition of the veld as well as a significant decline in animal performance

12. The highest returns per hectare recorded by the low stocking rate treatment (0,83 cows plus calves per hectare) and the lowest returns at the very high stocking rate.

13. Veld condition assessments indicated over utilization in all the treatments. The higher the stocking rate the greater the change in VCS.

Chapter 4.

The grazing behaviour of first calvers and nature cows on veld at different stocking rates was observed over two consecutive seasons. The study concentrated on the social interactions as well as the grazing behaviour of the two classes of cows in an attempt to clarify the good performance of the first calvers. A representative sample (20%) of the animals were clearly marked and observed. A total of six observations during the first season and nine during the second season were undertaken. The observations were carried out between 08h00 and 16h00.

The main findings were:

1. In neither of the two seasons did any one class of cow graze for significantly longer periods than the other.

2. The time spent grazing increased over the season but varied according to camp size. The increase in grazing time over the season was lower in the small camps than the large camps.

3. At the start of the first season, there were strong associations between the first calvers and the mature cows in Tr.1 and Tr.2 whilst grazing in Tr.4 appeared to be random. At the end of the season there were strong associations between the two classes of cows in all three treatments.

4. At the start of the second season, there were strong associations between the first calvers and the mature cows in all three treatments. At the end of the grazing season, the two classes of cows in Tr.4 grazed further apart. It was concluded that, as the grazing pressure increased, social interactions declined in importance.

5. As the days shortened, the intervals between grazing periods decreased until the end of May when grazing activity became continuous within the periods of observation. This situation was largely a response to the declining quantity and quality of herbage.

6. A clear leadership/followership pattern was observed in the grazing behaviour. In all three stocking rates, the first calvers were seen to establish the grazing patterns and the mature cows followed.

7. No agonistic behaviour was noted whilst the animals were grazing, but several cases were observed at lick troughs where space was limited. In such situations the larger mature cows dominated the first calvers.

8. There was a decrease in the time spent suckling during the day and a decline in the suckling activity over the season. There was no significant difference between the first calvers and the mature cows in the time spent suckling their calves.

9. Alloparental care was noted on several occasions in the early part of each grazing season.

REFERENCES

- ACOCKS, J.P.H., 1953. Veld types of South Africa. Pretoria: Dept. Agric. (Bot. Survey Memoir No.28).
- ACOCKS, J.P.H., 1966. Non-selective grazing as a means of veld reclamation. Proc. Grassld. Soc. Sth. Afr. 1:33.
- AGRIQUEST, 1980. Farm survey. Cedara: Dept Agric. & Fisheries. Natal Region.
- ALLDEN, W.G., 1970. The effects of nutritional deprivation on the subsequent productivity of sheep and cattle. Nutr. Abstr. & Rev. 40:1167.
- ALLDEN, W.G., 1981. Energy and protein supplements for grazing livestock. In: World Animal Science. Grazing Animals. Ed. F.H.W. Morley. Amsterdam: Elsevier.
- AL-SUDEARY, A.M., 1982. Role of informatics in agriculture. Agora 2:24.
- ANDERSON, J.H. & WILLHAM, R.L., 1978. Weaning weight correction factors from Angus field data. J. Anim. Sci. 47:124.
- ARNETT, D.W., HOLLAND, G.L. & TOTUSEK, R., 1971. Some effects of obesity in beef females. J. Anim. Sci. 33:1129.
- ARNOLD, G.W., 1985. Ingestive behaviour. In: World Animal Science. Ethology of farm animals. Ed. A.F Fraser. Amsterdam: Elsevier.
- ARNOLD, G.W. & DUDZINSKI, M.L., 1978. Ethology of free-ranging domestic animals. Amsterdam: Elsevier.
- BAILEY, P.J., BISHOP, A.H. & BOORD, C.T., 1974. Grazing behaviour of steers. Proc. Aust. Soc. Anim. Prod. 10:303.
- BAKER, R.D., ALVAREZ, F. & LE DU, Y.L.P., 1981. The effects of herbage allowance upon the herbage intake and performance of suckler cows and calves. Grass and Forage Sci. 36:189.
- BAKER, R.D., BALL, C., KILKENNY, J.B. & WALSH, A., 1972. Suckled calves. Beef Prod. Handbook No. 3. Milton Keynes: Meat & Livestock Comm.
- BAKER, R.D., YOUNG, N.E. & LAWS, J.A., 1982. Changes in body composition of cattle exhibiting compensatory growth. Anim. Prod. 34:375 (Abstr.).
- BAKER, R.D., YOUNG, N.E. & LAWS, J.A., 1985. Changes in the composition of cattle exhibiting compensatory growth and the modifying effects of grazing management. Anim. Prod. 41:309.
- BALL, C., BROADBENT, P.J. & DODSWORTH, T.L., 1971. Energy and protein supplements for straw-based winter diets for suckler cows. Anim. Prod. 13:237.
- BEAL, W.E., SHORT, R.E., STAIGMILLER, R.B., BELLOWS, R.A., KALTENBACH, C.C. & DUNN, T.G., 1978. Influence of dietary energy intake on bovine pituitary and luteal function. J. Anim. Sci. 46:181.

- BEAMES, R.M., 1959. Molasses and urea as a supplement to low quality pasture hay for cattle. Queensland J. agric. Sci. 17:205.
- BELLOWS, R.A., SHORT, R.E., ANDERSON, D.C., KNAPP, B.W. & PAHNISH, O.F., 1971. Cause and effect relationships associated with calving difficulty and calf birth weight. J. Anim. Sci. 33:407.
- 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
- BELYEA, R.L., FROST, G.R., MARTZ, M.A., CLARK, J.L. & FORKNER, L.G., 1978. Body composition of dairy cattle by Potassium - 40 liquid scintillation detection. J. Dairy Sci. 61:206.
- BEMBRIDGE, T.J., 1985. Overcoming communication barriers in agricultural extension. S. Afr. J. Agric. Ext. 14:38.
- BENNETT, I.L. & HOLMES, C.R., 1987. Formation of a feed order in a group of cattle and its relationship with grazing behaviour, heat tolerance and production. Appl. Anim. Behav. 17:9.
- BENNINK, M.R., WARD, G.M., JOHNSON, J.E. & CRAMER, D.A., 1968. Potassium content of carcass components and internal organs of cattle as determined by 40K and atomic absorption spectrometry. J. Anim. Sci. 27:600.
- BOND, J. & WILTBank, J.N., 1970. Effect of energy and protein on estrus, conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.
- BONSMA, F.N. & JOUBERT, D.M., 1957. Factors affecting the regionalisation of livestock production in South Africa. Pretoria: Dept. Agric. (Sci. Bull. 380).
- BOOYSEN, P. de V., 1966. A physiological approach to research in pasture utilization. Proc. Grassld. Soc. Sth. Afr. 1:77.
- BOOYSEN, P. de V., 1969. An evaluation of the fundamentals of grazing systems. Proc. Grassld. Soc. Sth. Afr. 4:84.
- BOOYSEN, P. de V., KLUG, J.R. & YORK, B.S., 1974. Number of camps for rotational grazing of veld. Proc. Grassld. Soc. Sth. Afr. 9:145.
- BOOYSEN, P. de V., TAINTON, N.M. & FORAN, B.D., 1975. An economic solution to the grazing management dilemma. Proc. Grassld. Soc. Sth. Afr. 10:77.
- BOWDEN, D.M., 1977. Growth, reproductive performance and feed utilization of F₁ crossbred beef heifers calving as 2-year-olds. J. Anim. Sci. 44:872.
- BRANSBY, D. , 1981. The value of veld and pastures as animal feed. In: Veld and pasture management in South Africa. Ed. N.M. Tainton. Pietermaritzburg: Shuter & Shooter in association with University of Natal Press.
- BREDON, R.M., 1976. The composition and intake of veld for beef cattle in bioregions 3 and 4. Cedara: Dept. Agric., Natal Region. (Unpublished final report. Facet No. N5311/05/1/1).

- BREDON, R.M. & LYLE, A.D., 1971. Production systems for beef cattle in East Griqualand: Supplementation of summer veld for grazing livestock. Final Report N-Ko 5/2. Natal Region. Dept. Agric. Technical Services.
- BROADBENT, P.J., BALL, C. & DODSWORTH, T.L., 1969. The effect of plane of nutrition during calthood on the subsequent performance of Hereford X Ayrshire steers. *Anim. Prod.* 11:155.
- BROWN, C.J., 1960. Influence of year and season of birth, sex, sire and age of dam on weights of beef calves at 60, 120, 180 and 240 days of age. *J. Anim. Sci.* 19:1062.
- BURFENING, P.J., 1974. Dairy-beef crossbreeding : II. Age and weight at puberty. *J. Anim. Sci.* 38:1320 (Abstr.).
- BURFENING, P.J., KRESS, D.D., FRIEDRICH, R.L. & VANIMAN, D., 1978. Calving ease and growth rate of Simmental-sired calves. I. Factors affecting calving ease and growth rate. *J. Anim. Sci.* 46:922.
- BUTLER, W.R., EVERETT, R.W. & COPPOCK, C.E., 1981. The relationship between energy balance, milk production and ovulation in postpartum Holstein cows. *J. Anim. Sci.* 53:742.
- CAPPER, B.S., PRATCHETT, D., RENNIE, T.W., LIGHT, D., RUTHERFORD, A., MILLER, M., BUCK, N.G. & TRAIL, J.C.M., 1977. Effects of rumen stimulatory licks on reproductive performance and live-weight gain of beef cattle in Botswana. *Anim. Prod.* 24:49.
- CARNEGIE, A.B. & TULLOH, N.M., 1968. The in vivo determination of body water space in cattle using the tritium dilution technique. *Proc. Aust. Soc. Anim. Prod.* 7:308.
- CARSTAIRS, J.A., MORROW, D.A. & EMERY, R.S., 1980. Postpartum reproductive function of dairy cows as influenced by energy and phosphorus status. *J. Anim. Sci.* 51:1122.
- CARSTENS, N.W., 1970. An economic analysis of farming in the Northern beef cattle areas of South West Africa. Economic Series No. 76. Dept. Agric. Economics and Marketing.
- CHESTNUTT, D.M.B., 1984. Effect of weight change on the performance of autumn-calving suckler cows. *J. agric. Sci. (Camb.)* 102:353.
- CHIGARU, P.R.N. & TOPPS, J.H., 1981. The composition of body-weight changes in underfed lactating beef cows. *Anim. Prod.* 32:95.
- CILLIERS, J.W., 1986. Beef production on summer veld and on improved veld. Research Highlights. Dept. Agric. and Water Supply. Pretoria.
- CLANTON, D.C., 1978. Non-protein nitrogen in range supplements. *J. Anim. Sci.* 47:765.
- CLANTON, D.C., JONES, L.E. & ENGLAND, M.E., 1983. Effect of rate and time of gain after weaning on the development of replacement beef heifers. *J. Anim. Sci.* 56:280.
- CLANTON, D.C. & ZIMMERMAN, D.R., 1970. Symposium on pasture methods for maximum production in beef cattle: protein and energy requirements for female beef cattle. *J. Anim. Sci.* 30:122.

- CORAH, L.R., DUNN, T.G. & KALTENBACH, C.C., 1975. Influence of prepartum nutrition on the reproductive performance of beef females and the performance of their progeny. *J. Anim. Sci.* 41:819.
- CORDOVA, F.J., WALLACE, J.D. & PIEPER, R.D., 1978. Forage intake by grazing livestock : a review. *J. Range Manag.* 31:430.
- CRABTREE, R.M., HOUSEMAN, R.A. & KAY, M., 1974. The estimation of body composition in beef cattle by deuterium oxide dilution. *Proc. Nutr. Soc.* 33:74 (Abstr.).
- CRAIG, J.V., 1986. Measuring social behavior: social dominance. *J. Anim. Sci.* 62:1120.
- CRAMPTON, E.W., 1957. Interrelations between digestible nutrient and energy content, voluntary dry matter intake and the overall feeding value of forages. *J. Anim. Sci.* 16:546.
- CRICHTON, J.S. & VAN SCHALKWYK, A.P., 1986. Utilization of maize residues by pregnant beef cows in the high rainfall sourveld areas of Dundee. Annual Report. Natal Region. Dept. Agric. Dundee.
- CROXTON, D. & STOLLARD, ROSALYN J., 1976. Use of body condition scoring as a management aid in dairy and beef herds. *Anim. Prod.* 22:146 (Abstr.).
- CUNDIFF, L.V., WILLHAM, 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.
- CURTIS, S.E. & HOUP, K.A., 1983. Animal ethology: its emergence in animal science. *J. Anim. Sci.* 57:234.
- DALEY, D.A., TATUM, J.D. & TAYLOR, R.E., 1983. Accuracy of objective and subjective preslaughter estimates of beef carcass fat thickness. *J. Anim. Sci.* 56:1.
- DANKWERTS, J.E. & KING, P.G., 1984. Conservative stocking or maximum profit : a grazing management dilemma? *J. Grassld. Soc. Sth. Afr.* 4:25.
- DANKWERTS, J.E. & VAN ROOYEN, C.J., 1980. Maximum profitability as a criterion for optimization of utilization intensity. *Proc. Grassld. Soc. Sth. Afr.* 15:53.
- DENNY, R.P. & BARNES, D.L., 1977. Trials of multi-paddock grazing systems on veld. 3. A comparison of six grazing procedures at two stocking rates. *Rhodesia J. Agric. Res.* 15:129.
- DENNY, R.P. & STEYN, J.S.H., 1977. A comparison of a 16-paddocks-to-one-herd system with a four--paddocks-to-one-herd system using breeding cows. 15:119.
- DICKERSON, G.E., KUNZE, N., CUNDIFF, L.V., KOCH, R.V., ARTHAUD, V.H. & GREGORY, K.E., 1974. Selection criteria for efficient beef production. *J. Anim. Sci.* 39:659.
- DUNN, T.G., INGALLS, J.E., ZIMMERMAN, D.R. & WILTBANK, J.N., 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. *J. Anim. Sci.*

29:719.

DUNN, T.G. & KALTENBACH, C.C., 1980. Nutrition and postpartum interval of the ewe, sow and cow. *J. Anim. Sci.* 51(Suppl.II):29.

DUNN, T.G., RONE, J., KALTENBACH, C.C., VAN DER WALT, L.A., RILEY, M.L. & AKBAR, A.M., 1974. Hormone changes during underfeeding of beef cows. *J. Anim. Sci.* 39:206.

ECONOMIDES, S.J., MILLER, T.B., TOPPS, J.H., GELMAN, A.L. & KEITH, D.G., 1973. A preliminary study of the milk production, bodyweight changes and some blood characteristics of underfed beef cows. *Br. vet. J.* 129:63.

EDWARDS, P.J., 1981. Grazing management. In: *Veld and pasture management in South Africa*. Ed. N.M. Tainton. Pietermaritzburg: Shuter & Shooter in association with University of Natal Press.

ELOFF, C.H.P., 1971. Increased weaning masses by means of breeding and selection. Lecture Series No. 13. Transvaal Region. Dept. Agric. Technical Services. Pretoria.

ENGELS, E.A.N. & MALAN, A., 1973. Die benutting van veld met droe en lakterende koeie. *Glen Agric.* 2:13.

FERRELL, C.L., 1982. Effects of postweaning rate of gain on onset of puberty and productive performance of heifers of different breeds. *J. Anim. Sci.* 55:1272.

FONTENOT, J.P. & BLASER, R.E., 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: selection and intake by grazing animals. *J. Anim. Sci.* 24:1202.

FORAN, B.D., TAINTON, N.M. & BOOYSEN, P.de V., 1978. The development of a method for assessing veld condition in three veld grass types in Natal. *Proc. Grassld. Soc. Sth. Afr.* 13:27.

FOURIE, J.H., ENGELS, E.A. & ROBERTS, B.R., 1986. Herbage intake by cattle on *Tarhachanthus* veld in the Northern Cape as affected by stocking rate and grazing system. *J. Grassld. Soc. Sth. Afr.* 3:85.

FOURIE, J.H., OPPERMAN, D.P.J. & ROBERTS, B.R., 1985. Influence of stocking rate and grazing systems on available grazing in the Northern Cape. *J. Grassld. Soc. Sth. Afr.* 2:24.

FOX, D.G., JOHNSON, R.R., PRESTON, R.L., DOCKERTY, T.R. & KLOSTERMAN, E.W., 1972. Protein and energy utilization during compensatory growth in beef cattle. *J. Anim. Sci.* 34:310.

FRASER, A.F., 1968. *Reproductive behaviour in ungulates*. London: Academic Press.

FREER, M., 1981. The control of food intake by grazing animals. In: *World Animal Science. Grazing Animals*. Ed. F.H.W. Morley. Amsterdam: Elsevier.

FRIEND, T.H. & POLAN, C.E., 1974. Social rank, feeding behaviour and free stall utilization by dairy cattle. *J. Dairy Sci.* 57:1214.

FROOD, MOIRA J. & CROXTON, D., 1978. The use of condition scoring in

dairy cows and its relationship with milk yield and live weight. *Anim. Prod.* 27:285.

GAMMON, D.M., 1978. A review of experiments comparing systems of grazing management on natural pastures. *Proc. Grassld. Soc. Sth. Afr.* 13:75.

GAMMON, D.M., 1983. Veld management. Stocking rate and drought conditions. *Zimbabwe agric. J.* 80:183.

GARMENDIA, J.C., WETTEMANN, R.P., LUSBY, K.S., BAKER, J.C. & GEISERT, R.D., 1986. Factors affecting mobilization of body fat in lactating beef cows. *Okla. Agric. Exp. Sta. Misc. Publ.* 118:312.

GILLIS, W.A., BURGESS, T.D., USBORNE, W.R., GREIGER, H. & TALBOT, S., 1973. A comparison of two ultrasonic techniques for the measurement of fat thickness and rib eye area in cattle. *Can. J. Anim. Sci.* 53:13.

GLEESON, P.A., 1972. Effect of plane of nutrition on spring-born calves during their first winter and on their subsequent growth rate and reproductive performance. *Ir. J. agric. Res.* 11:31.

GRAHAM, J.F., 1982. The effect of body condition of beef cows at calving and post calving nutrition on calf growth rate and cow fertility. *Proc. Aust. Soc. Anim. Prod.* 14:309.

GREGORY, K.E., LASTER, D.B., CUNDIFF, L.V., KOCH, R.M. & SMITH, G.M., 1978. Heterosis and breed maternal and transmitted effects in beef cattle. II. Growth rate and puberty in females. *J. Anim. Sci.* 47:1042.

GREGORY, K.E., LASTER, D.B., CUNDIFF, L.V., SMITH, G.M. & KOCH, R.M., 1979. Characterization of biological types of cattle - Cycle III: II. Growth rate and puberty in females. *J. Anim. Sci.* 49:461.

GROSSKOPF, J.F.W., 1976. Die herkonnspie van lakterende vleisraskoeie as beperkende faktor by die praktiese toepassing van ovulasiesinchronisasie. Stellenbosch. Univ. Stellenbosch (Ph.D. Thesis).

GUERRA, J.C., THWAITES, C.J. & EDEY, T.N., 1972. Assessment of the proportion of chemical fat in the bodies of live sheep. *J. agric. Sci. (Camb.)* 78:147.

HADJIPIERIS, G., JONES, J.G.W. & HOLMES, W., 1965. The effect of age and live-weight on the feed intake of grazing wether sheep. *Anim. Prod.* 7:141.

HAFEZ, E.S.E. & SCHEIN, M.W., 1962. The behaviour of cattle. In: *The behaviour of domestic animals*. Ed. E.S.E. Hafez. London: Balliere, Tindall & Cox.

HALE, D.H., 1975. Nutrition, hormones and fertility. *Rhod. agric. J.* 72:69.

HANCOCK, J., 1954. Studies on grazing behaviour in relation to grassland management. I. Variations in grazing habits of dairy cattle. *J. agric. Sci. (Camb.)* 44:420.

HANCOCK, K.L., KROPP, J.R., LUSBY, K.S., WETTEMANN, R.P., BUCHANAN, D.S. & WORTHINGTON, C., 1985. The influence of postpartum nutrition and

weaning age of calves on cow body condition, estrus, conception rate and calf performance of fall-calving beef cows. Okla. Agric. Exp. Sta. Misc. Publ. 117:181.

HARESIGN, W., 1980. Body condition, milk yield and reproduction in cattle. In: Recent advances in animal nutrition. London: Butterworths.

HARESIGN, W., 1981. The influence of nutrition on reproduction in the ewe. I. Effects on ovulation rate, follicle development and luteinizing hormone release. Anim. Prod. 32:197.

HARWIN, G.O., 1979. Factors affecting the attainment of future goals in livestock production. S. Afr. J. Agric. Ext. 8:34.

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. & THERON, E.P., 1975. Research on Radical Veld Improvement. Proc. Grassld. Soc. Sth. Afr. 10:59.

HEITSCHMIDT, R.K., KOTHMAN, M.M. & RAWLINS, W.J., 1982. Cow-calf response to stocking rates, grazing systems and winter supplementation at the Texas Experimental Ranch. J. Range Manag. 35:204.

HERBEL, C.H. & NELSON, A.B., 1966. Species preference of Hereford and Santa Gertrudis cattle on a southern New Mexico range. J. Range Manag. 19:177.

HILL, J.R. Jr., LAMOND, D.R., HENDRICKS, D.M., DICKEY, J.F. & NISWENDER, G.D., 1970. The effects of undernutrition on ovarian function and fertility in beef heifers. Biol. of Reprod. 2:78.

HODGSON, J. & WILKINSON, J.M., 1967. The relationship between live-weight and herbage intake in grazing cattle. Anim. Prod. 9:365.

HOLDER, J.M., 1962. Supplementary feeding of grazing sheep - its effect on pasture intake. Proc. Aust. Soc. Anim. Prod. 4:154.

HOLLOWAY, J.W., STEPHENS, D.F., WHITEMAN, J.V. & TOTUSEK, R., 1975. Efficiency of production of 2- and 3-year-old Hereford, Hereford X Holstein and Holstein cows. J. Anim. Sci. 41:855.

HOLMES, W., JONES, J.G.W. & DRAKE-BROCKMAN, R.M., 1961. The feed intake of grazing cattle. II. The influence of size of animal on feed intake. Anim. Prod. 3:251.

HOLNESS, D.H., HOPLEY, J.D.H. & HALE, D.H., 1978. The effects of plane of nutrition, live weight, temporary weaning and breed on the occurrence of oestrus in beef cows during the postpartum period. Anim. Prod. 26:47.

HORTON, G.M.J. & HOLMES, W., 1978. Compensatory growth by beef cattle at grassland or on an alfalfa-based diet. J. Anim. Sci. 46:297.

HULL, J.L., MEYER, J.H., BONILLA, S.E. & WEITKAMP, W., 1965. Further studies on the influence of stocking rate on animal and forage production from irrigated pasture. J. Anim. Sci. 24:697.

JAMISON, H.M., CHRISTIAN, L.L., TEMPLE, R.S. & BUTTS, W.T. Jr., 1965.

Factors affecting variations in intra-cow production in beef cattle. *J. Anim. Sci.* 24:287 (Abstr.).

JEFFERIES, B.C., 1961. Body condition scoring and its use in management. *Tasm. J. Agric.* 32:19.

JOHNSON, I.D. & OBST, J.M., 1984. The effects of level of nutrition before and after 8 months of age on subsequent milk and calf production of beef heifers over three lactations. *Anim. Prod.* 38:57.

JONES, R.J. & SANDLAND, R.L., 1974. The relation between animal gain and stocking rate - derivation of the relation from the results of grazing trials. *J. agric. Sci. (Camb.)* 83:335.

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

JOUBERT, J.S.G., 1983. Die ekonomiese impak van tegniese navorsing. In: Die inslag van landbounavorsing op doeltreffende landbouproduksie: Lesings gelewer op die Vergadering van Direkteure. Pretoria: Dept. Agric.

KARTCHNER, R.J., 1981. Effects of protein and energy supplementation of cows grazing native winter forage on intake and digestibility. *J. Anim. Sci.* 51:432.

KELLOGG, D.W. & MILLER, D.D., 1977. Response of cows during early lactation to a low energy ration for 4 days. *J. Anim. Sci.* 44:118.

KILKENNY, J.B., 1978. Reproductive performance of beef cows. *World Rev. Anim. Prod.* 14:65.

KLOSTERMAN, E.W., SANFORD, L.G. & PARKER, C.F., 1968. Effects of cow size and condition and ration protein content upon the maintenance requirements of mature beef cows. *J. Anim. Sci.* 27:242.

KOCH, R.M., 1972. The role of maternal effects in animal breeding. VI. Maternal effects in beef cattle. *J. Anim. Sci.* 35:1316.

KOCK, S.W. & PRESTON, R.L., 1979. Estimation of bovine carcass composition by urea dilution technique. *J. Anim. Sci.* 48:319.

KROPP, J.R., HOLLOWAY, J.W., STEPHENS, D.F., KNORI, L. MORRISON, R.D. & TOTUSEK, R., 1973. Range behaviour of Hereford, Hereford X Holstein and Holstein non-lactating heifers. *J. Anim. Sci.* 36:797.

KROPP, J.R., STEPHENS, D.F., HOLLOWAY, J.W., WHITEMAN, J.V., KNORI, L. & TOTUSEK, R., 1973. Performance on range and in drylot of two-year-old Hereford, Hereford X Holstein and Holstein females as influenced by level of winter supplementation. *J. Anim. Sci.* 37:1222.

LAMOND, D.R., 1970. The influence of undernutrition on reproduction in the cow. *Anim. Breed. Abstr.* 38:359.

LAMOND, D.R., HOLMES, J.H.G. & HAYDOCK, K.P., 1969. Estimation of yield and composition of milk produced by grazing beef cows. *J. Anim. Sci.* 29:606.

LANGLANDS, J.P., 1968. The feed intake of grazing sheep differing in

age, breed, previous nutrition and live-weight. *J. agric. Sci. (Camb.)* 71:167.

LASLEY, J.F. & BOGART, R.W., 1943. Some factors influencing reproductive efficiency of range cattle under artificial and natural breeding conditions. *Mo. Agric. Exp. Sta. Res. Bull.* 376.

LÁSTER, D.B., GLIMP, H.A. & GREGORY, K.E., 1972. Age and weight at puberty and conception in different breeds and breed-crosses of beef heifers. *J. Anim. Sci.* 34:1031.

LASTER, D.B., SMITH, G.M., CUNDIFF, L.V. & GREGORY, K.E., 1979. Characterization of biological types of cattle (Cycle II). II. Postweaning growth and puberty of heifers. *J. Anim. Sci.* 48:500.

LAWRENCE, T.L.J. & PEARCE, J., 1964a. Some effects of wintering yearling beef cattle on different planes of nutrition. I. Liveweight gain, food consumption and body measurement changes during the winter period and subsequent grazing period. *J. agric. Sci. (Camb.)* 63:5.

LAWRENCE, T.L.J. & PEARCE, J., 1964b. Some effects of wintering yearling beef cattle on different planes of nutrition. II. Slaughter data and carcass evaluation. *J. agric. Sci. (Camb.)* 63:23.

LESCH, S.F., LOUW, B.P., JONES, R.J. & WHITEHEAD, N., 1980. Natal beef guide. Cedara: Dept. Agric. & Fisheries, Natal Region.

LESMEISTER, J.L., BURFENING, P.J. & BLACKWELL, R.L., 1973. Date of first calving in beef cows and subsequent calf production. *J. Anim. Sci.* 36:1.

LINDLEY, C.E., EASLEY, G.T., WHATLEY, J.A. Jr. & CHAMBERS, D., 1958. A study of the reproductive performance of a purebred Hereford herd. *J. Anim. Sci.* 17:336.

LISHMAN, A.W. & SMITH, V.W., 1968. The influence of early or late summer calving and of supplementary feeding on the growth of the calf and reproductive performance of the cow in the Thornveld of Natal. Final Report N-Ce 115/2. Natal Region. Dept. Agric. Technical Services. Cedara.

LISHMAN, A.W., ALLISON, S.M.J., FOGWELL, R.L., BUTCHER, R.L. & INSKEEP, E.K., 1979. Follicular development and function of induced corpora lutea in underfed postpartum anestrous beef cows. *J. Anim. Sci.* 48:867.

LITTLE, D.A. & McLEAN, R.W., 1981. Estimation of the body chemical composition of live cattle varying widely in fat content. *J. agric. Sci. (Camb.)* 96:213.

LITTLE, D.A. & MORRIS, J.C., 1972. Prediction of the body composition of live cattle. *J. agric. Sci. (Camb.)* 78:505.

LOFGREEN, G.P., MEYER, J.H. & HULL, J.L., 1957. Behaviour patterns of sheep and cattle being fed pasturage or sortage. *J. Anim. Sci.* 16:773.

LOHMAN, T.G., BALL, R.H. & NORTON, H.W., 1970. Biological and technical sources of variability in bovine carcass lean tissue composition. II. Biological variation in potassium, nitrogen and water. *J. Anim. Sci.* 30:21.

- LOUW, B.P., 1984. Intensive beef production on cultivated pastures in a sub-tropical environment. Pietermaritzburg: Univ. of Natal (Ph.D Thesis).
- LOUW, B.P., LISHMAN, A.W. & THOMAS, C.R., 1988. The influence of severe mass losses and gains on ovarian activity in beef cows. S. Afr. J. Anim. Sci. 18. In press.
- LOWMAN, B.G., SCOTT, N. & SOMERVILLE, S., 1976. Condition scoring of cattle. Revised Ed. Bull. E. Scot. Coll. Agric. No. 6.
- LUDEMANN, C.J.F., 1971. The improvement of body mass at weaning by means of feeding and management. Lecture Series No. 13. Transvaal Region. Dept. Agric. Technical Services. Pretoria.
- MALECHEK, J.C., 1984. Impacts of grazing intensity and specialized grazing systems on livestock response. Developing Strategies for Effective Rangeland Management. NRS/NAS. Boulder: Westview.
- MANGUS, W.L. & BRINKS, J.S., 1971. Relationship between direct and maternal effects on growth in Herefords : environmental factors during pre-weaning growth. J. Anim. Sci. 32:17.
- MARINCOWITZ, G., 1986. Controlled selective grazing - Soutpans formula for increased beef production. Research Highlights. Dept. Agric. and Water Supply. Pretoria.
- MCCARRICK, R.B., HARRINGTON, D. & CONWAY, A., 1963. The effect of energy restriction between 20 - 24 months of age on subsequent growth and carcass development of beef cattle. Ir. J. agric. Res. 2:131.
- McCLURE, T.J., 1965. Experimental evidence for the occurrence of nutritional infertility in otherwise clinically healthy pasture-fed lactating dairy cows. Res. vet. Sci. 6:202.
- MEAKER, H.J., 1984. Effective extensive beef production as a prelude to fattening. S. Afr. J. Anim. Sci. 14:158.
- MEISNER, H.H., VAN STADEN, J.H. & PRETORIUS, ELMA., 1980. In vivo estimation of body composition in cattle with tritium and urea dilution I. Accuracy of prediction equations for the whole body. S. Afr. J. Anim. Sci. 10:175.
- MES, MARGARETHA G., 1958. The influence of veld burning or mowing on the water, nitrogen and ash content of grasses. S. Afr. J. Sci. 54:83.
- MEYER, J.H., HULL, J.L., WEITKAMP, W.H. & BONILLA, S., 1965. Compensatory growth responses of fattening steers following various low energy intake regimes on hay or irrigated pasture. J. Anim. Sci. 24:29.
- MILLER, R.K., MERSMANN, H.J., FERRELL, C.I. & TATUM, I.D., 1982. A comparison of methods for measuring fat depth in beef cattle. J. Anim. Sci. 55:251 (Abstr.).
- MORLEY, F.H.W., 1981. Management of grazing systems. World Animal Science. Grazing Animals. Ed. F.H.W. Morley. Amsterdam: Elsevier.
- MOSS, G.E., PARFET, J.R., DIEKMAN, M.A., LEMENAGER, R.P & HENDRIX, K.S., 1982. Pituitary luteinizing hormone (LH), follicle stimulating hormone (FSH), serum progesterone (P) and hypothalamic gonadotropin

releasing hormone (GnRH) in beef cows in varied body condition. *J. Anim. Sci.* 55(Suppl. I):374.

MULVANEY, P., 1978. Cited by W. Haresign, 1980. In: Recent advances in animal nutrition. London: Butterworths.

MURRAY, J.A., 1919. Meat production. *J. agric. Sci. (Camb.)* 9:179.

NELSEN, T.C. & KRESS, D.D., 1981. Additive and multiplicative correction factors for sex and age of dam in beef cattle weaning weight. *J. Anim. Sci.* 53:1217.

NELSEN, T.C., LONG, C.R. & CARTWRIGHT, T.C., 1982. Postinflection growth in straightbred and crossbred cattle. II. Relationships among weight, height and pubertal characters. *J. Anim. Sci.* 55:293.

NEVILLE, W.E. Jr., 1974. Comparison of energy requirements of nonlactating and lactating Hereford cows and estimates of energetic efficiency of milk production. *J. Anim. Sci.* 38:681.

NEVILLE, W.E. Jr. & McCULLOUGH, M.E., 1969. Calculated energy requirements of lactating and nonlactating Hereford cows. *J. Anim. Sci.* 29:823.

NICOL, A.M. & SHARAFELDIN, M.A., 1975. Observations on the behaviour of single suckled calves from birth to 120 days. *Proc. N.Z. Soc. Anim. Prod.* 35:221.

N.R.C., 1971. Nutrient requirements of Domestic Animals, No. 3, Nutrient Requirements of Dairy Cattle. Fourth Revised Ed. Washington: National Academy of Sciences - National Research Council.

N.R.C., 1976. Nutrient Requirements of Domestic Animals, No. 4, Nutrient Requirements of Beef Cattle. Washington: National Academy of Sciences - National Research Council.

N.R.C., 1984. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Beef Cattle. Sixth Revised Ed. Washington: National Academy of Sciences - National Research Council.

O'DONOVAN, P.B., 1972. Errors associated with expressing pasture intake as dry rather than organic matter at high stocking intensities. *J. agric. Sci. (Camb.)* 78:97.

O'DONOVAN, P.B., 1984. Compensatory gain in cattle and sheep. *Nutr. Abstr. & Rev. - Series B.* 54:389.

OWENS, F.N., LUSBY, K.S., MIZWICKI, K. & FERERO, O., 1980. Slow ammonia release from urea: rumen and metabolism studies. *J. Anim. Sci.* 50:527.

PALSSON, H. & VERGES, J.B., 1952a. Effects of the plane of nutrition on growth and the development of carcass quality in lambs. Part I. The effects of high and low planes of nutrition at different ages. *J. agric. Sci. (Camb.)* 42:1.

PALSSON, H. & VERGES, J.B., 1952b. Effects of the plane of nutrition on growth and the development of carcass quality in lambs. Part II. Effects on lambs of 30 lb carcass weight. *J. agric. Sci. (Camb.)* 42:93.

PANARETTO, B.A., 1963. Body composition in vivo. I. The estimation of

total body water with antipyrine and the relation of total body water to total body fat in rabbits. *Aust. J. agric. Res.* 14:594.

PATIL, J.S. & DESHPANDE, B.R., 1979. Changes in bodyweight, blood glucose and serum proteins in relation to the appearance of post-partum oestrus in Gir cows. *J. Reprod. Fertility* 57:525.

PHILLIPS, J.F.V., 1973. The agricultural and related development of the Tugela Basin and its influent surrounds. Pietermaritzburg: Natal Town and Regional Planning (Report No.19).

PRESTON, T.R. & WILLIS, M.B., 1974. Intensive beef production. Oxford: Pergamon.

RAKESTRAW, J. LUSBY, K.S., WETTEMANN, R.P. & WAGNER, J.J., 1986. Postpartum weight and body condition loss and performance of fall-calving cows. *Theriogenology* 26:461.

RALEIGH, R.J., 1970. Symposium on pasture methods for maximum production in beef cattle: manipulation of both livestock and forage management to give optimum production. *J. Anim. Sci.* 30:108.

RASBY, R.J., WAGNER, J.W., WETTEMANN, P.P., GEISERT, R.D. & LUSBY, K.S., 1986. Influence of body condition of beef cows on pituitary and ovarian function. *Okla. Agric. Exp. Sta. Misc. Publ.* 118:333.

REINHARDT, V. & REINHARDT, ANNIE, 1981. Cohesive relationships in a cattle herd (*Bos Indicus*). *Behaviour* 77:121.

REYNOLDS, W.L., DeROUEN, T.M., & BELLOWES, R.A., 1978. Relationships of milk yield of dam to early growth rate of straightbred and crossbred calves. *J. Anim. Sci.* 47:584.

RICHARDS, M.W., SPITZER, J.C. & WARNER, M.B., 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. *J. Anim. Sci.* 62:300.

RICHARDS, M.W., WETTEMANN, R.P. & SCHOENEMANN, H.M., 1986. Effect of restricted intake on cyclic ovarian activity and estrus in Hereford cows. *Okla. Agric. Exp. Sta. Misc. Publ.* 118:308.

RICHARDSON, F.D., OLIVER, S. & CLARKE, G.P.Y., 1976. Analysis of some factors which affect the productivity of beef cows and of their calves in a marginal rainfall area of Rhodesia. I. Factors affecting calving rate. *Anim. Prod.* 21:41.

ROBERTS, S., LeFEVER, D.G. & WILTBank, J.N., 1970. Increasing reproductive efficiency in a cow herd. *J. Anim. Sci.* 30:1032 (Abstr.).

ROY, J.H.8., 1980. *The Calf*. 4th Ed. London: Butterworths.

RUSH, I.G. & TOTUSEK, R., 1976. Supplemental value of feed grade biuret and urea-molasses for cows on dry winter grass. *J. Anim. Sci.* 42:497.

RUSSEL, A.J.F., DONEY, J.M. & GUNN, R.G., 1969. Subjective assessment of body fat in live sheep. *J. agric. Sci. (Camb.)* 72:451.

RUTTER, L.M. & RANDEL, R.D., 1984. Postpartum nutrient intake and body condition: effect on pituitary function and onset of estrus in beef

cattle. *J. Anim. Sci.* 58:265.

RUTTER, N., 1968. Time lapse photographic studies of livestock behaviour outdoors on the College Farm, Aberystwyth. *J. agric. Sci. (Camb.)* 71:257.

SATTER, L.D. & SLYTER, L.L., 1974. Effect of ammonia concentration on rumen microbial protein production in vitro. *Br. J. Nutr.* 32:199.

SAUBIDET, C.L. & VERDE, L.S., 1976. Relationship between liveweight, age and dry-matter intake for beef cattle after different levels of food restriction. *Anim. Prod.* 22:61.

SCOTT, J.D., 1947. Veld management in South Africa. Pretoria: Dept. Agric. (Bull. No. 278).

SELK, G.E., WETTEMANN, R.P., LUSBY, K.S. & RASBY, R.J., 1986. The importance of body condition at calving on reproduction in beef cows. *Okla. Agric. Exp. Sta. Misc. Publ.* 118:316.

SHORT, R.E. & BELLOWS, R.A., 1971. Relationships among weight gains, age at puberty and reproductive performance in heifers. *J. Anim. Sci.* 32:127.

SKINNER, J.D., 1964. Urea and molasses as a supplement in sweet bushveld. *Proc. S. Afr. Soc. Anim. Prod.* 3:125.

SMITH, G.M. & FITZHUGH, H.A. Jr., 1968. Homogeneity of relationships between dams and progeny weights. *J. Anim. Sci.* 27:1129 (Abstr.).

SOMERVILLE, S.H., LOWMAN, B.G., EDWARDS, R.A. & JOLLY, G., 1983. A study of the relationship between plane of nutrition during lactation and certain production characteristics in autumn-calving suckler cows. *Anim. Prod.* 37:353.

SPEEDING, C.R.W., 1975. Foreword. In: *Study of Agricultural Systems*. Ed. G.E. Dalton. London: Applied Scientific.

STEENKAMP, J.D.G., VAN DER HORST, C. & ANDREW, M.J.A., 1975. Reconception in grade and pedigree Afrikaner cow of different sizes - postpartum factors influencing reconception. *S. Afr. J. Anim. Sci.* 5:103.

STONAKER, H.H., 1958. Breeding for beef. *Colo. Agric. Exp. Sta. Bull.* 501 S.

STRICKLIN, W.R. & KRAUTZ-SCANAVY, C.C., 1984. The role of behaviour in cattle production: A review of research. *Appl. Anim. Ethol.* 11:359.

STRICKLIN, W.R., WILSON, L.L. & GRAVES, H.B., 1976. Feeding behavior of Angus and Charolais-Angus cows during summer and winter. *J. Anim. Sci.* 43:721.

SWANSON, E.W., 1957. The effect of fattening dairy heifers upon their growth and lactation. *J. Dairy Sci.* 40:611 (Abstr.).

SWANSON, E.W., 1960. Effect of rapid growth with fattening of dairy heifers on their lactational ability. *J. Dairy Sci.* 43:377.

SYME, G.J. & SYME, L.A., 1979. Social structure in farm animals.

Amsterdam: Elsevier.

SYMINGTON, R.B., 1969. Factors affecting postpartum fertility in cattle with special emphasis on the hormonal aspects of the problem in ranch cows in Southern Africa. *Proc. S. Afr. Soc. Anim. Prod.* 8:29.

TAINTON, N.M., 1981. The effect of defoliation on plant communities - some general considerations. In: *Veld and pasture management in South Africa*. Ed. N.M. Tainton. Pietermaritzburg: Shuter & Shooter in association with University of Natal Press.

TAINTON, N.M., 1985. Recent trends in grazing management philosophy in South Africa. *J. Grassld. Soc. Sth. Afr.* 4:4.

TAINTON, N.M., EDWARDS, P.J. & MENTIS, M.T., 1980. A revised method for assessing veld condition. *Proc. Grassld. Soc. Sth. Afr.* 15:37.

TAINTON, N.M., GROVES, R.H. & NASH, R.C., 1977. Time of mowing and burning of veld: short term effects on production and tiller development. *Proc. Grassld. Soc. Sth. Afr.* 12:59.

THOMPSON, E.F., BICKEL, H. & SCHURCH, A., 1982. Growth performance and metabolic changes in lambs and steers after mild nutritional restriction. *J. agric. Sci. (Camb.)* 59:381.

THOMPSON, W.R., MEISKE, J.C., GOODRICH, R.D., RUST, J.R. & BYERS, F.M., 1983. Influence of body composition on energy requirements of beef cows during winter. *J. Anim. Sci.* 56:1241.

TOPPS, J.H., 1977. The relationship between reproduction and undernutrition in beef cattle. *World Rev. Anim. Prod.* 13:43.

TRIBE, D.E., 1950. Influence of pregnancy and social facilitation on the behaviour of the grazing sheep. *Nature (London)* 166:74.

VAN NIEKERK, A., 1982a. Condition scoring as a guide to the nutritional status of the beef cow and its implications in reproductive performance. *S. Afr. J. Anim. Sci.* 12:79.

VAN NIEKERK, A., 1982b. The effect of body condition as influenced by winter nutrition, on the reproductive performance of the beef cow. *S. Afr. J. Anim. Sci.* 12:383.

VAN NIEKERK, A., 1984. Reproduction and growth responses of two breeds of beef cattle in two contrasting environments. Pietermaritzburg: University of Natal. (MSc. Agric. Thesis).

VAN NIEKERK, A., 1986. The reproductive responses of two breeds of beef cows and the performance of their progeny in two contrasting environments. *S. Afr. J. Anim. Sci.* 16:209.

VAN NIEKERK, A. & LOUW, B.P., 1980. Condition scoring of beef cattle. Cedara: Dept. Agric. & Fisheries, Natal Region (Bull. N2/80).

VAN SCHALKWYK, A.P. & LESCH, S.F., 1970. Urea supplementation on winter veld. Pretoria: Reprint Farming in Sth. Afr. Publ. No. 400.

VENTER, A.D. & DREWES, R.H., 1969. A flexible system of management for Sourveld in Natal. *Proc. Graasld. Soc. Sth. Afr.* 4:104.

VON BERTALANFFY, 1950. The theory of open systems in physics and biology. *Science* 111:23

VON BERTALANFFY, 1979. *General System Theory*. Rev. Ed. New York: George Braziller.

WAGNON, K.A., 1963. Behavior of beef cows on a Californian range. *Calif. Agric. Exp. Sta. Bull.* 799.

WAGNON, K.A., LOY, R.G., ROLLINS, W.C. & CARROLL, F.D., 1966. Social dominance in a herd of Angus, Hereford and Shorthorn cows. *Anim. Behav.* 14:474.

WALDO, D.R., 1986. Symposium: Forage utilization by the lactating cow. Effect of forage quality on intake and forage-concentrate interactions. *J. Dairy Sci.* 69:617.

WANYOIKE, M. MARGARET, & HOLMES, W., 1981. The effects of winter nutrition on the subsequent live-weight performance and intake of herbage by beef cattle. *J. agric. Sci. (Camb.)* 97:221.

WARD, H.K. & TIFFIN, J. de W., 1975. Progress in beef cow productivity. *Rhod. agric. J.* 72:1.

WARNICK, A.C., MEADE, J.H. & KOGER, M., 1960. Factors influencing pregnancy rate in Florida beef cattle. *Fla. Agric. Exp. Sta. Bull.* 623.

WESTON, R.H., 1959. The efficiency of wool production of grazing Merino sheep. *Aust. J. agric. Res.* 10:865.

WILSON, L.L., GILLOOLY, J.E., RUGH, M.C., THOMPSON, C.E. & PURDY, H.R., 1969. Effects of energy intake, cow body size and calf sex on composition and yield of milk by Angus-Holstein cows and preweaning growth rate of progeny. *J. Anim. Sci.* 28:789.

WILSON, P.N. & OSBOURN, D.F., 1960. Compensatory growth after undernutrition in mammals and birds. *Biol. Rev.* 35:324.

WILT BANK, J.N., 1976. Management for good reproduction during hard times. Unpublished Report.

WILT BANK, J.N., 1977. Managing beef cows to get them pregnant. Proc. The Range Beef Cow Symp. Chadron, Nebraska.

WILT BANK, J.N., GREGORY, K.E., SWIGER, L.A., INGALLS, J.E., ROTH LIS BERGER, J.A. & KOCH, R.M., 1966. Effects of heterosis on age and weight at puberty in beef heifers. *J. Anim. Sci.* 25:744.

WILT BANK, J.N., KASSON, C.W. & INGALLS, J.E., 1969. Puberty in crossbred and straightbred heifers on two levels of feed. *J. Anim. Sci.* 29:602.

WILT BANK, 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.

WILT BANK, J.N., ROWDEN, W.W., INGALLS, J.E. & ZIMMERMAN, D.R., 1964. Influence of postpartum energy level on reproductive performance of Hereford cows restricted on energy intake prior to calving. *J. Anim. Sci.* 23:1049.

WRIGHT, I.A., RUSSEL, A.J.F. & HUNTER, E.A., 1986. The effect of winter food level on compensatory growth of weaned, suckled calves grazed at two sward heights. *Anim. Prod.* 43:211.

ZIMMERMAN, J.E., POPE, L.S., STEPHENS, D. & WALKER, G., 1957. Effect of feeding different levels of winter supplement and age at first calving on the performance of range beef cows and replacement heifers. *Okla. Agric. Exp. Sta. Misc. Publ.* 48.

Appendix 1. Quartic equations from which the lactating cows' growth curves were derived. First phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$				
Y = mean animal mass		X = days from start of trial		
	Tr. 1	Tr. 2	Tr. 4	Tr. 5
Season: 1978/79				
b0 =	413,664	409,045	410,366	420,844
b1 =	1,449	0,545	1,018	0,269
b2 =	-0,0271	-0,0099	-0,0213	-0,0082
b3 =	0,00020	0,00009	0,00018	0,00008
b4 =	-0,0000005	-0,0000002	-0,0000005	-0,0000002
R =	0,8800	0,9475	0,9485	0,6178
Season: 1979/80				
b0 =	453,498	451,054	455,361	441,643
b1 =	0,5687	0,1851	-0,2113	0,1865
b2 =	-0,01363	-0,01054	-0,00006	-0,01237
b3 =	0,00013	0,00012	0,00004	0,00013
b4 =	0,0000003	-0,0000004	-0,0000001	-0,0000004
R =	0,9485	0,9656	0,9710	0,8403
Season: 1980/81				
b0 =	427,665	408,944	417,628	414,901
b1 =	1,2831	1,1460	1,1276	0,4140
b2 =	-0,01988	-0,02734	-0,02702	-0,01937
b3 =	0,00015	0,00025	0,00023	0,00021
b4 =	-0,0000004	-0,0000007	-0,0000006	-0,0000006
R =	0,9735	0,9132	0,9521	0,7643
Season: 1981/82				
b0 =	396,276	403,369	400,7676	398,483
b1 =	1,0637	-0,3739	-0,1818	-0,2167
b2 =	0,01185	0,01164	0,00019	-0,01644
b3 =	0,00008	-0,00007	0,00006	0,00031
b4 =	-0,0000002	0,0000001	-0,0000003	-0,0000014

Appendix 2. Quartic equations from which the lactating cows' condition score curves were derived. First phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$ $Y = \text{mean condition score value} \quad X = \text{days from start of trial}$					
		Tr. 1	Tr. 2	Tr. 4	Tr. 5
<u>Season 1979/80</u>					
b0	=	3,1625	2,8952	3,0956	2,7991
b1	=	0,00380	0,01075	-0,00261	0,00734
b2	=	-0,000128	0,000220	0,000043	-0,000188
b3	=	0,0000013	-0,0000016	-0,0000003	0,0000016
b4	=	-0,000000004	0,000000003	0,000000005	-0,000000005
R	=	0,8420	0,7725	0,8606	0,8977
<u>Season 1980/81</u>					
b0	=	2,8723	2,7007	2,8425	2,6909
b1	=	0,01440	0,01432	0,03831	0,00722
b2	=	-0,000300	-0,000494	-0,000184	-0,000462
b3	=	-0,0000024	-0,0000043	-0,0000016	-0,0000042
b4	=	-0,000000006	-0,000000011	-0,000000004	-0,00000001
R	=	0,6993	0,8476	0,9248	0,9569
<u>Season 1981/82</u>					
b0	=	2,5032	2,6822	2,3158	2,5932
b1	=	0,00122	-0,02086	0,00375	-0,01968
b2	=	0,000196	0,000435	-0,000093	0,000127
b3	=	-0,0000015	-0,0000028	0,0000012	0,0000011
b4	=	0,000000003	0,000000006	-0,000000005	-0,00000001
R	=	0,9361	0,7119	0,7659	0,8539

Appendix 3. Quartic equations from which the calf growth curves were derived. First phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$					
$Y = \text{mean animal mass}$		$X = \text{days from start of trial}$			
		Tr. 1	Tr. 2	Tr. 4	Tr. 5
<u>Season 1978/79</u>					
b0	=	63,8533	62,0044	65,7120	66,0959
b1	=	0,72106	0,74621	0,70341	0,7132
b2	=	0,000913	-0,003512	-0,001674	-0,00307
b3	=	-0,0000099	0,0000411	0,0000308	0,000032
b4	=	0,00000002	-0,00000013	-0,00000012	-0,0000001
R	=	0,9989	0,9997	0,9977	0,9978
<u>Season 1979/80</u>					
b0	=	72,5974	74,8005	81,8249	69,6380
b1	=	0,64865	0,80976	0,56237	0,97132
b2	=	-0,000298	-0,005491	0,004447	-0,009526
b3	=	0,2246179	0,0000683	-0,0000228	0,0000881
b4	=	-0,00000096	-0,00000022	0,00000003	-0,00000025
R	=	0,9988	0,9958	0,9993	0,9987
<u>Season 1980/81</u>					
b0	=	74,8656	67,8167	67,8340	70,2925
b1	=	0,77456	0,00512	0,54111	0,51285
b2	=	-0,000691	0,001603	0,001225	0,000123
b3	=	0,0000214	0,0000097	0,0000024	0,0000095
b4	=	-0,00000009	-0,00000077	-0,00000032	-0,00000006
R	=	0,9990	0,9983	0,9982	0,9962
<u>Season 1981/82</u>					
b0	=	64,4501	65,3936	68,7348	67,6056
b1	=	0,83459	0,51028	0,36951	0,24817
b2	=	-0,000422	0,003662	-0,000358	-0,007493
b3	=	0,0000085	-0,0000157	-0,0000253	-0,0000829
b4	=	-0,00000004	0,00000001	-0,00000009	0,00000032
R	=	0,9988	0,9992	0,9978	0,9938

Appendix 4. Quartic equations from which the mature lactating cows' growth curves were derived. Second phase of experiment

$Y = b_0 + b_1X + b_2 X^2 + b_3 X^3 + b_4 X^4$			
Y = mean animal mass		X = days from start of trial	
	Tr. 1	Tr. 2	Tr. 4
Season: 1982/83			
b0	425,903	422,653	424,489
b1	0,3659	- 0,0805	0,3038
b2	- 0,00292	- 0,00114	- 0,00225
b3	0,000036	0,000036	- 0,000011
b4	- 0,0000001	- 0,0000002	- 0,00000004
R =	0,9645	0,9356	0,7060
Season: 1983/84			
b0	458,693	442,411	456,292
b1	0,5629	0,9267	0,9068
b2	- 0,00053	- 0,01343	- 0,01687
b3	- 0,000005	0,000108	0,000133
b4	- 0,00000002	- 0,0000003	- 0,00000004
R =	0,9786	0,9650	0,8364
Season: 1984/85			
b0	454,112	478,632	464,960
b1	- 0,0825	- 0,3364	0,5321
b2	0,00210	- 0,00035	- 0,01963
b3	0,000002	0,000062	0,000201
b4	- 0,00000005	- 0,0000003	- 0,00000006
R =	0,9560	0,9268	0,7768
Season: 1985/86			
b0	457,945	450,732	468,330
b1	0,5625	- 0,1614	0,3906
b2	- 0,00331	0,010906	0,00897
b3	0,000020	- 0,000070	- 0,004249
b4	- 0,00000007	0,0000001	0,00000002
R =	0,9583	0,9800	0,9560
Season: 1986/87			
b0	492,961	476,391	487,793
b1	- 1,1494	- 2,2288	- 2,0695
b2	0,02542	0,04198	0,03741
b3	- 0,000130	- 0,000251	- 0,000225
b4	0,0000002	0,0000005	0,00000004
R =	0,8158	0,7900	0,7866

Appendix 5. Quartic equations from which the lactating mature cows' condition score curves were derived. Second phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
Y = mean condition score change		X = days from start of trial	
	Tr. 1	Tr. 3	Tr. 4
Season: 1982/83			
b0	3,344	3,147	3,194
b1	- 0,0106	- 0,0124	- 0,0095
b2	0,00009	0,00013	0,00003
b3	- 0,0000002	- 0,0000004	0,0000005
b4	- 0,0000000006	- 0,0000000003	- 0,0000000003
R =	0,9586	0,9384	0,9124
Season: 1983/84			
b0	3,229	2,859	3,058
b1	0,0023	0,0036	0,0018
b2	- 0,00008	- 0,00008	- 0,00011
b3	0,000001	0,000001	0,000001
b4	- 0,000000004	- 0,000000004	- 0,000000004
R =	0,9884	0,9792	0,9582
Season: 1984/85			
b0	2,972	2,948	2,790
b1	- 0,0003	0,0070	0,0087
b2	0,00008	- 0,00019	- 0,00021
b3	- 0,0000005	0,000002	0,000002
b4	0,0000000008	- 0,000000005	- 0,000000005
R =	0,9604	0,9804	0,9409
Season: 1985/86			
b0	2,972	2,980	3,354
b1	0,0036	- 0,0029	- 0,0028
b2	- 0,00008	0,00004	- 0,00005
b3	0,0000007	- 0,000014	0,0000008
b4	- 0,000000002	- 0,0000000003	- 0,000000003
R =	0,9399	0,9932	0,9934
Season: 1986/87			
b0	2,862	2,830	2,973
b1	- 0,0005	- 0,0056	- 0,0033
b2	- 0,00001	0,00012	0,00005
b3	0,0000005	- 0,0000009	- 0,0000004
b4	- 0,000000002	0,000000002	0,000000004
R =	0,9804	0,9757	0,9592

Appendix 6. Quartic equations from which growth curves for first-calf-heifers were derived. Second phase of experiment

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
Y = mean animal mass			
X = days from start of trial			
	Tr. 1	Tr. 2	Tr. 4
<u>Season: 1984/85</u>			
b0	394,329	388,037	379,486
b1	0,3831	- 0,0693	0,5398
b2	- 0,00677	- 0,00524	- 0,01829
b3	0,000064	0,000087	0,000176
b4	- 0,0000002	- 0,0000003	- 0,0000005
R =	0,9424	0,9045	0,6811
<u>Season: 1985/86</u>			
b0	389,995	411,265	403,680
b1	- 0,1436	- 0,4444	- 1,1881
b2	0,00598	0,01159	0,02227
b3	- 0,000025	- 0,000054	- 0,117068
b4	0,000000009	0,00000005	0,0000002
R =	0,9264	0,9579	0,9446
<u>Season: 1986/87</u>			
b0	419,724	408,074	401,801
b1	- 0,9339	- 1,1303	- 1,8016
b2	0,01448	0,02486	0,03511
b3	- 0,000062	- 0,000143	- 0,000227
b4	0,00000007	0,0000003	0,0000005
R =	0,8899	0,8799	0,8458

Appendix 7. Quartic equations from which condition score curves for first-calf heifers were derived. Second phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
Y = mean condition score change		X = days from start of trial	
	Tr. 1	Tr. 2	Tr. 4
Season: 1984/85			
b0	2,967	3,099	2,889
b1	-0,0043	-0,0043	0,0068
b2	0,00006	-0,00004	-0,00025
b3	-0,0000002	0,0000009	0,000002
b4	0,0000000001	-0,000000003	-0,000000006
R =	0,9461	0,9884	0,9779
Season: 1985/86			
b0	2,869	2,998	2,950
b1	0,0040	-0,0625	0,0030
b2	-0,00004	0,00164	-0,00013
b3	0,0000003	-0,000008	0,000001
b4	-0,0000000009	0,000000007	-0,000000005
R =	0,9213	0,9578	0,9867
Season: 1986/87			
b0	2,959	2,975	3,003
b1	0,0038	0,0048	-0,0029
b2	-0,00012	-0,00015	0,0000008
b3	0,000001	0,000001	0,0000003
b4	-0,000000003	-0,000000004	-0,000000002
R =	0,9767	0,9612	0,9785

Appendix 8. Quartic equations from which the dry pregnant cows' growth curves were derived. Second phase of experiment.

$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$ $Y = \text{mean animal mass}$			
$X = \text{days from start of trial}$			
	Tr.1	Tr. 2	Tr. 4
Season: 1982/83			
b0	437,432	421,236	449,973
b1	1,8498	1,8417	1,3266
b2	- 0,02166	- 0,02212	- 0,00947
b3	0,000144	0,000154	0,000026
b4	- 0,0000003	- 0,0000004	- 0,00000001
R =	0,9915	0,9950	0,9785
Season: 1983/84			
b0	463,653	476,419	420,800
b1	0,9785	1,3404	1,1005
b2	- 0,00403	- 0,01773	- 0,01194
b3	0,000025	0,000137	0,000088
b4	- 0,00000009	- 0,0000004	- 0,0000002
R =	0,9903	0,9725	0,9507

Appendix 9. Quartic equations from which the dry pregnant cows' condition score curves were derived. Second phase of experiment.

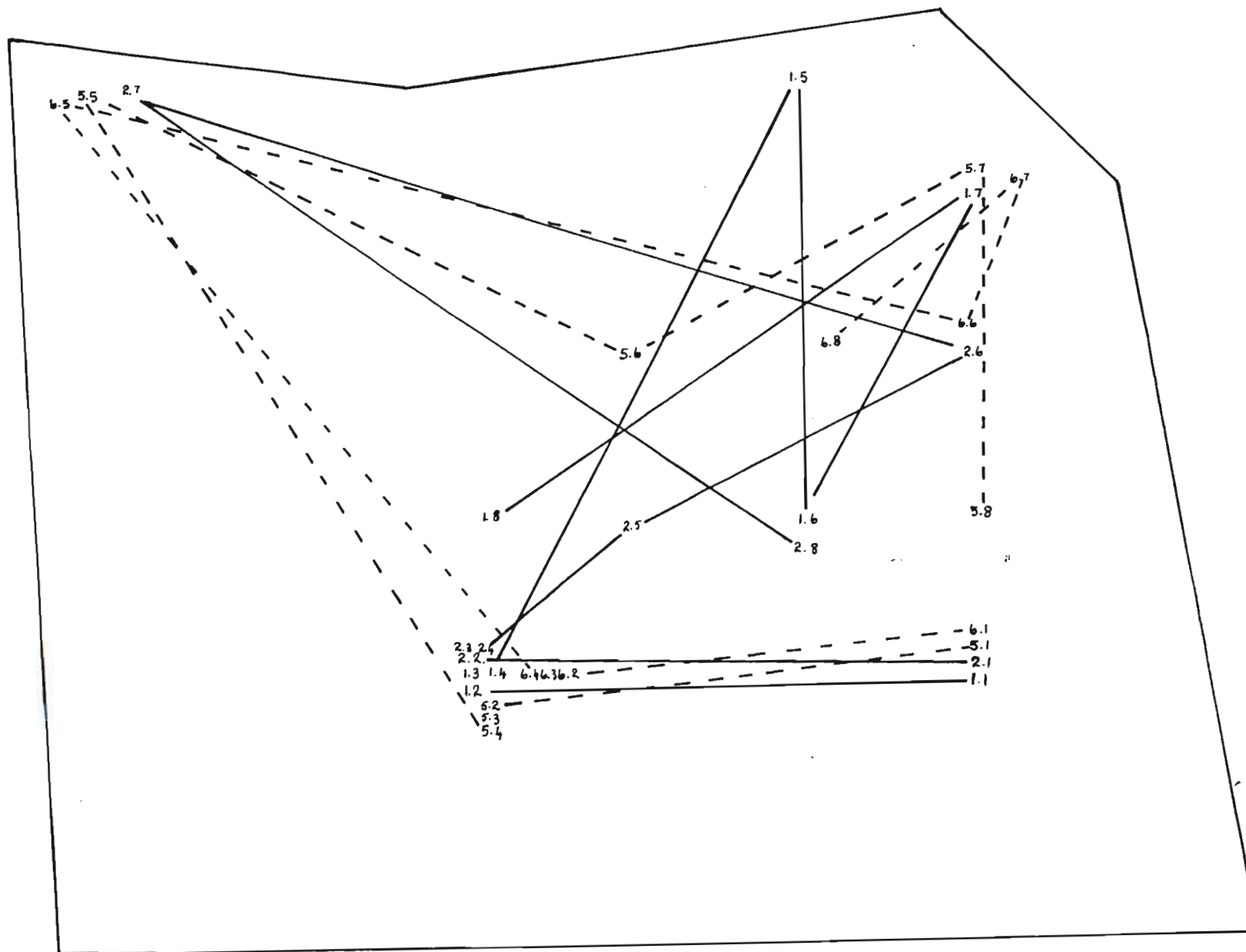
$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
Y = mean animal mass		X = days from start of trial	
	Tr. 1	Tr. 2	Tr. 4
Season: 1982/83			
b0	3,593	3,707	3,731
b1	0,0075	-0,0080	-0,0081
b2	-0,00021	0,00003	0,00002
b3	0,000002	0,0000005	0,0000005
b4	-0,000000005	-0,000000003	0,000000002
R =	0,7535	0,4367	0,4779
Season: 1983/84			
b0	3,460	3,278	3,230
b1	0,0040	0,0142	-0,0034
b2	0,00008	-0,00015	0,00013
b3	-0,0000007	0,000001	-0,0000009
b4	0,000000001	-0,000000003	0,000000001
R =	0,9328	0,9271	0,8040

Appendix 10. Quartic equations from which growth curves for calves born to lactating mature cows were derived. Second phase of experiment.

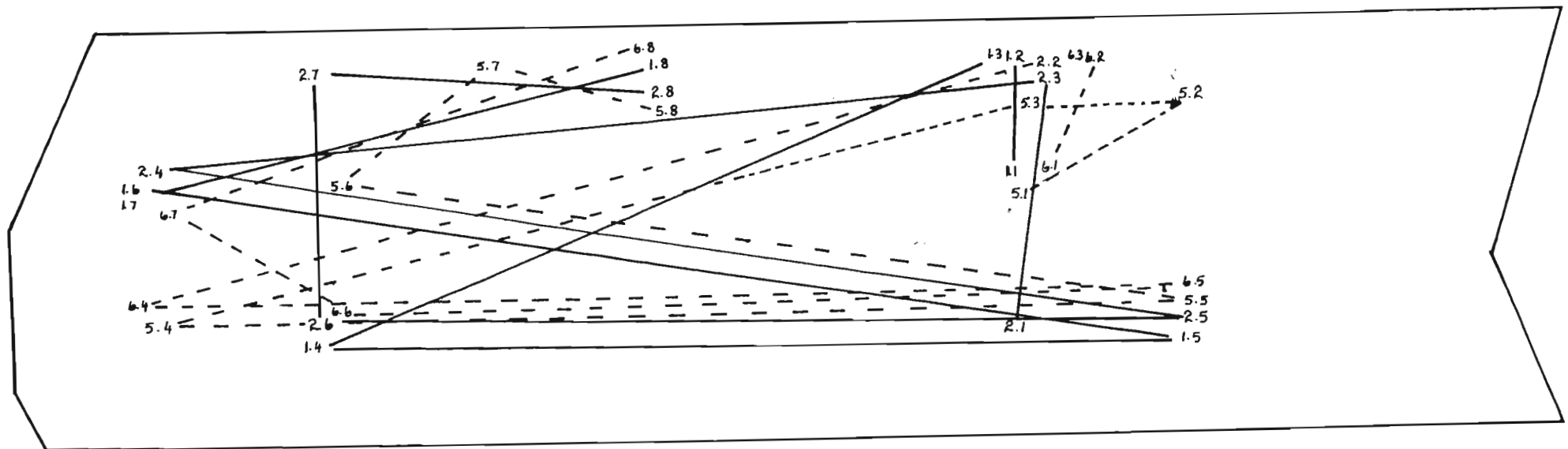
$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
Y = mean animal mass		X = days from start of trial	
	Tr. 1	Tr. 2	Tr. 4
<u>Season: 1982/83</u>			
b0	55,455	65,769	64,444
b1	0,5937	0,5621	0,5130
b2	0,00236	0,00204	0,00565
b3	- 0,000001	0,000001	- 0,000043
b4	- 0,00000004	- 0,00000005	0,00000009
R =	0,9995	0,9996	0,9986
<u>Season: 1983/84</u>			
b0	78,273	70,136	79,818
b1	0,8283	0,8600	0,7646
b2	0,00245	- 0,00205	0,00082
b3	- 0,000011	0,000026	0,000001
b4	- 0,00000002	- 0,0000001	- 0,00000005
R =	0,9978	0,9993	0,9983
<u>Season: 1984/85</u>			
b0	75,123	81,827	74,326
b1	0,5390	0,4891	0,5135
b2	0,00344	0,00094	0,00034
b3	- 0,000006	0,000027	0,000028
b4	- 0,00000004	- 0,0000001	- 0,0000001
R =	0,9993	0,9987	0,9989
<u>Season: 1985/86</u>			
b0	73,434	73,926	70,699
b1	0,8960	0,8909	0,6855
b2	0,00105	- 0,00026	0,00198
b3	- 0,000005	0,000007	- 0,000007
b4	- 0,00000002	- 0,00000005	- 0,00000003
R =	0,9991	0,9994	0,9990
<u>Season: 1986/87</u>			
b0	65,079	58,844	58,735
b1	0,8767	0,9456	0,9413
b2	- 0,00049	- 0,00272	- 0,00392
b3	0,000009	0,000028	0,000036
b4	- 0,00000005	- 0,00000009	- 0,0000001
R =	0,9977	0,9988	0,9989

Appendix 11. Quartic equations from which growth curves for calves born to first-calf heifers were derived. Second phase of experiment

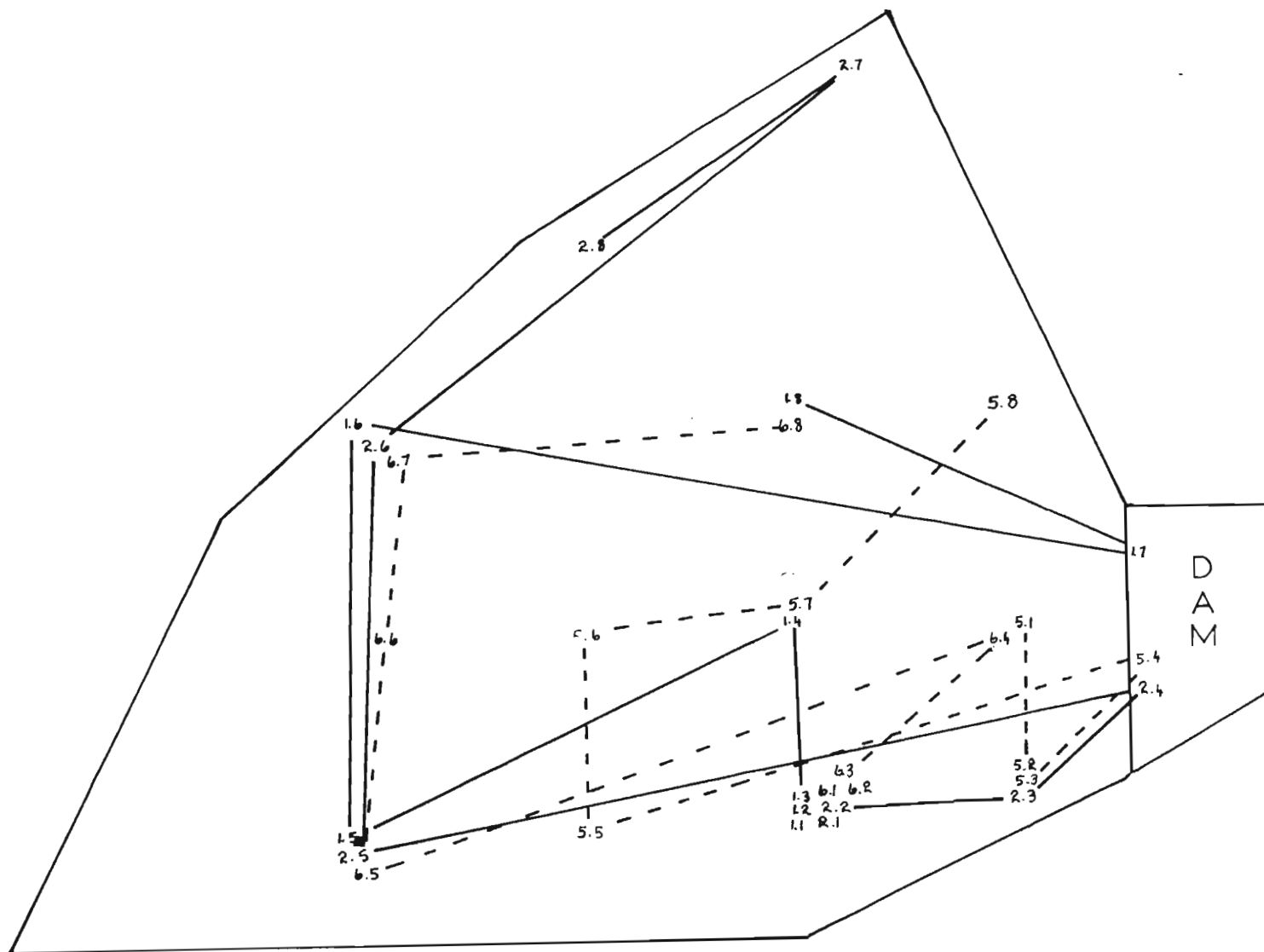
$Y = b_0 + b_1X + b_2X^2 + b_3X^3 + b_4X^4$			
$Y = \text{mean animal mass}$		$X = \text{days from start of trial}$	
	Tr. 1	Tr. 2	Tr. 4
Season: 1984/85			
b0	79,306	83,601	78,495
b1	0,4425	0,4510	0,6599
b2	0,00349	0,00068	-0,00417
b3	- 0,000006	0,000025	0,000054
b4	- 0,00000004	- 0,0000001	- 0,0000002
R =	0,9988	0,9987	0,9983
Season: 1985/86			
b0	89,725	93,413	98,121
b1	0,9421	0,8066	0,6798
b2	- 0,00040	0,00222	0,00413
b3	0,0000004	- 0,000009	- 0,000027
b4	- 0,00000003	- 0,00000002	0,00000002
R =	0,9978	0,9993	0,9988
Season: 1986/87			
b0	83,915	81,265	79,565
b1	0,8978	1,0852	0,8061
b2	- 0,00223	- 0,00554	- 0,00273
b3	0,000018	0,000040	0,000022
b4	- 0,00000007	- 0,0000001	- 0,00000008
R =	0,9969	0,9978	0,9985



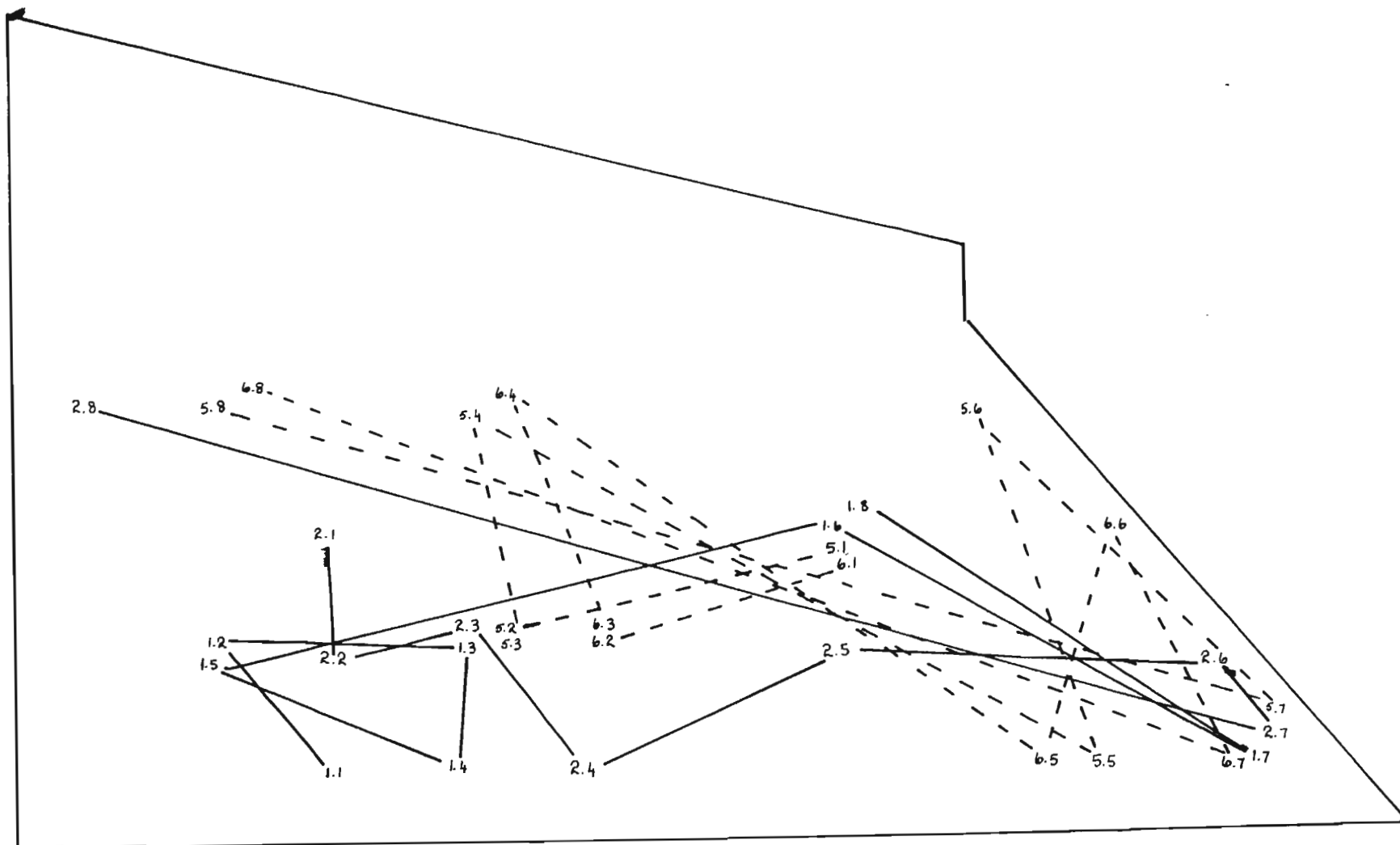
Appendix 13. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.1 presented at hourly intervals for the first observation (21/3/86) in the large camp (Camp 2L).



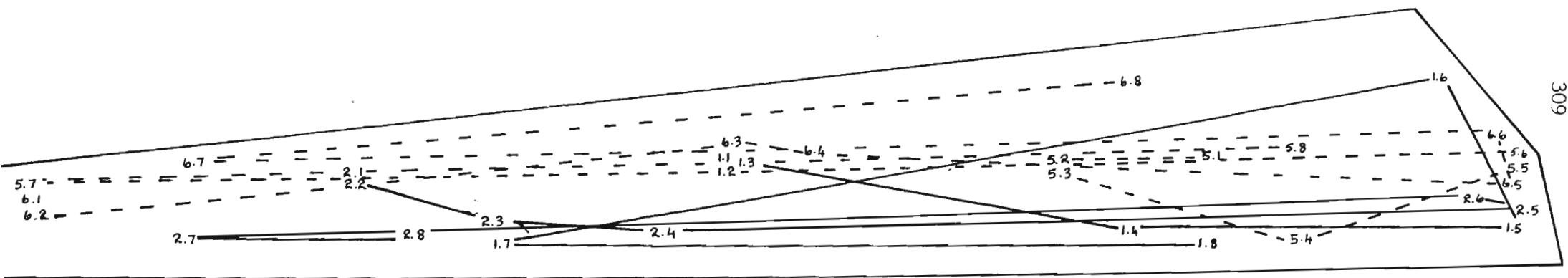
Appendix 14. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.2 presented at hourly intervals for the first observation (21/3/86) in the large camp (Camp 2L).



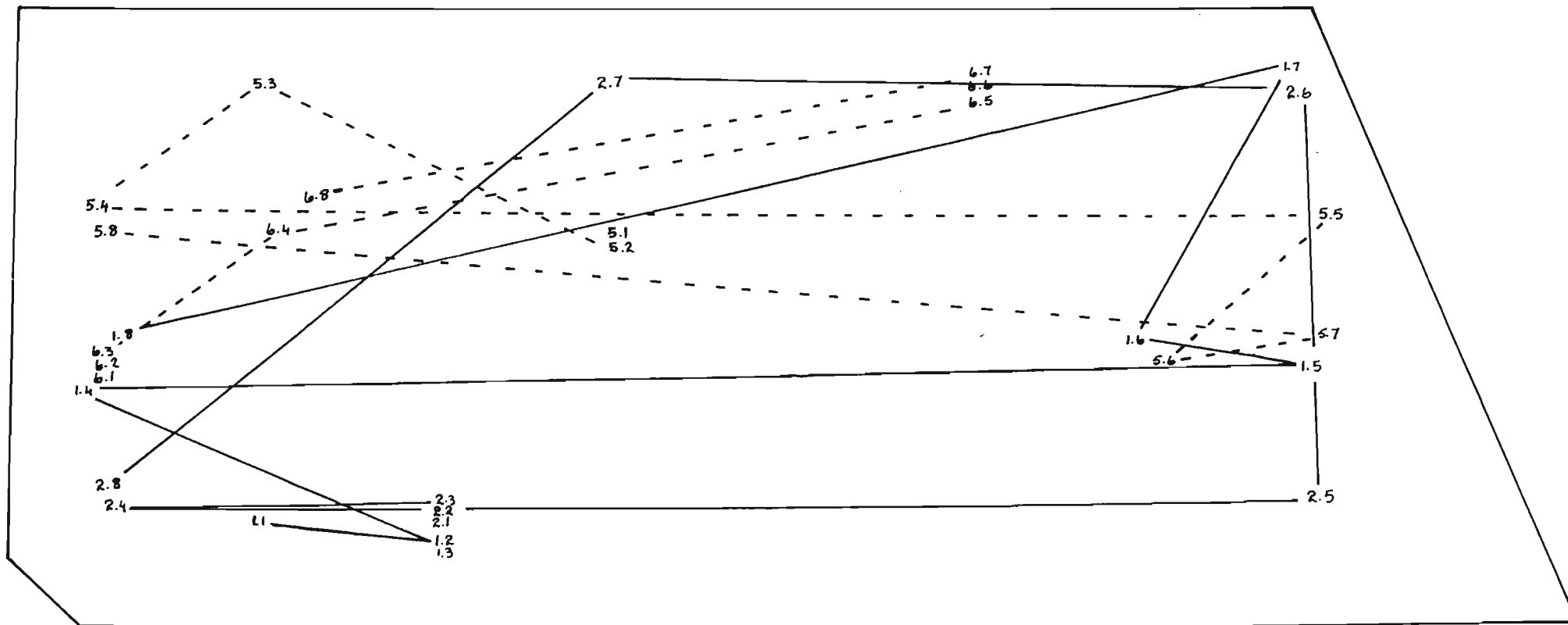
Appendix 15. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.4 presented at hourly intervals for the first observation (21/3/86) in the large camp (Camp 2L).



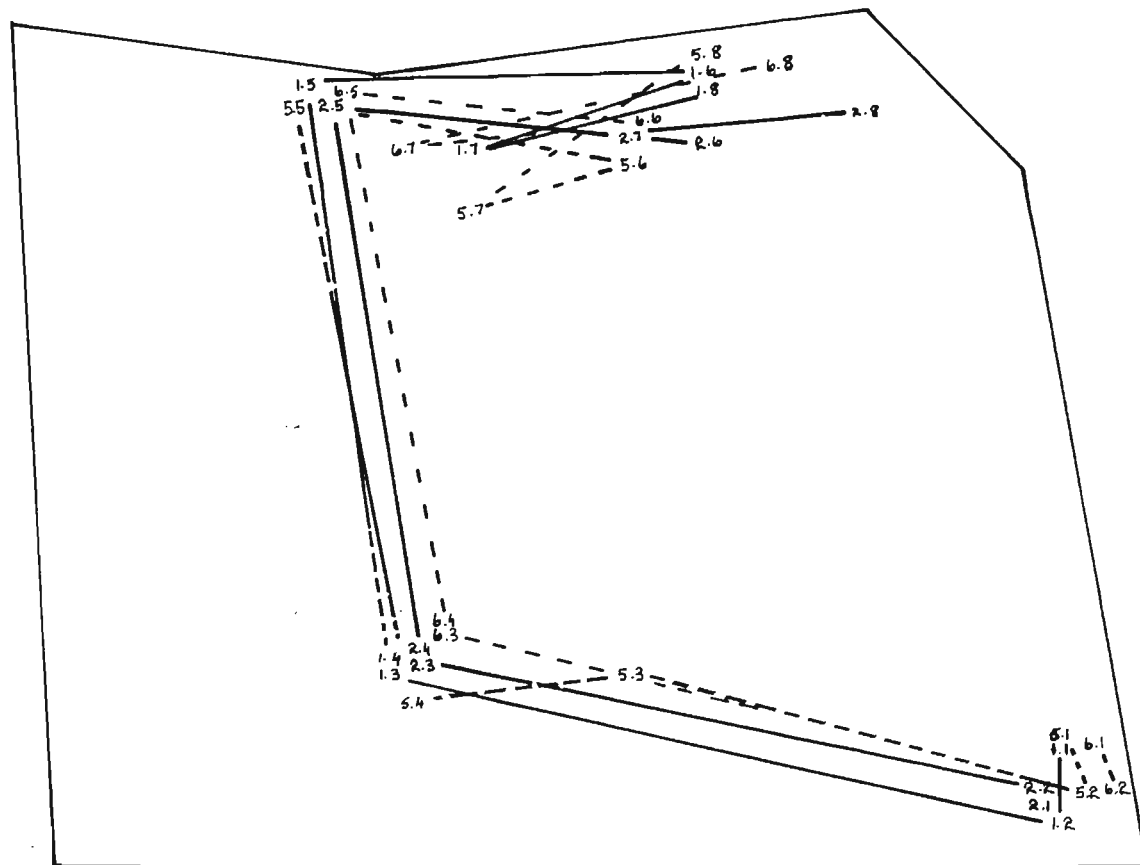
Appendix 16. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.1 presented at hourly intervals for the last observation (3/6/86) in the small camp (Camp 3S).



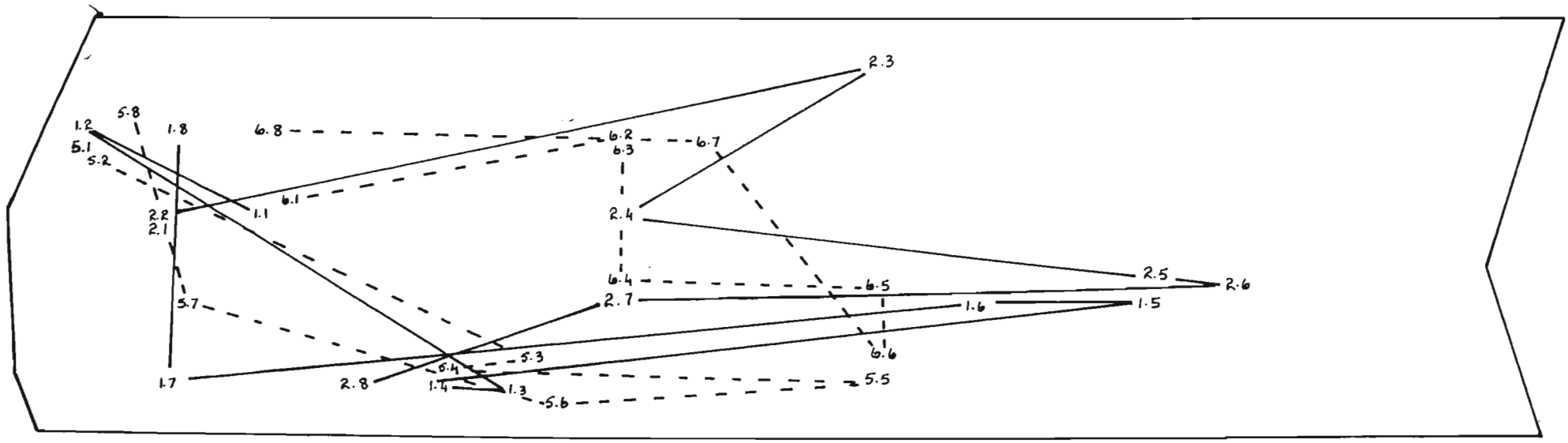
Appendix 17. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.2 presented at hourly intervals for the last observation (3/6/86) in the small camp (Camp 3S).



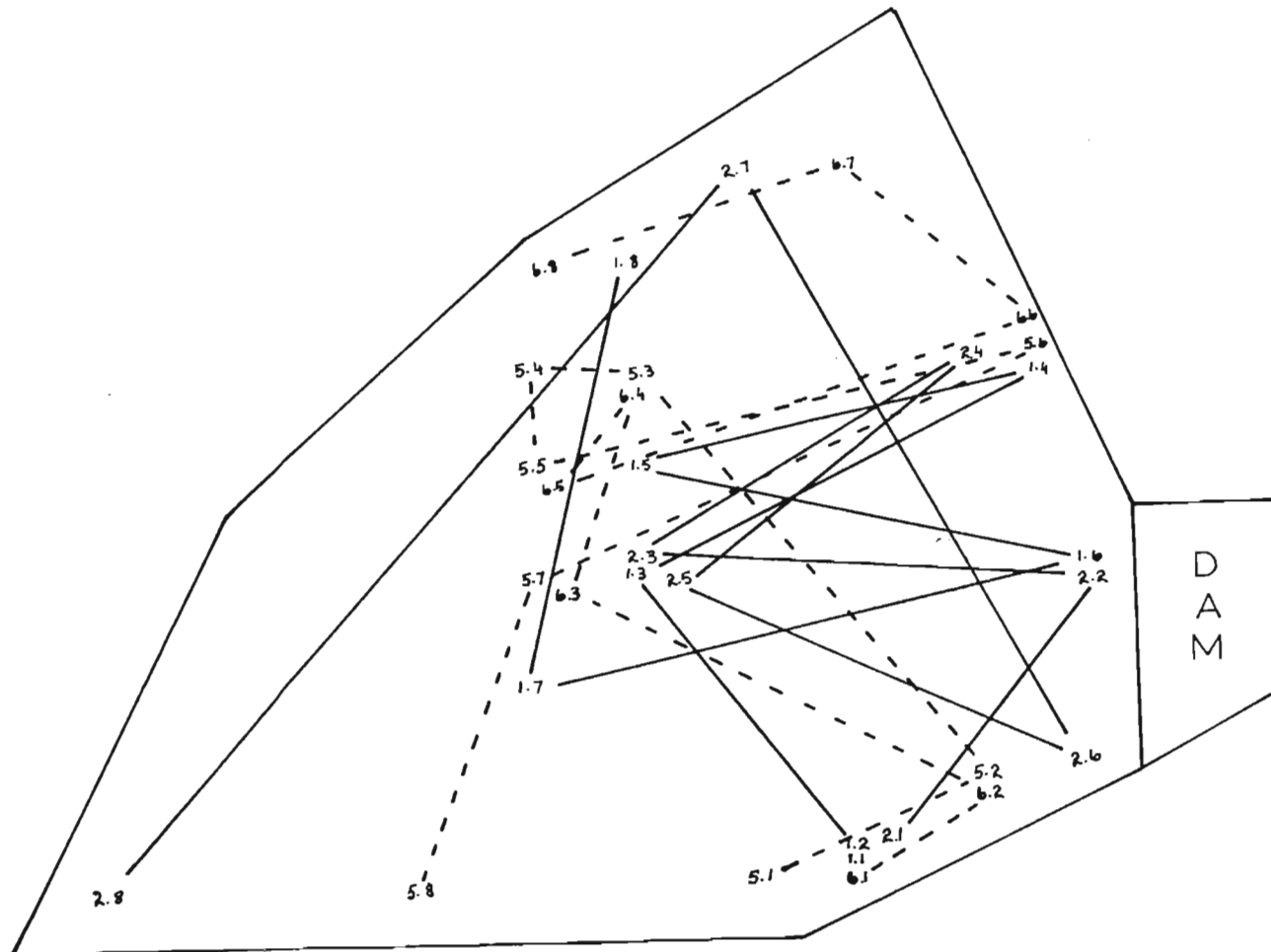
Appendix 18. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.4 presented at hourly intervals for the last observation (3/6/86) in the small camp (Camp 3S).



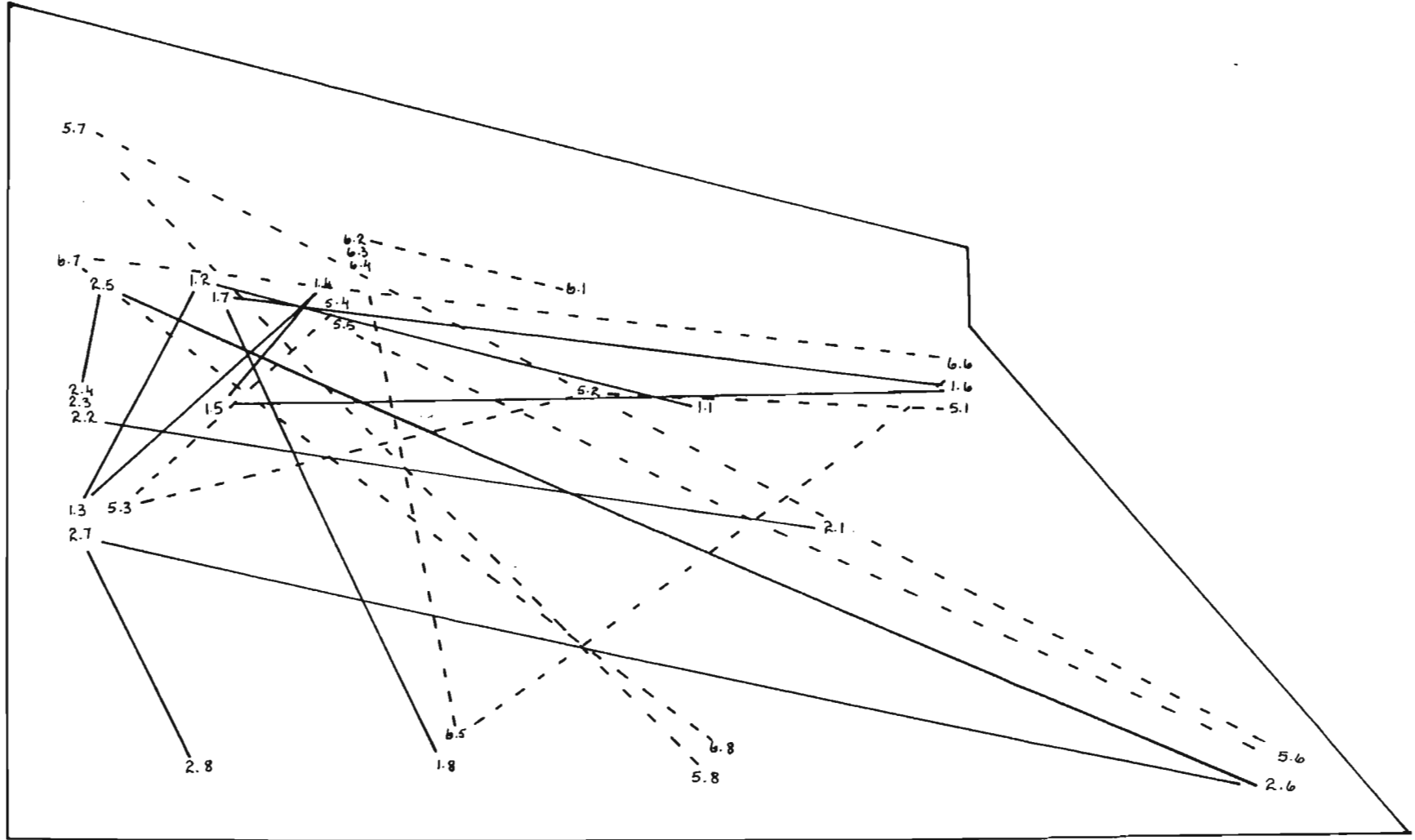
Appendix 19. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.1 presented at hourly intervals for the first observation (18/11/86) in the large camp (Camp 2L).



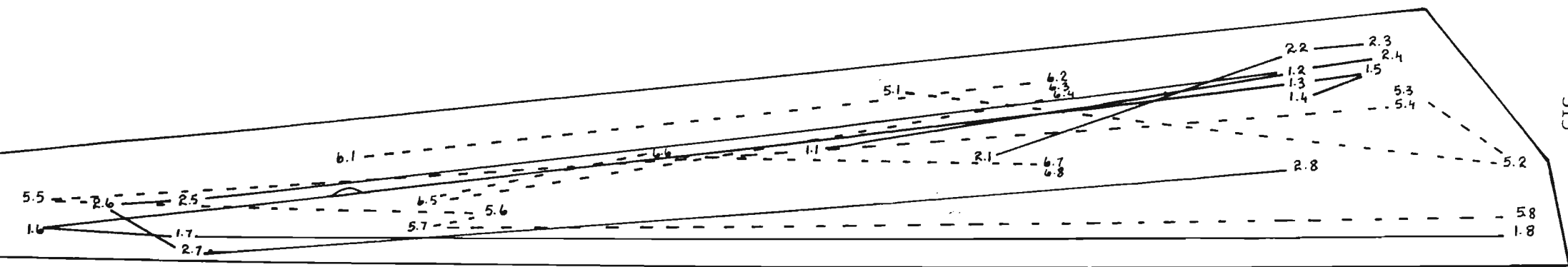
Appendix 20. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.2 presented at hourly intervals for the first observation (18/11/86) in the large camp (Camp 2L).



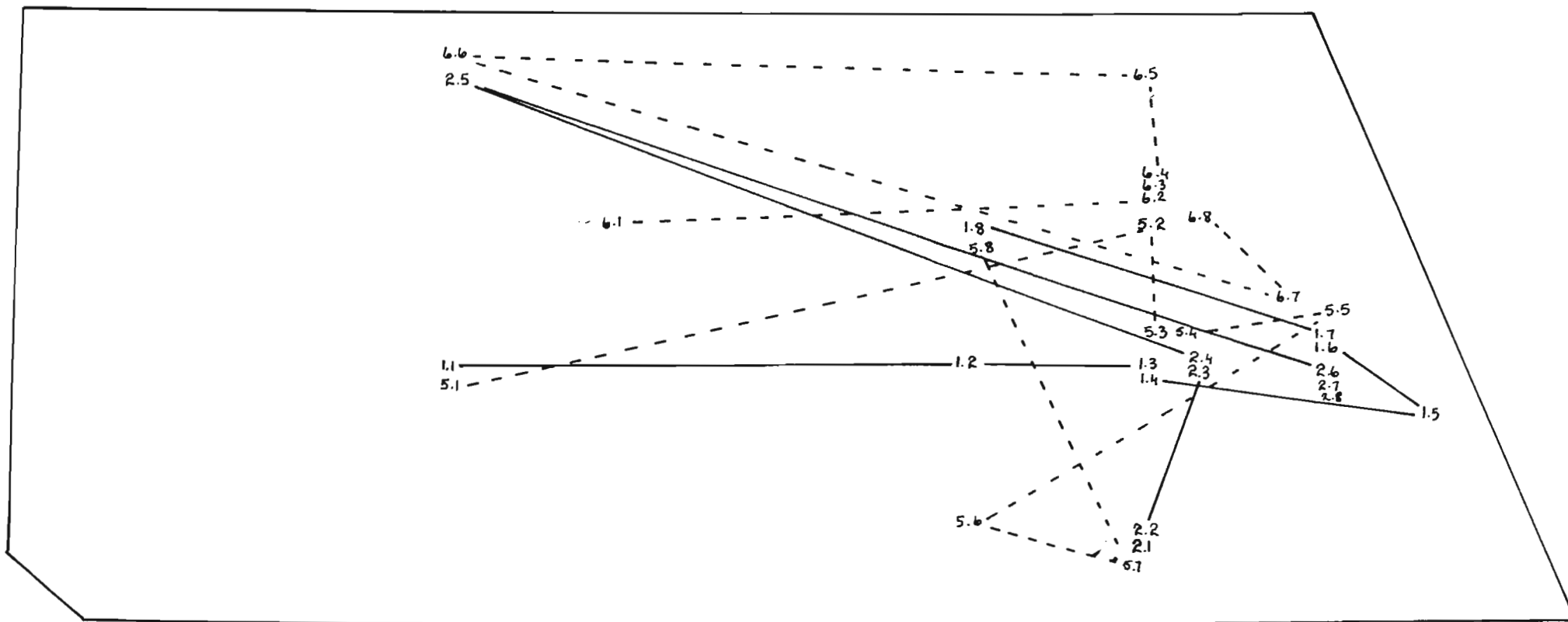
Appendix 21. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.4 presented at hourly intervals for the first observation (18/11/86) in the large camp (Camp 2L).



Appendix 22. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.1 presented at hourly intervals for the last observation (20/5/87) in the small camp (Camp 3S).



Appendix 23. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.2 presented at hourly intervals for the last observation (20/5/87) in the small camp (Camp 3S).



Appendix 24. The grazing patterns of two first calvers (No's 1 and 2) and two mature cows (No's 5 and 6) in Tr.4 presented at hourly intervals for the last observation (20/5/87) in the small camp (Camp 3S).