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BEEF PRODUCTION FROM KIKUYU
AND ITALIAN RYEGRASS /

by

A
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ABSTRACT

Four grazing trials to characterise cultivated pastures, in terms of beef production, were conducted in Bioclimate 3 of Natal.

Dual purpose and British beef type cows were run on kikuyu at stocking rates from 2,81 to 7,30 cows plus calves per ha. During the eight seasons of the trial the seasonal rainfall varied from 580 to 933 mm. There was a positive linear relationship between rainfall and pasture yield with maximum yield of kikuyu being recorded during February - March. Stocking rate affected pasture yields only during favourable rainfall seasons. Crude protein (CP) and crude fibre (CF) of kikuyu fluctuated markedly within and between seasons. However, CP increased and CF decreased as stocking rate increased. There were significant relationships between stocking rate and (a) calf performance, (b) calf livemass gain, (c) period required to attain maximum mass, (d) period on pasture for the cows, and (e) cow mass change.

Weaners were run on irrigated Italian ryegrass at 5, 7 and 9 weaners per ha for four seasons. Stocking rate had little effect on the growth pattern of the pasture but affected dry matter yields. Reducing the stocking rate resulted in increased pasture yields and CF content but reduced CP levels of material on offer. Steers exhibited higher gains than heifers but lower carcass grades and stocking rates for maximum gain per ha (SR_{max}). Livemass gains of 1315 and 1224 kg per ha can be expected at SR_{max} of 6,85 and 9,54 for steers and heifers respectively.

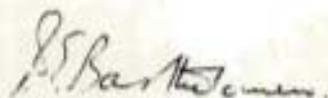
Yearling heifers run at four stocking rates on kikuyu for one season showed a negative linear relationship between stocking rate and gain and a positive linear relationship between pasture height and gain. A SR_{max} of 8,85 allows for a livemass gain of 1 040 kg per ha.

The effect of feeding concentrates on foggaged kikuyu was evaluated. Foggaged kikuyu can be used as a source of roughage for fattening steers. However, as the steers became adapted to the concentrate the intake of kikuyu declined from 39 to 19% of their daily intake.

Regressions derived from the characterisation trials allow for developing beef systems for different situations.

DECLARATION

I hereby declare that this thesis and the associated research comprises my own original work, except for assistance which is acknowledged or where due reference is made in the text. I also declare that the results contained in this thesis have not been previously submitted by me in respect of a degree at any University.



P E Bartholomew

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INTRODUCTION

The Natal Mistbelt 'Ngongoni Veld (Acocks, 1975), or Bioclimatic group 3 (Phillips, 1973), is characterised by the presence of a pioneer grass, Aristida junciformis, giving rise to a secondary succession grassland (Phillips, 1973).

Aristida junciformis is a hardy pioneer, with an extensive root system, producing large quantities of seed (Venter, 1968). The grass is highly unpalatable (Theron & Booysen, 1966; Edwards, 1981a) with tensile strength properties of the leaves nearly twice that of the next most unpalatable species, Tristachya leucothrix (Theron & Booysen, 1968). Once A. junciformis has invaded the veld the grazing capacity of the veld is drastically reduced (in some cases the grazing capacity is negligible), and the possibility for regeneration of the more palatable species is remote (Venter, 1968). Jones, Theron & Venter (1967) established that the potential of 'Ngongoni veld was of the order of 22 kg beef per ha per annum. These workers concluded that this figure could not be improved upon by the application of conventional grazing systems. Furthermore, the low stocking rate of 3,2 ha per animal unit being applied in this veld type (Anon., 1974), receiving an annual precipitation in excess of 800 mm, clearly indicates low animal production of 'Ngongoni veld relative to the potential of the area.

It is, therefore, no wonder that while referring to Bioclimate 3 in "The Development Programme for the Natal Region", it is stated that "The future of the veld in animal production systems is likely to diminish considerably due to its low potential ..." (Anon., 1974). Forty five percent of Biogroup 3 is veld, with an average farm size of 545 ha, much of which is too steep or unsuited to annual cropping. Clearly there is a need to improve the productivity of this high potential area.

The potential for increasing the output of beef and improving the productivity of the 'Ngongoni veld by the use of intensive established pastures has been emphasised by numerous authors (Davies, 1966; Scott, 1966, 1967; Edwards & Booysen, 1972; Edwards, 1966, 1983). While Theron, Lesch & Mappledoram (1974) have recorded success with reinforcing Highland Sourveld (Acocks, 1975) with introduced species, little success has been achieved in 'Ngongoni veld, either with sod seeding (the rows are invaded by A.junciformis and Eragrostis plana) or fertilising and oversowing (Edwards, 1983). In re-evaluating veld reinforcement in Natal, Edwards (1983) concludes that "Veld should be replaced rather than reinforced where this is feasible ..".

That there are large areas suited to the replacement of 'Ngongoni veld with intensive pastures is clearly shown by Edwards & Scotney (1978), while the implications of improved productivity per animal and per unit area is evident from the data of numerous authors (e.g. Luitingh, 1974; Harwin & Lombard, 1974; Harwin & Theron, 1975; Lishman, 1980; Edwards, Scotney, Bartholomew & Tainton, 1980).

The selection of a pasture species depends on the environment, the purpose for which the pasture is required, the time of year when the pasture is to be utilised and the number of years for which it is to be grown (Scott, 1981). Furthermore, in selecting a species for improving productivity it is important that, relative to the existing vegetation, the nutritive value will be improved, that animal production will be increased, that changes in management required to maximise production from the introduced species are practical and that the benefits are realisable in economic or other terms (Evans, 1982).

Dry matter yields in excess of 12 000 kg per ha for dryland Pennisetum clandestinum (kikuyu) (Cross, 1979) and 11 000 kg per ha for irrigated Lolium multiflorum (Italian ryegrass) (Rhind & Goodenough, 1976) have been recorded from cutting trials conducted at Cedara, located in the 'Ngongoni

veld. Cross (1979a) states that "...kikuyu remains the choice for summer pastures" for intensive grazing systems in the high potential areas. Heard (1976) is of the opinion that Italian ryegrass is the fodder crop with the greatest potential for cool season growth in the Natal Midlands.

Tainton, Barrow & Bransby (1982) have reported on the profitability of beef steers on kikuyu pastures in Bioclimatic group 6 (Phillips, 1973), but there is a paucity of information on beef production on either kikuyu or Italian ryegrass in Bioclimatic group 3. Taylor (1949) reported that moderately fertilised dryland kikuyu pastures yielded in excess of 11 200 kg milk per ha per annum, while Bredon & Stewart (1978) state that for a 500 kg cow stocked at 0,29 ha per cow the potential of dryland kikuyu is 12 kg milk per cow per day in spring, declining to 5 to 8 kg milk per cow per day in autumn. The potential of well managed irrigated Italian ryegrass (in Biogroup 3) stocked at 0,36 ha per 500 kg cow, for 8 months, is 16 kg of 4% fat corrected milk per cow per day. The chemical composition of the herbage of both kikuyu and Italian ryegrass, harvested during periods of active growth of the grasses (Taylor, 1949; Bredon & Stewart, 1978; Jones, Arnott & Klug, 1980), clearly indicates nutrient levels in excess of the animals requirements for maintenance (Lesch, Jones, Louw, Archibald & Kaiser, 1974; Bredon & Stewart, 1978; Jones et al., 1980; Bransby, 1981b; Baker, 1982a; Minson, 1982).

Seen in the light of the dry matter yield potential, of both kikuyu and Italian ryegrass, the relatively high nutritional value of these grasses, in relation to animal requirements, and the low productivity of the 'Ngongoni veld, there is clearly a niche for these grasses in improving individual animal performance and animal production per unit area.

"The level of animal production from grazed pastures is an expression of the quantity and quality of the feed ingested and the efficiency of utilisation by the animal" (Evans, 1982). While the importance of measuring

animal productivity from pastures is widely accepted, the type of experimentation, the techniques and management that should be applied to establish the relationship between pasture production and animal performance, and the interpretation, or mathematical models, to describe animal and pasture response are numerous and varied. These topics have been repeatedly and very comprehensively reviewed and discussed by numerous authors, including Mott (1960, 1980), Petersen & Lucas (1960), Riewe (1961), Petersen, Lucas & Mott (1965), Matches, Martz & Thompson (1974), Owen & Ridgman (1968), Morley & Spedding (1968), Cowlshaw (1969), Conniffe, Browne & Walsh (1970), Hart (1972, 1978), Jones & Sandland (1974), Blaser, Jahn & Hammes (1974), Sandland & Jones (1975), Connolly (1976), Tainton (1976), Morley (1978), Riewe (1980), Holmes (1980), Blaser (1981) and Crowder & Chheda (1982). Suffice it to say that it is generally accepted that stocking rate probably has the greatest influence on pasture and animal productivity, that trials to evaluate pastures in terms of animal performance should include at least two stocking rates (preferably more) and that both pasture and animal parameters should be monitored for a fuller understanding of the animal-plant complex.

The overall objective of the present investigation was aimed at intensive beef production. More specifically, the trials were designed to provide information that has direct practical value and which will contribute to increasing both the tempo and quantity of beef production as a result of improved animal performance and increased production per unit area. Both kikuyu and Italian ryegrass were selected for evaluation. Dryland kikuyu was evaluated in terms of the cow plus calf (i.e. production of weaners), the growing out of yearling heifers and as foggage with a fattening ration for 20 month old steers. Italian ryegrass was evaluated with weaners, with the object of producing 15 to 18 month old slaughter animals and heifers for early mating.

The experimental strategy followed was one of characterisation in terms

of component research, as opposed to systems research. While the fuller implications of the effect different levels of soil fertility (particularly nitrogen) have on pasture and thus animal productivity are recognised, resource limitations (and the fact that some of the trials had both animal husbandry and pasture science objectives and inputs) precluded this important aspect in the characterisation trials. As a result kikuyu, intended for dryland non arable situations, has been researched at a moderate level of nitrogen, while Italian ryegrass, on intensive irrigation land, has been evaluated with a high level of nitrogen input.

CHAPTER 1

AN OUTLINE OF POSSIBLE INTENSIVE BEEF PRODUCTION SYSTEMS FOR THE

'NGONGONI VELD

1.1 The overall beef scene

It is generally accepted that the growing out and finishing of animals for slaughter is more lucrative than the production of a weaner calf for sale (i.e. running a breeding herd). This is so because feeding and maintaining the breeding herd is the major cost in producing an animal for slaughter. Thus for example, in producing 450 kg slaughter animals, approximately 70% of the total feed nutrients utilised by the herd are required to get the calves to weaning age (Harwin 1973). In the same context, seen in the present economic climate, it is more economical to run the breeding herd on the veld and the growing animal on intensive cultivated pastures (van Niekerk, Hardy, Mappledoram & Lesch, 1984). Thus the system of producing the weaner calf in the extensive areas (Sweetveld) and growing and finishing them in the intensive areas (Sourveld), proposed by Scott in 1951, still has considerable merit. However, there are several important implications to be considered in the long term planning of the beef strategy or enterprise. It must be remembered that the beef industry is entirely dependent on the constant supply of weaners. This seen in the light of the repeated call for the need to increase beef production (Tidmarsh, 1966; Harwin, 1973; Luiting, 1974; Harwin & Theron, 1975; Schoeman, 1977; Lishman, 1980; Anon., 1984a) means an increased supply of weaners.

Competition for weaners, especially in view of the increased profitability of growing and finishing animals, relative to producing weaners, is likely to increase dramatically in the future. The extensive

(low rainfall) areas are, in most instances, stocked to capacity. Increased weaner production from these areas is limited to improving management (e.g. improving calving percentages, reducing calf mortality and dystocia) and possibly breed selection. Because of the profitability of growing out and finishing animals for slaughter, many farmers in the extensive areas are reducing their breeding herds to finish some of their own weaners - thus reducing the availability of weaners. In addition farmers in areas (both semi-intensive and intensive) producing weaners off veld, and where veld reinforcement and/or replacement with improved species is possible, are intensifying and finishing all or part of their own weaner crop. Furthermore, competition from large feedlot concerns and drastically escalating transport costs are factors to be considered in respect of competition for weaners and contributory factors in inflating weaner prices: thus reducing the overall profitability of growing and finishing weaners for slaughter.

In 1974 Luiting stated that "... increased plant production (roughage, grass, foddercrops) is unquestionably the most important factor for future increases in beef production ...". However, intensification in terms of faster turnover of animals and increased carrying capacity creates the need for more weaners (Lishman, 1980). The increased numbers of weaners could be provided for by (i) earlier marketing of animals, thus increasing the proportion of effective breeding cows, (ii) increasing the output of weaner calves per 100 cows through increased input of management and technology (e.g. feeding level and onset of early oestrus, multiple births), (iii) increasing the number of effective cows through increased stocking rates and improved forage production systems (Harwin & Lombard, 1974; Lishman, 1980).

Seen in the light of the dependence of the beef industry on the availability of weaners and the extremely low production potential of the 'Ngongoni veld, a programme was initiated to study alternative beef strategies which the individual farmer could use as a basis to formulate his

own beef system. Within the limits set by the natural resources on a farm, and the need to maintain or improve these resources, the aim of pasture production for intensive beef production systems is to establish the most favourable economic relationship between area of land and the provision of feed for conversion to animal products. Two important aspects relating to the red meat industry have been emphasised by Lombard (1979). Firstly, any strategy decided upon takes from three to six years to show an influence. Secondly, unpredictable climatic, economic and social circumstances make it almost impossible to predict supply and product prices for several years in advance.

It is in the light of the above that possible intensive beef production systems are proposed. While the severe limitations to the proposed systems are recognised (nl. being based on research findings from a limited number of pasture species that are suited to the area), it is nevertheless felt that, in view of the inadequacy of animal performance data from other species, the systems represent a starting point and as such can make a valuable contribution to the beef farmer in the 'Ngongoni veld of Natal.

1.2 Aspects relating to intensive beef systems

Figure 1.1 illustrates some of the options or combinations of strategies that are open to the farmer in the Mistbelt 'Ngongoni Veld of Natal. These strategies are based on dryland kikuyu and irrigated Italian ryegrass for grazing, with Eragrostis curvula hay and maize silage providing the winter feed. In Fig. 1.1 the solid line rectangles represent aspects which were researched and are reported on in detail in this dissertation, while the broken line rectangles represent aspects from the literature and ad hoc observations. Veld is included to make provision for those farmers who have veld available for incorporating in the system, and for those who may use veld as an interim measure while the veld is being replaced by improved

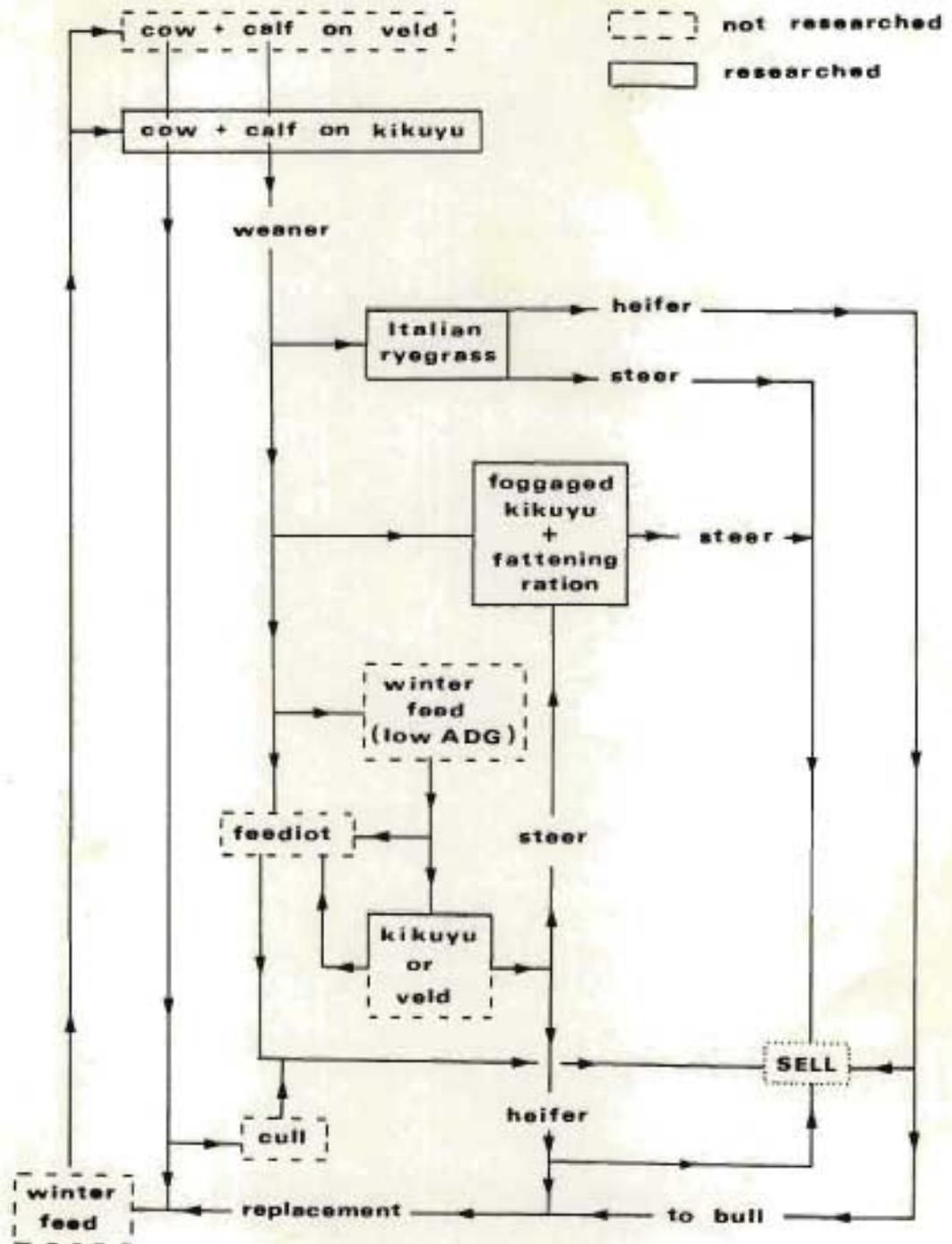


Fig. 1.1 Some possible intensive beef production systems for Bioclimate 3.

pasture species.

1.2.1 Cow plus calf: weaner production

If weaners are not bought in from elsewhere, the breeding herd (cow plus calf in Fig. 1.1) serves to generate the weaners which are grown out and finished for slaughter. Although aspects relating to the intensification of the breeding herd (e.g. age at calving, age of culling, crossbreeding, multiple births, multiple suckling, synchronisation of heat, beef from the dairy herd) are of immense importance in the intensive pasture situation (Harwin & Lombard, 1974; Lishman, 1980), these aspects are beyond the scope of this dissertation.

As mentioned earlier, in the cow-calf system approximately 70% of the total nutrient requirements to market a 450 kg steer is required to get the calf to weaning age. Thus any system which reduces the cost of producing a weaner is likely to be beneficial to the overall beef strategy. The relationships between number of animals per ha, weaning weights, length of the winter period for the dam and the cost of winter feed are aspects which are of particular importance and need to be considered.

As the stocking rate of the cow plus her calf increases there is a reduction in the average daily gain (ADG) of the calf. However, up to a certain stocking rate there is an increase in total calf livemass gain per ha (Baker, Le Du & Alvarez, 1981). Beyond this stocking rate total calf livemass gain per ha declines. At the same time there is a greater mass loss of cows at high as opposed to the low stocking rate (Silvey, Coaldrake, Haydock, Ratcliff & Smith, 1978; Baker et al., 1981; van Niekerk et al., 1984). Baker et al. (1981) state that with cow-calf systems decisions on pasture management should be based on the cow and not on the calf. The implications of this, for the 'Ngongoni veld, are that for tropical pastures stocked at high stocking rates the cows and calves will need to be removed

from the pasture sooner than at low stocking rates. This has a two fold effect on the overall system. Firstly, individual calves will be lighter, although there are more per ha, and secondly, the winter feed period for the cows will be much extended. At low stocking rates fewer larger calves will be weaned and the cows will have a low winter feed requirement.

The relationship between stocking rate- cow and - calf performance forms a major part of the research to be reported on in detail. In the absence of research data, and particularly the effect of stocking rate on animal performance for the cow plus calf on 'Ngongoni veld, it is currently generally recommended that weaner calves be produced at low stocking rates on the veld (of the order of 3 ha per cow plus calf) and that the calf be provided with a creep feed. A breeding herd run on good 'Ngongoni veld at Cedara has shown that without creep feeding of the calves a weaning mass of approximately 165 kg can be expected. However, with creep feeding (advocated by several researchers for improving the performance of suckling calves: Harwin & Venter, 1970; Blaser, Hammes, Fontenot, Polan, Bryant & Wolf, 1980; Lishman, Lyle, Smith & Botha, 1984) weaning masses of the order of 200 to 215 kg are possible with early calving. Due to the veld being ready for grazing fairly late in spring and due to the particularly low quality of the veld towards the end of the season (affecting cow condition), provision must be made for a long winter feeding period for the dams.

1.2.2 Winter feeding of dams

In view of the high costs involved in overwintering the dam and the need for a high calving percentage, it seems appropriate at this stage to briefly discuss the implications of cow mass loss and cow condition, while on kikuyu pasture or veld with a calf at foot. Besides the adverse effects that undernutrition (excessively high stocking rates) of a cow has on her ability

to conceive, it has been found that a cow in a very thin condition, or a condition score of 1,5 (van Niekerk & Louw, 1980) at the onset of winter, requires 90 days of intensive feeding to achieve a condition score of 3,0 at calving. On the other hand a cow in a slightly better condition, with a condition score of 2,0 achieves a condition score of 3,0 in 49 days at less than half the cost (van Niekerk, 1982a). It is no wonder that Baker et al., (1981) are of the opinion that decisions on pasture management should be based on the cow and not the calf.

Nevertheless, important as the winter feed costs may be it is the overall beef strategy that is the decisive factor. The farm's ability to provide winter feed and the overall beef system (number of weaners required, mass of weaners required, weaner prices, price of finished animal, cow replacement rate) can influence the decision as to the overall strategy to be followed and thus the cost input for winter feed for the cows (i.e. the summer stocking rate).

1.2.3 The weaner and the end product

Figure 1.1 illustrates some of the options that are open to the entrepreneur for finishing animals for the market or for providing replacement heifers for the breeding herd.

Whether the weaners are bought in or whether they are "home grown" is at this stage immaterial. What is important is that they are available, since the growing out and finishing of the animal represents the phase of beef production with the greatest profit margin. Equally important is that the correct type of animal is utilised for the different options available. Thus for example, a late maturing breed may not be suited, if top grades are the aim, for finishing on Italian ryegrass since physiological development must precede "fattening" of the animal. A late maturing breed may, however, be well suited to a system of winter feed at a low ADG and then

kikuyu for finishing (cf. Fig. 1.1).

In establishing the overall objective and in formulating the final system(s) for finishing animals for slaughter the "target masses and target dates" concept of Edwards (1981b) is most appropriate. On the basis of the model of Jones & Sandland (1974), which describes the stocking rate - animal gain relationship in terms of a simple straight line, the performance of the grazing animal (Italian ryegrass and kikuyu in Fig. 1.1) is determined. By taking into account the availability of fodder, both for winter and summer, the farmer can establish target masses and target dates (knowing or predicting abattoir beef prices) and formulate the overall beef system within the limitation of his resources.

In terms of increasing the tempo of beef production the feedlot, Italian ryegrass and foggage with a fattening ration offer the best prospects, while winter feeding followed by summer kikuyu provides for a somewhat slower tempo of beef production. The relationship between stocking rate and animal gain on Italian ryegrass will form a major study to be reported on later, while the kikuyu phase following winter feeding at a low ADG and foggaged kikuyu with a fattening ration (Fig.1.1) will form lesser parts of the research reported on. Feedlotting, providing for good animal performance (Lesch, Jones, Low, Archibald & Kaiser, 1974) and winter feeding (van Niekerk, 1982) are not covered by research findings in this dissertation, but play a vital role in the choice of growing and finishing strategies to be followed.

1.3 Characterisation of pastures

A model to describe the relationship between stocking rate and the performance of grazing animals is illustrated in Fig. 1.2. The simple linear model $y = a - bx$ (where y = gain per animal; x = stocking rate in animals per ha; a and b are constants) describing the relationship between

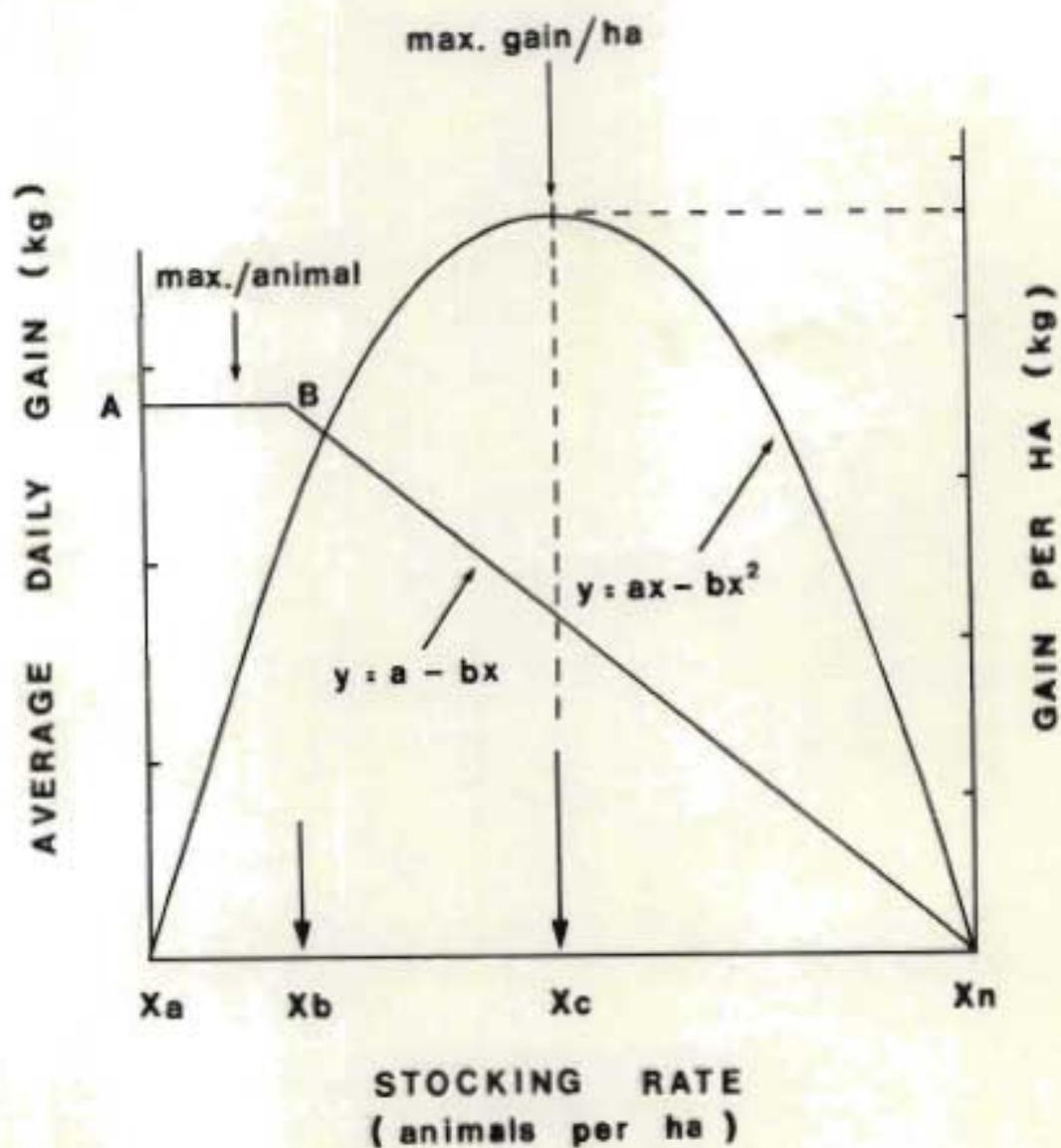


Fig. 1.2 The theoretical relationship between stocking rate and average daily gain ($y = a - bx$) and between stocking rate and livemass gain per ha (after Jones & Sandland, 1974 and Edwards, 1981b).

animal gain and stocking rate (line BXn, Fig. 1.2) indicates that there is a uniform rate of decline in animal performance with increasing stocking rate, from Xb to Xn. The line AB in Fig. 1.2 indicates the area of no improvement or gain per animal as the stocking rate is reduced below Xb, indicating that the availability of more feed per animal does not improve animal performance. This may be due to the potential of the animal having been reached or due to pasture quality restricting animal performance. Edwards (1981b) does, however, point out that animal performance may decline as the stocking rate is reduced below Xb in situations where there is accumulation of old material. Since the model $y = a - bx$ is empirical, no biological determinants exist for a and b and their value must be determined experimentally for each pasture and class of grazing animal (Hart, 1978).

The animal gain per unit area model, describing the relationship between animal gain per unit area and stocking rate, proposed by Jones & Sandland (1974), is illustrated in Fig. 1.2. This model, a quadratic of the form $y = ax - bx^2$ (where y = animal gain per area; a, b and x as before), is derived by multiplying individual animal performance (in the model $y = a - bx$) by the stocking rate, x (i.e. the number of animals per area). From Fig. 1.2 it can be seen that the gain per area model has an asymptote at stocking rate Xc. This stocking rate represents the stocking rate at which maximum gain per area is attained.

Although the Jones & Sandland (1974) model, describing the relationship between stocking rate and animal performance, has been criticised because it does not account for minor deviations from linearity, it has few parameters which are easily determined and remains a good approximation (Connolly, 1976; Hart, 1978; Edwards, 1981c). Furthermore, minor deviations from linearity are not likely to lead to serious biases in the estimation of economically optimum stocking rates (Morley, 1978).

Animal numbers alone do not adequately describe the influence the pasture has on the animal or the animal on the pasture. While conversions

to animal numbers in terms of livestock units (Anon., 1980) or fodder units (Jones et al., 1980) are useful for planning purposes and acceptable for estimating the number of animals of a different class that may be carried on an area, they are less acceptable for predicting animal production per area and "... completely unacceptable for estimates of individual animal performance" (Edwards, 1981c). Due to the empirical nature of the Jones & Sandland (1974) model and due to the different grazing habits and nutritional requirements of different classes of livestock it is necessary that the animal gain - stocking rate relationship be determined for each pasture type and class of grazing animal (Hart, 1978; Edwards, 1981c).

Characterisation of pastures in terms of the pastures potential for animal production, in the present context, is seen as establishing the relationship between the effect of stocking rate of a particular class of animal and the performance of both the animal and the pasture, when the pasture being grazed is the only feed available. To this end the model of Fig. 1.2, describing the relationship between stocking rate and animal performance, is used. At least three stocking rate treatments are required to establish the stocking rate animal performance relationship. However, for beef production in practice, the BXn portion of the relationship (Fig. 1.2) is of major concern and only two stocking rates are required to characterise this portion of the model. Monitoring the effect stocking rate has on pasture availability, intake, regrowth and quality can provide valuable information in explaining the complex animal - plant interactions and should form an integral part of characterisation of the pasture.

In the present context characterisation of the pasture is regarded as a type of component research. It has different objectives and is clearly distinct from the research approaches where, for example, animal performance is evaluated where calves receive a creep, where animals are supplemented on pasture, where different forages and/or management practices are evaluated simultaneously or where put and take techniques are applied to maintain

constant herbage availabilities or grazing pressures. Similarly, in such characterisation, mowing to remove unpalatable or ungrazed material is considered to be unacceptable.

Thus characterisation is aimed at establishing the potential of the pasture "on its own", when subjected to different stocking rates using a standard management procedure free from the requirement for daily subjective decisions by the operator. In this way, periods during which pasture growth and/or quality exceed animal requirements as well as those periods during which intake or quality restrict animal performance, can be identified. Once these periods or times have been identified further research can be conducted to characterise pasture - animal relationships at these specific times, if necessary, or extrapolations from other trials could be used to provide reliable and realistic data for commercial application.

Systems research, in contrast, can result from the integration of components research, usually with a computer to provide for the evaluation of all possible combinations of the components research data available.

Compared with the field evaluation of beef production systems, the characterisation approach has two relatively important drawbacks. Firstly, the response of the animal when moved from, for example, one feed to another is measured in the field system but is not catered for in the component approach (additional research may be needed on the effect of adaptation on animal performance). Secondly, in characterising a pasture (component research) it is generally accepted that the grazing system should be the same for all stocking rate treatments (to eliminate stocking rate - management interactions), whereas in the field system the "appropriate" management can be used for each stocking rate being evaluated. In view of the vast amount of controversial literature on grazing systems which should be applied in animal grazing trials, monitoring pasture availability over the season at different stocking rates may well provide valuable information on the grazing system that could provide for improved pasture management and

animal performance. However, in the absence of such information the researcher has no option but to apply a grazing system which he feels is appropriate to the pasture species and which is within the limits of practicality.

Since it is the linear relationship ($y = a - bx$) between stocking rate and animal performance that is of paramount importance in the characterisation of a pasture, in terms of animal performance, significant differences between stocking rate treatments are of little consequence. It is, however, normally conceded that the stocking rate treatments used should fall on either side of that stocking rate which will provide for maximum animal gain per area (i.e. X_c in Fig. 1.2). Furthermore, because of the linear relationship between stocking rate and gain it is not necessary that the same stocking rate treatments be applied every year. What is important, however, is that the relationship be established from the results obtained over a number of seasons.

CHAPTER 2

COW PLUS CALF ON KIKUYU

Introduction

As emphasised earlier the veld in Bioclimate 3 has a low animal production potential and is not suited to either producing or growing out and fattening weaners. If beef is to be produced in this Bioclimate it must therefore depend largely on forage produced from cultivated pastures. The question which then arises is whether beef can be produced economically on such pastures. Suggestions that this may be so may be read into the statement of Edwards (1982) that, for the moist grasslands of Natal, cultivated pastures can support 6,5 times more animal production than the same area of veld. Costs which must be allocated to land would therefore be considerably lower for cultivated pastures than for veld for each unit of animal product. Also, as Harwin (1980) has pointed out, there is considerable economic benefit to even a 5% increase in weaning mass of calves. Since weaning mass is likely to be considerably higher on cultivated pastures than on the veld of Bioclimate 3, this may have an important influence on the profitability of a beef enterprise. However, no economic assessment of weaner production off cultivated pasture is possible until data are available to make such an assessment. Therefore it was considered necessary in this study to characterise cultivated pastures in Bioclimate 3 in terms of their potential to produce weaners.

In reviewing the literature on the class and breed of animal to use for evaluating pastures Silvey (1977) states that "... any class of beef cattle would be sensitive and suitable for evaluating grazed pastures". However,

where the pasture is to be evaluated for breeding purposes the cow plus calf must be used (Silvey, 1977) as the results obtained from growing animals may not be applicable to the cow-calf situation (Petritz, Lechtenberg & Smith, 1980). Furthermore, Neville & McCormick (1983) have shown that a given pasture area can support approximately 75% more dry cows than lactating cows and their calves. Where cows and calves are used for evaluating pastures there are however a number of factors that make the detection and interpretation of true differences between treatments complex and difficult (Silvey, 1977).

Livemass gains of calves (irrespective of sex, breed and genetic potential) depend largely on the availability of milk and other feeds. Lactating beef cows on an energy deficient diet will tend to maintain milk production at the expense of body reserves (Silvey, 1977; Trigg & Topps, 1981; Somerville, Lowman, Edwards & Jolly, 1983). However, the higher the plane of nutrition of the cow, the higher will be her milk yield (Somerville et al., 1983) and the better will be the performance of the calf (Rouquette, Randel, Florence & Tomaszewski, 1980). Since livemass gain of the calf is primarily dependent on milk intake during the first 3,5 months post partum (Blaser et al., 1980) the quality and amount of herbage taken in by the calf will have relatively little influence on calf gains early in the season (Petritz et al., 1980). However, as the calf matures, growth is less dependent on milk from the dam and more dependent on herbage intake (Drewry, Brown & Honea, 1959; Petritz et al., 1980; Blaser et al., 1980). Thus the level of feed intake (other than milk) becomes more important in determining calf performance as the calf matures (Somerville et al., 1983; Petritz et al., 1980).

Although much of the beef cow-calf research reported on in the literature involves the evaluation of forage systems (Mannetje & Coates, 1976; Parker & van Keuren, 1979), a comparison of different pasture species (Petritz et al., 1980) or grazing systems (Kothmann & Mathis, 1970), the

evaluation of nitrogen levels at constant pasture availabilities (Gordon, Knori, Gould & Totusek, 1975), or different pasture qualities (Holloway, Butts, Beaty, Hopper & Hall, 1979), it is clear that stocking rate has a major influence on the profitability of the cow-calf enterprise. Increasing the stocking rate results in increased calf livemass gain per ha but a reduction in the average calf mass per cow (Mannetje & Coates, 1976; Heitschmidt & Rawlins, 1979; Johnson, Heitschmidt, Frasure & Price, 1981a, 1981b; Rodel, Parkin, Holness & Boulwood, 1982) since lighter calf weaning masses are associated with increased stocking rates (Mannetje & Coates, 1976; Johnson et al., 1981a, 1981b).

Petritz et al. (1980) state that although the cow accounts for the major portion of the herbage consumed her mass gain is of minor importance. However, cow mass at calving affects calf weaning mass (Lishman, Lyle, Smith & Botha, 1984) and there is a direct relationship between calf weaning mass and mass change of the cow during lactation (Morris & Wilton, 1976). Furthermore, to produce and raise a calf annually the cow must be in optimum condition at the onset of winter, at calving and at mating (van Niekerk, 1982a). Increasing the stocking rate results in reduced cow mass (Johnson, Heitschmidt, Frasure & Price, 1981a; Baker, Barker & Le du, 1982). Such mass loss during the summer grazing period would need to be made up during the winter. However, winter feeding costs of the cow represent a large cost item in the production of a beef weaner (van Niekerk, 1982b; Somerville et al., 1983) so that winter feeding may be more costly than ensuring the maintenance of cow mass during the summer. Clearly the effect of stocking rate on the mass and condition of the lactating beef cow should be assessed in trials involving the breeding herd.

There are two further issues which are relevant to any research on cow-calf systems.

1. Improved performance (average daily gain) and higher weaning masses for steers than for heifers have been reported by numerous researchers (e.g.

Mannetje & Coates, 1976; Rouquette et al., 1980; Eden & Smit, 1982). However, the difference in weaning mass between steers and heifers is consistent at different stocking rates (Rouquette et al., 1980). Thus sex of calf is important in assessing the effect of treatment on calf performance.

2. With beef cows and calves "... the effective stocking rate is rarely affected by cow size, unless extremes such as the South Devon or Angus crosses are considered" (Anon., 1977). However, calf mass is likely to be high when breeds or crosses with a high growth potential (Paterson, Venter & Harwin, 1980) and high milk yields are used (Parker & van Keuren, 1979). Furthermore, large type cows eat more and gain more mass than do smaller type cows (Klosterman, Byers & Parker, 1979). Clearly milk production, cow type and cow size can be important attributes to be considered in optimising per animal and per ha production from cultivated pastures.

The complete dearth of information on the performance of the beef cow and her calf on kikuyu in Bioclimate 3 (and in fact in South Africa), and the need for animal performance data from kikuyu led to a cow-calf trial being initiated at Broadacres in 1975. Due to the major influence stocking rate can have on the profitability of the cow-calf enterprise (Baker, 1982b; Allen & Kilkenny, 1984b) and the possible effect animal breed (or type) and size may have on profitability, stocking rate and animal type constituted the treatments. The experiment had both Pasture Research and Animal Research objectives and inputs. Aspects relating to the effect of stocking rate and animal type on milk production, milk quality, the relationship between milk production and calf performance, reconception, oestrus and anoestrus, cow condition and the relationship between pre- and post-weaning performance of the calves is reported in detail by Louw (1984), the Animal Science officer responsible for the trial.

2.1 Methods and materials

2.1.1 Site

The experiment was conducted at Broadacres, a research farm adjacent to Cedara College and Research Station, situated some 15 km north west of Pietermaritzburg. Located at $29^{\circ} 32'S$ and $30^{\circ} 17'E$ and at an altitude of approximately 1 150 m above sea level the area receives a mean (67 years) annual rainfall of 877 mm with an annual evaporation of 1 577 mm. A plan of Broadacres, indicating the experimental area, is presented in Fig. 2.1.

Dominance of A. junciformis in the veld renders the veld of the area of low potential for animal production. The veld is typical of the Natal Mistbelt 'Ngongoni Veld as described by Acocks (1975).

Soils, aspect and slope vary over the 17,8 ha experimental area. The soils are all of the Hutton form (MacVicar et al., 1977). Although they vary in depth they are all deeper than 30 cm. Slope and aspect vary from flat (camp W1) to a 10 to 20% south facing slope (camps W2, W3, W4), to 10 to 15% east facing slope (camps Y1 to Y4 and X1 to X4) and a 12% north east facing slope (camps Z1 to Z4) - see Fig. 2.1.

2.1.2 Treatments

Stocking rates and animal type constituted the treatments which were not replicated. The treatments applied were not consistent over the seasons. Table 2.1 shows the stocking rates and animal type treatments that were applied for each of the seasons evaluated. During the first four seasons two animal breeds were each run at two stocking rates. From 1980/81 to 1983/84 the two breeds were blocked within stocking rate treatments and four stocking rate treatments were used. From 1981/82 additional animals and

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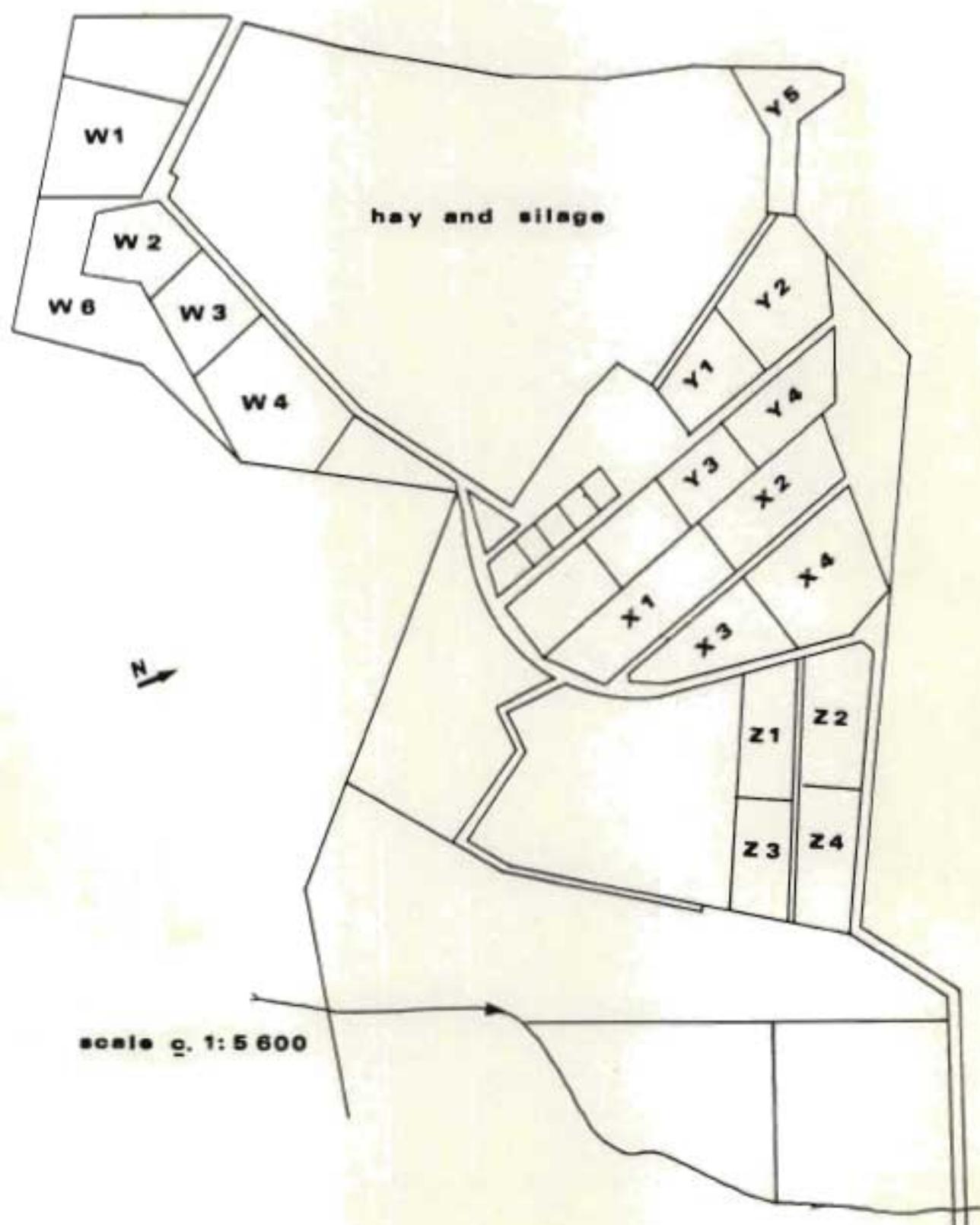


Fig. 2.1 Plan of experimental area used for kikuyu grazing trials

TABLE 2.1 Basic information relating to stocking rates applied, animal type, weaning, time on pasture and nitrogen application dates for each of the seasons of the cow-calf trial.

Season	1976/77				1977/78				1978/79				1979/80			
Animal type (1)	Sim		Her		Sim		Her		Sim		Her		Sim		Her	
Stocking rate	4,12	6,74	4,49	6,74	4,12	6,74	4,12	7,30	4,49	6,74	4,87	7,30	4,49	6,74	4,87	7,30
Number of animals (2)	11	12	12	12	11	12	11	13	12	12	13	13	12	12	13	13
Cows																
Simmentaler	10	11	-	-	10	11	-	-	9	9	-	-	11	9	-	-
Hereford type	1	1	12	12	1	1	11	13	3	3	13	13	1	3	13	13
Mature cows	11	12	12	12	11	12	11	13	11	12	11	12	8	10	13	12
First calvers	-	-	-	-	-	-	-	-	1	-	2	1	4	2	-	1
Calves																
Steer	5	7	7	7	6	5	5	4	9	7	7	5	6	7	6	9
Heifer	6	5	5	5	5	7	6	9	3	5	6	8	6	5	7	4
Date onto pasture	22/10/76				17/10/77				16/10/78				12/10/79			
Date off pasture																
Cows	23/6	26/5	23/6	23/6	21/7	29/6	7/8	11/7	12/7	28/6	2/8	21/6	16/5	5/5	3/7	16/5
Calves (3)	16/5	5/5	6/6	16/5	11/7	27/4	11/7	25/5	28/6	14/6	5/7	14/6	9/5	28/4	9/5	9/5
Days on pasture	264	216	264	264	277	255	294	267	269	255	290	248	216	205	264	216
Date of N application (83 kg N/ha/ application)	4/11/76 6/12/76 8/ 2/77				20/ 9/77 5/12/77 7/ 2/78				21/ 9/78 11/12/78 12/ 2/79				5/ 9/79 3/12/79 12/ 2/80			

Season	1980/81				1981/82				1982/83				1983/84			
Animal type (1)	Sim & Her		Sim & Her		Sim & Her		Sim & Her		Sim & Her		Sim & Her		Sim & Her			
Stocking rate	3,00	4,12	5,62	7,30	3,00	4,12	5,34	6,74	3,00	4,12	5,34	6,74	2,81	3,93	5,06	6,46
Number of animals (2)	8	11	10	13	16	22	19	24	16	22	19	24	15	21	18	23
Cows																
Simmentaler	3	3	3	5	9	13	10	10	11	6	6	14	9	10	8	8
Hereford type	5	8	7	8	7	9	9	14	5	16	13	10	6	11	10	15
Mature cows	8	11	10	13	11	15	13	18	13	16	15	19	13	20	16	20
First calvers	-	-	-	-	5	7	6	6	3	6	4	5	2	1	2	3
Calves																
Steer	4	5	4	7	10	14	6	17	12	11	9	12	8	17	10	15
Heifer	4	6	6	6	6	8	13	7	4	11	10	12	7	4	8	8
Date onto pasture	17/10/80				20/11/81				1/11/82				24/10/83			
Date off pasture																
Cows	2/7	2/7	4/6	30/4	19/7	24/6	27/5	17/5	6/6	2/6	21/3	21/3	9/7	9/7	4/6	21/5
Calves (3)	2/7	18/6	30/4	22/4	21/6	14/6	17/5	17/5	6/6	16/5	10/6	10/6	18/6	18/6	21/5	7/5
Days on pasture : cows	258	258	230	195	241	216	188	178	217	213	140	140	259	259	224	209
Date of N application (83 kg N/ha/ application)	2/ 9/80 3/12/80 15/ 2/81				1/ 9/81 15/12/81 15/ 2/82				30/ 8/82 9/12/82 9/ 3/83*				22/ 8/83 5/12/83 21/ 2/84			

(1) Sim = Simmentaler, Her = Hereford type

(2) Cow plus her calf = 1 stocking rate unit

(3) Date off pasture for the calves = weaning date; except for 1982/83 for the two heavy stocking rates when the cows were removed at weaning and the calves remained on pasture

* Due to the exceptionally dry season the last N dressing was applied only after rain

pasture area were available and more animals were used per stocking rate treatment.

Variations in soil type, soil depth, aspect and slope necessitated blocking of the pasture areas. With reference to Fig. 2.1, camps W1 to W4, Y1 to Y4, X1 to X4 and Z1 to Z4, constituted the four blocks. Each of the camps 1 to 4, within a block, was randomly allocated to stocking rate and breed treatments so that four camps were allocated to each stocking rate and breed treatment. Thereafter each camp was sub-divided to provide eight camps per stocking rate and breed treatment around which the animals allocated to that treatment were rotated. From 1976/77 to 1980/81 only blocks W and X were used. During these seasons each camp (W1 to W4 and X1 to X4) was split into four sub-camps. All four blocks were used from 1981/82 onwards.

Animal types used were a dual purpose type (late maturing large animals with a potential for high milk production), represented by Simmentalers, and a "British beef" type (early maturing small animals with low milk production) represented by Hereford x Afrikander animals which were upgraded, as the trial progressed, to Hereford type animals.

A pilot trial conducted during the 1975/76 season indicated that the Hereford type animal required a higher stocking rate than the Simmentalers for maximum calf livemass gain per ha. Thus the generally higher stocking rates for the Herefords, relative to the Simmentalers, for the first four seasons (Table 2.1). The generally lighter stocking rates for the 1982/83 season resulted from a shortage of cows with calves.

All cows on the trial had a calf at foot.

Analysis of the data will be described at the appropriate stage of data presentation.

2.1.3 Management

Pasture

Soil P and K levels were maintained at or above 20 and 150 ppm respectively. The 250 kg N applied annually was split into three dressings of 83 kg N per ha per application. Dates of N application are shown in Table 2.1. From 1978/79 the first N dressing of the season was applied as ammonium sulphate. Otherwise the source of N was limestone ammonium nitrate. Spreading of fertiliser was the only tractor operation on established kikuyu pastures.

The kikuyu in the W and parts of the Y block (Fig. 2.1) had been established for some time (more than ten years). During 1974 the X block was planted to kikuyu while those Y block areas without kikuyu (largely Y3 and Y4) and the Z block were established in 1978.

A fixed grazing rotation was followed throughout the trial period. The animals rotated through the eight sub-camps with a fixed period of stay of 3,5 days in any one sub-camp. This rotation allowed for a 24,5 day regrowth period. Although this grazing system is not the ideal, it eliminates the subjectivity involved in deciding when to move animals from a camp (particularly with different stocking rates and thus grazing pressures) and provides for a fixed period of regrowth for all treatments. This rigid rotation worked well in practice. Characterisation of kikuyu with this grazing system is particularly useful when recommendations are made to the unenlightened (pasture management-wise) farmer.

Grazing commenced when the mean pasture disc meter height (see Appendix 1) was 10 cm (in some seasons a shortage of winter feed necessitated earlier grazing). For all seasons grazing commenced in the W block followed by the Y, X and Z blocks.

Animals

All cows with calves and those due to calve were re-randomised at the start of each season. Not all cows had calved by the time grazing started. Cows were grouped according to breed, mass, age, sex and mass of calves (for cows due to calve breed, mass and age) before being allocated at random, within groups, to the different stocking rate treatments.

A standard inoculation, dipping and dosing programme, recommended by the Animal Science section at Cedara, was followed and implemented by Louw (1984). All calves were dehorned and male calves were castrated.

Heat detection and artificial insemination of the cows was carried out by "Sonny Boy" (Robert Mkhabela, Animal Science section, Cedara) during the three month mating season from November to January.

While on pasture the animals had free access to water and a salt (40%), dicalcium phosphate (40%), feedlime (15%) and molasses powder (5%) lick. Mean daily intake of the lick was 130 g per cow.

Calves were weaned when the mean calf mass remained constant or declined over two consecutive weighings. Each treatment was considered separately. At weaning the calves were removed from the pasture but the cows remained at pasture. An exception to this weaning strategy was that followed during the severe drought season of 1982/83. At the two high stocking rates during this season, all animals were removed from the pasture at weaning. After a seven day settling down period the calves were returned to their respective pasture treatments and the cows remained on winter feed: slow growth of the pasture was adequate for the weaners but not for the cows.

The criterion used for removing the cows from the pasture changed over the seasons. Mean mass loss of the cows was used during the first two seasons. On losing 10% (for the 1976/77 season) or 5% (for the 1977/78 season) of post calving mass the cows were removed from pasture. However, mean mass loss proved to be inefficient in that stage of pregnancy can mask

cow mass change (Silvey & Haydock, 1978). Furthermore, the reliability of determining mean post calving mass in a herd with a three month calving period is questionable. From 1978/79 onwards, cow condition score (van Niekerk & Louw, 1980), stage of pregnancy and mean pasture height (as determined with the pasture disc meter) were used as criteria for removing cows from the pasture. Cows were removed from pasture when the mean pasture disc height was 3 cm or less, when cows declined to a condition score of 2,5, or 6 weeks before the mean calving date, whichever occurred first. On removal from pasture the cows were fed to attain a condition score of 3 by the end of winter. During the last three seasons the quality of the winter feed available (particularly the drought induced low quality of the maize silage which resulted from a low grain content) necessitated removing the cows earlier. The low quality winter feed would have precluded animals from attaining the target condition score by the end of winter had their condition been too low at the start of winter.

2.1.4 Measurements

Pasture

Pasture availability, apparent intake and regrowth, following defoliation, were determined with the pasture disc meter (see Appendix 1 for specifications, use and calibration). The number of camps monitored per stocking rate treatment and the number of random readings taken per camp per occasion varied over the trial period (Table 2.2). The number of sample pairs taken for calibration of the disc meter are given in Table 2.2. Calibration samples, which were cut to ground level using sheep shears, were bulked for each treatment on each calibration occasion. The bulked samples were used for the analysis of N, P, K, Ca, Mg and crude fibre.

TABLE 2.2 Pasture disc meter readings and disc meter calibrations derived from each stocking rate treatment (involving eight camps) for each of the seasons.

VARIABLE	S E A S O N							
	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84
Pasture disc meter readings								
No of camps monitored	2	2	2	2	4	8	8	8
No of readings per occasion (1)	50	100	100	100	100	200	200	200
Pasture meter calibrations (2)								
No per occasion	25	25	25	30	30	30	30	30

(1) = the same number of random readings were taken per camp both before and after grazing the camp being monitored

(2) = the same camp (usually camp five) was used to calibrate the disc meter before and after grazing of that camp: during 1976/77, 1977/78 and 1978/79 seasons the disc meter was calibrated only before grazing

Animals

In addition to animal measurements relating to detailed animal studies of the trial by Low (1984), mentioned earlier, animal mass was determined. During the season both cows and calves were weighed fortnightly. Towards the end of the season when the rate of calf livemass gains started declining the calves were weighed weekly. The cows were weighed weekly when it was seen that their mass was declining rapidly.

2.2 Climatic data

The meteorological station which provided the rainfall and temperature data is situated some 0,5 km south east of the experimental area. Thanks are to Mr B Reynolds and Mrs J Miller (Agro. Met., Cedara) for making the data freely available.

Mean monthly and total seasonal rainfall for each of the seasons for which the trial was conducted are given in Fig. 2.2. The monthly mean maximum and minimum temperatures, for the period of the trial, are shown in Fig. 2.3.

From Fig. 2.2 it is obvious that rainfall received at the experimental site varied markedly between seasons. The 580 mm recorded for the 1982/83 season was the lowest recorded in 50 years at Cedara (the previous lower rainfall was 577 mm for the 1932/33 season). With the exception of the 1978/79 and 1983/84 seasons, when precipitation was above the 67 year mean, all other seasons received less rain than the mean for the area. Nevertheless, the variation from 580 to 933 mm of rain per season over the experimental period 1976/77 to 1983/84, provided a wide range of moisture conditions for evaluating pasture and animal responses.

Distribution of rain during the season varied widely for the different seasons (Fig. 2.2). Not only did the onset of spring rains vary from one

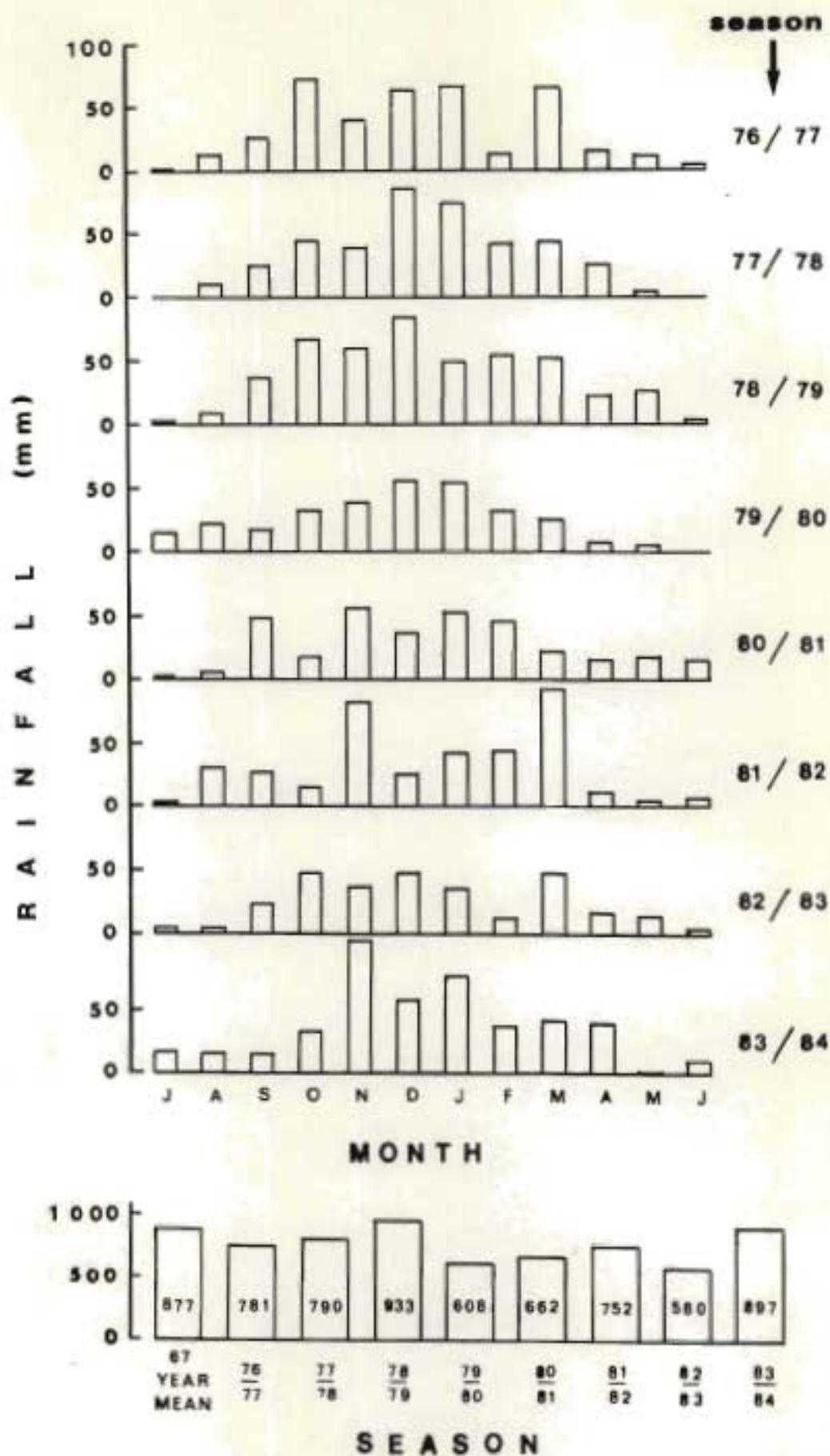


Fig. 2.2. The mean monthly and total seasonal rainfall for the experimental site for each of the seasons of the trial.

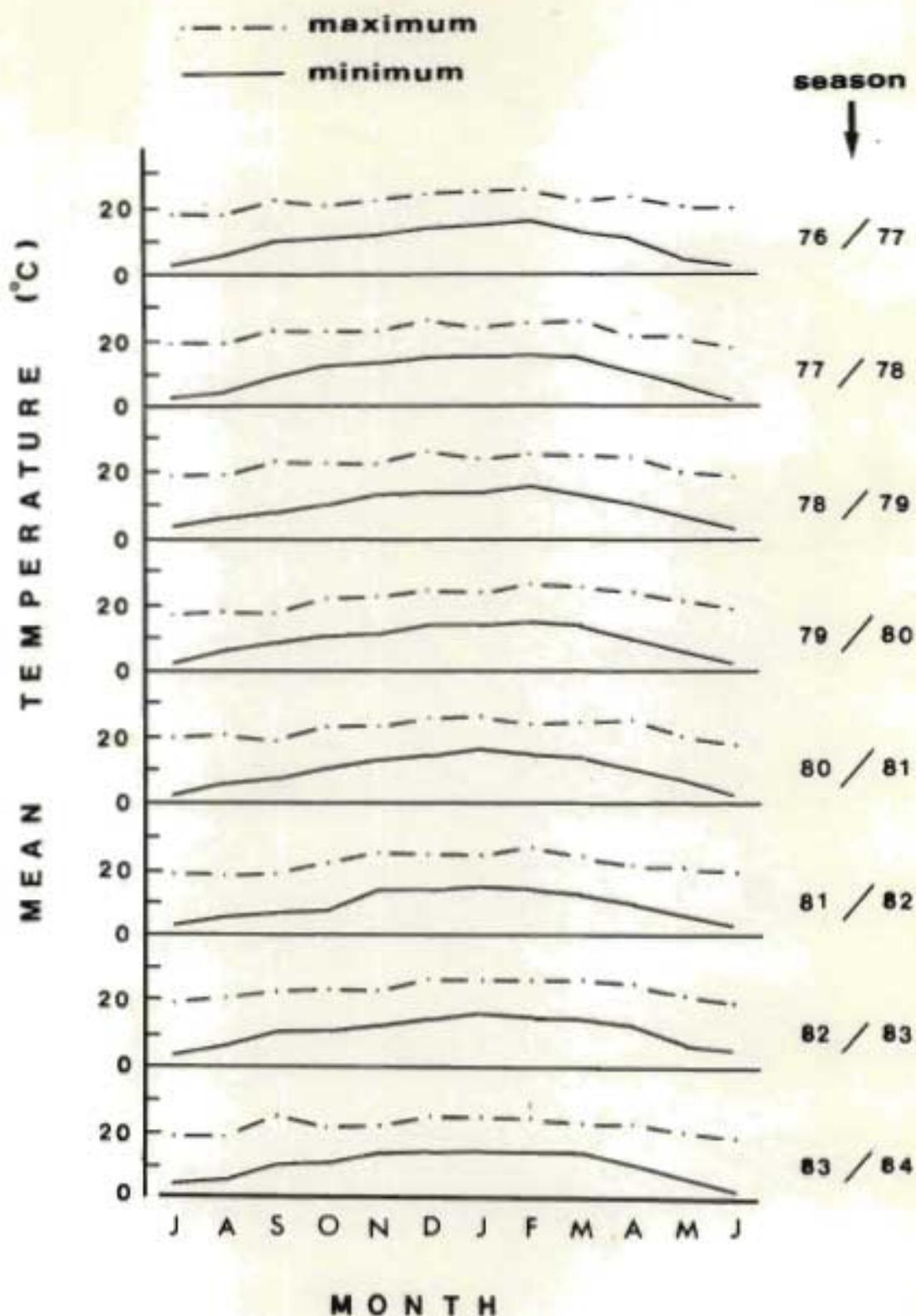


Fig. 2.3 Mean monthly maximum and minimum temperatures for each of the seasons of the trial (Stevenson screen temperatures).

season to the next, but the rainfall pattern during the season and the tailing off of precipitation at the end of summer followed inconsistent patterns for the separate seasons (Fig. 2.2). Thus, in addition to large variations in amount of rain the varied pattern and distribution of rain, over the seasons, provided for a range of growth conditions for characterising kikuyu in terms of animal performance.

Monthly mean maximum and minimum temperatures (Fig. 2.3) showed considerably less variation between seasons than did precipitation. Mean monthly maximum temperatures followed a similar pattern and levels for the separate seasons. The greatest fluctuations in mean maximum temperature between seasons occurred in September.

Although the pattern and level of mean minimum temperatures was similar for the respective seasons the greatest variation was during spring. Thus, for example, during 1981/82, to a lesser extent during 1978/79 and an even lesser extent during 1983/84, the spring mean minimum temperatures remained below 10°C for longer than was recorded for the other seasons.

2.3 Results

2.3.1 Pasture parameters

2.3.1.1 Regression of disc height on yield

The 9 300 disc meter calibration pairs (disc height and pasture yield under the disc) recorded from the trial were subjected to regression analysis. Of these, 5 100 were before grazing and 4 200 after grazing. Initially (during 1977/78 and 1978/79) it was considered necessary to monitor the relationship between disc height and yield only before grazing. From 1979/80 onwards the disc meter was calibrated both before and after grazing the fifth camp during each grazing cycle.

Multiple regression analysis and stepwise regression analysis with forward selection, using the variables disc meter calibration (before and after grazing), years (seasons), rainfall, stocking rate and time of the year revealed several interesting and surprising inter-relationships between the variables.

Disc meter height and season were the only variables significantly ($P < 0.001$) correlated with yield. Due to the difficulty of defining "season", both numerical values (0 to 5) and total seasonal rainfall were used in separate regression analyses. Clearly the significant seasonal effect was a reflection of "the better the season the higher the yield".

Although there was no significant correlation between yield (from disc meter calibration) and time of season (time is in weeks with the first week in August = week 1), multiple regression analyses indicated a significant positive contribution of time to the multiple regression equation involving disc height, rainfall (linear, quadratic and cubic) and time, to predict pasture yield.

Inclusion of disc height, rainfall (in lieu of seasons), and time in a multiple regression equation, to predict pasture yield, had little effect on the regression coefficient for the disc height variable, i.e. when compared with the regression equation to predict yield from disc height as the only variable. The regression coefficient for disc height was 242.79 for the equation involving only disc height and 241.53 for the regression involving disc height, rainfall and time. The respective correlation coefficients were 0.816 and 0.827 (a marginal increase for 9 300 disc calibration samples taken over six seasons). However, the multiple regression equation provides for growth (due to the time factor) at the end of the season after growth has stopped (as measured by disc meter height). This constitutes a serious limitation since the end of the season can be critical when the decision to remove animals from the pasture is based on pasture availability. Overestimation of pasture availability at the end of the season is thus

regarded as a serious limitation to the practical application of this multiple regression equation.

In view of the uncertainty of (i) defining a season (other than those of the trial) in terms of total rainfall, and (ii) the overestimation of pasture availability, particularly at the end of the season, it is felt that the theoretical 3% increase in explaining variation in pasture yield by including rainfall and time in the equation to predict yield, is not justified.

The linear regression equation to predict pasture yield from the single variable disc meter height is regarded as appropriate for a wide range in total seasonal rainfall and stocking rates. Prediction of pasture yield (y), in kg dry matter per ha, from disc meter height (d), in cm, is given by the equation

$$y = 749,5 + 242,79 (\pm 10,37)d$$

($r = 0,816^{**}$ for 9 300 disc meter calibration pairs)

It is interesting to note that the slope of the above regression (242,79) is not markedly different from the slope of 291,19 derived for foggaged kikuyu (Chapter 5). The difference is 48 kg dry matter per ha per cm of disc height.

Both multiple and stepwise regression analyses revealed that stocking rate did not contribute significantly to determining yield. The trend was, however, as expected: increasing the stocking rate resulted in reduced pasture yields. It is probable that the overriding effect of season (large variation in rainfall and length of season) masked any real stocking rate effect. The effect of stocking rate on pasture yield will be discussed more fully later.

Perhaps the most surprising result from the regression analyses was the lack of any significant difference in the relationships between disc height

and pasture yield in recently grazed and grown out pasture. This lack of difference in the height - yield relationship of the sward before and after grazing implies that the bulk density (or mass of dry matter per volume) of the pasture was the same before utilisation as it was after grazing. Based on the physiognomy of the grass sward a constant bulk density at different horizons of the sward seems unlikely. Furthermore, linear regression equations, relating kikuyu yield to disc meter height, presented by Bransby (1983) show that at the same disc height there is a greater amount of material in the recently grazed sward than there is in the ungrazed sward (i.e. the bulk density increases in lower horizons). However, it is probable that in the present trial the actual calibration and differences in sward structure contributed to the lack of significant differences when comparing the height - yield relationship between recently grazed and grown out pastures.

Linear regressions, estimating pasture yield from disc height, reported by Bransby (1983), have 'b' values considerably higher than recorded for the present trial. This is so whether the regression from the present trial is compared with either the before or after grazing regressions derived from early or late season calibrations, presented by Bransby (1983). Clearly the kikuyu from the present trial was less dense than the kikuyu pasture used by Bransby (1983). It is probable that the relatively open sward of the present trial resulted from the grazing management applied: a short period of stay followed by a long regrowth period. A cutting trial run in conjunction with the grazing trial indicated a dense mat formation with frequent cutting and a lax more open sward with infrequent defoliation. Thus it is possible that the relatively open sward from the grazing trial in fact exhibited similar bulk densities at different horizons within the sward, thus accounting for similar disc height - yield relationships for the grazed and ungrazed situations.

It must be conceded that it is more difficult to harvest (with hand sheep shears) all the ungrazed material from a closely grazed kikuyu sward than from an ungrazed sward. Clearly this may have played a role in reducing differences, if real, between disc height - yield calibrations before and after grazing. Additional to the factors contributing to the lack of difference between regressions predicting yield from disc height in grown out and recently grazed swards is the fact that ungrazed areas and dung pat areas, sampled after grazing, may have masked real differences had they existed. On the other hand, trampled areas would have provided high yields for low disc height readings.



2.2.1.2 Herbage production: effect of rainfall and stocking rate

Total seasonal herbage production was determined by difference. For each camp monitored during the grazing season, herbage left following grazing was subtracted from herbage available at the next grazing. Summation of mean yield per grazing cycle, less residual material at the end of the season, provided total herbage production for the season. The regression equation $y = 749,5 + 242,79d$, using mean pasture disc meter height (d), was used to estimate kg dry matter per ha (y), both before and after grazing. Inadequate fencing of sub-camps during the 1976/77 and 1977/78 seasons resulted in the animals periodically breaking through to the next camp in the grazing cycle. Consequently, total herbage production was not determined for these two seasons.

The highly significant relationship between mean annual rainfall and pasture yield, at different stocking rates, is shown in Fig. 2.4. Although the effect of the seasonal distribution of rain on yield has not been accounted for it is clear that there was, as would be expected, a linear increase in dry matter yield with increasing rainfall. Higher dry matter yields recorded for a rainfall of 608 mm (1979/80) than for 622 mm (1980/81)

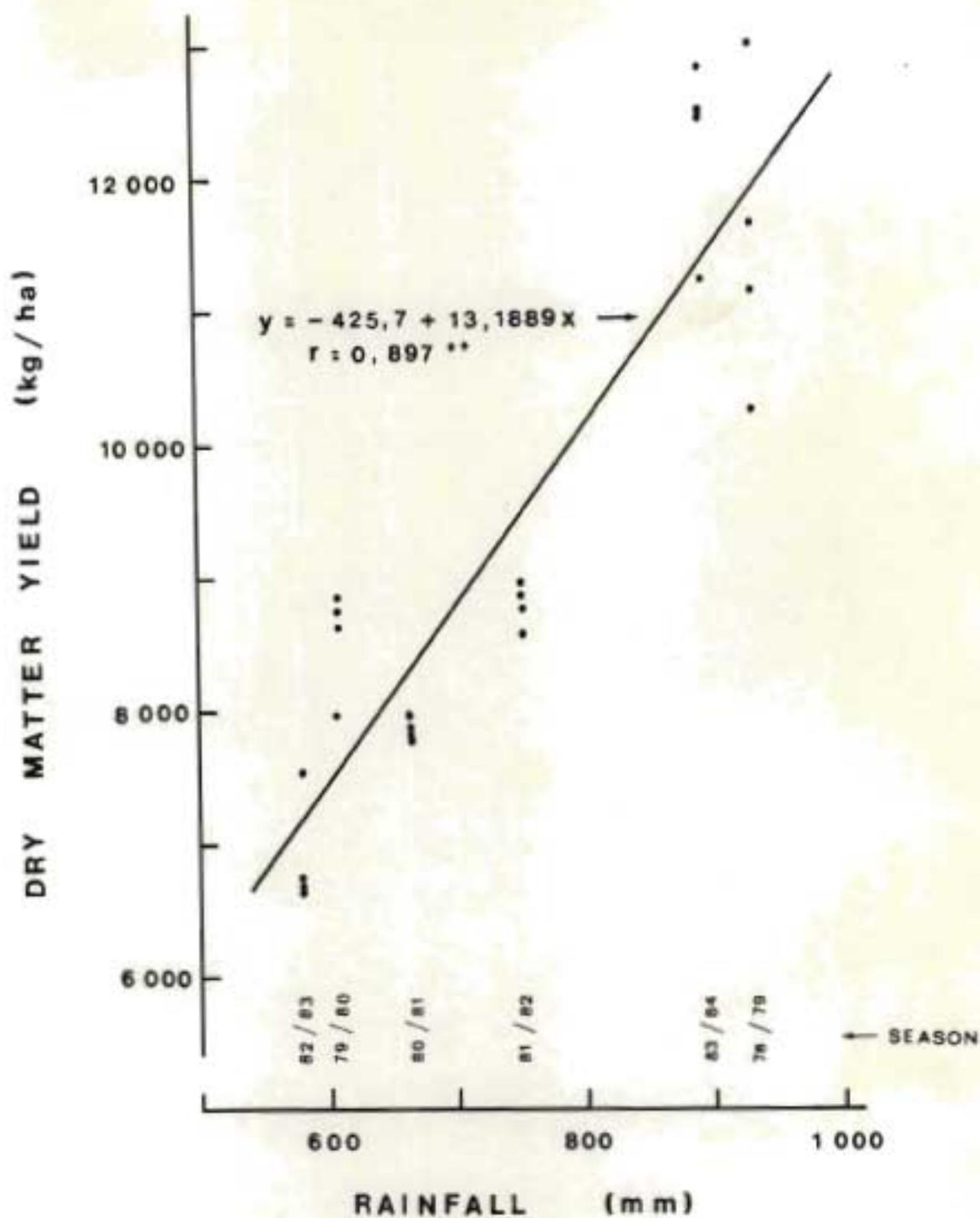


Fig. 2.4 The relationship between mean seasonal rainfall and seasonal dry matter yield of kikuyu (at each of the stocking rates used) for the 1978/79 to 1983/84 seasons.

can be ascribed to a more favourable distribution of rain during 1979/80 than during 1980/81 (cf. Fig. 2.2). Clearly amount and distribution of rain are important in determining yield.

Multiple regression analyses showed stocking rate to have no significant effect on total seasonal dry matter production. However, the indications were that the more favourable the growing season, in terms of amount and distribution of rain, the higher were pasture yields at the low, relative to high, stocking rates. A highly significant multiple linear regression equation derived from yield data for the 1981/82 and 1983/84 seasons (i.e. relatively high rainfall with four stocking rate treatments) indicates this reduction in pasture yield with increasing stocking rate. This effect of rainfall (f) and stocking rate (s) on total seasonal pasture production (y), in kg dry matter per ha, is given by the equation $y = -8333,27 - 246,84s + 24,2172 f$ ($r = 0,987^{**}$ for $n = 8$).

The increased pasture yield response to low stocking rates during favourable rainfall seasons and the lack of a yield response to stocking rate during unfavourable seasons poses several interesting possibilities. Firstly, the techniques used in the trial may not have been sufficiently sensitive or accurate enough to measure pasture yield differences due to stocking rate in relatively dry seasons. Secondly, even though the high stocking rate treatments resulted in a greater removal of leaf area, relative to the low stocking rate treatments, sufficient leaf material may nevertheless have remained (kikuyu is stoloniferous) to provide for rapid regrowth from current photosynthesis. Alternatively, high levels of labile reserves, resulting from a relatively long regrowth period, may have resulted in high regrowth rates despite severe defoliation at high stocking rates. Although high leaf area indices may reduce pasture growth rates (Booyesen, 1966) it seems unlikely that this was the case in the present trial, since during favourable rainfall seasons pasture yields increased with an increase in the amount of pre - and post - grazing material (i.e. as

stocking rate was reduced). Thirdly, the overriding factor limiting pasture production during unfavourable seasons was neither photosynthetic rate nor labile reserves per se, but available soil moisture. Seasons with more favourable moisture regimes provided for increased yields with lighter stocking rates. This indicates, perhaps, that during favourable seasons the effect of increased photosynthetic activity, resulting from more lenient defoliation, may have manifest itself in increased yields. Fourthly, results and observations from a cutting trial, run in conjunction with the grazing trial, indicate that the initial regrowth (3 to 4 weeks) from kikuyu cut 9 weekly was considerably slower than from more frequently defoliated plots (regrowth from plots cut every 9 weeks was from new tillers initiated below ground level, while regrowth from more frequently defoliated plots was from existing tillers and stolons). On occasions there were pasture areas in the light stocking rate treatments which were not defoliated at consecutive grazings. Slow growth, due to adverse weather conditions, forced the animals to graze these previously ungrazed areas. Grazing of this old material may have resulted in slow regrowth from these areas. The overall effect of grazing the previously avoided areas may have been to reduce the overall growth rate of the pasture and thus yields at the lighter stocking rates. Lastly, the loss of material through senescence, both natural and as a result of trampling, was not measured or estimated. It is probable that at low stocking rates (taller herbage at low than at high stocking rates), much of the taller material which was trampled did not erect itself. This trampled material may have constituted a loss of dry matter. At high stocking rates the relatively short material, compared with low stocking rate treatments, which was trampled may have erected itself following post-grazing disc readings. This erected material would thus have been included as growth when availability was determined at the next grazing cycle.

There is indeed a need to investigate more fully the effect of stocking

rate and available soil moisture on the growth (physiological and morphological) and senescence in kikuyu swards. In view of the fixed rotational grazing system followed in the present trial (the advantages and need for such a system have already been mentioned), the effect of stocking rate on the morphology and physiology of kikuyu would provide invaluable information in formulating the grazing system for specific on-farm situations (i.e. for the stocking rate selected).

2.3.1.3 Herbage on offer and apparent intake

Herbage on offer

The effect of stocking rate and season on the mean availability of pasture to the animals during the season, for the 1978/79 to 1983/84 seasons, is shown in Fig. 2.5. Mean herbage on offer (availability) was determined by applying the disc height - yield regression equation to the mean disc height determined for each grazing cycle.

From Fig. 2.5 it can be seen that the amount of herbage on offer to the animals varied markedly during the season and between seasons. Differences in herbage on offer between seasons can be attributed largely to differences in total seasonal rainfall and to the distribution of rain during the season.

As shown earlier, meaned over all seasons, stocking rate did not significantly affect pasture dry matter yields. However, as has also been shown, the effect of stocking rate on pasture production was more pronounced during seasons with favourable soil moisture conditions. The data of Fig. 2.5 do not represent pasture growth rate per se but mean herbage on offer per cow-calf unit per grazing cycle (per 3,5 days). Thus although increased herbage on offer reflects increased growth of the pasture it also reflects accumulation of herbage. Nevertheless, the data of Fig. 2.5 indicate the

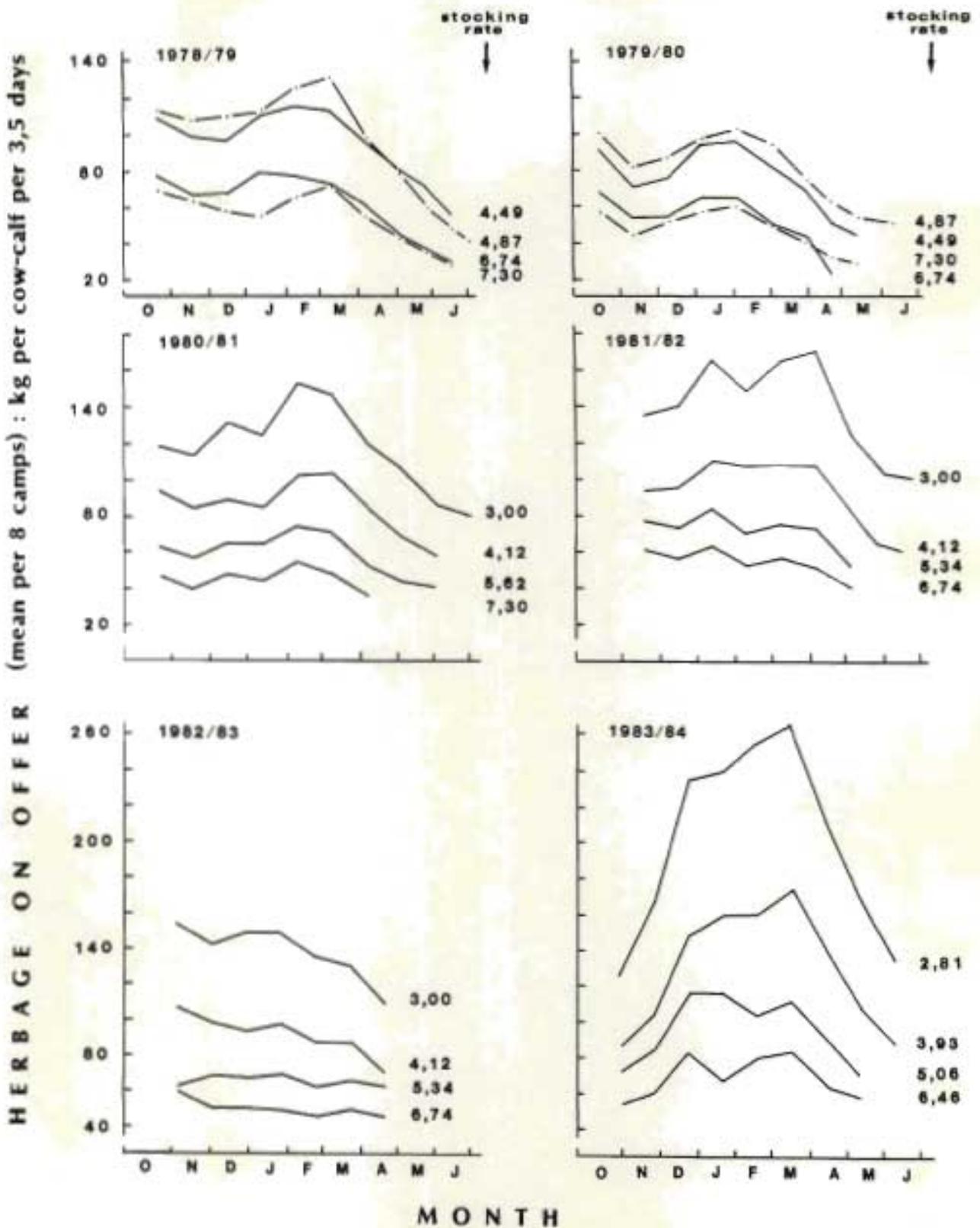


Fig. 2.5 Mean herbage on offer per cow-calf unit (per 3,5 day period of stay), at each of the stocking rates, during the season on kikuyu fertilised with 250 kg nitrogen per ha per season.

increased growth rates recorded for the low, compared with the high, stocking rate treatments (inflated through accumulation) during seasons with favourable soil moisture conditions (e.g. 1981/82, 1983/84).

While it is accepted that the data of Fig. 2.5 do not illustrate absolute pasture growth rates they do illustrate the finding that for most seasons maximum growth from kikuyu can be expected towards the end of February - early March (high day and cool night temperatures). This high autumn production is in accordance with the findings of Goold (1979). Both rainfall and temperature apparently affected initiation of growth in spring and cessation of growth in autumn. Data from the present trial (although not analysed statistically) confirm the findings of Colman & O'Neill (1978) that growth of kikuyu is greatly reduced or ceases when the mean temperature falls below 10°C.

In order to assess the overall effect of stocking rate on herbage on offer, mean pasture on offer was calculated for each stocking rate used for the period 1978/79 to 1983/84. The relationship between mean herbage on offer per cow-calf unit (per 3,5 day period of stay in a camp) and stocking rate is illustrated in Fig. 2.6. From Fig. 2.6 it can be seen that as the stocking rate was reduced so there was progressively more herbage on offer per cow-calf unit. The large standard deviations (shown in Fig. 2.6), particularly at the lighter stocking rates, were a result of mean herbage on offer having been derived from mean availability per grazing cycle over all seasons (both within and between season variations were large - cf. Fig. 2.5).

Apparent dry matter intake

Estimation of apparent dry matter intake (y), in kg dry matter per cow-calf unit per 3,5 days, from herbage on offer (x), in kg dry matter per cow calf unit per 3,5 days, is given by the regression equation $y = 0,403x -$

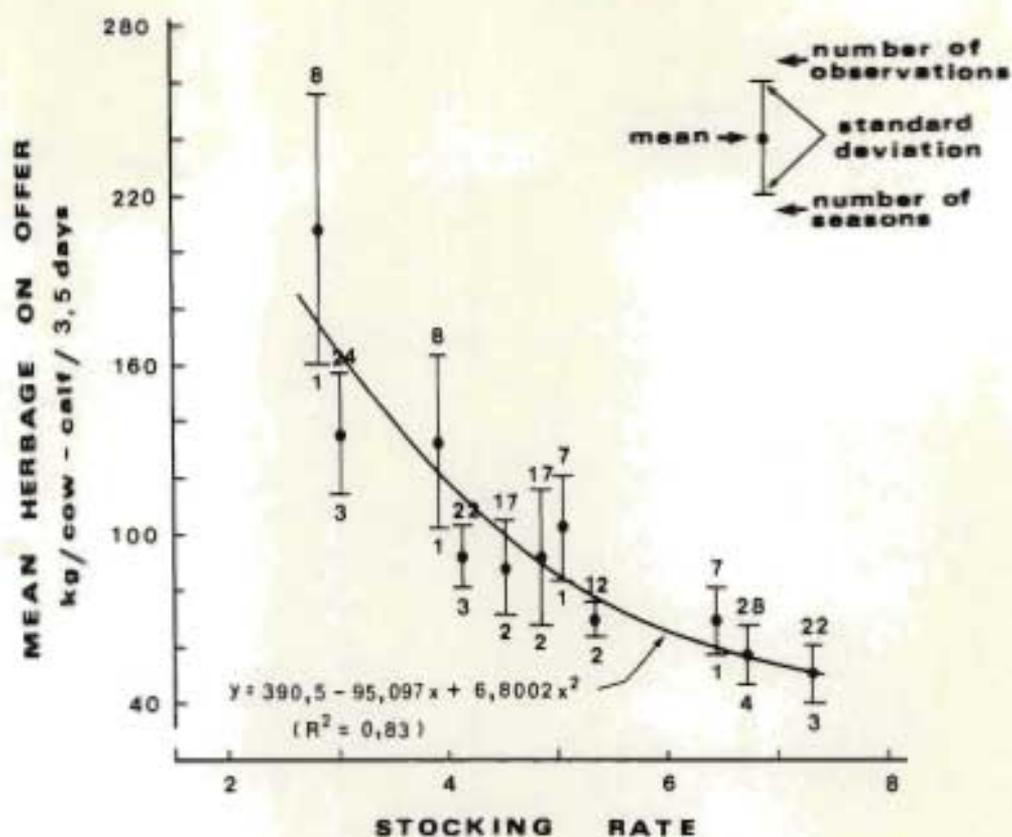


Fig. 2.6 The relationship between stocking rate and herbage on offer (mean for the season) per cow-calf unit per 3,5 days (i.e. period of stay in each kikuyu camp).

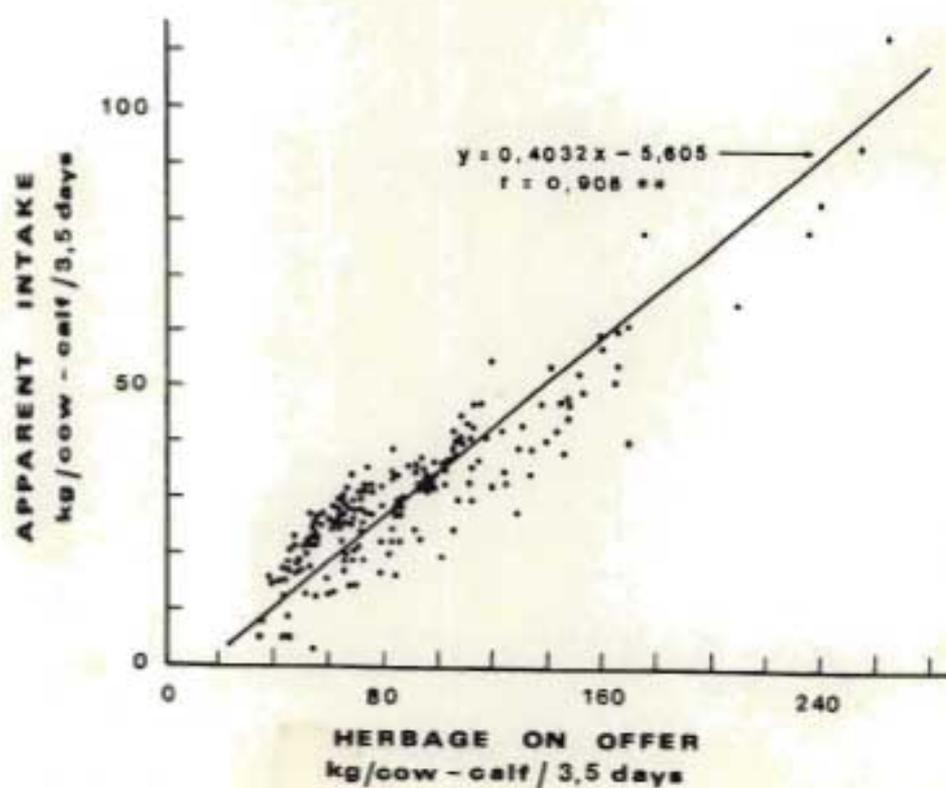


Fig. 2.7 The relationship between herbage on offer per cow-calf unit per 3,5 days and apparent dry matter intake of kikuyu per cow-calf unit in 3,5 days (from the same camp as in Fig. 2.6).

5,605 ($r = 0,908^{**}$ for $n = 179$). Approximately 82% of the variation in dry matter intake is explained by this equation. This relationship between herbage on offer and apparent dry matter intake is shown in Fig. 2.7. The data to derive this relationship was from all stocking rate treatments for the 1978/79 to 1983/84 seasons; data following weaning was not included. Apparent intake for the 1978/79 and 1979/80 seasons, during which the two breeds were each run at two stocking rates, revealed no significant breed effect on intake. Thus all data were pooled to derive the above herbage on offer - apparent intake relationship.

Apparent dry matter intake was determined from the difference between herbage on offer at the start of grazing a camp and herbage left after grazing that camp, plus growth (estimated from regrowth rates) during the period of occupation of the camp. Clearly wastage of herbage was included in apparent intake.

In relating present results to published results cognisance must be taken of differences in class of animal, pasture species, techniques and units used. A linear relationship between herbage on offer and intake was also recorded by Marsh & Murdoch (1974), Reardon (1977) and Stuth, Kirby & Chmielewski (1981). Reardon (1977) found both herbage allowance per head and pasture yield per ha to significantly affect the linear regression predicting intake. Bartholomew et al. (1981) recorded a linear relationship between total herbage consumed and total herbage offered.

Marsh & Murdoch (1974) found that if the relationship between intake and herbage on offer (linear relationship) is expressed on a grazing pressure basis then the relationship between availability and intake is curvilinear. If efficiency of pasture utilisation is taken into account (i.e. reduced efficiency of utilisation as availability increases), as shown by Stuth et al. (1981), then the data from the present trial reflect the well documented curvilinear relationship between availability and intake (Willoughby, 1959; Greenhalgh, Reid, Aitken & Florence, 1966; Allden & Whittaker, 1970; Trigg & Marsh, 1979; Blaser, 1982).

2.3.1.4 Herbage quality

Herbage samples cut to ground level from the disc meter calibration cuts were bulked for each treatment, milled, sub-sampled and analysed for N, P, K, Ca, Mg and crude fibre (CF). For the 1978/79 season only before grazing samples were available. Both before and after grazing samples were analysed for the 1979/80 to 1982/83 seasons. Lack of funds precluded analysis of samples taken during the 1983/84 season.

Crude protein (CP)

Percentage CP of the herbage was determined by multiplying percentage N of the herbage (Kjeldahl method) by 6.25. The effect of stocking rate and season on the CP of the herbage, both before and after grazing, is illustrated in Fig. 2.8.

From Fig. 2.8 it can be seen that the CP level of the herbage, both before and after grazing, did not follow a consistent pattern for the different seasons. The levels of CP fluctuated markedly within and between seasons and between stocking rates.

For each of the seasons, excluding the 1981/82 season when the CP of the herbage increased, there was a marked decline in CP of ungrazed material during early February. The decline in CP during February was more marked at high than at low stocking rates. This sharp drop in CP was followed by an equally rapid increase in CP of the herbage on offer in late February - early March (Fig. 2.8).

The consistent rapid drop in CP during early February (for all seasons except for the 1981/82 season) suggests that CP is implicated in the "autumn slump" in milk production from kikuyu reported by Bredon (1980). From Fig. 2.8 it may be inferred that the drop in CP during February, followed by the

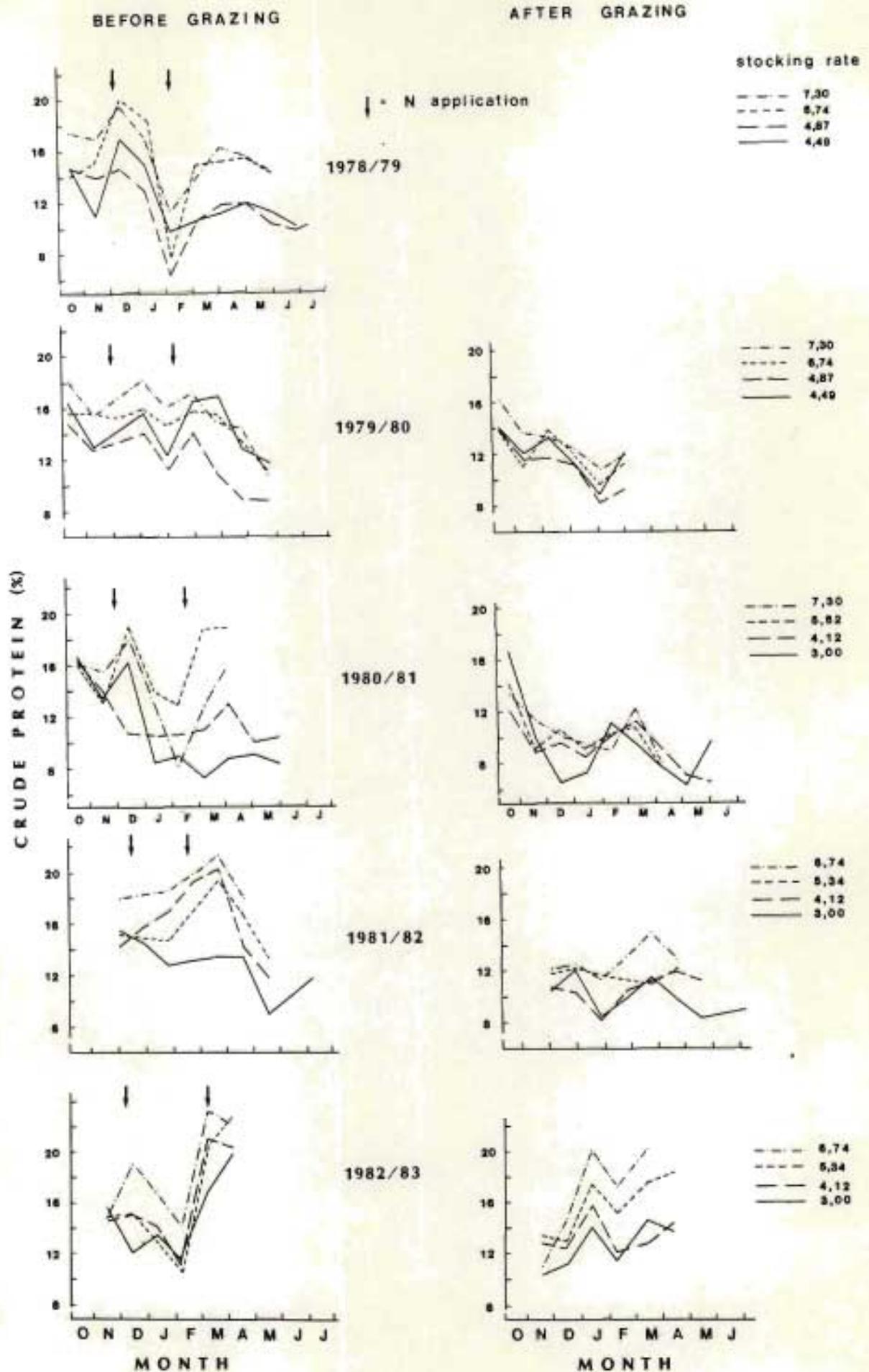


Fig. 2.8 The effect of season, stocking rate and time on the percentage crude protein of kikuyu before and after grazing.

subsequent rapid increase in CP, was related to N fertilisation. It is accepted that the level of N used in the trial was lower than that required for optimum dry matter production (Cross, 1979a). Thus it is possible that the pasture had "run out of N" by February, resulting in the recorded drop in CP (Whitney, 1974b). The application of N resulting in the subsequent increase in CP. However, data from the 1981/82 and 1982/83 seasons did not indicate that the drop in CP resulted from a lack of N. Firstly, the 1981/82 season did not exhibit the February drop in CP recorded for the other seasons. Secondly, during the 1982/83 season the rapid increase in CP, following the decline in February, occurred before the last N application. Furthermore, in view of the low yields recorded for the very dry 1982/83 season (compared with the 1981/82 season for example), it seems unlikely that N was limiting. Thus although N may well be implicated in the CP trends discussed it seems probable that other factors were also involved.

Mc Cree (1974) has shown that the maintenance coefficient (respiration) for both clover and sorghum is strongly temperature dependent: the higher the temperature the greater the respiration. Wilson (1985) states that up to 50% of photosynthetic uptake can be lost through dark respiration. Furthermore, Davisson & Milthorpe (1965) and Dilz (1966) have suggested that proteins may be mobilised to produce energy for growth following defoliation. Thus it seems probable that proteins could be utilised for respiration. Mean minimum temperatures (controlling respiration at night) for the area increased from July and, for most seasons, reached a peak in January - February. After February mean minimum temperatures started declining (Fig. 2.3). Of all the seasons the 1981/82 season, which did not show the marked drop in CP during February, had the lowest temperatures during this period. While it is suggested that temperature, or more specifically respiration, is implicated in the February slump in CP, it is obvious that a detailed study is required to elucidate this.

The CP levels of the residual herbage after grazing did not fluctuate as

markedly as in the ungrazed sward (Fig. 2.8). Nevertheless the CP levels were markedly different in the different seasons. That the animals selected herbage with a high CP content is indicated by the marked drop in CP in the residual material (Fig. 2.8).

Crude protein values for kikuyu reported in the literature range from 5,6 to 39,4% (Breakwell, 1923; Taylor, 1949; Whitney, 1974a; van Ryssen, Short & Lishman, 1976; Bogdan, 1977; Cross, 1979b; Colman & O'Neill, 1978; Andrews & Crofts, 1979; Bredon, 1980; Dugmore, 1985), while those for the present trial ranged from 6,5 to 23,3%. The data of Fig. 2.8 show the large effect season and stocking rate had on the CP content of kikuyu. Thus caution should be exercised when comparing CP levels with values from trials subjected to different N levels, defoliation frequencies and sampling techniques.

On several occasions the CP levels of the herbage dropped below that required for lactating and growing animals (N.R.C., 1976). These lower CP values were associated with the lower stocking rates. However, samples for analysis were cut to ground level. Thus the low stocking rate treatments had a greater bulk of older ungrazed material. The low stocking rate treatments would thus be expected to have lower CP values than the high stocking rate treatments.

While it is recognised that both low (less than 6%; Lippke, 1980) and high (above 20%) CP in the herbage may adversely affect dry matter intake (Milford & Minson, 1965), cognisance should be taken of the animals ability to select for quality (Bredon, Torell & Marshall, 1967). For the present trial it is not possible to establish with certainty that animal performance was adversely affected by herbage CP levels. However, indications were that low CP may have affected animal performance at the light stocking rate, at least for some seasons. Since the CP levels seldom exceeded 20% it seems unlikely that intake and animal performance would have been affected adversely by high CP values.

Multiple regression equations to predict the CP content of the herbage, from stocking rate and time, were highly significant ($P < 0.001$) for each of the seasons for both the ungrazed and residual material (Appendix 2). Both stocking rate and time contributed significantly to the predictive equations. However, the vast differences in the equations from one season to the next renders the overall (mean for all seasons) regression equations (for both before and after utilisation), though highly significant, of little predictive value (Appendix 2). The data of Fig. 2.8 clearly show the spuriousness of providing a mean regression, from the present data, for predictive purposes.

Crude fibre (CF)

Analysis of the disc meter calibration samples for percent CF was done by the feeds laboratory, at Cedara, using the method described by the A.O.A.C. (1965).

The percent CF of the herbage at each grazing cycle, before and after grazing, is shown in Fig. 2.9. As with CP there were marked fluctuations in CF during the season and large differences in percent CF between seasons. While CP followed a distinct pattern (February dip) over the season, there was no seasonal pattern for CF. However, the trends in CF within seasons were essentially similar for all stocking rate treatments.

For the 1978/79 and 1980/81 seasons the trend was for CF to increase with time for both the before and after grazing samples. During the 1979/80 and 1981/82 seasons there was, apart from fluctuations in CF, no apparent trend with time in the pre-grazing samples. However, for these seasons CF of the residual material increased (1981/82) and decreased (1979/80) with time. The CF declined with time in the dry 1982/83 season both in before grazing and residual samples. For most seasons and stocking rates the CF content of the herbage was higher following grazing than it was before

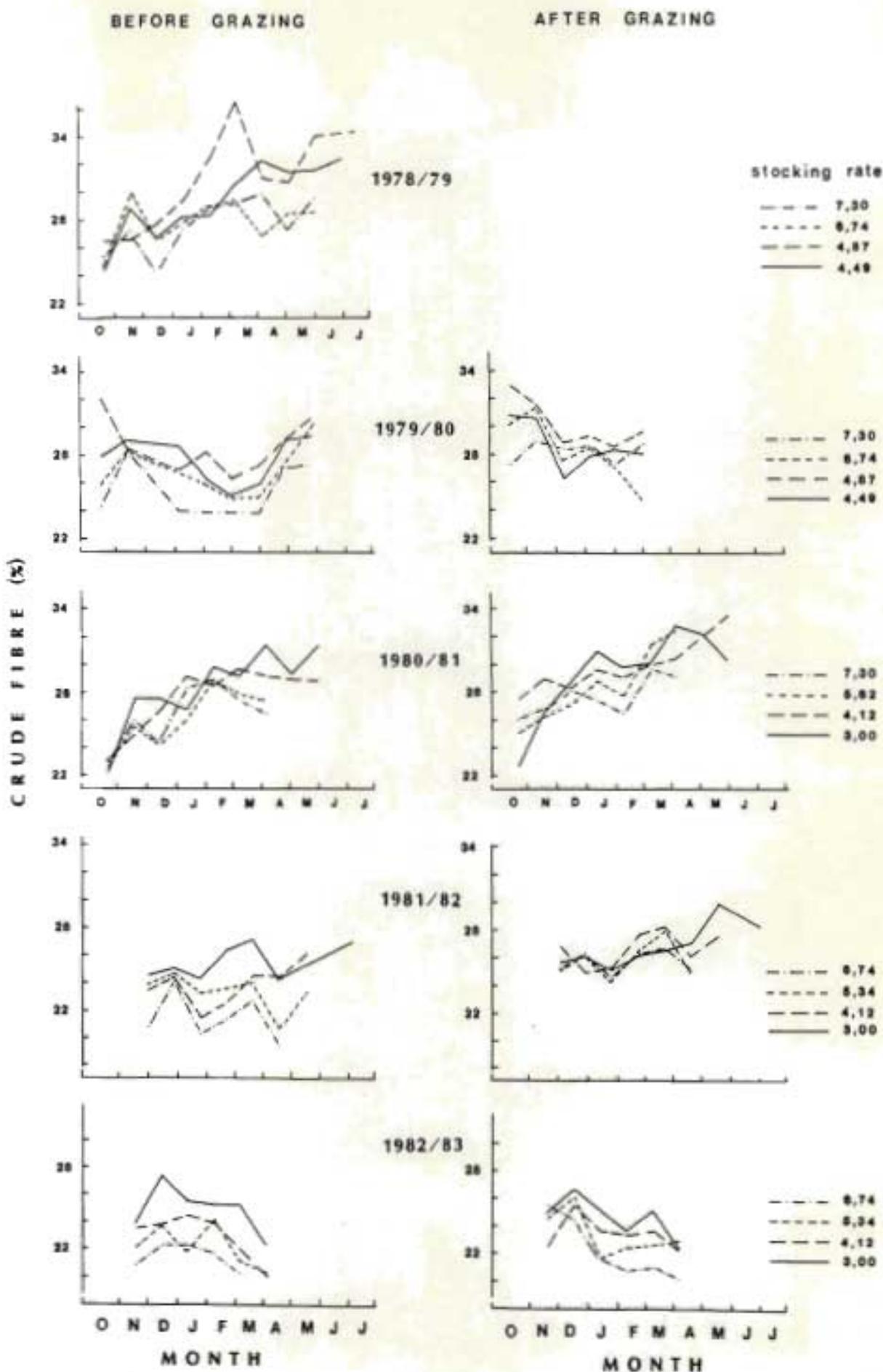


Fig. 2.9 The effect of season, stocking rate and time on the percentage crude fibre of kikuyu before and after grazing.

grazing.

Multiple regression analysis of the CF data indicated a significant contribution of both stocking rate and time to the equations to predict CF of the herbage. These highly significant ($P < 0,01$) regression equations, given in Appendix 2, and the data of Fig. 2.9, show the negative effect of stocking rate on CF (both before and after grazing) : as the stocking rate was increased so there was a concomitant decrease in CF of the herbage. However, the magnitude of this stocking rate effect, in predicting CF, varied markedly between seasons. The significant contribution of time to the multiple regression equation, was, as expected from the data of Fig. 2.9, very different for the different seasons (Appendix 2).

As was the case for CP the use of the mean regression (over all seasons) to predict CF of kikuyu would be misleading. The low percent variation accounted for by the regression equations (though the equations were significant) renders these mean equations of little or no value. Large variations in the percent CF shown in Fig. 2.9 clearly indicate the spuriousness of fitting a mean curve to represent changes in CF over the season.

Despite large variations (between seasons) and fluctuations (within seasons) in the CF of kikuyu the values recorded for the present trial (19,4 to 34,5% CF) were within the range (16,7 to 36% CF) reported in the literature (Moore & Mott, 1973; van Ryssen et al., 1976; Bogdan, 1977; Cross, 1979b; Bredon, 1980; Dugmore, 1985).

While it is generally accepted that the digestibility of herbage decreases with an increase in CF (e.g. Moore & Mott, 1973; Hacker & Minson, 1981 - quoting Patterson, 1935 & French, 1961), indications are that this is not so for kikuyu. Dugmore (1985) found a positive linear relationship (in vivo) between CF and digestible organic matter for kikuyu. In discussing this relationship Dugmore (1985) quotes several researchers who have also recorded improved digestibility of the dry matter with increased CF

values for kikuyu.

The implications of increased digestibility with increasing CP, for the present trial, are interesting. Higher CP values for the low stocking rate treatment, compared with the high stocking rate treatment, implies more energy available to animals at low stocking rates. While this may be true for the cow, with a well developed rumen, improved digestibility of CP may not be beneficial to the calf. The source of nutrients for the calf changes (as shown earlier) from largely milk to largely herbage, as the calf matures. It is accepted that rumen development of the calf is particularly rapid (in terms of growth and functional capacity: Miller, 1979). However, the younger animal has a higher protein requirement relative to energy requirement, than the older animal (Miller, 1979). If CP intake by the calf is limited, due to restricted dry matter intake resulting from high CP levels, the performance of the calf may well be affected adversely.

Total digestible nutrients (TDN)

Total digestible nutrient content of the herbage was determined from percent CP and percent CF using the regression proposed by Bredon & Meaker (undated) : $TDN = 75,1 + 6,0 \log \% CP - 0,75 \% CF$. The seasonal change in the TDN content of the pasture, before and after grazing the fifth camp, is shown for each of the stocking rates used, in Fig. 2.10.

The TDN values shown in Fig. 2.10 may well represent underestimates of TDN, particularly when high CF values were recorded (Fig. 2.9). This in view of the positive relationship between CF and digestibility discussed earlier and the negative relationship between CF and TDN in the regression used to determine TDN.

Although there were no within or between season patterns of change in TDN values, higher values were associated with higher stocking rates. This positive relationship between stocking rate and TDN is shown by the data of

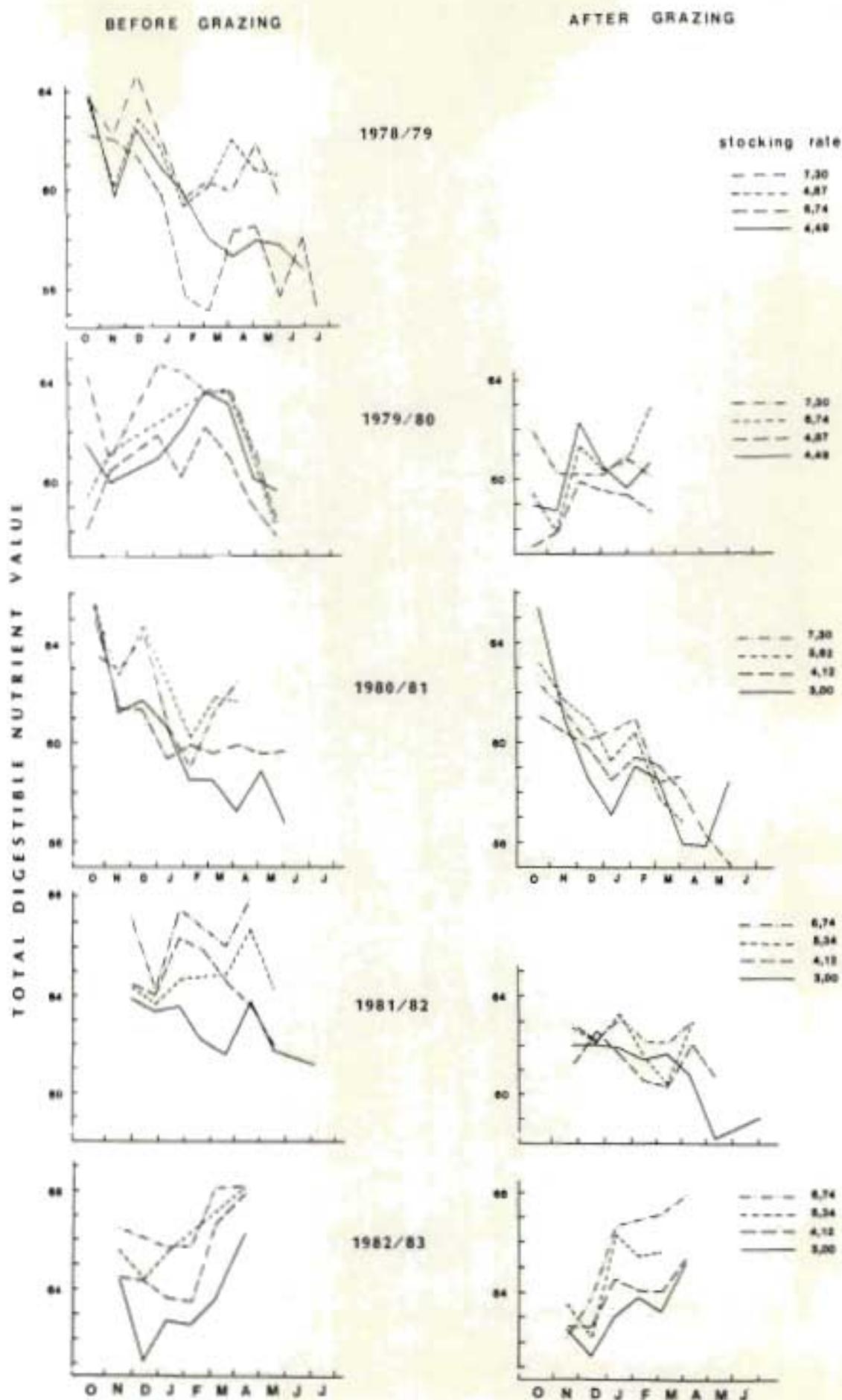


Fig. 2.10 The effect of season, stocking rate and time on the total digestible nutrient value of kikuyu before and after grazing.

Fig. 2.10 and by the multiple regression equations predicting TDN from stocking rate and time, given in Appendix 2.

As was the case for both CP and CF the regression equations to predict TDN from stocking rate and time were significant for individual seasons (both before and after grazing)- Appendix 2. However, the lack of a seasonal pattern, and the low percent variation accounted for by the mean regression equation to predict TDN, precludes the use of the regression based on all the seasons data for predictive or modelling purposes.

The reported values, computed on a similar basis as those for the present trial for grazed kikuyu in Natal, range from 51,2 to 66,5 (Cross, 1979b; Bredon, 1980; Dugmore, 1985). For the present trial the TDN of the dry matter varied from 53,7 to 68,1.

It may be argued that in view of the established energy requirements for different classes of animals (e.g. N.R.C., 1976; A.R.C., 1980; Kearl, 1982) the daily TDN intake of the animals should be determined for the present trial. This would indicate at what times of the season energy intake could be expected to limit animal performance. However, in the present trial this would seem somewhat optimistic and be of little practical (predictive) value. It seems illogical to attempt to partition mean energy intake (from dry matter intake and change in TDN concentration determined at the start and end of a 3,5 day grazing period) into lactating cow and calf components on a daily basis. In addition, daily dry matter and TDN intake will vary over the 3,5 day period of stay, particularly when herbage availability becomes limiting (Jones, 1971; Trigg & Marsh, 1979; Allison *et al.*, 1982). Furthermore, the validity of a mean daily intake of energy, established from intake over a period of time, in predicting performance from daily energy requirements is questionable. Added to this are the large differences in TDN concentrations and dry matter availabilities recorded for separate seasons. Thus parameters relating time of season and energy intake to animal requirements would be applicable only to the season in question.

2.3.1.5 Herbage quality and animal selection

The major factors which influence herbage intake by animals are the quantity, quality (Holmes, 1980) and digestibility of herbage (Bryant, 1980), retention time in the reticulorumen (Laredo & Minson, 1973), the animals energy requirements (Osbourn, 1980) and ease of prehension by the animal (Stobbs, 1973).

While there are large differences in the digestibility (Hacker & Minson, 1981) and palatability (Stobbs, 1975) of plant parts, animals graze relatively larger proportions of the relatively more nutritious fractions of the sward (Crowder & Chheda, 1982). It is now widely appreciated that animals select herbage with a higher CP and lower CF content than the herbage on offer.

The relationship between pre- and post-grazing CP and CF content of the herbage was compared for the period 1979/80 to 1982/83 to establish the selection pattern in this trial. These relationships are shown in Fig. 2.11.

From the data of Fig. 2.11 it is obvious that the animals selected for herbage with high CP content and selected against herbage with a high CF content. It is interesting to note that the values above and below the 1:1 ratio, for CP and CF respectively (Fig. 2.11), were recorded during the dry 1982/83 season or at the end of the season (low pasture availability). It is probable that the relatively large errors associated with clipped quadrats was responsible for these deviations.

Regressions to predict CP and CF of herbage following grazing a camp for 3,5 days, from the CP and CF of the herbage on offer before grazing, shown in Fig. 2.11, were highly significant ($P < 0,01$). Neither season nor stocking rate contributed significantly to the regression predicting residual CP or CF from CP and CF before grazing.

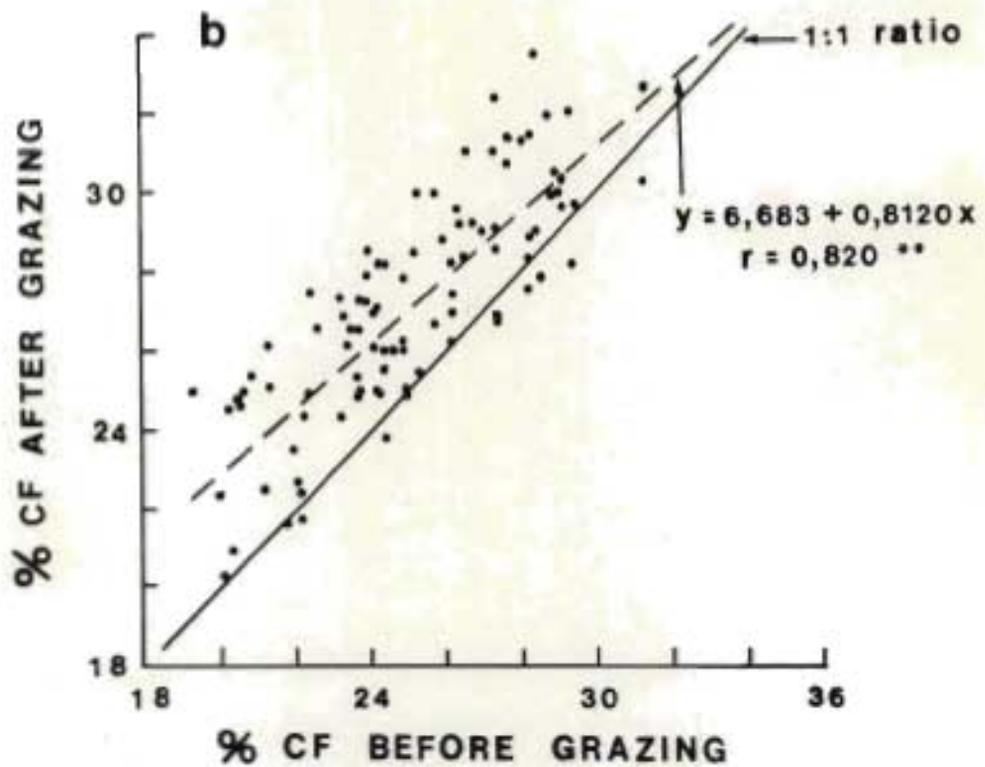
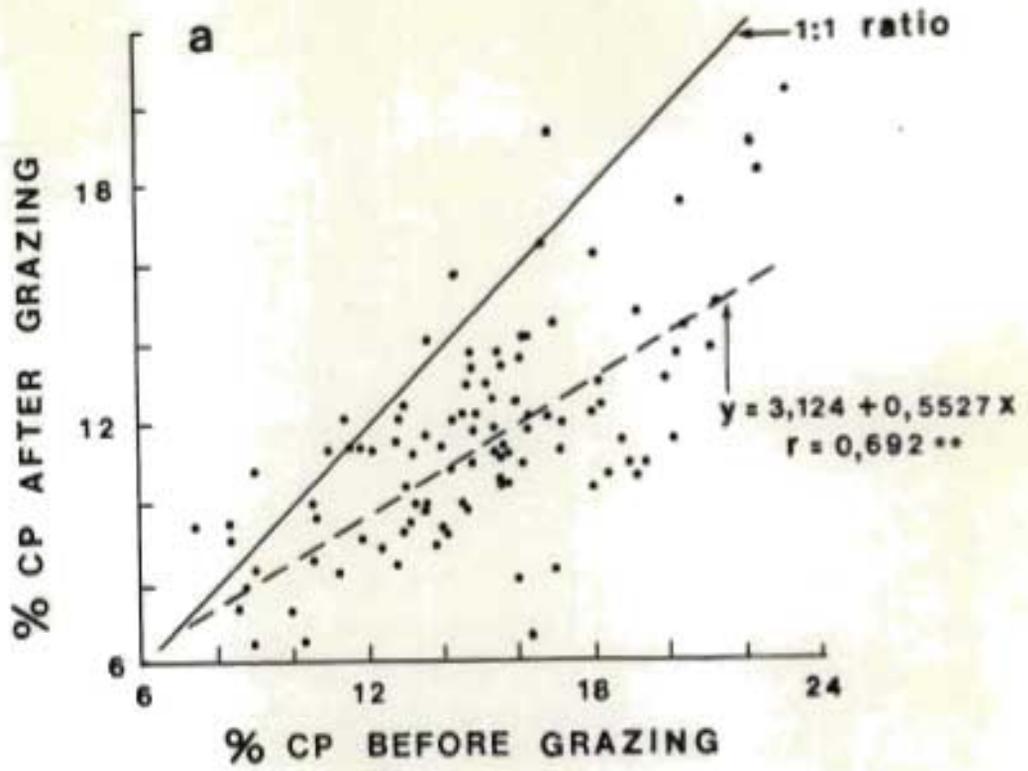


Fig. 2.11 The relationship between the crude protein (a) and crude fibre (b) content of kikuyu before and after grazing.

The significant relationships between herbage on offer and intake, and between CP or CF on offer and residual CP or CF, suggests prediction of nutrient (including energy) intake by the animals. However, partitioning of nutrient disappearance from the pasture into cow and calf intakes, to predict animal performance, would be suspect. van der Kley (1956) has indicated excess intake of protein by animals turned into a fresh pasture and reduced protein intake at the end of the grazing period. Added to this is the fact that during periods of grazing stress calf performance is buffered by milk from the dam (Baker, 1982b). A reduced milk supply encourages the calf to eat more grass. However, the calf is unable to compensate by eating more grass when reduced milk supply results from limited pasture availability (Baker, 1982b). Thus the partitioning of intake derived from dry matter, CP and CF disappearance rates from the pasture (over a 3,5 day period), to predict animal performance (based on daily nutrient requirements), should be viewed with circumspection.

Relationships between CP and CF before and after grazing, together with dry matter disappearance during grazing, provides an indication of times of excess or deficiencies of nutrients. However, the lack of distinct patterns, or levels, of dry matter or quality components for the separate seasons precludes the use of "mean" values for predictive purposes.

It is perhaps appropriate at this stage to discuss briefly the possibility of obtaining "representative mean" herbage quality and herbage yield curves over the season. Dry matter yield and growth rate of the pasture was found to be dependent on amount and distribution of rainfall. Thus the use of frequency and distribution data (perhaps in conjunction with temperature data), for a particular area, may well allow for the selection of the appropriate growth curve. However, establishing "mean" quality curves is perhaps more complex. High CP values, for example, were associated with both high and low pasture growth rates.

In the present trial only one camp in the grazing cycle was sampled for

herbage quality (all camps were monitored for dry matter production). The rapid changes in CP and CF from one grazing cycle to the next (4 weeks) suggests that monitoring of only one camp was insufficient. That the quality of herbage offered to the animals in the camp which was monitored was representative of the herbage is not questioned. However, the rapid change in quality, over relatively short periods of time, suggests that the animals were not offered this quality of herbage for the entire grazing cycle (8 camps). It is accepted that sampling more camps, for quality, involves greatly increased costs. Nevertheless, it is strongly recommended that more than one camp be monitored in situations where rapid changes in quality are suspected, or known to occur. Representative quality curves can only be established once the variability in quality has been determined.

2.3.2 Animal parameters

Animal mass is the only animal parameter which will be presented and discussed in detail. As mentioned earlier other parameters relating to animal responses have been reported on in detail by Louw (1984). Suffice it to say that (i) there were no significant breed, stocking rate or seasonal effects on reconception, (ii) milk production of the cows increased linearly as stocking rate was reduced, (iii) Simmentalers produced significantly ($P < 0,05$) more milk per lactation than did the Herefords, and (iv) there was a positive relationship between milk production and calf performance and between calving date and calf performance.

Thanks are to Mr J Lyle for computerizing the analysis procedure developed for analysing animal data. For the present trial quartic functions were fitted to the animal data.

2.3.2.1 Calf performance

2.3.2.1.1 Calf growth

The livemass change of suckling calves subjected to different stocking rate treatments are shown in Fig's 2.12 and 2.13 for the Simmentalers and Herefords respectively.

Growth of the calves followed the expected pattern. As the stocking rate was reduced calf performance improved. This was so for each of the seasons for both Simmentaler and Hereford calves.

Comparison of the livemass gains of the calves reveals that the shape of the growth curves were essentially similar for all seasons and stocking rates (Fig's 2.12 and 2.13). However, towards the end of the season the growth rate of the calves at the higher stocking rates declined or became negative rather abruptly (with few exceptions). At the lighter stocking rates the calves tended to maintain a slow growth rate for a relatively long period of time prior to weaning.

Differences in the length of the grazing seasons (largely rainfall induced) affected (i) the time of commencement of grazing, and thus the initial mass of the calves and stage of lactation of the cow at the start of the season, and (ii) time of weaning, affecting the period "available" for calf gain. These differences (initial calf mass, stage of lactation, period on pasture and the effect of stocking rate on calf growth prior to weaning) necessitate careful evaluation and interpretation of the effect of stocking rate on mean calf performance over the seasons.

It is accepted that the calf performance data can be compared and analysed in many different ways (including multiple regression analysis with many variables such as corrected birth mass, 210 days corrected weaning mass, average daily gain, milk production of dams, season, days post

SIMMENTALER CALVES

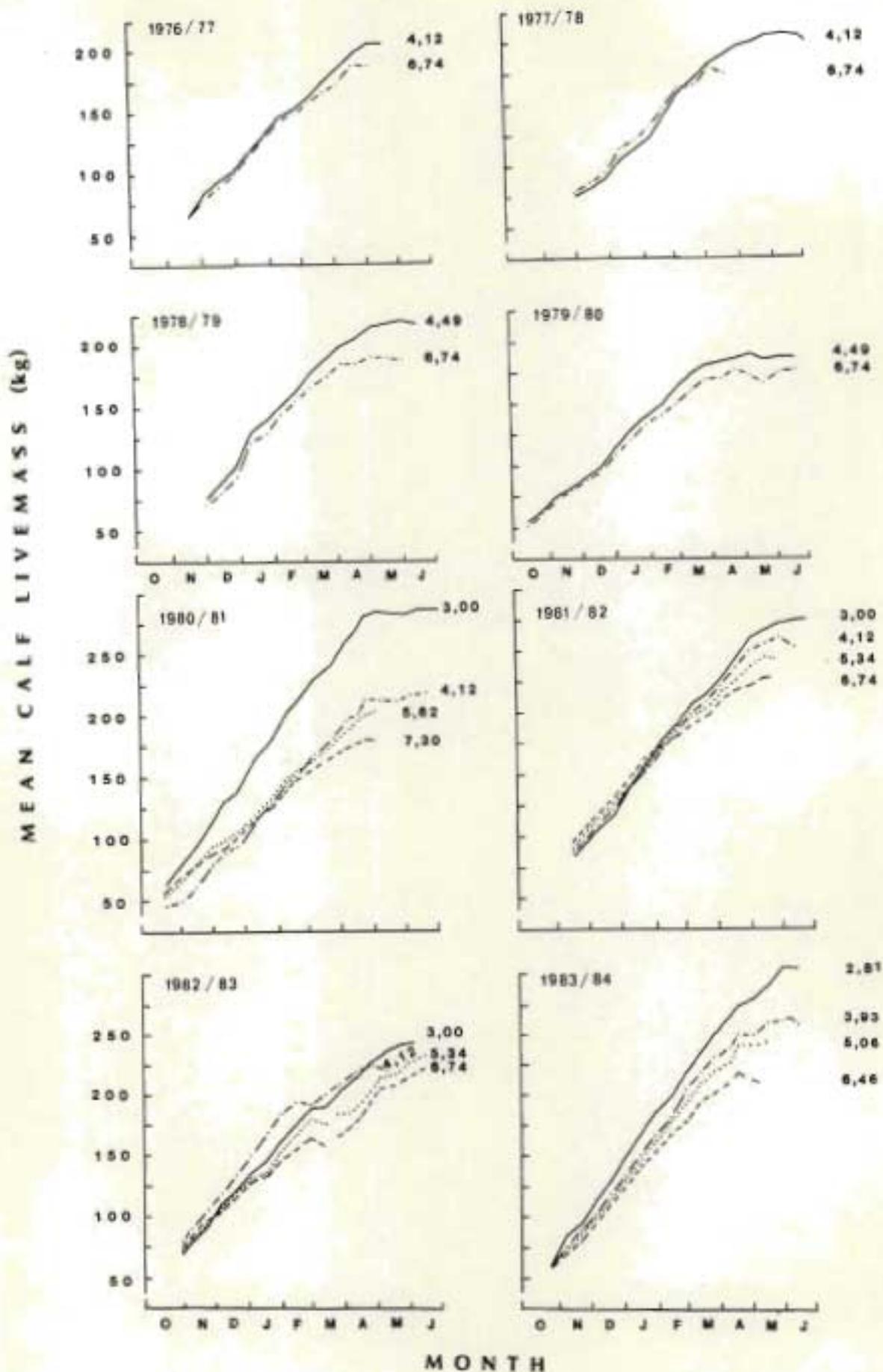


Fig. 2.12 The effect of stocking rate and season on the cumulative livemass gain of suckling Simmentaler calves (mean for steer and heifer)

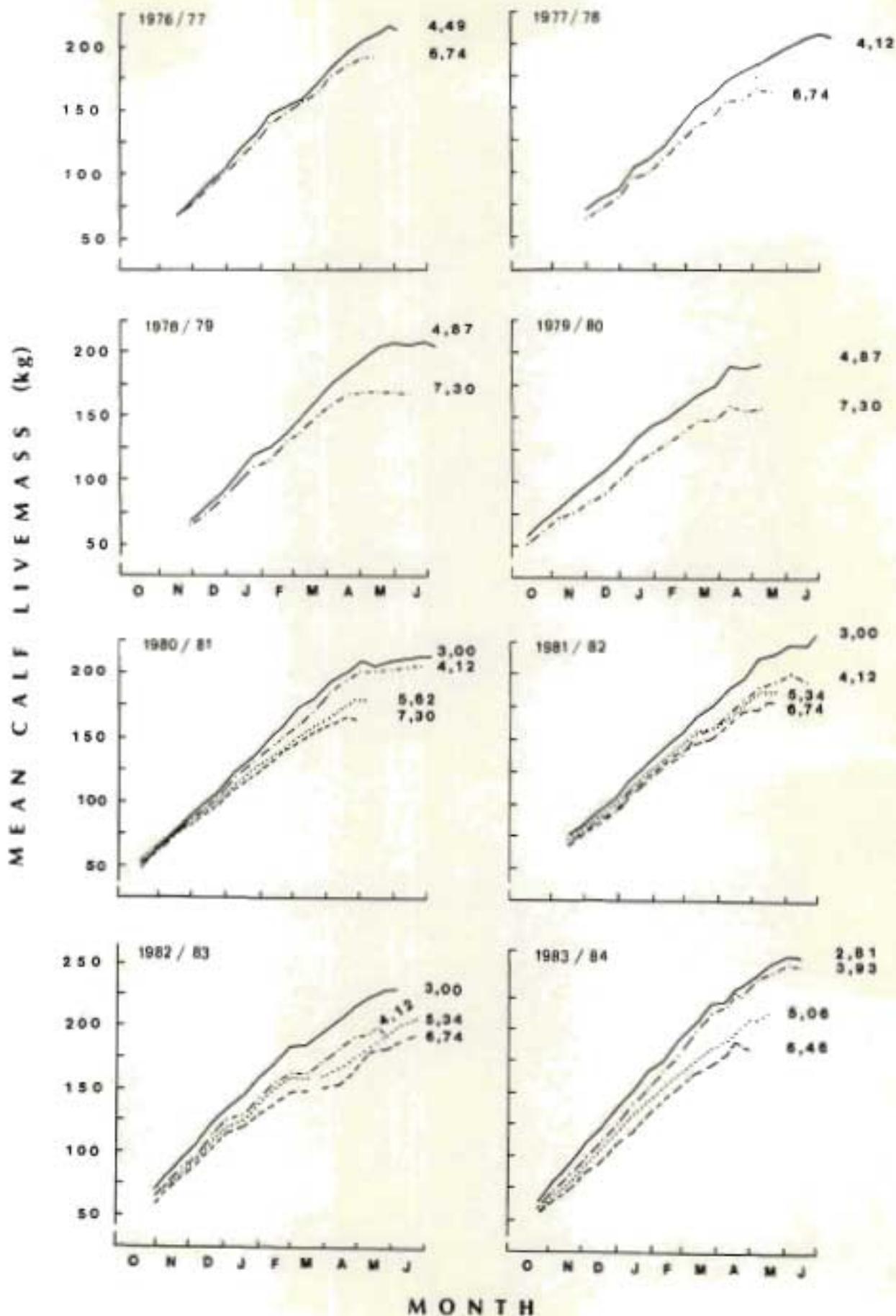


Fig. 2.13 The effect of stocking rate and season on the cumulative livemass gains of suckling Hereford calves (mean livemass at the end of the period)

partum). However, the primary objective is to provide information that can be of direct application to the farm situation.

The relationship between stocking rate and calf performance is illustrated in Fig. 2.14. Linear regressions (Jones & Sandland, 1974, model) describing the relationship between stocking rate and average daily gain (ADG) and between stocking rate and calf livemass gain per season are given in Tables 2.3 and 2.4 respectively.

2.3.2.1.2 Breed differences

From the data of Fig. 2.14 and Tables 2.3 and 2.4 it can be seen that the Simmentalers had a lower stocking rate providing for maximum livemass production per ha (SR_{max}) than did the Hereford type animals. This was so whether SR_{max} was determined from ADG or livemass gain per season. In view of the slightly higher mass of the Simmentalers, compared with the Herefords, it would be expected that the Simmentalers would have a slightly lower SR_{max} . The data also show that, within the range of stocking rates used, the Simmentaler calves performed better than did the hereford type calves.

The performance of the calves of the two breeds were compared over all seasons and stocking rate treatments. From Table 2.5 it can be seen that, in terms of livemass gain, (i) for both breeds the performance of the steers was 6% higher than that of the heifers, and (ii) the Simmentaler steers had 11,7% and the heifers 11,6% higher livemass gains than the Hereford type calves. Superior performance of steer over heifer calves has been reported by several researchers (e.g. Marnette & Coates, 1976; Rouquette *et al.*, 1980; Eden & Smit, 1982).

Of particular interest from the data of Table 2.5 are (i) the similar starting mass of the two breeds (the Simmentaler steer and heifer calves were slightly heavier than their Hereford counterparts) and, (ii) the low

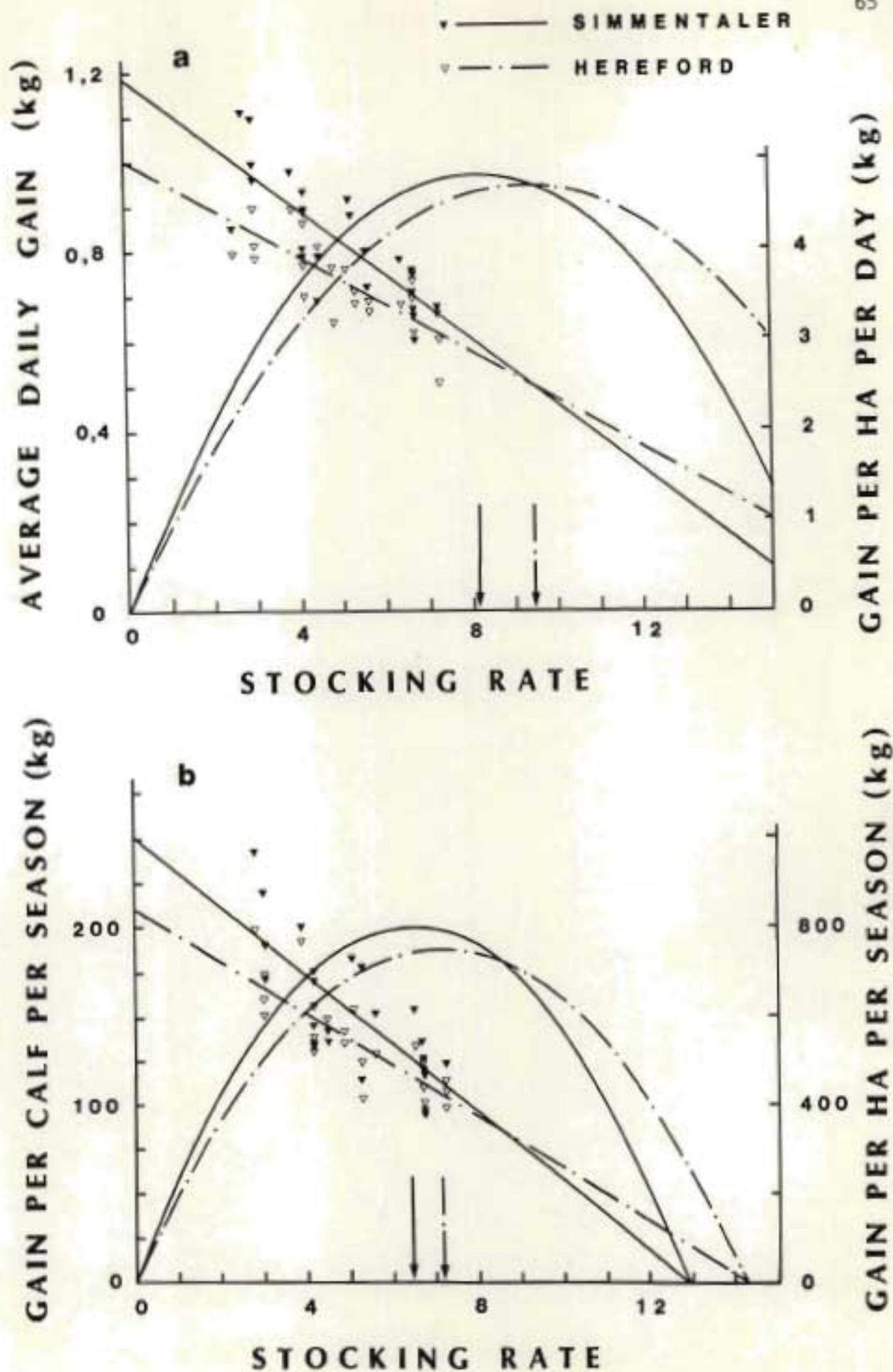


Fig. 2.14 The relationship between stocking rate and the performance of suckling calves. (a) The relationship between stocking rate and average daily gain. (b) The relationship between stocking rate

TABLE 2.3 The relationship between stocking rate and average daily gain of calves (based on the period from the end of calving until the calves from the highest stocking rate treatment attained maximum mass in any one season); for the 1975/76 to 1983/84 seasons.

BREED	SRmax	Calf livemass gain (kg/ha/day)	n	Corr. coeft. (r) [±]
Simmentaler (all calves)				
y = 1,1866 - 0,0724x	8,19	0,593	26	0,7972
yh = 1,1866x - 0,0724x ²				**
Hereford type (all calves)				
y = 0,6700 - 0,0527x	9,48	0,499	26	0,8185
yh = 0,6700x - 0,0527x ²				**

ADG = average daily gain (kg per calf)

y = ADG

yh = calf livemass gain (kg per ha per day)

x = stocking rate (cow plus her calf = 1 unit) in units per ha

SRmax = stocking rate providing for maximum calf livemass gain per ha

n = number of observations (each observation represents the mean calf gain per stocking rate treatment)

TABLE 2.4 The relationship between stocking rate and calf livemass gain per animal and per hectare (based on maximum mass attained by the calves at each stocking rate for the period 1976/77 to 1983/84).

BREED/SEX	SRmax	Livemass gain (kg) at SRmax per calf per ha		n	Corr. coeff. (r)*
Simmentaler					
All calves (heifers & steers)					
y = 250,85 - 19,3714x	6,48	125	813	24	0,7455
yh = 250,85x - 19,3714x ²					
Heifer calves					
y = 234,86 - 16,9492x	6,93	117	814	24	0,6291
yh = 234,86x - 16,9492x ²					
Steer calves					
y = 262,75 - 20,9207x	6,28	131	825	24	0,7657
yh = 262,75x - 20,9207x ²					
Hereford type					
All calves (heifers & steers)					
y = 210,37 - 14,6512x	7,18	105	755	24	0,8068
yh = 210,37x - 14,6512x ²					
Heifer calves					
y = 212,67 - 15,8896x	6,69	106	711	24	0,8072
yh = 212,67x - 15,8896x ²					
Steer calves					
y = 205,22 - 12,9102x	7,95	103	816	24	0,7976
yh = 205,22x - 12,9102x ²					

y = livemass gain (kg) per calf

yh = calf livemass gain per ha (kg)

x = stocking rate (cow plus her calf = 1 unit) in units per ha

SRmax = stocking rate providing for maximum calf livemass gain per ha

n = number of observations (each observation represents the mean calf gain per stocking rate treatment)

* = all correlation coefficients significant at the 1% level of significance

TABLE 2.5 The effect of sex and breed of calf on the relative performance of calves (calf performance data meaned over all stocking rates and all seasons from the birth of the last calf, in any one seasons, to maximum mass attained for each treatment for each of eight seasons)

VARIABLE	BREED			
	Simmentaler (Sim)		Hereford type (Her)	
	Heifers	Steers	Heifers	Steers
Initial mass (kg)	60,57 ±3,80	70,86 ±2,91	58,35 ±1,57	66,89 ±2,34
Livemass gain (kg)	147,94 ±2,91	157,38 ±8,10	130,78 ±6,14	139,02 ±5,21
Number of calves	84	130	116	125
Improved				
performance of:				
(a) Steers over heifers	6,0%		5,9%	
(b) Sim steers over				
Her steers			11,7%	
(c) Sim heifers over				
Her heifers			11,6%	

number of Simmentaler heifer calves born during the trial period (low heifer numbers did not result from differences in calf mortality between bull and heifer calves, at or soon after birth).

2.3.2.1.3 Optimising calf production

In the cow-calf context maximising calf production per ha is perhaps a somewhat nebulous concept. However, the relationship between stocking rate and the mass gain of an individual calf is of paramount importance. It is the mass of the calf at weaning that is important. The weaned calf is the saleable, in the context of the demand for weaners of different masses, or usable product in the sense that weaner mass is important in terms of the overall breeding and marketing strategy: i.e. the target masses of animals at target dates concept.

While the relationship between stocking rate and ADG (Fig. 2.14a) may be of interest (for example where early weaning is contemplated to maintain a desired ADG for the calf), gain per calf to weaning (Fig. 2.14b) is of greater practical value. Both ADG and calf gain relationships with stocking rate, do not directly take time on pasture into account. However, the stocking rate - calf gain relationship was determined when calf mass reached a maximum in each stocking rate treatment, and thus incorporates the time factor. The ADG - stocking rate relationship was based on the period from the last calf born to maximum mass of the highest stocking rate treatment in any one season. It is not realistic to establish the ADG - stocking rate relationship for the period from the last calf born to maximum mass attained by calves at each individual stocking rate treatment. This in view of the effect of stocking rate on calf growth discussed earlier. Maximum mass was achieved much earlier in the high stocking rate treatment than in the low stocking rate treatments, where calves continued to gain slowly over a long period prior to weaning. In contrast, at the high stocking rates there was

an abrupt decline in growth rate immediately prior to weaning. Thus while the calves of the light stocking rate treatments attained a higher mass than calves from the high stocking rates, the ADG's to weaning were not very different because they were calculated over a longer time period. These "similar" ADG's would result in unrealistically high SR_{max}. Since the relationship between stocking rate and ADG (Fig. 2.14a and Table 2.3) was based on the period to maximum mass of the highest stocking rate treatment, extreme care should be exercised in utilising this relationship, particularly for periods longer than those of the present trial.

Within the objectives of the trial it is considered that (irrespective of the length of the grazing period) the relationship between stocking rate and livemass gain per calf (Fig. 2.14b and Table 2.4) is appropriate for "optimising calf production". This relationship provides for the prediction of either calf mass that can be expected at a particular stocking rate, or selection of a stocking rate to provide for a desired calf gain (by re-arrangement of the equations of Table 2.4). Due to differences in performance between Simmentalers and Herefords and between steers and heifers (Table 2.5), regression equations relating calf gain to stocking rate are given for each of the breeds and sexes in Table 2.4.

In view of the large year to year variation in the length of time required for calves to attain maximum mass, time was included as a variable in a multiple regression analysis. Equations using stocking rate and time to predict calf livemass gain, or the stocking rate required to effect a desired gain, are given in Table 2.6. These equations are depicted, for selected stocking rates, in Fig. 2.15. Of particular interest is the regression equation for the Simmentaler heifer calves. The negative constant for this regression (Table 2.6) is considerably different from the constants for the other regressions. Furthermore, meaned over all stocking rates and seasons the performance of Simmentaler steer calves was superior to the performance of heifer calves (Table 2.5). The opposite is shown by

TABLE 2.6 The relationship between calf livemass gain (based on maximum mass attained at each stocking rate treatment), stocking rate and length of time on pasture (mean for 1976/77 to 1983/84 seasons).

BREED/SEX	n	r
Simmentalers		
All calves (heifer & steer)		
y = 53,64 - 9,6206x + 0,7642t	24	0,8601**
x = 5,576 - 0,1039y + 0,0794t		
Heifer calves		
y = - 8,25 - 5,1061x + 0,9453t	23	0,8254**
x = - 1,616 - 0,1958y + 0,1851t		
Steer calves		
y = 71,55 - 11,2657x + 0,7385t	24	0,8646**
x = 6,351 - 0,0888y + 0,0656t		
Hereford type		
All calves (heifer & steer)		
y = 65,41 - 8,0039x + 0,5582t	24	0,9023**
x = 8,172 - 0,1249y + 0,0697t		
Heifer calves		
y = 63,86 - 9,1828x + 0,5758t	24	0,9031**
x = 6,954 - 0,1089y + 0,0627t		
Steer calves		
y = 89,92 - 7,7095x + 0,4464t	24	0,8853**
x = 11,664 - 0,1297y + 0,0579t		

y = calf livemass gain in kg

x = stocking rate (cow plus her calf = 1 unit) in units per ha

t = time in days

n = number of observations (each observation represents the mean calf gain per stocking rate treatment)

r = multiple correlation coefficient; all significant at 1% level of significance

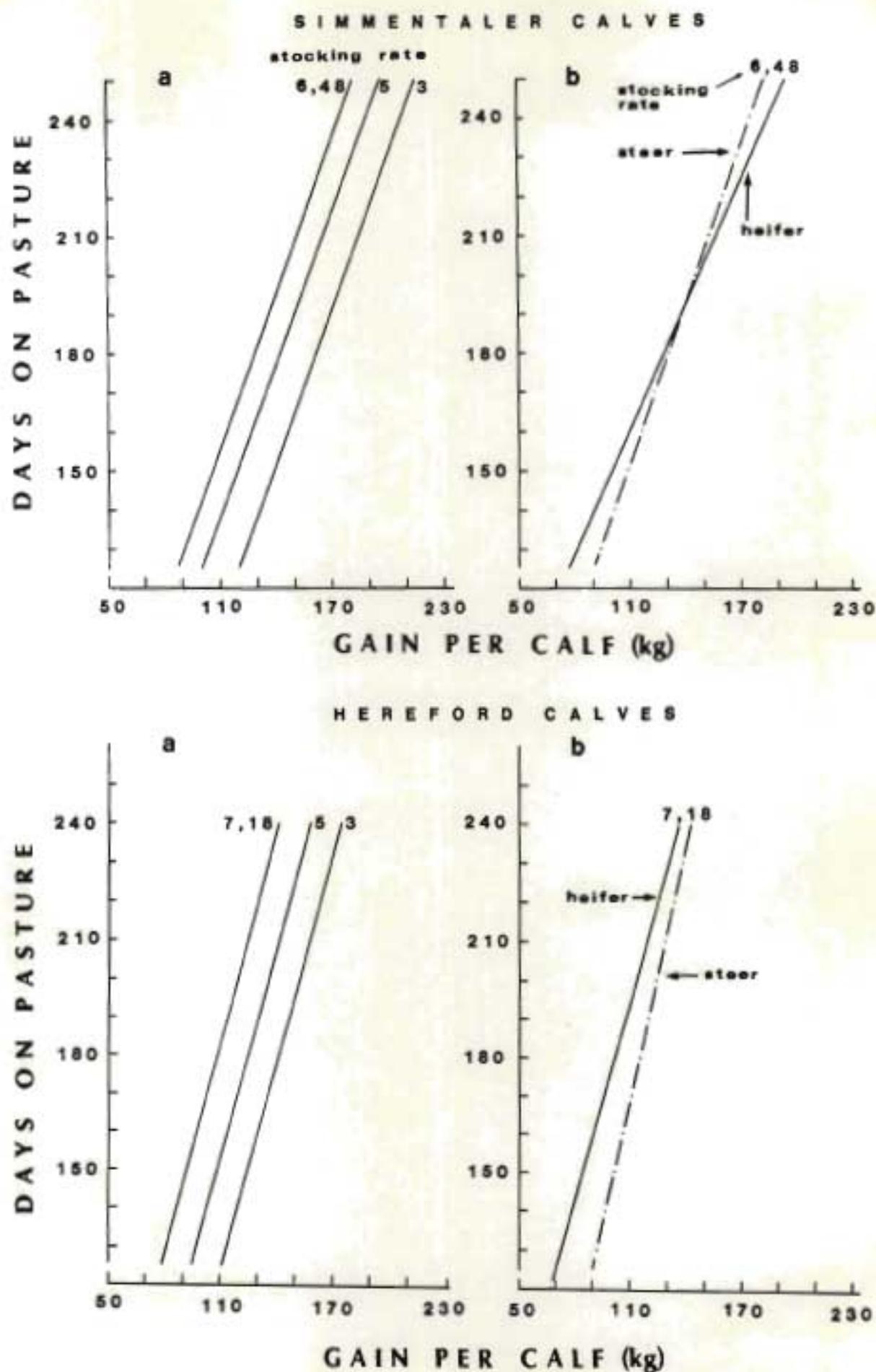


Fig. 2.15 Relationship between stocking rate, gain per calf and length of the grazing season, for steer and heifer calves together (a) and

the livemass gains of steer and heifer calves after 145 days (Fig. 2.15b).

It is difficult to explain the markedly different constants in the regression equations (Table 2.6). The low number of Simmentaler heifers (Table 2.5) and the fact that for some seasons there were either no heifers or only one heifer per treatment, may well have contributed to this deviation. Thus the regression equation for the Simmentaler heifers may not be entirely representative (it also had the lowest multiple correlation coefficient, though highly significant - Table 2.6). Although Rouquette et al. (1980) state that differences in weaning mass between steers and heifers is consistent at different stocking rates, the superior performance of the Simmentaler heifer over the steer after 145 days (Fig. 2.15b) seems possible. At the relatively high stocking rate (6,48 cows plus calves per ha), shown in Fig. 2.15b, it is possible that limited pasture availability (restricted intake) could preclude the steer calves from expressing their potential superior performance over the heifers.

The regressions of Table 2.6 (illustrated in Fig. 2.15) were derived from a range of stocking rates applied over a number of extremely variable seasons. Since these regressions account for a large percentage of variation in predicting calf livemass gain from kikuyu, it is considered that they can be used with confidence in Bioclimatic group 3.

In planning a cow-calf enterprise it is necessary to be able to predict, with a certain amount of confidence, calf performance. However, it is equally necessary to predict mass and/or condition change of the cows mothering the calves.

2.3.2.2 Cow performance

The importance of cow mass and cow mass change has been emphasised by

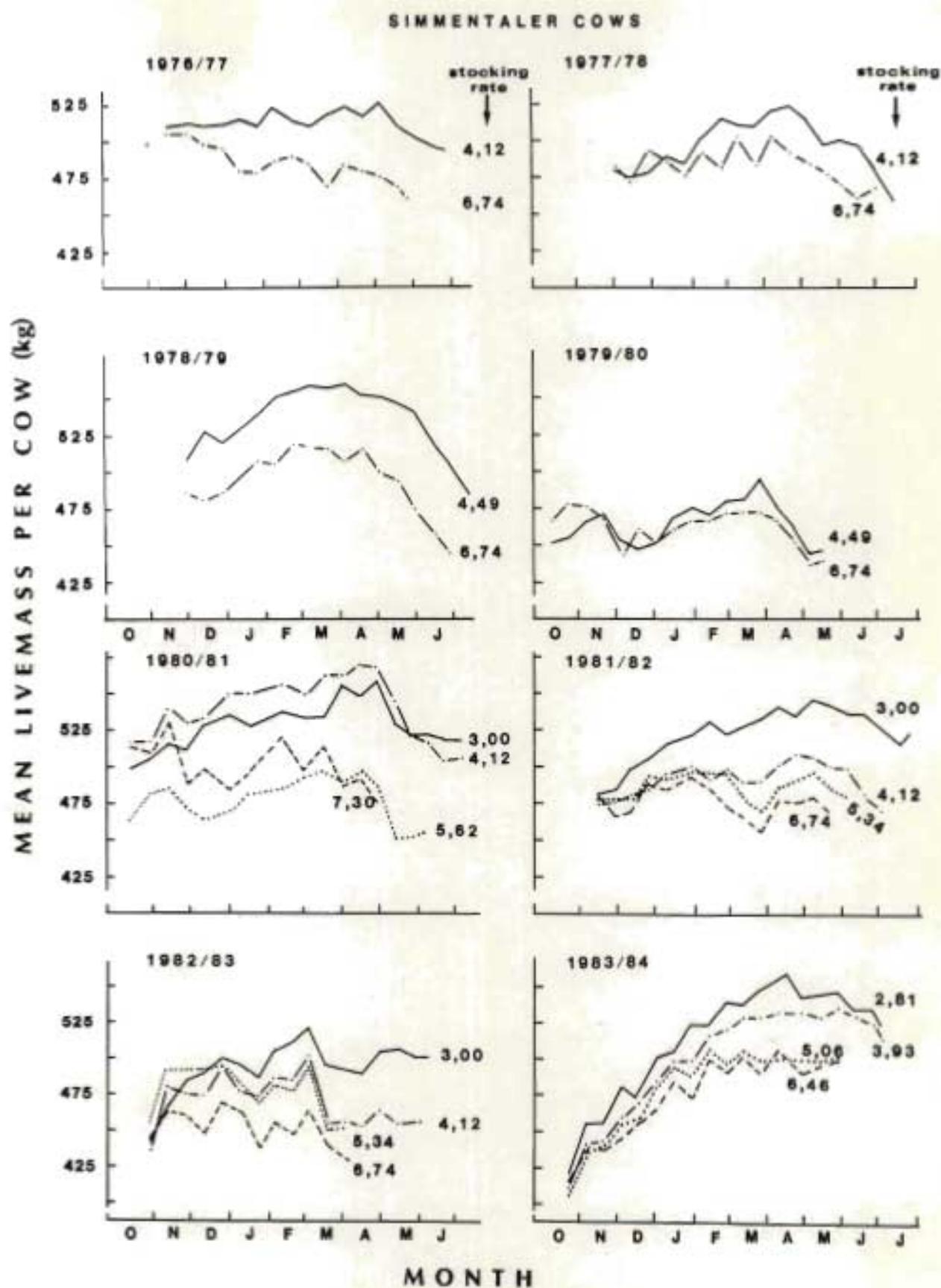


Fig. 2.16 Mass change of lactating Simmentaler cows subjected to different stocking rates on kikuyu.

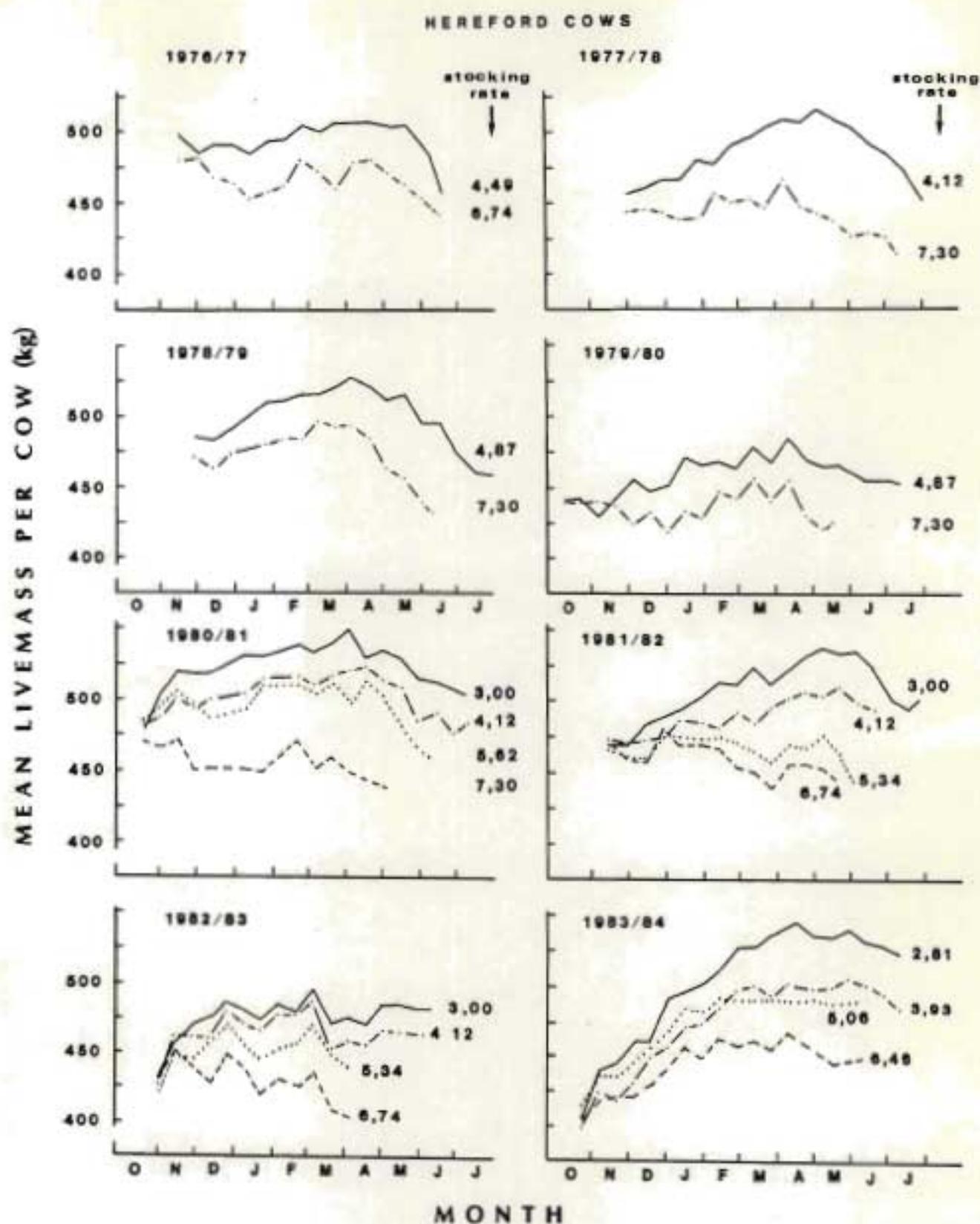


Fig. 2.17 Mass change of lactating Hereford cows subjected to different stocking rates on kikuyu.

SIMMENTALER COWS

PERCENT LIVEMASS CHANGE OF COWS

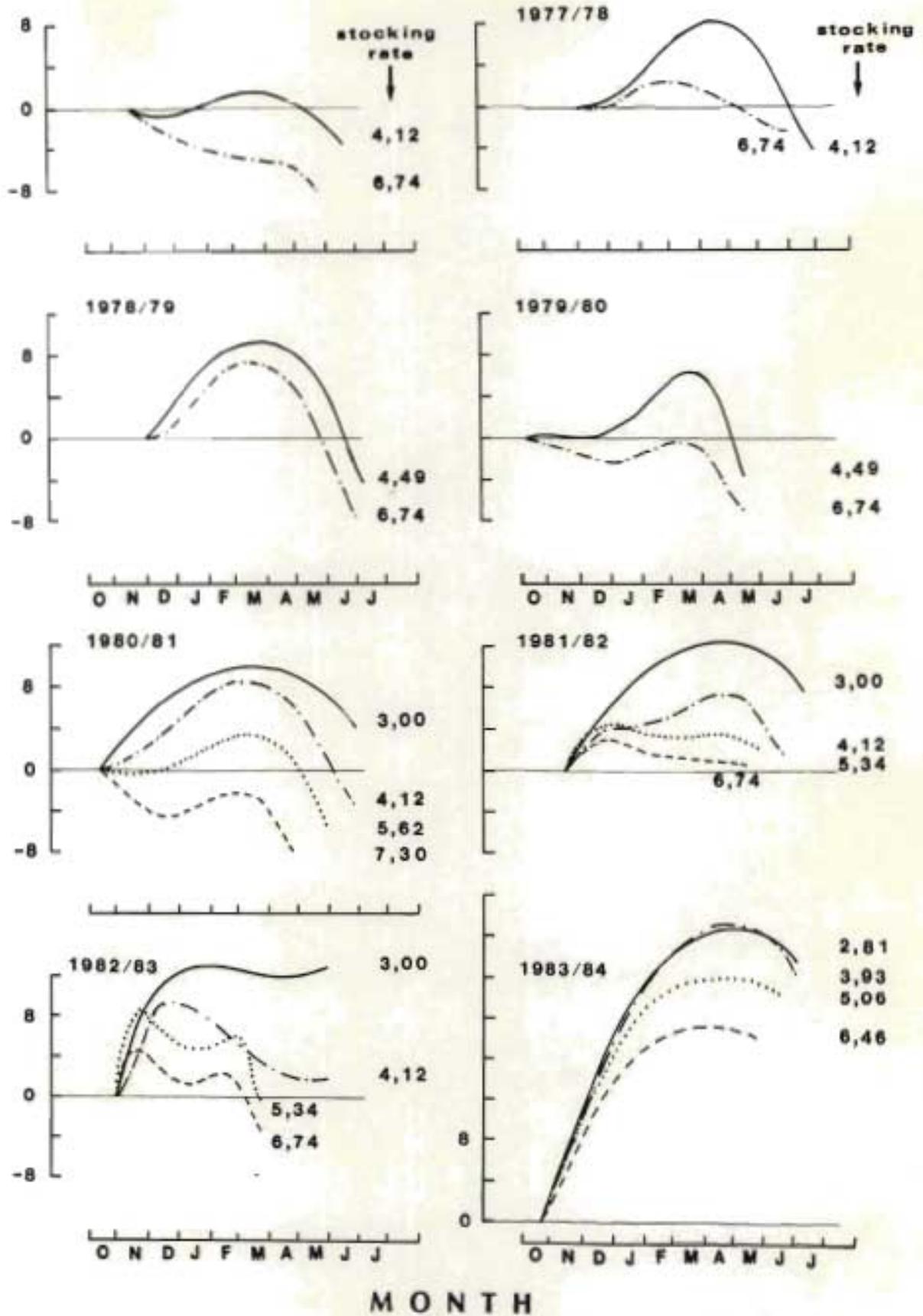


Fig. 2.18 Percentage mass change of lactating Simmentaler cows subjected to different stocking rates on kikuyu.

HEREFORD COWS

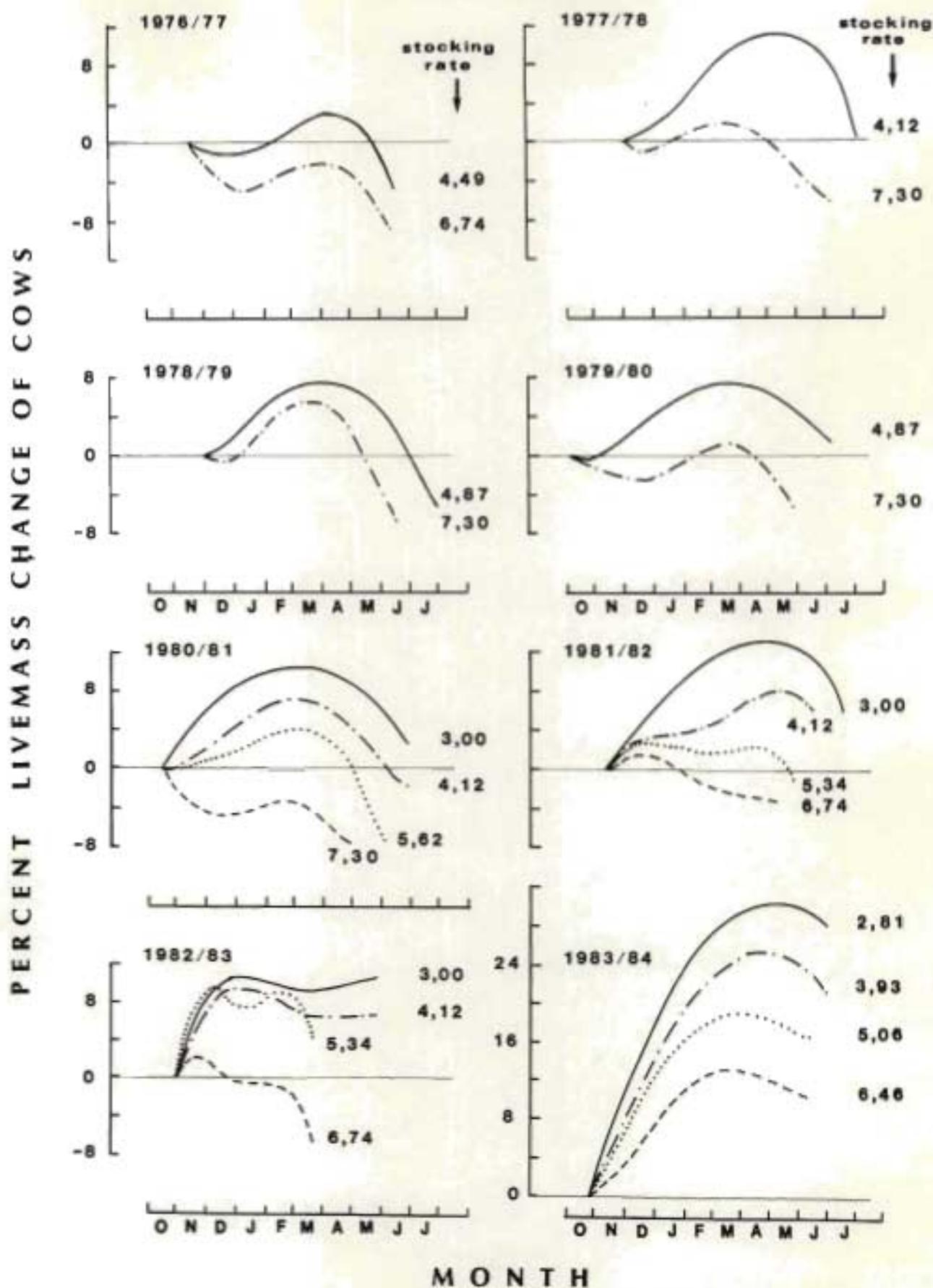


Fig. 2.19 Percentage mass change of lactating Hereford cows subjected to different stocking rates on kikuyu.

several authors (e.g. Lishman et al., 1984; van Niekerk, 1982a; Morris & Wilton, 1976).

2.3.2.2.1 Mass change of cows

The mass change of lactating Simmentaler and Hereford cows subjected to different stocking rates on kikuyu is shown in Fig's 2.16 and 2.17 respectively. Percentage mass change of the Simmentaler and Hereford cows is illustrated in Fig's 2.18 and 2.19 respectively.

Irrespective of breed or stocking rate the pattern of mass change of the cows followed a consistent pattern for each of the seasons: a gradual increase in mass, reaching a peak mass in March, followed by a decline in mass prior to the animals being removed from the pasture. This pattern may be masked by fluctuations from one weighing to the next and by initial mass differences between stocking rates (Fig's 2.16 and 2.17). However, the consistent pattern of mass change is clear from the percentage mass change illustrated in Fig's 2.18 and 2.19. The degree of mass change was, however, affected by stocking rate and season.

For both breeds the effect of stocking rate on mass change was consistent over the season. The higher the stocking rate the less the gain per cow (with peak mass in March) and the sooner and more rapid mass loss occurred towards the end of the season.

Differences in cow mass loss and gain between seasons can be related to pasture availability. Both pasture availability (Fig. 2.5) and peak cow mass (Fig's 2.18 and 2.19) occurred during March. In relating pasture availability to cow mass change it can be seen that, with few exceptions, cow mass change appeared to follow the pattern of pasture availability. However, this relationship proved to be non-significant as a result, no doubt, of several interdependent factors. (It must be remembered that pasture availability per cow refers to per cow plus her calf until weaning,

after which availability is per cow without her calf). Firstly, relatively high pasture availabilities (and thus high dry matter intake by the cow) early in the season, were accompanied by low ADG's for the cow. Being early in the cows lactation much of the nutrients ingested would have been used for milk production and not mass gain. Calf dry matter intake during early lactation, and while the calf was still small, would have been low. Secondly, during February - March with high pasture availability (the cows were in an advanced stage of lactation and thus low milk production) and low nutrient requirements for milk production, nutrients would have been available for mass gain. However, at this time calf dry matter intake would have been increasing, providing for increased competition for available herbage. Thirdly, following weaning, herbage available per cow would have been markedly increased, providing for higher intake (relative to pre-weaning) and thus improved performance with the same herbage availability per cow (availability per cow before weaning = availability per cow plus her calf; availability per cow post weaning = per cow only). Fourthly, during favourable seasons for herbage production, the cows remained on the pasture for longer than during unfavourable seasons. As pregnancy advances more nutrients are required for foetus growth and less nutrients are available for body growth. This pregnancy factor would manifest itself differently in different stocking rate treatment. The high stocking rate animals were always removed from pasture before the low stocking rate animals (removal was usually at similar pasture availabilities). For the same pasture availability the high stocking rate animals would not have needed to divert as much nutrient to foetus growth as the low stocking rate cows. Lastly, the non-significant relationship between pasture availability and cow performance may have been masked by (i) the extremely variable seasons, (ii) inconsistent and variable herbage quality changes from season to season, and (iii) the fact that the criteria

for removing the cows from pasture varied during the trial period.

A significant relationship between herbage available and cow mass change could be a useful pasture management tool. However, in a fixed stocked situation there is little the farmer can do to vary stock numbers without affecting the overall beef strategy. Furthermore, as shown earlier (cf. 2.3.2), reduced stocking rates appeared to improve pasture yields only during favourable seasons. During such seasons there would be a lesser need to adjust herbage availability to promote cow performance. It is obvious that much research is needed to evaluate the need for and the fuller on-farm implications of put and take systems.

2.3.2.2.2 Length of grazing season

Winter feeding of the cow constitutes a major cost item in the production of weaners (van Niekerk, 1982b; Somerville et al., 1983). Thus the length of the summer grazing period is important in that it determines the winter feed period.

The relationship between stocking rate and the period for which the cows, at the different stocking rates, were on pasture is shown in Fig. 2.20. This relationship was derived for all seasons (1976/77 to 1982/83) and stocking rates used.

Despite the extremely variable seasons and the changes in the criteria for removing cows from pasture the relationship between stocking rate and period on pasture was highly significant ($P < 0,001$). This relationship, between stocking rate and period on pasture, can be a useful tool in planning a cow-calf operation on kikuyu. Although only 72% of the variation in the length of the grazing season is accounted for the regression provides a guide as to the length of the winter feeding period (by difference) at different stocking rates.

Prediction of the grazing period, and thus length of the winter feed

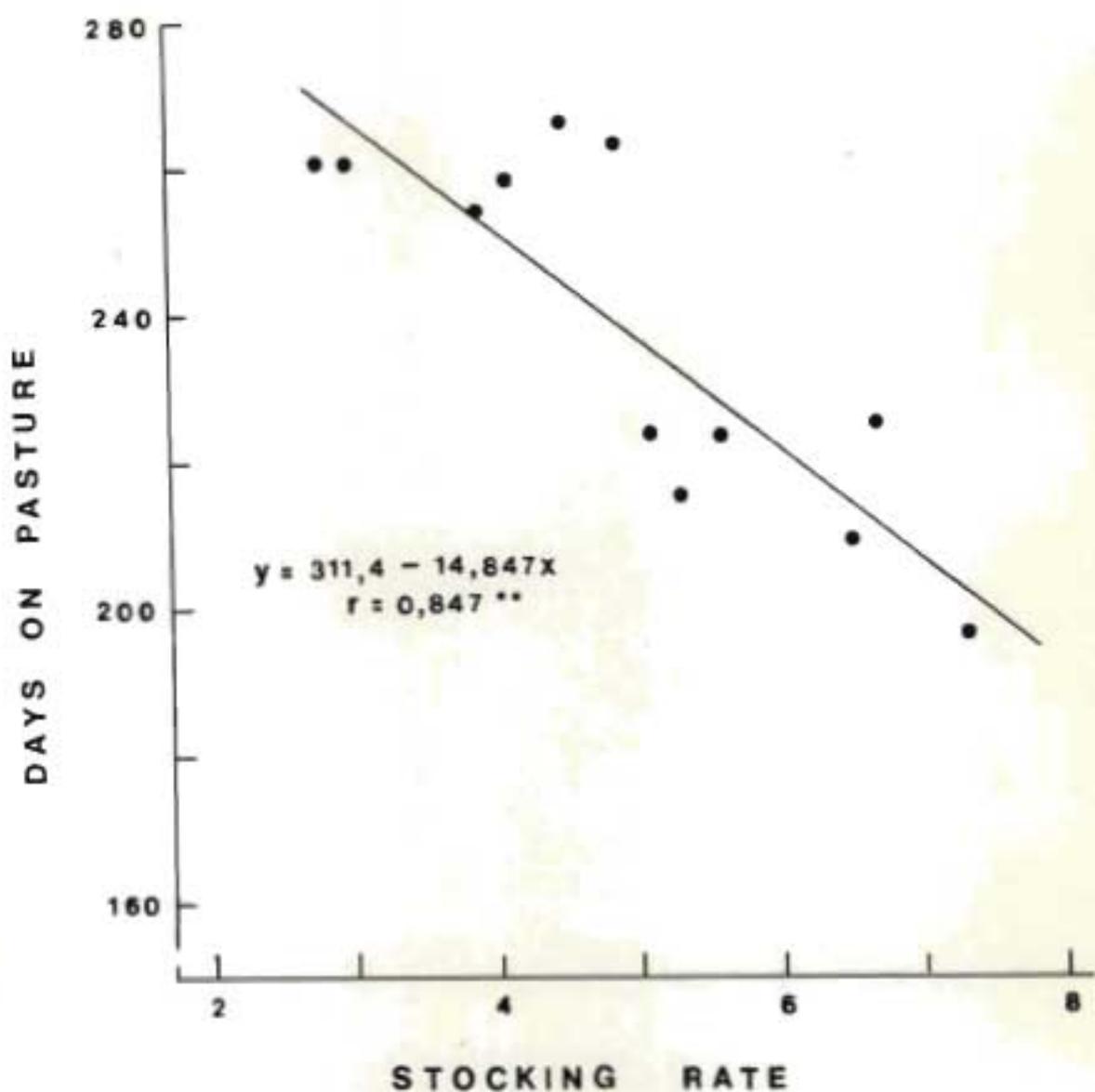


Fig. 2.20 The relationship between stocking rate and period on pasture for the cows (mean for 1976/77 to 1983/84 seasons and for Simmentaler and Hereford cows).

period (providing for estimation of quantity of feed required), is useful in planning a cow-calf enterprise. However, prediction of cow mass change (gain or loss) would provide added refinement to any planning operation in that the quality of the winter feed required (e.g. to effect maintenance or gain) could be appropriately provided for.

2.3.2.2.3 Stocking rate, time, rainfall and cow mass change

The mass change of the lactating beef cow is the result of many interrelated and interacting factors.

In an attempt to establish some of the factors which affect cow mass change multiple regression analysis, using the variables stocking rate, period on pasture and rainfall (affecting pasture yield) was used. These highly significant ($P < 0,001$) regression equations are given in Table 2.7 for both Simmentaler and Hereford type cows. Re-arrangement of the regressions, to predict cow mass change, can provide for estimates of either stocking rate or period on pasture (Table 2.7).

The relationship between cow mass change, stocking rate, period on pasture and rainfall are illustrated for two precipitation levels, and for maintenance of cow mass, a mass loss of 20kg and a mass gain of 20kg, in Fig. 2.21.

It is beyond the scope of this dissertation to discuss winter feeding of the cow per se. However, prediction of change in cow mass while on pasture provides a useful guide as to the quantity and quality of winter feed required to achieve a desired mass and/or condition at calving in spring.

2.3.3 Selection of the appropriate stocking rate

Based on the predictive equations presented earlier, selection of the "appropriate" stocking rate could start at any one of several points. The

TABLE 2.7 The relationship between stocking rate, period on pasture, total seasonal rainfall and livemass change of cows, with a calf at foot, grazing kikuyu (mean of eight seasons). Calves were weaned when they failed to show livemass gain.

Multiple linear regression				n	r
Simmentaler cows					
y	=	104,43 - 24,247x - 0,7996t + 0,27399z			
t	=	103,43 - 30,324x - 1,2506y + 0,3427z	24	0,7266**	
x	=	4,31 - 0,0412y - 0,0330t + 0,0113z			
Hereford type cows					
y	=	95,14 - 21,088x - 0,4976t + 0,18175z			
t	=	191,20 - 42,379x - 2,0096y + 0,3653z	24	0,7576**	
x	=	4,51 - 0,047y - 0,0236t + 0,0086z			

y = mass gain or mass loss per cow, in kg

x = stocking rate (cow plus her calf = 1 unit), in units per ha

t = time on pasture in days

z = annual rainfall in mm

n = number of stocking rate data points used to determine the multiple linear regression

r = multiple correlation coefficient

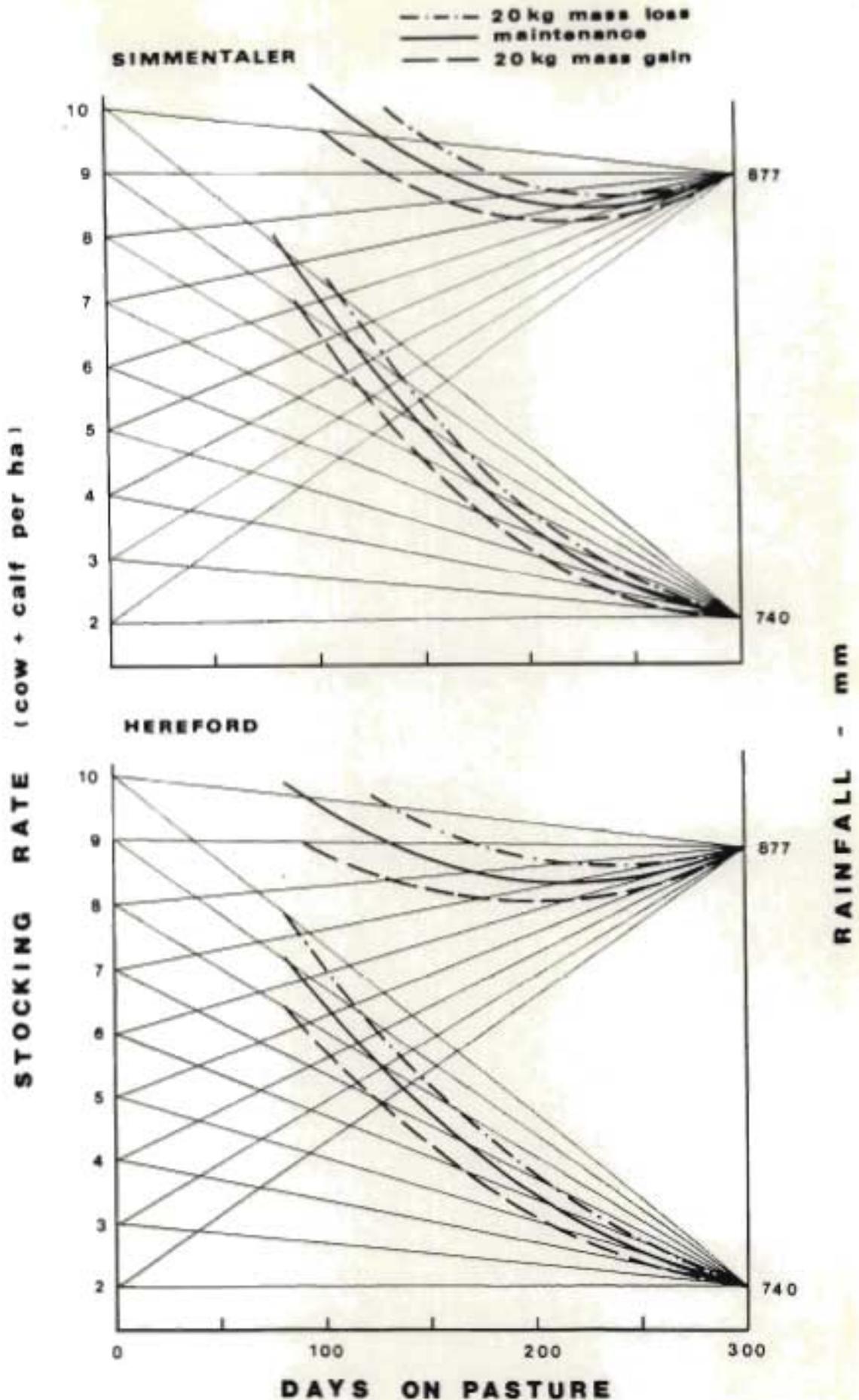


Fig. 2.21 The relationship between stocking rate, period on pasture, seasonal rainfall (741 and 877mm shown) and mass change of Simmentaler (a) and Hereford (b) cows (for regression

starting point would depend largely on available information (e.g. date on which grazing can commence) and aims. For example, should the aim be to produce weaners of a specified mass the appropriate stocking rate would be selected from the regression of stocking rate on calf livemass gain (Table 2.4 and Fig. 2.14b). Based on a starting date for grazing (24th October in Bioclimate 3) the period required to attain the specified mass can be determined from the relationship between stocking rate, livemass gain and period on pasture (Table 2.6 and Fig. 2.15). This period required to attain the mass specified will (i) indicate whether the weaners will be ready when required, and (ii) provide the data required to establish whether this is feasible for the cows (Fig. 2.20: the relationship between stocking rate and period on pasture for the cows). Once the feasibility of the period on pasture for the cows has been established, time (period) and the stocking rate (selected for calf gain) for the appropriate rainfall, would be used in the regression to predict cow mass change (Table 2.7 and Fig. 2.21). Cow mass change, together with the winter feeding period (determined by difference), would allow for estimates of quantity and quality of winter feed required for the cows. Depending on the objectives of weaner production and the limitations (e.g. provision of winter feed) of individual situations the regressions developed from the results of this trial could be used in different ways.

The overall objective to maximise profits from a cow-calf system, for a specific set of conditions, can be achieved by using the predictive models. However, it is fully realised that there are still many limitations and that considerable research is required to improve the accuracy of prediction for weaner production.

2.4 Discussion

Much of the discussion relating to the cow-calf trial has been dealt with while presenting the results. However, it is considered that several interesting points need further discussion and clarification.

As shown earlier (Fig. 2.6), as the stocking rate was reduced so there was progressively more herbage on offer per cow-calf unit. Added to this was the fact that the more herbage there was on offer the higher was the apparent dry matter intake (Fig. 2.7). In view of the quadratic relationship between herbage on offer and stocking rate, and the linear relationship between stocking rate and apparent intake, it would be expected that gain per calf per unit reduction in stocking rate would increase progressively. However, the relationships between stocking rate and ADG and between stocking rate and livemass gain (Fig. 2.14) showed no significant deviation from linearity.

There could be several reasons why the recorded animal performance - stocking rate relationship was linear, despite the fact that herbage availability and intake data suggest a curvilinear response. Firstly, wastage of pasture was not measured. The relationship between apparent intake and herbage on offer would be curvilinear if wastage were taken on a proportionate basis (increased wastage with an increase in herbage on offer). This would reduce the relative differences in predicted intake between high and low stocking rates. Secondly, the CP and CF of the herbage on offer were higher and lower respectively, for the high than for the low stocking rate treatments. Thus, although there was more herbage on offer to the low stocking rate animals (and therefore a higher intake of dry matter), the quality of herbage on offer was lower than that for the high stocking rate treatments (there was no significant effect of stocking rate on selection for CP or against CF - Fig. 2.11). It is possible that the high

stocking rate animals compensated, to a certain extent, for lower herbage intake by having a higher quality intake. Also, it is possible that the high stocking rate animals, being subject to a greater intake restriction, were more efficient in converting ingested nutrients to animal products than were the low stocking rate animals (McMeekan, 1960; A.R.C., 1980). Fourthly, the cows ability to buffer calf performance, through milk supply (Baker, 1982b), could well have compensated to a certain extent for low dry matter intake of the high stocking rate animals, relative to intake of low stocking rate animals. Lastly, there may have been insufficient data in the "light stocking rate range" to have been able to detect a significant deviation from linearity, if it exists, in the relationship between stocking rate and calf performance: this particularly in view of the large number of below average rainfall seasons. During these low rainfall seasons herbage availability limited dry matter intake on several occasions, even at the lighter stocking rates.

The main aim in characterising kikuyu was to provide realistic and reliable information for planning cow-calf systems. To this end it is considered that the present trial has provided much useful information.

Large variations in the seasons for which the trial was conducted and the range in stocking rates applied (using two animal types) make the significant relationships between (i) seasonal rainfall and herbage production, (ii) stocking rate and herbage availability, (iii) herbage on offer and apparent dry matter intake, and (iv) stocking rate and animal performance, useful planning aids. However, there is a need to assess more critically seasonal fluctuations in the nutritive value of kikuyu. Data from the present trial indicate that kikuyu is either subject to rapid changes in quality (perhaps related to short term climatic variations) or the techniques used to monitor quality were inadequate (cf. section 2.3.3). For predictive planning it would be desirable to have realistic and reliable herbage quality parameters. These quality curves could introduce

flexibility into the planning of a beef system. For example, a particular system is designed to produce weaners of a specific mass. During the season the price for a heavier weaner becomes attractive. Herbage quality curves would provide a basis for deciding whether early weaning (allowing for higher dry matter intakes of the calves if they remained on the kikuyu) would permit attainment (through increased daily gains) of the new target mass.

The main limitation resulting from the lack of reliable (though significant) regressions to predict herbage quality changes during the season, is seen as restricting the ability to predict animal performance should the system be changed during the season.

Highly significant, and it is considered reliable, regressions were developed to predict cow and calf performance. These regressions, based on animal performance recorded during eight seasons in which rainfall ranged from 580 to 933 mm, can be of immense value in planning systems for the production of weaners from kikuyu. The regressions relating (i) calf livemass gain to stocking rate, (ii) calf livemass gain to time on pasture to attain a desired gain, (iii) stocking rate to period on pasture for the cows, and (iv) stocking rate, period on pasture and rainfall to cow mass change, can be invaluable in determining the "optimum" system for a specific set of conditions. Depending on the objectives of weaner production (e.g. specific weaner mass at a specific date) or resource limitations (area of pasture, ability to provide winter feed, quality of winter feed) planning would start with different regressions. However, all the regressions (i) to (iv) above are required to assess the feasibility and profitability of the system "selected".

The regressions developed are ideally suited to computerization. If computerized, large numbers of possible permutations, based on available resources, changing objectives, differences in price predictions, winter feed costs etc., could be evaluated and the most profitable system selected

for a specific set of conditions. However, what is important, whether computerized or not, is the fact that the equations developed provide a means of predicting, for a specific set of conditions, stocking rate, calf performance, weaning mass, the period required to attain the weaning mass, the length of time the cows can remain on pasture (and thus the quantity of winter feed required for the cows) and the mass change of the cows (and thus the quality of feed required to get the cow back to the condition required at calving in spring).

Prediction of rainfall, a variable requiring a value in the cow mass change equation, could be a problem. However, the use of several rainfall values (from meteorological records) could be used in the predictive equation. The separate results, from using different rainfall values, would provide a guide as to the range of cow mass change that could be expected for different rainfall seasons. It may at first seem a disadvantage to have to predict rainfall. However, the need to provide a rainfall value in the regression to predict cow mass change could be beneficial to the planning of the system. Cow mass change is markedly affected by rainfall, which also determines to a large extent the length of the period on pasture and thus the winter feed period (quantity and quality of feed required). Thus, for example, data on the minimum rainfall that could be expected at a particular site could provide valuable information on the fodder bank required for that particular site.

Results from the present trial have provided considerable information (largely in the form of regression or predictive equations) for use in planning cow-calf systems on kikuyu. However, the predictive equations, or models, have been derived from a characterisation trial involving a fixed grazing system and a single level of nitrogen. As such the limitations of the models should be recognised. Despite the possible limitations of these predictive models (and the need for further research to improve on them) they are invaluable tools for planning weaner production from kikuyu

pastures.

2.5 CONCLUSIONS

A Pasture aspects

- * Kikuyu yields can be predicted from pasture disc meter height.
- * There was a highly significant positive relationship between seasonal rainfall and pasture dry matter yields.
- * Meaned over all seasons, stocking rate did not affect pasture yields. However, during seasons with favourable moisture regimes pasture yields increased as stocking rate was reduced.
- * As stocking rate was reduced there was progressively more herbage on offer per cow-calf unit. Availability of herbage to animals was markedly affected by large variations between seasons.
- * Maximum growth from kikuyu was recorded towards the end of February - early March.
- * There was a highly significant linear relationship between herbage on offer and apparent dry matter intake per cow-calf unit.
- * Levels of CP and CF fluctuated within and between seasons. For most seasons CP was at its lowest during February.
- * As stocking rate was increased CP increased and CF declined.
- * Irrespective of stocking rate, animals selected for herbage with a high CP and against herbage with a high CF.

B Animal aspects

- * There were highly significant linear relationships between stocking rate and calf ADG and between stocking rate and calf livemass gain per season.
- * The larger Simmentaler type animals had lower stocking rates providing

for maximum calf livemass gain per season than did the lighter Hereford type animals.

- * Simmentaler calves had approximately 12.6% better performance than the Hereford type calves. For both breeds the steer calves had, on average, a 6% higher performance than the heifer calves.
- * Cow livemass change followed a consistent pattern (though at different levels) for the separate seasons. Maximum mass, for most seasons, was attained during March.
- * There were highly significant relationships between (i) stocking rate and period on pasture for the cows (ii) livemass gain of the calves and time to attain maximum mass at different stocking rates, (iii) stocking rate and period on pasture for the cows and (iv) cow mass change as dependent on rainfall, period on pasture and stocking rate.
- * The predictive equations can be of immense value in planning cow-calf systems on kikuyu, allowing for prediction of calf mass (and time to attain mass), prediction of cow mass change and period on pasture for the cows (and thus winter feed requirements) for specific stocking rates.

C. Research needs

Considerable research is required to quantify:

- * the effect of defoliation height and frequency at different times of the season on physiological, morphological and chemical changes of kikuyu and,
- * the complex pasture-animal interface, with special emphasis on partitioning of pasture intake into cow and calf components: while this is an extremely complex relationship, particular attention should be given to the period from 90 days post partum, i.e. when calf performance

CHAPTER 3

WEANERS ON IRRIGATED ITALIAN RYEGRASS

Introduction

In planning intensive beef production systems on pastures it is necessary to have parameters or models which describe the response of animals at different stocking rates. Hodgson (1977) stresses the need for reducing grain inputs into finishing beef animals weighing 200 kg or more and the need to produce more forage of a higher quality and with better utilisation by the grazing animal.

Italian ryegrass (Lolium multiflorum Lam.) is a temperate grass species with a high dry matter yield (Rhind & Goodenough, 1976) of high quality herbage (Bredon & Stewart, 1978; Jones et al., 1980). The grass is well adapted to grazing (Frakes, 1982) and the Midmar cultivar provides reasonable production during the colder months of the year (Rhind & Goodenough, 1976).

High moisture and fertility requirements of Italian ryegrass make it an expensive pasture. Consequently the grass is utilised largely for milk production, providing for a high return. However, it is felt that high quality pasture could be efficiently utilised by young beef animals which have a high nutritional requirement (Blaser et al., 1980). If the strategy is to market early spring born calves as top quality beef at 15 months of age (before they cut their permanent teeth), it is generally accepted that, in Biogroup 3, a period of finishing in a feedlot is necessary. Currently it is generally accepted in practice that if animals are to be finished on pasture alone this will have to be on summer pasture (generally kikuyu) and that by the time the animals are marketed they may have cut their permanent

teeth, thus qualifying for lower grades.

There appears to be controversy as to the relative performance of steers and heifers and thus the role sex should play in the intensive pasture situation. Maynard (1980) reports that heifers put on fat and are marketable sooner than steers, albeit at a lower mass. Harpster, Fox & Magee (1977) found that in the feedlot steers had higher average daily gains, more fat and better feed conversion than heifers: these authors do, however, state that the heifers were inferior to the steers at the start of the trial. Ritchie, Fox & Woody (1977) found heifers to be similar to steers in average daily gain but were more efficient in feed conversion than steers.

Characterisation of Italian ryegrass using both steer and heifer weaners would help to clarify the steer - heifer situation. Furthermore, besides providing valuable information on the marketability of 15 month old animals, the use of heifers, particularly in an intensive pasture system, will also provide valuable information relating to the early mating of heifers.

It may be argued that the breed of animal should be considered in trials to evaluate the marketability of young animals. Although breed differences are real and although maturity or readiness for slaughter may well play a role Fox & Black (1977) do not consider that there is a need to make adjustments in energetic efficiency, for the feedlotting situation, for British breeds or for British x Exotic crosses.

The present trial was aimed at characterising Italian ryegrass cv. Midmar using both steer and heifer weaners. In view of the importance of monitoring both pasture and animal response this has been done within the limits set by available funds, facilities and manpower.

3.1 Methods and Materials

The experiment was conducted at Cedara College and Research Station located some 15 km north west of Pietermaritzburg. Sited on a toe slope position with a gentle northern slope of about 3%, the experimental site is at an altitude of 1 060 m above sea level, located at a latitude of 29° 32'S and a longitude of 30° 17'E. Natural vegetation of the area is typically that of the Natal Mistbelt 'Ngongoni Veld as described by Acocks (1975) with A.junciformis giving rise to a secondary succession grassland. As mentioned earlier the potential of this veld for animal production is of the order of 22 kg livemass gain per ha per annum.

The area receives a mean annual rainfall of 877 mm with an annual mean evaporation of 1 577 mm. Summers are hot and winters cold with frequent frosts. Minimum winter temperatures at the experimental site are affected by the close proximity of a national highway and railway line, both of which impede the drainage of cold air from the area.

Soils at the experimental site are of the Wilgenhof series of the Bainsvlei form (Mac Vicar et al., 1977). These soils have a high potential for pasture production (Edwards & Scotney, 1978; Edwards et al., 1980). Annual soil analyses were done to ensure that the soil fertility status was maintained above 20 ppm P and 150 ppm K, and that the acid saturation level was below 35%; this is in accordance with the pasture fertiliser advisory programme established by the Pasture Section at Cedara. The pasture was fertilised annually with 375 kg N per ha. The nitrogen applications were split into five dressings of 75 kg N. The first application was when the seedlings were 3 to 4 cm tall (i.e. early March), the second dressing in early May, the third at the end of June, the fourth in mid-August and the last dressing at the end of September - early October. The camp being grazed and the next camp to be grazed were always fertilised a week later

than the other camps which were all fertilised at the same time.

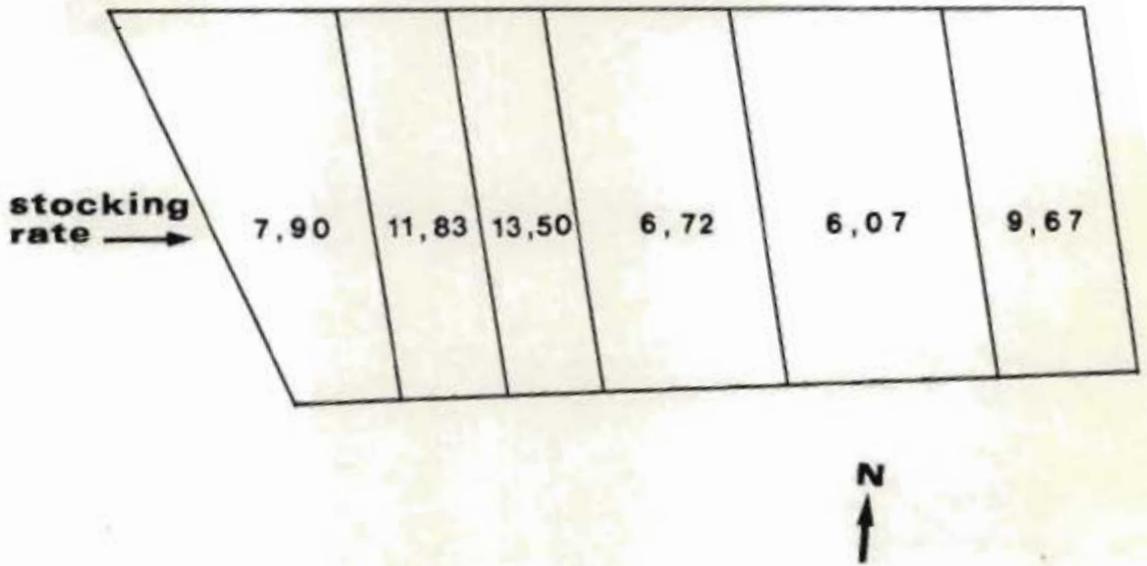
Limited irrigation facilities at the Research Station dictated the irrigation schedule. Approximately 25 mm of irrigation water was applied weekly with an overhead sprinkler system.

The Midmar cultivar of L.multiflorum was used throughout. Annual re-seeding, at 25 to 30 kg certified seed per ha, was into a fine tilth seedbed, using a conna-shea seed-drill, during mid - February: unavailability of seed necessitated a mid - March planting for the 1979 season.

In the absence of data on the performance of weaners on irrigated Italian ryegrass the 1978 season served as a "pilot trial" (only animal mass was monitored). The field layout of the experiment is illustrated in Fig. 3.1, while the basic information relating to the treatments applied, the grazing system used and the number of camps monitored to assess pasture availability and/or regrowth/utilisation are shown in Table 3.1. Sub-division of camps within a treatment was by means of electric fencing. The area designated CG in Fig. 3.1 was continuously grazed. It was originally designed to allow additional animals to the experiment to be maintained on a similar diet to those on the trial, so that animals would be available to replace experimental animals should they be needed. However, such a need seldom arose, and animal and pasture performance was monitored on this area throughout the trial period.

The trial was originally planned as a randomised block design with two replications. However, apart from the 1978 season, which served as a pilot trial, the electric fencing was repeatedly "destroyed" by two rogue animals in the 1979 season: this replication was thus continuously grazed, i.e. one camp per treatment. From the 1980 season onward the need to evaluate the difference between steers and heifers and the importance of early mating of heifers resulted in one replicate being grazed by steers and the other by heifers. In view of the characterisation approach where a minimum of two

1978 season



1979, 1980, 1981, 1982 seasons

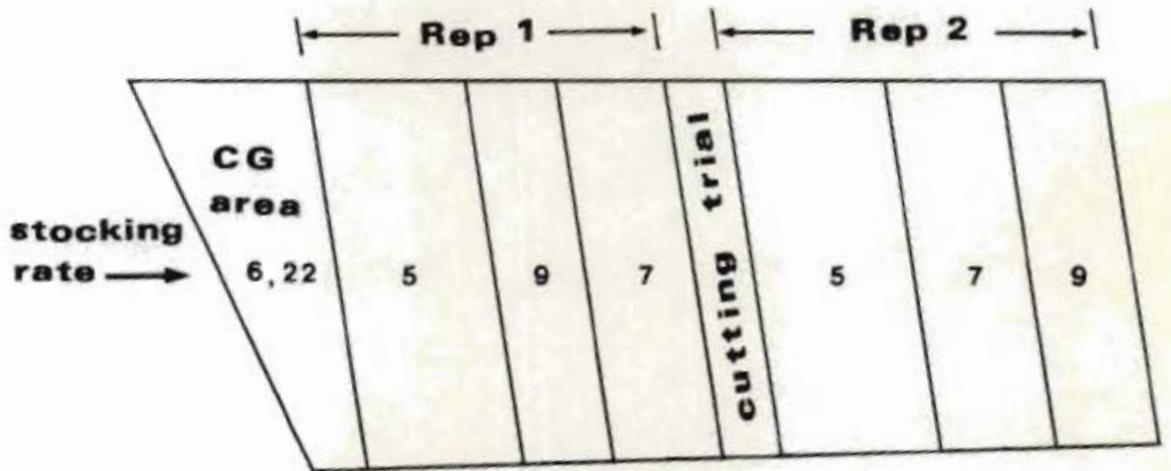


Fig. 3.1 Field layout of weaner stocking rate trial on irrigated Lolium multiflorum.

TABLE 3.1 Basic information relating to treatments applied and pasture recordings for the different seasons of the weaner stocking rate trial on irrigated Italian ryegrass.

YEAR	DATE		Rep [*]	Grazing system	Stocking rates (SR) weaners/ha	No of weaners per SR	Sex S=steer H=heifer	No of camps per SR	DISC METER RECORDINGS		
	onto pasture	off pasture							No camps monitored	No readings per occasion	Type of reading **
1978		29/11/78	-	cont	11,83;13,50						
	1/5/78	19/12/78	-	cont	7,90; 9,67	5	S & H	1	nil	-	-
		18/1/79	-	cont	6,07; 6,72						
1979	7/5/79	2/1/80	I	rot	5, 7, 9	3	S	6	1	50	IN,OUT,R
			II	cont	5, 7, 9	3	S	1	1	50	A
			C	cont	6,2	3	S	1	nil	-	-
1980	28/4/80	19/12/80	I	rot	5, 7, 9	3	S	8	4	50	IN,OUT,R
			II	rot	5, 7, 9	3	H	8	4	50	IN,OUT,R
			C	cont	6,2	3	S & H	1	1	100	A
1981	4/5/81	4/1/82	I	rot	5, 7, 9	3	S	8	8	50	IN,OUT
			II	rot	5, 7, 9	3	H	8	8	50	IN,OUT
			C	cont	6,2	3	S & H	1	1	100	A
1982	3/5/82	24/12/82	I	rot	5, 7, 9	3	S	8	8	50	IN,OUT
			II	rot	5, 7, 9	3	H	8	8	50	IN,OUT
			C	cont	6,2 & 4,3	3 to 2	S & H	1	1	100	A

- * I = Replicate I
 II = Replicate II
 C = Additional area adjacent to trial grazed continuously
- ** IN = Reading taken immediately prior to grazing
 OUT = Reading taken when animals removed from a camp
 R = Regrowth readings during period from OUT to IN
 A = Readings taken when rotationally grazed camps were monitored
 rot = Rotational grazing
 cont = Continuous grazing

NOTE

- Δ Set stocked throughout
 Δ Period of occupation for rotational grazing = 3,5 days
 Δ Animals used were Hereford x Simmentaler and Simmentaler x Hereford weaners of c. seven months at the start of each season

stocking rates are required and the low number of degrees of freedom (for the analysis of variance) generated by three treatments and two replications (restricted area, irrigation and funds precluded more replications) it was decided that the original statistical design be abandoned. This proved not to be a loss. In fact additional information was obtained in this way.

The area adjacent to the trial (CG area, Fig. 3.1), although not part of the characterisation trial, also served to provide useful additional information. This area received the same irrigation and fertiliser as the trial.

Results from a cutting trial run in conjunction with the grazing trial showed, in the 1979 season, that dry matter yields at a 4 week cutting interval were significantly higher ($P < 0.01$) than the yields from a 3 week cutting interval. This indicated the superiority of and need for a longer regrowth period between defoliations. Since the period of stay in any one camp in the grazing trial was fixed at 3.5 days per camp the grazing system was changed from 6 camps (3 week cycle) to 8 camps (4 week cycle) from the 1980 season onwards.

Pasture availability, apparent intake and regrowth was monitored (see Table 3.1) with the pasture disc meter (see Appendix 1 for specifications, use and calibration). A minimum of 50 random disc positions was taken on each occasion. With each grazing cycle the same camp (usually camp 3) was used to calibrate the disc meter before and after grazing. Twelve random positions (10 in 1979) in each treatment provided the calibration data. The calibration samples, which were cut to ground level using sheep shears, were bulked for each treatment and used for chemical analyses (N, P, K, Ca, Mg and crude fibre) and for the 1980, 1981 and 1982 seasons provided the material for leaf, stem and dead material separations. Separation for leaf, stem and dead material was done on sub-samples taken from each calibration sample every second grazing cycle. All samples were dried to a constant mass at 85° C.

Weaners for the trial were obtained from a Student Farm herd (run on Cedara) which is subjected to a "criss - cross" breeding programme. The weaners used were thus Hereford x Simmentaler and Simmentaler x Hereford. After weaning the animals were given a 7 to 10 day settling down period, on ad lib. E.curvula hay and foggaged kikuyu, before being sorted into uniform groups, by messers B P Louw and A van Niekerk of the Animal Science section at Cedara, dosed, dipped and placed on the trial. All animals were weighed weekly at the same time of the day (08h00) without starvation: water was withheld from the afternoon of the day prior to weighing. While on pasture the animals had free access to water and a 2:1:: bonemeal: salt lick. The animals were dosed at 8 to 10 weekly intervals, with a broad spectrum anthelmintic, and dipped twice while on the trial.

Analysis of the data, resulting from abandoning the original design, will be described at the appropriate stage of data presentation.

3.2 Results

3.2.1 Herbage production

Since stocking rate is regarded as the singularly most important factor affecting animal production from pastures (Edwards, 1981b), it is necessary to assess pasture productivity and availability at different stocking rates. This can provide valuable information in terms of periods when pasture availability is likely to limit animal performance: particularly with pasture species which exhibit highly variable seasonal growth patterns. Furthermore, several researchers (Edwards & Mappledoram, 1979; Parkin & Boulword, 1981; Bransby, 1981a) have found reasonable relationships between pasture availability and animal performance. Thus, information relating to pasture availability and animal performance may be useful in contributing to an explanation of the complex pasture - animal relationships.

3.2.1.1 Pasture growth and availability

The effect of stocking rate on seasonal pasture availability and growth, expressed as pasture meter disc height, is illustrated in Fig. 3.2. For each of the years evaluated the pattern was essentially similar. The somewhat erratic values for the 1979 season can be attributed to the fact that during this season only one camp was monitored (50 readings per sampling). During the 1980 season four camps were monitored (i.e. 400 readings per grazing cycle), while all camps were disced (800 readings per cycle) during 1981 and 1982. Weekly regrowth was, however, not monitored during 1981 and 1982. One hundred disc positions were taken on the continuously grazed areas.

Figure 3.2 illustrates the marked seasonal growth pattern, expressed as pasture disc meter height, of grazed Italian ryegrass. These data show that the growth pattern closely followed the seasonal drift in temperature. Differences in pasture growth rates and herbage availability (expressed as disc height) between years appears to be largely due to seasonal differences in mean minimum and maximum temperatures (Fig.3.2).

For each of the years, and for the mean over the 1980,1981 and 1982 seasons, stocking rate appeared to have no effect on the seasonal growth pattern. However, stocking rate did affect pasture growth rates with the lighter stocking rates providing for higher pasture growth rates. Differences between growth rates at stocking rates of five and seven were greater than those between seven and nine weaners per ha.

The continuous grazing treatments for the 1979 season clearly indicates the effect stocking rate and the seasonal growth pattern of the pasture had on pasture availability (Fig. 3.2a). Similar trends are indicated for the continuously grazed area (Fig. 3.2f) where the effect of reducing the stocking rate, during 1982, is clearly reflected in increased pasture

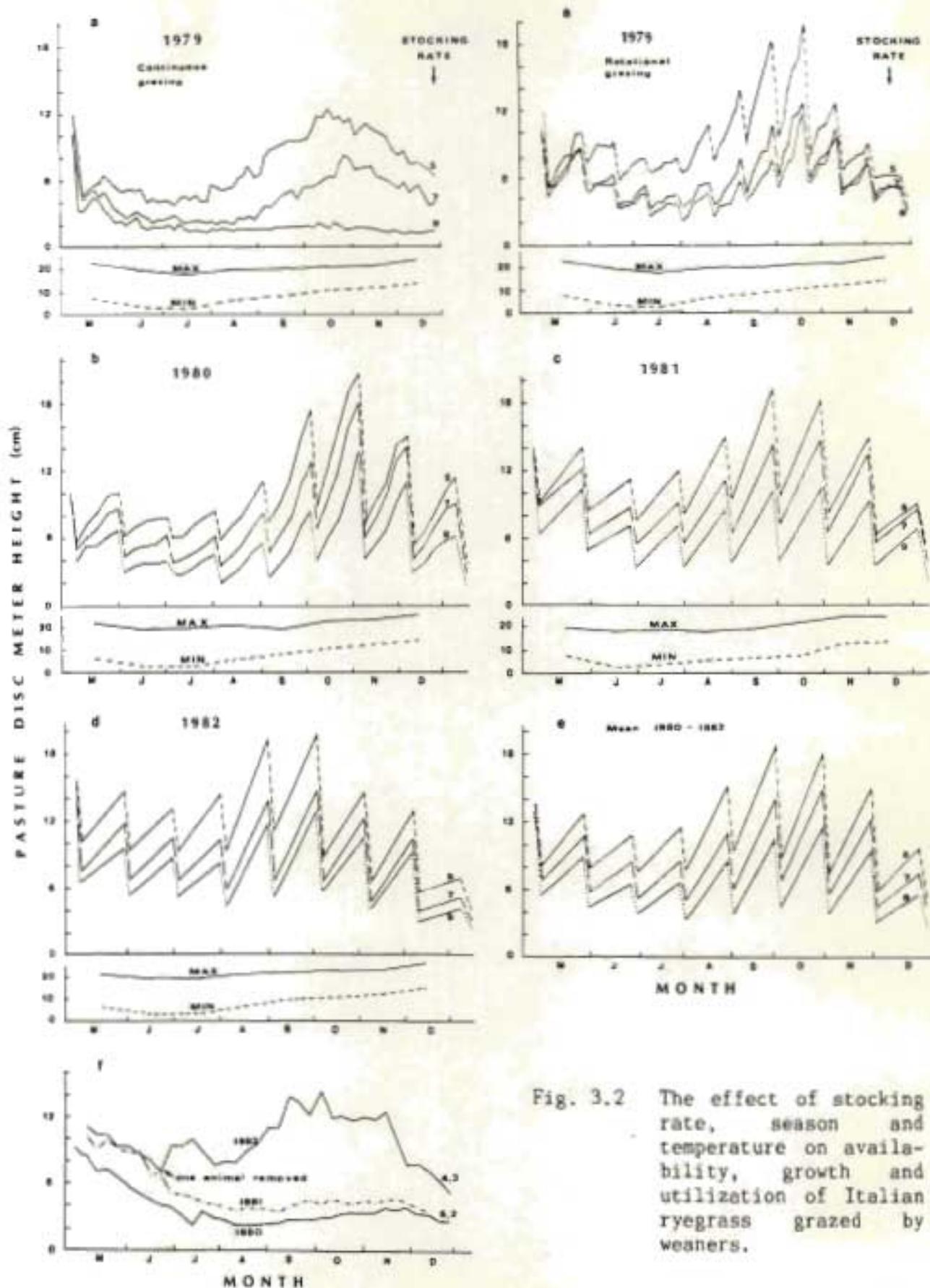


Fig. 3.2 The effect of stocking rate, season and temperature on availability, growth and utilization of Italian ryegrass grazed by weaners.

3.2.1.2 Regressions of disc height on yield

The disc meter calibration samples taken before and after each grazing cycle were subjected to regression analysis. Analysis of the data indicated that both stocking rate and the time at which samples were taken (before or after grazing) contributed significantly to the regression of disc height on yield. Neither year nor time of the season affected the regression of height on yield.

In view of the remarkable similarities in disc heights for the different years (Fig. 3.2) it is not surprising that the yield - height relationship was unaffected by years. This is in agreement with Earle & Mc Gowan (1979) who found no difference in the b coefficients of the linear regression of yield on height equations between years. However, that time of the year had no effect on the yield - height relationship is surprising. The large variation in residual material (after grazing) over the season (Fig.3.2) and the large accumulation of plant residues would have been expected to influence the yield - height relationships (Vartha & Matches, 1977). This coupled with the morphological changes associated with flowering would, it is thought, have altered the bulk density relationships of the pasture. However, Earle & Mc Gowan (1979) found that the percentage dry matter of the herbage had little effect on the yield - height relationship, while Leaver (1982) and Mc Gowan & Earl (1978) found only marginal changes in the relationship over the season.

Regression equations derived from the relationship between pasture disc meter height and herbage yield under the disc meter are given in Table 3.2, while the regression lines depicted by these equations are illustrated in Fig. 3.3. The application of the separate equations to the disc data of Fig. 3.2, to determine dry matter intake per animal, clearly indicated the marked differences between the intake data derived from using the different

TABLE 3.2 Regression equations derived from the relationship between pasture disc meter height and dry matter yield under the disc meter at the different stocking rates (over all seasons).

Equation	Variable	n	r
Eq 1	$y = 1\,101,0 + 156,06d$	3 816	0,779**
Eq 2	Before grazing		
	Stocking rate		
	5 $y = 1\,990,7 + 101,90d$	768	0,659**
	7 $y = 1\,291,2 + 125,58d$	768	0,745**
	9 $y = 817,6 + 150,95d$	768	0,824**
	After grazing		
Stocking rate			
5 $y = 1\,978,1 + 128,44d$	648	0,496**	
7 $y = 912,8 + 211,79d$	648	0,638**	
9 $y = 161,9 + 320,44d$	648	0,817**	
Eq 3	$y = 2\,580,3 + 145,72d - 179,13s - 245,81i$		0,845**

y = dry matter yield in kg per ha

d = pasture disc meter height

i = before grazing

r = correlation coefficient

s = stocking rate

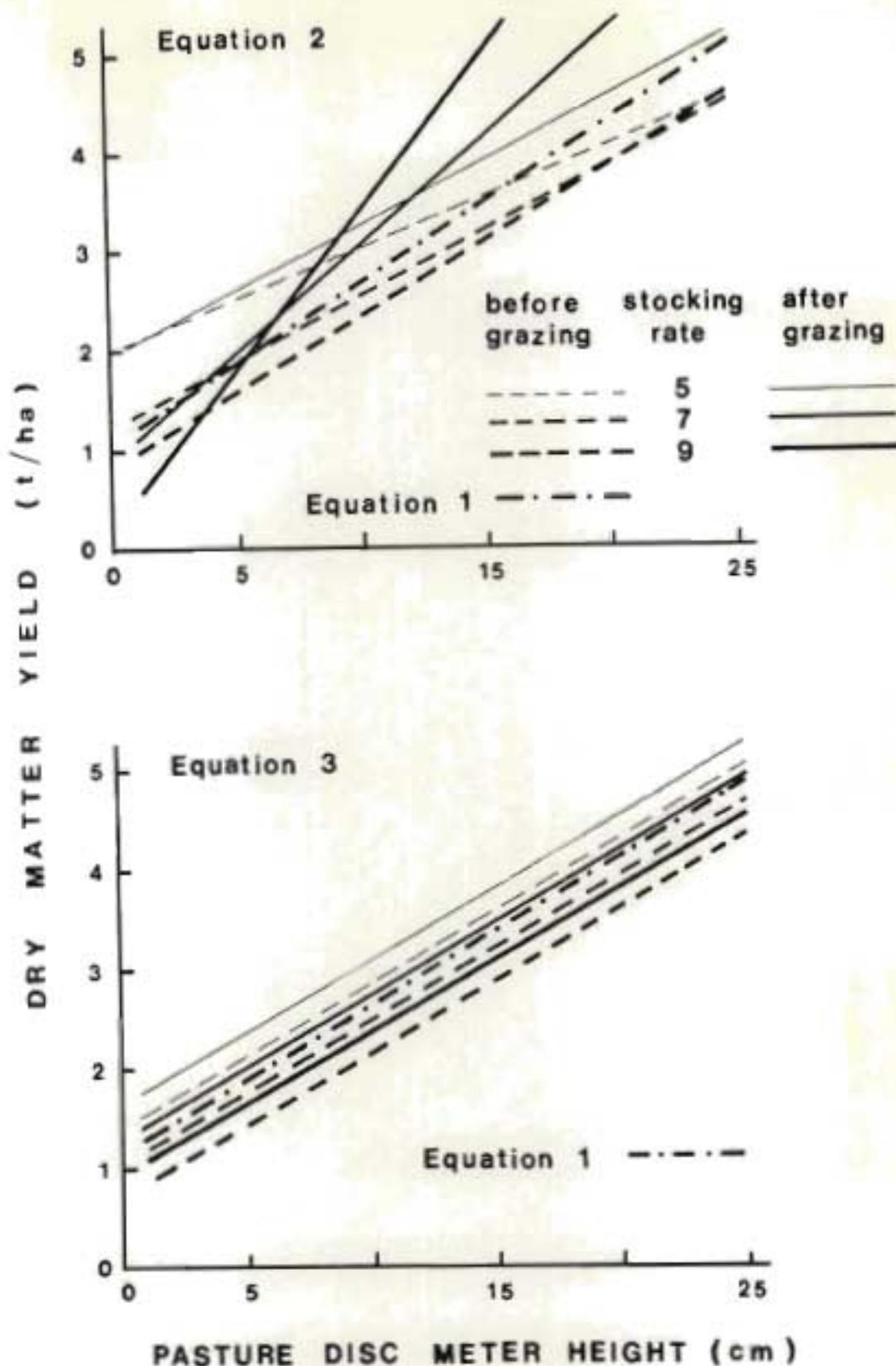


Fig. 3.3 Regression lines depicting the relationship between pasture disc meter height and dry matter yield per hectare (see Table 3.2 for regression equations).

TABLE 1.3 The effect of stocking rate and season on the apparent daily dry matter intake per animal. Estimates are from regression equations based on disc height (see Table 1.2 for equations) and animal performance - herbage quality data (Ap: after Baker, 1982: pages 88 - 89) for the 1980, 1981 and 1982 seasons.

Grazing cycle	Stocking rate	Mean apparent daily dry matter intake (kg) per animal per grazing cycle											
		1980				1981				1982			
		Eq 1	Eq 2	Eq 3	Ap	Eq 1	Eq 2	Eq 3	Ap	Eq 1	Eq 2	Eq 3	Ap
1	5	5.55	2.77	3.56	3.28	7.33	3.29	5.26	8.03	7.77	3.37	5.59	5.35
	7	4.58	3.56	3.04	3.82	6.55	2.67	3.67	5.00	6.10	3.52	4.48	4.78
	9	4.37	4.51	2.99	3.28	5.57	3.20	3.81	4.52	5.59	3.08	3.74	4.21
2	5	4.91	1.99	2.33	4.15	7.13	2.92	4.32	7.64	6.61	2.33	4.00	7.80
	7	3.82	3.06	1.96	3.82	4.81	2.98	3.10	6.09	4.43	2.27	2.63	7.18
	9	2.29	3.14	0.79	2.83	3.74	2.63	2.21	5.09	2.94	1.49	1.63	5.31
3	5	2.81	1.03	1.18	5.20	4.40	1.30	2.32	8.08	4.73	1.16	2.62	9.02
	7	2.18	1.99	0.64	4.63	3.06	1.71	1.38	6.57	3.37	1.53	1.71	9.47
	9	0.84	1.89	0	3.16	2.38	2.40	1.22	5.59	2.35	1.12	1.06	6.28
4	5	3.32	1.00	1.52	6.32	4.86	1.52	2.91	8.81	6.37	2.23	4.69	9.60
	7	2.35	2.45	1.00	5.65	3.25	1.99	1.78	7.10	5.92	2.34	2.69	9.51
	9	1.36	2.88	0.35	3.96	2.53	2.73	1.37	5.76	5.11	1.33	1.72	6.82
5	5	4.98	1.80	3.37	7.24	7.23	2.09	5.18	9.00	10.94	4.40	8.00	9.44
	7	3.24	2.50	1.99	6.65	4.26	2.50	2.87	7.56	6.55	4.14	4.69	9.69
	9	2.18	3.30	1.17	5.30	3.32	3.22	2.08	6.20	5.11	3.64	3.34	7.11
6	5	11.26	5.59	8.78	7.93	12.36	6.12	9.39	9.16	13.64	7.07	10.33	8.78
	7	5.80	3.56	4.30	7.29	5.65	3.99	4.72	7.75	7.48	4.67	5.32	9.10
	9	3.68	3.59	2.58	6.14	4.40	4.17	3.00	6.37	5.14	3.54	3.41	7.14
7	5	16.82	9.46	13.09	8.70	12.71	6.61	9.56	8.79	9.84	5.04	7.24	7.79
	7	10.08	7.80	8.20	7.25	6.15	4.97	5.56	7.52	6.61	4.97	4.73	7.71
	9	6.76	5.90	3.89	6.58	4.78	4.79	3.31	6.25	4.07	3.92	3.02	6.54
8	5	12.09	6.78	9.04	8.81	10.50	5.54	7.18	7.74	9.12	4.80	5.66	6.90
	7	7.95	6.38	5.77	6.58	5.31	5.03	5.18	6.97	5.92	4.94	3.60	5.65
	9	5.36	5.77	3.74	4.92	4.14	4.21	2.52	6.65	4.39	4.80	2.68	5.25
9	5	8.69	4.76	5.64	neg.	5.37	2.59	2.88	neg.	2.63	0.99	0.61	neg.
	7	5.42	4.95	3.67	gain	3.95	3.41	2.34	gain	1.91	2.11	0.31	gain
	9	3.70	4.82	2.16		3.07	4.12	1.64		1.24	2.40	0.09	

regressions. This data is given in Table 3.3.

In order to obtain some estimate of "expected" dry matter intakes, animal performance data, together with herbage quality, was used to calculate intake. Steer and heifer performance was meaned and the method proposed by Baker (1982a) was used. These dry matter intakes are also given in Table 3.3. Large discrepancies exist between intake derived from animal performance data and those derived from the regression equations. During periods of low pasture availability (grazing cycles 3 and 4), predictions based on animal performance are higher than those from the regression equations. For periods of high pasture availability, intakes predicted from the regression equations are both higher and lower than intakes based on animal performance. However, during periods of low pasture availability dry matter on offer to the animals was such that it precluded the intakes predicted from animal performance data.

Equation 3 (Table 3.2) has the highest correlation coefficient, accomodates the effect of stocking rate, and distinguishes between yield estimates in both the before and after grazing situations. However, the unrealistically low intake figures, particularly during periods of low pasture availability suggests that this regression is unreliable and should be discarded. Equation 2 (Table 3.2), like equation 3, also caters for the effects of stocking rate and grazing. However, the relatively low correlation coefficients of equations 2 (although highly significant) and the generally low intake estimates (at times the low stocking rate animals had lower intakes than the high stocking rate animals) suggests that these equations are also unreliable.

Results from the multiple regression analysis indicate that several factors are involved in the disc height - herbage yield relationship of Italian ryegrass. Since time, resulting in the accumulation of ungrazed residual material over the season, had no significant effect on the height - yield relationship, but time of sampling (before versus after grazing) did,

some factor(s) other than accumulation must have been involved.

The relatively large proportion of dead material (rejected by the grazing animals: Jones, 1981) following grazing is accounted for in the calibration taken after grazing. However, the rapid disappearance of this dead material (Hunt, 1965; Tainton, 1974; Wilman & Mares Martins, 1977; Marnette, 1978) immediately following grazing means that it is not included in the before grazing estimate of the next cycle. Added to this is the fact the more severe trampling in the high, relative to the low, stocking rate treatments, increases the proportion of material which is trampled, dies and disappears before the next grazing cycle. Furthermore, it is highly probable that the less severe trampling, at the low stocking rate, is less damaging to leaf material and allows for much of the trampled material to erect itself and thus be included in the next before grazing calibration. Therefore, it seems likely that the significance of the before and after grazing effects and the stocking rate effects on the regression are likely to be spurious.

Thus it is felt that equation 1 (Table 3.2), although not accounting for stocking rate or before or after grazing effects, provides for more realistic dry matter intake figures than do equations 2 and 3. However, compared to the estimates of intake derived from animal performance data, equation 1 provides for relatively high animal intake of dry matter at high levels of pasture availability and relatively low intakes during periods of low pasture availability. Nevertheless equation 1 is considered to be a good practical approximation. It is interesting that Castle (1976), working with ryegrass and cocksfoot, states that as a rough approximation 1 cm on the vertical disc meter scale measures a yield of 160 kg dry matter per ha. This is not very different from the value of 156,06 kg dry matter per ha per 1 cm height for equation 1.

3.2.1.3 Dry matter yields and utilisation

Using the regression equation $y = 1\ 101,0 + 156,06 d$ (y = yield in kg dry matter per ha, d = mean pasture meter disc height), total seasonal herbage dry matter production and utilisation was determined for each of the seasons. The effect of stocking rate and type of weaner (heifer or steer), on total seasonal production per ha and utilisation per ha, is shown in Table 3.4 and Fig. 3.4.

From Table 3.4a it can be seen that there was a remarkably similar level of herbage production for each of the seasons (means over stocking rates, steers and heifers). However, the effect of stocking rate on dry matter yields indicates that as stocking rate is reduced there is an increase in herbage production. Furthermore, for each of the seasons, at the same stocking rate, the generally lighter mass of the heifers, compared with the steers, resulted in slightly higher pasture yields being recorded from the heifer than from the steer treatments.

The increase in yield associated with reduced stocking rate is related to the severity of defoliation affecting regrowth rates. The more severe defoliation at the high, relative to the low stocking rate, resulted in a greater reduction of leaf area and of stubble on the high stocking rate treatment. This would have reduced the net assimilation rate and the available energy substrates of the plants of this treatment. At the light stocking rate, on the other hand, the relatively higher leaf area index and amount of stubble remaining after defoliation would have provided for higher regrowth rates (Donald & Black, 1958; Booysen, 1966; Youngner, 1972), and thus greater total herbage production per ha over the season. Similarly the superior herbage yields recorded for the heifers, as opposed to the steers, can be related to residual leaf area and stubble. The heifers, although harvesting more material per ha of pasture than the steers, defoliated the

TABLE 3.4 The effect of stocking rate, season and sex of weaner on the annual dry matter production (a) and utilization (b) of Italian ryegrass determined from pasture disc meter readings (yield in kg/ha = 1101,0 + 156,06 disc height) : material remaining after removing the animals excluded.

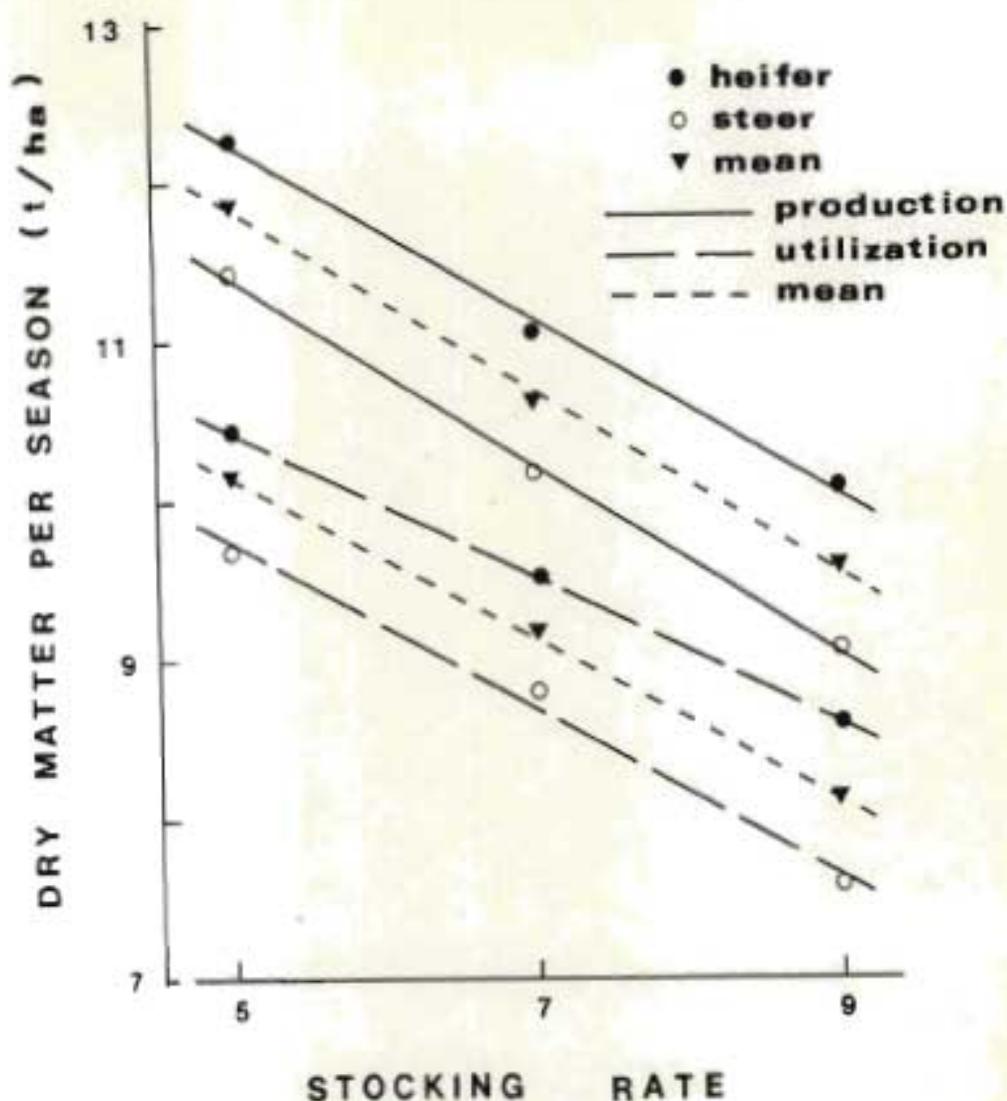
(a) Dry matter production

Season	STOCKING RATE						Mean
	5		7		9		
	Heifer	Steer	Heifer	Steer	Heifer	Steer	
1979	-	11 325	-	9 378	-	8 890	9 864
1980	11 691	11 719	10 725	10 355	9 170	8 968	10 438
1981	12 358	11 515	10 570	10 643	10 612	9 114	10 802
1982	12 799	11 093	11 842	9 543	10 414	9 092	10 797
Mean *	12 283	11 442	11 046	10 180	10 065	9 058	10 679
SE	± 322	± 184	± 410	± 329	± 451	± 45	

(b) Dry matter utilization

1979	-	9 477	-	7 738	-	7 161	8 125
1980	9 800	9 916	9 071	9 186	7 660	7 508	8 857
1981	10 554	9 713	9 066	9 381	9 215	7 641	9 262
1982	11 009	9 435	10 329	7 999	8 962	7 650	9 231
Mean *	10 454	9 688	9 489	8 855	8 612	7 600	9 116
SE	± 353	± 139	± 420	± 432	± 482	± 46	

* = 1980, 1981 and 1982 seasons



Regression equations		r
Production		
Heifer	$y = 15\,012 - 555,50x$	0,9978
Steer	$y = 14\,399 - 596,00x$	0,9994
Mean	$y = 14\,706 - 575,25x$	0,9988
Utilization		
Heifer	$y = 12\,741 - 460,50x$	0,9996
Steer	$y = 12\,368 - 522,00x$	0,9933
Mean	$y = 12\,686 - 507,00x$	0,9996

r = correlation coefficient : all values $P < 0,001$

y = kg dry matter per ha

x = stocking rate in weaners per ha

Fig. 3.4 The effect of stocking rate and sex of weaner on mean total seasonal dry matter production and utilization.

sward less severely than did the steers. This was because of increased yields produced by the pastures grazed by the heifers.

As was the case for levels of herbage production, the levels of pasture utilisation per ha were remarkably similar for each of the seasons (means over stocking rates, steers and heifers). Furthermore, utilisation of the pasture followed the pattern of herbage production. Increased utilisation (in terms of kg dry matter per ha) was recorded for those treatments with the higher levels of herbage production. Thus the lighter stocking rates had the higher levels of production and utilisation. Similarly, heifers utilised more material per ha than did the steers (Table 3.4, Fig. 3.4).

The pattern of herbage production and utilisation should, however, be seen in relation to the possible effects of the disappearance of trampled material mentioned earlier (3.2.1.2). In the regression equation used to determine dry matter production and utilisation cognisance is not taken of this seemingly important component of grazed Italian ryegrass. It is possible, therefore, that the high stocking rate treatments in fact produced more material, and that more of this was utilised, than is suggested by the data.

However, when seen on a percentage basis, utilisation (expressed as a percentage of herbage production) was not affected by stocking rate, steer or heifer treatments. Percent utilisation ranged from 84 to 86% with a mean utilisation of $85,35 \pm 0,43\%$, over all treatments and seasons.

3.2.2 Herbage quality

While it may be reasonable to judge pasture quantity and quality by recording the overall gain or loss in animal mass for the whole season, data which reflect changes in animal performance (and therefore in forage quality and quantity) throughout the season may be extremely useful in the

interpretation of the results of characterisation trials. It is necessary to monitor pasture quality to establish whether or not there are times during which pasture quality restricts animal performance and the possible effects this may have on the overall profitability of the system.

The effect of stocking rate, over the seasons evaluated, on the seasonal variations in crude protein (CP), crude fibre (CF) and total digestible nutrient (TDN) contents of the herbage, before and after grazing, are illustrated in Fig's 3.5, 3.6 and 3.7 respectively. Multiple regression equations fitted to the CP, CF and TDN data are presented in Table 3.5.

3.2.2.1 Crude protein

It is evident from Fig. 3.5 that the before grazing CP values followed a consistent pattern over the four seasons (Fig. 3.5 a,b,c,d) and that the after grazing values also showed a consistent, but different, pattern over the three seasons (Fig. 3.5 e,f,g). The multiple regression polynomials fitted to the CP data clearly indicate those factors having the greatest influence on variations in the CP content over the season (Table 3.5).

The highly significant difference ($P < 0,001$) between the percent CP before and after grazing, is to be expected. The animals obviously selected a high quality diet (leaves in preference to stem and dead material - Fig's 3.8, 3.9) and rejected herbage with a lower protein content. However, the CP level of the material left after grazing remained above 14% until the end of October in all years except 1981 when it fell below 10% in November - December, (Fig 3.5f). This clearly indicates the high CP status of accumulated and old material. Even in the 1982 season, when a considerable amount of residual material accumulated, the CP content remained high through to the end of the season (Fig. 3.5g).

From the regression polynomials and the data of Fig. 3.5 it is clear that time had a considerable effect on changes in the percent CP of the

TABLE 3.5 Regression equations describing the relationship between stocking rate, time, before (IN) and after (OUT) grazing on the crude protein, crude fibre and total digestible nutrient content of Italian ryegrass (equations are of the form $y = b_0 + b_1x + b_2y + b_3y^2 + b_4z$)

Variable/ Year	Constant	IN or OUT (IN = 0; OUT = 1) (x)	Time in weeks, 1 = first week in May time (y)	1 = time ² (y ²)	Stocking rate in weaners/ha (z)	Multiple correlation coefficient R
	b_0	b_1	b_2	b_3	b_4	
Percent crude protein (y =)						
1979	23.84		+ 0.245 f	- 0.01575 h	ns	0.918 h
1980	17.50	- 4.61 h	+ 0.489 h	- 0.01985 h	+ 0.348 g	0.875 h
1981	19.93	- 4.96 h	+ 0.449 h	- 0.01913 h	ns	0.859 h
1982	17.24	- 3.57 h	+ 0.221 g	- 0.01103 h	+ 0.380 g	0.851 h
Mean *	17.94	- 4.47 h	+ 0.386 h	- 0.01660 h	+ 0.291 h	0.871 h
Percent crude fibre (y =)						
1979	22.33		- 0.150 f	+ 0.01607 h	- 0.433 g	0.953 h
1980	24.70	+ 1.69 h	- 0.525 h	+ 0.02739 h	- 0.674 h	0.962 h
1981	23.81	+ 2.14 h	- 0.297 h	+ 0.01999 h	- 0.460 h	0.910 h
1982	23.72	+ 3.24 h	ns	+ 0.00680 g	- 0.618 h	0.920 h
Mean *	24.13	+ 2.46 h	- 0.278 h	+ 0.01834 h	- 0.584 h	0.902 h
Total digestible nutrients (y =)						
1979	66.20		+ 0.170 g	- 0.01474 h	+ 0.352 g	0.959 h
1980	63.88	- 1.95 h	+ 0.479 h	- 0.02338 h	+ 0.582 h	0.969 h
1981	64.85	- 2.35 h	+ 0.296 h	- 0.01821 h	+ 0.369 h	0.917 h
1982	64.72	- 2.94 h	+ 0.019 h	- 0.00668 h	+ 0.518 h	0.924 h
Mean *	64.28	- 2.68 h	+ 0.299 h	- 0.01719 h	+ 0.495 h	0.920 h

ns = not significant

f = significant at 5% level of significance

g = significant at 1% level of significance

h = significant at 0.1% level of significance

* = mean for 1980, 1981 and 1982 seasons

herbage over the season. The highly significant effect of time ($P < 0.001$) was probably related not only to growth rates of the pasture but also to the physiology of the plant. During the 1979, 1980 and 1981 season, declining growth rates of the pasture (Fig. 3.2) were associated with relatively constant or slightly declining CP values until the end of June, whereas during the 1982 season constant, or slightly increasing, growth rates resulted in increasing CP over the same period. As pasture growth rates increased from the end of July, for all stocking rates and all seasons, there was a concomitant increase in the percent CP of the herbage until the end of August.

Although the CP content of the pasture appeared to follow pasture growth rate until the end of August, this was not so from September to November (cf. Fig's 3.2 and 3.5). High pasture growth rates from the end of August were accompanied by declining CP levels. Although the accumulation of older material with a lower CP content, resulting in a dilution effect (Anon., 1979), may well have contributed to reduced CP with high growth rates, it is felt that flowering had the greatest effect. Crude fibre analysis (Fig. 3.6) and leaf-stem determinations (Fig. 3.8) clearly indicate increases in CP content and stem fractions of the pasture from August. This coupled with the fact that the "closing down date" (to prevent animals grazing emerging inflorescences) for seed production from Midmar ryegrass is the end of September (Rhind, 1980) and the fact that for this cultivar the average heading date (date on which 50% of inflorescences emerge) is 27 October (Rhind & Goodenough, 1976), points to flowering stems, which have a lower CP content than leaves (Kilcher & Troelsen, 1973), contributing largely to the declining CP content from the end of August.

Considering the mean over all seasons, the highly significant ($P < 0.001$) effect of stocking rate on the percent CP in the herbage (Table 3.5)

indicates increasing CP levels of the herbage as stocking rate is increased. Although stocking rate did not significantly affect CP levels during the 1979 and 1981 seasons, the same trends were nevertheless indicated (Fig. 3.5). In view of the consistent trends and similar CP levels of the herbage in the after grazing situation, over the different seasons (Fig. 3.5 e,f,g), it is felt that the significant effect of stocking rate on the percent CP may well have been due largely to the dilution effect mentioned earlier, rather than to an effect on the relative production of leaf and stem. Thus although the growth rate of the pasture increased with a reduction in stocking rate, and therefore greater quantities of young high quality material were produced through the season on the low as compared with the high stocking rate treatments, the accumulation of low quality old forage at low stocking rates was such that overall CP content declined.

The percent CP of the herbage on offer on the continuously grazed area followed essentially the same pattern and levels of CP as on the rotationally grazed pasture.

With the exception of the 1981 season when the recorded after grazing percent CP was below 10% at the end of November - early December, the percent CP of the herbage (before and after grazing) was consistently higher than the N.R.C. (1976) requirement of 10% CP for an average daily gain of 0,9 kg for a 350 kg animal.

The mean effects of stocking rate and time, over all seasons, on the pasture CP levels both before and after grazing is illustrated in Fig. 3.5h. This figure, derived from the mean polynomial regression of Table 3.5, aptly depicts the effects of stocking rate and time on the CP content of the pasture, recorded for the separate seasons, and indicates the relatively high CP content of the pasture even towards the end of the season.

3.2.2.2 Crude fibre (CF)

The effect of stocking rate and time on the CF content of the herbage on offer to the animals at each grazing cycle and the CF content of the material remaining after each grazing are illustrated in Fig. 3.6 and described by the regression polynomials of Table 3.5. Although the magnitude of change in CF was not as great during the 1982 season as it was during the other seasons, the pattern of change followed a remarkably consistent pattern for each of the seasons.

Differences in the CF content of the herbage before and after grazing ($P < 0,001$ for each of the seasons and for the mean over seasons) reflect differences due to animals selecting material with a low CF content and avoiding material containing high CF. Since the stems contain higher CF than the leaves and as the animals were selecting against stems (cf. Fig. 3.9b) the higher CF content of the herbage remaining after grazing, compared with the CF content before grazing, was as expected. Since it was obvious that animals selected leaves in preference to stems, the relative difference between the CF content of the herbage before and after grazing was not as high as would be expected. This indicates the relatively low CF content of the stems. It should, however, be pointed out at this stage that in the present trial "stems" include leaf sheaths and "leaves" refer only to leaf blades.

The highly significant effect of time on the CF content of the herbage on offer ($P < 0,001$ for the 1979, 1980 and 1981 seasons, $P < 0,01$ for the 1982 season) was characterised by fairly constant CF values (approximately 20%) until August, after which there was a rapid increase in CF until the end of the season. As was the case with the CF content of the herbage, the CF values remained fairly constant when pasture growth rates were slow. With increasing growth rates, from August, lower CF values would be expected, but

this was not found to be so. There was a rapid increase in CF with increasing pasture growth rates after August. It is felt that the same physiological process, flowering, that resulted in declining CF values after August, also resulted in increasing CF values during this time. The marginally slower increase in CF values, after August, during the 1982 season is reflected by the lesser contribution of time, compared with the other seasons, in the regression equation (Table 3.5).

Stocking rate had a significant effect ($P < 0,01$ for 1979; $P < 0,001$ for 1980, 1981, 1982 and the mean for the last three seasons) on the CF content of the herbage. From Fig. 3.6 it can be seen that, with few exceptions, the lighter the stocking rate the higher was the CF content of the herbage. It would seem that the dilution effect, resulting from the accumulation of more ungrazed material at the light, relative to the heavy stocking rate, was largely responsible for increasing CF values as the stocking rate was reduced.

The mean percent CF of the herbage, as influenced by time and stocking rate, for both before and after grazing is illustrated in Fig. 3.6h. Although one may not expect differences in the initial CF values (early May) for the different stocking rate treatments, the range of c. 2% is not dissimilar from the recorded values. Consequently it is felt that the regression polynomial of Table 3.5 aptly depicts the change in CF and provides for a realistic approximation.

Crude fibre values for the continuously grazed area followed a similar pattern to the rotationally grazed treatments. However, during the 1980 and 1981 season the CF values were generally lower, after August, than for the rotational treatments. The higher CF values of the continuously grazed area, during 1982, relative to the previous two seasons, can be ascribed to the reduced stocking rate during 1982 (6,22 during 1980 and 1981, and 4,2 during 1982). This resulted in the accumulation of large quantities of ungrazed material during 1982.

3.2.2.3 Total digestible nutrients (TDN)

Changes in the TDN values of the herbage, for both before and after grazing, as affected by stocking rate and time followed, as for CP and CF, a remarkably consistent pattern (Fig. 3.7). The 1982 season did however, exhibit lower magnitudes of seasonal variation in TDN content than did the other seasons. Since both CP and CF followed consistent patterns of change over all seasons and since TDN is derived from CP and CF ($TDN = 75,1 - \%CF \times 0,75 + 6 \log \%CP$) it is to be expected that the TDN values would also follow a consistent pattern.

The highly significant difference ($P < 0,001$) in TDN values between before and after grazing indicates that the animals selected herbage with a high TDN value (i.e. high CP and low CF). The consistently higher TDN values of the herbage before grazing compared with the low TDN herbage after grazing follows the same pattern as discussed for CP (i.e. animals selected leaves in preference to stem and dead material).

Time had a highly significant effect ($P < 0,001$) on the TDN content of the pasture on offer and on the residual herbage (Table 3.5). For each of the seasons the TDN value of the herbage before grazing remained fairly constant, above a value of 66, until the end of August. After August there was a rapid, almost linear, decline in TDN for all seasons and stocking rate treatments, until the end of the season (Fig. 3.7). The pattern of change in TDN values of the residual material, although largely influenced by grazing, followed a similar pattern to the TDN levels before grazing, except that for the 1981 and 1982 season there was a continuous decline in TDN with time. The reduced magnitude of change in TDN with time (although highly significant) during the 1982 season, compared with the other seasons, is reflected in the B1 and B2 values of the regression polynomial (Table 3.5).

The significant effect ($P < 0,001$) of stocking rate (Table 3.5) on the TDN

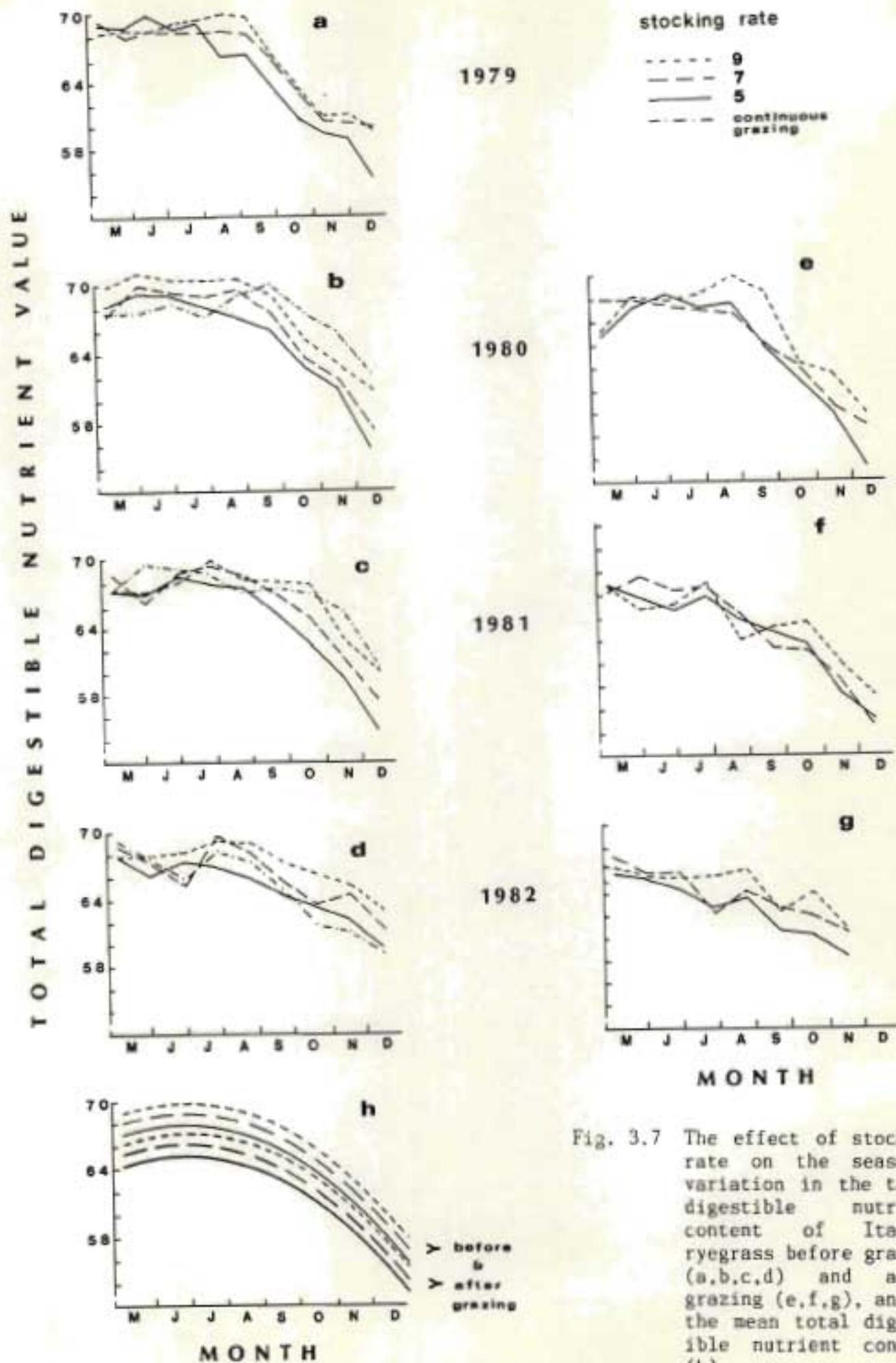


Fig. 3.7 The effect of stocking rate on the seasonal variation in the total digestible nutrient content of Italian ryegrass before grazing (a,b,c,d) and after grazing (e,f,g), and on the mean total digestible nutrient content (h).

value of the herbage serves to confirm the stocking rate - crude protein, - crude fibre trends presented earlier for these herbage quality components. The high stocking rate treatment, although having lower pasture growth rates than the low stocking rate, had higher leaf/stem ratios, over the season (Fig. 3.8), and less dilution from ungrazed material and thus had higher TDN values for the before grazing situation. Although not catered for in the multiple regression equation it is evident from Fig. 3.7 that the effect of stocking rate on the TDN values was greater in the material on offer than in the residual material.

Changes in the TDN values of the herbage with time is illustrated, for each of the stocking rates used, in Fig. 3.7h. Although providing for a perhaps somewhat wide range in TDN levels for the different stocking rates at the start of the season some 85% of the variation in TDN values is catered for by the regression polynomial of the means shown in Table 3.3.

The recorded and predicted (mean regression equation) TDN values indicate that TDN may restrict animal performance. According to N.R.C. (1976) standards, 64% TDN is required for an average daily gain of 0,7 kg for a 200 kg animal. The percent TDN requirement for gain increases rapidly as animal mass and/or individual gain per animal increases (N.R.C., 1976). Thus the declining TDN values towards the end of the season, recorded for each of the seasons, may impose restrictions on individual animal gain. The effect of TDN limiting animal performance will be more severe at light stocking rates, selected for high individual animal performance, than at stocking rates designed for mediocre gains per animal. These restrictions do not include limitations on TDN intake resulting from low availability of herbage or limited dry matter intake.

From Fig's 3.7b and 3.7c it can be seen that the continuously grazed area, with a stocking rate of 6,22 weaners per ha, maintained higher TDN values after August than did the rotationally grazed treatments. During the 1982 season this area was stocked at 6,22 weaners per ha until early June,

after which the stocking rate was reduced to 4,2 weaners per ha. The accumulation of ungrazed material at this low stocking rate was no doubt responsible for the low TDN values recorded for the 1982 season.

3.2.3 Gross morphology

Disc meter calibration samples taken at every second grazing cycle were sub-sampled and separated into leaf (leaf blades only), stem (including leaf sheath) and dead material. Surface litter was not included in the sample and may have been a source of error when collecting the material from the cut area.

The effect of stocking rate on the mean leaf/stem ratio, for 1980, 1981 and 1982 seasons, and on the percentage leaf, stem and dead material, over all seasons, is illustrated in Fig. 3.8. In the before grazing situation a stocking rate of 9 weaners per ha had a consistently higher leaf/stem ratio than for a stocking rate of 7 weaners per ha. A stocking rate of 7, in turn, had consistently higher leaf/stem ratios than for a stocking rate of 5 weaners per ha (Fig. 3.8). In the after grazing situation there was no apparent trend in terms of the effect of stocking rate on leaf/stem ratios. With the exception of the first grazing cycle, when the effect of stocking rate was to reverse the before grazing leaf/stem ratios, the leaf/stem ratios of the residual material were essentially similar at all stocking rates.

In view of the higher pasture growth rates at the low stocking rate, compared with the high stocking rate, it would be expected that the low stocking rate would have resulted in higher leaf/stem ratios than the high stocking rate. From Fig. 3.8a it is clear that the higher stocking rate with the slower pasture growth rates, had the higher leaf/stem ratios. Since all samples were cut to ground level at each sampling occasion, and since there was consistently more residual material (after grazing) on the

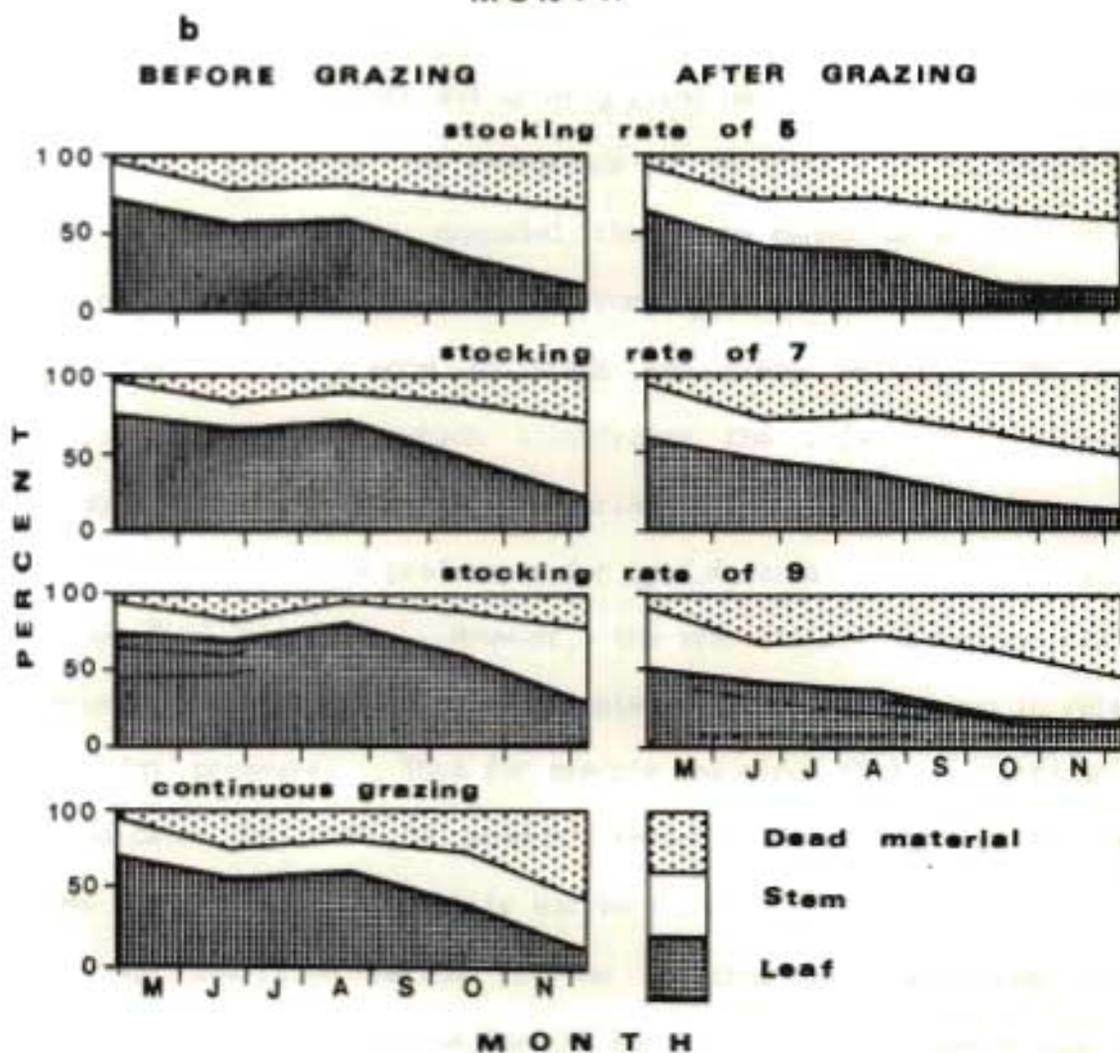
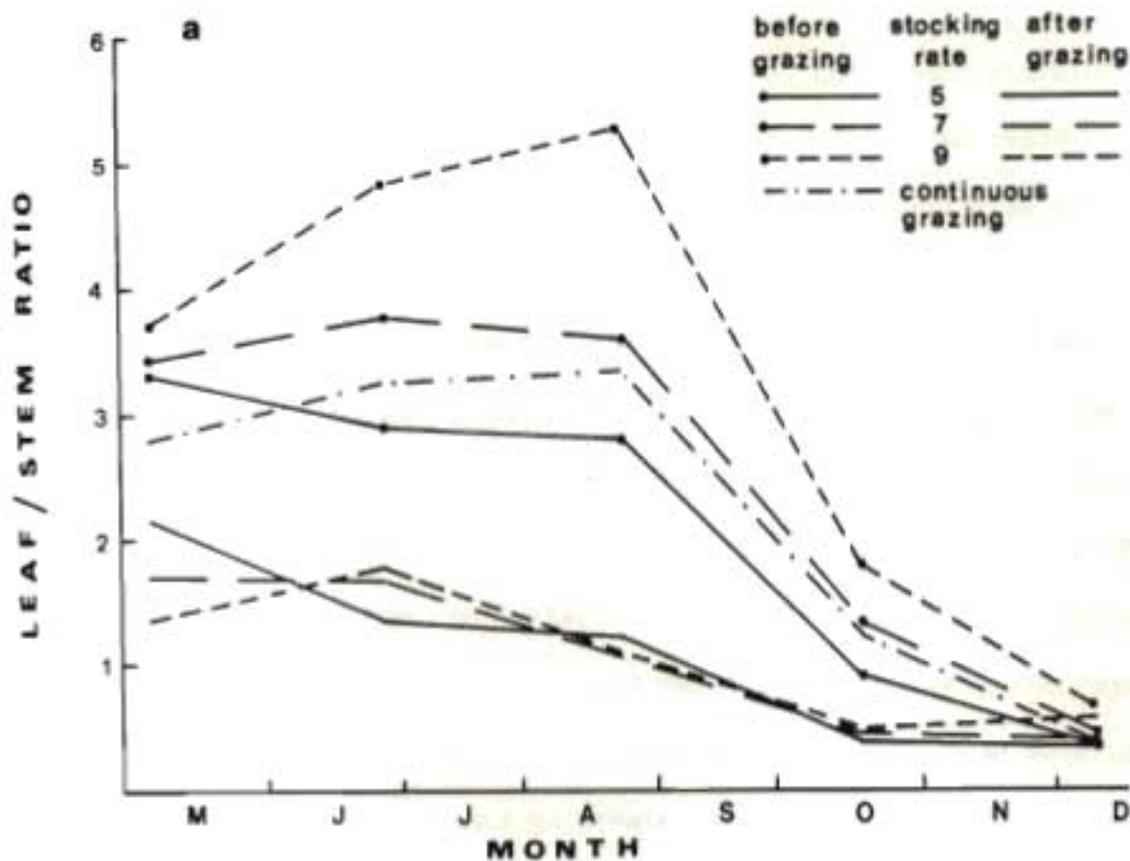


Fig. 3.8 The effect of stocking rate on the seasonal variations of ...

weaner performance.

The effect of stocking rate on the cumulative livemass change of the weaners during the 1978 season is illustrated in Fig. 3.10a. Although pasture availability was not monitored, it is evident from the consistent growth pattern of this species over the seasons (Fig. 3.2) that animal performance followed closely the growth rate of the pasture. Slow animal growth rates were associated with slow pasture growth, and vice versa. At the high stocking rate (13,5 weaners per ha), however, the pasture was unable to provide for the animals requirements for production from early July (Fig. 3.10a). The seemingly superior performance of the 9,69 weaners per ha, compared with the stocking rate of 7,90, is attributable to the fact that the stocking rate treatment of 9,69 weaners per ha was located at one end of the trial. At this end of the trial there was a narrow strip of moribund kikuyu running down the length of the camp. It was thought that the effect of this kikuyu would have been insignificant, but apparently it did affect animal performance. The kikuyu providing for a certain amount of foggage during the earlier part of the season and again contributed to animal performance once growth commenced in October.

The relationship between stocking rate and animal performance, based on the Jones & Sandland (1974) model (section 1.3), over a 210 day grazing period is illustrated in Fig. 3.10b. These data show that maximum livemass gain, for the 210 day period, was achieved at a stocking rate of 6,80 weaners per ha. Furthermore at this stocking rate the animals would have a daily gain of 0,669 kg and provide a per ha gain of 4,54 kg per day: providing for a total livemass gain of 955 kg per ha for the 210 day period.

Based on the results from this pilot trial it was decided that stocking rates of 5, 7 and 9 weaners per ha would be used to characterise Italian ryegrass. These stocking rates span that stocking rate providing for maximum gain per ha and thus fulfill the requirements for characterisation discussed in section 1.3.

Observations from the pilot trial revealed that, particularly at the high stocking rates, low herbage availability (and thus low intake) restricted animal performance. Maintenance of an extremely low leaf area index (visual observation) by the high stocking rate animals precluded reasonable pasture growth rates. It was also decided that a rotational grazing system would be followed to provide for improved pasture regrowth rates and rationing of herbage to the animals. This is in accordance with the more recent findings of Brockett, Gray & Lyle (1982) and Bransby (1983) who found that at high stocking rates rotational grazing was superior to continuous grazing.

3.2.4.2 Stocking rate and animal performance

Characterisation of Italian ryegrass at stocking rates of 5, 7 and 9 weaners per ha was conducted for the 1979, 1980, 1981 and 1982 seasons. Basic information relating to this phase of the trial is given in Table 3.1.

Livemass change over the season

The effect of stocking rate on the mean cumulative livemass change of the weaners over the season is illustrated in Fig. 3.11. Data of Fig. 3.11 represents the means for both steers and heifers for the 1980, 1981 and 1982 seasons. Only steers were used during 1979. With the exception of stocking rates of 5 and 7 for the 1982 season, the total livemass gain of the animals followed the pattern of dry matter utilisation (Table 3.4). Increased herbage intake resulted in increased livemass gain.

Although the general pattern of livemass change over the seasons was similar, herbage availability and quality appeared to influence the rate and pattern of livemass gain.

Thus, for example, during the 1979 and 1980 seasons the slow growth

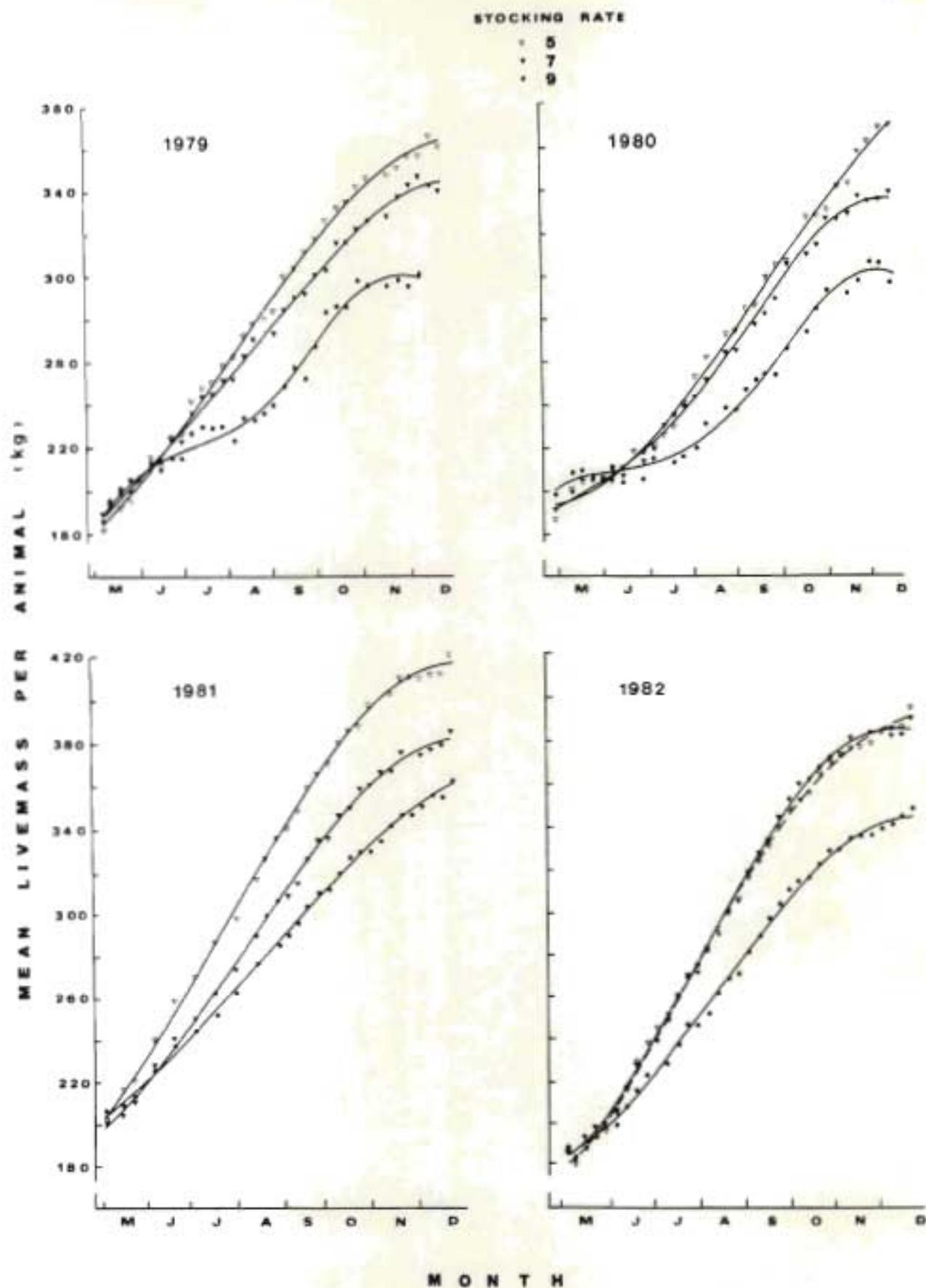


Fig. 3.11 The effect of stocking rate on the cumulative livemass change of weaners grazing irrigated Italian ryegrass

rates of the high stocking rate animals during June and July can be related to low pasture availability during this period. High CP and TDN values recorded during this period (Fig. 3.5 and 3.7) preclude quality restricting animal performance. From Fig. 3.2 it can be seen that, for June and July during 1979 and 1980, the availability of herbage, in terms of mean disc height, was of the order of 4 cm. For this period the dry matter on offer was 7 to 9 kg per animal per day. Visual estimates indicate that herbage below a mean disc height of 1,5 cm is unavailable to the weaners. Thus it is estimated that the herbage available to the high stocking rate animals during June and July, for 1979 and 1980, was of the order of 1,6 to 2,1 kg dry matter per animal per day. During the 1981 and 1982 seasons the levels of recorded herbage availability, at the high stocking rate, was considerably higher during June and July than it was during the previous two years (Fig. 3.2). This increased pasture availability during 1981 and 1982, compared with 1979 and 1980, did not result in the reduced animal growth rates recorded for the 1979 and 1980 seasons.

Figure 3.11 clearly illustrates the almost identical livemass change at stocking rates of 5 and 7 weaners per ha for the 1982 season. Animals at these stocking rates exhibited clearly different gains during the other seasons. Herbage availability (Fig. 3.2) and dry matter utilisation (Table 3.4) data indicate that, in keeping with the pattern of livemass change for the other seasons, the lower stocking rate should have had the higher gains. Thus the similarity in gains between the two stocking rates points to either variation among the animals, or in herbage quality, or both. Although the animals at a stocking rate of 7 were slightly lighter than those at a stocking rate of 9 at the start of the trial, individual animal performance (within treatments) followed essentially the same pattern. However, differences between steers and heifers, at the two stocking rates, showed that steers at a stocking rate of 5 had better gains than steers stocked at 7 weaner per ha. For the heifers the situation was reversed, the heavier

stocking rate producing slightly higher livemass gains.

The similarity in mean livemass gain at the two lighter stocking rates thus indicates herbage quality as being involved. Relatively high CP and TDN values of the herbage, both in the before and after grazing situation, for both these stocking rate treatments (Fig's 3.5 and 3.7) indicates that high daily gains could be expected from both these treatments. However, higher TDN values in the after grazing situation at a stocking rate of 7, implies that herbage on offer to these animals was less diluted from accumulated residual material. The higher stocking rate animals were thus able to select a higher quality diet. This effect was more pronounced for the lighter heifers with higher levels of herbage availability, than for the steers. Thus the increased nutrient intake of animals at the higher stocking rate compensated for lower dry matter intakes. This provided for similar livemass gains at the two lighter stocking rates during the 1982 season.

3.2.4.3 Optimising production

A reduction in herbage availability, together with declining herbage quality towards the end of the season (cf. Fig's 3.2, 3.5, 3.6, 3.7) resulted in deminishing animal growth rates at this time. Since herbage availability, in particular, was lowest in the high stocking rate treatments, animals from this treatment were the first to exhibit slow and/or negative growth. The linear model used in the analysis of animal performance data (section 1.3), although providing for maintenance, does not take cognisance of negative gain. Thus the time at which treatments were compared was based on animal performance of the high stocking rate treatment. For each of the seasons evaluated this cut-off point was shown consistently to be in the region of 210 days from the start of the trial.

The average daily gains (ADG) of the animals for the different

treatments, for the separate seasons, are given in Table 3.6 and illustrated in Fig. 3.12. Also shown in Table 3.6 are the stocking rates providing for maximum livemass gain per ha (SR_{max}), the predicted ADG's at these stocking rates and the total livemass gain per ha that can be expected, at SR_{max} , for the 210 day period. The procedure outlined by Edwards (1981b) was used to determine SR_{max} according to the Jones & Sandland (1974) model (cf. section 1.3).

From Fig. 3.12 it can be seen that the regression lines depicting the relationship between stocking rate and ADG had similar slopes when seen separately for the heifers, steers and heifers plus steers. The slopes of the stocking rate - ADG relationship for the heifers exhibited the largest year to year variation, with the steers plus heifers showing the least variation in the relationship between stocking rate and ADG over the seasons. However, cognisance should be taken of the limitation(s) imposed by the potential of the animal and/or pasture (Fig. 1.2). From the data of Table 3.6 and Fig. 3.12 it would seem that in some years and for some treatments this potential, whether pasture or animal, had been reached or, at least, approached. This is shown by the small differences in ADG's recorded for stocking rates of 5 and 7 for the steers during 1980, for the heifers during 1981 and for both the steers and the heifers during 1982.

Data from the trial does not provide for a means of establishing point B in Fig. 1.2. Since the data clearly indicates a trend towards the potential (of the animal or the pasture) being reached at the low stocking rate, it is felt that this treatment should be excluded, for all seasons, in determining SR_{max} . It may, however, be argued that, particularly for the heifers during 1982, the stocking rate of 7 may well lie at or near the "potential". However, from Fig. 3.12 it would seem that, relative to the slopes of the stocking rate - ADG lines for the other seasons, this was not so. Furthermore, the substantial increase in animal performance, when the stocking rate was increased from 7 to 9 weaners per ha, indicates that the

TABLE 3.6 The effect of season and stocking rate (in weaners per ha) on the performance of steers and heifers grazing Italian ryegrass as the only feed : all data in kg and determined over a 210 day grazing period.

Season	Type	Average daily gain (ADG) at stocking rate (SR)			SRmax	ADG at SRmax	Livemass gain/ha at SRmax
		5	7	9			
1979	R	0,906	0,773	0,529	7,41	0,698	1086
	C	0,793	0,673	0,539	8,76	0,556	1023
	Mean	0,849	0,723	0,545	8,14	0,619	1058
1980	S	0,857	0,837	0,472	7,25	0,698	1063
	H	0,791	0,575	0,521	8,16	0,551	944
	Mean	0,817	0,686	0,496	7,65	0,614	986
1981	S	1,124	0,868	0,695	7,68	0,823	1327
	H	0,870	0,837	0,673	11,55	0,569	1380
	Mean	0,997	0,837	0,684	8,86	0,694	1292
1982	S	1,056	0,977	0,715	8,87	0,756	1408
	H	0,814	0,907	0,741	8,96 a	0,744	1400
	Mean	0,935	0,942	0,728	7,90 a	0,846	1404
Mean	all data	0,900	0,797	0,613	8,87	0,636	1185
					7,83 a		
Mean 1980 to	S	1,012	0,894	0,627	7,89	0,759	1258
					6,85 a		
1982	H	0,825	0,773	0,645	11,81	0,531	1317
					9,54 a	0,611	1224

* R = rotational grazing (6 camps) all steers
 C = continuous grazing (1 camp)
 S = steers) rotational grazing (8 camps)
 H = heifers)

SRmax = stocking rate providing for maximum livemass gain per ha
 a = SRmax determined from stocking rates of 7 and 9 only

Note : Since the animal mass was determined from regression equations fitted separately to each "type" in the table means are not necessarily the mean of R plus C or S plus H.

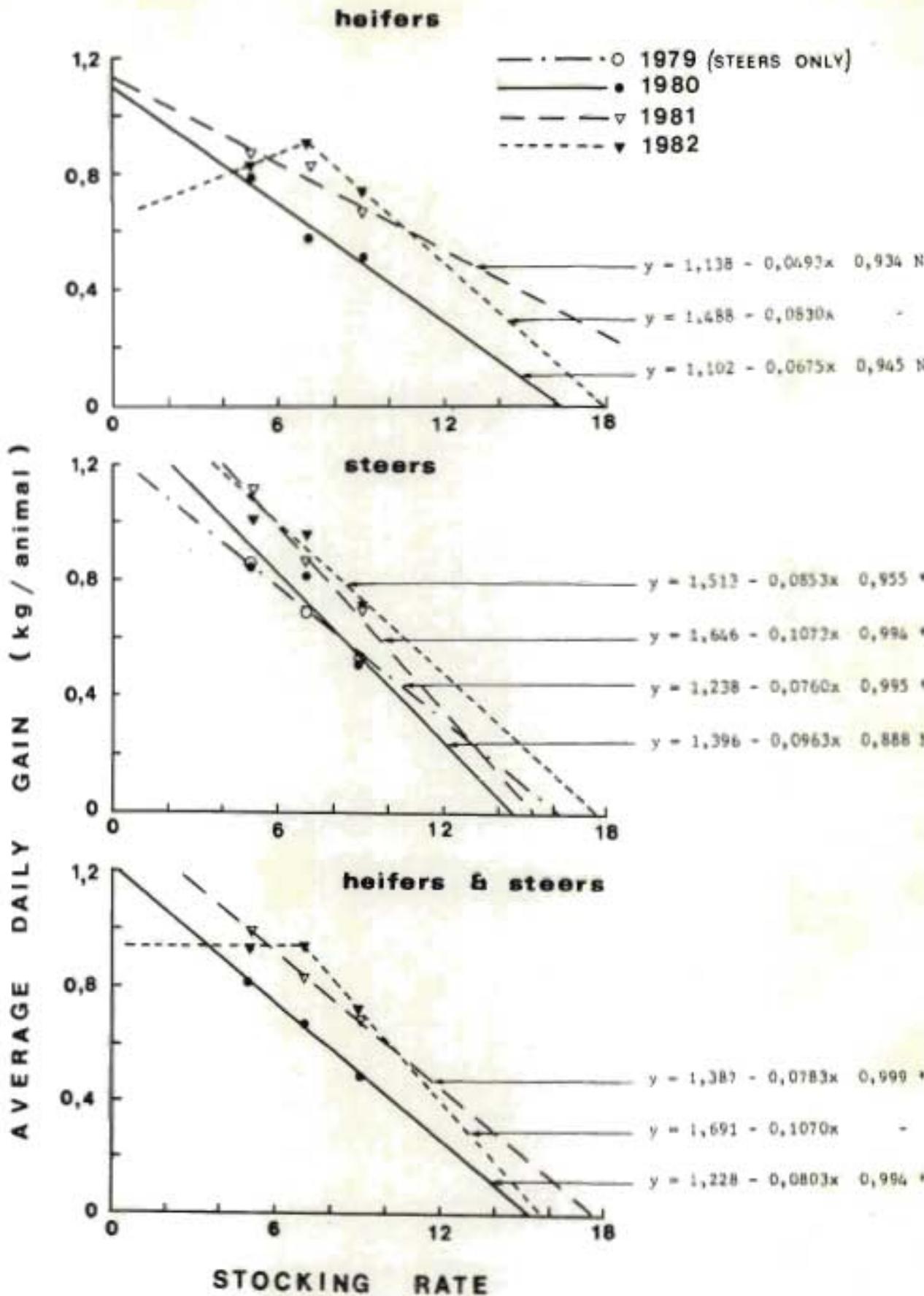


Fig. 3.12 The relationship between average daily gain and stocking rate for weaners grazing irrigated Italian ryegrass (over a 210 day grazing period).

stocking rate of 7 was not at the potential.

Based on the mean ADG's over seasons, SRmax was determined using two (stocking rates 7 and 9) and all three stocking rates (Table 3.6). These data show that in all cases SRmax was lower when determined from two than it was when determined from three stocking rates. This suggests that the lighter stocking rate lies on or near the AB line of Fig. 1.2.

Figure 3.13 illustrates the relationship between stocking rate and ADG, and between stocking rate and livemass gain per ha, determined from stocking rates of 7 and 9 weaners per ha (the mean ADG for a stocking rate of 5 is also shown). Since the potential of the pasture is regarded as the maximum animal performance that can be expected from the pasture (within the limits set by the animal), this potential is not a mean of animal performance over seasons, but the maximum production that is recorded in any one season. Consequently, for the limited number of seasons for which the trial was conducted, a tentative potential is indicated by the dotted line in Fig. 3.13 (i.e. the biological potential).

From Fig. 3.13 and Table 3.6 it can be seen that the stocking rates providing for maximum livemass gain per ha are 9,54; 6,85 and 7,83, the animals having ADG's of 0,611; 0,914 and 0,721 for the heifers, steers and heifers plus steers respectively, for the 210 day period. Thus it would seem that for slaughter animals, steers would be the most profitable. Relative to the heifers fewer steers would have to be cared for and marketed for the same, or slightly higher, livemass gain per ha. However, since the heifers provided for a better finish the price differences between grades may influence the type (steer or heifer) of weaner that will be most profitable.

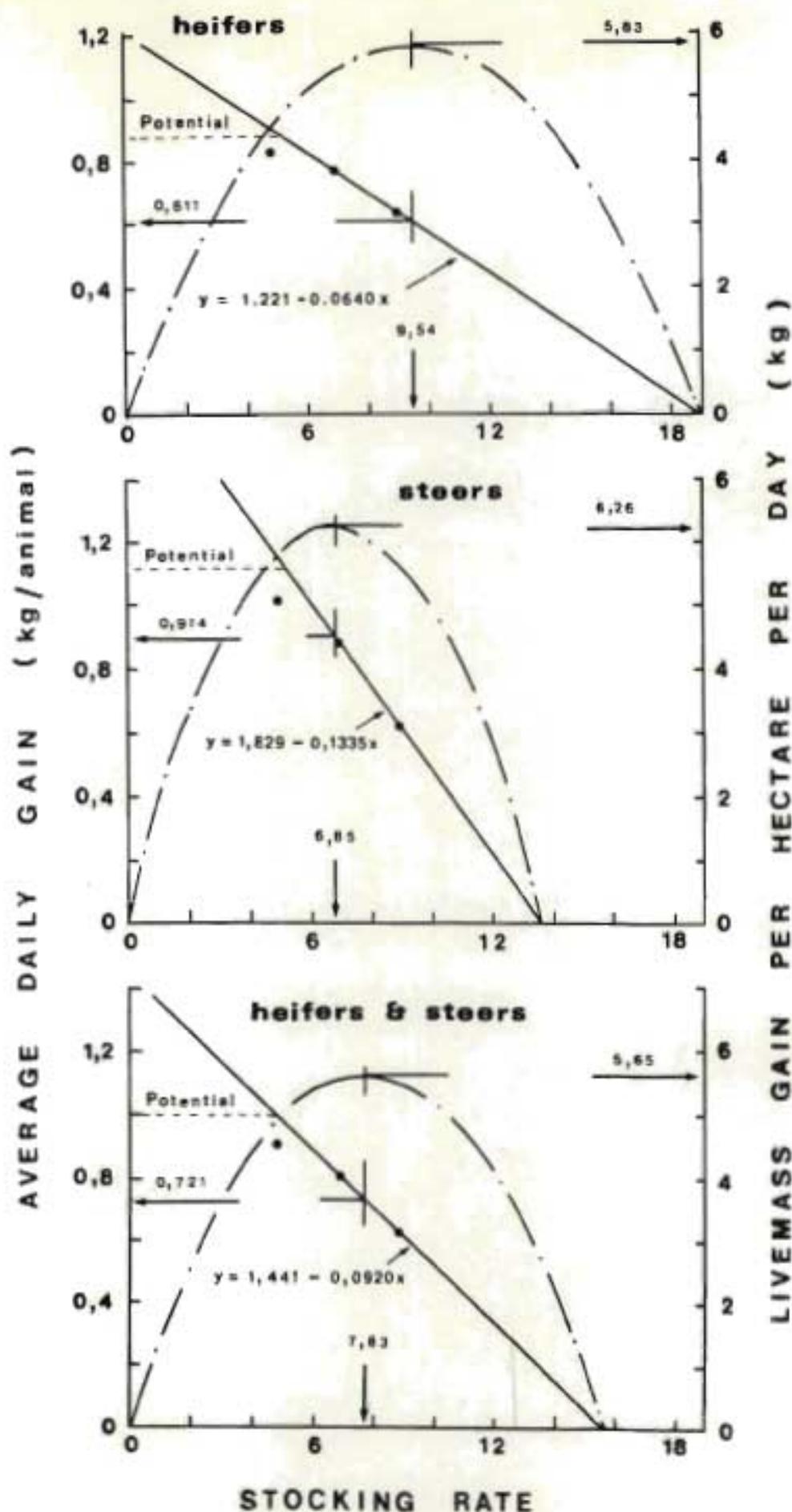


Fig. 3.13 The relationship between stocking rate and animal performance indicating weaner stocking rates providing for maximum livemass gain per ha (210 day grazing period).

3.2.4.4 Animal grades

The South African meat grading system, based largely on animal age (permanent teeth cut or not), conformation and fat cover, was changed during 1981. Thus only data from 1981 onwards was suited to providing data on animal grades for use in economic analysis.

Animals from the 1981 and 1982 seasons were required for other trials and were thus not slaughtered. However, the late Dr G O Harwin, from Stockowners, Tweedie, and Mr W Smith, from Stockowners, Pietermaritzburg, graded the animals on the hoof at the end of the 1981 and 1982 seasons. In addition to grading the animals, these two gentlemen estimated the dressing percentage of the animals. The fact that they argued about 0,5% difference in dressing percentage clearly indicates the level of expertise. Thus the grading of the animals is presented with confidence. However, the small number of animals involved per treatment restricts somewhat the general value of the data.

For the 1981 and 1982 seasons, at similar stocking rates, grading for the heifers was higher than for the steers. At a stocking rate of 5 weaners per ha all the heifers graded Super A, while 50% of the steers graded Super A and 50% graded A1. For a stocking rate of 7 weaners per ha all the heifers graded Super A while the steer gradings were 17% Super A and 83% A1. At 9 weaners per ha 50% of the heifers graded Super A and 50% graded A1, while for the steers all graded A1, but there was a possibility of 17% being down - graded to 3.

On the continuously grazed area the animals were graded only at the end of the 1982 season. At the low stocking rate of 4,2 weaners per ha the heifer graded A2 (overfat) and the steer Super A.

The Super A grade animals had an estimated mean dressing percentage of

54,3, while the A1 animals had a mean dressing percentage of 52,1. Although this is a seemingly small difference it represents 8,8 kg for an animal with a livemass of 400 kg. At a floor price of R2.39 per kg this difference in dressing percent amounts to R21.03 per animal. This difference is further increased if the grade price difference is also taken into account. Based on a floor price of R2.39 for Super A and R2.34 for A1 (Anon. 1984b) the value of an animal with a livemass of 400 kg would be R519.11 for Super A and R487.66 for A1.

3.2.5 Economics of slaughter animals

The overall objective of characterising Italian ryegrass, in terms of weaner performance, was to establish the relationship between stocking rate and animal performance. However, once this relationship has been established it is possible to determine the stocking rate that will provide for the greatest economic returns.

It is accepted that there are many variables (including unknowns and uncertainties) involved in an economic analysis of characterisation trials. Seasonal variations, product prices, availability of weaners and their cost, interest rates, fertiliser and labour costs, fuel and machinery costs are but some of the variables involved. Nevertheless it is necessary to establish, within the limits set by the trial and the existing economic climate, the profitability, or otherwise, of weaners on irrigated Italian ryegrass.

The economic models used in this section are based on, and derived from, those of Booysen (1975), presented by Edwards (1981b), and Booysen, Tainton & Foran (1975).

According to Booysen (1975), the optimum economic stocking rate (S_0) is given by the equation $S_0 = br - m/2cr$, where b = daily gain per animal - in kg, r = product price per kg, m = interest on purchase price plus variable

costs associated with holding extra animals - per animal per day, and $c = b/2 \times SR_{max}$. Based on this equation the optimum economic stocking rate was determined separately for the heifers and steers, and for the mean for heifers and steers over all years. Purchase price of the animals was estimated at R1.20 and product price at R1.25 per kg livemass. Initial livemass was taken as 189,8; 199,1 and 194,5 kg for the heifers, steers and the mean respectively. An interest rate of 20% and a cost of R9.50 per animal (veterinary and lick) was assumed for the 210 day period.

Optimum economic stocking rates based on the stocking rate - ADG relationship

The optimum economic stocking rate was found to be 6,27; 5,22 and 5,51 for the heifers, steers and heifers plus steers respectively. At these stocking rates the respective average daily gains per animal would have been 0,820; 1,132 and 0,934 kg, with livemass gains per ha of 1 071, 1 241 and 1081 for the 210 day period. For the heifers, steers and the mean, the economic optimum stocking rate is less than SR_{max} (cf. Table 3.6). This is in agreement with the findings of other workers (Booyesen et al., 1975; Hart, 1972).

The inclusion of stocking rate - carcass grade and stocking rate - dressing percent, and varying beef prices in estimation of stocking rates providing for maximum profit per ha (SR_{mp})

The economic optimum stocking rate model estimates the stocking rate at which profit is maximised. However, the use of average daily gain, to predict So , precludes inclusion of the effect that animal grades and dressing percentage may have on So . Furthermore, since minimum producer prices are established periodically by the abattoir, for carcasses of

different grades and mass, it is probably less precise to estimate product price on a livemass basis than on a carcass basis. Thus it is felt that a model to predict profit per ha at various stocking rates, including the effects of stocking rate on carcass grades and on dressing percent, will be more meaningful in determining the effect of stocking rate on the profitability of slaughter beef production.

Method

In determining the profit per ha at various stocking rates the model proposed by Booyesen (1975) was adapted to include the effect of animal grade and dressing percent on profitability. Interest charges on variable costs for the pasture and animal have also been included in the equation.

Profit per ha at various stocking rates was thus determined using the following equation.

$$\text{Profit} = b - [v + (f \times s) + i] \quad \dots\dots\dots \text{Eq (4)}$$

where, (1) $b = (m \times g_1 \times h_1 \times r_1) + (m \times g_2 \times h_2 \times r_2) - (a \times s)$

m = total livemass per ha at end of period

g_1 = percent animals of grade 1 (Super A)

g_2 = percent animals of grade 2 (A1)

h_1 = dressing percent at g_1

h_2 = dressing percent at g_2

r_1 = product price of carcass at g_1 (R-c/kg)

r_2 = product price of carcass at g_2 (R-c/kg)

a = initial cost per animal (R-c)

s = stocking rate (animals/ha);

(2) v = variable cost per ha for the pasture (irrigation, land preparation, seed, fertiliser, etc.);

(3) f = variable cost per animal for the period on pasture (veterinary, licks, dipping);

(4) i = interest charges calculated as :-

$$i = e \left[h + d + (a \times s \times p/365) + (v/n \times t_1/365) + (s \times f/n \times t_2/365) \right]$$

where,

e = interest rate (%)

h = land price

d = cost of land development

p = days on pasture

n = number of periods during the season when fertiliser, fuel for irrigation, licks etc. are purchased - it is assumed that not all fertiliser, fuel etc. is obtained at the start of the season; interest is calculated on a pro-rata basis.

t = total number of days for which interest is to be paid (based on pro-rata basis of n): t_1 may differ from t_2 in that fertiliser for establishment may be purchased before animal licks.

Assumptions

In order to apply this model it is necessary that certain assumptions be made. Land (h) was valued at R500 per ha with a development cost (d) of R255 per ha. Variable costs per ha of pasture (v) and per animal (f) were estimated at R620 and R9.50 respectively, while the interest rate (e) was fixed at 20% per annum (E N C Whitehead, personal communication: Dept. Agric. Econ., Cedara). Beef prices (r) were based on minimum producer

prices paid at the Cato Ridge abattoir (Anon., 1983, 1984b). It was assumed that the fifth quarter would cover abattoir and animal transport costs.

Results

Using Eq (4) and the above assumptions, together with animal performance data (section 3.2.4.3), animal grades and dressing percent data (section 3.2.4.4), profit per ha was determined for the mean response of heifers and steers to stocking rate. The effect of stocking rate and changing beef prices, for different carcass grades, on profit per ha, are given in Table 3.7 and illustrated in Fig. 3.14.

From Table 3.7 and Fig. 3.14 it can be seen that changing the price per kg of carcass results in greater changes in heifer stocking rates providing for maximum profit per ha (SRmp), than in steer SRmp. Clearly this is related to the effect that changing the stocking rate has on average daily gain and production per ha when heifers and steers are used. A unit change in stocking rate results in a relatively large change in average daily gain for the steers, but a relatively small change in average daily gain for the heifers (cf. Fig. 3.13). When the product price (ignoring carcass grades) is increased from R2.34 to R2.48 per kg carcass, SRmp for the heifers increases from 7,95 to 8,28 (0,33 units) while the SRmp for the steers increases from 6,32 to 6,50 weaners per ha (0,18 units).

Thus, as the product price increases SRmp tends towards SRmax, for both heifers and steers (Table 3.7 and Fig. 3.14), while with a reduction in the product price SRmp tends towards the biological optimum stocking rate (i.e. the potential of the pasture).

When carcass grades and their associated prices are also included in determining SRmp, then SRmp again tends towards the biological optimum stocking rate. This is so, for both steers and heifers, whether the average price is increased (Fig. 3.14, compare curves 1 and 3) or decreased (Fig.

TABLE 3.7 The effect of stocking rate and product price on the profitability (in Rands per ha per season) of weaners grazing irrigated Italian ryegrass. Since carcass grades and dressing percent were determined only for animals at stocking rates of 5, 7 and 9, variables were assumed to be linear for intermediate stocking rates.

Stocking rate (SR)	Profit (R/ha) for a range of carcass values (R/kg) for different grades							
	All grades R2-34		All grades R2-48		Super A R2-39 (1) A1 R2-34		Super A R2-48 (2) A1 R2-39	
	Heifer	Steer	Heifer	Steer	Heifer	Steer	Heifer	Steer
4	108	399	230	539	153	416	230	473
5	261	527	405	691	313	543	405	616
6	374	583	541	767	434	599	541	676
7	456	569	643	768	523	581	643	662
8	468	478	672	689	523	485	640	565
9	442	321	660	538	482	321	591	398
SRmp	7,95	6,32	8,28	6,50	7,61	6,30	7,73	6,32
Profit	469	586	674	776	524	601	642	680
(a)	1	2	3	4	5	6	7	8
ADG	0,712	0,985	0,691	0,961	0,734	0,988	0,726	0,985

SRmp = Stocking rate providing for maximum profit per ha

ADG = average daily livemass gain at SRmp

(1) minimum producer price from September 1984 (Anon., 1984b)

(2) minimum producer price from November 1983 (Anon., 1983)

(a) Regression equation depicting the profit per ha (y), in Rands, as dependent on stocking rate (x)

	r
1. $y = -1\ 001,01 + 369,350x - 23,2071x^2$	0,999
2. $y = -832,58 + 451,796x - 35,9693x^2$	0,999
3. $y = -1\ 001,75 + 404,547x - 24,4105x^2$	0,999
4. $y = -832,85 + 495,386x - 38,1223x^2$	0,999
5. $y = -1\ 080,49 + 413,294x - 26,5006x^2$	0,998
6. $y = -833,97 + 459,913x - 36,8543x^2$	0,999
7. $y = -1\ 155,64 + 464,283x - 29,9716x^2$	0,998
8. $y = -863,65 + 490,017x - 38,8818x^2$	0,999

→ = stocking rate giving highest profit / ha
 Carcass valued at (R-c / kg):

1. R2-34	2. R2-48
3. SA = R2-39	4. SA = R2-48
A1 = R2-34	A1 = R2-39

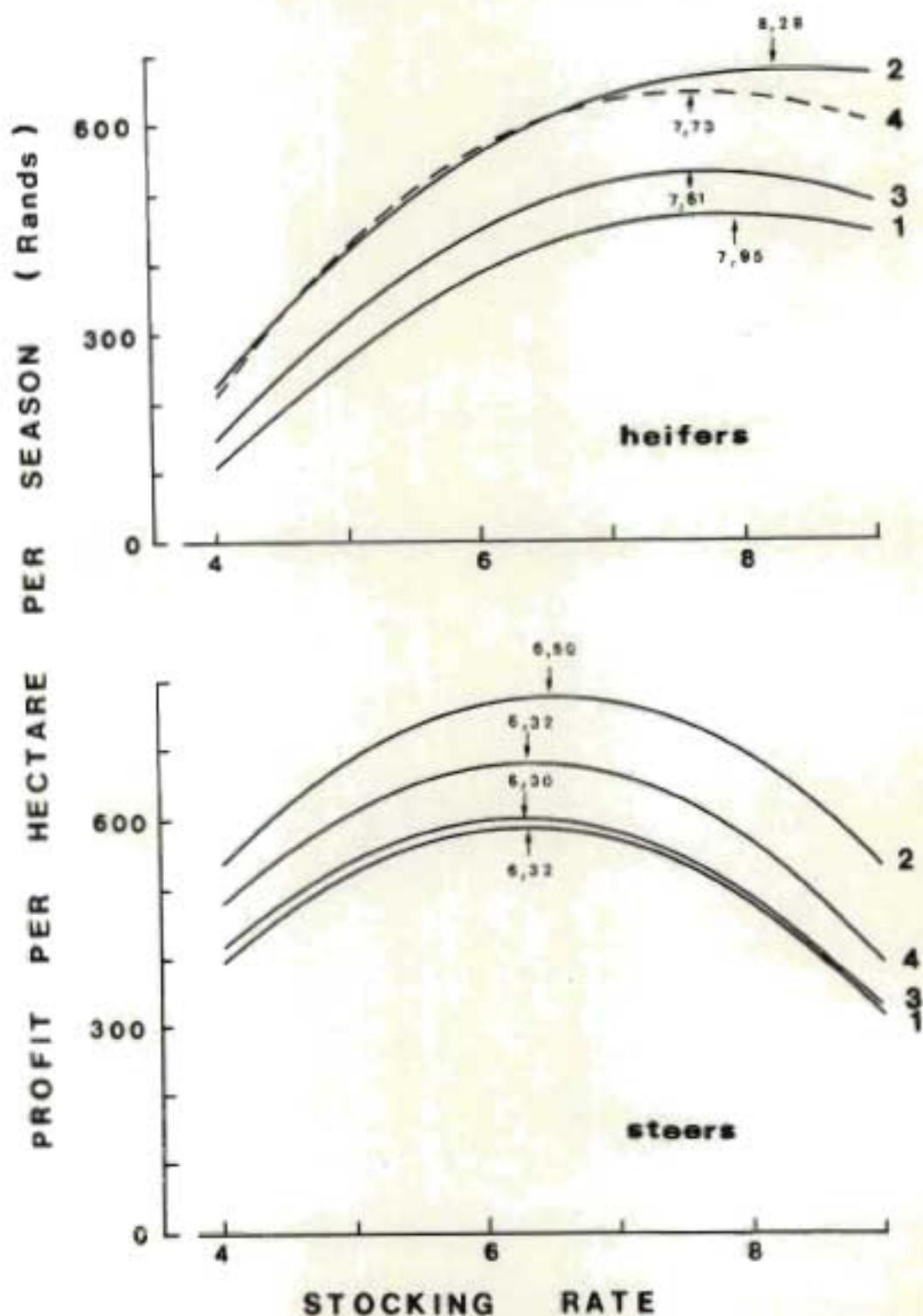


Fig. 3.14 The effect of stocking rate and carcass price on the profit per ha, from weaners grazing Italian ryegrass as the sole feed (SA = super A grade; A1 = grade A1).

3.14, compare curves 2 and 4). Thus SRmp tends towards that stocking rate at which there is an optimum economic relationship between the higher grades (and thus greater profit per animal), at the lower stocking rates, and the higher animal gains per ha (at reduced profit per animal due to lower carcass grades) at the higher stocking rates.

The economic benefits derived from using steers, as opposed to heifers, for the production of slaughter animals from irrigated Italian ryegrass is clearly indicated by the data. While the heifers graded better than the steers, the price differential between grades was insufficient to compensate for the reduced ADG of heifers when compared with steers.

3.2.6 Effect of sex of animal on nutrient intake and performance

In view of the differences in performance, grading, SRmax and SRmp between heifers and steers, it was considered necessary to examine more closely the differences in the response of animals of different sex.

The mean apparent intake of TDN, CP and dry matter by the heifers and steers, at each of the stocking rates evaluated, is given in Table 3.8. These data were derived from the mean intake and stocking rate for seven grazing cycles (196 days) for the 1980, 1981 and 1982 seasons. Since animals on some treatments had negative gains during the eighth grazing cycle these data were not included.

From Table 3.8 it can be seen that the heifers had a consistently higher apparent dry matter and nutrient (TDN and CP) intake than did the steers. However, the differences in dry matter and nutrient intake was not consistent over all stocking rates. When expressed as a percent (steer = 100%), the differences in apparent intake of dry matter and nutrients between heifers and steers was higher at the low stocking rate than it was at the high stocking rate. The percent difference was, however, not consistent (linear) over all stocking rate levels. For dry matter, TDN and

TABLE 3.8 The effect of stocking rate and sex of weaner on the mean apparent daily intake of total digestible nutrients (TDN), crude protein (CP) and dry matter, and on the average daily gain per animal (ADG) for a 196 day period (values in kg per animal per day).

Stocking rate	Sex	TDN	CP	Dry matter	Mean ADG (196 days)
5	Steer	5,217 (0,370)	1,949 (0,159)	7,531 (0,606)	1,038 (0,101)
	Heifer	6,995 (0,608)	2,638 (0,010)	9,875 (0,828)	0,839 (0,024)
Diff. between steer & heifer*		34,1%	35,4%	31,1%	19,2%
7	Steer	3,801 (0,229)	1,619 (0,117)	5,275 (0,343)	0,918 (0,062)
	Heifer	4,796 (0,498)	1,983 (0,235)	6,721 (0,742)	0,796 (0,106)
Diff. between steer & heifer*		26,2%	22,5%	27,4%	13,3%
9	Steer	3,767 (0,119)	1,784 (0,129)	5,150 (0,268)	0,650 (0,062)
	Heifer	4,143 (0,135)	1,809 (0,234)	5,650 (0,140)	0,671 (0,070)
Diff. between steer & heifer*		10,0%	1,4%	9,7%	3,1% (a)

* = Steer taken as 100%

(a) = superior ADG of heifer
SE shown in brackets

CP, differences in apparent intake by heifers and steers, between stocking rates of 9 and 7, were considerably greater than the differences between stocking rates of 7 and 5.

At the high stocking rate the increased intake of dry matter and nutrients by the heifers, relative to the steers resulted in higher mean ADG of the heifers over the 196 days. However, at the two lighter stocking rates the steers, with the lower dry matter and nutrient intakes than the heifers, had the higher ADG's (Table 3.8).

It is suggested that the effect of stocking rate and intake of nutrients (TDN and CP) on the relative differences in performance of heifers and steers is related to the physiological differences between the sexes, and to the pattern of muscle and fat deposition in relation to the quantities of nutrients ingested.

Under a high plane of nutrition (e.g. stocking rates of five and seven) skeletal, muscle and fat tissue development is not restricted (Lesch *et al.*, 1974). However, heifers deposit fat sooner than do steers (Maynard, 1980) and more nutrients are required for fat deposition than for muscle development (Amir & Kali, 1974). Data from the trial show that at the same stocking rate heifers had a higher nutrient (TDN and CP) intake than the steers (Table 3.8), but the heifers also deposited more fat than did the steers (at the same stocking rate heifers graded higher than the steers). Thus although the steers, at the two lighter stocking rates, had higher average daily gains with lower levels of nutrient intake than the heifers, indicating greater efficiency of the steers in converting nutrients to growth, this does not reflect the increased nutrient requirement for the increased deposition of fat exhibited by the heifer.

As declining nutrition limits animal performance, less fat, relative to muscle, is deposited (Amir & Kali, 1974). At the stocking rate of 9 weaners per ha, relative to 5 and 7 weaners per ha, both steers and heifers had reduced nutrient intake. This limited the nutrients available for fat

deposition (indicated by reduced grades of both steers and heifers when compared with animals at the lighter stocking rates). Thus it would seem that at the higher stocking rate, with limited nutrients available for fat deposition, the efficiency of conversion of nutrients to animal products (largely muscle) was similar for both the steers and the heifers. The slightly higher nutrient intake of the heifers, compared with the steers, resulted in slightly improved performance and grading of the heifers.

Clearly there is a need to monitor the differences between steers and heifers in terms of the relative rates of muscle development and fat deposition, over the season. This could be important in terms of the marketability of the animals in relation to fluctuating beef - grade prices. Thus, for example, knowledge of when the animals could attain a certain grade (with respect to fat deposition) could play a role in introducing flexibility into the marketing strategy adopted. In this way the farmer can be best equipped to take advantage of the rapidly fluctuating beef price - grade structure.

3.2.7 Pasture limitations to animal performance

The ability of the pasture to fulfill the animals requirements for maintenance and production depends largely on the level of nutrient intake by the animal, and the size of the animal.

Based on the mean pasture utilisation, forage quality and stocking rate, the mean daily apparent intake of TDN and CP was determined separately for the heifers and steers for each of the grazing cycle for 1980, 1981 and 1982. The mean intake of TDN and CP for the three seasons is given in Table 3.9, while the effect of animal mass on the animals requirement for TDN, for maintenance and production (after Kearn, 1982), is shown in Table 3.10.

In general the levels of CP intake, seen in the light of the animals

TABLE 3.9 The effect of stocking rate (SR), sex and liveweight on the mean daily total digestible nutrient (TDN) and crude protein (CP) intake, per animal, per grazing cycle (Cycle) of 28 days, for the 1980, 1981 and 1982 seasons (all values in kg).

SR	Cycle	HEIFER			STEER		
		TDN	CP	Mean mass	TDN	CP	Mean mass
5	1	5,78	1,63	196	4,98	1,68	212
	2	4,27	1,30	216	4,46	1,55	242
	3	3,00	1,21	240	3,06	1,35	274
	4	3,72	1,77	268	3,84	1,72	305
	5	6,04	2,89	296	4,98	2,78	336
	6	9,18	3,41	322	8,06	3,07	364
	7	9,09	3,19	345	8,02	2,32	388
	8	7,24	2,13	362	6,49	2,33	408
	9	4,11	1,15	379	3,99	1,00	409
7	1	3,24	1,21	194	3,94	1,44	209
	2	2,79	0,89	212	2,61	1,12	232
	3	1,76	0,73	237	2,11	0,98	258
	4	2,76	1,46	266	2,61	1,52	286
	5	3,52	1,95	295	3,22	1,54	315
	6	5,63	2,31	320	3,75	1,88	343
	7	6,44	2,15	338	6,00	1,79	367
	8	4,86	1,52	344	5,50	1,57	385
	9	3,38	1,11	334	3,12	0,88	387
9	1	3,56	1,24	197	3,25	1,17	210
	2	2,29	0,91	211	2,17	0,92	223
	3	1,80	0,77	229	1,17	0,64	237
	4	1,85	1,00	251	1,56	0,98	253
	5	2,56	1,30	274	2,30	1,12	273
	6	3,39	1,63	297	3,12	1,57	292
	7	3,97	1,50	315	3,48	1,61	316
	8	3,24	1,18	325	3,04	1,10	333
	9	2,36	0,92	324	2,10	0,83	338

TABLE 3.10 The effect of animal mass on the daily requirement for total digestible nutrients (TDN), for heifers and steers, for an average daily gain (ADG) of 0,25; 0,5; and 1,0 kg (after Kearn, 1982).

Animal mass (kg)	TDN requirement (kg)					
	Heifer ADG			Steer ADG		
	0,25	0,5	1,0	0,25	0,5	1,0
200	2,3	2,8	3,8	2,2	2,8	3,7
225	2,5	3,1	4,2	2,4	3,0	4,0
250	2,7	3,3	4,5	2,6	3,2	4,3
275	2,9	3,6	4,9	2,8	3,5	4,7
300	3,1	3,8	5,2	3,0	3,7	5,0
325	3,3	4,1	5,5	3,2	3,9	5,3
350	3,5	4,3	5,8	3,3	4,1	5,6
375	3,7	4,5	6,2	3,5	4,4	5,9
400	3,9	4,7	6,5	3,7	4,6	6,2

requirement for production given by Kearl (1982) and Bredon (1977), were adequate for an ADG of 1,0 kg or more. Exceptions to this were as follows:

(i) levels of CP intake by heifers, at a stocking rate of 7, may have restricted the ADG to 0,6 kg for grazing cycle 2 during 1980 and grazing cycle 3 during 1982;

(ii) at a stocking rate of 9 heifers per ha low CP intakes may have limited the ADG of the animals to 0,6 kg during cycle 3 in 1981 and cycle 2 in 1982;

(iii) for the steers low CP intake, at a stocking rate of 9, may have limited ADG to 0,2 kg for the third grazing cycle of 1980 and 1981, and

(iv) at a stocking rate of 7 steers per ha low CP intakes may have restricted ADG of the animals to 0,4 kg during the last grazing cycle of 1980.

The mean data of Table 3.9 show the trends recorded over the three seasons.

Comparison of Table 3.9 and 3.10 reflect the limitations to animal performance that may have resulted from restricted TDN intake. Thus for example, TDN intake, at a stocking rate of 5 steers or heifers per ha, indicates that the level of animal production will be restricted to an ADG of between 0,5 and 1,0 kg for grazing cycles 3 and 4, and to less than 0,5 kg during the last grazing cycle. For the other grazing cycles TDN intakes provide for an ADG greater than 1,0 kg. At a stocking rate of 7 weaners per ha the ADG's of both steers and heifers is likely to be restricted to less than 0,5 kg for grazing cycles 2,3,4,5, and 9, while for grazing cycle 2 for the heifers and cycle 2 and 3 for the steers, the ADG may be less than 0,25 kg. Based on TDN intake, weaner performance at a stocking rate of 9 weaners per ha is likely to be restricted to an ADG of less than 0,25 kg for grazing cycles 2,3,4,5,8 and 9, for both the steers and heifers, and to less than 0,5 kg for cycle 6 for the heifers and cycle 6 and 7 for the steers.

Clearly, the number of grazing cycles during which TDN intake does not restrict animal performance to less than 1,0 kg decreases from the lightest to the heaviest stocking rate.

The data clearly indicate the effect of stocking rate on the apparent intake of TDN and CP, and the effect this intake of TDN and CP is likely to have on animal performance at different times of the season. The effect of slow pasture growth rates during grazing cycles 2 and 3 (Fig. 3.2) is reflected in reduced nutrient intake and thus animal performance at all stocking rates, during this period. Increasing the stocking rate, although resulting in increased herbage quality (section 3.2.2), resulted in reduced pasture growth and availability, and thus reduced nutrient intake and animal performance. High pasture growth rates and availability (cycles 6 and 7) provided for increased nutrient intakes and animal performance at all stocking rates.

3.2.8 Growing out replacement heifers

The strategy of mating 14 to 15 month old heifers, to calve down at 2 years of age, requires a high level of animal nutrition to ensure that the animals reach the desired two-thirds of their mature mass, for the breed, at mating (Lesch *et al.*, 1974; Bredon & Stewart, 1978). Minimum heifer mass, at mating, should be 280 kg for British beef type animals, and 320 kg for dual purpose type animals (B P Louw, personal communication).

Heifer performance data from the trial shows that the minimum mass for mating at 14 to 15 months can be attained on irrigated Italian ryegrass (section 3.2.4.3). However, since it is generally accepted that the breeding season, for beef animals, commences in early November (B P Louw, personal communication), the heifers must attain the minimum mating mass by this time. Assuming the heifers start grazing the ryegrass on 1 May, this means that there are 183 days for them to attain their mating mass.

Since the relationship between stocking rate and animal performance changes over the season (i.e. with time; Edwards, 1981b) this relationship was recalculated, for the heifers only, for a 180 day period from 1 May.

The mean response of heifers at stocking rates of 7 and 9, for the 1980, 1981 and 1982 seasons, was used. This relationship, between stocking rate (x) and heifer performance, expressed as ADG (y) over the 180 day period, is given by the regression equation $y = 1,5865 - 0,0915x$.

In determining the stocking rate that will provide for the minimum mating mass of the heifers it is necessary to have, or assume, an initial mass (at 1 May). From the difference between the final mass required and the initial mass, the required ADG can be determined from the period (in days) to attain mating mass. However, in order to determine the stocking rate that will provide for the required ADG, it is necessary to re-arrange the above equation: thus $x = 17,339 - 10,929y$.

Based on the economic assumptions and equation 4 of section 3.2.5, and the above equation to predict stocking rate, the appropriate stocking rate and cost of growing out heifers was determined for two breed types. The data are given in Table 3.11. Initial and final value of the heifers and interest on the value of the animal have been excluded from the calculation of the costs presented in Table 3.11.

From Table 3.11 it can be seen that the initial mass of the heifer has a major influence on the cost of growing out the heifer. Caution should be exercised in extrapolating beyond the mass of the animals used in the trial (i.e. below 180 and above 200 kg) because of the effect of the initial mass on the stocking rate - ADG relationship. Nonetheless the extrapolated values have been included to show the effect initial mass has on the cost of growing out the heifer. Clearly the cost difference between British beef and dual purpose type animals is related to the higher mass required, at mating, by the dual purpose type animal. Thus, compared with the British beef type, the dual purpose animal requires a lighter stocking rate to allow for higher ADG's in order to attain the required mass within the 183 day period. In view of the high pasture costs, the lighter stocking rates resulted in high costs per animal.

TABLE 3.11 The effect of initial mass and breed type on the predicted stocking rate (SR) and cost of growing out heifer weaners for mating at 14 to 15 months (i.e. 183 days on Italian ryegrass).

Initial (weaning) mass (kg)	Gain required per animal (kg)		ADG required (kg)		Predicted SR (heifers/ha) to provide required gain		Cost per animal for 183 days (R)		Cost per animal per day (R)	
	Brit	Dual	Brit	Dual	Brit	Dual	Brit	Dual	Brit	Dual
160	120	160	0,656	0,874	10,17	7,79	91-24	116-06	0-50	0-63
170	110	150	0,601	0,820	10,77	8,38	86-72	108-59	0-47	0-59
180	100	140	0,546	0,765	11,37	8,98	82-67	102-01	0-45	0-56
190	90	130	0,492	0,710	11,96	9,58	79-09	96-25	0-43	0-53
200	80	120	0,437	0,656	12,56	10,17	75-79	91-24	0-41	0-50
210	70	110	0,383	0,601	13,15	10,77	72-84	86-72	0-40	0-47

Brit = British breed type animals to be mated at a mass of 280 kg

Dual = Dual purpose type animals to be mated at a mass of 320 kg

3.3 Discussion

The growth pattern of Italian ryegrass was apparently greatly affected by temperature. Pasture growth rates were slow during the cooler months and highest in spring. Slow growth from mid-November was probably associated with completion of the life cycle of the plant (indicated by reduced tillering) and high temperatures.

Slow growth of the pasture during the cooler months resulted in reduced pasture availability at all stocking rates at this time. Although pasture quality (TDN and CP) was high at this time, restricted dry matter intake, by the animal, resulted in reduced TDN and CP intake which affected animal performance. The high stocking rate animals, although having a higher quality forage on offer than the light stocking rate animals, had less dry matter on offer and their production was restricted more than the lighter stocking rate animals. The increased quality did not compensate for the greater restriction on intake at the high stocking rate.

In order to improve animal performance during this period of slow pasture growth (i.e. the colder months), availability of high quality feed to the animals must be increased. Although this can be achieved by supplementary feeding (hay and/or silage and concentrates) it is felt that at this stage pasture management strategies should be investigated. Since the younger animal has a higher protein and lower TDN requirement than the older animal (Miller, 1979) and since protein is expensive, a justifiable policy may be to accept relatively poor performance during the winter and to feed concentrates (with lower protein) to older animals prior to being removed or immediately on removal from the pasture. The feeding of bulk feeds such as hay and/or silage alone, unless of very high quality (particularly protein), may not produce the required improvement in animal performance (Lesch *et al.*, 1974).

A factor to be borne in mind, should concentrate feeding be contemplated during winter, is the possibility of this feeding nullifying, particularly at high stocking rates, any benefits that may accrue from compensatory growth when pasture availability increases. Although Jury, Everitt & Dalton (1980) state that poorly reared animals cannot be relied upon to exhibit compensatory growth after weaning, compensatory growth is a well documented phenomenon (Hart, 1972). Thus the possibility of benefit being derived from compensatory growth further suggests that the feeding of concentrates should be delayed until later on in the season.

Pasture strategies that could be investigated to improve herbage availability during the winter slow pasture growth period include:-

- (i) earlier planting in an attempt to establish a forage buffer;
 - (ii) increasing the number of camps to provide for a longer regrowth period, and thus higher yields, between grazings, and
 - (iii) providing for a rapid grazing rotation during the first two grazing cycles in an attempt to maintain a high leaf area index, and thus high pasture growth rates, while temperatures are conducive to pasture growth (Tainton, 1981b); in so doing a forage buffer might well be established.
- With earlier planting of Italian ryegrass it will be necessary that weeds be effectively controlled. Furthermore, frequent irrigations, particularly during hot spells, may be needed to keep the soil cool and to ensure that the seedlings do not suffer from drought stress. Since Italian ryegrass is the temperate species with higher growth rates than alternative species during winter, there are, at present, no other species that could be included in a mixture to provide for increased pasture availability at this time. However, the inclusion of a temperate legume, such as white clover (Trifolium repens), although having a slower growth rate than Italian ryegrass during winter, has a higher nutritive value and digestibility than Italian ryegrass (Wilman, Koocheki, Lwoga & Samaan, 1977; Jones et al., 1980). Thus, although quantity of herbage may still limit intake, the

improved quality of this intake may well result in improved animal performance.

Pasture limitations to animal performance towards the end of the season followed the expected pattern. A reduction in both the quantity and quality of herbage on offer, and thus nutrient intake by the animal, resulted in declining animal gains from early November. Performance of the high stocking rate animals was affected sooner and more severely than performance of the low stocking rate animals. Since the life cycle of the plant is nearing completion in November, management strategies to improve pasture growth rate and/or pasture quality of the existing sward are likely to be only marginally successful in improving animal performance.

In order to improve the slow growth rates of the animals, resulting from pasture limitations towards the end of the season, and to extend the grazing period (to attain higher animal mass, or, particularly in the case of steers, higher grades, or to reach a later market) it is felt that several options or strategies offer possibilities.

1. Italian ryegrass could be established with white clover. Besides the general improvement in animal performance obtained from the inclusion of clover in grass pastures (Thomas & Raymond, 1970; Rattray & Joyce, 1974; Barrick, 1978; Marsh & Laidlaw, 1978) and the possibility of increased dry matter yields from grass-clover pastures compared with pure grass pastures (Brockman & Wolton, 1963), the clover could prove valuable in extending the grazing season and in improving the declining animal performance recorded towards the end of the season. Although white clover has higher growth rates than Italian ryegrass from October, and produces well during November and December (Jones *et al.*, 1980), reasonable per ha production from the clover pre-supposes a reasonable clover population at this time. However, the adverse effect that high levels of nitrogen (Murphy, 1970) and severe competition from the grass (Tainton, 1981c), particularly at the light

stocking rate, may have on clover survival will need to be evaluated under grazing conditions. Clearly stocking rate will affect the degree of shading of clover by the grass (competition) and hence survival of the clover. Thus it would be expected that the clover is likely to make a greater contribution to animal performance at high, rather than at low stocking rates. Although bloat is a very real problem when animals graze clover based pastures (Todd, 1970; Tainton, 1981c), it can be controlled provided adequate precautions are taken (Tainton, 1981c).

2. Italian ryegrass could be oversown with an appropriate cultivar of the same species during September - October. Goodenough, Macdonald & Morrison (1984) have shown that Italian ryegrass can be successfully established, in Bioclimate 3, during July, August, September and October. It is felt that introducing a new generation of Italian ryegrass plants (not necessarily the same cultivar), at a time when tillering of the old generation of plants is declining, may well provide for increased growth from the pasture at a time when increased production is required to maintain or improve animal performance. Row planting of both generations of ryegrass, short defoliation of the existing sward prior to overseeding, overseeding each camp as the animals are removed, and extending the period of absence (increase the number of camps or the period of stay) to allow for c. 6 weeks from planting to first utilisation, may be necessary to achieve success with this strategy.

3. Animals may be fed a supplement or concentrate while on pasture. The literature abounds with references to the feeding of concentrates for growing out and for finishing animals on pasture for slaughter. Clearly, supplementary or concentrate feeding on pasture can improve animal performance and can extend the length of the grazing season. However, supplementary feeds substitute for pasture at different rates, depending on the quality and quantity of the supplement and on pasture quality and

availability. This will clearly affect SRmax and SRmp and each level of concentrate fed will have to be evaluated separately to assess its profitability. In view of the improved animal performance, reported by numerous workers (e.g. Riley, Corah & Fink, 1976; Linn, Goodrich & Meiske, 1976; Bates, Fox & Bergen, 1977; Woody & Fox, 1977; Kargaard & van Niekerk, 1980; Theron & Harwin, 1983), from the addition of monensin to the supplement or feed, it would seem that this growth stimulant offers distinct possibilities and should be considered if supplementation on pasture is contemplated.

Characterisation of Italian ryegrass in terms of the production of 15 to 16 month old slaughter animals shows, with existing costs and product prices, the economic benefit of using steer weaners as opposed to heifer weaners. However, as the price difference between carcass grades increases, so the difference in profit per ha between heifers and steers narrows (Table 3.7). The relationship between sex of animal, carcass grade prices and SRmp provide for many different strategies that could be advocated, depending largely on initial weaner price, or value, and on product prices.

Thus, for example, for the farmer who produces weaners and limited irrigable pasture area precludes growing out all the weaners, it may be more profitable, overall, to sell the steer weaners (steers usually attain a higher price than heifers of the same age and mass) and fatten the heifers on pasture. The higher the carcass grade price difference and the greater the initial price difference in favour of the steer the more profitable this system would be.

It is felt that an extremely important factor to be considered when using heifers for the production of slaughter animals, is the "quality" of the heifer weaner. Unless the weaner originates from a breeding programme specifically designed to produce animals for slaughter, the heifer to be finished for slaughter on pasture, whether produced on the farm or bought in, will inevitably be of the "cull type". However, if bred on the farm the

farmer does have an idea of the genetic potential of the cull heifer and thus its suitability for fattening. Clearly the "cull type" heifer would have been rejected as a replacement heifer, due to poor performance or some other animal selection criteria, and is likely to have a poorer performance than the average heifer. Thus, in practice, relative to the steer weaner (not selected for on the basis of poor performance and representing the true mean of the population), the heifer may have an even lower profitability than recorded for the present trial. For the farmer who buys in weaners to fatten on pasture, it will probably be more profitable to use steers than heifers. However, the generally cheaper price paid for heifers may, depending on product grade prices, favour the heifer in terms of overall profitability.

Another important factor to consider when using heifers for slaughter animals is the livemass at the start of grazing (1 May). The low ADG's recorded for the heifers, particularly at the high stocking rate, may result in small carcasses which have a lower producer price than larger carcasses of the same grade. Thus the predicted ADG of 0,691 kg for a SRmp of 8,82 for the heifers (Table 3.7) may, depending on dressing percent, produce a light carcass (falling into a lighter mass class within the grade, with a lower price per kg) if the initial mass is less than c. 187 kg. Since steers are generally heavier than heifers at weaning, and have higher ADG's than heifers, initial mass is less important with the steer than it is with the heifer.

Results from the trial clearly show the feasibility of using irrigated Italian ryegrass for the growing out of replacement heifers. Although Hull & Raguse (1978) advocate the use of supplemental feeding on irrigated pastures for the growing out of heifers to be mated at 14 to 15 months of age, data from the present trial indicate that supplementation is unnecessary. The cost of growing the heifer out to a mateable mass is largely affected by the initial mass of the weaner. Clearly this cost must

be compared with and evaluated against factors such as the costs of rearing the weaner to an age of two years (i.e. two winters and a summer), the quicker return from the early mated heifer and the loss in return from not using the ryegrass pasture for growing out slaughter animals (if irrigable land is limiting). Thus the profitability or otherwise of growing out heifers to be mated at 14 to 15 months will depend on the resources of each farm in relation to the overall beef strategy.

The use of zeranol and progesterone-estradiol implants in steers grazing pastures has resulted in increased animal performance ranging from 11 to 21% (Basarab, Gould & Weisenburger, 1984). Hart, Balla & Waggoner (1983) reported that zeranol based implants improved the performance of steers grazing crested wheatgrass by 13%, while Theron & Harwin (1983) state that improved performance of from 12 to 15% can be expected from zeranol implanted animals on pasture. Theron & Harwin (1983) recommend the use of zeranol based implants "...at all times". Thus it would seem that the use of animal growth promoters (as implants) may well improve the performance of both steers and heifers grazing irrigated Italian ryegrass. The use of growth promoters is, however, not recommended for animals intended for breeding (Basarab *et al.*, 1984; Anon., 1982).

The pasture parameters monitored have provided useful information on the response of the plant to grazing, to temperature and on the effect morphological growth stages had on the herbage on offer to the grazing animal. Besides aspects relating to the effect of temperature on pasture growth rate and the effect stocking rate had on herbage production, utilisation, quality and gross morphology, flowering had a pronounced effect on the quality (and it would seem quantity) of herbage on offer to the grazing animal.

Data from the trial show that following flowering there is a rapid, almost linear, decline in herbage quality. This decline in quality is accompanied by a declining growth rate of the pasture. Very little is known

about the flowering and tillering processes of the Midmar cultivar of Italian ryegrass. It has been established that reproductive apices are susceptible to removal by the grazing animal from the end of September. However, there is no information on factors or processes responsible for floral induction or initiation. Furthermore, the time and height of elevation of tiller apices and the effect of decapitation of apices on the development of lateral tiller initials (Tainton, 1981a) is not known. There is indeed a paucity of information on factors affecting tillering of Midmar both before and after flowering.

It is felt that more detailed physiological studies, particularly of the flowering process and the effect flowering has on tillering and on tillering per se, are necessary for the development of management strategies to curtail declining herbage quality and pasture production following flowering. Thus, for example, should it be possible to prevent flowering, the lateral tiller initials which degenerate once a tiller flowers (Tainton, 1981a), may develop into productive vegetative tillers and thus increase pasture quality and production at a time when flowering results in declining quality and reduced growth of the pasture. However, information on the flowering process and tillering is necessary before improved pasture management strategies can be formulated and evaluated in practice.

In retrospect, the stocking rates selected to characterise irrigated Italian ryegrass may well have been heavier. Data from the trial show that the lightest stocking rate (i.e. five weaners per ha) was at or near the biological optimum. Animal performance data from this stocking rate was thus excluded when determining the linear relationship between stocking rate and animal performance. This relationship was therefore derived from only two stocking rates. While only two stocking rate treatments are required to establish the relationship between stocking rate and animal performance (section 1.3), the criticisms associated with the fitting of a regression to only two data points, without replication, is fully realised. However, in

view of the remarkably similar slopes of the stocking rate - ADG relationship for the different seasons, the data are presented with confidence. Clearly, had there been large differences in the slope of the stocking rate - animal gain relationship between seasons the validity of the mean slope, based on only two stocking rate treatments, could have been questionable (particularly in view of the remarkably similar dry matter yields recorded for each of the seasons).

While it may be "nice to know" the biological optimum for beef production (it is necessary to know this in the dairying context), determination of both SR_{max} and SR_{mp} show that this information is of limited practical significance. Obviously the more data points used to determine the relationship between stocking rate and animal performance the greater is the confidence that can be placed on the regression equation describing this relationship. Furthermore, the larger the number of stocking rate treatments, particularly when SR_{max} is not known, the greater is the possibility of the treatments spanning SR_{max} (cf. 1.3). Determination of SR_{max} for the present trial indicates that the stocking rates selected to characterise irrigated Italian ryegrass in terms of beef production, should have been heavier for both the steers and the heifers. Furthermore, the heifers should have had higher stocking rates than the steers. This is indicated by a SR_{max} of 6,85 for the steers and 9,54 for the heifers.

Results from the trial show that 15 to 16 month old slaughter animals, both steers and heifers, and replacement heifers to be mated at 14 to 15 months of age, can be profitably produced on irrigated Italian ryegrass in Bioclimate 3.

3.4 Conclusions

Pasture production and utilisation

- * The growth pattern of irrigated Italian ryegrass is consistent over seasons. Pasture growth rate is high in autumn, slows down during winter, increases to a peak during spring and declines from October, following flowering.
- * Stocking rate has little effect on the pasture growth pattern but affects dry matter yields. Decreasing the stocking rate results in increasing dry matter yields per ha.
- * The lighter the stocking rate the higher the pasture yield and the higher the amount utilised per ha.

Pasture quality

- * Increasing the stocking rate results in increasing herbage quality (CP and TDN) and reduced CP of the herbage on offer to the animals.
- * Herbage CP and TDN values decline rapidly, almost linearly, following elevation of the flowering stem, while CP increases rapidly after flowering.

Pasture morphology

- * Animals select leaves in preference to stems and stems in preference to dead material.
- * Higher leaf/stem ratios are associated with higher stocking rates.

Animal performance

- * Steer and heifer weaners perform differently. At the same stocking rate steers have a higher ADG and lower SR_{max} than do heifers. However, heifers fatten sooner and attain higher grades than steers.
- * Both steer and heifer weaners can be profitably grown out, on irrigated Italian ryegrass, for slaughter. With the present carcass grade price structure, profit per ha is greater from steers than it is from heifers.
- * Due to the higher grades attained by heifers, relative to steers, increasing the price difference between grades reduces the profitability of steers relative to heifers.
- * With an overall increase in beef prices, SR_{mp} tends towards SR_{max}, while with increasing price differences between grades, SR_{mp} tends towards the biological optimum.
- * Heifer weaners with a mass of less than c.187 kg at weaning may produce light carcasses.
- * Italian ryegrass can be used to grow out heifer weaners to be mated at 14 to 15 months of age. Lighter weaners and heavier breeds require lighter stocking rates than heavier weaners or lighter breeds.

Pasture limitations to animal performance

- * Slow pasture growth during winter restricts animal performance at all stocking rates at this time. The lighter the stocking rate the less severe this restriction.
- * Restricted pasture availability and declining herbage quality towards the end of the season (following flowering) limits the performance of the animals at this time. The higher the stocking rate the sooner and more severe is the restriction on animal performance.

Research needs

- * Pasture management strategies to establish a forage buffer to compensate for slow pasture growth, and thus low herbage availability, during winter.
- * The possibility of white clover, established with Italian ryegrass, providing for increased pasture availability and quality, particularly towards the end of the season, and thus improved animal performance.
- * Physiological studies on tillering and of the flowering process to provide basic information on which to formulate pasture management strategies to curtail declining pasture growth rates at the end of the season.
- * Monitoring the relative rates of muscle tissue development and of fat deposition of the animals. Knowledge of body composition will provide for greater flexibility in terms of marketability of the animals in relation to fluctuating beef prices.
- * Supplementary or concentrate feeding is not regarded as being of high priority at this stage. However, the provision of a "supplement buffer" (i.e. a high quality feed which is less palatable and less acceptable to the animal than the pasture), as proposed by Greenhalgh (1975), may qualify as a pilot trial type of research based on grass silage as the supplement.

YEARLINGS ON KIKUYU

Introduction

It is generally accepted that it is more profitable to grow out and finish animals for slaughter than it is to produce weaners (Chapter 1). However, as indicated by Tainton et al. (1982), most of the research relating to kikuyu in South Africa has been undertaken on small plot cutting trials. Little research has been directed at beef production from kikuyu. Rethman, Eden, Beukes & de Witt (1977) evaluated kikuyu with beef animals receiving ad lib. concentrate. Bransby (1984) compared continuous and rotational grazing systems to assess the potential of kikuyu, in Bioclimate 6, for growing out young beef animals. Tainton et al. (1982) measured the response of steers, implanted with growth stimulants, grazing kikuyu at four levels of nitrogen. The put-and-take research technique was used. Livemass gains ranging from 1 008 to 1 132 kg per ha, reported by Tainton et al. (1982), indicates the potential of kikuyu for beef production in a Bioclimate (upper reaches of 6) not very different from Bioclimate 3 (Phillips, 1973).

The need to evaluate kikuyu, in terms of beef production, is seen in relation to the options open to the farmer (Fig. 1.1) in planning his overall beef strategy. Thus there is a need to characterise kikuyu in terms of the effect of stocking rate on animal performance. In this regard the characterisation approach (cf. 1.3) has been adopted.

4.1 Methods and materials

The trial was conducted in camps Y5 and W6 (Fig. 2.1) at Broadacres (for climate and location see Chapter 2). Four stocking rates of 8, 10, 12 and 14 yearling heifers per ha constituted the treatments which were replicated. Replicate 1 (camp Y5) was on a north-eastern aspect with a slope of 8 to 12% while replicate 2 was on a northern slope of 6%.

Drakensberger heifers with an initial age of 12 months and starting mass of 164,9 kg were used. The heifers had been overwintered, at a low plane of nutrition, on maize silage and *E. curvula* hay. There were six heifers per treatment, three per replicate.

The kikuyu pasture used had been utilised for an identical trial during the previous season (1976/77). Poor condition of the pasture at the start of the 1976/77 season, the short period of the trial (14/1/77 to 26/5/77) and an outbreak of army worm (necessitating removal of the animals from the trial for 17 days) rendered the results from the 1976/77 season spurious. Of particular significance in abandoning the results from this season was the large variation in the degree of damage caused by the army worm across the different stocking rate treatments. However, the 1976/77 season did serve to improve the pasture for the 1977/78 trial. During 1976/77 the soil P status was raised to 15 ppm P (soil K was > 150 ppm) and, with the aid of the army worm, much of the Mshiki was eliminated.

The pasture was top-dressed with 250 kg nitrogen per ha. The nitrogen was split into three dressings of 83 kg N per ha and applied in early September, mid-December and mid-February.

During the trial season (1977/78) all stocking rate treatments were set stocked and continuously grazed (one camp per treatment). Pasture disc meter readings (100 random positions per camp per replication per occasion) were taken to monitor pasture availability at 3 to 4 weekly intervals. The

pasture disc meter was not calibrated and no herbage samples were taken for proximate analyses.

While on pasture the animals had free access to water and to a salt:di-calcium phosphate (1:1) lick. All animals were weighed fortnightly, without starvation, at the same time of the day (08h30). The animals were dosed twice with an anthelmintic while on pasture. Mr A van Niekerk (Animal Science section, Cedara) was responsible for the weighing and well-being of the animals.

The trial commenced on 3/11/77 and ended on 30/5/78 (208 days).

4.2 Results

4.2.1 Pasture availability

The effect of stocking rate on mean (two replications) pasture availability, in terms of disc meter height, is illustrated in Fig. 4.1a. Differences in initial pasture height were due to the effect of the previous seasons stocking rate trial (the same treatments were allocated to the same camps in 1976/77 and 1977/78). From Fig. 4.1a it can be seen that increasing the stocking rate resulted in reduced pasture availability (in terms of disc height). The relatively small difference in pasture height between stocking rates of 12 and 14 heifers per ha can be related to pasture variation. Pasture areas allocated, at random, to the stocking rate of 12 animals per ha treatment coincided with the poorer pasture areas (largely the presence of Mshiki) in both replications. Although much of the Mshiki was eliminated during the 1976/77 season, some remained in the camps allocated to the 12 heifers per ha treatment. It was thought that this small amount of weed would not have affected kikuyu production or pasture measurements. Apparently this was not the case. It would be expected that the Mshiki, being more rigorous than the kikuyu, would have "inflated" mean

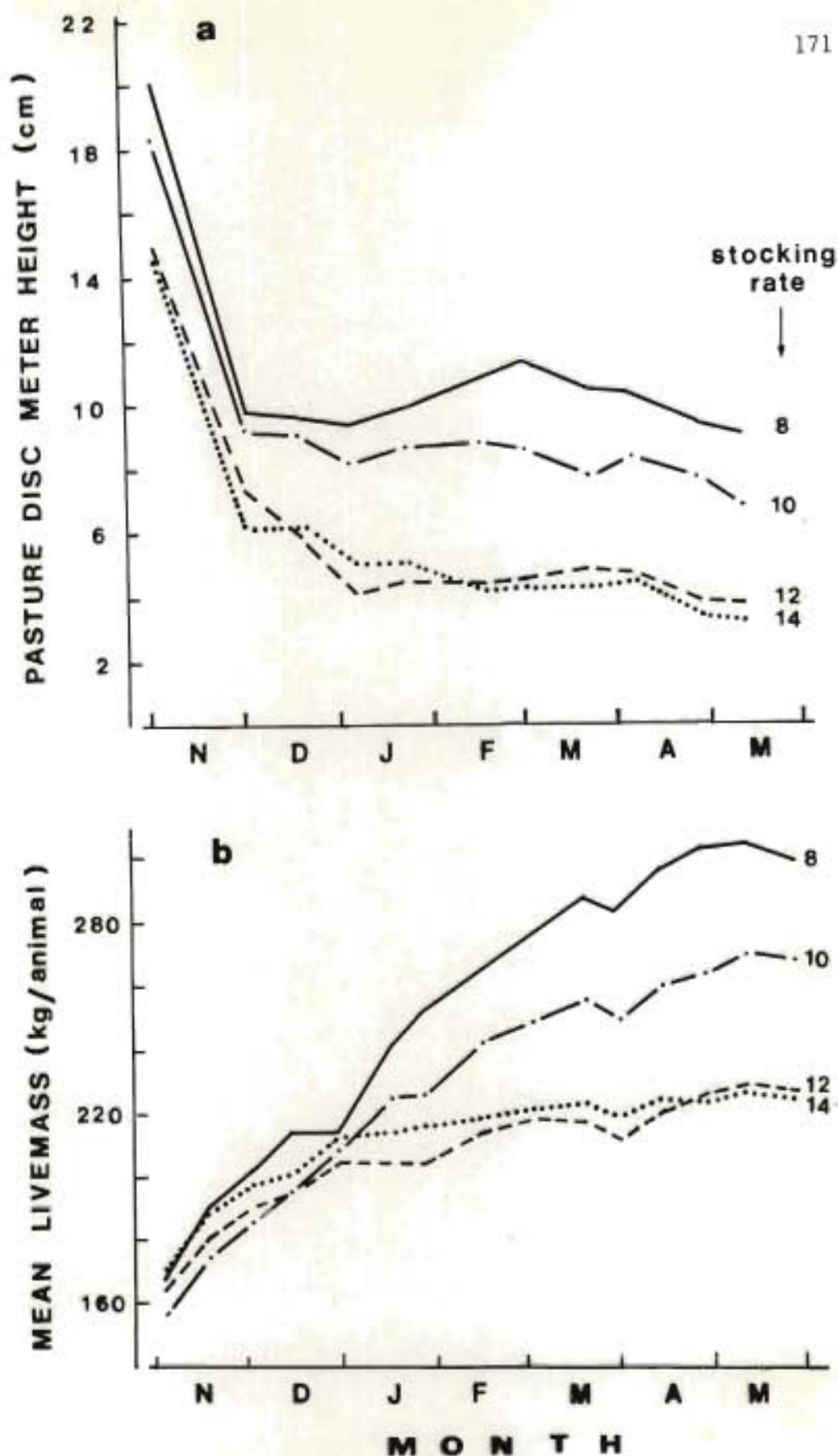


Fig. 4.1 The effect of stocking rate and time on (a) mean pasture availability (as pasture disc meter height), and (b) mean livemass gains of yearling heifers grazing kikuyu.

disc height readings. However, the animals grazed the Mshiki shorter than they did the kikuyu. Thus the Mshiki, although occupying less than 8 to 10% (visual estimate) of the pasture area, appeared to affect pasture production and thus animal performance, as will be seen later in the discussion.

Notable features of the pasture height were, apart from the first month when there was a rapid drop in mean pasture height, the small variations in height recorded for each of the treatments over the trial period (Fig. 4.1a) and the relatively large differences in pasture height between all but the two heaviest stocking rate treatments.

4.2.2 Animal performance

The effect of stocking rate on the livemass change of yearling Drakensberger heifers, grazing kikuyu as the sole feed, is shown in Fig. 4.1b. Livemass gains of animals from the different stocking rate treatments show that differences in animal performance between stocking rate treatments were inconsistent. Differences in livemass gain of animals stocked at 12 and 14 heifers per ha did not follow the expected pattern which was recorded between stocking rates of 8 and 10 heifers per ha and between 10 and 12 (or 10 and 14) heifers per ha (Fig. 4.1b). Although the initial mass of the animals stocked at 14 heifers per ha was higher than that at 12 animals per ha, the "similar" performance of animals from these two treatments is ascribed to "similar" pasture availabilities (Fig. 4.1a) for these two stocking rate treatments.

Comparison of Figs 4.1a and 4.1b illustrate the dependence of animal performance on pasture availability (disc height). Reducing the stocking rate resulted in increased mean pasture height with a concomitant increase in livemass gain per animal.

As the original objective of the trial was to characterise kikuyu in terms of growing out heifers for breeding at two years of age, final mass

was the sole animal orientated objective. The animals were thus not assessed for slaughter qualities.

Based on quartic equations fitted to the animal livemass data, maximum mass of the animals was attained after 188, 203, 203 and 184 days at stocking rates of 8, 10, 12 and 14 heifers per ha respectively. Livemass gains per animal at the respective stocking rates were 129, 114, 64 and 56 kg.

4.2.3 Relationship between stocking rate and animal performance

The relationships between stocking rate and animal performance and between stocking rate and gain per ha, determined over a 180 day period, are illustrated in Fig. 4.2. Analysis of the data based on the Jones & Sandland (1974) model (cf. 1.3) show that SR_{max} can be expected at 8,85 yearling heifers per ha. At SR_{max} the predicted average daily gain of the animals would be 0,653 kg with a daily gain per ha of 5,78 kg (i.e. 1 040 kg per ha for the 180 day period). Daily gain per animal (y) is dependent on stocking rate (x), in heifers per ha, and is given by the equation $y = 1,305 - 0,0737x$ ($r=0,962^{**}$).

As a result of the stocking rate treatment of 12 heifers per ha having a relatively poor pasture, compared with the pastures of the other stocking rate treatments, the relationship between stocking rate and animal performance was also determined using data from stocking rates of 8, 10 and 14 heifers per ha. Daily livemass gain per animal (y), using only three stocking rates to calculate the relationship between stocking rate (x) and animal performance is given by $y = 1,272 - 0,0683x$ ($r=0,998^{**}$). This regression predicts SR_{max} to be 9,32 heifers per ha, daily animal gain at SR_{max} to be 0,636 kg and a livemass gain per ha per day of 5,93 kg (i.e. 1067 kg per ha for 180 days).

Comparison of predictions of animal performance based on the regressions

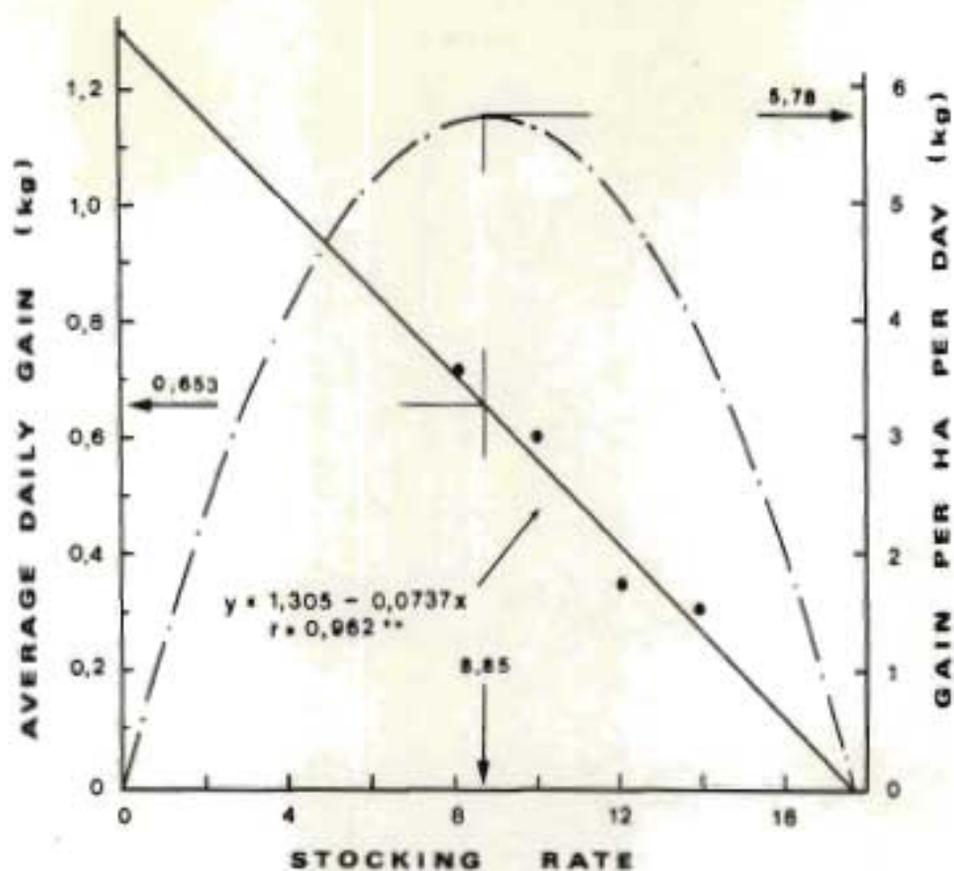


Fig. 4.2 The relationship between stocking rate and average daily gain per animal, and between stocking rate and liveweight gain per ha per day, for yearling heifers grazing kikuyu.

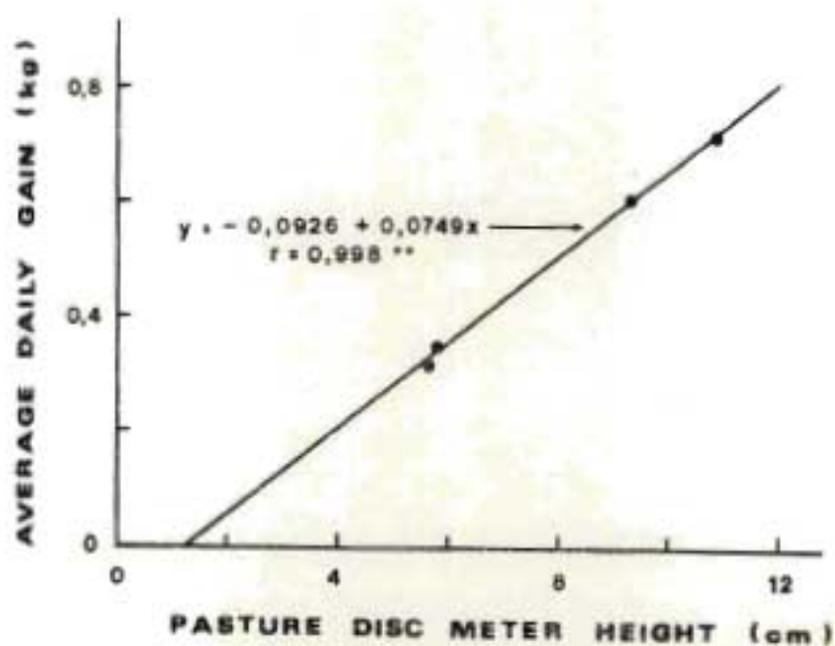


Fig. 4.3 The relationship between mean pasture height (over the season) and average daily gain per animal.

derived from three or from four stocking rate treatments indicate several interesting points. The correlation coefficient was higher (as would be expected) for the regression excluding animal performance data from the "weedy" pasture. Estimates of SR_{max} increased from 8,85 to 9,32 heifers per ha for regressions derived from four and three stocking rates respectively. Predictions of average daily gain, gain per ha per day and livemass gain per ha for 180 days differ only marginally when the two regression equations are compared. Thus, for example, at SR_{max} daily gain per animal decreases by 0,017 kg, livemass gain per ha per day increases by 0,15 kg and total gain per ha increases by 27 kg for the 180 day period when predictions from the regression derived from three stocking rates are compared with those from the regression derived from all stocking rate treatments.

It is considered that differences between the above two equations, in predicting animal performance, are small and of little consequence. This as a result of (i) the small differences in predicted animal performance, (ii) large seasonal variations that can occur in pasture production and thus animal performance (Bransby, 1984), (iii) the trial having been conducted for only one season, and (iv) the fact that 90% of maximum livemass gain per ha occurs over a fairly wide range of stocking rates (Edwards, 1981b). However, what is important is that the "deviation" of animal response, from the linear response, at a stocking rate of 12 heifers per ha can be related to pasture availability (height).

4.2.4 Pasture - animal relationships

As a result of the relatively constant pasture availability (disc meter height) recorded over the season at each of the stocking rate treatments (Fig. 4.1a), it seemed justifiable to relate mean pasture availability to animal performance. The relationship between mean pasture height, over the season, and daily gain per animal is illustrated in Fig. 4.3. Prediction of

daily gain per animal (y) from mean pasture disc height (d) is given by the highly significant ($P < 0,001$) equation $y = - 0,0926 + 0,0749d$ ($r = 0,998$). This regression equation clearly indicates the positive relationship between pasture availability and animal performance.

Of particular significance in comparing the average daily gain - stocking rate relationship (Fig. 4.2) with the average daily gain - pasture height relationship (Fig. 4.3) are the slopes of the separate regression equations. The former relationship has a negative slope of 0,0737 while the latter relationship has a similar but positive slope of 0,0749. The highly significant multiple linear regression equation $ADG = 0,0762 - 0,0092x + 0,0663d$ ($r=0,9989$) to predict average daily gain (ADG) from stocking rate (x) and mean pasture height (d) aptly describes the relationship between animal performance, stocking rate and mean pasture height.

4.2.5 Cost of growing out yearlings

The low initial mass of the heifers coupled with the relatively high stocking rate used precluded the production of slaughter animals by the end of May. Consequently, valuation of the animals is extremely difficult. Furthermore, with this system (yearlings onto pasture in spring and off pasture in May) it would be inadvisable to sell low grade animals in autumn. The general trend of beef prices (Stockowners News from 1982 to 1984) is that all beef grades have high prices in spring but the lower beef grades have their lowest prices of the year in autumn.

As a result of the animals from the trial not being ready for slaughter (low mass gains per animal) and the recommendation that low grade animals should not be sold in May, the costings are directed at the growing out of the animals. Annual variable costs of R309 per ha (250 kg N and 15 kg P) for the pasture and R10 per animal have been assumed. Land price has been taken at R300 per ha (non-arable land) and an interest rate of 20% has been

applied throughout.

At SRmax (using the regression derived from all four stocking rates), based on the above charges, the cost of 1 kg livemass gain would have been 50,8c. However, the most economic livemass production, 50,4c per kg livemass gain, would have been at a stocking rate of 8 heifers per ha. The cost per kg livemass gain increases at stocking rates above and below 8 heifers per ha. For example, at stocking rates of 6, 8 and 12 the cost per kg livemass gain would have been 53,3; 50,4 and 61,9c (with ADG's of 0,863; 0,715 and 0,421 kg) respectively for the 180 day period. Costs per animal, at stocking rates of 6, 8 and 12, would have been R82.77, R64.86 and R46.73 to produce per animal gains of 155, 129 and 76 kg respectively.

It may be argued that if the animals are to be finished on the farm the use of a high stocking rate on pasture (not the most economical in terms of cost per kg livemass gain) to provide more animals for finishing, may prove more profitable overall. However, besides the feed resources and facilities (and their associated costs) available for finishing animals for slaughter, it is important to consider the interrelationship and interdependence of several factors.

- (i) The higher the stocking rate on pasture the lower the initial mass of the animals for the finishing phase and the longer and more expensive the finishing phase will be.
- (ii) The cost of producing 1 kg livemass gain in the feedlot is of the order of R1.20 (B P Louw, pers. com.), compared with c. 51c on kikuyu.
- (iii) Unless very high stocking rates are used while on pasture, resulting in low ADG's and low gains per animal, compensatory growth cannot be expected in the finishing phase.
- (iv) The higher cost per kg livemass gain increases above a stocking rate of 8 heifers per ha.

Clearly, the overall strategy will vary from farm to farm. Product price

fluctuations, availability and cost of concentrate formulations, the market envisaged and the managerial ability of the farmer are all involved in formulating the strategy to maximise profits.

4.3 Discussion

The heifers used in the present trial were some 43 kg lighter, at 12 months of age, than the average for the breed (Bosman, Hunlun & Gibson, 1984). Assuming a mature mass of 460 kg (Bosman et al., 1984) and two thirds of mature mass at mating (1 November), data from the trial show that at SRmax the heifers would have to be fed to gain 25 kg in 5 months (i.e. an ADG of 0,163 kg) to reach mateable mass at 2 years. Clearly this is feasible, even on a low plane of nutrition. Had the initial mass of the heifers been higher (in line with the average for the breed), the heifers could have attained mating mass by the end of May at SRmax. However, had they been heavier at the start of the trial a lower stocking rate would have been necessary to enable them to achieve the same level of animal performance (Zoby & Holmes, 1983).

Data from the present trial serves to confirm the linear relationship between stocking rate and animal performance found by other workers (e.g. Jones & Sandland, 1974; Hart, 1978; Edwards & Mappledoram, 1979; Rodel & Boulwood, 1981; Bransby, 1984). Furthermore the data indicate the dependence of animal performance on pasture availability (Petersen, Lucas & Mott, 1965; Marsh, 1977; Bartholomew et al., 1981).

Pasture availability (measured as disc meter height) over the season followed a particularly interesting pattern. Data from the cow-calf trial (Chapter 2) show that under a rotational grazing system kikuyu can be defoliated to a mean disc meter height of 2 cm. Thus it is surprising that, apart from the first month when there was a rapid drop in pasture height, fluctuations in pasture height were less than 2 cm at each stocking rate

treatment. Furthermore, at no time was the mean pasture disc height less than 3 cm (even at the high stocking rate treatment where low animal gains resulted from restricted intake: Marsh & Murdoch, 1974). This suggests that under continuous grazing kikuyu forms some sort of "stubble barrier" (as with E. curvula : McIlvain & Shoop, undated) below which the animals are reluctant to graze.

In using the overall regression of disc height on yield from the cow - calf trial (Chapter 2), a mean disc height of 3 cm represents 1 478 kg dry matter per ha. This is within the range of 500 to 1 500 kg dry matter on offer per ha where Bartholomew et al. (1981) found herbage consumption to fall to zero. For stocking rates of 12 and 14 heifers per ha the herbage on offer to the animals below a mean pasture height of 3 cm may well have been unavailable. However, at stocking rates of 8 and 10 it seems unlikely that availability of herbage precluded the animals from grazing the pasture shorter (herbage on offer at the end of the season was 2 936 and 2 328 kg per ha respectively). That dry matter intake was limited by "available" herbage is shown by the lack of any appreciable seasonal change in pasture height at a stocking rate of 10, particularly during periods of high pasture growth rate. Increased or high pasture growth rate is indicated by increased pasture height only at the light stocking rate during February (Fig. 4.1a). Thus while there were large differences in animal performance between stocking rates of 10 and 12 there were also large differences in pasture height between these two stocking rate treatments (Figs 4.1a, 4.1b). Furthermore, animals at a stocking rate of 10 had not reached either the pasture or animal potential (animals at a lighter stocking rate had a better performance). As the pasture was set stocked and continuously grazed it is difficult to explain why the animals stocked at 10 heifers per ha (and in relation to the data of Figs 4.1 and 4.2, 8 heifers per ha) did not graze the pasture shorter. It would seem that some sort of pasture or grazing barrier developed. Furthermore, it would seem that this barrier was

"established" early on in the season. There is indeed a need to examine the effects of defoliation on the morphology of continuously grazed kikuyu swards. Knowledge of sward morphological changes may well indicate grazing management strategies that could improve pasture utilisation and animal performance.

The need to monitor both pasture and animal parameters in grazing trials (Matches, 1969; Mannelje, Jones & Stobbs, 1976; Hart, 1984) is clearly evident from the present trial. This is so whether treatments are replicated or not. Thus, for example, had pasture availability (height) not been monitored in the trial it might have been concluded that animal response to increased stocking rate, particularly at the higher stocking rates, was quadratic. However, when seen in relation to pasture height (Fig. 4.1a), it is evident that the relationship between pasture height and animal performance, within the stocking rate range evaluated, was linear (Fig. 4.3). Calibration of the disc meter and monitoring of herbage quality would no doubt have added considerably to an explanation of animal and pasture response to stocking rate. Morphological studies coupled with quality analyses (particularly of different vertical strata within the sward) would further serve to provide data for improved pasture management.

The highly significant multiple linear regression of animal performance, stocking rate and mean pasture height shows, as would be expected, the interdependence of these factors. This multiple regression equation could be a useful management tool to offset year to year variations in pasture production. Since the regression accounts for 99% of the variation, without the need to predict yield (yield is usually estimated from rainfall which is difficult to predict), it can introduce flexibility into the management system. For example, should it be necessary to attain a certain level of animal gain over the season animal numbers or, preferably, pasture area could be adjusted to accommodate the animal gain required. This put-and-take strategy would, however, require flexibility of the overall beef enterprise.

Flexibility would involve, largely, alternative feeding, finishing or marketing strategies should it be necessary to reduce the stocking rate (grazing pressure), or a strategy to utilise foggage should it be necessary to increase the grazing pressure (i.e. reduce area).

Much research will be needed before the put-and-take (animals or area) systems can be advocated. It may be argued that should it be necessary to remove animals from the pasture the farmer must "cut his losses" and be satisfied. However, if provision is made (in the form of a fodder reserve or feedlotting facilities) in the overall beef system for the eventuality of having to remove animals, the overall profitability may be improved relative to selling animals at a loss or low profit margin. These strategies revolve largely around testing different systems, or hypotheses (pen and paper or computer analyses) and are beyond the scope of this dissertation. However, it would be necessary to assess, from a research point of view, the effect that changing pasture height, resulting from changing grazing pressure, will have on animal performance (particularly if a grazing barrier is established, and whether this barrier will affect intake and thus animal performance). Furthermore, there is a need to determine herbage quality changes over the season. Changing the grazing pressure during the season may well affect pasture growth rate and the quality of the herbage eaten by the animals and thus animal performance. Clearly there is a need for more detailed studies on the physiology, morphology, yield and quality of continuously grazed kikuyu swards.

Much has been written about the merits of early and late maturing beef breeds (e.g. Preston & Willis, 1974; Allen & Kilkenny, 1984). Suffice it to say that the early maturing breeds attain marketable condition at a lighter mass but earlier age than the late maturing breeds. Thus it may be possible to produce 18 month old slaughter animals off kikuyu, using an early maturing breed, if the initial mass of the animals is greater than 200 kg and the stocking rate is less than six heifers per ha. However, the later

maturing type of animal, as used in the present trial, has the potential for attaining a higher mass than the earlier maturing types and may provide for greater overall profits if fed for longer. Although animal type is regarded as an important aspect requiring research, the use of feeding standards (A.R.C., 1980; N.R.C., 1976) could play an invaluable role in assessing the possible effects of breed differences (within classes of animals) in the interim. However, quantification of the response of the pasture (quantity and quality) to different stocking rates is required before feeding standards can be used with confidence.

It is conceded that the stocking rate - animal performance relationship should be established from trials conducted over a number of years. However, the similar levels of animal livemass gain per ha reported by Tainton et al. (1982) for the upper reaches of Bioclimate 6 (not very different from Bioclimate 3), strengthens the confidence that can be placed on the stocking rate - animal performance relationship established from one seasons results from the present trial. Tainton et al. (1982) report livemass gains of 1 008, 1 026 and 1 079 kg per ha from kikuyu fertilised with 150, 300 and 450 kg nitrogen per ha per annum respectively. The predicted livemass gain at SR_{max} for the present trial fertilised with 250 kg nitrogen per ha per annum was 1 040 kg per ha.

For the production of slaughter animals it is considered that animal type and the low initial mass of the heifers were major factors which precluded the attainment of slaughter condition by the end of May. Although steers could be expected to exhibit better performance than heifers (Chapter 3) it is doubtful whether steers with an initial mass similar to the mass of the heifers used in the trial, would have produced slaughter animals. However, what is particularly significant for the present trial is that the heifers used had been overwintered at a low plane of nutrition (low cost ration) before being placed on the kikuyu, were grown out on the kikuyu at a low cost per kg livemass gain and were ideal store animals at the end of the

trial period (i.e. the animals were ideally suited to finishing for slaughter either in a feedlot or on foggaged kikuyu with a fattening concentrate supplement).

4.4 Conclusions - based on only one season's results

- * There is a highly significant negative linear relationship between stocking rate and animal performance, and a highly significant positive linear relationship between pasture height and animal performance.
- * The highly significant multiple linear relationship between animal performance, stocking rate and pasture height offers distinct possibilities in terms of introducing flexibility into the overall beef system.
- * Replacement heifers can be economically grown out on kikuyu during summer.
- * At SR_{max} (8,85 heifers per ha) the cost per kg livemass gain is of the order of 5lc.
- * At SR_{max} and 250 kg N per ha, livemass gains of 1 040 kg per ha can be expected over a 180 day period.
- * Breed and initial animal mass are important considerations in the production of slaughter animals. Initial mass is less important in the growing out of heifers to be mated at 2 years of age.
- * It is unlikely that slow maturing animals could be finished for slaughter at 18 months of age on kikuyu (as the sole feed) fertilised with 250 kg N per ha per annum. However, summer kikuyu provides ideal store animals of the late maturing animal types.

Research needs

- * There is a need to quantify herbage yield and herbage quality over the season, at different stocking rates, for several seasons.
- * The effect of stocking rate and grazing pressure on the sward morphology (and availability of herbage to the animals) needs to be researched to provide information to improve pasture management (particularly pasture utilisation) and thus animal performance.
- * Characterisation of kikuyu with early maturing breeds needs to be undertaken to assess the possibility of:
 - increasing the tempo of beef production, and
 - providing animals requiring a shorter finishing period (less dependent on grain).
- * Supplementation with concentrates on pasture offers possibilities but is not regarded as being of high priority at this stage

CHAPTER 5

LONG YEARLINGS ON FOGGAGED KIKUYU PLUS CONCENTRATE

Introduction

Where summer pastures are based on kikuyu the season (largely rainfall and temperature) and overall pasture management (nitrogen level, stocking rate, grazing system) may well result in excess forage at the end of the season. Removal of this accumulated material is necessary to improve the quality and dry matter intake of spring growth (Roos, 1975) and to maintain the vigour of the pasture.

The CP content of kikuyu increases as the level of applied nitrogen is increased (Whitney, 1974a; Bogdan, 1977). However, herbage CP declines with maturity, the CP content levelling off after six weeks regrowth (Whitney, 1974a). Although Bogdan (1977) states that "... unfavourable conditions and in old herbage CP content may be as low as 7 or 5 per cent", Holder (1976) found that the CP content of kikuyu remained above 12% after 99 days regrowth. Colman & O'Neill (1978) and Andrews & Crofts (1979) measured the highest CP content of kikuyu in winter. Despite high CP and TDN (Bredon, 1980) values being recorded towards the end of the growing season animal performance from kikuyu, at this time, is often considerably lower than predictions based on proximate analyses (Bredon, 1980; Marais, 1980). However, the CP and TDN values of kikuyu may be modified, particularly with utilisation, during the dormant period.

Little published information is available on the performance of animals grazing foggaged or accumulated kikuyu. Rethman, Eden, Beukes & de Witt (1977) found that 284 kg steers grazing foggaged kikuyu had an average daily gain 0,20 kg for 127 days. Clearly this is satisfactory for overwintering animals which are to be finished for slaughter the following season.

However, this level of animal performance is unsatisfactory if the tempo of beef production is to be increased or if animals are to be finished during winter for slaughter.

Fogged or accumulated kikuyu could, however, be used to provide the roughage for animals fed a concentrate mix. In this way the accumulated herbage could be effectively utilised. The herbage would provide the roughage to complete the ration and removal of excess growth would provide for efficient pasture management.

In view of the benefits that may accrue from using accumulated or fogged kikuyu to provide the roughage for animals fed a concentrate mix, a trial was conducted to evaluate the contribution of accumulated kikuyu to animal performance.

5.1 Methods and materials

The trial was conducted in camp Y5 (Fig. 2.1) at Broadacres (Chapter 2). Intermittent light grazing of the 1,139 ha of kikuyu by dry cows and replacement heifers continued until the end of February, after which the pasture was withdrawn from grazing. The pasture received 73 kg nitrogen per ha in September and again in December. Soil P and K levels were greater than 20 and 150 ppm respectively.

Six Simmentaler x Hereford steers with an initial age of c. 20 months and mass of 329.5 kg (range 294 to 405 kg) were used in the trial. The trial commenced on 18.5.79 and ended on 9.8.79 (83 days). Termination of the trial was based on visual evaluation (B P Low) of the readiness of the animals for slaughter.

Pasture availability was monitored with the pasture disc meter (200 random readings per occasion) at weekly intervals. The pasture disc meter was calibrated (50 random positions per calibration) at the start of the trial, on 19.6.79, 17.7.79 and at the end of the trial. At each calibration

the material was bulked, milled and sub-sampled for analysis of CP and CF.

The concentrate mix, fed ad libitum to the steers, consisted of 70% maize meal, 20% broiler litter and 10% voermol molasses meal. On a dry matter basis the concentrate had 11,9% CP and a TDN value of 82,9. The dry matter content of the mix was 87%. Formulation, feeding and measurement of daily intake of the concentrate was carried out by B P Louw (Animal Science section, Cedara). In view of the high mineral content of the broiler litter no mineral lick was provided.

5.2 Results

5.2.1 Regression of yield on disc height

Estimates of kikuyu dry matter yield (y), in kg per ha, from pasture disc height (d), in cm, is given by the equation $y = 2\,573,5 + 291,185d$. The relatively low, although highly significant ($P < 0,001$), correlation coefficient of 0,5956 (for $n = 200$) for the regression equation was, it is felt, largely due to the effect of trampling. The effect of trampling is reflected by the high value of the intercept of the regression equation.

5.2.2 Quantity and quality of herbage on offer

As a result of good rains during the 1978/79 season (Fig. 2.21), coupled with lax utilisation of the pasture during the season, there was considerable accumulation of kikuyu by the time the trial started.

Using the regression equation presented above and mean pasture disc meter height, pasture availability was calculated, at weekly intervals, for the duration of the trial. Changes in pasture availability, with time, are illustrated in Fig. 5.1a, while the quality (CP, CF and TDN) of the herbage is shown in Fig. 5.1b.

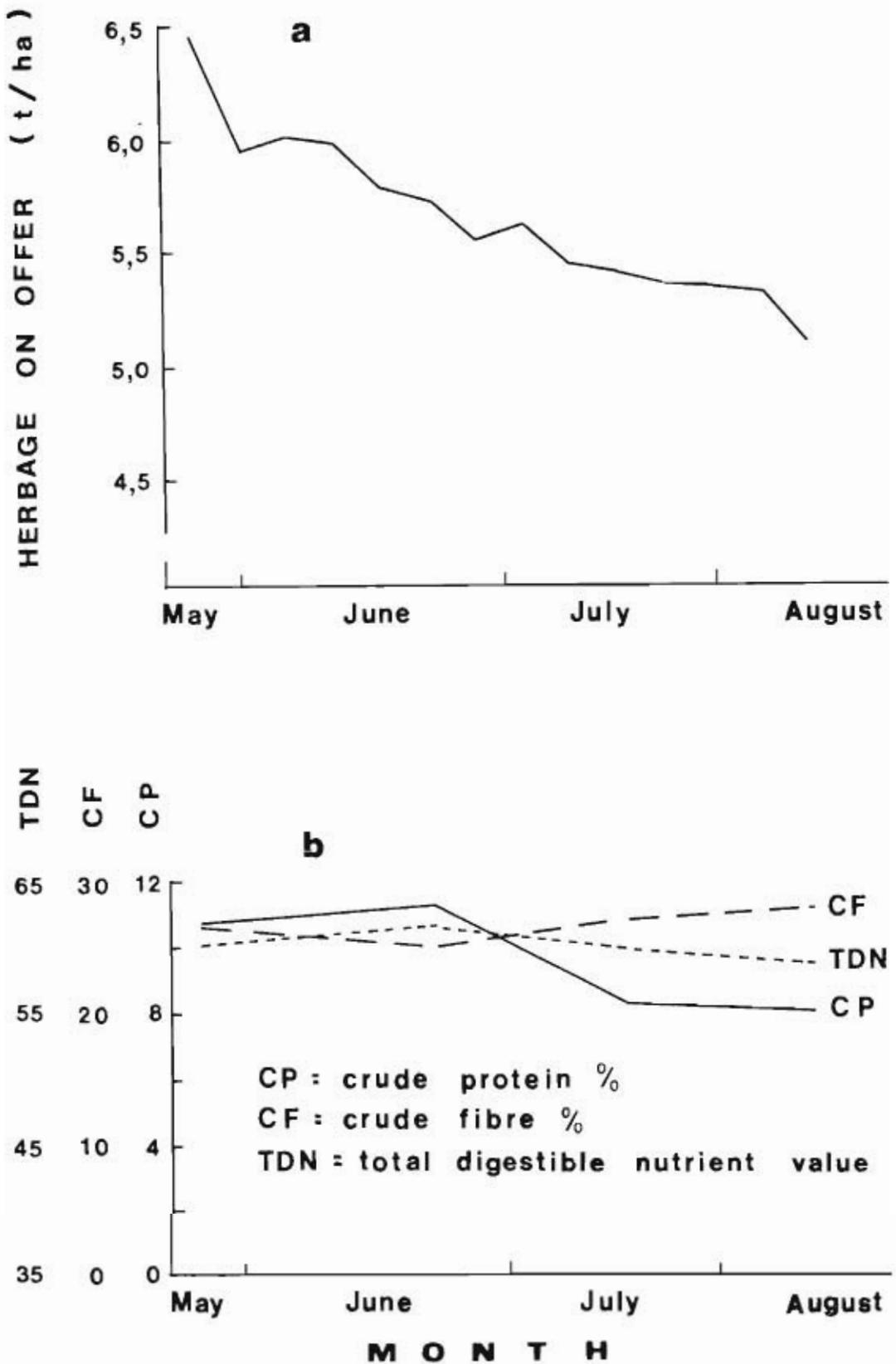


Fig. 5.1 Changes in the quantity (a) and quality (b) of foggaged kikuyu grazed by long yearling steers receiving concentrates *ad libitum*.

From Fig. 5.1a it can be seen that, apart from the first week, utilisation of the pasture was remarkably regular for the duration of the trial. Higher pasture utilisation during the first week, compared with the subsequent period, can be attributed to the animals having to adapt to the concentrate mix (compare histograms of Fig. 5.2). It may be argued that the higher pasture utilisation recorded during the first week was a result of the animals selecting high quality herbage. As the quality of herbage on offer declined (through selection) so also did subsequent dry matter intake from the pasture. However, from Fig. 5.1b it can be seen that the quality of the herbage varied little over the first five weeks.

That the animals did select for herbage with a high CP content and against herbage with a high CF content, after the fifth week, is indicated by the data of Fig. 5.1b. However, since there was no pasture control treatment the effect of plant maturation and frost (affecting respiration and leaf senescence or leaf drop) on herbage quality, cannot be assessed. Nevertheless, whatever factors are involved (leaf selection, leaf drop, increased respiration, ageing) it is clear from Fig. 5.1b that the quality of herbage on offer to the animals declined with time.

5.2.3 Animal performance and dry matter intake

The mean livemass change of the animals receiving an ad lib. concentrate mix on kikuyu forage is illustrated in Fig. 5.2. Also shown in Fig. 5.2 is the relative contribution of kikuyu to animal daily dry matter intake, meaned for three periods.

From Fig. 5.2 it can be seen that the rate of mean livemass gain of the animals varied little over the experimental period. Over the 83 day period of the trial the animals had a mean average daily gain of 1,12 kg, with a mean daily dry matter intake of 11,54 kg per animal per day (3,08% of bodymass). The contribution of the pasture to total dry matter intake

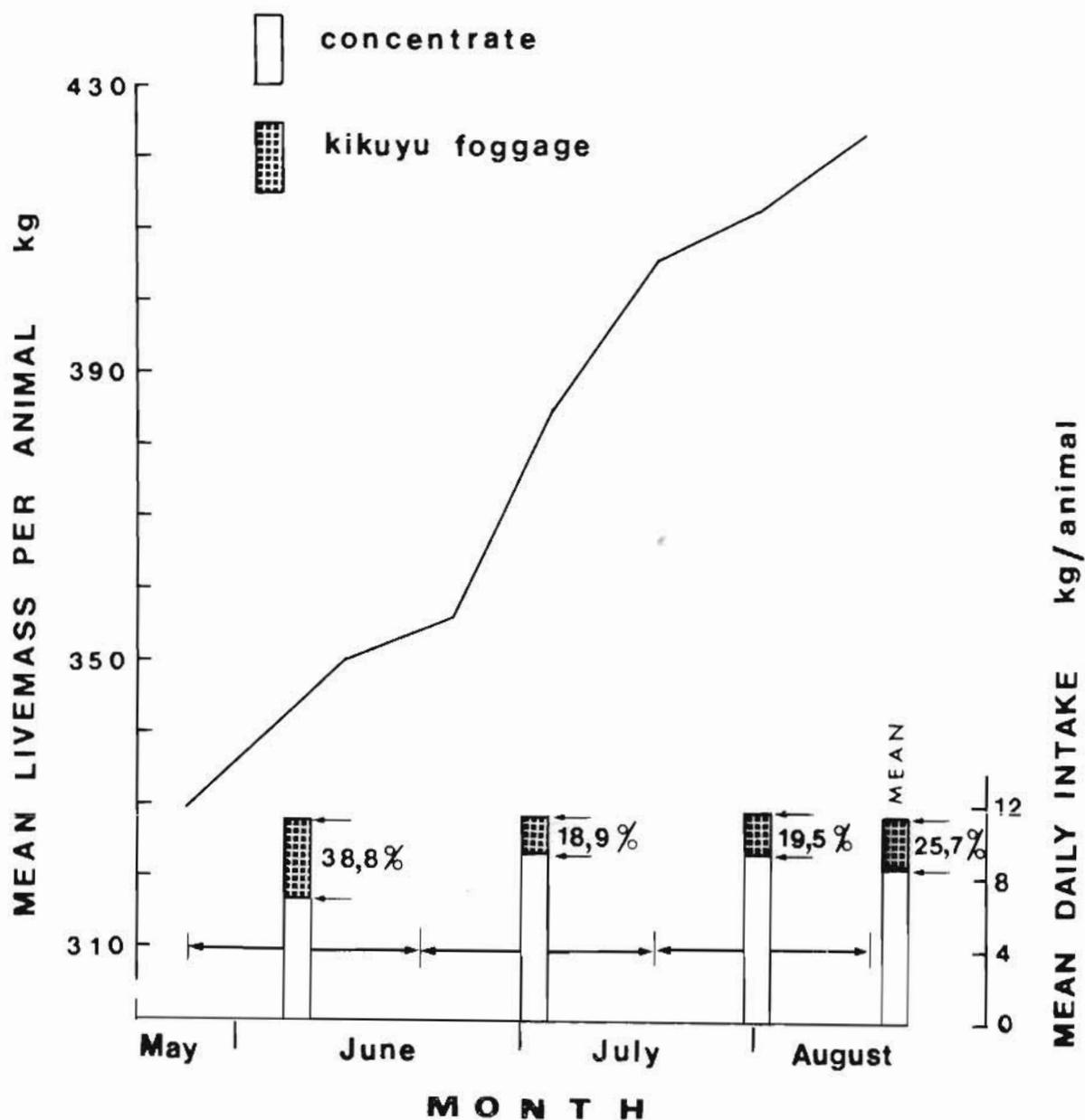


Fig. 5.2 Livemass change and mean dry matter intake of long yearling steers fed a fattening ration *ad libitum* on foggaged kikuyu.

decreased from 38,8% for the first third of the trial to approximately 19% for the last two thirds of the trial (histogram of Fig. 5.2). Meaned over the whole experimental period the pasture contributed 25,7% of the total dry matter intake of the animals.

The animal grading system has changed since the trial was conducted. However, in relating the new grading system to the old grading system the animals were judged as three Prime B animals, two B1 animals and one Grade 3 animal (B P Louw, pers. com.).

5.3 Discussion

Results from this trial clearly indicate the feasibility of utilising accumulated kikuyu to provide the roughage for animals fed an ad lib. concentrate mix. The results do, however, indicate several areas where refinement (to the overall system used) is needed and where additional information is required.

Decisions on the marketability of slaughter animals are largely subjective. Evaluation of carcass grades (and thus readiness of animals for slaughter) is dependent on the level of expertise attained by the operator. With small numbers of animals it is not practical to market one or two animals at a time. Thus the grades attained in the present trial were completely acceptable. However, on a farm scale, provided a high level of expertise in grading animals on the hoof is available, it is probable that top grades could be attained for most, if not all, animals by marketing in batches when the desired grade is attained. The high growth rates of the animals at the end of the trial (Fig. 5.2) indicates that higher animal weights would have been possible. Since the animals were putting on fat towards the end of the trial, it is possible that animals in the lower grades could have been up-graded if fed for a longer period.

Refinements to the system, as applied in the present trial, revolve

largely around pasture management. Compared with published CP values for kikuyu at the end of the growing season (Coleman & O'Neill, 1978; Andrew & Crofts, 1979; Bredon, 1980) the CP values recorded for the present trial were low. It would seem that the low CP values recorded at the start of the trial were a result of (i) lax utilisation during the season resulting in fibrous material (largely stems) being accumulated from the beginning of the season; (ii) the low level of nitrogen applied (146 kg N/ha), and (iii) withdrawing the pasture from grazing too early in the season, resulting in much of the new growth, following the last utilisation, being "old" by the time the trial started (Bogdan, 1977). Clearly these are all factors which can be controlled, by judicious pasture management, to improve the CP content of the herbage.

Apart from improved quantity and quality of herbage resulting from increased nitrogen levels, grazing management to improve quality will inevitably result in reduced pasture availability at the end of the season. Improved quality and reduced quantity of pasture must, however, be evaluated against the contribution required from the pasture in the total ration. Although this is largely an accounting exercise it must be remembered that the animals have a minimum roughage (S F Lesch, pers com.) and CF (Bredon & Stewart, 1978) requirement. It is not the intention to expound on concentrate formulations. However, the overall ration formulation should be investigated for situations where foggaged kikuyu supplies the roughage for fattening rations. In this regard the quality and quantity of herbage required should provide the basis for pasture management strategies.

The high incidence of trampling (visual observation and shown by the regression of disc height on yield) can, it is considered, be related to the high dry matter available. Increasing the stocking density (sub-division of camp) would reduce trampling and thus wastage of kikuyu. However, with an increased stocking density strict monitoring will be required to ensure that animal performance is not limited by a restricted roughage intake

(particularly if quality of the pasture is an important factor in the ration formulation). Since the pasture contributed 39% of the ration eaten during the first third of the trial period and 19% for the remainder of the trial the stocking pressure will have to be adjusted accordingly. In view of the low cost of pasture, relative to the cost of concentrate mixes, it would seem that there is a need to establish at what level of pasture availability intake of roughage will be restricted (at the expense of increased concentrate intake). From the data of the present trial it would appear that after the phase of "adaptation to the concentrate mix" this factor will remain fairly constant (Fig. 5.2).

Most animal finishing systems, particularly if conducted during winter, involve carting and feeding the complete ration. Furthermore, most of the finishing systems advocated in the Natal Region rely on maize silage and hay to supply the roughage (Lesch et al., 1974). The greatest effort and labour input is in the feeding of the roughage component of the ration. In this respect the feeding of the concentrate mix (the easier portion of the ration to feed) on the pasture constitutes a distinct advantage particularly since there are a number of other advantages to feeding the concentrate mix on the pasture. Such a system will mean, for example, that (i) special feeding pens are unnecessary; (ii) mechanical operations and storage facilities for hay and silage are minimised to providing a fodder reserve (insurance against a poor season); (iii) there is no transfer of plant nutrients, through carting hay or silage from the land, and (iv) the period required by the animals to adapt to the concentrate mix is much reduced. According to S F Lesch and B P Louw (pers. comm.) this latter point is a distinct advantage in terms of animal performance. If the animals had been on kikuyu they would need to adapt only to the concentrate mix (without affecting performance). Where animals are fed a complete ration (e.g. in a feedlot) they need to adapt to all components of the ration: this adaptation may take as long as three weeks (Snyman, 1984). While adapting to a complete feed

ration animal performance can be adversely affected (S F Lesch, pers. comm.).

There are, however, disadvantages associated with the feeding of a fattening concentrate on foggaged kikuyu. In the farm situation supervision and the control of animals is likely to be less intense than, for example, in a feedlot (confined area). Unthrifty animals may not be noticed at an early stage. Monitoring of pasture availability, at regular intervals, may be necessary to ensure the availability of adequate herbage of the desired quality. If the quality of the roughage constitutes an important factor in formulating the concentrate mix, cognisance must be taken of the declining quality of the foggage as it is utilised and/or with time (Fig. 5.1b).

Managerial disadvantages of feeding a fattening concentrate on foggaged kikuyu are not considered to be major stumbling blocks. However, the lack of protection for the animals against adverse weather conditions could well affect animal performance (Hahn, 1974; Ames & Ray, 1983). Obviously the degree to which animal performance may be affected will vary from site to site.

It is well established (and documented) that level of nitrogen, height and frequency of defoliation, rate and age of regrowth affects the quality of kikuyu. However, results from this trial indicate the need to investigate the effect of age of regrowth, senescence and temperature (particularly frost) on the quality of foggaged or accumulated kikuyu. Aspects relating to trampling and plant part selection by the animal also deserve investigation. Information on these aspects will provide a fuller understanding of the animal - plant processes involved in feeding a fattening concentrate on foggaged kikuyu.

5.4 Conclusions - based on only one season's results

- * Foggaged kikuyu can be effectively utilised as a source of roughage for 20 month old animals fed a fattening concentrate on the pasture.
- * An average daily gain of 1,12 kg over 83 days produced satisfactory slaughter grades. Of the mean daily dry matter intake of 11,54 kg (3,08% of livemass) the foggage contributed 25,7%.
- * The contribution of the pasture to animal dry matter intake declined as the animals became adapted to the concentrate mix. Once adapted to the concentrate the contribution of the pasture to dry matter intake by the animals remained fairly constant at 19%.
- * Apart from the possible effects of adverse weather conditions during winter on animal performance, disadvantages of feeding a fattening concentrate on foggaged kikuyu (supplying the roughage) revolve around management (supervision). It is felt that the advantages of this system outweigh the disadvantages.
- * There is a need to investigate the effects of age of regrowth, maturity (senescence) and of temperature (particularly frost) on morphological and quality changes of grazed foggaged kikuyu.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

Much of the discussion relating to the trials reported on has been dealt with. However, several important aspects warrant further discussion and/or elucidation.

The component research approach has proved extremely valuable in providing data for predictive and planning purposes. Characterisation of individual pasture species, in terms of animal performance (using several stocking rates), provides the parameters for the relative components (e.g. weaners on irrigated ryegrass, cow plus calf on kikuyu). Formulation of the on farm system is achieved by optimising and integrating the individual components within the limits set by available resources. Computerisation of the regressions for the separate components would provide for ease of comparison of different systems and strategies (varying inputs such as prices, weaner mass, winter feed costs etc.) and allow for selection of the system that will maximise profits. Whether selection of the final beef system is with the aid of a computer or using a calculator, it is considered that the component approach is sound and practical.

While the regressions derived from the characterisation trials, reported on in this thesis, allow for flexibility in terms of selection of stocking rates, animal performance and period on pasture, their lack of flexibility and limitations due to limited information on the effects of grazing systems and nitrogen fertilisation on production should be recognised. Furthermore, there are other pasture species and mixtures that need to be characterised, in terms of beef production, in Bioclimate 3 of Natal, and there are other classes and types of animals that need to be evaluated.

Several important aspects relating to the results from the

characterisation trials reported on are clear.

1. As has been indicated by numerous researchers (e.g. Alder, 1965; Morley & Spedding, 1968; Jones & Sandland, 1974; Connolly, 1976; Hart, 1978; Riewe, 1980), grazing trials should be conducted using several (preferably more than two) stocking rates. It is the relationship between stocking rate and animal performance that is of paramount importance in characterisation trials, not differences between stocking rates. In this context the statement by Hart (1972) that a range of stocking rates be included in grazing trials "... even at the cost of replication", is endorsed. Furthermore, Jones & Sandland (1974) state that since the relationship between stocking rate and animal gain remains linear over a wide range of stocking rates "... then three rates would provide an estimate of this linear relation without the need for replication...". (As shown in Fig 1.2 this relationship can normally be represented by two separate straight lines: A to B and B to Xn in Fig 1.2). Although data from the present trials showed a linear relation between stocking rate and animal performance, there is controversy about the actual shape of the stocking rate - animal gain relationship. The inclusion of a range of stocking rate treatments, in lieu of replication, would allow for a low stocking rate to establish the potential of the pasture (line AB in Fig. 1.2), ensure that the high stocking rates are beyond the critical level (point B in Fig. 2.1) and indicate possible deviations from linearity.

2. Herbage availability and herbage quality should be monitored during the season both before and after grazing. Absolute dry matter intake by the grazing animal remains an elusive measurement. However, the difference between herbage (both quantity and quality) on offer and residual herbage provides a measure of apparent intake and thus an indication of when in the season (or at what stocking rate) animals are likely to perform poorly.

This was clearly shown by the trial with weaners on Italian ryegrass (Chapter 3). In view of the animals selective grazing habits care should be exercised in interpreting "sufficiency" or "deficiency", especially with rotational grazing where animals remain in a camp for several days.

3. There is a need for objectively determined pasture management when characterising pastures in terms of animal performance. In the present trials fixed stocking was used throughout. For the rotationally grazed trials a fixed rotation was used. It is fully recognised that the time of the season when plants are defoliated, together with frequency and intensity of defoliation of pastures, can markedly affect herbage production (Brougham, 1956, 1959, 1960). In rotationally grazed pastures there are many grazing strategies (number of camps, period of stay, period of absence) that can be applied. Hodgson et al. (1981) are of the opinion that "... substantial variations in management may have a relatively small impact upon the amount of herbage harvested, particularly from grazed swards". This statement may be comforting to the researcher using a fixed grazing system, and be applicable where herbage available to the animals is not limiting. However, marked differences in defoliation intensity, herbage availability and herbage quality recorded for the present trial (both quantity and quality were found to be limiting in certain treatments), suggest that management is important in stocking rate trials, particularly with widely spaced stocking rates. Within the objective of establishing the relationship between stocking rate and animal performance it is considered that the researcher should use a system appropriate to the pasture and to the type and class of animal (but this may be unknown). Whatever system is used it is important that it be objectively applied to all stocking rate treatments. Because of this it is recommended that fixed stocking be used for characterising pastures in terms of beef production.

4. The need for "sward state" (physiological, morphological and structure of the sward canopy) studies has been emphasised by numerous workers (e.g. Stobbs, 1973; Barthram, 1981; Grant, Barthram & Torvell, 1981; Hodgson, 1982, 1985; Wilson, 1985). Results from the present trials indicate the need for sward state parameters to be monitored, quantified and related to management and climate. Morphological and physiological studies, together with quantity and quality changes, would be valuable in explaining the complex animal-plant relationship. In addition, information relating to the effect of grazing on changes within the sward (e.g. tillering, leaf/stem ratios, senescence) could prove invaluable in formulating the grazing management to be applied (e.g. period of stay, period of absence and whether these should change over the season or not - cf. point 3 above). However, if subsidiary trials are used to study sward state it is considered that these should (i) be conducted under grazing conditions using the appropriate class of animal, (ii) that the treatments be within the realms of practicality, and (iii) that studies should span the whole grazing season. Important parameters relating to the grazed sward include leaf/stem ratios, tillering, senescence (natural and through trampling), availability or accessibility (ease of prehension) and the role of carbohydrates and protein in regrowth following defoliation.

5. An aspect relating to the formulation of beef systems, from results obtained from component research, is the period required for animals to adapt when changed abruptly from one feed to another. The initial growth response of weaners, following their introduction to Italian ryegrass, was not consistent over seasons. During the first few weeks on Italian ryegrass initial growth of the weaners, during different seasons, was either negative, positive or zero. This varied growth of the weaners, together with (i) mass loss for heifers and young bulls, following their introduction to ryegrass, recorded by Riewe, Pounders & Lippke (quoted by Murhead,

1985), and (ii) the fact that feedlot animals may take up to three weeks to adapt to a ration (Snyman, 1984), strongly suggests the need to evaluate the effect that changing the feed has on animal performance. The effect on animal performance from changing the feed is particularly pertinent to the formulation of systems using the component approach.

In conclusion, while kikuyu and Italian ryegrass are regarded as the most suitable pastures for intensive beef production in Bioclimate 3, there are other pasture species/mixtures and classes of animals that can be used for the production of beef in this Bioclimate. These pastures and classes of animals need to be characterised to provide more "components" for optimising beef production systems for any given set of conditions.

Nevertheless, the data gleaned from the characterisation trials reported on in this dissertation represent a start. As such the regressions developed should be extremely valuable in planning beef systems involving the cow plus calf on kikuyu, yearlings on kikuyu, the finishing of long yearlings on foggaged kikuyu and the use of irrigated Italian ryegrass for the growing out of heifers for early mating and for the production of 15 to 16 month old slaughter animal.

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Use

Operation of the pasture disc meter was as follows: (i) the outer cylinder with disc was lifted to the stop plug of the central rod, (ii) the central rod was held perpendicular to the ground, with moderate downward pressure applied with the thumb to the top of the stop plug, (iii) the outer cylinder with disc was released while maintaining downward pressure on the stop plug, and (iv) the height of the pasture (disc meter height) was read from the central rod at the position corresponding with the upper end of the outer sleeve. The disc is operated with one hand.

All disc meter readings reported on were taken while walking through the camp in a zig-zag pattern. Disc readings which were obviously affected (physically) by dung were ignored and a reading was taken adjacent to the pat. All readings taken were recorded.

Calibration

To calibrate the disc a reading was taken before a shallow aluminium collar was placed over the disc. The collar was pressed down firmly before the disc was removed. Herbage within the collar was then cut to ground level with sheep shears. Dry mass of the clipped material was determined. This calibration procedure provided the data for the regressions relating pasture disc meter height to dry matter yield under the disc.

Calibration samples were taken at random in the camp used for calibration of the disc. When a calibration site happened to be on a moist dung pat or when the height reading was affected by dung, the position of the disc was moved to exclude the pat.

All calibration samples taken were included in the regression analyses of disc height on yield (i.e. including samples taken on trampled sites). Inclusion of all samples (i.e. not discarding "apparent" outliers) provides for a more realistic regression, although, statistically, not providing for high correlation coefficients.

APPENDIX 2 Multiple regression equations to predict the percent crude protein (A), crude fibre (B) and total digestible nutrients (C) of kikuyu from stocking rate (s) and time (t) : time is in weeks with the first week in August = week 1.

SEASON	REGRESSION EQUATION	n	R	R ²
A crude protein (y = percent crude protein)				
Before grazing				
1978/79	$y = 9,76 + 1,440 s - 0,213 t + 0,0018 t^2$	39	0,704	0,496
1979/80	$y = 8,23 + 0,797 s + 0,300 t - 0,0080 t^2$	31	0,727	0,528
1980/81	$y = 16,69 + 0,870 s - 0,477 t + 0,0058 t^2$	32	0,676	0,457
1981/82	$y = - 8,77 + 1,165 s + 0,833 t - 0,0141 t^2$	28	0,750	0,563
1982/83	$y = 31,46 + 0,835 s - 1,903 t + 0,0418 t^2$	24	0,836	0,698
Mean	$y = 9,96 + 0,780 s + 0,167 t - 0,0043 t^2$	154	0,443	0,196
After grazing				
1979/80	$y = 17,50 + 0,376 s - 0,596 t + 0,0098 t^2$	24	0,773	0,597
1980/81	$y = 15,60 + 0,267 s - 0,429 t + 0,0056 t^2$	32	0,639	0,409
1981/82	$y = 6,03 + 0,760 s + 0,114 t - 0,0018 t^2$	27	0,722	0,521
1982/83	$y = - 3,46 + 1,358 s + 0,717 t - 0,0095 t^2$	24	0,827	0,684
Mean	$y = 10,33 + 0,593 s - 0,083 t + 0,0009 t^2$	107	0,367	0,120
B crude fibre (y = percent crude fibre)				
Before grazing				
1978/79	$y = 26,67 - 0,858 s + 0,375 t - 0,0037 t^2$	39	0,782	0,611
1979/80	$y = 39,12 - 0,881 s - 0,630 t + 0,0120 t^2$	31	0,730	0,533
1980/81	$y = 19,98 - 0,371 s + 0,567 t - 0,0074 t^2$	32	0,833	0,693
1981/82	$y = 30,48 - 0,961 s - 0,184 t + 0,0033 t^2$	28	0,739	0,546
1982/83	$y = 17,41 - 0,917 s + 0,924 t - 0,0195 t^2$	24	0,909	0,826
Mean	$y = 29,94 - 0,227 s - 0,307 t + 0,0070 t^2$	154	0,378	0,143
After grazing				
1979/80	$y = 37,05 - 0,418 s - 0,445 t + 0,0072 t^2$	24	0,648	0,420
1980/81	$y = 22,56 - 0,221 s + 0,387 t - 0,0035 t^2$	32	0,806	0,716
1981/82	$y = 27,68 - 0,236 s - 0,116 t + 0,0033 t^2$	27	0,675	0,456
1982/83	$y = 30,78 - 0,580 s - 0,214 t + 0,0015 t^2$	24	0,761	0,549
Mean	$y = 32,75 - 0,110 s - 0,450 t + 0,0087 t^2$	107	0,278*	0,078
C total digestible nutrients (y = total digestible nutrients)				
Before grazing				
1978/79	$y = 61,15 + 0,928 s - 0,331 t + 0,0033 t^2$	39	0,792	0,627
1979/80	$y = 50,40 + 0,615 s + 0,689 t - 0,0135 t^2$	31	0,759	0,576
1980/81	$y = 67,46 + 0,446 s - 0,524 t + 0,0067 t^2$	32	0,828	0,686
1981/82	$y = 56,70 + 0,916 s + 0,274 t - 0,0049 t^2$	28	0,791	0,626
1982/83	$y = 71,95 + 0,818 s - 1,013 t + 0,0215 t^2$	24	0,917	0,842
Mean	$y = 58,46 + 0,278 s + 0,288 t - 0,0067 t^2$	156	0,405	0,164
After grazing				
1979/80	$y = 54,83 + 0,400 s + 0,215 t - 0,0035 t^2$	24	0,510*	0,260
1980/81	$y = 65,16 + 0,267 s - 0,373 t + 0,0036 t^2$	32	0,814	0,708
1981/82	$y = 59,44 + 0,354 s + 0,111 t - 0,0029 t^2$	27	0,735	0,540
1982/83	$y = 53,06 + 0,693 s + 0,471 t - 0,0059 t^2$	24	0,869	0,756
Mean	$y = 56,39 + 0,222 s + 0,331 t - 0,0065 t^2$	107	0,281*	0,079

n = number of data points

R = correlation coefficient

* = significant at the 5% level of significance; all other correlation coefficients significant at the 1% level of significance