Species preference by cattle and forage production in the Sourish Mixed Bushveld

by

YVETA STROLENY FORD

Submitted in partial fulfilment of the

requirements for the degree

MAGISTER SCIENTIAE

in the Faculty of Science

(Department of Botany)

University of Pretoria

Pretoria

Supervisor: Prof. G.J. Bredenkamp

Co-Supervisor: Prof. N.F.G. Rethman

December 1993

I dedicate this thesis to my parents,

Pavel and Alena Stroleny,

the best that I could wish for.

ABSTRACT

Species preference by cattle and forage production

in the Sourish, Mixed Bushveld

by

YVETA STROLENY FORD

Supervisor: Prof. G.J. Bredenkamp

Co-supervisor: Prof. N.F.G. Rethman

DEPARTMENT OF BOTANY

UNIVERSITY OF PRETORIA

MAGISTER SCIENTIAE

This study attempts to give a better understanding of some aspects of growth and utilisation of grass species in the Sourish, Mixed Bushveld.

The results show that in the Sourish, Mixed Bushveld cattle exhibit a preference for *Panicum maximum* above that of *T.triandra* and *S.sphacelata* and that the degree of preference changes with time of year. It was also found that animals graze selectively even when grazing pressure is high and that at different times of the year animals will return to tufts and tillers of

preferred species up to 4 times. The mean leaf height appears to have some influence on the selection of a particular species but the time of year has a much stronger influence.

A significant amount of forage was removed from *T.triandra* but not from *P.maximum* or *S.sphacelata*.

UITTREKSEL

Spesies voorkeur deur beeste en voer produksie

in die Suuragtige-Gemengde Bosveld

deur

YVETA STROLENY FORD

Studieleier: Prof. G.J. Bredenkamp

Medeleier: Prof. N.F.G. Rethman

DEPARTEMENT PLANTKUNDE

UNIVERSITEIT VAN PRETORIA

MAGISTER SCIENTIAE

'n Beter begrip van baie aspekte van groei en ontwikkeling van verskillende gras spesies is nodig om die beste weidingsbestuursstrategie te selekteer.

Die doel van hierdie studie is om, deur navorsing, kennis ten opsigte van sekere aspekte van ontwikkeling en benutting van gras spesies in hierdie veldtipe daar te stel.

Die resultate toon aan dat beeste in die Suuragtige-gemengde Bosveld hoofsaaklik 'n voorkeur aan *Panicum maximum* bo-oor *T.triandra* en *S.sphacelata* toon en dat die graad van voorkeur tussen seisone wissel. Verder is gevind dat selektiewe beweiding selfs onder 'n hoë weidruk plaasvind en dat in verskillende seisone beeste tot 4 keer terug keer na die selfde polle en lote van verkieste spesies. Voorkeur mag deur gemiddelde blaar hoogte beïnvloed word maar seisoen het 'n groter effek.

'n Betekenisvolle hoeveelheid voer is van *T.triandra* verwyder maar nie van *P.maximum* of van *S.sphacelata.*

ACKNOWLEDGEMENTS:

The author wishes to thank the following people:

Dr A.J. Aucamp and the Roodeplaat Grassland Institute for making this study possible,

Prof. G.J. Bredenkamp, Botany Department, University of Pretoria, for his assistance and encouragement,

Mrs M. Smith, Institute of Agrimetry, for her invaluable assistance with all the statistical analyses,

The Institute for Soil, Climate and Water for doing the soil classification of the study area,

Gerrie Trytsman for all his help with the field work,

My parents, Mr and Mrs Stroleny, for their support and their financial assistance,

My colleague and friend, Tammy Swain for her unwavering encouragement to believe in myself.

TABLE OF CONTENTS

PAGE

CHAPTER 1

INTRODUCTION

The vegetation in Southern Africa evolved in the presence of a sparse human population and multispecies populations of herbivores. These included grazing, browsing, rooting and debarking animals with a wide range of diet preferences and feeding patterns. The types of animals present, the proportions of the different species and the total number of animals present varied in the different vegetation types and regions depending on the availability of food and water (Barnes, 1982). When the early European pioneers arrived in South Africa they found an abundance of indigenous game species. These species played an important role in the evolution of the South African grasslands and no doubt existed in some form of dynamic equilibrium with the different grassland types. The natural equilibrium between the game and the plant communities was unavoidably disturbed by the arrival of these pioneers who not only hunted the game but also introduced domestic livestock to compete with and eventually replace the game. With the disruption of this equilibrium and the concentration of large numbers of livestock in areas for long periods of time, veld deterioration eventually followed at such an alarming rate that on the 4th May 1934 parliament introduced a decision for research to be conducted to combat this deterioration (Preller, 1969). This program stressed at the outset the fundamental importance of instituting research on veld management and veld reclamation, as it was felt that in these two subjects lay the key to the whole situation (Pole Evans, 1938). Although a number of sincere voices started calling loudly for the application of sound veld management as the key to the conservation of our soil and to increased animal production from the veld, acceptance was sporadic and general exploitation and denudation continued at an alarming pace and still continues today. In most cases these changes are detrimental as they result in lower grazing capacity, soil erosion and general degradation of the environment (Aucamp, 1990).

An understanding is needed of many aspects of herbage growth and utilisation in order to select possible management strategies. Barnes (1972) stated that while knowledge of growth patterns and defoliation aspects in grasses is a prerequisite for rational use of the veld, current knowledge of this subject is far from adequate. Descriptions of the composition of swards in terms of their plant species and the proportions and state (live or dead) of the various morphological units are essential parts of most studies of the effects of management on herbage production (Grant, 1981). Classification of the material into individual species and their components will be necessary in studies of the effects of management on plant species composition and sward production. One of the most striking characteristics of tropical grassland and savanna ecosystems in particular, is the marked seasonal variation in primary production (Long *et al.* 1992). Variations in growth rate occur as a consequence of genetic potential of seasonal patterns of plant development as well as in response to environmental factors such as climate, nutrient supply and management (Hodgson, 1981). The main driving force of this seasonal variation is rainfall and the main patterns of growth are closely associated with alternate wet and dry seasons. A further complicating issue in bushveld/savanna is the complex interaction between herbaceous and woody plants (Smit & Rethman, 1992). The susceptibility of a plant to any given treatment can be strongly influenced by its current stage of development. Both the botanical composition and the growth of the sward are likely to be affected, not only by the current treatment, but also by the cumulative treatments applied earlier in its lifetime. Danckwerts (1989) found that veld that is subjected to a long period of overgrazing is more likely to become dominated by less digestible species than correctly grazed veld. For sustainable herbivore production the valuable natural resource of native pastures must remain in a stable and productive condition. Management strategies should therefore aim to achieve an adequate vegetation cover of desirable species that protect the soil from erosion and provide forage for quantitative and qualitative livestock nutrition.

Natural veld is an important source of forage in the Sourish, Mixed Bushveld, (Acocks, 1988), of the Transvaal. The floristic composition, especially in terms of the palatability of the perennial grasses to livestock, is a primary determinant of grazing capacity (Barnes *et al.* 1984). Veld is typically heterogeneous and is made up of a mixture of species of varying acceptability to livestock. If improved livestock production is to be achieved off any pasture then it is necessary that those plants that make the greatest contribution to this production be maintained in both their abundance and vigour (Danckwerts, 1984). Stoddard and Smith (1955) indicated that on most pastures the correct use of the two to four most important species resulted in correct grazing for the entire pasture. There have been recent advances in the knowledge available on the growth and habitat preferences of the most important grasses in the Sourish, Mixed Bushveld (Jordaan *et al.* 1991, Smit & Rethman, 1992), but Jordaan *et al.* (1991) found that one of the biggest problems of veld management in the Transvaal Bushveld is still that management strategies are applied without any species preference studies being conducted in any of the different veld types. Management is often based on results from research conducted in other areas or on non-scientific observations.

It has been found that grass species can be classified as preferred, intermediate or avoided according to their acceptability to cattle (O'Reagain & Mentis, 1989a). Species preference is discussed in detail in Chapter 3. It is also known that sourveld, in general, has complex management requirements because much of it is a fire climax and because of the large variety of unacceptable species which may dominate the sward under mismanagement (Edwards, 1981).

The formulation of acceptable grazing management strategies requires a sound understanding of the effect of domestic livestock on natural veld under different grazing systems. This is complicated by dissimilar responses of different plant communities to the same grazing management impact. It was therefore decided to identify the most important species in the Sourish, Mixed Bushveld and to determine the preference cattle exhibit for them. It was also attempted to determine the forage production of the three most important species to make an attempt at improving management in this veld type.

The objectives of this study were, therefore, to determine:

a) which grass species are preferred by cattle in the Sourish, Mixed Bushveld;

b) whether this preference changes at different times of the year;

c) whether the preference for species changes with a decline in the overall availability of feed;

d) and to determine the forage production and utilisation of the 3 most abundant grass species in the Sourish, Mixed Bushveld.

CHAPTER 2

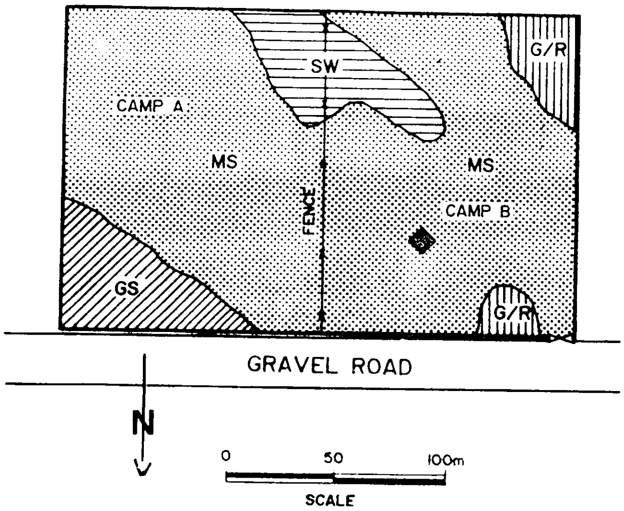
EXPERIMENTAL SITE

2.1 Location and Climate

The study was conducted at the Roodeplaat Grassland Institute, situated 30 km north east of Pretoria, at longitude 28° 21' west and latitude 25° 35' south. The altitude is 1164 m above sea level. For the period 1951 - 1993 the mean maximum temperatures in January and July were 29.5° C and 20.7° C respectively, while the mean minimum temperature was 16.7° C in January and 2.3° C in July. The mean long-term seasonal rainfall in the area is 658.4 mm per year concentrated in the period October to April. During June and July light frosts may occur. A four hectare camp that is representative of the veld type of Sourish, Mixed Bushveld (Acocks, 1988) was selected. The study site is exceptional in that, prior to this experiment, it had not been grazed for five years and the residual effects of differential grazing intensity can therefore be discounted. For practical purposes, due to farm management restrictions, this camp was divided into two 2 hectare camps, Camp A and Camp B, before experimentation began.

2.2 Soils

The soil types mapped by the Institute for Soil, Climate and Water, are illustrated in Figure 2.1. Mispah, Glen Rosa and Swartland soil forms are typically shallow and rocky.



LEGEND:

DEPTH AND PROPERTIES

MS <200mm OVERLYING ROCK - FINE SANDY LOAM MISPAH FORM

GS 200-350mm OVERLYING WEATHERED ROCK - FINE SANDY LOAM GLEN ROSA FORM

SW 0-150mm FINE SANDY LOAM
150-500mm FINE SANDY CLAY LOAM, MODERATELY STRUCTURED SWARTLAND FORM
500 + WEATHERED ROCK (SHALE)

G/R DOLERITE OUTCROP >60% ROCK MISPAH FORM AND ROCK
LIMITED SOIL COVER

◆ RUIN

Figure 2.1 Soil classification of the study area (MacVicar *et al.* 1977)

2.3 Species composition

The Sourish, Mixed Bushveld is comprised of both woody and herbaceous plants. The herbaceous component of the vegetation is, however, potentially more productive on a sustained basis than the woody component and the investigation was thus confined to the herbaceous component of the vegetation. Both camps in the experimental site are typical of the Sourish, Mixed Bushveld and are dominated by *Acacia tortilis* and *Acacia robusta. Ziziphus mucronata, Grewia flava, Rhus leptodictya,* and *Acacia nilotica* also occur on the experimental site. It was of interest to note that *Panicum maximum* was found only under the tree canopies and on the ruins of a previous settlement. Bosch & van Wyk (1970) and Smit & Rethman (1989) found that *P.maximum* is very often associated with trees, especially *Acacia* spp. They also noted that *P.maximum* plants found under tree canopies had a significantly higher mean production than those plants which occur out in the open. Trees play an important role in *P.maximum* existence, occurence and distribution due to the fact that they enrich the soil thereby making it favourable for the growth of *P.maximum* and they also provide the semi-shade environment favoured by this species. The most common forb in both camps was *Aloe greatheadii,* with both camps having a large number of individuals present.

Three hundred step-points, were conducted each day during periods of occupation in each camp along six 50 m totally randomly located transects (each days survey was conducted on a different transect). The nearest rooted living plant to each point was recorded (Mentis, 1981b). In the absence of a strike, the species of the nearest grass plant to the strike was recorded. If no living species was located within a 25 cm radius of the strike the observation was recorded as bare ground. Non - grass individuals were recorded as forbs. The herbaceous species composition was calculated as the mean of the percentage composition recorded each day during the period of occupation. It was, however, noted that the percentage species composition varied between seasons in Camp A, (see Table 2.1).

TABLE 2.1 PERCENTAGE SPECIES COMPOSITION AND COEFFICIENTS OF VARIATION IN CAMP A IN NOVEMBER 1989, FEBRUARY 1990, APRIL 1990 AND NOVEMBER 1990

	November 1989		February 1990		April 1990		November 1990	
Species	%	CV	%	CV	%	CV	%	CV
Aristida congesta subsp. *congesta*	0.06	100.0	0.48	45.77	0.40	53.03	-	-
Aristida congesta subsp. *barbicollis*	0.40	100.0	0.05	100.0	0.25	66.23	-	-
Bare ground	0.34	62.81	-	-	-	-	-	-
Cymbopogon plurinodis	-	-	0.33	38.47	0.57	29.60	-	-
Digitaria eriantha	-	-	0.23	63.25	-	-	-	-
Elionurus muticus	0.06	100.0	0.05	100.0	-	-	0.72	34.88
Eragrostis chloromelas	3.26	33.96	3.93	19.21	3.90	30.98	4.67	10.42
Eragrostis gummiflua	0.40	100.0	0.55	40.04	-	-	-	-
Forbs	0.86	41.70	0.23	63.25	-	-	0.92	31.94
Heteropogon contortus	0.06	100.0	4.67	18.39	3.25	18.05	4.67	17.73
Hyparrhenia hirta	0.60	74.35	-	-	0.67	34.94	1.35	48.24
Loudetia simplex	-	-	2.72	16.69	1.52	35.75	8.27	16.79
Melinis repens	-	-	0.50	64.08	0.40	77.06	-	-
Panicum maximum	27.26	2.86	16.45	16.09	19.02	14.70	14.25	15.84
Pogonarthria squarosa	-	-	-	-	0.07	100.0	-	-
Setaria sphacelata	58.53	5.14	48.95	5.48	44.00	6.68	32.93	4.82
Themeda triandra	8.34	15.60	20.83	9.40	25.92	13.60	32.25	3.98

Where there are no values recorded indicates that the species was not encountered during sampling. As the transects were randomly located no differentiation was made between the various soil types and a variation of about 10% in frequency must be allowed for. Percentage canopy cover was not measured in either of the camps but the variation in frequency of *P.maximum* can be due to the location of transects (i.e. some transects passed beneath trees and some did not). A variation in the frequency of annual grasses can also be expected as they only germinate after the rains. The low frequency for *T.triandra* in November 1989 is due to the fact that this period was used as a trial run and there was a problem with identifying species as many were not yet flowering. The trial was repeated in November 1990 to compensate for the poor data collected in November 1989. To obtain the species composition for Camp A the mean percentage species composition over the different seasons was taken. The means for both camps and their coefficients of variation (CV) are listed in Tables 2.2 and 2.3.

TABLE 2.2 MEAN PERCENTAGE SPECIES COMPOSITION AND COEFFICIENTS OF VARIATION (CV) FOR CAMP A

Species	%	CV
Aristida congesta subsp. *congesta*	0.32	34.80
Aristida congesta subsp. *barbicollis*	0.13	48.92
Bare ground	0.34	62.81
Cymbopogon plurinodis	0.43	24.28
Digitaria eriantha	0.23	63.25
Elionurus muticus	0.23	44.20
Eragrostis chloromelas	3.90	11.29
Eragrostis gummiflua	0.48	42.98
Forbs	0.63	26.59
Heteropogon contortus	3.16	17.58
Hyparrhenia hirta	0.85	31.34
Loudetia simplex	3.96	22.15
Melinis repens	0.46	47.21
Panicum maximum	19.37	8.11
Pogonarthria squarrosa	0.07	100.00
Setaria sphacelata	47.06	6.20
Themeda triandra	21.02	10.68

TABLE 2.3 MEAN PERCENTAGE SPECIES COMPOSITION AND COEFFICIENTS OF VARIATION (CV) FOR CAMP B

SPECIES	%	CV
Aristida congesta subsp. *congesta*	1.19	20.28
Aristida congesta subsp. *barbicollis*	0.10	100.00
Cymbopogon plurinodis	1.96	20.31
Digitaria eriantha	0.10	100.00
Eragrostis chloromelas	7.20	5.02
Heteropogon contortus	0.14	100.00
Loudetia simplex	1.04	44.03
Melinis repens	0.10	100.00
Panicum maximum	40.60	6.77
Pogonarthria squarrosa	1.00	35.72
Setaria sphacelata	17.26	11.56
Themeda triandra	21.13	5.88

In camp A, the six most abundant species comprised more than 98% of the total species composition. Only these six species; *Eragrostis chloromelas, Heteropogon contortus, Loudetia simplex, Panicum maximum, Setaria sphacelata* and *Themeda triandra*; will later be considered for preference rating, since too few individuals of other species were encountered to give a reliable estimate of their utilisation. The CV for all species comprising 19% or more of the total botanical composition in camp A was less than 11% . The CV for species comprising from 1% to 4% of the total composition was less than 25% . For species comprising less than 1% of the sward, the CV is understandably large and varies greatly.

In camp B the percentage composition was recorded between days of occupation. The CV for species comprising 15% and more in camp B was less than 12%. The CV for species comprising between 2% and 10% was less than 11% in both cases. For species comprising less than 2% of the sward the CV again varied greatly and was usually very large due to the fact that very few individuals of a particular species were encountered. In camp B, again the six most abundant species comprised more than 96% of the total species composition and only these species (*Eragrostis chloromelas, Cymbopogon plurinodis, Panicum maximum, Setaria sphacelata, Themeda triandra* and *Heteropogon contortus*) were later be considered for preference rating.

TABLE 2.4 GROUPING OF GRASS SPECIES ACCORDING TO THEIR ECOLOGICAL STATUS AND THEIR PERCENTAGE SPECIES COMPOSITION AT DIFFERENT TIMES OF THE YEAR

Ecological status	Species	Nov 89	Feb 90	Apr 90	Nov 90
Decreaser	*Digitaria eriantha*	-	0.23	-	-
	Panicum maximum	27.26	16.45	19.02	14.25
	Setaria sphacelata	58.53	48.95	44.00	32.93
	Themeda triandra	8.34	20.83	25.92	32.25
Increaser I	*Cymbopogon plurinodis*	-	0.33	0.57	-
	Hyparrhenia hirta	0.60	-	0.67	1.35
	Loudetia simplex	-	2.72	1.52	8.27
Increaser IIa	*Aristida congesta* subsp. *congesta*	0.06	0.48	0.40	-
	Aristida congesta subsp. *barbicollis*	0.40	0.05	0.25	-
	Heteropogon contortus	0.06	4.67	3.25	4.67
	Pogonarthria squarrosa	-	-	0.07	-
Increaser IIb	*Elionurus muticus*	0.06	0.05	-	0.72
	Eragrostis chloromelas	3.26	3.93	3.90	4.67
Increaser IIc	*Eragrostis gummiflua*	0.40	0.55	-	-
	Melinis repens	-	0.50	0.40	-

Classification of species was based on van Oudtshoorn (1991) and on Smit & Rethman (1992). Smit & Rethman (1992) classified *P.maximum* as an Increaser IIa but the percentage species composition recorded above seems to indicate that *P.maximum* is a Decreaser. The veld condition of the study site would seem to be very good seeing that in Camp A 87% and in Camp B 79% of the total percentage species composition is made up of Decreasers. There is a general tendency for *P.maximum* and *S.sphacelata* to decrease. This is to be expected as both species are decreasers and the stocking rate applied was high (see section 2.4). There is also a tendency for *T.triandra* to increase. This was not expected as the species is traditionally a decreaser. The figure for November 1989 should not be taken to imply too much as improper sampling resulted in *T.triandra* being under - represented at this sampling time.

2.4 Management of experimental area

The original 4 hectare camp was grazed by 27.4 LSU/ha for 10 days during the winter in 1989. Bonsmara steers were used. The camp was then divided into Camp A and Camp B. An attempt was made to use similar classes of animals for all the trials, however, this was not always possible due to farm management restrictions. Camp A was grazed by 15.9 LSU/ha for seven days in November 1989, by 16.8 LSU/ha for seven days in February 1990, by 17.0 LSU/ha for five days in April 1990 and by 14.68 LSU/ha for five days in November 1990. Camp B was grazed by 14.2 LSU/ha for seven days followed immediately by 53.3 LSU/ha for three days in August 1990. Data for each grazing period were expressed as animal unit per grazing day in order to facilitate comparison between grazing periods. Grazing days were calculated according to metabolic mass of individual animals and expressed as LSU per grazing day, a LSU being that defined by Meissner *et al.* (1983). By this means the different periods of occupation by animals of different mass can be expressed on a comparable scale.

CHAPTER 3

SPECIES PREFERENCE

3.1 Introduction

Natural veld is an especially important element in the forage flow for livestock in the Sourish, Mixed Bushveld of the Transvaal. The grass layer essentially consists of perennial grasses such as *Panicum maximum*, *Themeda triandra*, *Heteropogon contortus* and *Setaria sphacelata* and its floristic composition, especially in terms of the palatability of the grasses to livestock, is a primary determinant of grazing capacity (Barnes *et al*, 1984). Bushveld is typically heterogeneous and is made up of a mixture of species of varying acceptability to livestock and therefore offers the grazing ungulate a range of species which might differ in their dietary qualities, morphology and structure (O'Connor, 1992). A knowledge of the diet of grazing and browsing animals, combined with the knowledge of the composition of the vegetation available to them, is of basic importance in the management of the vegetation and the development of efficient systems of animal production (Barnes, 1976).

It has been well documented that herbivores graze plants selectively (Tribe, 1952; Heady, 1975; Danckwerts *et al.* 1983; O'Reagain & Mentis, 1989a). It has also been found that moribund material (Willms *et al.* 1980) and plant structure (Gammon & Roberts, 1978;

Bransby, 1980; O'Reagain & Mentis, 1989b; Gammon & Twiddy, 1990) can also influence selection. The influence of species selection by grazing ungulates on the dynamics of plant communities has long been recognised (Weaver & Clements, 1938) and is implicit in the increaser - decreaser classification of rangeland species (Ellison, 1960; Foran *et al.* 1978). Patterns of selection will vary with changes in the moribundness of tufts, population size structure, stemminess resulting from grazing variability, spatial location and compositional differences (O'Connor, 1992).

The strategies of non-selective grazing (Acocks, 1966) and controlled selective grazing (Pienaar, 1968; Booysen, 1969) among others, have been developed to counter the effects of selective grazing. In order to counter the effects of selective grazing, knowledge of the preference for species by grazing animals is an essential prerequisite to the successful application of any grazing strategy. Mentis (1981a) defines the preference an animal may show for a particular species as the extent to which the animal will take that species in a larger proportion than that in which it occurs with other species. Petrides (1975) has defined a "preferred food species" as one which is proportionally more frequent in the diet of an animal than it is in the available environment and "food preference" as the extent to which a food is consumed in relation to its availability. It would probably be true to say that the extent to which animals practice both species and area selection will be reduced as stocking intensity increases.

The effects of livestock grazing on veld are related primarily to the direct effects of defoliation on the growth and reproduction of individual plants and the disparity that exists among individual plants in frequency and severity of defoliation, as a result of selection (Walker *et al.* 1989). Diet selection involves a hierarchy of decisions made by the grazing animal relative to the spatial assemblage of plants across a landscape, that can be classified as:

1) plant community

2) patch

3) plant (Senft *et al.* 1987).

Previous research on spatial distribution patterns of grazing has shown large differences in grazing intensity among plant communities and among patches in communities (Tanner *et al.* 1984; Ring *et al.* 1985).

Potential stocking rate depends not only on herbage production, but also on the fraction of this herbage that is eaten (Owen Smith & Cooper, 1988). Since plant species vary widely in their utilisation by herbivores, it is common practice when assessing veld for animal production to assign species to palatable and unpalatable categories (Grunow, 1980, Barnes *et al.* 1984). Palatability assessments are usually based on subjective judgements by experienced observers. However, the pattern of consumption of a plant species can vary with its growth stage, season, soil type, the animal species concerned and the availability of other plant species (Owen Smith & Cooper, 1988). Even species classed as unpalatable are eaten sometimes. Grazers reportedly select on the basis of tuft structure (Danckwerts *et al.* 1983; O'Reagain & Mentis, 1989b) and the quality of the leaf material (O'Reagain & Mentis, 1989b). Selection is evident between veld types, for areas within veld types, between species and within species, for specific tillers and plant parts. Emlen (1966) believes that dietary breadth should widen as overall food availibility declines. This implies that animals are likely to graze less selectively with diminishing herbage availability.

Foraging decisions made by the grazing animal in terms of whether to accept or reject different foods (species) when encountered; the way in which these foods are incorporated into the diet under conditions of changing food availability and the relative allocation of time and energy to seeking out these foods are poorly understood (O'Reagain & Mentis, 1989a). The development of the optimal foraging theory has permitted the formulation of precise, testable hypotheses to explain or predict such decisions made by the foraging animal. Optimal foraging theory is based on the assumption that a range of possible foraging strategies exists (Pyke *et al.* 1977) and that those individuals which feed most efficiently (i.e. forage optimally), will be favoured by natural selection, owing to their greater genetic contribution to subsequent generations (Estabrook & Dunham, 1976). Optimal foraging theory makes general predictions. One, that is relative to this study, is that the decision to eat a food is independant of its abundance but depends on the relative abundance of more preferred foods (Pyke *et al.* 1977).

Whatever is done, selective grazing will still occur. Management can only aim at reducing the extent to which it occurs. Different philosophies have evolved with regard to prevention or modification of selective grazing and increasing herbage and animal production (Acocks, 1966; Booysen, 1966, 1969; Pienaar, 1968; Savory, 1983; Tainton, 1985). Hatch & Tainton (1993) believe that evaluation of the action of the grazing animal at the individual plant level is fundemental to understanding the responses of grass plants to defoliation by grazing.

3.2 Procedure

Various experiments were conducted in Camps A and B to determine preference:

a) Each day during periods of occupation in Camps A and B the overall availability of forage was estimated by means of 100 standard disc pasture meter readings. The disc meter was calibrated before and after each period of occupation by the method described by Trollope & Potgieter (1986).

b) Fifty tufts each of *Themeda triandra*, *Setaria sphacelata* and *Panicum maximum* were permanently marked along three transects running lengthwise through both Camp A and B. Two tillers were permanently marked on each tuft using coloured electrical wire to distinguish between tiller 1 and 2. Each day during occupation these tufts were returned to and classified into utilisation classes according to the classification of Kruger & Edwards (1972) where;

class 1 - all leaf material has been removed

class 2 - more than 50% of leaf material has been removed

class 3 - less than 50% of leaf material has been removed

class 4 - ungrazed

The relative utilisation percentage (RUP) of each species was then calculated on a daily basis using the formula:

$$RUP = \frac{33.33\ (3 \times AT) + (2 \times BT) + (1 \times CT)}{T}$$

(Kruger and Edwards, 1972)

where:

AT is the number of individuals occurring in class 1

BT is the number of individuals occurring in class 2

CT is the number of individuals occurring in class 3

T is the total number of individuals of a species.

The overall mean leaf table height (cm) of each tuft was measured to determine if preference for a certain species increased or decreased with a change in height (tillers were not included in this measurement). Each day it was also recorded whether the tillers had been grazed or not. If either tiller had been grazed its bite height was recorded and the leaf tip was marked with Typists' corrective fluid (Tipp-Ex). This gave some indication of the number of times the same tillers and tufts are grazed within the same grazing period. Danckwerts (1984) and Stoltz & Danckwerts (1990) revealed no significant influence of marking compounds on grazing patterns.

c) As mentioned in Chapter 2, three hundred step points were conducted each day during periods of occupation in both camps along six 50 m randomly located transects. At each point the recorded species was classified into a utilisation class as above and the mean leaf table height was measured in cm.

3.3 Results

3.3.1 Overall forage availability

The disc meter was calibrated before and after each period of occupation. Regression analyses were initially performed on the before and after grazing calibration data separately to see if it is possible to estimate one variate (sample weight) from another (disc meter reading) with a certain degree of accuracy. The results of the fitted slopes are shown in table 3.1.

TABLE 3.1 PERCENTAGE VARIANCE ACCOUNTED FOR AND ESTIMATES OF REGRESSION COEFFICIENTS FOR THE SEPARATE BEFORE AND AFTER CALIBRATION DATA

	R^2		Estimate	
	Before	After	Before	After
<u>Camp A</u>				
November 1989	25.7	40.9	3.4	6.7
February 1990	28.8	18.8	2.6	3.6
April 1990	19.6	24.9	2.7	2.1
November 1990	28.0	12.0	2.1	3.5
<u>Camp B</u>				
August 1990	71.2	16.5	3.1	4.9

In Camp A the low R^2 values indicate that a low percentage of the variance is accounted for and sample weight can not be estimated from the disc meter reading with a high degree of accuracy. The estimate provides us with the value of m in the regression equation of $y = mx + c$, where x is the disc meter reading and y is the sample weight. Camp B has an R^2 of 71.2. This means that it is possible to predict sample weight from disc meter readings with 71% certainty. This is a better regression fit but it is still not sufficiently high enough to predict sample weight from disc meter redings without a large variation in the results. Due to the poor results obtained above the before and after grazing calibration data were combined and another regression analysis was performed on the combined data. The results of this regression are shown in table 3.2.

TABLE 3.2 PERCENTAGE VARIANCE ACCOUNTED FOR AND ESTIMATES OF REGRESSION COEFFICIENTS FOR THE COMBINED BEFORE AND AFTER DATA

	R^2	Estimate
Camp A		
November 1989	34.5	4.5
February 1990	24.6	1.7
April 1990	23.5	2.5
November 1990	13.5	2.4
Camp B		
August 1990	13.6	1.5

The different slopes and variations became more noticeable as the time of grazing was superimposed onto the graphs of sample weight versus disc meter reading (See Figures 3.1 to 3.5).

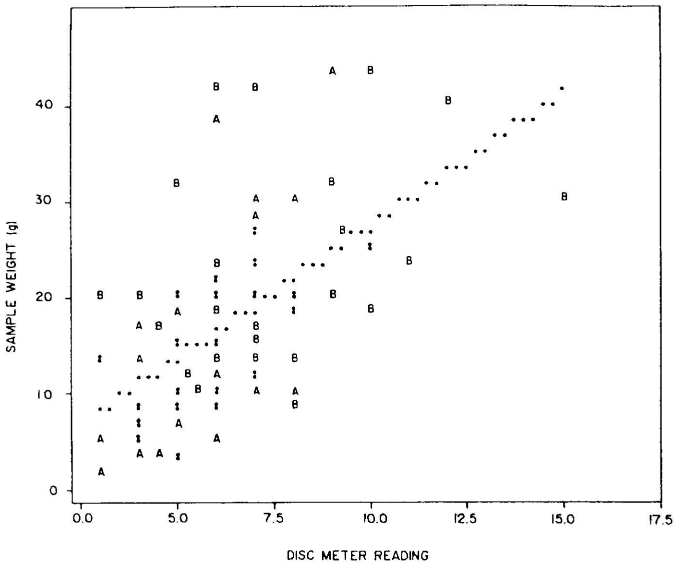


Figure 3.1 Regression of combined before and after calibration data in November 1989

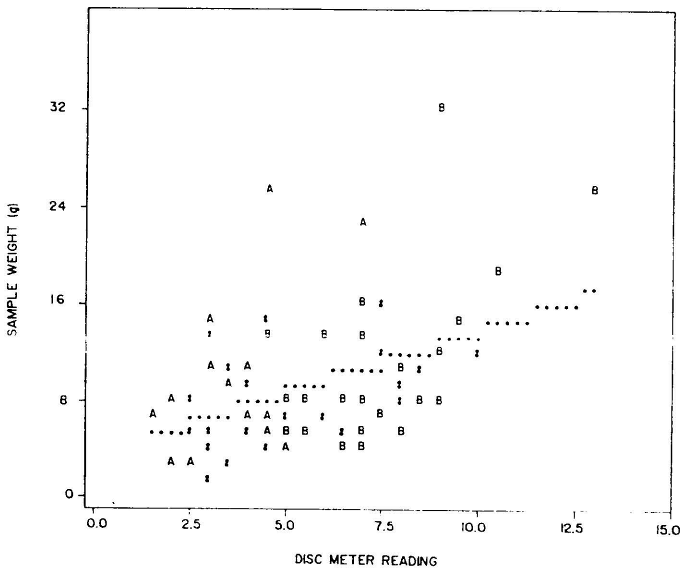


Figure 3.2 Regression of combined before and after calibration data in February 1990

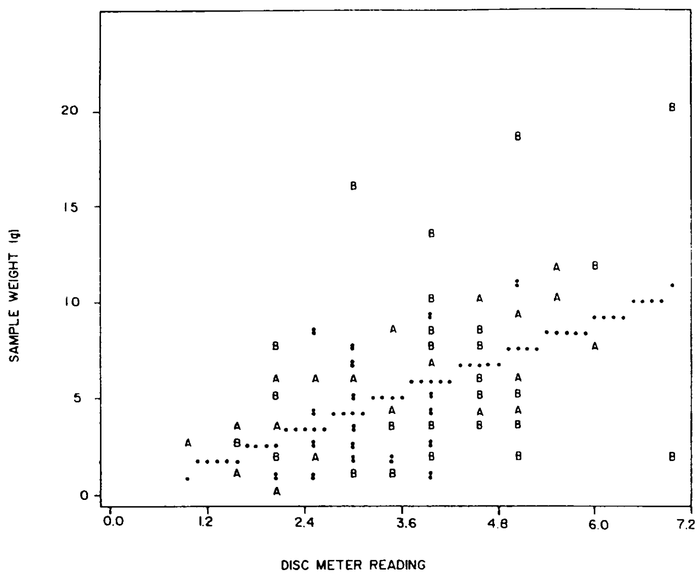


Figure 3.3 Regression of combined before and after calibration data in April 1990

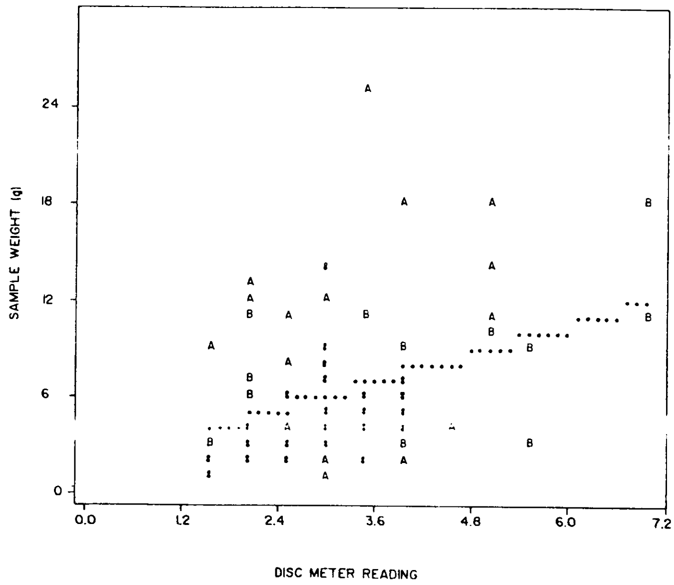


Figure 3.4 Regression of combined before and after calibration data in November 1990

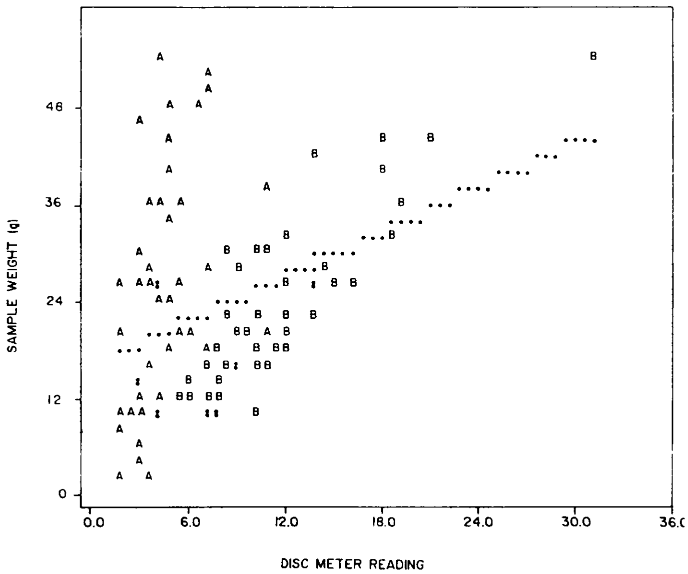


Figure 3.5 Regression of combined before and after calibration data in August 1990

From Table 3.2 and the above figures it can be seen that even when combining the before and after grazing calibration data the R^2 values were still found to be very low and the variation from the regression line was still great. The regression equations were therefore, not suitable to be used for predictive purposes.

Another regression was then performed where the average of the sample weight values was taken for a constant disc meter value and then weighted with the number of values making up that mean (e.g. there was only 1 sample weight at a disc meter reading of 1.5 but 6 sample weights at a disc meter reading of 3.5). The results of this regression are shown in table 3.3.

TABLE 3.3 PERCENTAGE VARIANCE ACCOUNTED FOR AND ESTIMATES OF REGRESSION COEFFICIENTS FOR THE COMBINED AND WEIGHTED CALIBRATION DATA

	R^2	Estimate
<u>Camp A</u>		
November 1989	79.3	4.5
February 1990	62.6	1.7
April 1990	86.5	2.5
November 1990	54.4	2.4
<u>Camp B</u>		
August 1990	27.5	1.5

There is a definate improvement and increase in percentage variance accounted for except in Camp B. This can be due to the fact that in winter the grass is dry and the readings are thus not dependable. From the above results it can be seen that in November 1989 sample weight can be predicted from disc meter readings with a 79% degree of accuracy and in April 1990 with a 86% degree of accuracy. At the other times of the year, and especially in winter, sample weight can be predicted from disc meter readings but with a very low accuracy.
It was therefore decided to plot the mean disc height for every day of occupation versus time. Regression analysis was performed on the data to test for linearity. Figure 3.6 shows the relationship between day of occupation and mean disc meter reading in Camp A for all the seasons combined and Figure 3.7 shows the same relationship in Camp B.

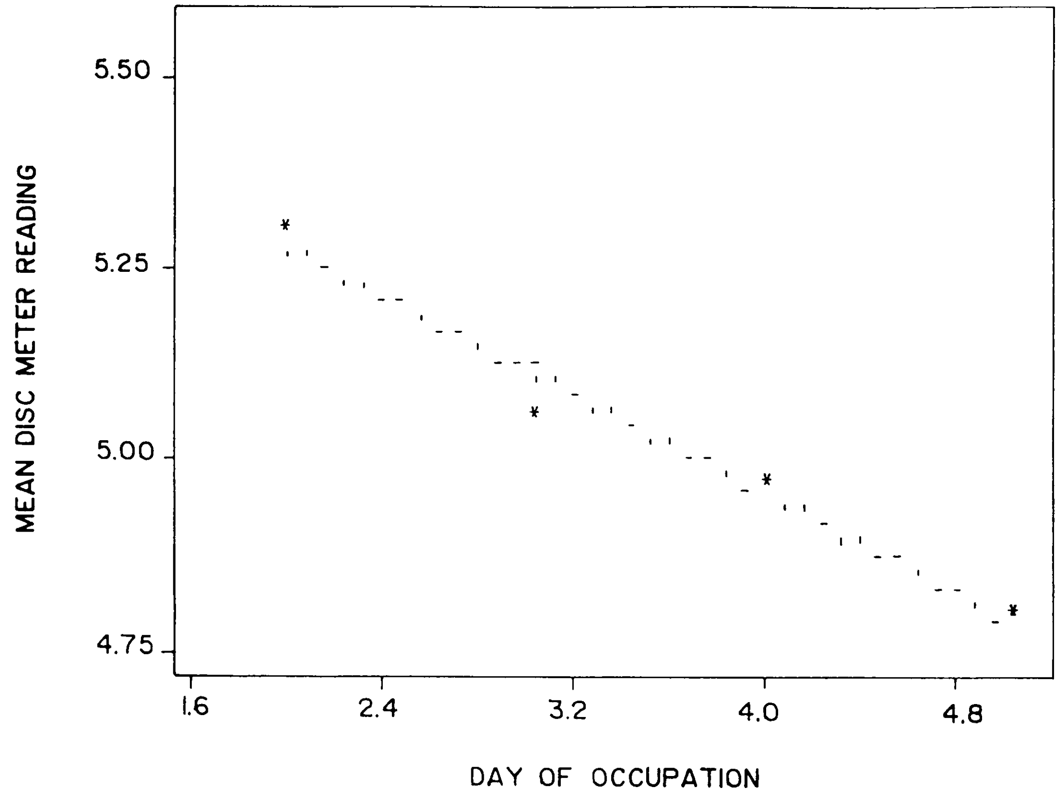


Figure 3.6 Relationship between day of occupation and mean disc meter reading in Camp A

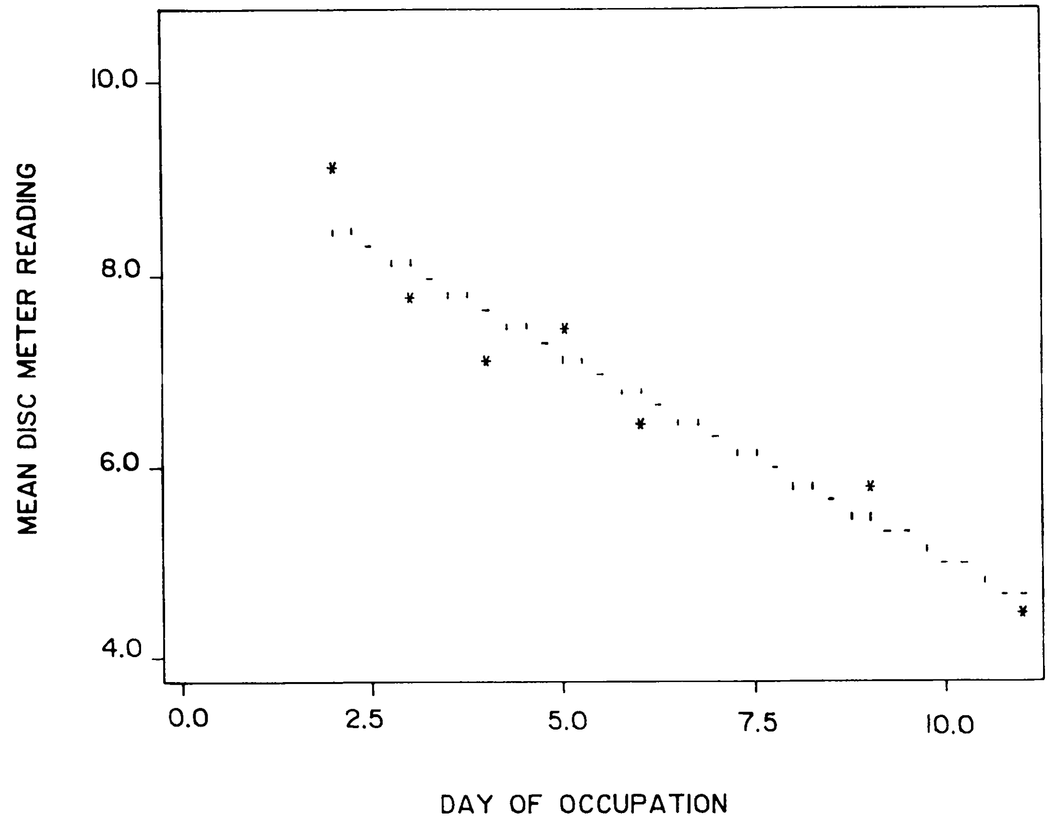


Figure 3.7 Relationship between day of occupation and mean disc meter reading in Camp B

From the above figures it can be seen that the relationship between mean disc meter reading and day of occupation in Camp A is linear and the percentage variation accounted for is 94.9% (R^2 = 94.9). In Camp B the relationship is also linear and the percentage variation accounted for is 89.7% (R^2 =89.7). Both these figures show a good linear fit and this implies that there was an unrestricted intake of forage and a linear decrease in the mean disc meter reading during periods of occupation. A theoretical model was proposed by Jones (1971) to describe the rate of herbage disappearance with time during periods of occupation in rotational grazing systems. According to this model, the quantity of available herbage should decrease linearly with time while herbage is abundant. When animals start searching for feed, daily intake per head should diminish, and the rate of disappearance of herbage would deviate from linearity, decreasing progressively with time. From the above graphs it can be seen that available herbage does decrease linearly and that herbage did not become restricted as there was no deviation from linearity.

3.3.2 Relative utilisation

3.3.2.1 Relative utilisation of marked tufts

The relative utilisation percentage (RUP) of the permanently marked tufts of *S.sphacelata*, *P.maximum* and *T.triandra* in Camp A at the different grazing times are shown in figures 3.8 to 3.11.

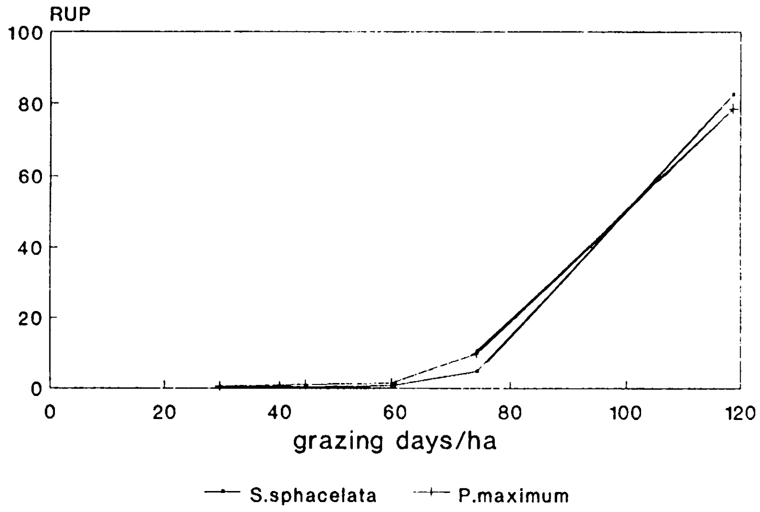


Figure 3.8 The RUP of S.sphacelata and P.maximum in Camp A in November 1989

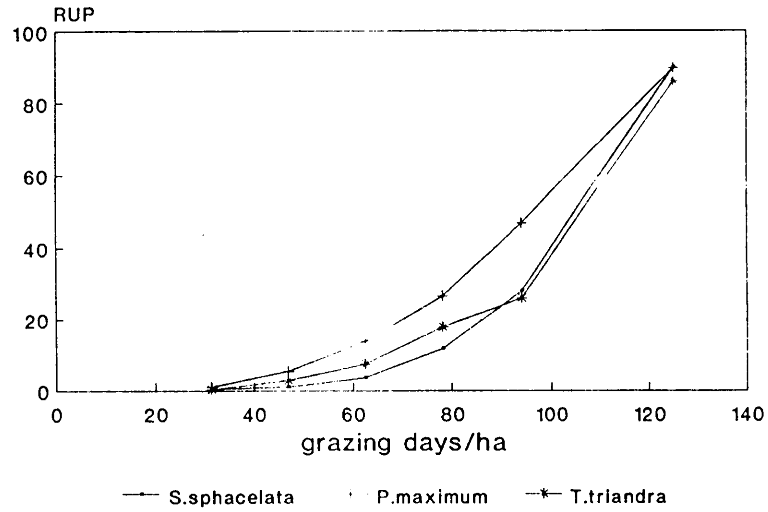


Figure 3.9 The RUP of S.sphacelata, P.maximum and T.triandra in Camp A in February 1990

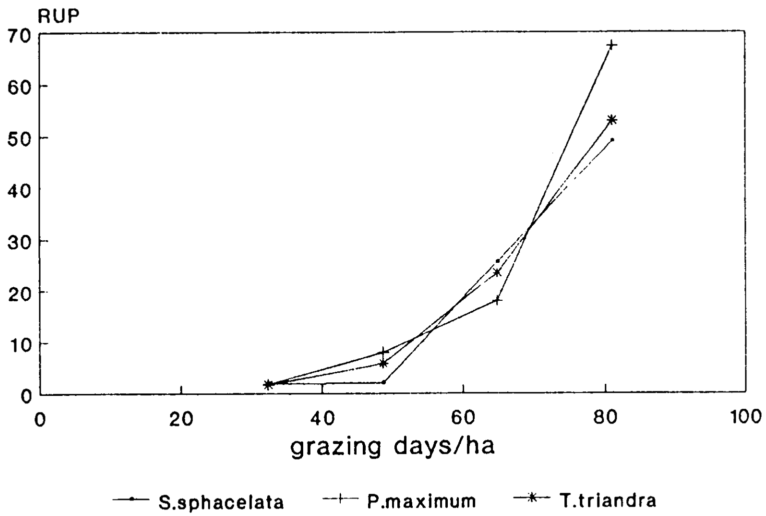


Figure 3.10 The RUP of S.sphacelata, P.maximum and T.triandra in Camp A in April 1990

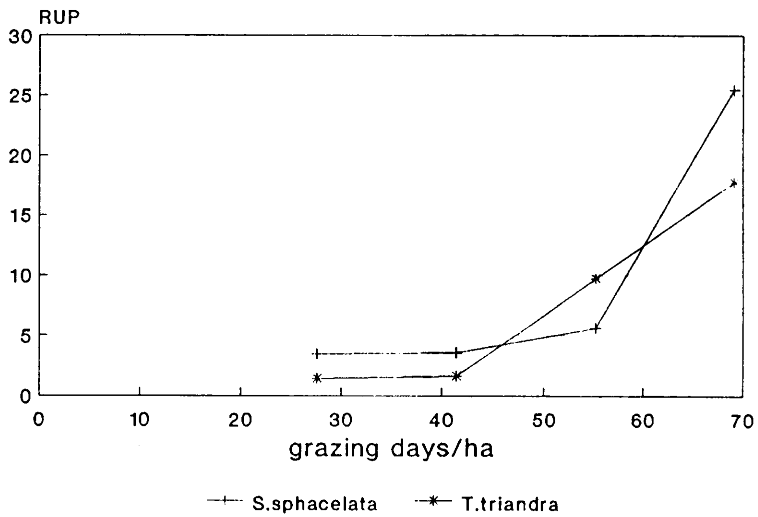


Figure 3.11 The RUP of S.sphacelata and T.triandra in Camp A in November 1990

The relative utilisation percentage of the permanently marked tufts of *P.maximum*, *S.sphacelata* and *T.triandra* in Camp B in August 1990 are shown in figure 3.12.

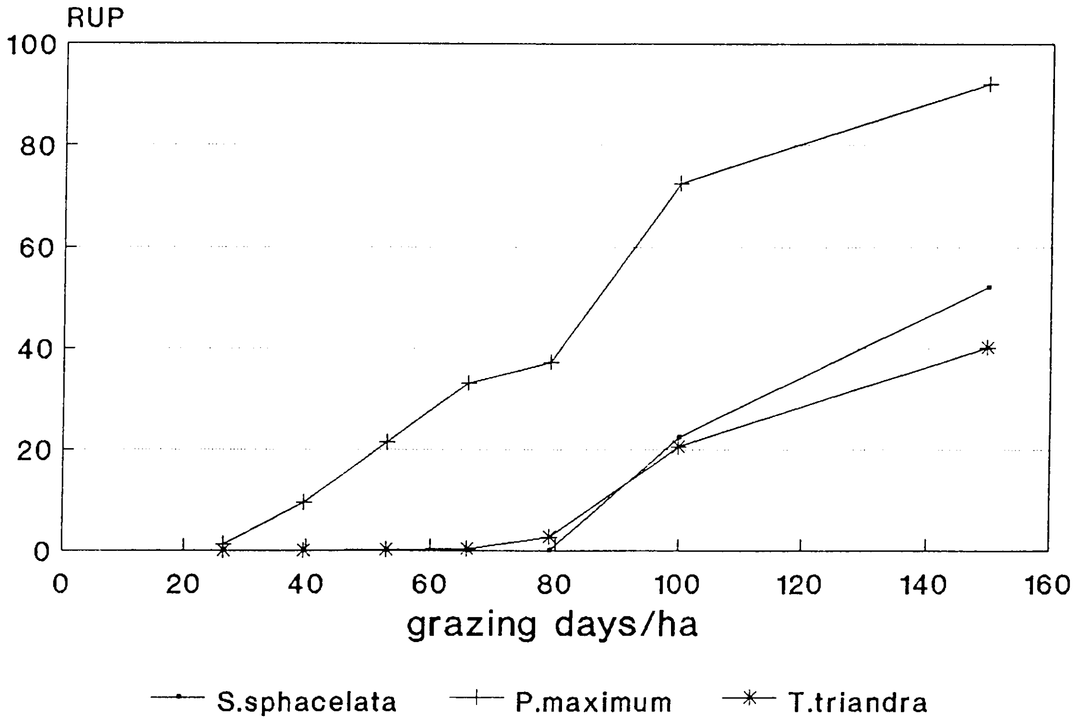


Figure 3.12 The RUP of *S.sphacelata*, *P.maximum* and *T.triandra* in Camp B in August 1990

The sequence in which grass species of different acceptability classes are selected by cattle through a grazing period, has been described by Daines (1980) in the Döhne Sourveld, by Danckwerts *et al.* (1983) in the False thornveld of the Eastern Cape and by O'Reagain & Mentis (1989a) in the Natal Sour Sandveld.

In November 1989 there was very little difference in the utilisation between *S.sphacelata* and *P.maximum*, both being utilised almost equally. In February 1990, *P.maximum* had the highest utilisation throughout the grazing period with *T.triandra* being the second most utilised species at the beginning of the grazing period and *S.sphacelata* the second most utilised species at the end of the grazing period. In April 1990, *P.maximum* was the most utilised species at the beginning and the end of the grazing period with *T.triandra* as the second most utilised species and *S.sphacelata* as the third most utilised species. In the middle of the grazing period the utilisation of *P.maximum* dropped and *S.sphacelata* was utilised the most. In November 1990, *S.sphacelata* had a higher utilisation percentage than *T.triandra* in the beginning and at the end of the grazing period. There is no data for *P.maximum* because the area was experiencing a drought at the time of the survey and *P.maximum* tufts had had no regrowth.

The above results show that in Camp A *P.maximum* was the most utilised species in all seasons, except in early summer (November) when *S.sphacelata* was utilised to the same degree. From this it can be deduced that in the Sourish, Mixed Bushveld cattle will select first for *P.maximum* and then for *T.triandra* or *S.sphacelata* depending on the season. This pattern of species selection corresponds with the conventional wisdom on the palatability of the three above species (O'Connor, 1992). Smit & Rethman (1989) believe that *P.maximum* is an important species in this veld type and deserves further attention due to its preference for a canopied subhabitat, its high production potential and its sensitivity to grazing management. O'Reagain & Mentis (1989b) contend that preferred species generally have a high leaf percentage, high leaf table height, low leaf density, have leaves of high crude protein content but intermediate tensile strength and are non - stemmy. *P.maximum* fits most of these requirements.

In Camp B, *P.maximum* was the most utilised species throughout the grazing period, with *T.triandra* being the second most utilised species until the middle of the grazing period when *S.sphacelata* becomes more utilised than *T.triandra*. It was of interest to note that for the first few days, before the stocking rate was increased, the animals did not eat any of the other species but concentrated on *P.maximum*. When the stocking rate was increased and the amount of *P.maximum* material available became limited, then the other species were grazed. The leaves of *P.maximum* in winter were very dry and hairy and did not look or feel very palatable, yet they were selected for almost exclusively at the beginning of the grazing period. This differs to what Kreuter & Tainton (1988) found in the Natal Sourveld. They found that cattle generally select for the smooth, glabrous, leafy components in the sward (mainly *T.triandra* and *H.contortus*) in favour of the other plant fraction of the herbage on offer. Broad hairy leaves, whose dry matter digestability and crude protein were almost equivalent to those of the glabrous leaf fraction, were on average, rejected by the cattle, presumably because of their hairyness.

In Camp A, *P.maximum* makes up only 19% of the total species composition and yet it had the greatest utilisation. This indicates that the cattle were definately selecting for this species because they had to look harder to find it. The *P.maximum* tufts were all located under trees and maybe the selection for this species is not only for its palatability but also for the convenience of shade under the tree. *T.triandra* makes up only 21% of the total species composition in Camp A while *S.sphacelata* makes up 47% and yet the animals selected more for *T.triandra* than for *S.sphacelata.* According to Petrides (1975) and Mentis (1981a) this then makes *P.maximum* and *T.triandra* species preferred above *S.sphacelata.*

In Camp B, *P.maximum* forms 40% of the total species composition and that explains the large difference in utilisation of *P.maximum* to *S.sphacelata* and *T.triandra.* The increase in the number of *S.sphacelata* and *T.triandra* tufts grazed with increasing stocking intensity implies that these two species were not preferred species during the winter grazing period. *S.sphacelata* makes up 17% and *T.triandra* 21% of the total species composition in Camp B and from the results it seems that in winter the animals first selected for *T.triandra* before selecting for *S.sphacelata*

P.maximum is generally regarded as a preferred pasture species, (Friedel & Blackmore, 1988), and has been reported by Donaldson & Rootman (1983) to decline under continuous grazing and grazing during the actively growing season. This also seems to be the case in this study because *P.maximum* was classed as a Decreaser species.

3.3.2.2 Percentage of tufts utilised

Figures 3.13 to 3.16 show the percentage of tufts of each of the three marked species that were utilised during the period of occupation in the different seasons in Camp A.

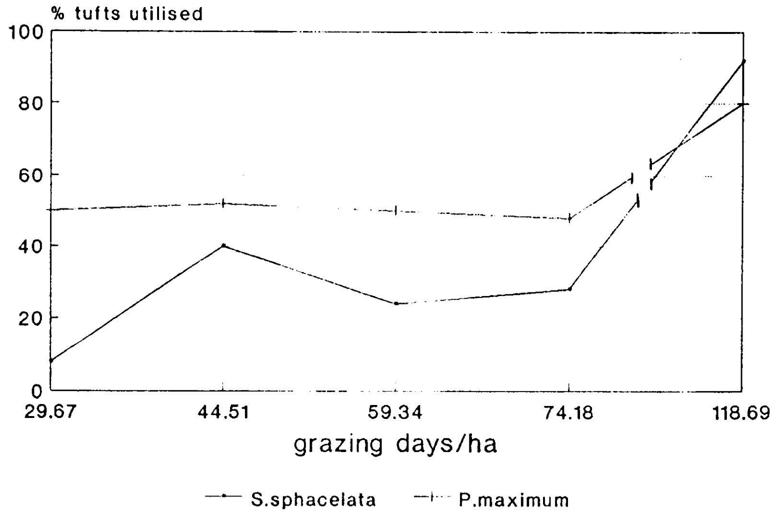


Figure 3.13 Percentage tufts utilised in Camp A in November 1989

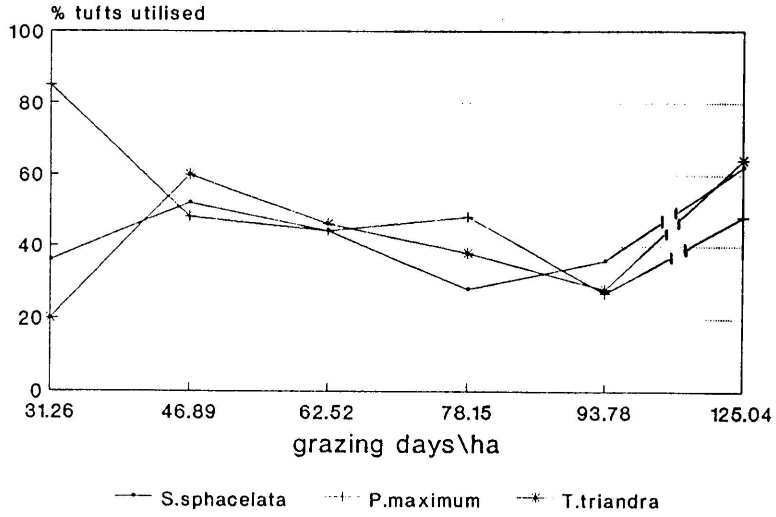


Figure 3.14 Percentage tufts utilised in Camp A in February 1990

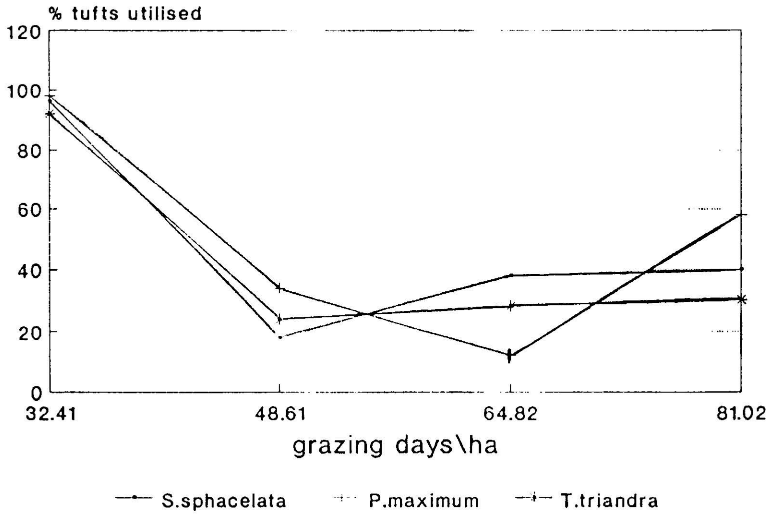


Figure 3.15 Percentage tufts utilised in Camp A in April 1990

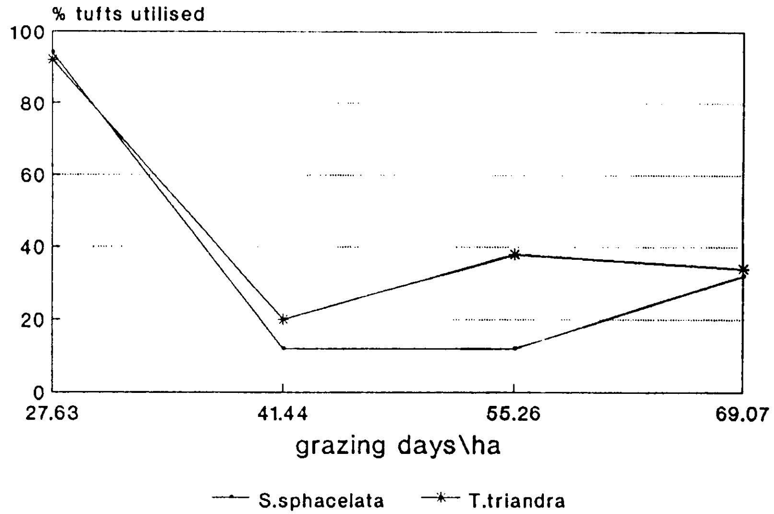


Figure 3.16 Percentage tufts utilised in Camp A in November 1990

Figure 3.17 shows the percentage of tufts of each of the three marked species that were utilised during the period of occupation in August 1990 in Camp B.

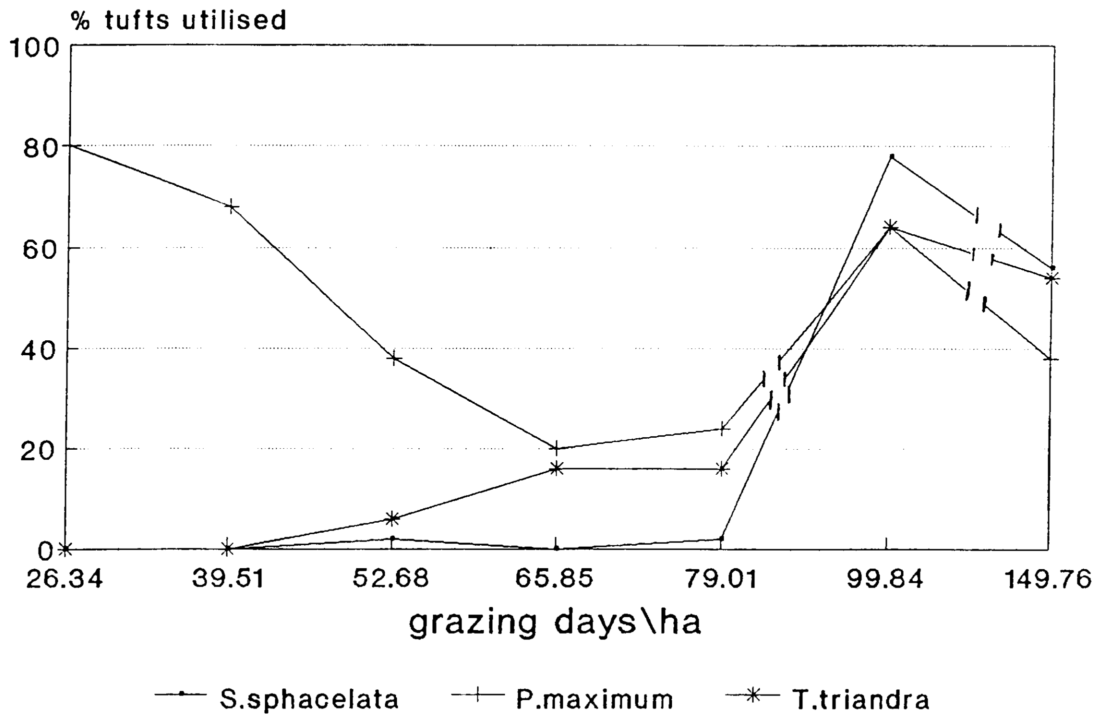


Figure 3.17 Percentage of tufts utilised in August 1990 in Camp B

The data for the percentage tufts that have been utilised corroborates the RUP data with *P.maximum* having a greater number of tufts utilised in early summer (November 1989) than *S.sphacelata* until the end of the grazing period when *S.sphacelata* had more tufts which were utilised. In late summer, (February), although *P.maximum* had the highest RUP throughout the grazing period, *S.sphacelata* and *T.triandra* had a higher percentage of tufts utilised at times during the grazing period. This seems to show that although *P.maximum* had fewer tufts utilised at a certain time they were utilised to a greater degree thus giving *P.maximum* a higher RUP. In late summer on the first day of grazing 86% of the *P.maximum* tufts were utilised, but *P.maximum* had a very low RUP for that day, only 2%. This means that although most tufts had been grazed they were not fully utilised. The utilisation of *S.sphacelata* tufts started at 36% and of *T.triandra* at 20% at the beginning of the period of occupation.

Jordaan *et al.* (1991) believe that the biggest drawback of the Kruger & Edwards (1972) method is that, although percentage utilisation is estimated on the basis of original availability of material, the volume of material that is available before utilisation can not be quantified. If utilisation studies are based on the Kruger & Edwards (1972) method and the amount of material that is removed is not taken into account, species with little material available for utilisation will be favoured above species with more utilisable material. Jordaan *et al.* (1991) therefore suggest that tuft volume (to describe available above-ground phytomass), in combination with utilisation classes (to describe the percentage material removed) is a more objective method by which utilisation can be described than previous methods that involve only utilisation studies.

In autumn, (April 1990), almost all the tufts of the three species were utilised (almost 100% of the tufts were grazed) on the first day, but they were not very well utilised because all the utilisation percentages were low. The percentage tufts utilised of each species decreased with each grazing day, but the RUP of each species increased with each grazing day. This therefore, means that at the beginning of occupation many tufts were sampled but not fully utilised and as the period of occupation progressed tufts were returned to and utilised to a greater degree.

In November 1990 *S.sphacelata* and *T.triandra* also started with almost 100% of the tufts being utilised on the first grazing day. This dropped on the second day and stayed below 40% tufts utilised for both species till the end of the grazing period. The RUP of both species at this time was low; 26% for *S.sphacelata* and 17% for *T.triandra.* Very little regrowth had taken place since April because of the lack of rain and the low RUP was due to this as there was little leaf material for the animals to utilise.

In winter, (August 1990), *P.maximum* started off with 80% of the tufts being utilised on the first day while *S.sphacelata* and *T.triandra* had no tufts utilised on the first and second days. These two species had a very low RUP until the stocking rate was increased, then the RUP for both species increased dramatically.

3.3.2.3 Relative utilisation of random tufts

The relative utilisation percentage of the 5 or 6 most abundant species encountered in the step-point survey in Camp A at the different grazing times are shown in figures 3.18 to 3.21.

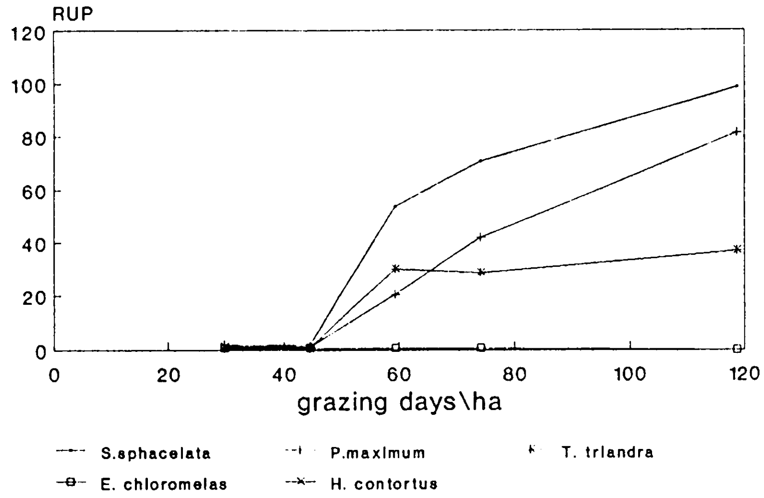


Figure 3.18 The RUP of the 5 most abundant species in Camp A in November 1989

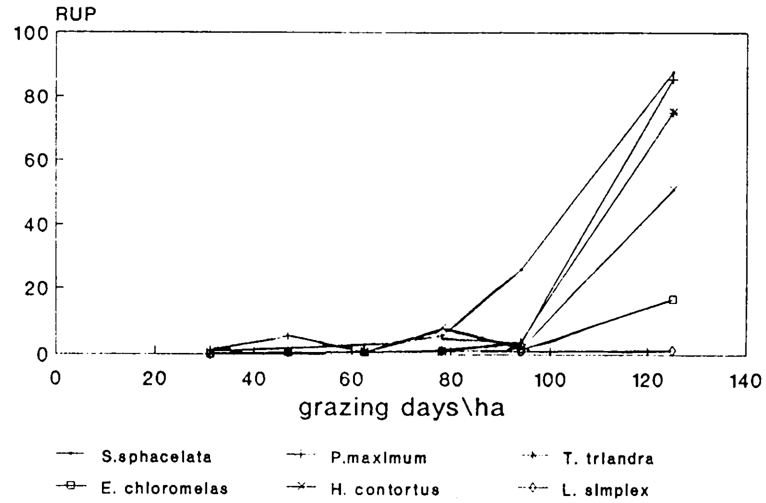


Figure 3.19 The RUP of the 6 most anundant species in Camp A in February 1990

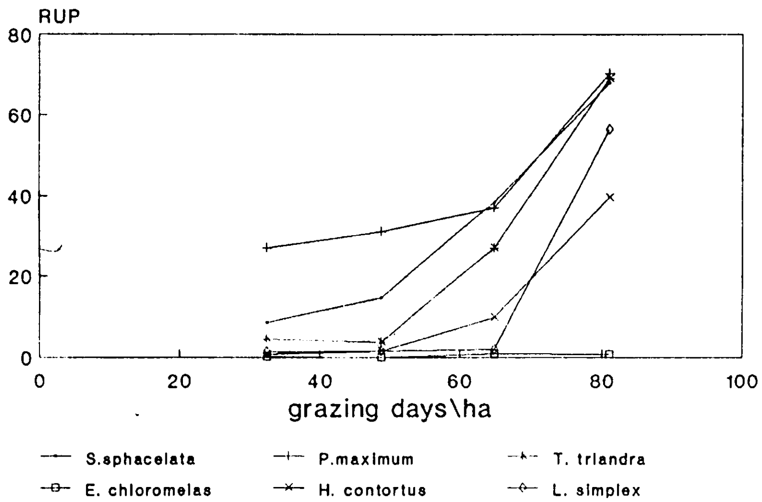


Figure 3.20 The RUP of the 6 most abundant species in Camp A in April 1990

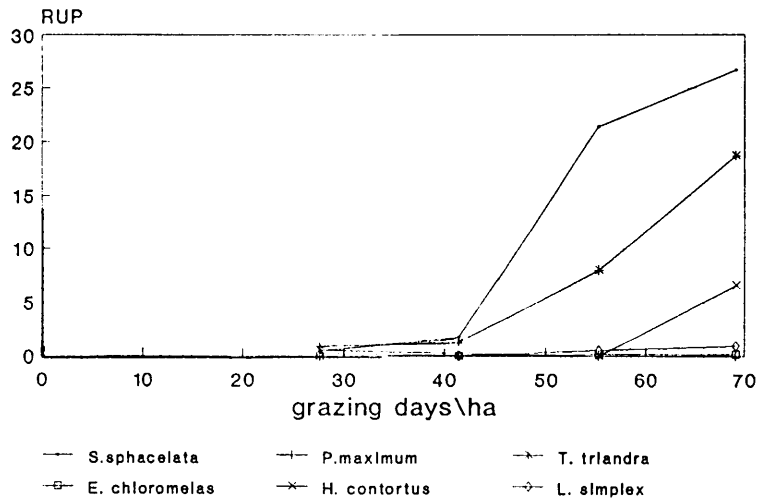


Figure 3.21 The RUP of the 6 most abundant species in Camp A in November 1990

The relative utilisation percentage of the 6 most abundant species encountered in the step-point survey in Camp B in August 1990 are shown in figure 3.22.

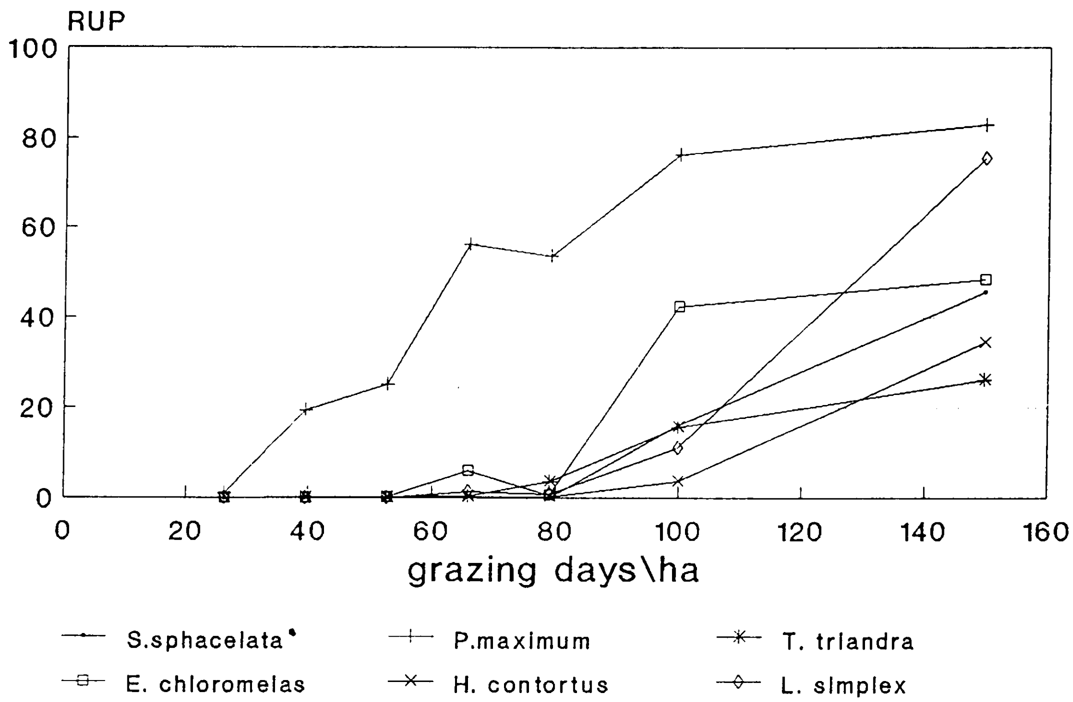


Figure 3.22 The RUP of the 6 most abundant species in Camp B in August 1990

From the above figures it can be seen that *P.maximum*, *S.sphacelata* and *T.triandra* had the highest utilisation at all times when compared to the other species encountered in Camp A. In early summer, (figure 3.18), *S.sphacelata* had the highest utilisation throughout the grazing period followed by *P.maximum* and *T.triandra*. The other species all had a very low utilisation at that time. Initially in late summer, (figure 3.19), *P.maximum* had the highest utilisation but at the end of the grazing period *S.sphacelata* became the most utilised species by a small margin. In late summer *H.contortus* was 51% utilised at the end of the grazing period and *E.chloromelas* was 18% utilised.

In autumn, (figure 3.20), *P.maximum* had the highest RUP at the beginning of the grazing period and this showed that the animals selected first for this species at this time of the year, followed closely by *S.sphacelata* and *T.triandra*. At the end of the grazing period the RUP between these three species showed little difference and this seems to indicate that when the availability of *P.maximum* became limiting the animals then selected for the other preferred species. It is of interest to note that at the end of the grazing period *L.simplex* was 56% utilised and *H.contortus* was 40% utilised.

In the early summer of 1990, (figure 3.21), *S.sphacelata* and *T.triandra* showed little difference in their RUP's at the beginning of the grazing period. At the end of the grazing period *S.sphacelata* was 27% utilised and *T.triandra* was 18% utilised. The low regrowth due to the low rainfall would explain the low RUP's observed.

In winter, (figure 3.22), *P.maximum* had the highest RUP from the beginning of the grazing period to the end and it is clear that the animals selected for this species. Two species of fairly low palatability, *L.simplex* and *E.chloromelas*, had a higher RUP at the end of the grazing period than *S.sphacelata*. *T.triandra* had the lowest RUP of the six species studied. This seems to indicate that *S.sphacelata* and *T.triandra* become much less palatable in the winter.

Based on the results of the relative utilisation scores obtained for the different grass species in the step-point survey the preference rating of the six most abundant species was determined in Camp A (Table 3.4) and Camp B (Table 3.5).

TABLE 3.4 PREFERENCE RATING OF THE 6 MOST ABUNDANT SPECIES IN CAMP A

REFERENCE RATING	EARLY SUMMER (NOVEMBER) BEGINNING OF GRAZING PERIOD	EARLY SUMMER (NOVEMBER) END OF GRAZING PERIOD	LATE SUMMER (FEBRUARY) BEGINNING OF GRAZING PERIOD	LATE SUMMER (FEBRUARY) END OF GRAZING PERIOD	AUTUM (APRIL) BEGINNING OF GRAZING PERIOD	AUTUM (APRIL) END OF GRAZING PERIOD
1	S. sphacelata	S. sphacelata	P. maximum	S. sphacelata	P. maximum	P. maximum
2	P. maximum	P. maximum	S. sphacelata	P. maximum	S. sphacelata	T. triandra
3	T. triandra	T. triandra	H. contortus	T. triandra	T. triandra	S. sphacelata
4	H. contortus	H. contortus	T. triandra	H. contortus	L. simplex	L. simplex
5	E. chloromelas	L. simplex	L. simplex	E. chloromelas	H. contortus	H. contortus
6	L. simplex	E. chloromelas	E. chloromelas	L. simplex	E. chloromelas	E. chloromelas

Brackets indicate where there was little preference shown between species (less than 10% difference in RUP)

TABLE 3.5 PREFERENCE RATING OF THE MOST ABUNDANT SPECIES IN CAMP B

Preference rating	Winter (August)
1	*P.maximum*
2	*L.simplex*
3	*E.chloromelas*
4	*S.sphacelata*
5	*H.contortus*
6	*T.triandra*

3.3.3 Regrazing of the tufts

Regrazing of the marked tufts is shown at different times of the year in Camp A in figures 3.23 to 3.26 and in Camp B in figure 3.27. Regrazing is also shown for the three main species *P.maximum*, *S.sphacelata* and *T.triandra* at different times of the year in figures 3.28 to 3.30.

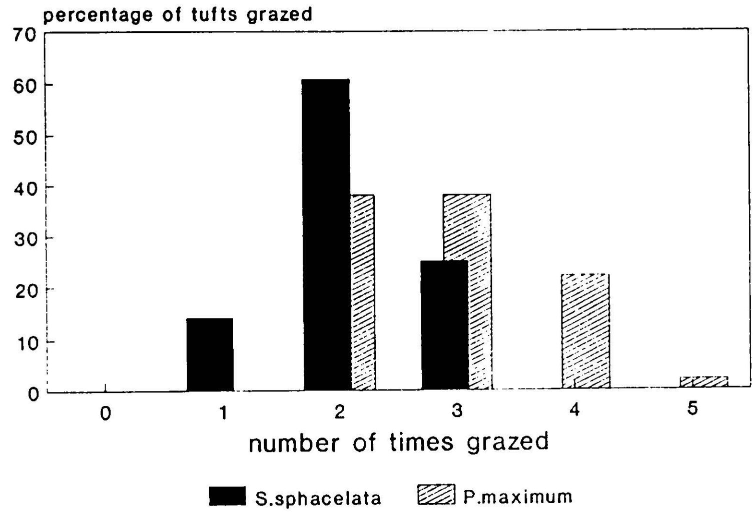


Figure 3.23 Regrazing of marked tufts in November 1989

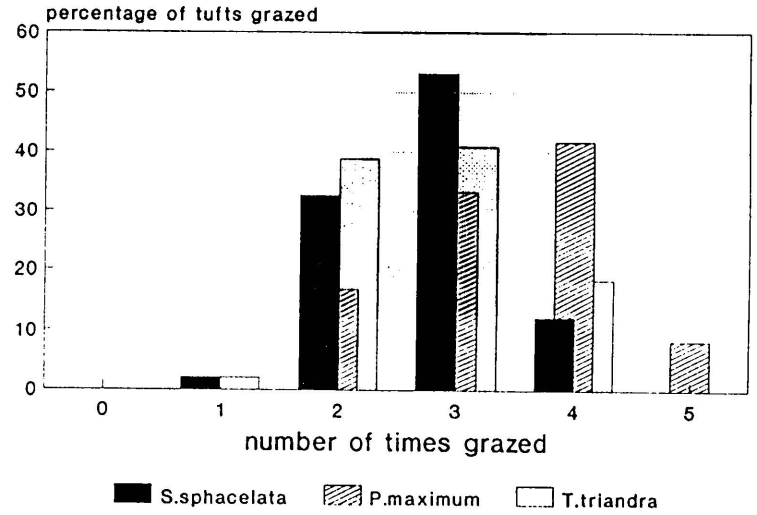


Figure 3.24 Regrazing of marked tufts in February 1990

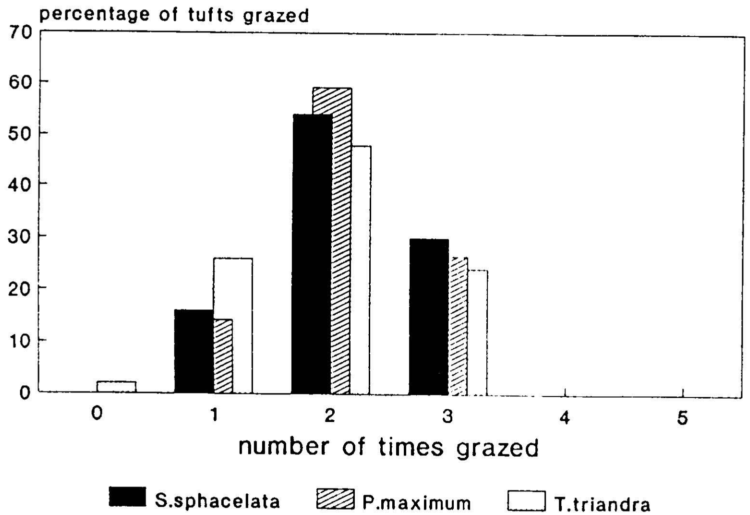


Figure 3.25 Regrazing of marked tufts in April 1990

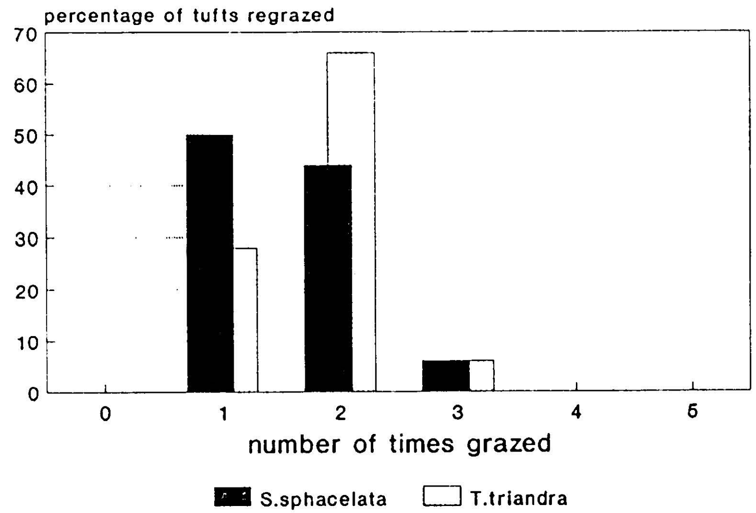


Figure 3.26 Regrazing of marked tufts in November 1990

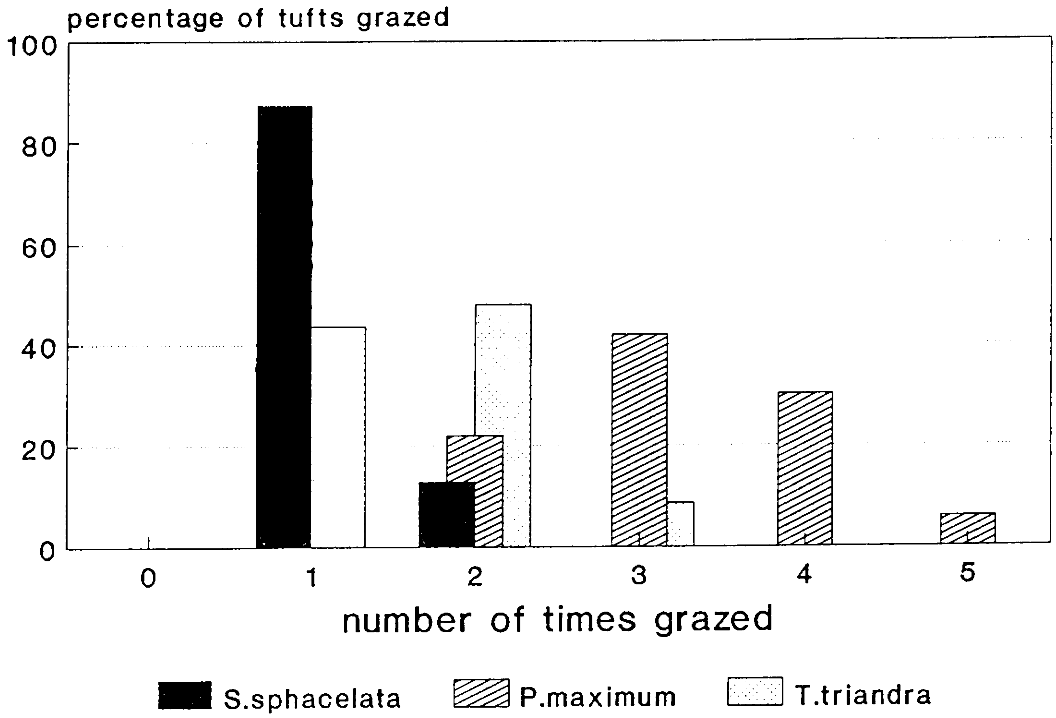


Figure 3.27 Regrazing of marked tufts in Camp B in August 1990

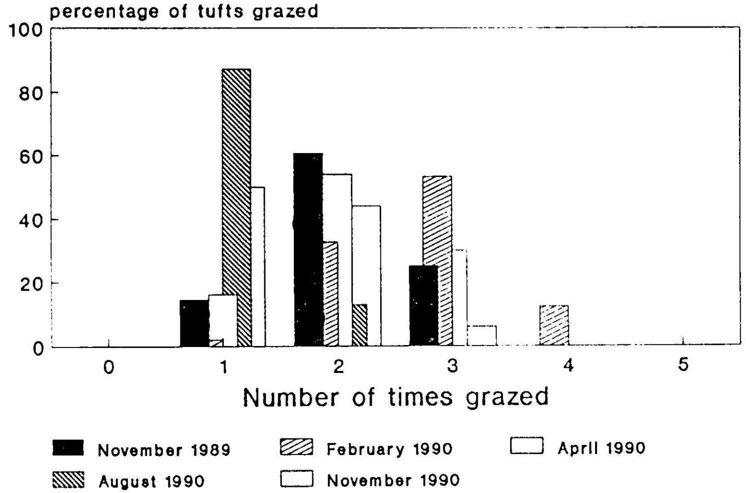


Figure 3.28 Regrazing of S.sphacelata tufts at different times of the year

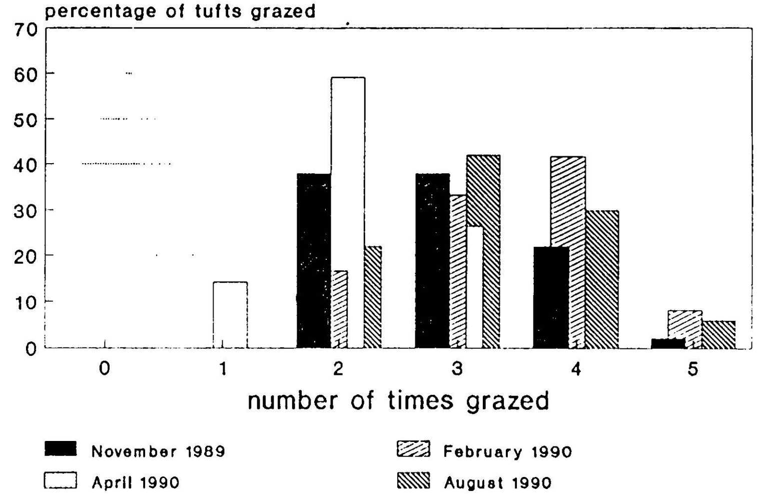


Figure 3.29 Regrazing of P.maximum tufts at different times of the year

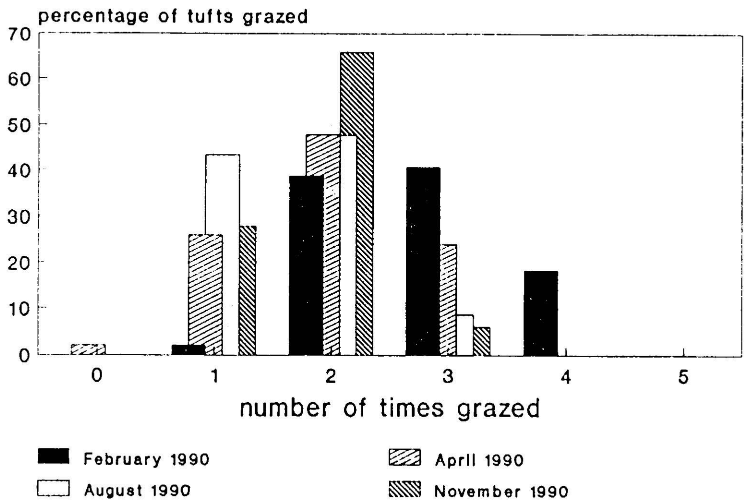


Figure 3.30 Regrazing of T.triandra tufts at different times of the year

In early summer 1989, (figure 3.23), 61% of *S.sphacelata* tufts were grazed twice, whereas 38% of *P.maximum* tufts were grazed three times. Two percent of *P.maximum* tufts were even grazed five times. *P.maximum* tufts were therefore returned to more often by the animals within one grazing period than *S.sphacelata.*

In late summer 1990, (figure 3.24), 54% of *S.sphacelata* tufts were grazed three times whereas 34% of *P.maximum* tufts were grazed three times and 42% were grazed four times. Fifty one percent of *T.triandra* tufts were grazed three times and 39% were grazed two times. *P.maximum* tufts were once again returned to more frequently than the other two species. In late summer all three of the species were returned to at least two or three times. The relative high frequency of regrazing of tufts, particularly of prefered species such as *P.maximum*, suggests that the stocking rate was too high and the period of occupation too long for that stocking rate.

In autumn 1990, (figure 3.25), the tufts of all three species were grazed mainly two times (i.e. they were returned to only once). Three percent of *T.triandra* tufts were ungrazed.

In the late summer 1990, (figure 3.26), 50% of *S.sphacelata* tufts were grazed only once and 44% were grazed twice. Sixty six percent of the *T.triandra* tufts were grazed twice. The reason why most tufts were returned to only once at this time was probably because very little regrowth had taken place and there was very little leaf material available to make it worthwhile for the cattle to return to the tuft more than once. The RUP of these two species at this time was not very high and this was probably because the animals would graze a tuft once or twice but would not remove all the leaf material. If one blade of leaf remained on the tuft it could not be classified as a class 1 tuft and this then affected the RUP that was calculated.

In winter 1990, (figure 3.27), 84% of *S.sphacelata* tufts were grazed only once while 43% of *P.maximum* tufts were grazed three times and 31% were grazed four times. Seven percent of *P.maximum* tufts were even grazed five times. Firty four percent of *T.triandra* tufts were grazed once and 47% were grazed two times. This clearly shows the animals preference for *P.maximum.*

When comparing the regrazing of the tufts for a particular species at different times of the year, (figure 3.28 to 3.30), it can be seen that *S.sphacelata* tufts were grazed only once and not returned to at all in the winter. In early summer and autumn most tufts were grazed twice (i.e. returned to only once). In the late summer tufts were grazed 3 to 4 times. It would seem that *S.sphacelata* is the most acceptable\palatable in early and late summer and least acceptable\palatable in winter. This could be due to the plant translocating its nutrients to the roots in autumn in preparation for winter, thus making the plant less palatable in the winter time.

In autumn most *P.maximum* tufts were grazed twice (i.e. returned to only once). In early summer most tufts were grazed between two and three times but in late summer and in winter most tufts were grazed mainly four times, sometimes up to five times. This seems to suggest that *P.maximum* retains its nutrients throughout the year and is especially acceptable\palatable in winter.

The *T.triandra* tufts were grazed only once or twice in winter and even species such as *L.simplex* and *H.contortus* had a higher RUP in the winter than *T.triandra*. In early summer the tufts were also grazed only once or twice, whereas in late summer they were grazed three to four times.This seems to indicate that in winter and early summer *T.triandra* is not very acceptable\palatable and only becomes palatable in the late summer. This can also be due to the translocation of nutrients back into the root system for the winter and it would seem that the translocation back into the leaves is not complete until late summer. Sourveld grasses don't retain their nutrients throughout the winter while sweetveld grasses do. From the above results it would seem that in the Sourish, Mixed Bushveld *S.sphacelata* and *T.triandra* tend more towards being sourveld grasses and *P.maximum* tends more towards being a sweetveld grass.

3.3.4 Regrazing of the tillers

Regrazing of the tillers is shown at different times of the year in Camp A, (figures 3.31 to 3.34) and in Camp B, (figure 3.35). Regrazing of the tillers is also shown for the three main species in figures 3.36 to 3.38.

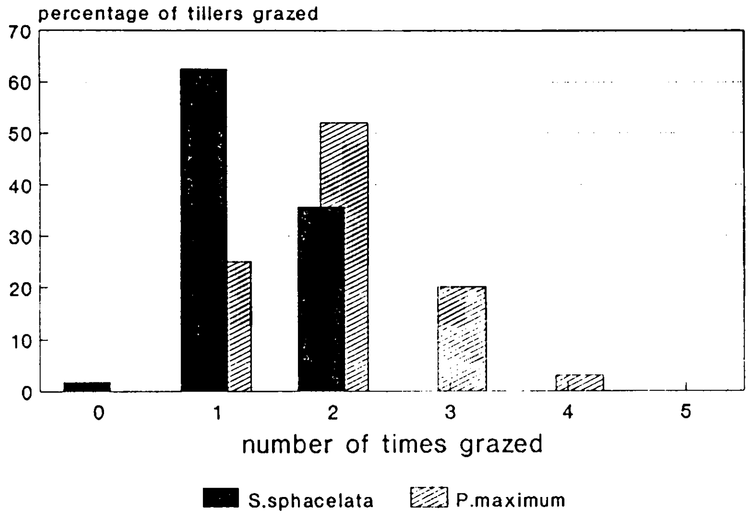


Figure 3.31 Regrazing of marked tillers in Camp A in November 1989

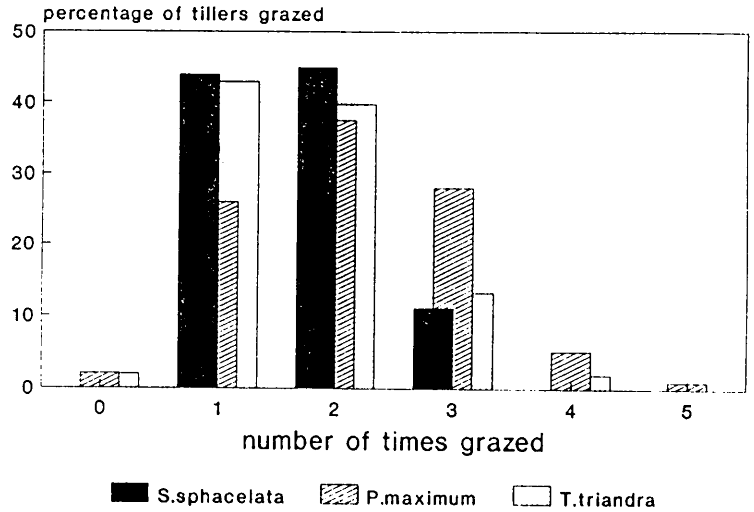


Figure 3.32 Regrazing of marked tillers in Camp A in February 1990

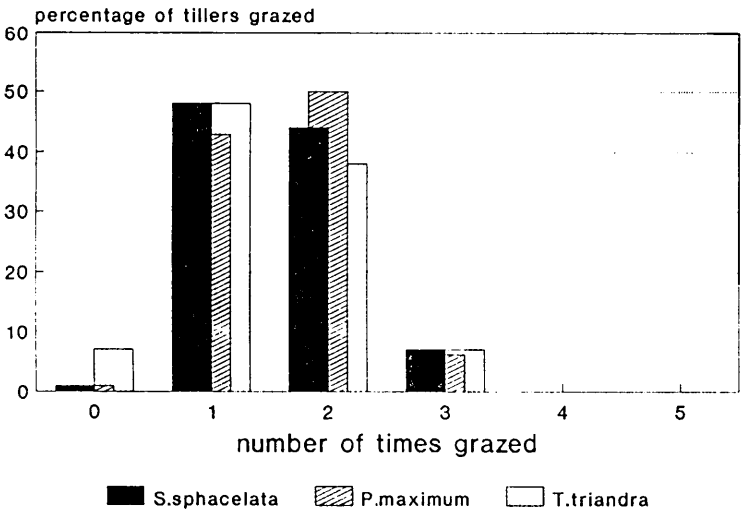


Figure 3.33 Regrazing of marked tillers in Camp A in April 1990

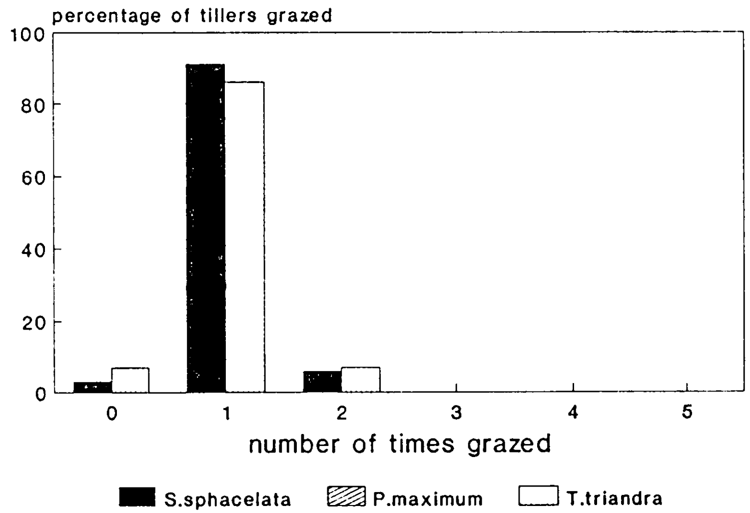


Figure 3.34 Regrazing of marked tillers in Camp A in November 1990

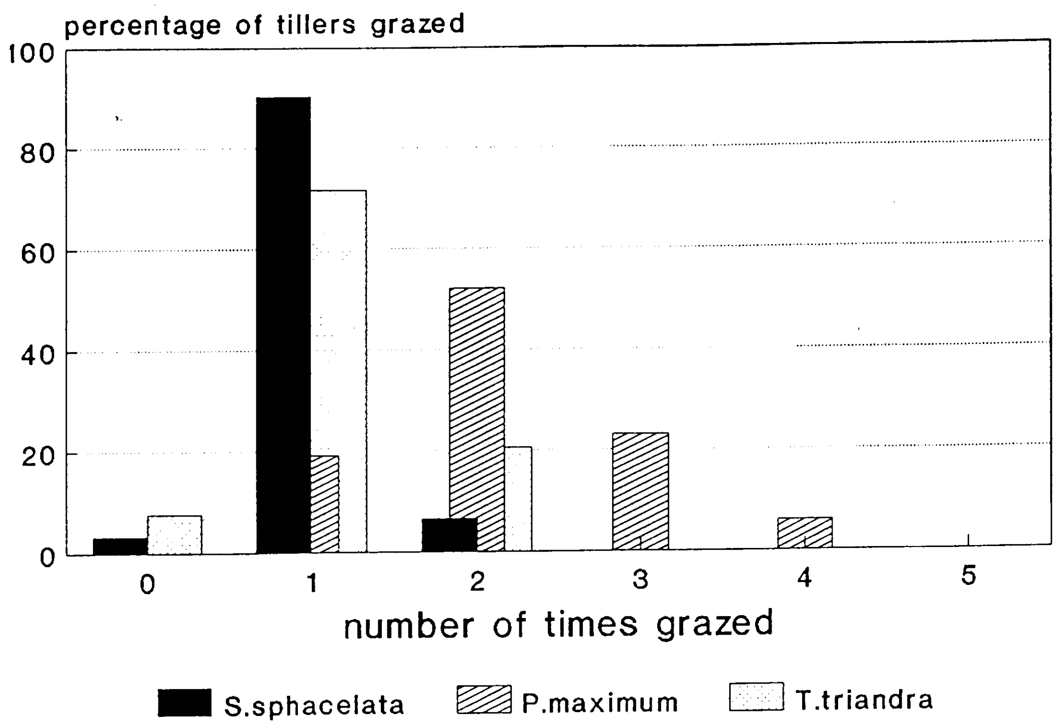


Figure 3.35 Regrazing of marked tillers in Camp B in August 1990

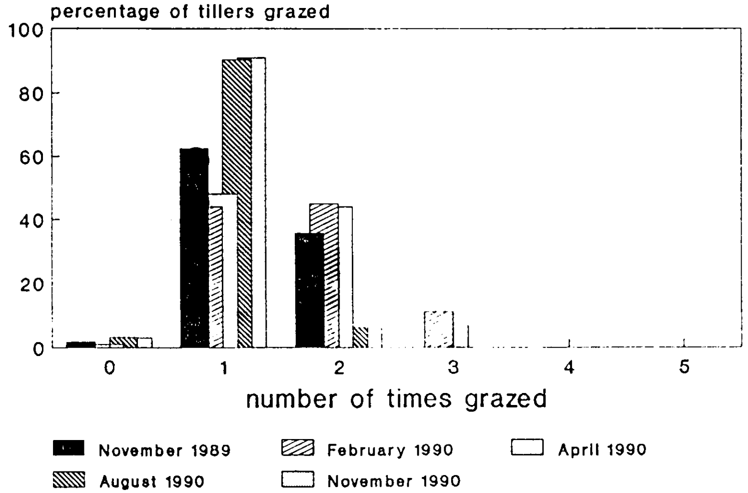


Figure 3.36 Regrazing of S.sphacelata tillers at different times of the year in Camp A

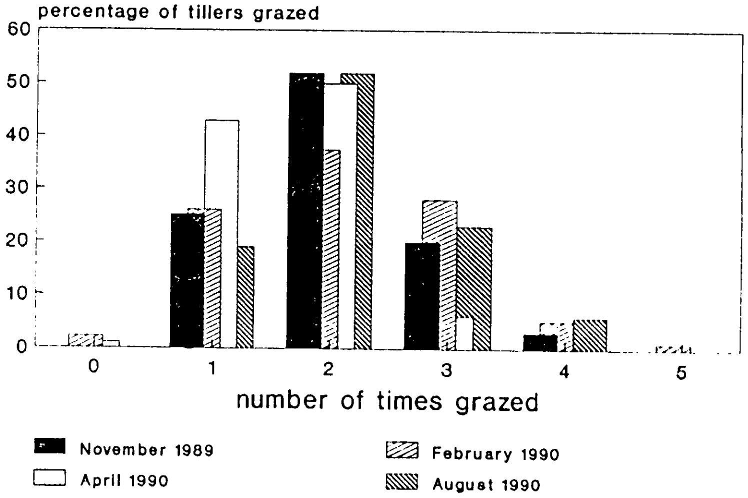


Figure 3.37 Regrazing of P.maximum tillers at different times of the year in Camp A

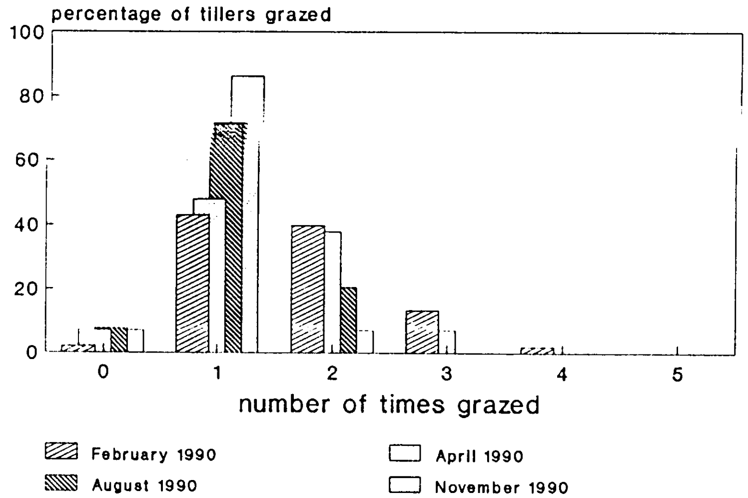


Figure 3.38 Regrazing of T.triandra tillers at different times of the year in Camp A

From the above figures it can be seen that in early summer the majority of *S.sphacelata* and *T.triandra* tillers were grazed only once whereas most of the *P.maximum* tillers were grazed at least twice. Some of the *P.maximum* tillers were grazed up to four times. In late summer the majority of *S.sphacelata* and *T.triandra* tillers were grazed once or twice and the majority of *P.maximum* tillers two or three times. In autumn the tillers of all three species were grazed mainly only once or twice. In winter most *S.sphacelata* and *T.triandra* tillers were grazed only once while most *P.maximum* tillers were grazed two or three times.

When comparing the regrazing of tillers of a particular species at different times of the year, (figures 3.36 to 3.38), it can be seen that *S.sphacelata* tillers are grazed only once mainly in winter and early summer. In autumn the tillers were grazed mainly twice and in late summer mainly two or three times. This is in accordance with the regrazing of the tufts data. In autumn *P.maximum* tillers were grazed mainly once or twice and in early summer mainly two times. In winter and late summer the tillers were grazed up to three and four times. The *T.triandra* tillers were grazed mainly once in all the seasons but in autumn they were grazed up to two times and in late summer some were grazed two to three times.

This data corroborates that which was found when measuring the regrazing of the tufts and which was discussed in the previous section.

3.3.5 Mean leaf height

The mean leaf heights of the marked tufts in Camp A are shown in figures 3.39 to 3.42 and in Camp B in figure 3.43. The mean leaf heights of the 6 most abundant species encountered in the step-point survey in Camp A are shown in figures 3.44 to 3.47 and in Camp B in figure 3.48.

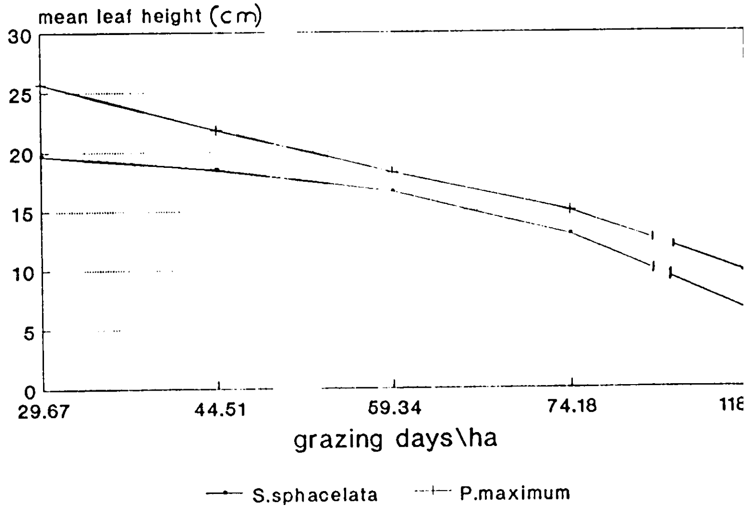


Figure 3.39 Mean leaf heights of the marked tufts in November 1989 in Camp A

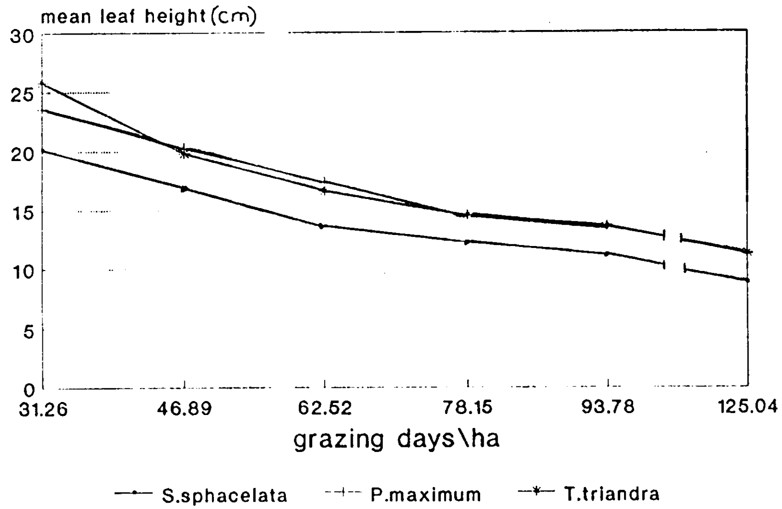


Figure 3.40 Mean leaf heights of the marked tufts in February 1990 in Camp A

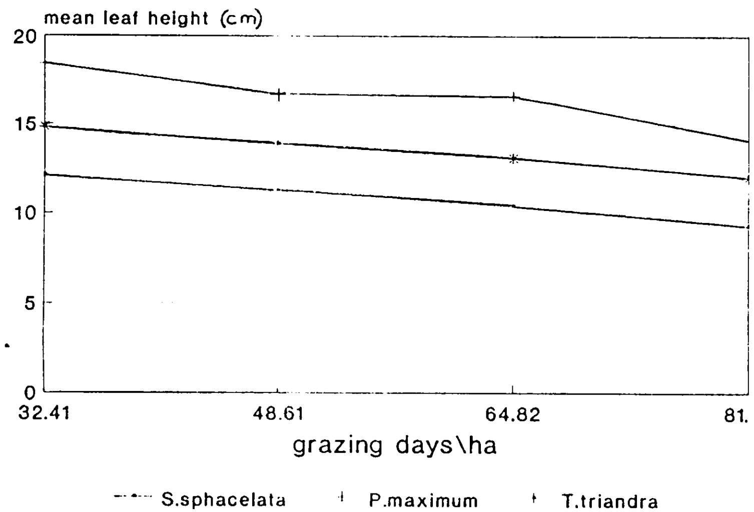


Figure 3.41 Mean leaf heights of the marked tufts in April 1990 in Camp A

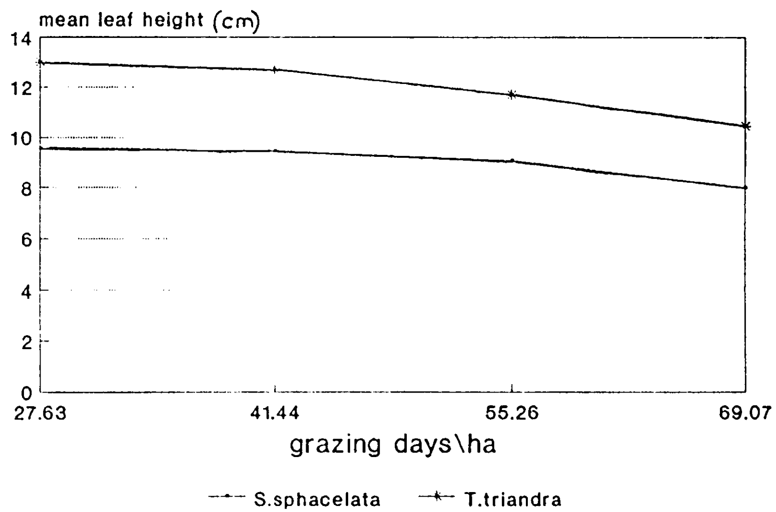


Figure 3.42 Mean leaf heights of the marked tufts in November 1990 in Camp A

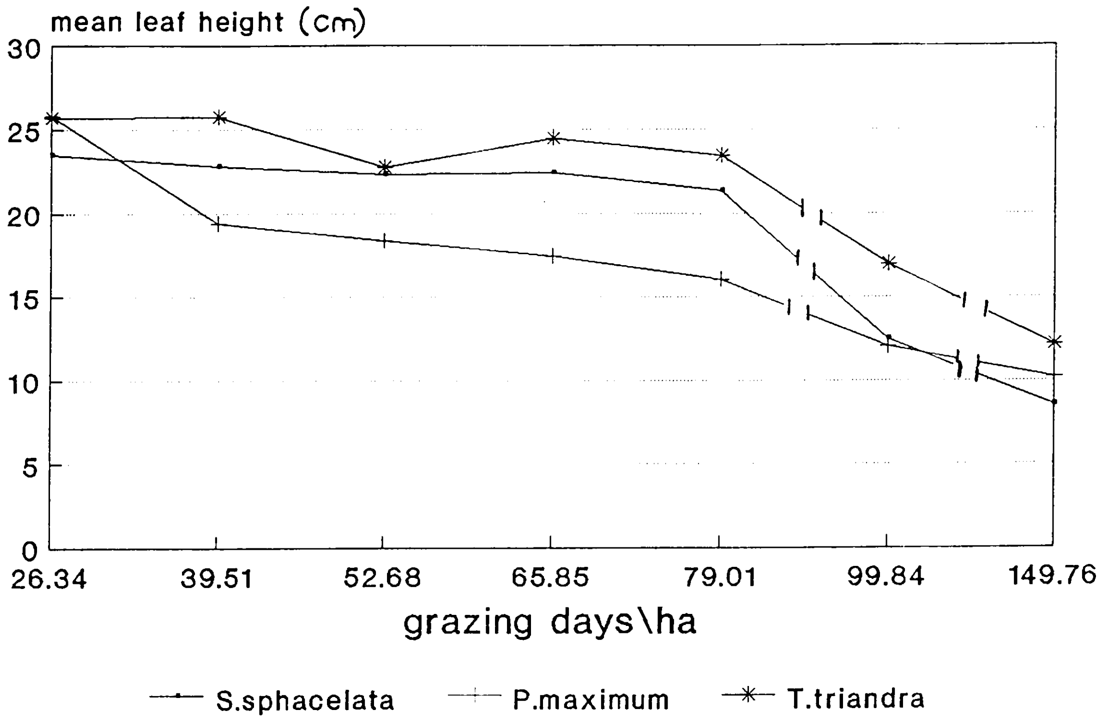


Figure 3.43 Mean leaf heights of the marked tufts in Camp B in August 1990

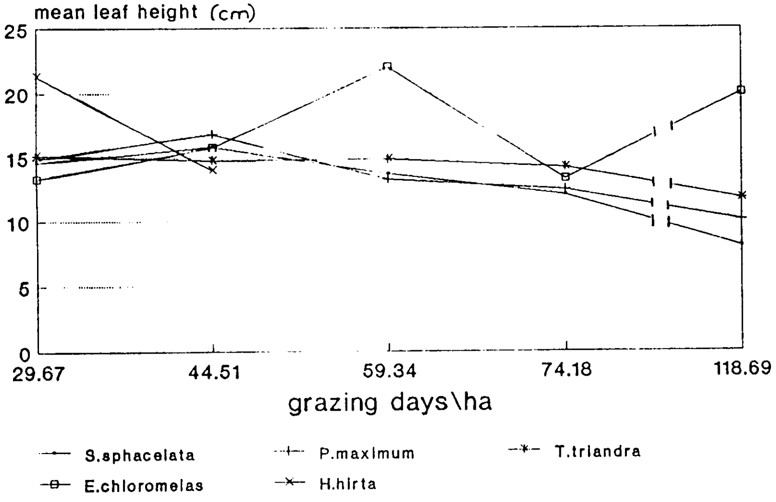


Figure 3.44 Mean leaf heights of the most abundant species in Camp A in November 1989

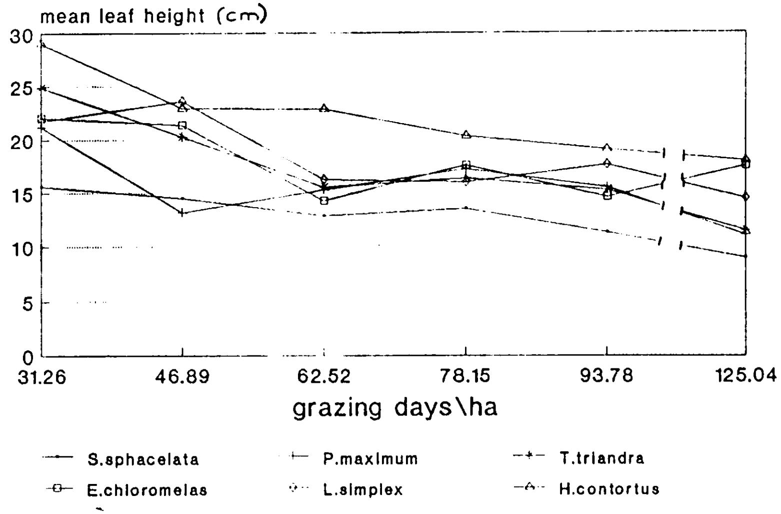


Figure 3.45 Mean leaf heights of the most abundant species in Camp A in February 1990

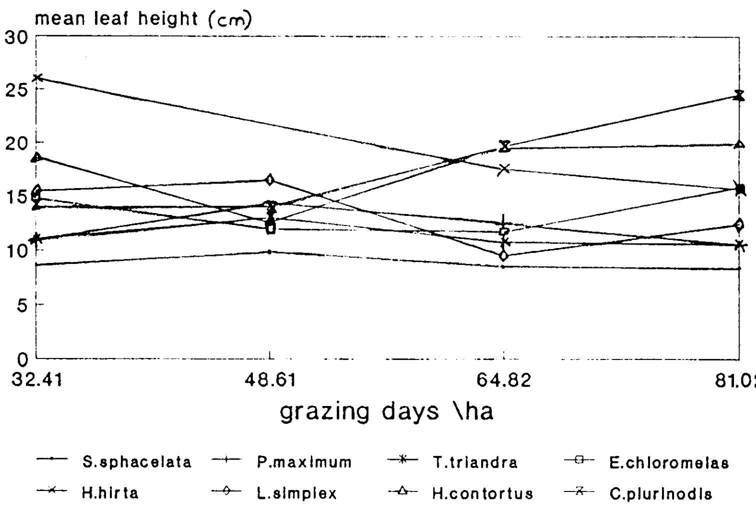


Figure 3.46 Mean leaf heights of the most abundant species in Camp A in April 1990

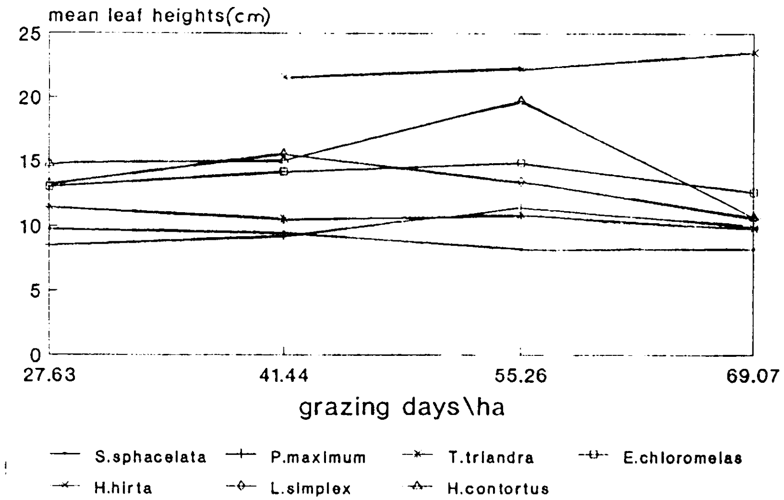


Figure 3.47 Mean leaf heights of the most abundant species in Camp A in November 1990

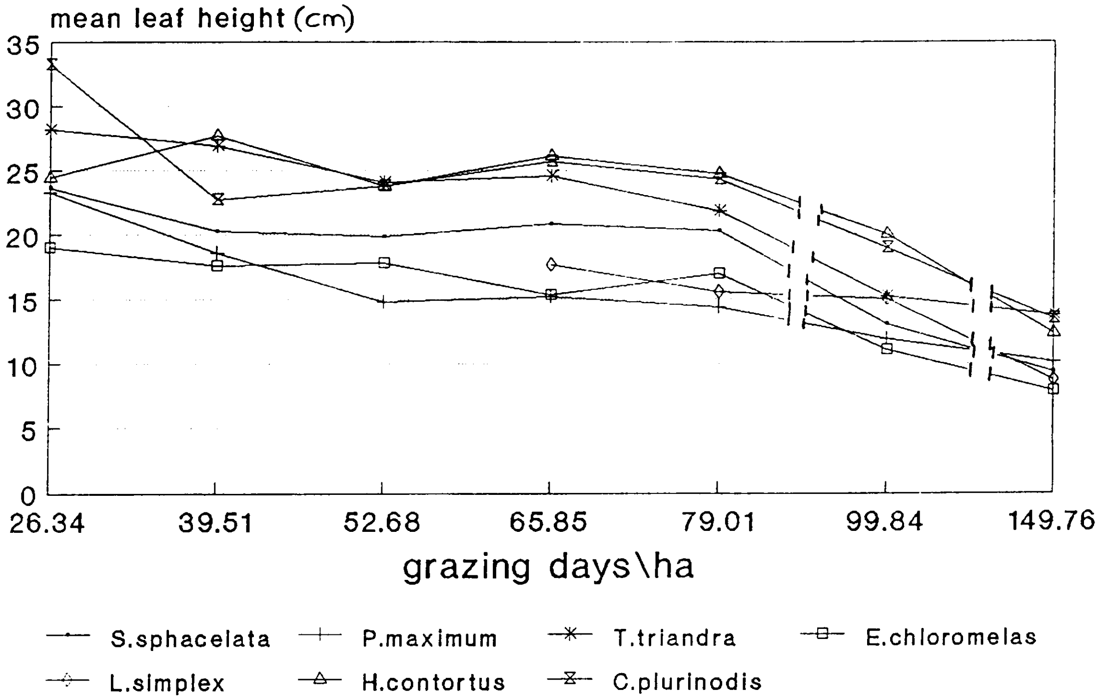


Figure 3.48 Mean leaf heights of the most abundant species in Camp B in August 1990

When looking at the marked tuft data, (figures 3.39 to 3.43), it can be seen that in early summer *P.maximum* had a greater mean leaf height than *S.sphacelata.* In late summer the mean leaf heights of *P.maximum* and *T.triandra* were similar and they both had a greater mean leaf height than *S.sphacelata.* In autumn *P.maximum* again had the greatest mean leaf height followed by *T.triandra* and *S.sphacelata.* It seems therefore that *P.maximum* has the greatest mean leaf height throughout the year in Camp A and *S.sphacelata* the shortest. The animals select mainly for *P.maximum,* but they also select for the other species at different times of the year and it seems that mean leaf height does influence their selection of a particular species but that selection is also more determined by the time of year. Danckwerts *et al.* (1983), found species preference to be positively related to leaf height. In Camp B, at the beginning of the grazing period, *P.maximum* and *T.triandra* have more or less the same mean leaf height and it is greater than the mean leaf height of *S.sphacelata.* The mean leaf height of *P.maximum* then drops to below that of both *T.triandra* and *S.sphacelata* due to the fact that *P.maximum* was so heavily utilised at this time of the year and the other two species were relatively unutilised until the stocking density was increased.

TABLE 3.6 REGROWTH OF THE SPECIES BETWEEN THE SEASONS

	Nov 89 - Feb 90	Feb 90 - Apr 90	Apr 90 - Nov 90
P.maximum	13.5 cm	7.0 cm	0.0 cm
S.sphacelata	13.0 cm	3.5 cm	0.7 cm
T.triandra	(was not recorded in Nov 89)	3.8 cm	1.0 cm

Table 3.6 shows the regrowth of the three main species between the seasons and it can be seen that *P.maximum* is the species with the greatest regrowth - 20.5 cm. This is measured in terms of height and not necessarily mass. This figure would have been even greater if there had been any regrowth between April and November 1990. *P.maximum* seems to be sensitive to overgrazing, particularly at times of drought stress, because whereas *S.sphacelata* and *T.triandra* recovered to some degree from the April grazing *P.maximum* did not recover at all. Donaldson & Rootman (1983) also found that *P.maximum* was sensitive to grazing. These values can only be used to indicate broad trends of regrowth due to the fact that there was so little rainfall.

When looking at the data obtained from the step-point survey, (figures 3.43 to 3.47), it can be seen that not much can be deduced from this data as the mean leaf table heights increase and decrease daily because the same tufts were not returned to every day. The only information that can be obtained from this is that *H.hirta*, *E.chloromelas*, *H.contortus* and *P.maximum* are the tall grass species; *L.simplex* and *T.triandra* are the medium sized species and *S.sphacelata* is the short grass species.

3.4 Discussion

Species preference doesn't necessarily reflect potential contribution to diet. Species which contribute little to diet might be highly preferred due to taste or some other related factor. De Beer *et al.* (1990) found that availability of plant material is the simgle most important factor affecting the utilisation of species (i.e. species with the greatest contribution to species composition are utilised the most). This would not seem to be the case in the Sourish, Mixed Bushveld as in Camp A *S.sphacelata* makes up 47% of the total species composition and *P.maximum* only 19% but *P.maximum* is utilised to a much greater degree than *S.sphacelata.*

The utilisation of marked tufts and random tufts differs for *S.sphacelata* and *T.triandra* at the beginning of the period of occupation in late summer (February) and autumn (April) but both the marked and the random tuft data shows that *P.maximum* was the most utilised species at the beginning of the period of occupation in all seasons except early summer (November), where the utilisation of *S.sphacelata* and *P.maximum* did not differ at the beginning of the grazing period. The general preference for *T.triandra* by cattle has varied between geographical locations and is partly associated with the composition of the community (O'Connor, 1992).

At the end of the period of occupation both the utilisation of the marked tufts and the random tufts show that *S.sphacelata* is the most utilised species in early summer (November) and late summer (February) and that *P.maximum* is the most utilised species in autum (April) and winter (August). This, therefore, shows that preference does change with a decline in overall availability of feed and also that preference does change at different times of the year. This would be better illustrated if more species made up a greater proportion of the total species composition of the study site and if more species, especially some Increaser I and II species, could have been marked and studied.

The regrazing of tufts and tillers data coroborates the utilisation data in that it can be seen that in all seasons *P.maximum* tufts and tillers are returned to many more times than *S.sphacelata* and *T.triandra* tufts and tillers. This could also be due to the fact that *P.maximum* tufts are larger and produce more leaf material.

The results imply that animals exhibit differential preference for species throughout periods of occupation. The question is at what points during periods of occupation should species be ranked for preference by cattle? Since animals graze preferred species first, ranking should be made before the animals are forced to utilise unpalatable plants due to insufficient availability of herbage. On the basis of proposals by Danckwerts (1981), the point in time where forage availability deviates from linearity is a logical point for ranking species. Before this point available forage is wasted and after this point animals may be forced to graze less palatable species. As was shown in Section 3.3.1 the point in time where forage availability deviates from linearity was not reached in this study and species were ranked at the beginning and at the end of the period of occupation.

In both Camps A and B *P.maximum* has the greatest mean leaf height throughout the year and *S.sphacelata* the shortest. Both species are selected for at different times of the year and it would seem that although mean leaf height does influence the preference for a particular species to a certain degree, selection is more determined by time of year (i.e the physiological stage of growth that the plant is in). The "critical" height below which animals avoid grazing plants is not absolute, but will depend on the mean height of all the grasses in the sward.

CHAPTER 4

FORAGE PRODUCTION AND UTILISATION

4.1 Introduction

Animal production off veld involves the use of the existing vegetation to its fullest potential, while maintaining the vigour of the veld grasses. Moreover, this must be achieved within the typically erratic rainfall patterns in areas of low rainfall and within the particular complex ecosystems pertaining to veld. Trees and bush components compete with grasses for water, nutrients and light and will therefore, affect forage production by grasses.

According to Tainton (1981) the grass component of the Sourish, Mixed Bushveld is of relatively little grazing value. The proportion of useful grasses has declined and the grassveld is now largely dominated by unpalatable or intermediate species like *Elionurus muticus*, *Loudetia simplex*, *Eragrostis curvula*, *Aristida canescens* and *Cymbopogon plurinodis*. Species like *Diheteropogon amplectens*, *Brachiaria nigropedata* and *Themeda triandra* form the more useful component of this sward as does *Panicum maximum* where it occurs under the trees. Mixed veld includes sweet and sour components and can therefore be regarded as an intermediate between the two. The relationship between sweet and sour (i.e. how much of each) as determined by the environmental conditions has an effect on the forage quality of the veld and on the period that the veld remains palatable. The Sourish, Mixed Bushveld tends more towards the sourveld side and therefore has sourveld characteristics such as possessing an inherent protective mechanism of low palatability in the mature growth stage (Roberts, 1981). Generally the sourveld is in better condition and shows less signs of erosion and deterioration than the sweetveld. This is no doubt due to its dense cover, and its rapid maturity and consequent unpalatability (Edwards, 1981).

The performance of ruminants is determined by the animal itself on the one hand and by the properties of the feed on the other (Bransby, 1981). The animal factors which influence performance are directly related to the efficiency of utilisation of absorbed nutrients by the body. These are in turn determined by characteristics such as breed, sex and physiological condition, inherent ability and by external environmental factors such as climate (Bransby, 1981). While it is accepted that animal production is a function of both dietary quality and intake (Ulyatt, 1973), the former variable is likely to be of particular importance in sourveld where dietary quality frequently falls below animal maintenance requirements (O'Reagain and Mentis, 1988).

According to Bransby *et al* (1977) the true forage value of a species is determined by the amount of grazeable material produced relative to the area it occupies. To insure a better understanding of the interactions of plants and animals in grazing trials, it is necessary to have some measure of the production, availability and consumption of forage. The factors are closely related to stocking rate and have a significant influence on the conversion of pasture to animal product (Bransby *et al*, 1977).

4.2 Procedure

At the beginning of each period of occupation fifty randomly selected tufts of *P.maximum*, *S.sphacelata* and *T.triandra* were clipped at soil level after their basal circumference had been measured by using a piece of string which was then measured off on a ruler. All leaf and stem material was included in the measurement. The material was then dried and weighed to a constant mass and yield was expressed as $gDMcm^{-2}$. The same procedure was repeated at the end of each period of occupation. The difference between the before and after readings was taken to indicate the amount of forage utilised per basal area (i.e. the forage availability and utilisation of each of the three species). This is, however, only a rough measurement of forage availiabilty as the material was not sorted to distinguish between dead and green material or between leaf and stem material.

A 2-way ANOVA was performed on the data from Camp A to determine if the main effects of grass species and times of year were statistically significant. A 1-way ANOVA was performed on the data from Camp B to determine if the main effect of grass species was statistically significant.

4.3 Results

4.3.1 Forage yield

Analysis of variance was conducted on tuft yields per unit basal area in each camp. Table 4.1 shows that in Camp A there was a significant interaction between the yield of *T.triandra* and the other two species and a significant interaction between the yield of *T.triandra* in late and early summer. There was no significant interaction between the yields of *S.sphacelata* and *P.maximum* at different times of the year and the yields before and after grazing. Only *T.triandra* shows significant differences in yields at different times of the year and yields before and after grazing.

TABLE 4.1 HERBAGE YIELDS (gDMcm^{-2}) OF THE THREE SPECIES CLIPPED BEFORE AND AFTER EACH PERIOD OF OCCUPATION, AND THE DIFFERENCE BETWEEN THE YIELDS RECORDED BEFORE AND AFTER GRAZING (B - A) IN CAMP A

Species	Season	Before grazing	After grazing	B - A
S.sphacelata	early summer	0.153	0.218	-0.065 NS
	late summer	0.111	0.055	0.056 NS
	autumn	0.058	0.038	0.020 NS
	early summer	0.053	0.058	-0.005 NS
P.maximum	early summer	0.187	0.127	0.060 NS
	late summer	0.159	0.047	0.112 NS
	autumn	0.149	0.064	0.085 NS
	early summer	-	-	-
T.triandra	early summer	-	-	-
	late summer	0.251	0.050	0.201 *
	autumn	0.232	0.213	0.019 NS
	early summer	0.181	0.066	0.115 **

* ($P < 0.05$)

** ($P < 0.01$)

NS (difference not statistically significant)

The above results indicate that in Camp A, a significant amount of forage was removed from *T.triandra* tufts in late and early summer. Significant amounts of forage were not grazed on *P.maximum* or *S.sphacelata* tufts at any time of the year. These poor results must be attributed to poor sampling and handling procedures because visually it was estimated that significant amounts of forage disappeared during periods of occupation. All three species showed low yields and larger samples of utilised tufts would have been needed to show significant differences.

In Camp B there was a significant difference between the yield of *T.triandra* and the other two species. There was no significant difference between the yields of *S.sphacelata* and *P.maximum* (Table 4.2).

TABLE 4.2 HERBAGE YIELDS ($gDMcm^{-2}$) OF THE THREE SPECIES CLIPPED BEFORE AND AFTER EACH PERIOD OF OCCUPATION, AND THE DIFFERENCES BETWEEN YIELDS RECORDED BEFORE AND AFTER GRAZING (B - A) IN CAMP B

Species	Season	Before grazing	After grazing	B - A
S.sphacelata	winter	0.173	0.058	0.115 NS
P.maximum	winter	0.187	0.120	0.067 NS
T.triandra	winter	0.494	0.193	0.301 **

* (P < 0.05)

** (P (0.01)

NS (difference not statistically significant)

4.4 Discussion

It has been indicated, (Danckwerts *et al.* 1985), that ranking of species according to potential importance should be a function of the preference exhibited by animals for each species and their productivity per unit basal area. The difference between forage yield per unit basal area of a species before and after grazing (amount eaten) is one means by which such ranking can be made, providing animals are forced to utilise swards until insufficient availability severely restricts intake per head, and provided that regrowth during grazing periods is negligible relative to amount eaten. Under such circumstances, the amount eaten is a function of both acceptability and availability per unit basal area. This is because animals in the veld type under consideration continue to graze selectively even when grazing pressures are high (indicated earlier in this study) and restricted intake per head at the end of each period of occupation would ensure that the amount eaten is not merely a reflection of chance encounters between animals and plants (Danckwerts *et al.* 1985).

Danckwerts *et al.* 1985 calculated indices for ranking species according to their potential importance at the experimental sites from the difference in forage yield before and after grazing (B-A in Tables 4.1 and 4.2). They did this by assigning a value of 100 to the largest amount eaten per species per unit basal area during a period of occupation, and expressing remaining amounts eaten during the period as percentages of largest amount eaten. Expressing this index as a percentage of the most important species during each period of occupation allows relative comparisons between grazing periods to be made.

Importance indices would be meaningless if animals were removed before sufficient availability restricted intake per head. It would appear that in this study the animals were removed too early and availability never restricted intake per head. This was due to problems with farm management that could not be overcome. Ranking of species into order of importance could therefore, not be done. It is suggested that larger samples of species should have been taken and that such a study is conducted in the near future.

CHAPTER 5

CONCLUSIONS

1. Cattle exhibit preference for different herbaceous species in the Sourish, Mixed Bushveld; *P.maximum* being the most preferred species with *T.triandra* and *S.sphacelata* also being selected for at different times of the year.

2. The degree of preference does change with time of year but for *P.maximum* and *S.sphacelata* these changes are not large. There is however, a marked decline in preference for *T.triandra* in winter and also a marked increase in preference for species such as *L.simplex* and *E.chloromelas*, which are usually classed as unpalatable, at this time of year.

3. Animals continue to graze selectively even when the grazing pressure is high, the range of selection just shifts to less palatable species as availability of more palatable species declines. This is contrary to Emlems' (1966) belief that animals graze less selectively as herbage availability diminishes.

4. Cattle may exhibit preference for the taller species in a particular sward, such as *P.maximum* provided those species have no physical or chemical deterrents to grazing. Species selection, however, seems to be more determined by the time of year.

5. A significant amount of forage was removed only from *T.triandra* tufts in early and late summer and in winter. Significant amounts of forage were not removed from *P.maximum* or from *S.sphacelata* tufts. Importance indices could not be calculated for the three species due to this and ranking of species into order of importance could therefore not be achieved.

SUMMARY

Species preference by cattle and forage production

in the Sourish, Mixed Bushveld

by

YVETA STROLENY FORD

Supervisor: Prof. G.J. Bredenkamp

Co-supervisor: Prof. N.F.G. Rethman

DEPARTMENT OF BOTANY

UNIVERSITY OF PRETORIA

MAGISTER SCIENTIAE

The objectives of this study were to determine which grass species are preferred by cattle in this veld type, whether this preference changes at different times of the year, whether the preference for species changes with a decline in the overall availability of feed and to determine the forage production and utilisation of the most abundant grass species in this veld type.

Preference was determined for species at different times of the year and it was found that *P.maximum* was the most preferred species followed by *T.triandra* and *S.sphacelata*. The preference for *P.maximum* did not change significantly at different times of the year. The

preference for *S.sphacelata* and especially for *T.triandra* decreased significantly in the winter.

The preference for species was found to change with a decline in the overall availability of feed, especially in winter where *P.maximum* was selected for to the exclusion of other species until the stocking rate was increased and the amount of *P.maximum* became limited.

A significant amount of forage was removed only from *T.triandra* tufts and not from *P.maximum* and *S.sphacelata* tufts. Importance indicies could therefore, not be calculated for the three species and ranking of species into order of importance could not be done.

OPSOMMING

Spesies voorkeur deur beeste en voer produksie

in die Suuragtige-Gemengde Bosveld

deur

YVETA STROLENY FORD

Studieleier: Prof. G.J. Bredenkamp

Medeleier: Prof. N.F.G. Rethman

DEPARTEMENT PLANTKUNDE

UNIVERSITEIT VAN PRETORIA

MAGISTER SCIENTIAE

Die doelstellings van hierdie studie was om vas te stel watter gras spesies deur beeste in hierdie veldtipe verkies word, of die voorkeur vir spesies tydens verskillende tye van die jaar verander en of die voorkeur vir spesies verander met 'n afname in totale beskikbaarheid van voer. Verder is daar gepoog om voerproduksie en benutting van die mees algemene gras spesies in hierdie veldtipe te bepaal.

Voorkeure is bepaal vir spesies gedurende die jaar en daar is gevind dat *P.maximum* die spesie met die grootste voorkeur was gevolg deur *T.triandra* en *S.sphacelata.* Die voorkeur vir *P.maximum* het nie betekinisvol verander gedurende die jaar nie maar die voorkeur vir

S.sphacelata en veral vir *T.triandra* het betekenisvol afgeneem in die winter.

Die voorkeur vir spesies het verander met 'n afname van beskikbare voer. *P.maximum* is, veral in die winter, verkies bo ander spesies totdat die veebelading verhoog is en die beskikbaarheid van *P.maximum* beperkend was.

'n Betekenisvolle hoeveelheid voer is verwyder van die *T.triandra* polle maar nie van *P.maximum* en *S.sphacelata* nie. Belangriksheidsindekse kon dus nie vir die drie spesies bepaal word nie. 'n Rangorder volgens belangrikheid van die spesies kon ook nie gedoen word nie.

REFERENCES

ACOCKS,J.P.H. 1966. Non-selective grazing as a means of veld reclamation. *Proc. Grassl. Soc. Sth. Afr.* 1: 33-40.

ACOCKS,J.P.H. 1988. Veld types of South Africa (3rd edition) *Mem. Bot. Surv. S. Afr.* 57.

AUCAMP, A.J. 1990. Bos in die bosveld: Bate of hindernis vir vleis produksie. *Agricola* 8: 11-17.

BARNES,D.L. 1972. Defoliation effects on perennial grasses - continuing confusion. *Proc. Grassl. Soc. Sth. Afr.* 7: 138-145.

BARNES,D.L. 1976. A review of plant-based methods of determining the diet and food preferences of grazing and browsing animals. *Proc. Grassl. Soc. Sth. Afr.* 11: 65-72.

BARNES,D.L. 1982. Management strategies for the utilisation of southern African savanna. In: Ecology of tropical savannas. Ecological studies 42. Ed: B.J.Huntley & B.H.Walker. Springer-Verlag, Berlin Heidelberg. pp 626-656.

BARNES,D.L.,RETHMAN, N.F.G., BEUKES, B.H. & KOTZE, G.D. 1984. Veld composition in relation to grazing capacity. *J. Grassl. Soc. South Afr.* 1(1): 16-19.

BOOYSEN,P.de V. 1966. A physiological approach to research in pasture utilisation. *Proc. Grassl. Soc. Sth. Afr.* 1: 77-85.

BOOYSEN,P.de V. 1969. An analysis of the fundamentals of grazing management systems. *Proc. Grassl. Soc. Sth. Afr.* 4: 84-91.

BOSCH,O.J.H. & VAN WYK,J.J.P. 1970. Die invloed van bosveldbome op die produktiwiteit van *Panicum maximum*: 'n Voorlopige verslag. *Proc. Grassl. Soc. Sth. Afr.* 5: 69 - 74.

BRANSBY,D.I. 1980. Herbage height as a determinant of the preference of steers grazing three pasture species. *Proc. Grassl. Soc. Sth. Afr.* 15: 153 - 156.

BRANSBY,D.I. 1981. The value of veld and pasture as animal feed. In: Veld and pasture management in South Africa. Ed: N.M.Tainton. Pietermaritzburg, Shuter & Shooter and University of Natal Press.

BRANSBY,D.I., BOOYSEN,P.DE V. & TAINTON,N.M. 1977. The evaluation of pastures and grazing management in terms of livestock production. *Proc. Grassl Soc. Sth. Afr.* 12: 77 - 82.

DAINES,T. 1980. The use of grazing patterns in the management of Döhne Sourveld. *Proc. Grassl. Soc. Sth. Afr.* 15: 185 - 188.

DANCKWERTS,J.E. 1981. The rate of herbage disappearance during periods of occupation in rotational grazing systems. *Proc. Grassl. Soc. Sth. Afr.* 16: 129 - 134.

DANCKWERTS,J.E. 1984. Towards improved livestock production off sweet grassveld. Phd thesis. University of Natal.

DANCKWERTS,J.E. 1989. The quality of herbage ingested by cattle in rotationally grazed semi-arid grassveld of the eastern Cape. *J. Grassl. Soc. Sth. Afr.* 6(2): 65-70.

DANCKWERTS,J.E., AUCAMP,A.J. & BARNARD,H.J. 1983. Herbaceous species preference by cattle in the False Thornveld of the Eastern Cape. *Proc. Grassl. Soc. Sth. Afr.* 18: 89 - 94.

DANCKWERTS,J.E., AUCAMP,A.J. & BARNARD,W.J. 1985. Forage production of some grass species in the False Thornveld of the Eastern Cape. *J. Grassl. Soc. South Afr.* 2(4): 31 - 34.

DANCKWERTS,J.E. & TROLLOPE, W.S.W. 1980. Assessment of the disc pasture meter on natural veld in the false thornveld of the Eastern Province. *Proc. Grassl. Soc. Sth. Afr.* 15: 47-52.

DE BEER,A.S., THERON,G.K. & BREDENKAMP,G.J. 1990. Floristiese verskille tussen ekotope in die Potchefstroom distrik. *J. Grassl. Soc. South Afr.* 7(2): 86 - 91.

DONALDSON,C.H. & ROOTMAN, G.T. 1983. Continuous grazing and fixed seasonal rotational grazing systems. Research facet T5411/41/1/1. Unpublished final report. Towoomba Research Station.

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

ELLISON, L. 1960. Influence of grazing on plant succession of rangelands. *Bot. Rev.* 26: 1 - 78.

EMLEN,J.M. 1966. The role of time and energy in food preference. *Am. Nat.* 100: 611-617.

ESTABROOK,G.F. & DUNHAM,A.E. 1976. Optimal diet as a function of absolute abundance and relative value of available prey. *Am. Nat.* 110: 401 - 41.

FORAN,B.D., TAINTON,N.M. & BOOYSEN,P.DE V. 1978. The development of a method for assessing veld condition in three grassveld types in Natal. *Proc. Grassl. Soc. Sth. Afr.* 13: 27 - 33.

FRIEDEL,M.H. & BLACKMORE,A.C. 1988. The development of veld assessment in the northern Transvaal savanna. I. Red Turfveld. *J. Grassl. Soc. South Afr.* 5: 26 - 37.

GRANT,S.A. 1981. Sward components. In: Sward Measurement Handbook. Ed: Hodgson *et al.* The British Grassland Society.

GAMMON,D.M. & ROBERTS,B.R. 1978. Patterns of defoliation during continuous and rotational grazing of the Matopos sandveld of Rhodesia. 1. Selectivity of grazing. *Rhod. J. Agric. Res.* 16: 117 - 131.

GAMMON,D.M. & TWIDDY,D.R. 1990. Patterns of defoliation in four- and eight-paddock grazing systems. *J. Grassl Soc. South Afr.* 7: 29 - 35.

GRUNOW,J.O. 1980. Feed and habitat preferences among some large herbivores on African veld. *Proc. Grassl. Soc. Sth. Afr.* 15: 141 - 146.

HATCH,G.P. & TAINTON,N.M. 1993. Effect of veld condition and stocking intensity on species selection patterns by cattle in the Southern Tall Grassveld. *Afr. J. Range & For. Sci.* 10(1): 11 - 20.

HEADY,H.F. 1975. Rangeland management. New York, McGraw Hill.

HODGSON,J. 1981. Sward studies: objectives and priorities. In: Sward Management Handbook. Ed: Hodgson *et al.* The British Grassland Society.

JONES,R.I. 1971. A theoretical analysis of foraging efficiency of grazing animals. *Proc. Grassl. Soc. Sth. Afr.* 6: 161 - 169.

JORDAAN,J.J., RETHMAN,N.F.G. & PIETERSE, P.A. 1991. 'n Tegniek om beskikbare bogrondse fitomassa van graspolle in ontblaringstudies te kwantifiseer. Tydskrif *Weidingsveren. S. Afr.* 8(4) 189 - 192.

KREUTER,U.P. & TAINTON,N.M. 1988. The effect of continuous and rotational grazing of sourveld on the selection of plant fractions by simmentaler heifers. *J. Grassl. Soc. South Afr.* 5(2): 68 - 71.

KRUGER,J.A. & EDWARDS,P.J. 1972. Benutting en relatiewe smaaklikheid van verskillende grasspesies. *Proc. Grassl. Soc. Sth. Afr.* 7: 146-155.

LONG,S.P., JONES,M.B. & ROBERTS, M.J. (Eds) 1992. Primary productivity of grass ecosystems of the tropics and sub-tropics. Chapman & Hall, London.

MACVICAR,C.N., DE VILLIERS,J.M., LOXTON,R.F., VERSTER,E., LAMBRECHTS,J.J.N., MERRYWEATHER,F.R., LE ROUX,J., VAN ROOYEN,T.H. & HARMSEMH.J.VON M. 1977. Grondklassifikasie. 'n Binomiese sisteem vir Suid-Afrika. Wetenskaplike pamflet 390, N.I.G.B. Dept. Landbou en Watervoorsiening, Pretoria

MEISSNER,H.H., HOFMEYER,H.S., VAN RENSBURG,W.J.J. & PIENAAR,J.P. 1983. Classification of livestock for realistic prediction of substitution values in terms of a biologically defined Large Stock Unit. Technical Communication No. 175. Pretoria: Dept. of Agriculture.

MENTIS,M.T. 1981a. Acceptability and palatability. In: Veld and Pasture management in South Africa. Ed: N.M.Tainton, Pietermaritzburg. Shuter & Shooter and University of Natal Press.

MENTIS,M.T. 1981b. Evaluation of the wheel-point and step-point methods of veld condition assessment. *Proc. Grassl. Soc. Sth. Afr.* 16: 89 - 94.

O'CONNOR,T.G. 1992. Patterns of plant selection by grazing cattle in two savanna grasslands: A plant's eye view. *J. Grassl. Soc. South Afr.* 9(3) 97 - 104.

O'REAGAIN,P.J. & MENTIS,M.T. 1988. Seasonal changes in the quality of diet selected by cattle grazing the Natal Sour Sandveld. *J. Grassl. Soc. South Afr.* 5(1) 48-51.

O'REAGAIN,P.J. & MENTIS,M.T. 1989a.Sequence and process of species selection by cattle in relation to optimal foraging theory on an old land in the Natal Sour Sandveld. *J. Grassl. Soc. South Afr.* 6(2) 71-76.

O'REAGAIN,P.J. & MENTIS,M.T. 1989b. The effect of plant structure on the acceptability of different grass species to cattle. *J. Grassl. Soc. South Afr.* 6(3) 163 - 170.

OWEN-SMITH,N. & COOPER,S.M. 1988. Plant palatability assessment and its implications for plant-herbivore relations. *J. Grassl. Soc. South Afr.* 5(2): 72 - 75.

PETRIDES,G.A. 1975. Principal foods versus preferred foods and their relations to stocking rate and range condition. *Biol Conserv.* 7: 161-169.

PIENAAR,A.J. 1968. Die plantegroei en weiveldbestuur op Soutpan. Dept. L.T.D. Transvaalstreek, Lesingreeks 1.

POLE EVANS,I.B. 1938. Pasture Research. Progress Report No.1. Union S. Afr. Dept. of Agric. Pretoria, Govt Printer.

PRELLER,J.H. 1969. Pasture research in South Africa: a historical review. Presidential address. *Proc. Grassl. Soc. Sth. Afr.* 4: 19-34.

PYKE,G.H., PULLIAM,H.R. & CHARNOV,E.L. 1977. Optimal foraging: a selective review of theory and tests. *Q. Rev. Biol.* 52: 137-154.

RING,C.B.,NICHOLSON,R.A. & LAUNCHBAUGH,J.L. 1985. Vegetational traits of patch-grazed rangeland in west-central Kansas. *J.Range Mngmnt.* 38: 51-55.

ROBERTS,B.R. 1981. Sweet and mixed grassveld. In: Veld and Pasture management in South Africa. Ed: N.M.Tainton. Pietermaritzburg, Shuter & Shooter and University of Natal Press.

SAVORY,A. 1983. The Savory grazing method or holistic resource management. *Rangelands* 5: 155-159.

SENFT,R.L.,COUCHENOUR,M.B.,BAILEY,D.RITTENHOUSE,L.R.SALA,O.E.SWIFT,D.M. 1987. Large herbivore foraging and ecological hierarchies. *Bioscience* 37: 789-799.

SMIT,G.N. & RETHMAN,N.F.G. 1989. Implikasies van subhabitat diversiteit en die rol van bestuur op die voorkoms van 'n aantal grasspesies van die Suuragtige-Gemengde Bosveld. *Tydskrif Weidingveren. S. Afr.* 6(1): 44 - 50.

SMIT,G.N. & RETHMAN,N.F.G. 1992. Inter-related floristic changes associated with different long-term grazing treatments in Sourish, Mixed Bushveld. *J. Grassl. Soc. South Afr.* 9(2) 76 - 82.

STODDARD,L.A. & SMITH,A.D., 1955. Range management. New York, McGraw Hill.

STOLTZ,C.W. & DANCKWERTS,J.E. 1990. Grass species selection patterns on rotationally grazed Döhne Sourveld during autumn and early winter. *J. Grassl. Soc. South Afr.* 7(2): 92 - 96.

TAINTON,N.M. 1981. The ecology of the main grazing lands of South Africa. In: Veld and Pasture management in South Africa. Ed: N.M.Tainton. Pietermaritzburg Shuter & Shooter and University of Natal Press.

TAINTON,N.M. 1985. Recent trends in grazing management philosophy in South Africa. *J. Grassl. Soc. South Afr.* 2(4): 4-6.

TANNER,G.W., SANDOVAL,L.D. & MARTIN,F.G. 1984. Cattle behaviour on a south Florida range. *J. Range Mngmnt.* 37: 248-251.

TRIBE,D.E. 1952. The relation of palatability to nutritive value and its importance in the utilisation of herbage by grazing animals. *Proc. 6th. Int. Grassl. Congr.* pp 1265-1270.

TROLLOPE,W.S.W. & POTGIETER,A.L.F. 1986. Estimating grass fuel loads with a disc pasture meter in the Kruger National Park. *J. Grassl. Soc. South Afr.* 3(4): 148 - 152.

ULYATT,M.J. 1973. The feeding value of herbage. In: Chemistry and biochemistry of herbage. Ed: G.W.Bulter & R.W.Bailey. London and New York, Academic Press III, pp 131-138.

VAN OUDTSHOORN,F.P. 1991. Gids tot grasse van Suid - Afrika. Briza Publikasies, Arcadia, Pretoria.

WALKER,J.W., HEITSCHMIDT,R.K. & DOWHOWER,S.L. 1989. Some effects of a rotational grazing treatment on cattle preferences for plant communities. *J. Range Mngmnt.* 42(2): 143-148.

WEAVER,J.E. & CLEMENTS,F.E. 1938. Plant ecology. McGraw-Hill, New York.

WILLMS,W., BAILEY,A.W. & MCLEAN,A. 1980. Effect of burning or clipping *Agropyron spicatum* in the autumn on the spring foraging behaviour of mule deer and cattle. *J. Appl. Ecol.* 17: 69 - 84.