THE INFLUENCE OF THE COMPOSITION OF MIXED KAROO VEGETATION ON THE GRAZING HABITS OF MERINO AND DORPER WETHERS

By

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ABSTRACT

THE INFLUENCE OF THE COMPOSITION OF MIXED KAROO VEGETATION ON THE GRAZING HABITS OF MERINO AND DORPER WETHERS.

The primary objective of this research project was to determine whether area-selective grazing, by Dorper and Merino wethers, took place in small grazing camps as governed by differences in vegetal cover. The main research techniques employed were the descending-point method for the determination of botanical composition, sub-division of the camps into grid-blocks to trace sheep movement in relation to vegetation patterning, fistulated animals to determine diet selection, the electronic theodolite for micro-topography, and few minor techniques.

The result have shown that area- patch- and species selective grazing are prevalent in small grazing camps under "normal" stocking densities, and that different breeds of stock (Merino and Dorper sheep) have different grazing patterns and diet selection. Climax and sub-climax areas were those primarily selected for grazing. There is little or no correlation between botanical composition and diet selected as per fistulated animal. The average distances travelled by Dorpers and Merinos was 2 km/day and 3.1 km/day respectively. Plant phenology did not have a detectable influence in the choice of diet.

The set hypothesis was not disproved.

Key words: **Selective grazing, Dorper/Merino, False Upper Karoo.**

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CHAPTER 1

INTRODUCTION

The Karoo agricultural region comprises approximately 29 million ha or 28% of the surface area of the Republic of South Africa, and is the largest extensive small stock farming region in this country. Approximately 23% of woolled sheep, 42% of non-woolled sheep, 65% of Angora goats and 13% of Boer goats in the Republic are farmed in the Karoo. These animals contribute some 26% of the wool, 64% of the mohair and 27% of the mutton in the country (Anon, 1986). The socio-economic importance of this vast stock farming region cannot be underestimated. This industry is practically entirely dependent on the natural vegetation (veld) as a source of food for the millions of farm stock.

The continued productivity of this natural resource is dependent, at least, on the maintenance of the current veld condition. Any research that would favour this resource in a practical way would be of value. This study thus also proposes to contribute to further understanding of the selective grazing processes and grazing habits associated with the grazing animal, in particular the Dorper and the Merino.

Over the past two centuries karoo vegetation has been the scene of vast change, retrogressive trends, deterioration and considerable change in botanical composition with accompanying degradation of the natural environment. So much so that, especially, the arid and semi-arid types of veld are in a process of subtle desert encroachment, active desertification and aridization (Tidmarsh, 1948; Acocks, 1988; Roux & Vorster, 1983). These negative effects were primarily induced by the impact of the established small stock industry with its attendant problems of overgrazing and mismanagement, which includes selective grazing processes. The latter is , in part, investigated in this thesis.

Apart from overgrazing, there are the detrimental effects of the mismanagement of the vegetation such as e.g. continuous grazing, grazing during sensitive phenophases of the vegetation, insufficient resting periods afforded to grazed vegetation to enable it to recover (Director Karoo Region, 1965) and occupying natural pastures with grazing animals poorly adapted to the particular vegetation, for example grazing sheep in grassveld instead of cattle, or goats in non-bushveld and so forth. It must be conceded, however, that economic factors, and tradition, dictate the choice of grazing animal and not so much the ecological requirements of the vegetation.

Overgrazing takes place when stock numbers are constantly in excess of the so-called long-term grazing capacity of the vegetation. According to the findings of the Drought Investigation Commission (1923) the general grazing capacity for the Eastern Mixed Karoo was determined at 1 SSU/1.7ha (Anon, 1923). In 1986 the estimated grazing capacity was 1 SSU/2.6ha (Anon, 1986) and in 1991 it was also 1 SSU/2.6 ha (Anon, 1991). It can be shown that since the final report of the Drought Investigation Commission (1923) that the arid and semi-arid grazing lands' long term estimated grazing capacity had decreased by as much as 53% at the present time. Overall, at present, a serious imbalance between grazing and the survival requirements of the vegetation exists.

Apart from the effects of selective grazing and mismanagement there are a considerable number of intrinsic factors associated with the grazing animal and habits of grazing; these are primarily the differences between breeds of animals and their selective grazing habits. In the latter instance one has largely to deal with differences in diet selection such as species selective grazing, patch (or spot) selective grazing and area selective grazing (also see page 8, selection for species and selection for preferred parts of plants).

In 1988 an extensive lay-out for the investigation of the effects of two different breeds of sheep, the Dorper and the Merino, on Karoo vegetation was initiated. The aim of this project (an official pasture research project, registered as project No. K5411/36/1/3 with the Department of Agriculture), for which the author is responsible, is to determine the optimum grazing capacity for the Eastern Mixed Karoo veld with different breeds of small stock at different stocking rates. This large lay-out afforded a prime opportunity to investigate, in greater detail, the influence of the composition of mixed karoo vegetation on the grazing habits, i.e. primarily area and spot selective grazing as apparently caused by vegetation patterning and differences in the acceptability (species selective grazing) of plant species, of Dorper and Merino wethers run in the project. A better understanding of these preferences and differences could lead to the advantageous manipulation of the grazer in order to decrease negative effects and/or to escape excessive selective grazing pressure.

CHAPTER 2

LITERATURE REVIEW

The following exposition of literature, relevant to this research project, elucidates the subject of animal grazing habits and selective grazing processes, as well as to draw the attention to the complex nature of selective grazing processes and animal behaviour. This study is a further contribution to some of the more pertinent aspects relevant to the science of veld management and botany.

2.1 SELECTIVE GRAZING:

The following impresses the involved and complex nature of selective grazing:

Selective grazing is the result of a stimulation reaction relationship between the plant and the animal. The palatability of the plant stimulates the animal to select the plant as a constituent of its diet. In other words the reaction of the animal to the stimulation is to graze the plant (Heady, 1964). According to Mentis (1981a) the palatability of a feed concerns the specific factors of the feed itself which determine the absolute attractiveness of the feed to the animals. Selective processes even apply to pastures with few species. Tidmarsh (1951) listed the palatabilities of species into different categories or groups. Blom (1981) extended this list and included 450 species. According to Botha (1981) the floristic and chemical analysis of the diet selected by domestic animals is of importance to research as this could lead to the explanation and the determination of the following:

i. The effect of species selection of the different free ranging animals on the floristic composition of veld over time.

ii. The effect of the different phenological phases of plant species on the diet selection pattern of the animals.

iii. The determination of the relative importance of different species as a grazing component.

The stimulation-reaction relationship in food selection and acceptance is controlled by a complex chain of events. It has been suggested that this chain consists of three inter-related systems (Young, 1948) viz.:

i. The first is within the body of the animal and includes items such as nerve stimuli initiated by energy release, blood sugar concentration, body temperature, movement of the digestive tract, the senses as well as tiredness of the mouth parts. This physiological system, is however, more associated with the stopping of intake than with the beginning of intake. (This aspect was not researched in this study.)

ii. The second includes the adaptiveness of the animal to the available herbage. There has, however, not been conclusive research done on the effect of change in available herbage on the selection pattern of the animal. This could possibly be effectively addressed by determining the selective grazing pattern at the beginning of a grazing cycle and contrasting it with that at the end of the cycle. (This present study has laid some foundation for the further study of this aspect.)

iii. The third system that affects the acceptance of plants is apparently the nutritive value of the herbage and the physical environment of the animal. According to Cowlishaw and Alder (1960) animals can recognize palatablity by making use of their senses of touch, taste, and smell. (In this study the main species involved were analyzed for the main chemical components to ascertain whether some particular element influenced palatability.)

All three systems, i to iii, are interrelated in a stimulation reaction chain of events that can include the following: recognition of food, movement to the food, appraisal, intake and cessation of intake. Species selective grazing may take place at any stage in the chain and can be controlled by any number of factors. This situation is better described by selective reaction rather than taste reaction in a definition of palatability, as the animal does not react on all the stimuli of the plants, but only on certain stimuli coming from certain plants (Arnold & Dudzinski, 1978). A whole range of factors interact to determine the composition of its diet on a particular day. These researchers produced a scheme depicting various factors responsible for diet selection. A summary of most of the factors that have an influences on the diet selected by free ranging domestic animals are reflected in Figure 1.

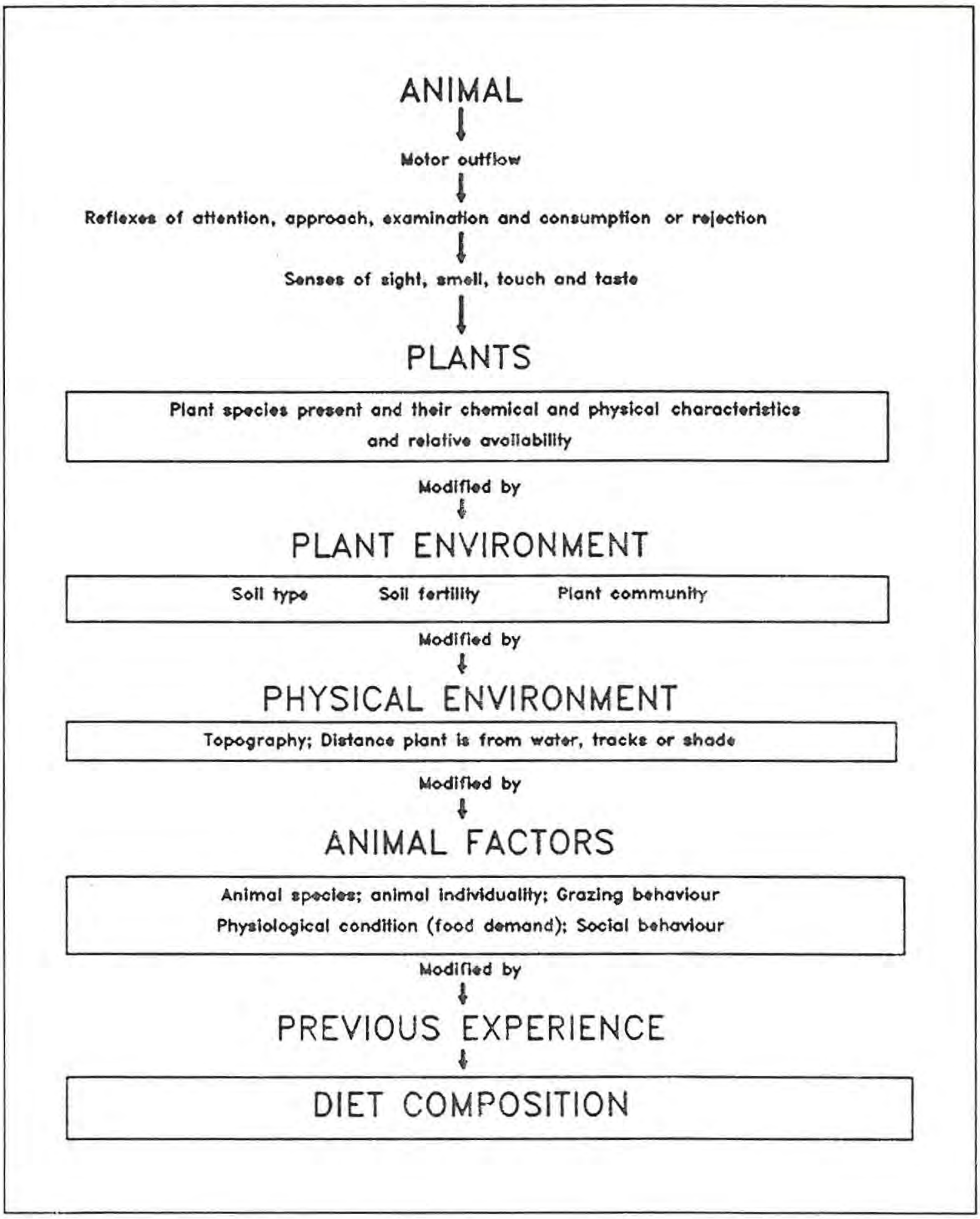


Figure 1 *A diagrammatic representation of factors influencing diet composition (Arnold & Dudzinski, 1978).*

The composition of the diet that an animal chooses may be quite unrelated to the proportions of various species, or plant parts, present and available to the animal. For example, on a semi-arid rangeland in New South Wales, Australia, Leigh and Mulham (1966) found that 80% of the diet, during one period of the year, was from plants that contributed only 1% of the total forage available.

2.2 SPECIES SELECTIVE GRAZING:

Areas of vegetation and individual species, in a veld grazing camp or paddock, are usually subjected to different grazing intensities as a result of area and species selective grazing by animals resulting from the heterogeneity, or lack of uniformity, in the vegetation and differences in palatability of species. According to Booysen (1967) species selective grazing is the habit of grazing animals to graze certain species in the sward in preference to others resulting in the over-utilization of the more preferred species and the under-utilization of the less sought after species.

Generally the process of species selective grazing is regarded to be the most general and detrimental process which operates at all times in all types of veld under grazing by domestic animals. It must be pointed out here that feral grazers such as springbok, kudu, wildebeest etc. all have their diet selection preferences. In the natural state, however, the diversity of natural grazers covers a wide range of species and ecological niches in contrast to the specialised domestic grazing animal (which is practically a "monoculture", so to speak) which concentrates its grazing on a relatively narrower spectrum of species. It can be reasoned that where a particular range of plants is grazed, that these would eventually deteriorate and became less competitive to those species that are very little grazed or not grazed at all. Over the last two centuries or so this process has indeed given rise to very significant changes in the composition of the vegetation (Acocks, 1988) and usually accompanied, though not always (Roux & Vorster, 1983) by a decrease in density of cover. Danckwerts, Aucamp and Barnard (1983) found that animals (cattle) continue to graze selectively even when swards were subjected to severe defoliation.

Species selective grazing can be further broken down into selection for species A in preference to species B, selection of preferred plants within species A, and of plant part selection.

2.3 AREA AND PATCH SELECTIVE GRAZING:

Apart from species selective grazing other selective grazing processes are also operational and can, in certain types of veld, be as detrimental as species selective grazing. The most important of these are area- and-patch-(or spot) selective grazing. Area selective grazing in a camp is where stock concentrate, or graze for longer periods of time, as opposed to other areas. This is usually where tracts of vegetation and constituent species are more acceptable (palatable) as dietary components. Such areas are usually vleis, areas of greater moisture concentration, special plant communities, along drainage lines, certain aspects, differences in soil type, and so on. To a major extent area selective grazing is governed by topography. On a lesser scale microtopography also has an appreciable influence on selective grazing. Microtopographical features could be, amongst others, shallow depressions, local alluvial deposits, obstructions creating improved soil moisture conditions, a low lying patch of brackish soil, ridges, pans, etc. Such patches are generally slightly to markedly different from the surrounding area of vegetation. Special attention is given to area- and patch-selective grazing in this study as this is primarily the main cause of influencing selective grazing habits and area occupation time by the grazing animals.

The frequency at which a plant or area of veld is grazed is also related to the pattern of grazing i.e. the movement of stock on the grazing area. Both sheep and cattle often restrict their grazing to certain favoured areas, thus creating enhanced heterogeneity in the vegetation, even in pastures composed of single species, (Arnold & Dudzinski, 1978).

2.4 DIET SELECTION:

The palatability (or acceptability) of a plant can also be defined as plant characteristics, or plant conditions, that stimulate the animal to graze the plant, whereas palatable has been defined as pleasing to the taste and therefore pleasing to the mind (Heady, 1964). The reasons for grazers to select their diet are extremely complex and difficult to explain. It is however clear that some areas, for example where vegetation is lush and fresh due to a favourable soil moisture status, are favoured by grazers. Also that the tougher and more sclerophyllous plant species are not readily eaten. On the other hand, grass in the fresh condition, is usually sought after by most grazers unless it is a "sour" or fibrous grass. A sour plant can be described as one that can start of as being palatable but on reaching maturity becomes unpalatable (Booysen, 1967; Trollope, Trollope and Bosch, 1990). The diet selection of Merino, Dorper, Boer goats and Afrikaner cattle was investigated in a comprehensive experiment by Botha (1981), and Botha, Blom, Sykes & Barnhoorn (1983). In these investigations it was found that diets of the different breeds of animals grazing on the same veld differ as a result of inherent behaviour and preferences, anatomical differences, physiological requirements, and limitations such as e.g. body size, width of mouth etc.

Heady (1964), mentioned the following five groups of factors that can influence selection namely: palatability, associated species, climate and topography, type of animal, and physiological status of the animal.

Palatability is determined by a host of chemical and physical characteristics of the feed viz.:

2.4.1 Chemical Composition.

The chemical composition of a plant plays an extremely important role in its palatability. So for example Louw, Steenkamp & Steenkamp (1967) found that karoo plants with a high ether extract are highly unpalatable. These extracts are largely resinous substances. A prime example is

Euryops spp. which is highly unpalatable due to concentrations of resins in the leaves and stems. Several compounds, including nitrates and tannin, are believed to decrease the palatability of plants. With the addition of sugar or saccharine to plants high in protein, potassium, calcium, iron, fat, nitrates and vitamins, the palatability of these plants increase (Wagnon & Gross, 1961). The same principle applies when spraying molasses on dry grass with a low palatability to make it more attractive to the grazer. It has been determined that sheep and cattle prefer fruits and leaves to stems (Heady & Torell, 1959). The actual chemical composition of the plant differs in the various parts of the plant. Leaves usually contain a higher ether extract and crude protein than the stem, but is lower in lignin, cellulose and crude fibre content. Perhaps more significant than the amount of any chemical compound is the combination of chemical compounds. Therefore, nutritive value is more generally used to describe the palatability of plants than the individual chemical compounds (Botha, 1979).

2.4.2 Growth Stage of the Plant.

In this study attention was also given to the phenological stage of the main species on the study sites. It is well-known e.g. that certain species are grazed more readily when flowering and others when not in flower. The older the plant the less palatable it becomes. This can be due to the fact that older plants are more woody and fibrous than younger plants. Younger plants have a higher moisture content and less harsh foliage. Grasses and broad-leaved bushes show an increase in crude fibre, lignin, cellulose and carbohydrate content with increasing age and a decrease in crude protein (Botha, 1979). These are actual changes in the plant itself and are further affected by a change in leaf-stem ratio (Heady, 1964). In a mixed grass-bush veld the selective grazing patterns would change all the time as all the plants do not reach maturity simultaneously.

2.4.3 Morphology of the Plant.

The external structure (morphology) of the plant can also affect the palatability or acceptability of the plant. Plant selection is e.g. effected by the presence or absence of thorns, hair, position of the leaves, stickiness and texture of the leaves and the stems (Heady, 1964). In the Karoo bush pastures some individual plants, or certain species, are e.g. not readily grazed as a result of the accumulation of dust and grit particles adhering to the sticky layer on the leaves.

2.4.4 Associated Species.

The selection of a specific plant, or species, is dependant on the availability of other choices. The selection of certain plant species also varies from veld-type to veld-type. Observations in the U.S.A. have shown that certain plants are readily eaten when available in small amounts. When the same plants were available in abundance, the position of these plants, in the selection pattern, changed markedly. A decrease in the availability of preferred species can also lead to a change in the selection pattern of the animal (Botha, 1979). In this present study, in order to place the species in perspective, botanical surveys were aimed especially with a view to identify and illustrate the variation in species composition and consequently the influence on grazing movement patterns.

2.4.5 Environmental Conditions.

Climate, topography and soil moisture have been listed as affecting palatability. These environmental factors affect palatability aspects of plants such as chemical composition and harshness of foliage (Cook, 1959). With this in mind the microtopography of the research sites, in this study, was surveyed.

2.5 KIND OF ANIMAL:

Selection grazing by various kinds of animals differ markedly with each breed and show an innate preference for certain plant species, plant parts, and plants in specific growth stages. The selection preferences by a breed and type also varies from animal to animal, from area to area, season to season, day to day and even within the same day (Arnold, 1964a).

The primary grazing habits of the four main animal types was described by Roux (1968) namely that the horse was primarily a short grazer (ground level), the sheep a low stratum grazer, the goat a multi-stratum grazer (and browser), and cattle a deep (low and high) stratum grazer. It should be clear from this that each type of grazer would have a different effect on the vegetation. In this study the Dorper was contrasted with the Merino. It stands to reason that the differences between these breeds would be much less than e.g. sheep versus goats, or goats versus cattle.

2.5.1 Daily Maintenance Behaviour.

The activities that each and every animal does every day are primarily those concerned with maintenance and survival-grazing, browsing and/or feeding on supplements, walking, ruminating, resting, defecating and urinating. However, all these are linked into a daily pattern of activities (Arnold & Dudzinski, 1978). In this research project grazing, resting and drinking were documented.

2.5.2 Physiological Status of the Animal.

The selective grazing pattern of the animal is closely associated with its physiological status, in other words, whether the animal is pregnant, lactating, fat, hungry, ill etc. The sense of sight, smell, touch and taste as well as instinct and experience of the type of grazing available can also have an effect on the selection pattern of the animal. In an experiment where the effect of the sense of taste, smell, sight and touch on the selection was determined, it was found that taste had the greatest effect and that the other senses were supplementary to taste. Smell did not have such an important effect on the selection pattern. Sight and touch were associated more with specific plant structure such as succulence and growth form. When all four senses were impaired, this did not lead to a completely random selection, although the percentage unpalatable plants in the diet increased (Kreuger, Laycock and Price, 1974).

In the case of this present study no impairment of the animals existed. However, the use of fistulated animals in the study of specific diet selection, impairment was inevitable. However, from all appearances, and the natural behaviour of these animals, it was concluded that fistulation had no effect on behaviour and diet selection.

There is general agreement that from a single plant, sheep and cattle eat leaf in preference to stem (Cook & Harris, 1950; Reppert, 1960), and green (or young) material in preference to dry or old (Cowlishaw & Alder, 1960). The material eaten, when compared with the material offered and rejected, is usually higher in nitrogen (Weir & Torell, 1959; Arnold, 1960; Bedell, 1971), phosphate (Staten, 1949; Cook, Stoddart & Harris, 1956) and gross energy (Cook *et al*, 1956), but low in fibre (Weir & Torell, 1959; Wallace, Free & Denham, 1972).

2.5.3 Time of Grazing.

Day-length, temperature, humidity, clouds, wind, rain, amount of feed available and variation between individuals, all influence the diurnal pattern of grazing (Arnold & Dudzinski, 1978). Both sheep and cattle are more active during the day than during darkness where grazing is concerned. Regression analysis showed that the proportion of night grazing was significantly related to total grazing time, daylength and latitude, with daylength being the most important. The higher daily humidity, the more night grazing can be expected. It was found that the time morning grazing began was only influenced by the time of sunrise, but that the time it stopped depended on how much grazing had been done the previous night, the time the animals started and the rate of humidity decreasing during the morning period. The start of the afternoon grazing was influenced by the maximum temperature, the time it occurred and by the time of sunset. The time afternoon grazing stopped depended on the time the animals started, the time of sunset, the temperature when the started and the maximum temperature (Arnold & Dudzinski, 1978). In this present study, the sheep were monitored during the daylight from sunrise to sunset as this was by far the major and dominant grazing period.

2.5.4 Time Spent Grazing.

The act of grazing involves the selection of herbage, its prehension, mastication and swallowing. The time spent grazing usually also includes the time spent searching for food. Grazing time varies in relation to the environment in which an animal finds itself on any given day. The animal varies the number of bites it takes and the size of these bites and both are influenced by the structure of the vegetation. Rate of eating will also be varied according to climatic conditions and the physiological status of the animal. In this respect the time factor was regarded to be extremely important in this study, as the time of occupation of a particular area was also directly related to the selective process and vegetation pattern (Arnold & Dudzinski, 1978).

2.5.5 Walking and Drinking.

These two aspects are very often associated when food is in short supply. On extensive rangelands the animals may have to compromise between the preferred frequency of drinking and the distance to travel from water to reach least heavily grazed areas. The distance walked per animal per day is primarily governed by the daily fodder requirement of the animal and external factors such as the availability of fodder, the size of the grazing area, and weather conditions. The average walking distance for a Merino wether on mixed Karoo veld was found to be 9.18 km/day, and for a Dorper ewe this figure is 5.9 km/day (Roux & Schlebusch, 1987). An average distance for sheep in a 125 ha camp varied from 5.2 km to 8.0 km per day (Louw, Havenga & Hamersma, 1948). According to Squires (1976) a distance of 13.6 km is the limit a Merino will walk on a specific day. In these respects, especially in the small camps employed in this study, it was of great interest to determine the distances travelled during the monitoring periods. It was also thought that, due to the small size of the camps, that expression of behaviour and selective grazing patterns would be accentuated as the daily intake of fodder would be approximately the same as in a large camp.

Squires (1976) found that sheep drinking twice a day did so at around 08:00 and 18:00 in summer. Factors such as type of herbage, temperature and humidity, number of watering points and distance to it, will also effect the frequency of watering. Merinos will drink water twice daily if the distance between food and water is less than 4.0 km. If the distance is more than 4.8 km the animals will take water only once a day (Du Toit, 1982). Watering being a very important activity, this study automatically also had bearing on this. An associated aspect, which one can regard as a somewhat forced situation, was the development of sparser vegetation, due to trampling, developing around watering points. In this study the troughs were however conveniently located.

2.5.6 Previous Grazing Experience.

The efficiency with which sheep harvest food by grazing is also influenced by experience (Arnold & Maller, 1977). Experience, particularly in early life, may alter the later behaviour of and animal, but relatively little research has been done on the effect of experience on the feeding behaviour of grazing ruminants. Lambs in a mediterranean environment learn what to select from a dry pasture by experience during the period when it is changing from a green pasture. If they are not allowed this experience and are transferred direct to dry feed, they eat less and perform worse than lambs with experience (Arnold, 1964b). Arnold & Maller (1977) showed that sheep, with no experience of two generally unpalatable plant species, ate much less of these than sheep with experience of the same plant material. Attention was given to this aspect in this present study, especially where fistulated animals were used; the sheep were however allowed to become well acquainted with the vegetation before determining diet selection differences.

2.5.7 Social Distance Between Individuals.

In an experiment Baskin (1975) found that the mean neighbouring distance between Merinos grazing was 3.1 m. Social distance is that distance over which two individuals can maintain social contact, i.e. the distance over which signals can be passed (Baskin, 1975). It should however be pointed out here that in karoo veld such distances may exceed 50 m or more and consequently does not hold true for all situations. In the latter case visual contact is probably sufficient to hold the flock communicative. In the results of this study presented here, it was however clear that in small camps this social contact was fairly close which had an advantage that by observing 3 individuals of the flock that these were decidedly representative of the whole flock.

2.5.8 Footpaths.

Footpath formation is a feature intimately and inseparably associated with the grazing animal. Roux (1967) classified footpaths into primary and secondary footpaths. Primary footpaths originate at the watering point and secondary footpaths originate out of the primary footpaths. Under high density stocking (21 Merino ewes on 3.1 ha for 14 days) 5.5 km of primary and 15.9 km of secondary footpaths developed within this short period of time. Hoofprints covered 20% of the ground surface.

The formation of footpaths also depends on the form of the camp and its size. Tracks tend to radiate from the watering points and to run parallel to the fences (Lynch, 1974). Lange (1969) coined the appropriate term "piosphere" for the zone of trampling around watering points and other places of excessive trampling. In his studies he investigated length, direction, and type of track. These researches showed a remarkable constancy of tracks to the near radial around watering points, and the navigational skills of sheep to maintain direction. This trampling effect and the development of footpaths in small and large camps afford a most profitable field for further investigation. In this study this aspect is illustrated having made use of aerial-balloon photography, otherwise it was not specifically studied.

2.6 CLIMATE, SOIL AND TOPOGRAPHY:

The grazing habits of the animal are changed by, e.g. variations in temperature, rainfall, drought cycle, soil texture and slope of the camp, and weather as a whole (Heady, 1964). Due to the relatively short duration of the observations in this study, it was not contemplated to examine this aspect, excepting soil texture and topography. Generally, with integrated farm planning, a major principle has evolved in terms of topography and types of veld, i.e. to fence off, or separate, different topographical veld types so as to create the greatest uniformity in the vegetation and grazing with a view to reduce species and area selective grazing to its lowest possible level. It stands to reason, that the smaller the grazing camp the greater the probability of attaining uniformity of the vegetation, and consequently the scaling down of most of the selective grazing processes. Such camps, large or small, also provide the infrastructure for the application of systems of grazing management, grazing strategies and the application of special grazing treatments (Donaldson & Vorster, 1989, and Roux, 1968).

Considering the foregoing, it was reasoned that in very small camps (paddocks) selective grazing processes would thus be nearly completely foiled. However, this was apparently not the case as observed in an experimental lay-out of small camps. Here it was clear that "micro area and patch selective grazing" took place and that overall species selective grazing was apparently as prevalent as in large grazing areas under "normal" grazing pressures. In certain grazing philosophies and practices attempts to thwart selective grazing, resort to high stocking densities in small camps (Acocks, 1966) was taken. Even here complete non-selective grazing could not be attained in heterogeneous vegetation (Roux, 1967).

2.7 HYPOTHESIS:

This present study was consequently undertaken to test the hypothesis that: **area- patch- and species selective grazing are prevalent in small grazing camps under "normal" stocking densities, and that different breeds of stock (Merino and Dorper sheep) have different grazing patterns and diet selection.** Overall one would thus suspect that selective grazing by stock cannot be effectively eliminated, even under "normal" stocking densities regardless of the size of the grazing camps or the size of paddocks.

2.8 KEY QUESTIONS:

Considering the foregoing and as has been indicated briefly in the foregoing chapter, the following questions were posed for study in order to test the hypothesis.

i. Do animals prefer to graze a certain area or areas in a small grazing camp (i.e. especially area-, patch-, species-, selective grazing)?

ii. To identify the main reasons for selective grazing behaviour as governed by vegetation composition and other physical site factors.

iii. The main species that are selectively grazed or not grazed.

iv. The influence of phenology on selective grazing.

v. To elucidate such other aspects as would contribute to the particular value of this research project.

CHAPTER 3

SITE DESCRIPTION

3.1 LOCALITY:

The study areas, Site A and Site B, consisted of two locations approximately 5 km apart (see Figure 2) and are situated on the grounds of the Grootfontein Agricultural Development Institute in the Middelburg C.P. district. The geographic co-ordinates of Site A is 31°25'45" S; 25°01'03" E at an altitude of 1307 m, and that for Site B 31°27'29" S; 25°03'37" E at an altitude of 1339 m. These co-ordinates, in the middle of the sites, were determined by making use of the Magellan GPS NAV 5000 (Figure 3) and positions can be traced exactly in the future. This is a handheld global positioning system and is able to provide the location and altitude of a site with an accuracy of 5 m. The co-ordinates for the specific experiment camps in the sites A and B, taken in their centres, are:

Site A Camp DA: 31°26'04" S; 25°01'03" N
Camp MA: 31°25'02" S; 25°01'03" N
Site B Camp DB: 31°27'02" S; 25°03'37" N
Camp MB: 31°27'56" S; 25°03'37" N

Figure 3 *The Magellan GPS NAV 5000, handheld global positioning system, used to determine the geographical coordinates of the two Sites, A and B, and for camps DA, MA, DB and MB.*

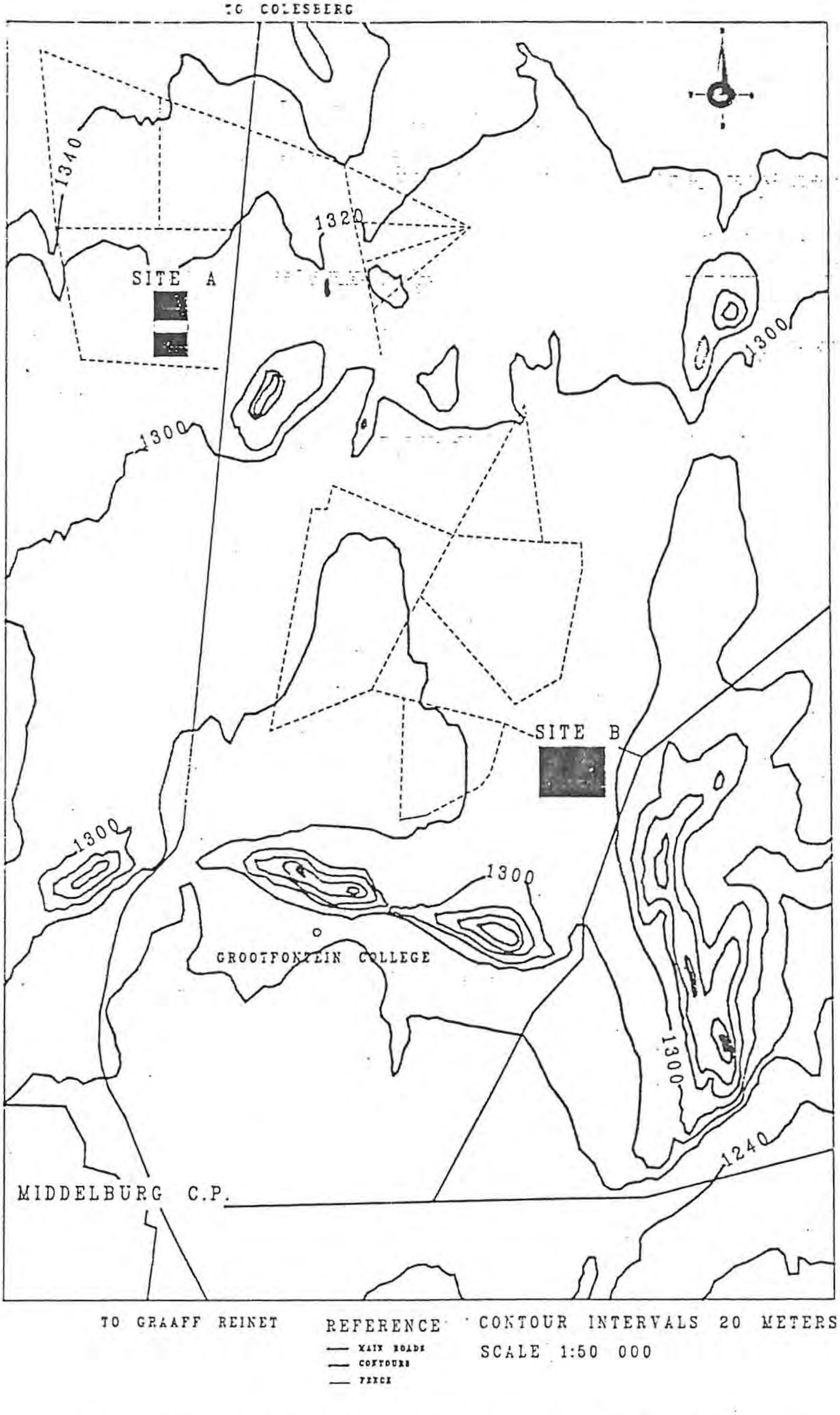


Figure 2 *Map of part of the Grootfontein College grounds to indicate the location of the two study areas, Sites A and B.*

The two Sites A and B differ considerably in vegetation composition and soil type. Both areas are located within Veld Type 36, False Upper Karoo (Acocks, 1988). According to Vorster (1985) the study area is situated in RHFA (Relative Homogeneous Farming Area) 4.8 of the Karoo Region, with a general grazing capacity of 16 ha/LSU (hectares per Large Stock Unit).

3.2 GEOLOGY AND GEOMORPHOLOGY:

The study areas fall within the Karoo System. According to Taljaard (1948) the principal subdivisions of this geological formation is the Dwyka, Ecca and Beaufort Group. The Dwyka is the oldest of the layers and bears fossils. Mesas, buttes, dolerite dykes, hills, sandstone shale hills and flats form part of the topography of this region. An important characteristic is the high frequency of mudstone that erode easily. This in turn give rise to soils that are highly erodible (Anon, 1986). Drainage in this very extensive area is primarily in a southern direction (Ellis, 1988).

Site A is situated on a relatively flat area overlain by aeolian and silt deposits on Lower Beaufort Group sandstones. Site B is a gradually sloping surface with a shallow soil overlying shales of the Beaufort series. The drainage of Site A is towards the south, and that for Site B towards the west.

3.3 MICROTOPOGRAPHY:

The microtopography of Site A is largely uniform and there is only a four metre decline in slope over a 500 m distance (0.8% slope). For Site B the slope is 6.5 m over a 400 m distance (1.6% slope). The landscape of Sites A and B is gently undulating to nearly level. There are no ridges or depressions of any particular significance. Figure 2 also depicts the general topography surrounding the two study areas. Sundoval, Benz, George & Mickelson (1964) determined that in areas where saline conditions are moderate (see Table 18), and the microrelief (microtopography) slightly uneven to almost flat, salts are concentrated in the depressions between the ridges. In the instances of Sites A and B the difference in elevation from crest to the lowest point of undulation is never more than

60 cm. This surface characteristic, nevertheless, causes marked effects on the patterning of the vegetation in some areas.

3.4 SOILS:

The soil in Site A is classified as a Hutton form with an orthic A-horizon on top of a red apedal B horizon (Macvicar, *et al*, 1977). The depth of the A-horizon varies between 5 and 10 cm. The pH, determined according to the KCL-method, as described in the Handbook of Standard Soil Testing Methods for Advisory Purposes (Anon, 1990), of this soil, varies between 5.1 and 6.1, and is thus more or less neutral. The conductivity is between 32 and 49 mS/m (Milli Siemans/metre) which indicates a slight brackishness or salinity) (see Table 18).

The soil in Site B is classified as a Mispah form (MacVicar, *et al*, 1977) with an orthic A-horizon on hard rock which is composed of bedrock and silcrete. The depth of the A-horizon varies between 5 and 15 cm. The average pH and conductivity are 6.5 and 45 m/Sm respectively which denotes a soil tending toward the alkaline.

Erosion of the soil surface by wind and water is an important factor in the Karoo (Roux & Opperman, 1986). It has been suggested that soil "capping" through splash erosion, and erosion of the A-horizon results in a poor germination environment for indigenous plant species. According to Walters (1951) wind erosion is a significant disturbance factor, as any light organic material is transported away from the site before it can be incorporated into the A-horizon.

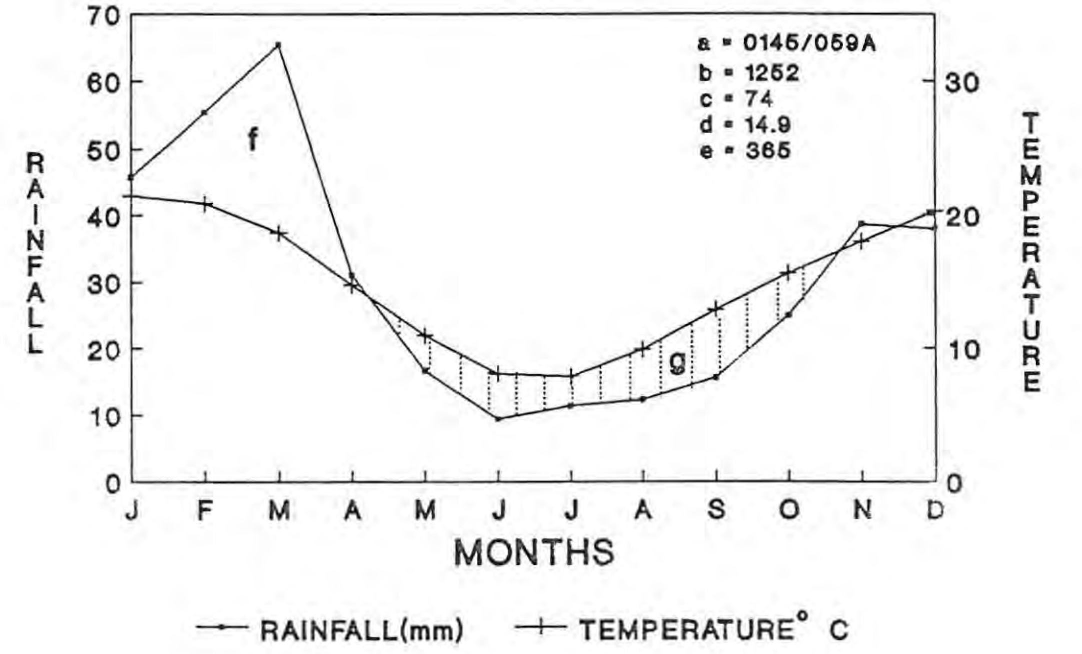
Site A is more prone to wind erosion, and on Site B water erosion is predominant. The general soil conditions on the two sites can be described as generally harsh, with that of Site B more arid than of Site A.

3.5 CLIMATE:

Figures 4, 5, 6, 7, and 8 provide the primary climatic data derived from data of the Grootfontein Weather Station No. 0145/059A. This weather station is situated 5.7 km from Site A and 3.2 km from Site B.

3.5.1 Climogram.

A climogram (Figure 4) was constructed according to the method of Walter, 1961.



Explanation:

a = Station number *e = Mean annual precipitation (mm)*
b = Altitude (m) *f = Humid period*
c = Number of years of observation *g = Arid period*
d = Mean annual temperature in °C

Figure 4 *Climogram for Grootfontein Weather Station representing Sites A and B.*

This figure shows the duration of the humid, f, and arid, g, periods of the year. The humid period is where the rainfall exceeds the temperature line, and the arid period where rainfall is below the temperature line.

Figure 5 depicts the rainfall recorded during the study period.

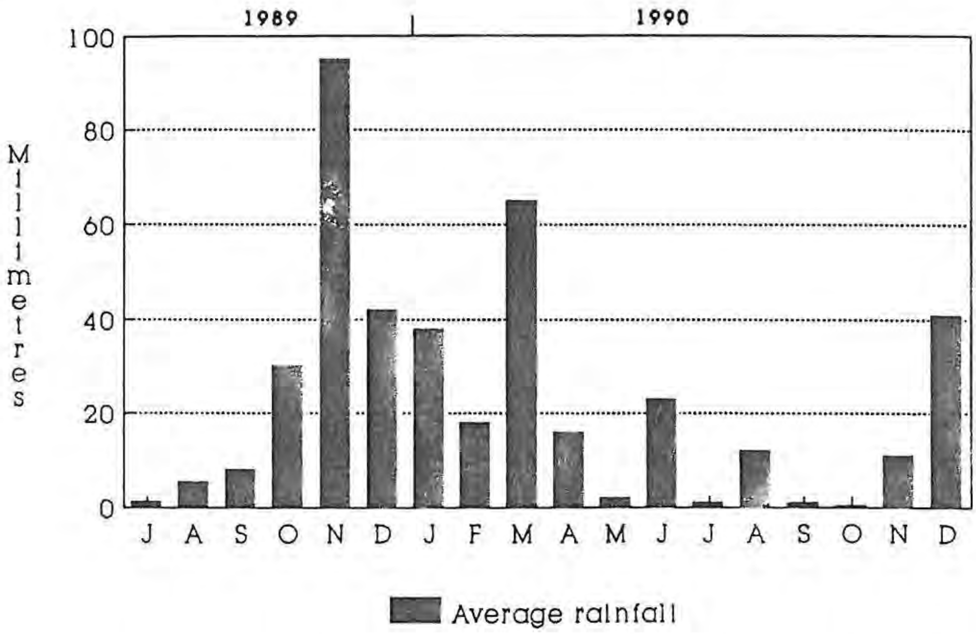


Figure 5 *The average monthly rainfall as recorded at the Grootfontein Weather Station during the period of observations on Site A and B.*

3.5.2 Average Temperature.

The mean annual temperature is 15°C with the summer (January) maximum temperatures as high as 40°C. July (winter) is the coldest month with a long term mean minimum temperature of -0.4°C (Koch,1991). Extremes as low as -12°C have been recorded. Figure 6 shows the run of the mean long term maximum, minimum and average temperatures.

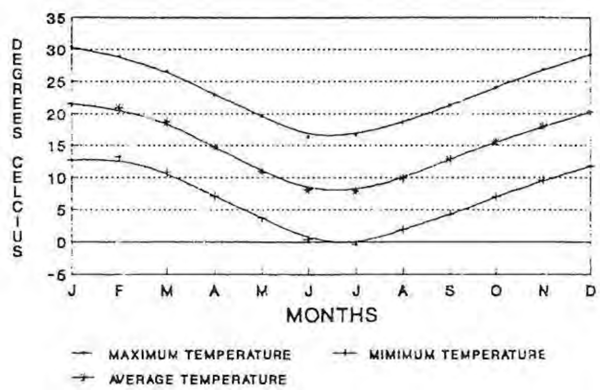


Figure 6 *The long term minimum, maximum and average temperature over a period of 74 years.*

3.5.3 Sun Hours.

Figure 7 shows the average long term sun hours as recorded at the Grootfontein Weather Station.

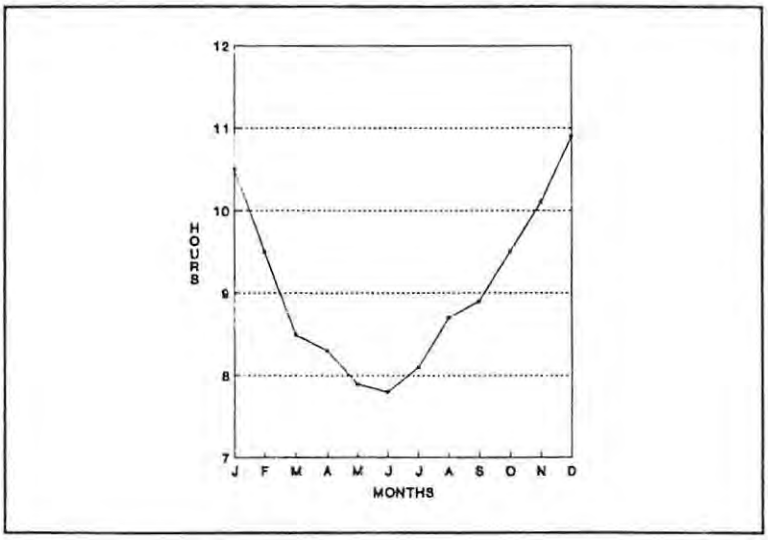


Figure 7 *The average long term sun hours.*

3.5.4 Wind.

Figure 8 shows the average long term wind speeds.

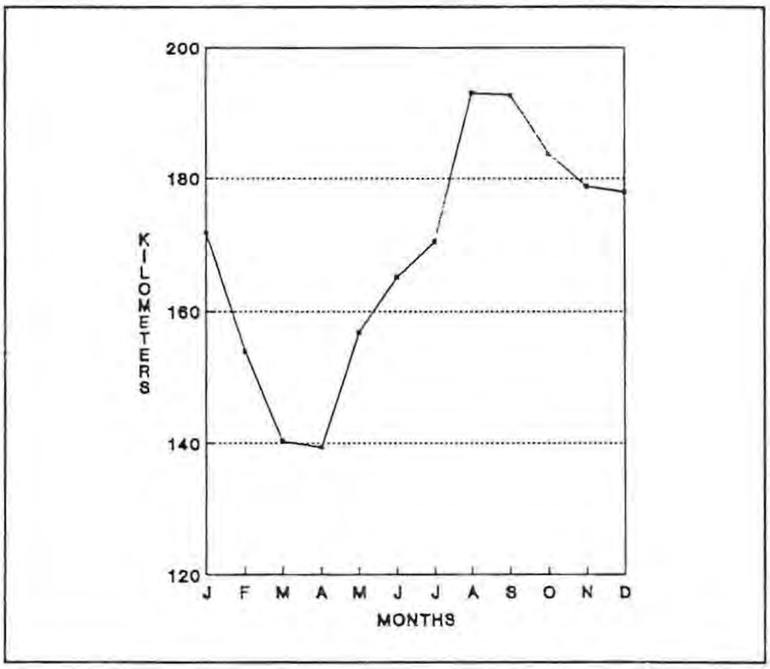


Figure 8 *The average long term wind speed.*

The dominant wind is from the north west. The month with the highest wind run is August. A southern wind is dominant during July. Winds can exceed speeds of more than 70 km/h, but this is the exception. The average windspeed varies between 4 and 28 km/h (J.Pollock, Grootfontein Weather Research Stn, Middelburg CP., pers.comm). According to Sampson (1988) most of the winds blow during the daylight hours with calmer air at night. The long term figure for wind calm periods is 43%.

3.5.5 Climate Classification.

By using the climatic data in conjunction with the Köppen classification for climate (Koeppe & De Long, 1958), the study area can be classified as a BSk type of climate that is a semiarid climate with cold winters (cool or cold steppe). This indicates further that the mean annual temperature is below 18° C, the mean annual precipitation is 360 mm and that the greatest proportion (75%) of this precipitation is during the summer. Frost is a general occurrence during the winter. It should be clear that the present vegetation is very well adapted to these extremes of climate. Furthermore, seasonal and moderate droughts occur from year to year. Disaster droughts occur only rarely. The sites are thus generally characterised by an arid climate with temperature extremes.

CHAPTER 4

VEGETATION

4.1 HISTORY OF VEGETATION MANAGEMENT:

Before 1903 the Grootfontein College grounds, which include Sites A and B, was privately owned. There were no camps, the veld was open and probably grazed continuously as deduced from the few stock watering points existing at that time. In 1903 the Imperial (British) Government acquired the land for a military cantonment. During this period (1903-1910) the first proper boundary fences were erected. The veld was grazed mostly by a large number of cavalry horses during this period and according to Roux (1969) this was the main cause for the high incidence of ***Eriocephalus ericoides*** which occurs on large areas where the grass cover had largely become grazed out and become replaced by ***E. ericoides***, which is characterized by a sturdy woody stem framework. According to McKnight (1958) horses and donkeys are known for their habit of pulling grasses and consuming only parts of them. Site A was especially subjected to this rather destructive treatment.

In 1910 the Government of the Union of South Africa acquired these grounds from the Imperial British Government. In 1911 the Grootfontein School of Agriculture was founded (Jensma, 1986). Since 1911 the grounds were grazed by Merino sheep on a loose managerial basis and no fixed grazing system or scheme was applied. The general veld management was however of a protective nature due to reduced stock numbers. This continued until 1969 when a three-camp rotational grazing system was applied on the so called group basis (Roux & Skinner, 1969). In 1980 this system was replaced by a two-camp group system. The overall stocking rate applied was 1 LSU/16 ha (LSU: Large Stock Unit). This is approximately 1 SSU/2.7 ha (SSU: Small Stock Unit). This treatment resulted in a relatively stable vegetation with the grass cover fluctuating according to the dictates of seasonal rainfall. The current veld condition, according to an assessment based on the Ecological Index Method (Vorster, 1982) is estimated to be 1 LSU/16.7 ha or 1 SSU/2.9 ha. The stocking rates maintained in the experiment camps were 1 SSU/ha.

4.2 VELD TYPE:

The Veld Type in which the study areas are situated is the False Upper Karoo and is situated between the Arid Karoo (Veld Type 29) in the west and the dry Sweet Grass veld, *(Cymbopogon-Themeda* Veld, Veld Type 50), in the east (Acocks,1988). The latter covers a limited area in the eastern Karoo Region and occurs mostly in the Burgersdorp district. Over the largest part of the False Upper Karoo the grass and shrub components are mixed in different proportions.

The principal grass species on the flats are pioneer grasses such as *Aristida congesta* and *A. curvata*, and sub-climax species such as *Eragrostis lehmanniana*. The most common karoo bushes on the flats are *Pentzia incana, Eriocephalus ericoides, Chrysocoma tenuifolia, Rosenia humilis, Salsola spp.* and *Pteronia spp.* (Roux & Vorster, 1983).

On the hills (broken country) there are mainly grass species such as *Aristida diffusa, Heteropogon contortus* and *Themeda triandra*. *Rhus erosa* is usually the most prominent shrub on the hills. In the leegtes (bottom lands) the cover mainly consists of grasses like *Eragrostis curvula, Sporobolus fimbriatus, Digitaria eriantha* and *Themeda triandra. Chrysocoma tenuifolia, Pentzia spp.* and *Pteronia spp.* are of the more important karoobush species.

One of the most important inherent characteristics of False Upper Karoo-veld is that the different components, i.e. trees, shrubs, karoo bushes, grasses (perennial and annual) and ephemerals, largely have different average growth cycles, each of which attain maximum growth activity and development in the same seasons or during specific seasons (Roux,1968). Research carried out by Du Preez (1971), on the production of ten common karoo bush species, over a period of three years, substantiated the growth cycles set out in Figure 9. It also stands to reason that where grazing takes place that these cycles would influence selective grazing processes.

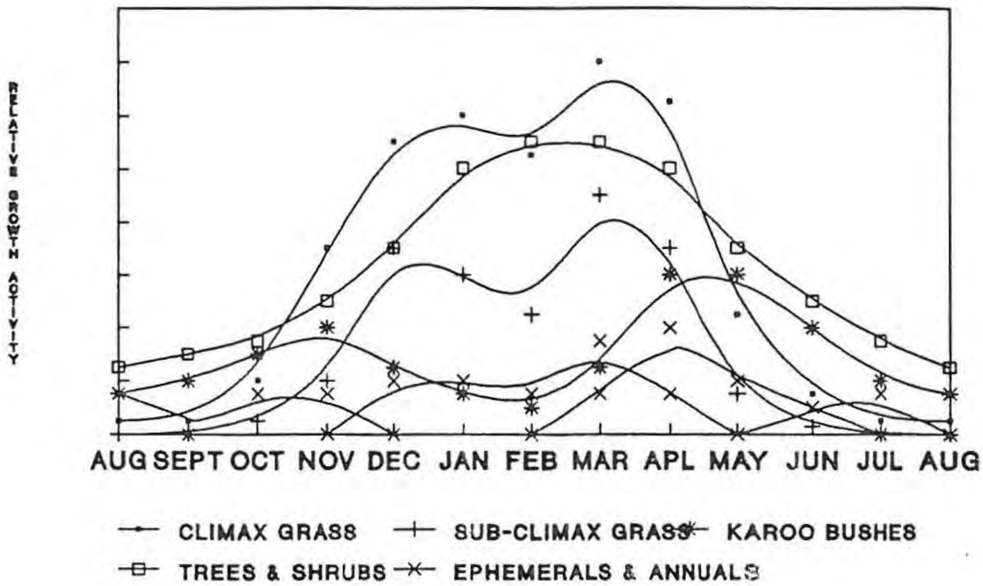


Figure 9 *The average growth cycles of the different veld components (Roux, 1968).*

Figure 10 A general view of *camp MA. Note the unevenness of the cover and the vegetation patterning. The dominant grass is* ***Aristida diffusa****. The shrubs are mainly* ***Eriocephalus ericoides*** *and* ***Pteronia tricephala****.*

4.3 VEGETATION ON SITE A AND B:

The two Sites A and B differ considerably in vegetation composition and soil type. The species composition for the sites are shown further on in Tables 3, 4, 5 and 6.

On Site A the dominant species are, in order of percentage cover, ***Aristida diffusa, Eriocephalus ericoides, Eragrostis lehmanniana*** and ***Tragus koelerioides***. Figure 10 is a general view of the vegetation on Site A.

The stage of succession of the vegetation on Site A is probably a sub-climax characterised by ***A. diffusa and E. lehmanniana***, which also represents a grazing climax (disclimax or plagioclimax, Oosting, 1952).

On site B the main species are ***Eriocephalus spinescens, A. diffusa, Pentzia incana, Sporobolus fimbriatus*** and ***Tragus koelerioides***. Figure 11 depicts the vegetation of Site B.

Figure 11 *The vegetation in Site B. The vegetation in the foreground is dominated by* ***Eriocephalus spinescens and Aristida diffusa***.

The successional stage of the vegetation of Site B is difficult to categorise; karoo shrubs are the dominant species with grass species subordinate. It is most probably an advanced plagiosere as defined by Tansley (1923). The habitat does not favour the development of a dominant grass cover due to the paucity of the soil type which is generally shallow and tending towards being arid. However, from all appearances and the history of this tract of vegetation, especially in respect of the shrub cover, it has reached a condition of considerable stability and resistance to change irrespective of the favourable grazing treatment applied in the past.

It must be pointed out that the terminology used here such as Climax Grass, Sub-Climax Grass primarily is connected to plant successional terminology. So for example *Themeda triandra* is a recognized important climax grass in many of South African grasslands. In Site A, *T. triandra* occurs scattered, or in large isolated patches. It is believed, that this could indicate a *Themeda* climax. Near the study area large continuous patches of *T. triandra* occur where protected from grazing, and that this grass *Themeda* could eventually form a climax such as has probably occurred before the influx of domestic stock. *Themeda* was thus classesd as a Climax Grass. The main secondary successional seres in Site A is regarded to be: Pioneer stage: *Aristida congesta* and annual herbaceous species, eg. *Tribulis terrestris*, *Ursinia nana* and *Pentzia annua*. Perennial pioneer grasses are *Tragus koelerioides* and *Cynodon incompletus*. The following and intermediate sere would be largely dominated by *Aristida diffusa*, *Eragrostis lehmanniana* and *E. obtusa*. These were classed as Sub-Climax Grasses. *T. triandra* would probably dominate in a mixed climax vegetation in an assosiation with *Sporobolus fimbriatus*, *Digitaria eriantha* and *E. curvula var. conferta*. At present, as a result of grazing, *Themeda* has not developed as a dominant. The latter grasses have all been classified as Climax Grasses. *T. triandra* and *D. eriantha* was seen by Acocks as climax grasses on the Kaap Plateau (Zacharias, 1990). It was therefore decided to group these four grass species as climax grasses with the rest as sub-climax or pioneer species. Grazing by domestic stock, especially where the grazing is in excess of the maintenance requirements of the vegetation, the pressure on grass eventually causes deterioration and consequent retrogression which leads to thinning-out of the vegetation developing grazed seres which could technically become grazing climaxes. As a result such species as *Eriocephalus spp.* and *Pteronia spp.* increase in the process of replacement of grasses.

The shrub species have been classed as Palatable, Less Palatable and Unpalatable in this study. In the evaluation of veld condition according to the ecological index method, Vorster (1980) classified species into five classes, namely: decreasers, increasers (2a, 2b and 2c) and invader species. These categories, as used by Vorster, are also included in Tables 1 and 2.

Appendix A is a check list of the species of the two study Sites.

CHAPTER 5

EXPERIMENTAL PROCEDURES, TECHNIQUES, RESULTS AND DISCUSSION

5.1 EXPERIMENT LAY-OUT:

In an existing large scale grazing experiment lay-out, consisting of two separate blocks (Figures 12 & 13), two camps were selected in each block in which to conduct the experiment for this thesis project. The selected camps are indicated in Site A as DA and MA (Figure 12) and in Site B as DB and MB, where D and M denote Dorper and Merino respectively (Figure 13). These camps were selected as they conformed to the aims of the present project as well as, per experiment block, to be as near to each other as possible and consequently of the same general vegetation composition. These two blocks of camps (Figures 12 and 13) were established in 1988.

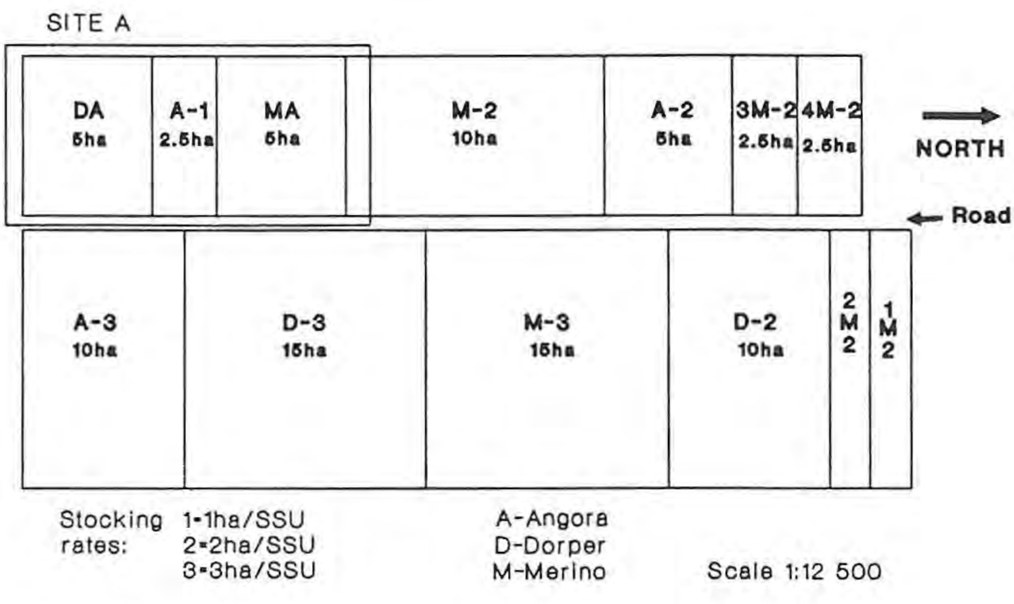


Figure 12 *The position of Site A in the so-called Afrikaner Block of camps. (Camp A1, 2.5 ha in area separates camps DA and MA.)*

The official grazing capacity as estimated for the veld in which the blocks are situated has been set at 1 LSU/16 ha (1 SSU/2.67 ha) by the department of Agriculture. The stocking rates in camps DA, MA, DB and MB, for the purpose of this project, can be regarded to be higher than the official rate. The stocking density per camp, during the time of occupation (ie. 4 months) amounted to 1SSU/0.5 ha. The reason for this was to "force" measurable results at an earlier time. In Site A, Camp DA and MA are separated by a small paddock of 2.5 ha. In Site B the two selected experiment camps are situated adjacent to each other.

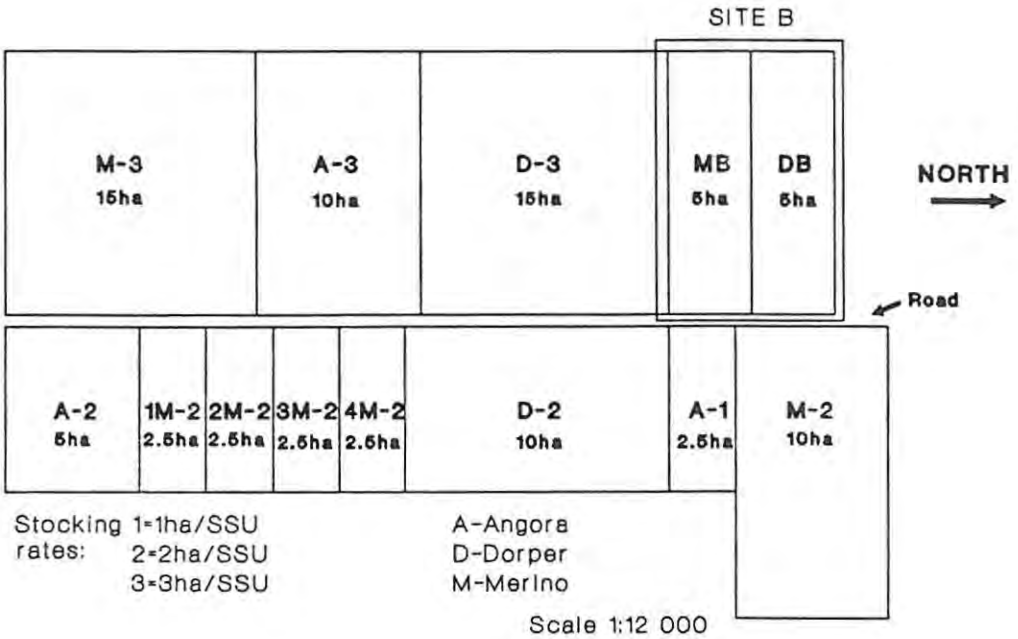


Figure 13 *The position of Site B in the so-called Hereford Block of camps.*

Camp MA was stocked with 10 Merino wethers for a period of four months. After the four months had elapsed the wethers are moved to Site B and placed into the corresponding camp, MB; the grazing period in MB was also four months. At the end of this period the animals were moved back to camp MA. This process was repeated alternately every 4 months. Camp DA was also stocked with 10 Dorper wethers and followed the same 4-month grazing rotation as applied for the Merinos. Some discrepancy arises here as to the stocking rates as, according to Meissner (1982) 1 Merino wether = 0.14 LSU, and 1 Dorper wether = 0.16 LSU. For the purpose of the experiment, this is however of little consequence, if any.

5.2 VEGETATION SURVEYS

5.2.1 Methods.

The descending-point method (Roux, 1963) was used to determine the vegetation composition in the four camps. This survey technique records basal cover (B), canopy cover (C), and canopy cover spread (S). In addition to these nearest plant (N) was recorded when no B-, C-, or S-cover strikes were recorded. This addition of N resulted that a plant was recorded with every point sample which thus enhanced the value of a survey especially in respect of the construction of species distribution figures.

Methods such as the step-point (Mentis, 1981b), wheel-point method (Tidmarsh & Havenga, 1955), point-centre-quarter (Heyting, 1968), and variable plot method (Hyder & Sneva, 1960) were also considered for the surveys. The main reason for deciding on the descending-point method was that basal, canopy and canopy spread-cover could be satisfactorily recorded as well to record species strikes sequentially in order to provide a basis for the construction of distribution figures.

In camps DA and MA the surveys were made in 15 parallel lines. Each line contained 179 point samples spaced 1.44 m apart, and the spacing between the lines were 13 m. As a result of the circumference of the wheels on the apparatus, used for this method, the distance between point samples is 1.44 m. Each complete survey thus contained 2685 point samples. The total surface area, of the camps was thus covered with systematic point samples according to the rules set out by Tidmarsh & Havenga (1955).

In camps DB and MB, the surveys were conducted in 9 parallel lines with a spacing of 13 m between the lines. Each line contained 277 points with a distance of 1.44 m between the point samples; this provided 2493 point samples per camp. The reason for this difference in line spacings and number of point samples between Sites A and B is that the shape of the camps differed (See Figures 14 & 15).

Camps DA and MA were each divided into a grid of small oblong grid-blocks each 13.33 m x 27.77 m size (see Figure 14) to give a total of 135 blocks per camp each with 20 point samples. This same procedure was applied to camps DB and MB. These two camps each contained 144 blocks and 17 point samples per grid-block (see Figure 15).

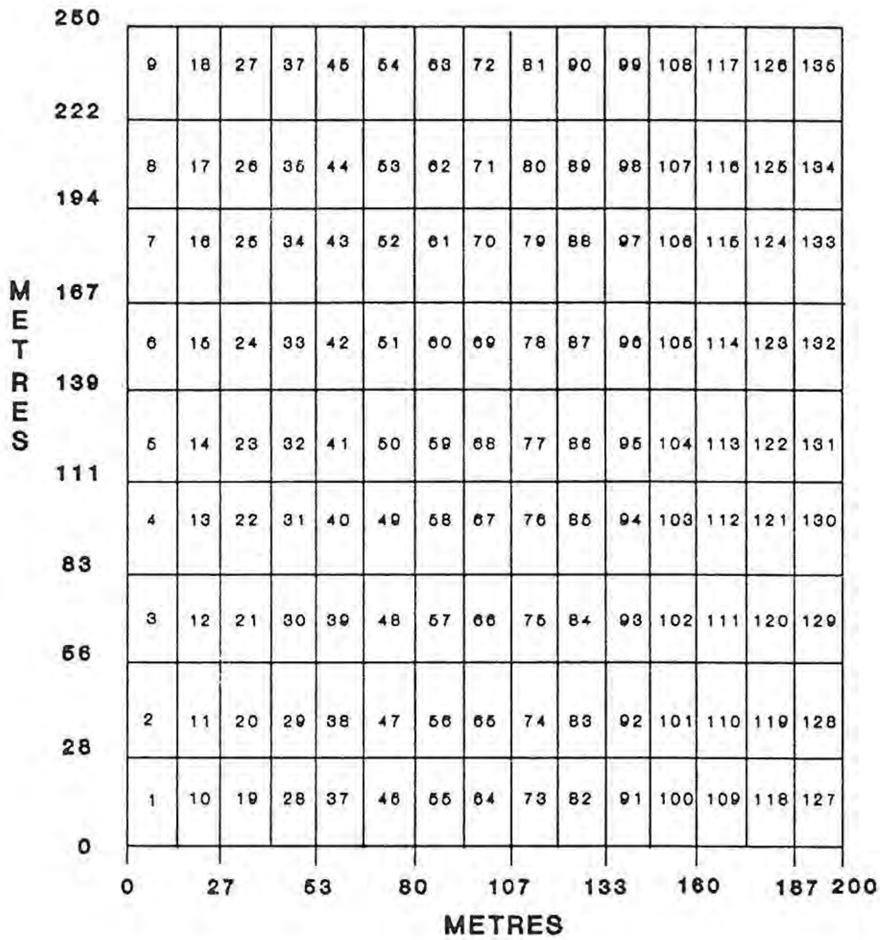


Figure 14 *The division of camps DA and MA, which are similar, into grid-blocks with serial numbers from 1 to 135.*

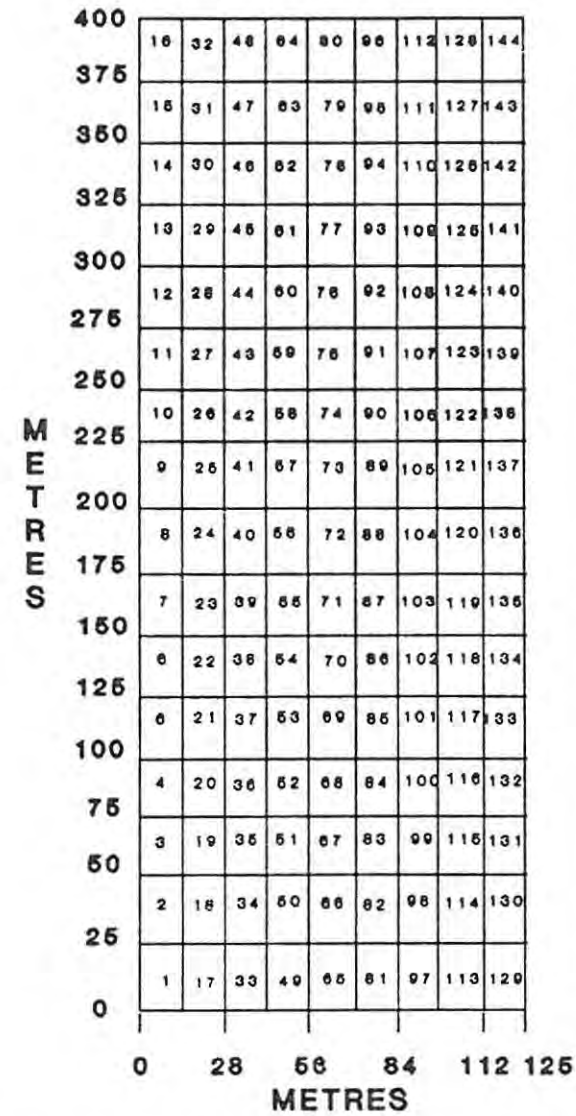


Figure 15 *The division of camps DB and MB into grid-blocks, which are similar, with serial numbers from 1 to 144.*

Since the distance between point samples, as well as the number of the strikes and the plant species recorded for that particular point was known, each of the grid-blocks provided a number of recorded species; each grid-block was in effect a small individual survey area. This means that each grid- block in camps DA and MA, was covered by 20 point samples, and that of Site B, 17 point samples per small block. The total strikes recorded for Site A, (as for Site B) were grouped into broad plant groups or single species groups (see Table 1). The grouping of species was made according to the classification by Blom (1981). If the percentage occurrence of a particular species was high this species was treated as a "group" on its own.

Table 1 *The classification of species into different groups for the surveys of camps DA and MA.*

GROUPS	SPECIES
DOMINANT SPECIES	*Aristida diffusa*
	Eriocephalus ericoides
PIONEER GRASS	*Aristida congesta*
(Increasers 2b)*	*Tragus koelerioides*
SUB CLIMAX GRASS	*Eragrostis lehmanniana*
(Increasers 2a)*	*E. obtusa*
CLIMAX GRASS	*Digitaria eriantha*
(Decreasers)*	*Eragrostis curvula var. conferta*
	Sporobolus fimbriatus
	Tetrachne dregei
	Themeda triandra
UNPALATABLE SHRUBS	*Pteronia glauca*
(Increasers 2c)*	*P. glomerata*
	P. sordida
	P. tricephala
	Rosenia humilis
OTHER	Species not included above

* Classification according to Vorster (1980).

Due to the greater variety of species on Site B the vegetation was grouped into 9 groups (Table 2). The reason for grouping the species was to decrease the number of variables in a survey.

Table 2 *The classification of species into different groups for the surveys of camps DB and MB.*

GROUPS	SPECIES
DOMINANT SPECIES	*Aristida diffusa*
	Eriocephalus spinescens
PIONEER GRASS (Increasers 2b)*	*Aristida congesta*
	Cynodon incompletus
	Tragus koelerioides
SUB-CLIMAX GRASS (Increasers 2a)*	*Eragrostis lehmanniana*
	E. obtusa
CLIMAX GRASS (Decreasers)*	*Digitaria eriantha*
	Eragrostis curvula var.conferta
	Sporobolus fimbriatus
PALATABLE SHRUBS (Increasers 2a)*	*Osteospermum leptolobum*
	Phymaspermum parvifolium
LESS PALATABLE SHRUBS (Increasers 2b)*	*Eriocephalus ericoides*
	Pentzia globosa
	P. incana
UNPALATABLE SHRUBS (Increasers 2c)*	*Pteronia glomerata*
	Rosenia humilis
	Lycium sp.
GEOPHYTES	*Mariscus capensis*
OTHER	Species not included above

* Classification according to Vorster (1980).

All the recorded N recordings in all the separate grid- blocks were grouped according to the classifications set out in Tables 1 and 2. Appendix B, Tables B1 to B4, give the grouping for every grid-block in Camps DA, MA, DB and MB.

The following serves as an example for the grouping of species for grid-blok No.1, Camp DA, (see Appendix B, Table B1):

1 - *Aristida diffusa (Ad)* (0)
2 - *Eriocephalus ericoides* (Ee) (2)
3 - Climax Grass (CG) (0)
4 - Pioneer Grass (PG) (12)
5 - Sub-Climax Grass (SG) (1)
6 - Unpalatable Shrubs (US) (2)
7 - OTHER (OTHE) (3)

The Lotus 1-2-3 computer programme was used to compile the vegetation survey tables and to do the sorting in a descending order of abundance, and calculations of the percentages and totals of the different strikes.

5.2.2 RESULTS and DISCUSSION.

Tables 3, 4, 5 and 6 show the species composition of camps DA, MA, DB and MB.

5.2.2.1 Site A.

In Camp DA, ***Aristida diffusa*** is the dominant species with a canopy spread of 14.75% out of a total cover of 44.26%; this is one third of the total cover. ***A. diffusa*** is followed by ***Eriocephalus ericoides*** (7.12%), ***Tragus koelerioides*** (6.67%) and ***Eragrostis lehmanniana*** (6%).

The dominant species for Camp MA is ***E. ericoides*** with a canopy spread cover of 17.06% out of a total cover of 54.93%. This is followed by ***E. lehmanniana*** (9.09%), ***E. curvula var. conferta*** (8.42%), ***T. koelerioides*** (7.04%), ***A. diffusa*** (4.25%) and ***Pteronia tricephala*** (2.31%).

5.2.2.2 Site B.

In Camp DB, ***E. spinescens*** (7.34%), ***A. diffusa*** (4.05%), ***Sporobolus fimbriatus*** (3.13%), ***Mariscus capensis*** (3.05%), ***Pentzia incana*** (2.84%), ***T. koelerioides*** (2.69%), ***A. congesta*** (2.57%), ***E. ericoides*** (1.72%), ***P. globosa*** (1.60%), ***Lycium cinereum*** (1.56%) and ***Phymaspermum parvifolium*** (1.28%) are responsible for the greater proportion of the total cover of 35.99%.

Table 3 *The botanical composition of camp DA.*

SPECIES	B%	C%	S%	N%	N1%
Aristida diffusa	1.49	13.07	14.75	8.60	23.35
Eriocephalus ericoides	0.19	4.55	7.12	3.35	10.47
Tragus koelerioides	0.60	6.67	6.67	15.64	22.31
Eragrostis lehmanniana	1.01	5.37	6.00	16.50	22.50
A. congesta	0.04	1.19	1.26	3.72	4.98
Eragrostis curvula var. conferta	0.15	1.04	1.15	0.78	1.93
Pteronia glomerata	0.07	0.74	1.00	0.22	1.22
Sporobolus fimbriatus	0.11	0.85	0.85	0.63	1.48
P. tricephala	0.00	0.45	0.71	0.26	0.97
P. glauca	0.00	0.34	0.68	0.34	1.02
Cynodon incompletus	0.00	0.63	0.63	1.56	2.19
Rosenia humilis	0.00	0.45	0.56	0.11	0.67
Eragrostis obtusa	0.00	0.52	0.52	0.71	1.23
Lycium cinereum	0.00	0.15	0.26	0.11	0.37
Pentzia incana	0.00	0.11	0.26	0.19	0.45
Themeda triandra	0.04	0.15	0.26	0.19	0.45
Eriocephalus spinescens	0.00	0.15	0.19	0.11	0.30
Plinthus karooicus	0.00	0.04	0.11	0.04	0.15
Salsola calluna	0.00	0.04	0.11	0.11	0.22
Hertia pallens	0.00	0.04	0.11	0.04	0.15
Walafrida geniculata	0.00	0.11	0.11	0.07	0.18
Indigofera alternans	0.00	0.11	0.11	0.15	0.26
Pteronia sordida	0.00	0.11	0.11	0.04	0.15
Salvia verbenaca	0.00	0.11	0.11	0.66	0.77
Phymaspermum parvifolium	0.00	0.04	0.08	0.07	0.15
Felicia muricata	0.00	0.04	0.08	0.15	0.23
Pterothrix spinescens	0.00	0.07	0.07	0.00	0.07
Tetrachne dregei	0.00	0.07	0.07	0.15	0.22
Protasparagus suaveolens	0.00	0.04	0.04	0.00	0.04
Dimorphotheca zeyheri	0.00	0.04	0.04	0.04	0.08
Eragrostis bicolor	0.00	0.04	0.04	0.07	0.11
Thesium hystrix	0.00	0.04	0.04	0.04	0.08
Eragrostis bergiana	0.00	0.04	0.04	0.19	0.23
Eberlanzia ferox	0.00	0.04	0.04	0.00	0.04
Osteospermum leptolobum	0.00	0.04	0.04	0.00	0.04
Lightfootia tenella	0.00	0.04	0.04	0.00	0.04
Schismus barbatus	0.00	0.00	0.00	0.04	0.04
Lessertia paucifolia	0.00	0.00	0.00	0.04	0.04
Pentzia globosa	0.00	0.00	0.00	0.04	0.04
Trichodiadema pomeridianum	0.00	0.00	0.00	0.15	0.15
Walafrida saxatilis	0.00	0.00	0.00	0.37	0.37
Aptosimum depressa	0.00	0.00	0.00	0.26	0.26
TOTAL	3.74	37.53	44.26	55.74	100.00

Number of point samples: 2685 N1=Total N-strikes
B=Basal cover C=Canopy cover
S=Canopy spread cover N=Nearest plant-strikes recorded

Table 4 *The botanical composition of camp MA.*

SPECIES	B%	C%	S%	N%	N1%
Eriocephalus ericoides	0.71	10.13	17.04	5.36	22.40
Eragrostis lehmanniana	1.42	5.10	9.09	10.24	19.33
Eragrostis curvula var. conferta	1.49	6.59	8.42	5.85	14.27
Tragus koelerioides	1.12	6.59	7.04	14.53	21.57
Aristida diffusa	0.74	2.61	4.25	1.71	5.96
Pteronia tricephala	0.04	1.64	2.31	0.37	2.68
Aristida congesta	0.25	1.08	1.71	2.09	3.80
Pteronia glauca	0.00	0.48	0.86	0.41	1.27
Walafrida saxatilis	0.00	0.45	0.67	1.71	2.38
Pteronia glomerata	0.07	0.41	0.63	0.04	0.67
Pentzia incana	0.00	0.41	0.60	0.26	0.86
Lycium cinereum	0.00	0.30	0.45	0.37	0.82
Tetragne dregei	0.04	0.11	0.26	0.34	0.60
Eragrostis obtusa	0.07	0.15	0.22	0.19	0.41
Felicia muricata	0.00	0.11	0.19	0.56	0.75
Plinthus karooicus	0.04	0.11	0.15	0.04	0.19
Chrysocoma tenuifolia	0.00	0.11	0.15	0.11	0.26
Hertia pallens	0.00	0.04	0.15	0.04	0.19
Osteospermum leptolobum	0.00	0.07	0.11	0.04	0.15
Rosenia humilis	0.00	0.04	0.07	0.07	0.14
Pteronia sordida	0.04	0.07	0.07	0.04	0.11
Phymaspermum parvifolium	0.00	0.04	0.07	0.22	0.29
Eragrostis bergiana	0.00	0.07	0.07	0.00	0.07
Sporobolus fimbriatus	0.00	0.07	0.07	0.14	0.21
Cymbopogon plurinodis	0.00	0.00	0.04	0.11	0.15
Themeda triandra	0.04	0.04	0.04	0.00	0.40
Indigofera alternans	0.00	0.04	0.04	0.04	0.80
Thesium hystrix	0.00	0.04	0.04	0.00	0.40
Cynodon incompletus	0.00	0.04	0.04	0.07	0.11
Pentzia globosa	0.00	0.04	0.04	0.00	0.40
Eriocephalus spinescens	0.00	0.00	0.04	0.04	0.80
Hermannia coccocarpa	0.00	0.00	0.00	0.04	0.40
Eragrostis curvula	0.00	0.00	0.00	0.04	0.40
TOTAL	6.07	36.98	54.93	45.07	100.00

Number of point samples: 2685 N1=Total N-strikes
B=Basal cover C=Canopy cover
S=Canopy spread cover N=Nearest plant-strikes recorded

Table 5 *The botanical composition of camp DB.*

SPECIES	B%	C%	S%	N%	N1%
Eriocephalus spinescens	0.16	5.86	7.36	3.13	10.49
Aristida diffusa	0.44	3.65	4.05	4.33	8.38
Sporobolus fimbriatus	0.56	3.01	3.13	1.89	5.02
Mariscus capensis	0.00	2.93	3.05	19.53	22.58
Pentzia incana	0.04	1.80	2.84	3.13	5.97
Tragus koelerioides	0.08	2.65	2.69	12.80	15.49
Aristida congesta	0.00	2.53	2.57	5.98	8.55
Eriocephalus ericoides	0.00	1.24	1.72	0.56	2.28
Pentzia globosa	0.04	1.20	1.60	0.60	2.20
Lycium cinereum	0.00	0.92	1.56	0.88	2.44
Phymaspermum parvifolium	0.04	1.00	1.28	1.40	2.68
Cynodon incompletus	0.00	0.52	0.52	1.81	2.33
Eragrostis curvula var. conferta	0.00	0.52	0.52	0.16	0.68
Eragrostis lehmanniana	0.00	0.40	0.44	1.68	2.12
Sporobolus ludwighii	0.00	0.36	0.36	0.84	1.20
Helichrysum lucilioides	0.00	0.28	0.32	0.08	0.40
Eragrostis bicolor	0.00	0.28	0.28	0.60	0.88
Eberlanzia ferox	0.00	0.16	0.24	0.24	0.48
Eragrostis obtusa	0.00	0.20	0.20	1.44	1.64
Walafrida geniculata	0.00	0.12	0.16	0.24	0.40
Plinthus karooicus	0.00	0.16	0.16	0.16	0.32
Salsola calluna	0.00	0.12	0.12	0.24	0.36
Chrysocoma tenuifolia	0.00	0.04	0.08	0.00	0.08
Thesium hystrix	0.00	0.08	0.08	0.04	0.12
Indigofera alternans	0.00	0.08	0.08	0.00	0.08
Delosperma tuberosum	0.00	0.08	0.08	0.08	0.16
Osteospermum leptolobum	0.00	0.08	0.08	0.00	0.08
Pteronia glomerata	0.00	0.04	0.04	0.00	0.04
Digitaria eriantha	0.00	0.04	0.04	0.00	0.04
Rosenia humilis	0.00	0.04	0.04	0.04	0.08
Nenax microphyllum	0.00	0.04	0.04	0.00	0.04
Commelina africana	0.00	0.04	0.04	0.00	0.04
Zygophyllum incrustatum	0.00	0.04	0.04	0.00	0.04
Trichodiadema pomeridianum	0.00	0.04	0.04	0.41	0.45
Ruschia unidens	0.00	0.04	0.04	0.04	0.08
Euphorbia chamaesyce	0.00	0.04	0.04	0.00	0.04
Hermannia pullchella	0.00	0.04	0.04	0.28	0.32
Felicia muricata	0.00	0.02	0.02	1.08	1.10
Hermannia coccocarpa	0.00	0.00	0.00	0.32	0.32
TOTAL	1.36	30.69	35.99	64.01	100.00

Number of point samples: 2493   N1=Total N-strikes
B=Basal cover   C=Canopy cover
S=Canopy spread cover   N=Nearest plant-strikes recorded

Table 6 *The botanical composition of camp MB.*

SPECIES	B%	C%	S%	N%	N1%
Eriocephalus spinescens	0.08	6.50	8.82	2.89	11.71
Aristida diffusa	0.44	6.54	7.50	6.94	14.44
Aristida congesta	0.04	3.77	3.85	7.82	11.67
Sporobolus fimbriatus	0.36	2.61	2.61	1.36	3.97
Pentzia incana	0.08	1.56	2.45	1.85	4.30
Tragus koelerioides	0.04	2.33	2.33	12.64	14.97
Mariscus capensis	0.00	1.89	1.93	15.72	17.65
Lycium cinereum	0.00	1.16	1.76	0.44	2.20
Phymaspermum parvifolium	0.12	0.92	1.56	1.32	2.88
Eriocephalus ericoides	0.04	0.88	1.04	0.24	1.28
Eragrostis curvula var. conferta	0.08	0.92	0.92	0.20	1.12
Pentzia globosa	0.04	0.64	0.84	0.36	1.20
Eragrostis lehmanniana	0.08	0.76	0.76	1.48	2.24
Walafrida geniculata	0.00	0.32	0.64	0.40	1.04
Thesium hystrix	0.00	0.52	0.64	0.24	0.88
Eragrostis obtusa	0.00	0.50	0.50	1.79	2.24
Eragrostis bicolor	0.04	0.44	0.44	0.44	0.88
Cynodon incompletus	0.00	0.40	0.40	0.68	1.08
Sporobolus ludwighii	0.00	0.28	0.32	0.32	0.64
Helichrysum lucilioides	0.00	0.24	0.28	0.00	0.28
Salsola calluna	0.00	0.24	0.24	0.08	0.32
Osteospermum leptolobum	0.00	0.12	0.20	0.00	0.20
Felicia muricata	0.00	0.16	0.16	0.68	0.84
Eberlanzia ferox	0.00	0.16	0.16	0.20	0.36
Trichodiadema pomeridianum	0.00	0.16	0.16	0.36	0.52
Plinthus karooicus	0.00	0.08	0.08	0.08	0.16
Delosperma tuberosum	0.00	0.04	0.04	0.04	0.08
Nenax microphyllum	0.00	0.00	0.04	0.00	0.04
Pteronia tricephala	0.00	0.04	0.04	0.00	0.04
Hermannia pullchella	0.00	0.04	0.04	0.04	0.08
Rosenia humilis	0.00	0.04	0.04	0.12	0.16
Euphorbia chamaesyce	0.00	0.04	0.04	0.00	0.04
Chrysocoma tenuifolia	0.00	0.04	0.04	0.04	0.08
Commelina africana	0.00	0.04	0.04	0.04	0.08
Pteronia glomerata	0.00	0.00	0.00	0.12	0.12
Ruschia unidens	0.00	0.00	0.00	0.04	0.04
Hermannia coccocarpa	0.00	0.00	0.00	0.12	0.12
TOTAL	1.44	34.38	40.91	59.09	100.00

Number of point samples: 2493   N1=Total N-strikes
B=Basal cover   C=Canopy cover
S=Canopy spread cover   N=Nearest plant-strikes recorded

The situation in Camp MB was more or less similar to that of camp DB with ***E. spinescens*** (8.82%), ***A.diffusa*** (7.50%), ***A. congesta*** (3.85%), ***S. fimbriatus*** (2.61%), ***P. incana*** (2.45%), ***T. koelerioides*** (2.33%), ***Mariscus capensis*** (1.93%), ***L. cinereum*** (1.76%), ***P. parvifolium*** (1.56%) and ***E. ericoides*** (1.04%) contributing to the 40.91% of the total canopy spread cover in this camp.

By making use of the Ecological Index Method (Vorster, 1982) the grazing capacity was determined for each camp and based on the respective survey results (Tables 3, 4, 5 and 6).

Site A: DA - 1 SSU/2.7 ha	Site B: DB - 1 SSU/4.0 ha
MA - 1 SSU/2.2 ha	MB - 1 SSU/3.3 ha

There is a significant difference between the stocking rates of the two sites. The dominant species in Camp DA is ***Aristida diffusa*** and in Camp MA it is ***Eriocephalus ericoides***. For both Camps DB and MB the dominant species is ***E. spinescens***. There is also a significant difference in the percentage canopy cover between Sites A and B. A species like ***Mariscus capensis*** was absent on Site A, but relatively abundant on Site B.

5.3 GRAZING PATTERNS:

5.3.1 Observations.

For the purpose of monitoring the sheep grazing patterns the camps DA, MA, DB, and MB were subdivided into blocks (grids) by making use of 1.8 m steel fencing droppers. The resulting blocks were 40 x 40 m for DA and MA, giving a total of 55, and for 41.6 x 41.6 m for DB and MB, giving a total of 30 blocks. The top 40 cm of every dropper was painted with a different bright colour (red, yellow, green, blue and white) so that it was easy to distinguish between boundaries of the different blocks. A plan of the blocks for each camp was drawn on suitable paper and the different colours of the droppers indicated. As a result of the measurements of the camps it was inevitable that half blocks resulted at the top end of the camps. This was however of no particular consequence.

A suitably sited observation post was established some short distance from each camp and from which the observation of animal movement could be monitored and indicated on the particular plan. Three Merinos and three Dorpers, out of the flock of ten, that was allowed to graze in every camp, were randomly selected. These animals were marked on both sides with coloured spray paint so that each animal could be easily identified from the observation post.

The observation of the movement of the marked sheep started half-an-hour before sunrise and ended half-an-hour after sunset. For Site A the observations were from the 3rd to the 5th of January 1990 and for Site B from 27 to 29 March 1990 (i.e. three consecutive days each). Observations were made at 15 minute intervals and the exact position of each marked sheep plotted on the plan. The actions of grazing, urinating, drinking water, standing still or lying down, and resting were recorded.

After the observation period all the data for a particular animal was plotted to produce a grazing pattern (Figure 16). If the animals were resting or drinking water, the time spent on these activities were taken into account for the construction of the grazing patterns *per se*. Each plotted distance (i.e. between two points) walked by the animals represents an interval of 15 minutes. The shorter the distance between two points the longer the time spent by the animal in that particular location. These distances were converted into time and totalled for each small block. Each block now provided an average time (minutes) the animal spent (grazed) in that particular area during the observation period.

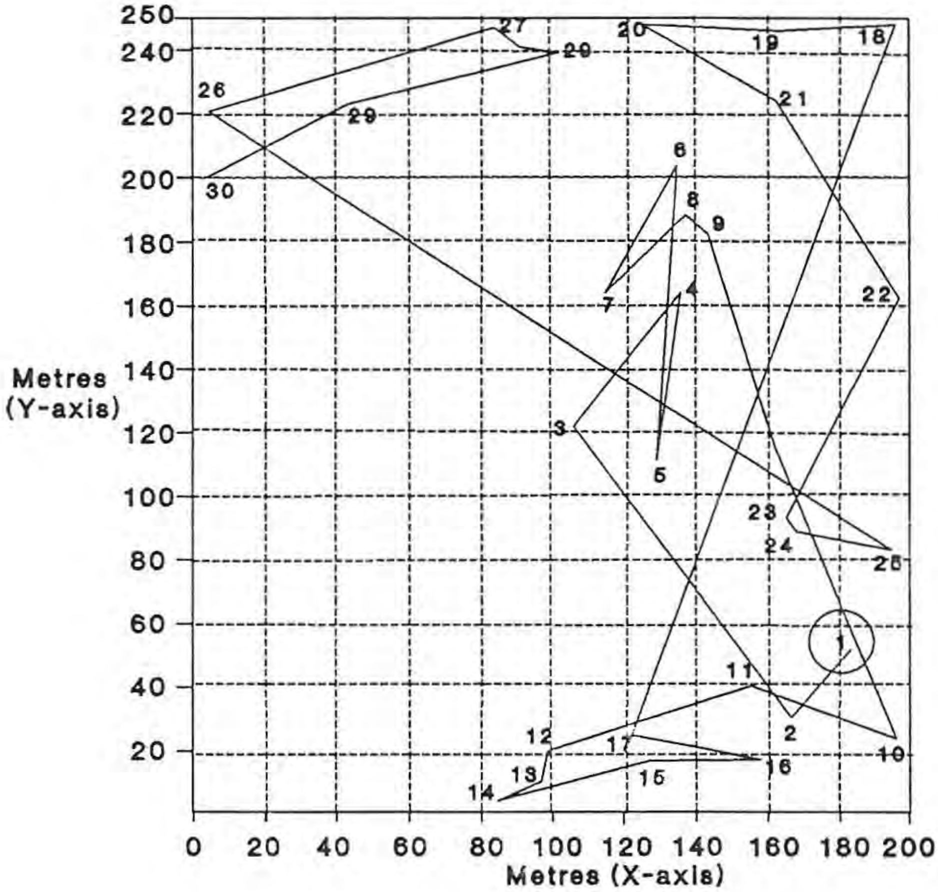


Figure 16 *An example of the division of a camp (Site A) into equally sized blocks (grids) and the recorded movement of a sheep at 15 minute intervals. The starting point is indicated by the small circle.*

The centre of each block served as a x and y co-ordinate to feed the average time (Ti) spent per block, as a z-value, into the Surfer computer programme. This programme takes all time co-ordinates into consideration to calculate and draw a time-occupation contour map (see Figure 18) of the sheep movements.

This figure thus depicts the average grazing pattern in the form of time-occupation contours for the observation period. The closer the contours the longer the time spent in that particular locality. Since the whole camp now consisted of time contours it became possible to lay a much finer grid (eg. the grid-blocks of the vegetation survey data) over these contours and to allocate, by inspection, a time unit for the smaller grid-blocks. The procedure described above was applied to all camps.

Every grid-block of each camp now carried a time unit (minutes) as well as its botanical composition according to the Group Classifications in Tables 1 & 2. Since the botanical composition for every block was known, an estimated grazing capacity for each block was allocated (by using the Ecological Index Method of Vorster, 1982) which added an extra parameter to the data. From the data ("layered data") a comprehensive and integrated picture could be obtained (Figure 17).

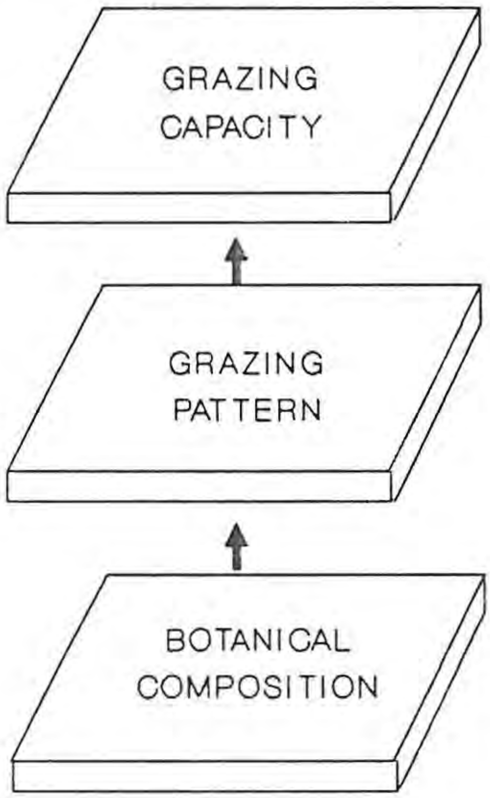


Figure 17 *Schematic representation of the 3 different "layers" of data that were analyzed for the project.*

5.3.2 Results and Discussion.

Figures 18 and 20 depict the average integrated grazing patterns in the four experimental camps according to time-occupation contours.

5.3.2.1 Site A (Figure 18 and 19).

It is clear that from the minute time-occupation contour map that the Dorpers (DA) avoided grazing in more than 50% of this camp (see Figure 18). The Merinos (MA), however, utilized a larger part of their camp although they tended to avoid the left and bottom left of the camp. It is also clear from the orthographic views that there were more periods of high intensity grazing in the Merino camp than in the Dorper camp. The longest average time the Dorpers grazed on a particular area was 13 minutes against the 25 minutes of the Merinos. The average time the Dorpers grazed per day during the observation period was 525 minutes(see Figure 19). This period consisted of two grazing periods, one in the morning (from 04:50 to 08:50) of 240 minutes and one in the afternoon (from 15:50 to 19:35) of 285 minutes. It must however be clearly understood that these patterns are governed by the distribution of species in the respective camps; the actual differences could only have been brought out by running the two flocks alternately in both camps. This could unfortunately not be accomplished due to the treatment established for the greater experiment lay-out. It is nevertheless very clear that patterns do exist as governed by vegetation composition.

The average time the Merinos grazed in camp MA was 555 minutes. This total time consisted of 4 grazing periods (see Figure 19). Two periods in the morning from 04:50 to 07:35 (165 min) and 08:50 to 10:05 (75 min). In the afternoon these were from 14:05 to 17:05 (180 min) and 17:20 to 19:35 (135 min). It is of interest to note that the Dorpers (camp DA) did not visit the watering point for drinking, during the daytime, while the Merinos drank water once in the afternoon from 17:05 up to 17:20 (15 min).

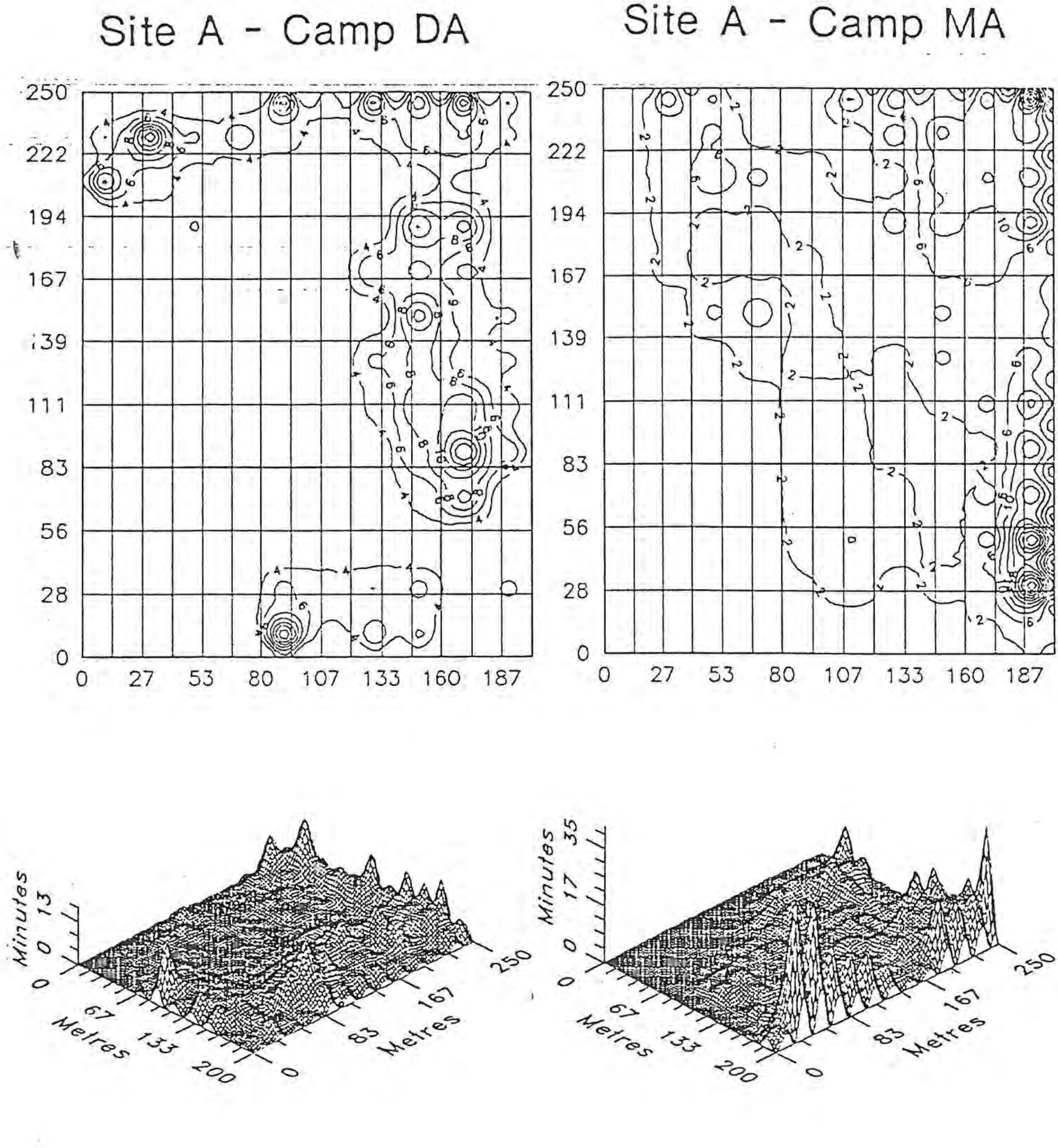


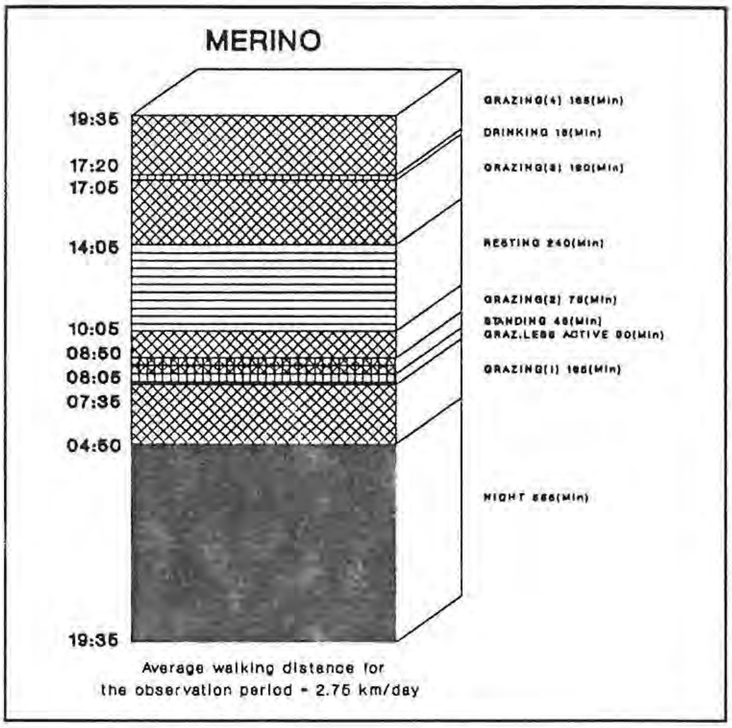
Figure 18 *Time-occupation contours with 2-minute intervals, for Dorpers and Merinos (Site A) with corresponding orthographic views of the contours. Peaks represent a greater time-occupation.*

The average walking distance for a Dorper during the observation period was 1.8 km/day and for a Merinos 2.75 km/day. The difference in distance was nearly one kilometre although the difference in grazing time only 30 minutes.

Figure 19 depicts the average grazing sequence for the Dorper and Merino wethers over the observation period. From these results it is clear that the Merinos walked more than the Dorpers to select food, or a suitable spot, where they could graze. Once such an area was located they tended to graze in this area for up to 25 minutes before searching for another suitable spot. The Dorpers, on the other hand, walked less to find food and never stayed more than 13 minutes on a particular spot. It also appears that the next preferred area was never far off. From these results it can be reasoned that Dorpers are not as selective as Merinos and are able to utilize the vegetation better than Merinos. Merinos on the other hand tend to walk more in search of food than the Dorpers; once a suitable spot was selected they can graze for up to 25 minutes on such a particular spot. Similarly here, it must be pointed out that this behaviour was in respect of the particular camps and cannot be summarily generalized.

Certain areas in the camps were over utilized by the Dorpers as well as by the Merinos, and other areas not utilized at all. It is also possible that once the preferred spot, or patch, had been sufficiently grazed they will move to other less preferred areas (less palatable vegetation) in the camp with an occasional re-visit to the previous "prime" spots.

From these results it can be concluded, for this particular vegetation composition, that the Merino appears to be a more selective grazer than the Dorper, and conversely, that the Dorper appears to be a less selective grazer and consequently utilizes a greater spectrum of species.



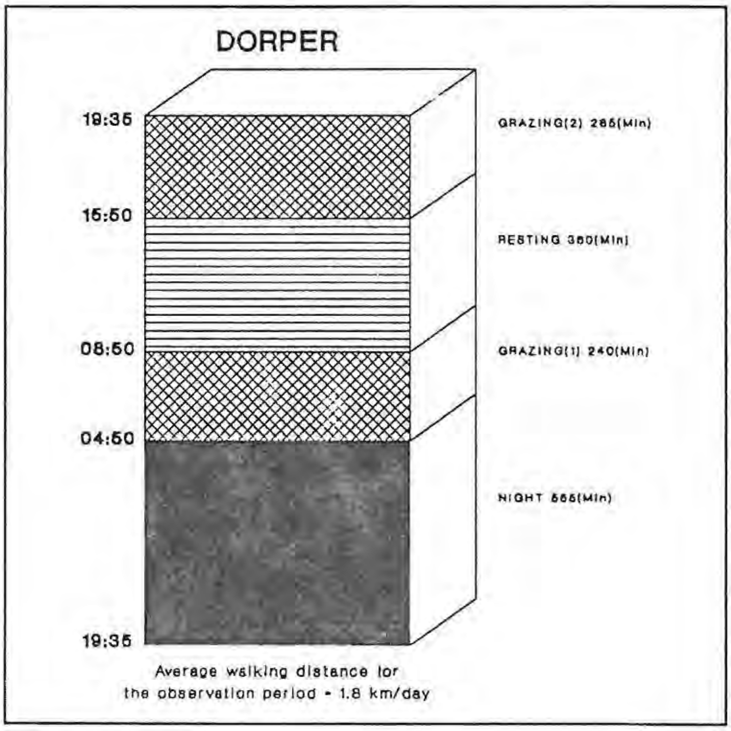


Figure 19 *The time subdivision of physical activities, displayed in minutes, of the Dorper and Merino sheep, on Site A. The time at which a particular action took place, as well as its duration in minutes, is shown.*

The resting period for the Dorpers was 360 minutes and for the Merinos, 240 minutes (Figure 19). Although the difference in the total grazing period was only 30 minutes, as pointed out above, the difference in resting was 120 minutes. In the grazing sequence for the Merinos 30 minutes were spent on a less active grazing period. During this period the Merinos were standing on one location in the camp and grazed occasionally on this spot. No serious grazing took place during this time (07:35 to 08:05). This was followed by a 45 minute period of standing still in one place.

5.3.2.2 Site B (Figure 20 and 21)

Figure 21 depicts the grazing sequence for the Dorpers and the Merinos. The situation in these two camps is more or less the same as for Site A. The Dorpers (DB) had not grazed an area of about 36% in this particular camp as observed over 3 days. For the Merinos (MB) this figure is about 45% (see Figure 20). The periods of grazing a particular area for the Dorpers never exceeded 18 minutes and that for the Merino's this figure was as high as 36 minutes on certain spots. The orthographic views gives an indication of where these preferred spots were (Figure 20).

The average grazing time for the Dorpers was 465 minutes and that for the Merinos, 570 minutes (Figure 21). The average grazing distance per day for the Dorpers was 2.23 km/day, and for Merinos 3.5 km/day. Again, as in Site A, there were two grazing periods for the Dorpers. The first period was in the morning from 06:30 until 10:45 (255 min). The second was in the afternoon from 15:00 to 18:30 (210 min). Inbetween was a resting period of 255 min (10:45 to 15:00).

For the Merinos there were five grazing periods (see Figure 21). The first one was from 06:30 to 07:45 (75 min) followed by a 45 min period from 08:00 to 08:45. The third and last period for the morning was from 09:15 to 11:00 (105 min). Two grazing periods followed in the afternoon from 12:30 to 13:30 (60 min) and from 13:45 to 18:30 (285 min).

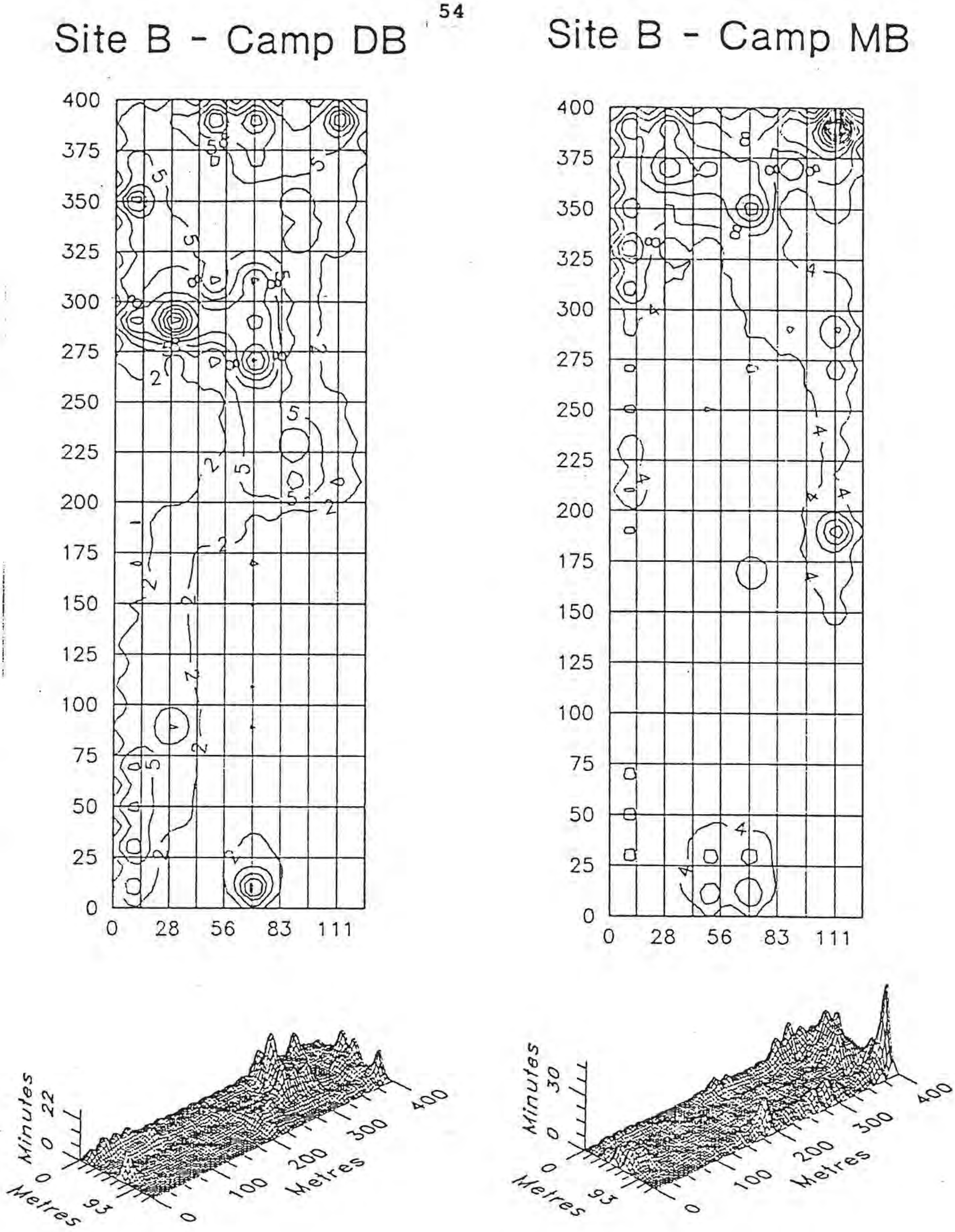


Figure 20 *Time-occupation contours with 2-minute intervals, for Dorpers and Merinos (Site B) with corresponding orthographic views of the contours. Peaks represent a greater time-occupation.*

The Merinos visited the watering point on two occasions during the day; once from 07:45 to 08:00 (15 min) and 13:30 to 13:45 (15 min). The Dorpers did not visit the watering point to drink during the daytime.

From these results, similar to that of Site A, the Merinos walked more than the Dorpers to select food or a suitable spot where they could graze; in this respect also being apparently more selective. Once such an area was found they tended to graze in this area for up to 35 minutes before searching for another suitable patch. The Dorpers on the other hand walked less to find forage and never stayed more than 18 minutes on a particular spot or patch.

It must be remembered that the camps had been grazed before, on the same basis, and not from the start of this study. Grazing patterns were thus already established and observations in the study can thus be regarded as a continuation of established patterns. Therefore, it can be safely argued that what has been recorded during the periods of observation reflect the selective grazing patterns of the sheep. From the results it can be concluded that the sheep preferred certain areas above others during the period of observation. These areas were over-utilized during this period as compared to the other areas.

Figures 18 and 20 were also used to allocate an average time for the grid-blocks in each camp (See Appendix B, Tables B1 to B4). By making use of these Tables, the average time allocated for each grid-block, as well as the botanical composition and the grazing capacity for a particular selected grid-block can be determined as follows: Select a specific grid-block number by making use of Figure 14 or 15. In Appendix B identify the required Site and Camp number. Look-up the number of the particular grid-block and read of the time, vegetation composition and grazing capacity for that particular selected grid-block or blocks.

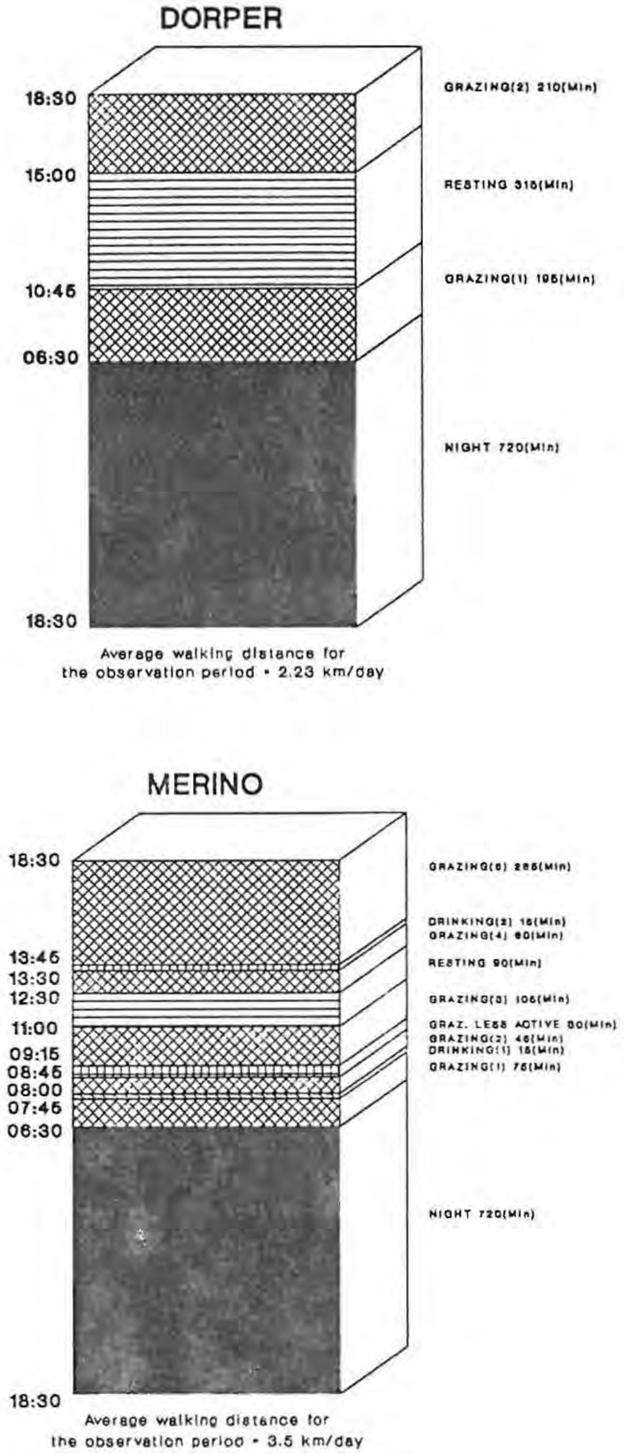


Figure 21 *The time subdivision of physical activities, displayed in minutes, of the Dorper and Merino sheep, on Site B. The time at which a particular action took place, as well as its duration in minutes, is shown.*

5.4 ANALYSIS OF DATA:

5.4.1 Statistical Analysis.

In each of the four experimental camps (DA, MA, DB and MB) two distinct areas were identified by using Figures 18 and 19 (time-occupation contours). The first area is where the highest concentration of time contours occur, and the second area, where there are no time contours. All these grid-block serial numbers are shown in Table 7.

Table 7 *The serial numbers of the grid-blocks that correspond with the identified High- and Low-occupation areas in the four camps.*

SITE A	High-occupation area	Low-occupation area
Camp DA	55;63;64;90;103;104 105;111;112;115;120 121 (n = 12)	1;2;3;4;5;6;7;10;11 12;13;14;15;16;19;20 21;22;23;24;25;28;29 30;31;32;33;34;35;37 38;39;40;41;42;43;44 47;48;49;50;51;52;53 57;58;59;60;61;62;66 67;68;69 (n = 54)
Camp MA	118;119;120;121;122 127;128;129;130;131 (n = 10)	1;2;3;4;5;10;11;12 13;14;19;20;22;23;28 29;30;31;32;37;38;39 40;46;47;48;49 (n = 28)
SITE B	**High-occupation area**	**Low-occupation area**
Camp DB	28;44;45;60;64;75;76 77;80;91;92;93;96; 106;128 (n = 15)	67;68;69;70;71;83;84 85;86;87;97;98;99 100;101;102;103;113 114;115;116;117;118 119;120;129;130;131 132;133;134 (n = 31)
Camp MB	13;14;15;30;31;32;46 47;48;62;63;64;78;79 80;94;95;96;110;111 112;127;128;143;144 (n = 25)	4;5;6;7;19;20;21;22 23;35;36;37;38;39;51 52;53;54;55;67;68;69 70;83;84;85;86;97;98 99;100;101;102;103 113;114;115;116;117 118;129;130;131;132 133;134 (n = 46)

In order to test statistically for the correlations that exist between time-occupation and the distribution of species, the following procedure was adopted.

A correlation matrix was created for each of the four camps by making use of the data in Appendix B (Tables B1; B2; B3; and B4). The two camps on Site A (DA & MA) each contain 135 (n = 135) grid-blocks and those of the camps on Site B (DB & MB), 144 grid-blocks (n = 144). These four matrixes (Appendix B, Tables B1 to B4) represent the camps as a whole. Another eight matrixes were created for the areas as set out in Table 7. The reason for the additional matrixes was to determine if there were significant correlations in the High-and-Low-occupation areas between the different variables in the different camps.

The correlation analysis procedure generates a matrix of correlation coefficients for each set of observed values. Correlation analysis often provides a preliminary view of the relationships among the variables, and also a normalized and scale-free measure of the linear association between two variables. The coefficient values lie between -1 and +1. A positive correlation indicates that the variables vary in the same direction, whereas a negative correlation indicates that the variables vary in the opposite direction. Statistically independent variables have an expected correlation of zero (Van Ark, 1981).

The computer programme, Statgraphics Ver.5 (1991), was used for the correlation analysis ($p=0.05$) on these twelve sets of data. The significance levels are based on the Student's t-distribution. If the values are small (less than 0.05) they indicate significantly non-zero correlations (Statgraphics Ver.5 Reference Manual, 1991).

5.4.2 Results and Discussion.

The results of the correlation analyses are displayed in Appendix C, Tables C1 to C12. Each correlation coefficient, r, is displayed in these tables with its corresponding significance level.

5.4.2.1. In Site A - Camp DA (Table 8).

The summarized results (Table 8) for all the blocks in Camp DA show that there is a negative correlation (r = -0.3766) between Time (Ti) spent grazing in the grid-blocks and the occurrence ***Aristida diffusa*** (Ad). R-squared (r^2) can now be calculated and this gives the proportion of variance of the variables, in this case, ***A. diffusa*** (Ad), that is associated with the other variable, Time (Ti), in a linear relationship. Since the correlation is negative, it indicates that if Time (Ti) increases then the count for ***A. diffusa*** is decreases and ***vice versa***. Since r^2 = 0.14, it indicates that only 14% of the variance of ***A. diffusa*** can explain the relation with Time. The presence of Pioneer Grass (r = 0.2563), Unpalatable Shrubs (r = 0.1446) and E. ericoides (r = 0.1635) have significant positive correlations in this camp as a whole with Time.

For the Low-occupation area r = 0.44 for the variables Ti and Ad (see Table 8). This indicates that where the Time-occupation in this camp (DA) is low, the chance of finding ***A. diffusa*** is approximately 19%. According to the results in Table 8 other species (OTHE) correlated (r = 0.613) best with a high-occupation time. Other Species (OTHE) is compiled from species not mentioned in Table 1, The Classification of Species, and appears in Table 4. Some of these species include ***Felicia muricata***, ***Indigofera alternans***, ***Pentzia globosa***, ***Phymaspermum parvifolium*** and ***Salsola calluna***. This clearly illustrates the preference of Dorpers for a type of mixed Karoobush vegetation which represents a retrogressive stage of grassland.

5.4.2.2 In Site A - **Camp** MA (Table 8).

In this camp it appears that Climax Grass (CG, r = 0.31) correlated significantly with the time-occupation (Ti) for the grid-blocks, and that there is a negative correlation between Time (Ti) and the variables Unpalatable Shrubs (US, r = -0.214), ***E.ericoides*** (Ee, r = -0.123) and Pioneer Grass (PG, r = -0.1577). In the Low and High-occupation areas all the correlations were of no significance except for Unpalatable Shrubs (US, r = 1) in the high occupation grid-blocks. The reason for this linear correlation of one (r=1) was that this particular variable (US) was a constant; all values for this variable (US), in the particular grid-blocks, was zero. This indicates that no Unpalatable Shrubs were present in these particular high-occupation grid-blocks.

Table 8 *The correlation coefficients (r) for Time (Ti, minutes) in relation to counts of the variables Sub-Climax grass (SG), Climax grass (CG), **Aristida diffusa** (Ad), Pioneer Grass (PG), Unpalatable Shrubs (US), **Eriocephalus ericoides** (Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha), as well as levels of significance for Site A.*

	Camp DA			Camp MA		
Variable	Total Blocks n = 136	Low n = 54	High n = 12	Total Blocks n = 136	Low n = 28	High n = 10
	Ti	Ti	Ti	Ti	Ti	Ti
SG	-0.0210 N.S	-0.0186 N.S.	-0.2263 N.S.	-0.0657 N.S.	0.0132 N.S.	-0.0817 N.S.
CG	-0.8960 N.S.	0.1839 **	-0.2425 N.S.	0.3052 ***	-0.1631 N.S.	0.3701 N.S.
Ad	-0.3766 ***	0.4377 ***	-0.3335 N.S.	0.0233 N.S.	-0.0754 N.S.	-0.4185 N.S.
PG	0.2563 ***	-0.5736 ***	0.1236 N.S.	-0.1577 ***	0.2014 N.S.	-0.3996 N.S.
US	0.1446 ***	-0.2325 ***	0.4306 N.S.	-0.2124 ***	0.1971 N.S.	1.0000 ***
Ee	0.1832 ***	0.0359 N.S.	0.1795 N.S.	-0.1232 ***	-0.0800 N.S.	0.0647 N.S.
OTHE	0.1635 ***	-0.2269 ***	0.6136 ***	-0.0768 N.S.	0.0140 N.S.	-0.1140 N.S.
SSU/ha	-0.3642 ***	0.5418 ***	-0.4424 *	0.2899 ***	-0.1984 N.S.	0.2962 N.S.

P < 0.001 (***) Significance level is between 0.0000 and 0.001
P < 0.01 (**) Significance level is between 0.001 and 0.01
P < 0.05 (*) Significance level is between 0.01 and 0.05
P ≥ 0.05 NS = Not significant

5.4.2.3 In Site B - Camp DB (Table 9).

For the total grid-blocks, both Geophytes (Geo, r = 0.347) and Climax Grass (CG, r = 0.298) have a significant positive correlation with Time (Ti). Pioneer Grass (PG, r = -0.229), Less Palatable Shrubs (LPS, r = -0.198) and ***A. diffusa*** (Ad, r = -0.191) have significant negative correlations with Time (Ti).

In the Low-occupation grid-blocks, Geophytes, (Geo), was negatively correlated (r = -0.30) with Time (Ti). For the High-occupation grid-blocks (area) none of the variables correlated significantly positively or negatively. This infers that the occurrence of the vegetation variables in these areas, presumably did not have a significant effect on time spent grazing in these areas.

5.4.2.4 In Site B - Camp MB (Table 9).

A. diffusa (Ad, r = -0.161) correlated negatively and Geophytes (Geo, r = 0.243) positively with Time-occupation (Ti) for all the grid-blocks. In these Low time-occupation grid-blocks there is also a significantly positive correlation for ***A. diffusa*** (r = 0.241) and a negative correlation for Climax Grass (r = -0.234). This means that the Merinos tend to avoid areas where ***A. diffusa*** is abundant. In the areas where Time-occupation is low, the chances of finding Climax Grass is small.

In the High-occupation grid-blocks, Climax Grass (CG), in relation to Time-occupation, has a correlation coefficient of 0.626 at P<0.001. This means that Merinos prefered areas in the camp where Climax Grass is abundant. Sub-Climax Grass (SG), Palatable Shrubs (Ps), Other Species (OTHE), and Grazing Capacity SSU/ha), in relation to Time-occupation, have r-values of 0.433, 0.292, 0.302 and 0.410, respectively. ***A. diffusa*** (r = -0.339) and Geophytes (r = -0.335) correlates negatively with Time-occupation.

By making use of Appendix C, Tables C1 to C12, the correlation between the rest of the variables can be checked. For eg. in Camp DA (Appendix C, Table C1) there is a negative correlation (r = -0.533) between Pioneer Grass (PG) and ***A. diffusa*** (Ad) and a positive correlation (r = 0.661) between ***A. diffusa*** and Grazing Capacity (SSU/ha). In Camp MB (Appendix C, Table C10), ***A. diffusa*** correlates significantly negative with all the other plant variables. This indicates that where ***A. diffusa*** is abundant in a camp, other species will be sparce or absent.

Table 9 *The correlation coefficients (r) for Time (Ti, minutes) in relation to the individual counts of the variables Sub-Climax grass (SG), Climax grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LSP), Geophytes (Geo),* ***Eriocephalus spinescens*** *(Es), Palatable Shrubs (Ps), Unpalatable Shrubs (US) and Grazing Capacity (SSU/ha), as well as levels of significance for Site B.*

	Camp DB			Camp MB		
Variable	Total Blocks n = 144	Low n = 31	High n = 15	Total Blocks n = 144	Low n = 46	High n = 25
	Ti	Ti	Ti	Ti	Ti	Ti
SG	-0.0371 NS	-0.0791 NS	0.0206 NS	0.0853 NS	-0.1175 NS	0.4334 ***
CG	0.2988 ***	-0.1071 NS	0.1164 NS	0.0759 NS	-0.2347 ***	0.6265 ***
Ad	-0.1906 ***	-0.0267 NS	-0.1478 NS	-0.1615 ***	0.2412 ***	-0.3394 ***
PG	-0.2298 ***	0.0480 NS	-0.0543 NS	0.0144 NS	-0.0990 NS	-0.0931 NS
LPS	-0.1982 ***	-0.2526 *	-0.0408 NS	-0.0800 NS	-0.0573 NS	0.0165 NS
Geo	0.3476 ***	-0.3008 ***	-0.0616 NS	0.2434 ***	0.0643 NS	-0.3358 **
Es	0.0780 NS	0.1859 NS	-0.1227 NS	-0.0631 NS	0.0667 NS	-0.1699 NS
Ps	-0.0312 NS	-0.0039 NS	0.1224 NS	-0.0296 NS	0.2773 NS	0.2927 *
US	0.0121 NS	0.2253 NS	0.0489 NS	-0.0765 NS	0.0728 NS	0.0829 NS
OTHE	-0.0299 NS	0.2473 *	0.1341 NS	-0.0274 NS	-0.1018 NS	0.3029 *
SSU/ha	0.0390 NS	-0.1174 NS	0.0662 NS	-0.0764 NS	-0.0019 NS	0.4107 ***

P < 0.001 (***) Significance level is between 0.0000 and 0.001
P < 0.01 (**) Significance level is between 0.001 and 0.01
P < 0.05 (*) Significance level is between 0.01 and 0.05
P ≥ 0.05 NS = Not Significant

5.4.3 Summary of Analysis of data.

There was a negative correlation (r = -0.3766) in Camp DA (Dorpers, Block A) between Time (Ti) spent grazing in the grid-blocks and the occurrence of ***Aristida diffusa***. Pioneer Grass (r = 0.2563), Unpalatable Shrubs (r = 0.1446) and ***Eriocephalus ericoides*** (r = 0.1635) have low positive correlations with Time (Ti) in this camp as a whole.

In Camp MA (Merinos, Block A), Climax Grass (r = 0.31) correlated significantly with time-occupation (Ti) for the grid-blocks in this camp. There was a negative correlation between Time (Ti) and the variables, Unpalatable Shrubs (US, r = -0.214), ***E. ericoides*** (Ee, r = -0.1577) and Pioneer Grass (PG, r = -0.1577). No Unpalatable Shrubs (US) were present in the High-occupation grid-blocks.

In the Low-occupation grid-blocks for Camp DB (Dorpers, Block B), Geophytes (Geo) was negatively correlated (r = -0.30) with Time (Ti). There were no significant correlations for any of the other variables in the High-occupation grid-blocks which infers that the occurrence of the vegetation variables in these areas, presumably did not have an influence on the occupation time grazing in these areas.

In Camp MB (Merino, Block B) it was clear that there was a high correlation (r = 0.626) between Time (Ti) spent grazing and the occurrence of Climax Grass (CG) in the High-occupation grid-blocks. There was also a tendency for the Merinos to have avoided areas where ***Aristida diffusa*** was abundant.

Overall, it was clear, that area- and species selective grazing did occur within areas occupied by the sheep.

5.5 PHYTOMASS

5.5.1 Methods.

The aim of phytomass determinations was to determine whether there was a difference in the phytomass on the different areas frequented or not frequented (High- and Low-occupation areas) (see Table 7) by the animals, as well as to determine the vegetation composition on a mass basis. The following procedure was followed:

In each of the four camps DA, MA, DB and MB, two representative areas were demarcated in which to determine phytomass. In each of these areas eight 5 m^2 quadrats were laid out randomly. One of these areas, per camp, was situated in localities most frequently visited by the grazing animals, and the other area not visited at all by the animals during the period of observation.

For every area 8 x 5 m^2 (40 m^2) of vegetation was harvested at ground level. The total area harvested in every camp (eg. DA) was 80 m^2. The vegetal material was sorted into similar species and then oven-dried at 50°C for 24 hr. The results were expressed in kg dry matter per hectare (kg/ha).

5.5.2 Results and Discussion.

5.5.2.1 Camp DA.

From Appendix D, Table D1, it is clear that in the area of High time-occupation, *Eriocephalus ericoides* (1857 kg/ha) was the greatest contributor to the total phytomass of 2830.25 kg/ha. This was followed by *Sporobolus fimbriatus* (375.75 kg/ha), *Pteronia glauca* (108 kg/ha) and *Eragrostis lehmanniana* (84 kg/ha). It is of interest to note that 31.25% of the Dorpers' diet, as determined with the fistulated animals for this area, consisted of *E. ericoides* (See Table 10).

Aristida diffusa (2639.5 kg/ha) was by far the largest contributor to the total phytomass of 3241.2 kg/ha for the low time-occupation area (see Appendix D, Table D1) followed by ***E. ericoides*** with 241.5 kg/ha. Although ***E. ericoides*** was not abundant, it contributed 32.44% (See Table 10) to the total diet selected on this location. From these results it seems that if the Dorpers had a choice (they were confined to these areas to select their diets) they would have avoided an area where ***A. diffusa*** is abundant.

5.5.2.2 Camp **MA**.

For both the High- and Low-occupation areas *E. ericoides* (high - 1903.5 kg/ha ; low - 1625 kg/ha) was the greatest contributor to the total phytomass (See Appendix D, Table D2). In the area of low occupation *P. tricephala* (1528 kg/ha) was second; the total phytomass for this low occupation area was 4296.74 kg/ha. This total is 1447.29 kg/ha more than that for the high occupation area with a total phytomass of 2849.45 kg/ha. *A. diffusa* adds 833.5 kg/ha to the total of the low occupation area and *A. congesta* was 459.3 kg/ha for the high-occupation area. Sub-Climax grass (for example, *Eragrostis lehmanniana*) form the largest part of the Merino's diet on both localities with 67.32% (high) and 65.37% (low) respectively (See Table 11).

These results indicate that *A. diffusa* (fibrous grass) and *P. tricephala* (unpalatable shrub) may be singled out as the main reason for the Merinos not grazing in areas where one or both of these species were abundant.

5.5.2.3 Camp DB.

The total phytomass for the High-occupation locality is 2352.63 kg/ha, and for the Low-occupation area, 2136.42 kg/ha (See Appendix D, Table D3). *Eriocephalus spinescens* was the most abundant in this locality with a total mass of 817 kg/ha. This is followed by *Sporobolus fimbriatus* (434 kg/ha) and *Pentzia globosa* (369.5 kg/ha).

In the Low-occupation area, ***E. spinescens*** was the most abundant with a phytomass of 747 kg/ha. This is followed by ***P. incana*** (380 kg/ha), ***E.ericoides*** (175 kg/ha) and ***Phymaspermum parvifolium*** (161 kg/ha).

The diet selected by the Dorpers (See Table 12) in the High occupation area consisted mainly of Sub-Climax Grass (52.05%), ***Helichrysum dregeanum*** (18.66%) and Climax Grass (11.32%). In the low occupation area, Sub-Climax Grass formed 79.96% of the diet, followed by ***P. incana*** (14.13%). It seems that Climax Grass (in this case ***S. fimbriatus***), since it is a very palatable component, may have played a role in influencing the grazing pattern of the Dorpers in this particular camp to some extent.

5.5.2.4 Camp MB.

The total phytomass for the High- and Low-occupation areas was 2034.78 kg/ha and 2654 kg/ha, respectively (See Appendix D, Table D4). ***E. spinescens*** (807 kg/ha), ***E.ericoides*** (216.5 kg/ha) and ***Phymaspermum parvifolium*** (152.3 kg/ha) have contributed the largest proportion to the phytomass of the High-occupation area. For the Low-occupation area ***A. diffusa*** (955.8 kg/ha), ***E. spinescens*** (807 kg/ha), ***Pentzia incana*** (210 kg/ha) and ***S. fimbriatus*** (128.8 kg/ha) made the largest contribution to the phytomass. Again it seems as if a high incidence of ***A. diffusa*** "repels" the Merinos from certain areas in the a camp. Although a climax grass like ***S. fimbriatus*** occurred in the Low-occupation area more abundantly than in the High-occupation area, the Merinos avoided these areas. Apparently Merinos do not prefer the taller Climax Grasses.

5.5.3 Summary of Phytomass.

From the results it was clear that in Camp DA, ***Eriocephalus ericoides*** was the most abundant in the High time-occupation area. This shrub contributed 65% to the total mass clipped in this high frequented area and formed 31.25% of the diet selected in this area. In the Low time-occupation area, *Aristida diffusa* formed 81.3% of the phytomass. ***E. ericoides*** formed 7.5% of the phytomass in this area and contributed 32.44% to the diet selected by the Dorpers in this area.

This clearly showed that the shrub, ***E. ericoides*** formed an important part of the diet in spite of the fact that it little to the phytomass. These results showed, that irrespective of the contribution of E. ericoides to the phytomass, it was an important dietary species.

In Camp MA, ***E. ericoides*** was the main contributor to the total phytomass for the High as well as the Low-occupation areas. For the Low-occupation area, ***Pteronia tricephala*** rated second. In both these localities Sub-Climax Grass formed the largest part of the Merinos' diet. The results also indicated that ***A. diffusa*** and *P. tricephala* could be singled out as the main reason for the Merinos not grazing in areas where one, or both, of these species were abundant. These species are undoubtedly not preferred dietary species.

In Camp DB, ***E. spinescens*** was the most abundant (approximately 35%) on both the High-and-Low areas. This was followed by ***Sporobolus fimbriatus*** for the High-occupation area. It seems Climax Grass may have played a role in influencing the grazing pattern of the Dorpers in this camp to some extent.

In Camp MB, ***E. spinescens*** formed 39.6% of the total mass clipped in the High-occupation area and ***A. diffusa*** 36% in the Low-occupation area. It seems that a high incidence of ***A. diffusa*** "repelled" the Merinos from certain areas in the camp.

5.6 FISTULA STUDIES:

5.6.1 Methods.

To determine the diet selection of the different animals oesophageal fistulated Dorper and Merino wethers (Figure 22) were used.

Figure 22 *Two of the oesophageal fistulated Dorpers that were used for the determination of the diet composition for this breed. The Dorper on the left is fitted with a stoppered fistula, i.e. when the animal is not used for diet selection; the one on the right is fitted with the collection bag. In this latter case the stoppered fistula is removed to allow the food to collect in the bag and not to pass to the rumen.*

Fistulation was basically done according to the method devised by Heady & Torell (1959). Four fistulated Merinos and four fistulated Dorpers were used for diet sampling in camps DA and MA, and DB and MB. Sampling took place over a period of two days after the animals were allowed ten days to become accustomed to the terrain and vegetation. On day one the animals were allowed to graze only on that area of the camp that was most frequently grazed, as was determined beforehand from the occupation time study. On day two the animals were allowed to graze in the area least frequently grazed. Technical staff were used to discreetly confine the animals to the High- and Low-occupation areas to ensure that diet selection took on these areas. Owing to the relative tameness of the animals this herding action posed no problem and the operation was regarded to be successful in terms of the objective.

The samples obtained from the Dorpers, on each of the sampling days, were thoroughly mixed and a composite sample used to determine the composition of the diet for a particular area. The same procedures were followed for the Merinos.

The microscopic point-method of Heady & Torell (1959) was followed to determine the floristic composition of the diet samples. Five-hundred point samples were determined under the microscope for each composite sample. Every plant particle recorded by a sampling "point", i.e. a crosshair in the microscope eyepiece, was identified up to species level and removed from the sample by means of a pincette and placed in a petri-dish. All species were kept separate. An exception was made in the case of grass, since it was not only time consuming but also difficult to determine the species of grass in the chewed sample. The grasses were however grouped into two different groups namely those with broad leaves (usually Climax Grasses) and those with narrow leaves (Sub-Climax Grass). All samples were oven dried at 50°C for 24 hr. The dried matter was weighed and the species finally expressed as percentages. This provided as accurate a measure as possible of the diet composition selected by the animals.

5.6.2 Results and Discussion.

Tabels 10 to 13 show the results of the diet selected by the different animals on the different localities (High and Low) in each of the experiment camps.

5.6.2.1 Camp DA (see Table 10).

The diet selected by the Dorpers in the two localities (DA and DB) was obviously very similar. The diet in the high occupation locality consisted mainly of Sub-Climax grass (40.2%), ***E. ericoides*** (31.25%), Climax grass (11.82%), ***Thesium hystrix*** (7.29%) and ***Felicia muricata*** (5.66%). The diet for the Low occupation area is Sub-Climax grass (51.28%), ***E. ericoides*** (32.44%), ***F. muricata*** (10.38%) and Climax grass (3.39%). The species composition (as determined with the phytomass clipping technique) of the two areas, was quite different (compare with Table D1, Appendix D). Phytomass, therefore, on a species basis, differs markedly from the diet selected on the same area. It is clear that the determination of phytomass has but little in common with the actual diet selected. In the first instance it is a case of non selective clipping, and in the second a case of definite diet selection.

Table 10 *The diet composition, on a percentage basis, of Dorpers in camp DA according to the fistula technique, in the High- and Low-occupation areas.*

SPECIES	High %	Low %
Sub-Climax grass	40.20	51.28
Eriocephalus ericoides	31.25	32.44
Climax grass	11.82	3.39
Thesium hystrix	7.29	0.00
Felicia muricata	5.66	10.38
Pentzia incana	0.91	0.00
Salvia verbenaca	0.48	1.99
E. spinescens	0.19	0.18
Plinthus karooicus	0.15	0.00
Tricodiadema pomeridianum	0.03	0.33
Helichrysum dregeanum	0.03	0.00
Dimorphotheca zeyheri	0.03	0.00
Total	100.00	100.00

5.6.2.2 Camp MA (See Table 11).

The diet selected by the Merinos on the High occupation area consisted mainly of Sub-Climax Grass (67.32%), Climax Grass (19.94%), ***E. ericoides*** (5.73%) and ***F. muricata*** (3.51%). On the Low occupation area the animals mostly selected Sub-Climax Grass (65.37%), Climax Grass (24.22%), ***E. ericoides*** (5.82%) and ***Trichodiadema pomeridianum*** (1.39%). The diet on both areas (High and Low) was very similar, although there was a considerable difference in species composition of the two areas as determined with the phytomass clipping technique (Compare with Table D2, Appendix D).

Table 11 *The diet composition, on a percentage basis, of Merinos in camp MA according to the fistula technique, in the High- and Low-occupation areas.*

SPECIES	High %	Low %
Sub-Climax grass	67.32	65.37
Climax grass	19.94	24.22
Eriocephalus ericoides	5.73	5.82
Felicia muricata	3.51	1.35
Chrysocoma tenuifolia	1.07	0.00
Pentzia incana	1.00	0.00
Gnidia polycephala	0.90	0.00
E. spinescens	0.32	1.38
Tricodiadema pomeridianum	0.17	1.39
Indigofera alternans	0.03	0.00
Helichrysum dregeanum	0.00	0.47
Total	100.00	100.00

5.6.2.3 Camp DB (See Table 12).

In the High-occupation area the diet of the Dorpers consisted mainly of Sub-Climax Grass (52.05%), ***Helichrysum dregeanum*** (18.66%), Climax Grass (11.32%), ***Trichodeadema pomeridianum*** (9.16%), ***Eberlanzia ferox*** (3.28%) and ***Pentzia incana*** (2%). ***H. dregeanum*** and ***T. pomeridianum*** are very palatable karoobush species. ***E. ferox*** is classified as unpalatable due to the presence of long, thin, spines on the stems (Blom, 1981). ***P. incana*** is a less palatable shrub but a very eatable species. It has eg. been shown by du Preez (196*) that an apparently unpalatable and inedible species ***Eberlanzia ferox***, is in fact palatable but that the precence of sharp thorns deters the grazing animal. When the spines are removed such as presenting it in pelleted form it is readily eaten. By examining the phytomass results (See Table D3, Appendix D) for this High area it is of interest to note that ***H. dregeanum***, and ***P. incana*** are not included in this table due to the low frequency of these plants in this specific area. The Dorpers, therefore, must have exercised a considerable degree of selectivity for choosing their diet in this area. Climax grass, ***S. fimbriatus*** occurred very abundantly, similarly the shrub ***E. ferox***. The highly palatable ***T. pomeridianum*** was also present in this area. Although the greater part of the diet (52.05%) was Sub-Climax Grass, it was not abundant.

In the Low-occupation area the diet was Sub-Climax Grass (79.96%) followed by the *P. incana* (14.13%) and ***Felicia muricata*** (2.41%), which is a very palatable shrub. According to Table D3, Appendix D (Phytomass for this area), ***P. incana*** and ***F. muricata*** are present in this area. The Sub-Climax grasses ***Eragrostis lehmanniana***, ***A. diffusa*** and ***E. obtusa*** are very sparse in this area although the larger proportion of the diet consisted of these grasses.

Table 12 *The diet composition, on a percentage basis, of Dorpers in camp DB according to the fistula technique, in the High- and Low-occupation areas.*

SPECIES	High %	Low %
Sub-Climax grass	52.05	79.96
Helichrysum dregeanum	18.66	0.13
Climax grass	11.32	1.83
Tricodiadema pomeridianum	9.16	0.43
Eberlanzia ferox	3.28	0.18
Pentzia incana	2.00	14.13
Cynodon incompletus	1.73	0.00
Eriocephalus ericoides	0.77	0.00
Delosperma tuberosum	0.74	0.52
Phymaspermum parvifolium	0.27	0.00
Chrysocoma tenuifolia	0.00	0.34
Lessertia paucifolia	0.00	0.07
Felicia muricata	0.00	2.41
Total	100.00	100.00

5.6.2.4 Camp MB (See Table 13).

The diet of the Merinos in the High-occupation area are, Sub-Climax Grass (74.28%), Climax Grass (17.4%), *P. incana* (4.67%) ***F. muricata*** (3.4%), ***H. dregeanum*** (2.38%) and *T. pomeridianum* (2.12%). ***P. incana*** and ***H. dregeanum*** were not encountered for clipping in this area (see Table D4, Appendix D). *F. muricata*, ***H. dregeanum*** and ***T. pomeridianum*** is classified by Blom (1981) as Palatable Shrubs and *P. incana* as a Less-Palatable Shrub. Sub-Climax Grass which formed the largest proportion of the diet was also not abundant in this area but nevertheless constituted a significant contribution to the diet selected. ***E. ericoides*** and ***E. spinescens*** is very abundant in this area, but the sheep hardly touched these.

Table 13 *The diet composition, on a percentage basis, of Merinos in camp MB according to the fistula technique, in the High- and Low-occupation areas.*

SPECIES	High %	Low %
Sub-Climax grass	74.28	64.91
Climax grass	17.40	17.93
Pentzia incana	4.67	7.44
Felicia muricata	3.40	3.78
Helichrysum dregeanum	2.38	0.14
Tricodiadema pomeridianum	2.12	1.16
Helichrysum lucillioides	1.06	0.00
Eberlanzia ferox	0.85	2.25
Lessertia paucifolia	0.64	0.34
Eriocephalus spinescens	0.25	1.27
E. ericoides	0.17	0.02
Dimorphotheca zeyheri	0.13	0.04
Delosperma tuberosum	0.13	0.00
Indigofera alternans	0.00	0.16
Chrysocoma tenuifolia	0.00	0.34
Gnidia polycephala	0.00	0.95
Total	100.00	100.00

In the Low-occupation area the diet selection was very similar to that in the High-occupation area. Sub-Climax grass (64.91%), Climax grass (17.93%), ***P. incana*** (7.44%), ***F. muricata*** (3.78%) and *E. ferox* (2.25%) formed the major part of the diet. According to the phytomass results (see Table D4, Appendix D) most of the species selected are present in this area. ***A. diffusa***, an awned grass, is the most abundant plant in this area. By direct observation of the animals, it appeared that there was a definite tendency for them to avoid areas where this grass was very abundant. When confined to graze in such an area, the diet selected was not very different from that in those areas where the animals preferred to graze. The logical explanation is that the animals (Dorpers as well as Merinos) generally avoid areas where *A. diffusa* is very abundant.

5.6.2.5 Chemical Properties.

The results of chemical analysis done by Louw, Steenkamp & Steenkamp (1968) and Steenkamp & Hayward (1979) were used to determine some of the nutritional properties of most of the species in the diet selected by the sheep (Table 14). This was done to see if there was a relationship between some of the nutritional properties and the preference for selecting certain species or avoiding them.

Table 14 *Nutritional properties of some of the species that occurred in the diet selection of the sheep. Note that* ***Pteronia tricephala****, an unpalatable shrub, is included in this list, but was not selected by the sheep in their diet.* ***Aristida diffusa*** *is also included due to its high occurrence in the botanical surveys.*

SPECIES	EE%	CP%	CF%	NFE%	K%	P%
Sub-Climax Grass	1.7	4.4	31.8	54.5	0.28	0.07
Climax Grass	2.3	10.7	26.9	50.7	0.61	0.11
Aristida diffusa	1.3	3.7	33.6	50.6	0.23	0.05
Chrysocoma tenuifolia	14.1	8.6	21.5	48.8	1.42	0.13
Eriocephalus ericoides	2.4	4.3	46.5	41.9	0.92	0.12
E. spinescens	2.1	7.5	41.7	41.6	1.49	0.12
Felicia muricata	6.7	12.3	22.3	50.3	0.74	0.13
Helichrysum dregeanum	2.8	6.3	30.4	52.0	0.58	0.06
Pentzia incana	2.8	5.7	43.7	41.9	1.15	0.09
Pteronia tricephala	10.3	8.0	21.4	53.5	1.35	0.12

Explaination:

EE - Ether extract CP - Crude protein
CF - Crude fibre NFE - Nitrogen free extract
P - Phosphorus K - Potassium

According to Brendon, Stewart and Dugmore (1987), crude protein (CP) is the sum of nitrogen in true protein and non-proteinic nitrogen multiplied by 6.25. Ether Extract (EE) is the crude oil or crude fat fraction of the feeds; Crude Fibre (CF) is the poorly digestible fraction of carbohydrates composed mainly of lignin, cellulose and hemicelluloses; and Nitrogen Free Extract (NFE) is the highly digestible fraction of carbohydrates.

According to Mentis (1981a) the preferences exhibited by animals have been correlated positively with crude protein, sugar content, fats, phosphorus and potassium. On the other hand there was a negative correlation with lignin and crude fibre.

Table 14 also suggests that a high ether extract (EE) in species influence the palatability negatively. Both ***Chrysocoma tenuifolia*** and ***Pteronia tricephala*** are high in ether extract. Allthough ***P. tricephala*** was available in the camps, it never occurred in the diet selected during the sampling period. ***C. tenuifolia*** was selected in very small quantities (approximately 0.34%) by Dorpers and Merinos. ***Felicia muricata*** and Climax Grass are relatively high in crude protein and low in ether extract. Both these species formed an important part of the diet of the Dorpers and the Merinos.

5.6.3 Summary of Fistula studies.

The diet selected by the Dorpers in Camp DA on the High- and-Low-occupation areas was very similar. Sub-Climax grass, ***Eriocephalus ericoides*** and Climax Grass formed the largest proportion of the diet. For the Merinos, in Camp MA, the selection was very similar.

In the High-occupation areas in Camp DB, the Dorpers selected Sub-Climax Grass (52%), ***Helichrysum dregeanum*** (18.66%) and Climax Grass (11.32%), and Sub-Climax Grass (79.96%), ***Pentzia incana*** (14.13%) and ***Felicia muricata*** (2.41%) in the Low-occupation area. From these results it was clear that Dorpers prefer grass to shrubs.

The Merinos in Camp MB selected Sub-Climax Grass (70%), Climax Grass (18%), ***Pentzia incana*** (6%) and ***Felicia muricata*** (3.6%) as the biggest part of their diets in the High- and-Low occupation areas. Similarly as with Dorpers, grass was preferred

Although there are considerable differences in the vegetation composition in all the High- and-Low occupation areas in the four camps, the sheep more or less preferred the same dietary compositions.

5.7 PHENOLOGY

5.7.1 Methods.

It is a well-known fact that the phenological stage of a plant plays a very important role in the diet selection of sheep. So e.g. will sheep readily graze fresh grass (as in summer) but will not readily graze dry grass (as in winter). Danckwerts (1984) found that the digestibility, due to the time of the year, of Sweetveld drops from about 64% digestibility in spring to about 57% digestibility in winter. Also when some species are flowering sheep will select some species in considerable quantities, when not in flower. Danckwerts (1987) also found that, during certain times of the year, plants are more sensitive to grazing. He also showed, by isolating the effect of time of the year, that ***Sporobolus fimbriatus*** and ***Themeda triandra*** are particularly sensitive to perturbations in spring.

It is therefore advantageous to determine the phenological cycles of the main species to arrive at some conclusion as to the phenological stage of a species at the time it was selected for grazing.

The growth stage of a plant is also a factor that influences the palatability of a plant. Animals prefer younger growth to that of older growth. Flower buds, flowers, fruit and seeds are high on the priority list of grazers because there is a lot more crude protein, fats and carbohydrates in them than in the leaves and stems. With the maturing of grass the crude protein, fibre and lignin content increases and makes the grass less acceptable to sheep. Sheep and cattle also concentrate more on eating leaves and fruit than stems (Heady & Torrel, 1959). It must be kept in mind that the observations (to determine the grazing pattern) of the animals were in early January 1990 (for Site A) and late March 1990 (for Site B). So where species were selected during this period, the phenologic stages at that time can be determined from Figures 24 to 29 or Appendix E, Table E1 to E3.

For this study an exclosure paddock (2 ha) near Site B was erected. In this paddock small communities and representative species were marked with a 16 gauge steel wire with a metal tag (10 x 7 cm) attached. The names of the species were stamped on the tags. By these identifications the communities and species were easy to relocate quickly. Nine communities, predominantly grass, and nine karoo bush communities were scored. Table 11 is a list of the plants that were phenologically scored, and their different group classifications according to Blom (1981).

Table 15 *The species that were scored for phenological development.*

GROUP CLASSIFICATION	SPECIES
PIONEER GRASS	*Aristida congesta*
	Tragus koelerioides
SUBCLIMAX GRASS	*Eragrostis lehmanniana*
	E. obtusa
	Aristida diffusa
CLIMAX GRASS	*Digitaria eriantha*
	E. curvula var.conferta
	Sporobolus fimbriatus
	Themeda triandra
PALATABLE SHRUBS	*Phymaspermum parvifolium*
LESS PALATABLE SHRUBS	*Eriocephalus ericoides*
	E. spinescens
	Pentzia globosa
	P. incana
UNPALATABLE SHRUBS	*Pteronia glauca*
	P. glomerata
	P. tricephala
	Rosenia humilis

A field scoring sheet was drawn-up to score the different phenophases of the species (Figure 23). The phenological data were collected every third week over a period of 500 days on 18 species. The observations started on the 1st of July 1989 and ended on the 15th November 1990. After a thorough investigation of a community the phenophases were scored according to the scales set out in Figure 23 (the field scoring sheet).

CAMP No: ________ SPECIES:		DATE:						
ITEM	**CATEGORY**							
i- ENVIRONMENTAL CONDITION	1-Arid							
	2-Dry							
	3-Moderate							
	4-Moist							
ii- PLANT CONDITION	1-Dry							
	2-Moderate							
	3-Fresh							
	4-Very fresh							
iii- STEM & SHOOT GROWTH	1-None							
	2-Little							
	3-Moderate							
	4-Active							
iv- LEAF GROWTH	1-None							
	2-Little							
	3-Moderate							
	4-Active							
v- FLOWER BUDS	1-None							
	2-Few							
	3-Moderate							
	4-Many							
vi- FLOWERS	1-None							
	2-Few							
	3-Moderate							
	4-Many							
Draw a crossmark(X) next to the dominant category of the particular item. Make a tickmark(√) above or below the crossmark to indicate variance in the item, up or down.								

Figure 23 *The field sheet used for the scoring environmental condition and phenological development.*

The simplicity and wide range of the category scales made determination quite accurate. The categories (in Figure 23) were quantified by making use of a scores table (Table 16). The quantified data were then used to construct the phenographs of the different categories, or where necessary, for a particular species (See Appendix E, Tables E1 to E3 for the quantified phenological data for the species that were scored during the course of the study).

Some of the items and categories are similar to that used by Hoffman (1989) and Zietsman, Van Wyk & Botha (1989). Figure 23 was however found to be very sound base for determining phenological cycles of Karoo species.

In Figure 23:

Environmental condition.

This could range from arid to moist and was largely based on the soil and rainfall.

Plant condition.

This ranges from dry to very fresh (lush) and is also directly related to growth activity. The categories were relatively easy to determine.

Stem and shoot growth.

This ranges from no growth, visible growth to very active growth. Stems and shoots usually clearly showed degrees of growth. Stem growth was more difficult to determine.

Leaf growth.

This ranges from no growth to active growth and could be relatively easily determined. Young, fresh, leaves usually indicated active growth, whereas absence of new and young leaves indicated little or no growth.

Flower buds.

Flower buds range from none to many. This category was, from inspection of plants, very easy to determine. This phase varied from species to species.

Flowers (date and number).

This was largely based on the presence of open flowers, and as such, was an easy item to categorize. In the case of grasses this was somewhat more difficult and often required special attention.

Table 16 *The quantification of scores and score combinations for the different phenophases.*

	Category scores, score combinations and score values.						
CATEGORY	A	B	C	D	E	F	G
1	X=10	X(20)	√				
2	X=40	√	X(30)	X(50)	√		
3	X=70			√	X(60)	X(80)	√
4	X=100					√	X(90)

This Table should be used in conjunction with the completed field score sheet (Figure 23) to quantify the different observations in the field scoring sheet. Observe the different categories (1 to 4) of the different phenophases in the field score sheet. **Match the crossmark, X; or the cross, X, and tickmark, √ combination; as determined for the specific date, with one of the scores or score combinations, (i.e. a X, or X√ or √X) in Table 16, to quantify that phenophase.** If a plant is scored and the dominant category of the phenophase is e.g. category 3, then the score for that phase is 70 (See Table 16). If a phase is between two categories (cross-tickmark or tickmark-cross-combination) match this combination with one of the category-scores under columns B to G. The particular score is indicated in brackets. Once all the data was quantified in this fashion phenographs were constructed to show the march of the phenology of the key plants, or groups, for the study period.

5.7.2 Results and Discussion.

The quantified phenological data for all the 18 species concerned are as displayed in Appendix E, Tables E1 to E3. From the results there is a strong tendency for species in the same groups to have similar phenological cycles. As a result the graphs of ***A. congesta*** (Pioneer Grass), ***E. lehmanniana*** (Sub-Climax Grass), ***S. fimbriatus*** (Climax Grass), ***P. parvifolium*** (Palatable Shrub), ***E. ericoides*** (Less Palatable Shrub) and ***P.tricephala*** (Unpalatable Shrub) were constructed (Figures 24 to 29) to represent the groups.

5.7.2.1 Pioneer Grass (Figure 24 - *Aristida congesta*).

For this grass all the different phenophases were declining sharply and reached the lowest levels at the end of January and early February. Growth of the leaves, stems and shoots reached an optimum rate during November 1989 and then commenced to decline until the lowest point at the end of January 1990 was reached. From this point all the phases became activated attaining peaks during the end of March 1990. The formation of flower buds started during February and reached a peak during the middle of March. The optimum flowering time was from the middle to the end of March.

5.7.2.2 Sub-Climax Grass (Figure 25 - *Eragrostis lehmanniana*).

During November 1989 all the phases reached an optimum level, excepting flower buds and flowers. During this period leaf growth was active attaining a relative value of nearly 75%. The relative value for the environmental condition during this time reached a value of nearly 80%. This clearly suggests that substantial moisture in the soil influences vegetative growth activities directly. From this stage there was a decline in all the phases which reached low values from mid to end January; the condition (dry/fresh) of the plants reached a value as low as 20%. From the beginning of February all the categories increased and reached a maximum during the beginning up to the middle of March before declining toward the Winter months. The relative value at this stage for leaf growth was nearly 80%. This grass reached its optimum flowering rate in the middle of March.

5.7.2.3 Climax Grass (Figure 26 - *Sporobolus fimbriatus*).

The cycles of this grass are very similar to that of the previous two grass components. During November 1989 leaf, stem and shoot growth reached a peak with leaf growth activity in the region of 70%. These cycles declined toward the summer months with the lowest relative values during the last two weeks of January 1990. This trend was followed by an increase in all the phenophases, reaching relative values that are higher than that during November. The optimum flowering rate occurred during the end of March 1990.

5.7.2.4 **Palatable Shrubs** (Figure 27 - ***Phymaspermum parvifolium***).

During November 1989 the cycles of the different phenophases reached the first significant peak after the winter months. From here on there was a decline in growth activity towards January 1990. This was followed by an increase in growth activity to form the second and the highest relative values during March 1990. The period of sustaining this peak of high activity was longer than that during November 1989. It is of interest to note that there were two flowering periods within one growth season. The first one occurred during November 1989 and the second one during March 1990. During March the leaf growth activity, as well as the stem and shoot growth reached a value of over 90%, whence a steady decline occurred in all the phases.

5.7.2.5 **Less Palatable Shrubs** (Figure 28 - *Eriocephalus ericoides*).

Here the cycles are quite different from that of the palatable shrubs. The variation in relative values throughout the seasons of the year (1989-1990) for leaf, stem and shoot growth was not more than 40%. The highest value for these phenophases occurred during the end of November 1989 for stem and shoot growth and during the beginning of March 1990 for leaf growth. There was a decline in activity from the end of December 1989 up to the end of January 1990; from here on there was an increase and the maximum flowering rate occurred during the second week of April. This species flowered only once.

5.7.2.6 **Unpalatable Shrubs** (Figure 29 - ***Pteronia* *tricephala***).

Flowering of this species occurred during August 1989 and 1990. Leaf, stem and shoot growth attained their optimum peaks during August 1989 and June 1990. Two smaller peaks for stem and shoot growth occurred during November 1989 and the end of January 1990. Leaf growth also attained a peak in the middle of November 1989 and toward the end of February 1990. Throughout the observation period the growth cycles never varied more than 40% on the relative value scale.

In early January 1990 all the different Groups reached a low growth activity rate after two months of active growth. This indicated that there was, due to the active growth period, an increase in the phytomass of the different groups, but that production was now less active. From the end of January to April 1990 the growth activities for the grasses and the Palatable Shrubs increased with an average peak during the end of March. This peak was substantially higher than that for the Palatable Shrubs. The growth activity for the Less Palatable Shrubs did not vary much throughout the year and the highest leaf growth rate was attained during the end of February 1990. For the Unpalatable Shrubs the optimum growth rate is during the winter months. All the cycles showed a very low activity rate or dormancy at the end of October 1990. This can primarily be ascribed to the prevailing dry winter to spring spell. During this time very little rain occurred (see Figure 5).

5.7.3 Diet Selection and Phytomass.

Table 17 shows the main components, in percentages (%), that made up the diet of the sheep on the different Sites (A & B), in the different camps (DA, MA, DB and MB) on the different localities (High & Low - occupation), as well as the total phytomass (kg/ha) for the species or groups.

From this Table (17) it appears if the phenophases of the different plant components did not have an effect on diet selection during January 1990. All the phases were at a low during this month and the animals selected most of the species in these areas (High and Low). Although some of the components were not abundant in certain areas, and the growth cycles in a downward phase, the animals preferred some species above species that were abundant and *vice versa*. A clear example is seen in

Table 17, Site A, Camp D1, for Sub-Climax grass, where this component forms 40.2% of the diet on the High-occupation area and with the a phytomass of only 89.3 kg/ha. For the Low-occupation area this component formed 51.25% of the diet with a phytomass of 2648.1 kg/ha.

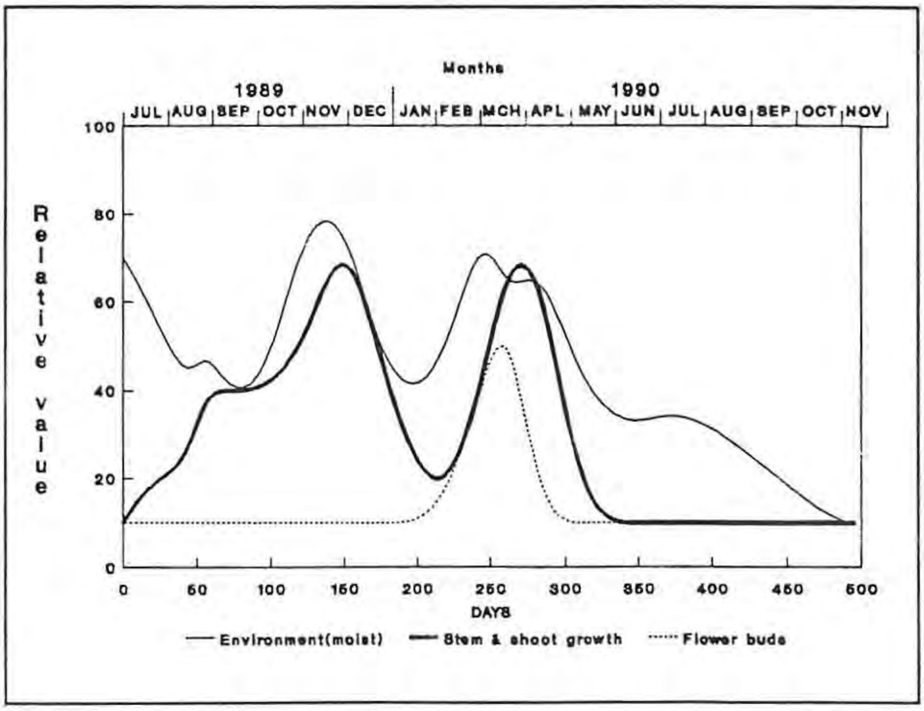
Table 17 *A summary of the diet selection and phytomass in the different camps on the different localities.*

	Diet Selection %		Phytomass kg/ha	
Site A: Camp D1	High	Low	High	Low
Sub-Climax grass	40.2	51.28	89.30	2648.10
Eriocephalus ericoides	31.25	32.44	1857.75	241.50
Climax grass	11.82	3.39	420.05	28.50
Thesium hystrix	5.66	0.00	14.00	0.00
Felicia muricata	7.29	10.38	0.00	36.00
Camp M1				
Sub-Climax grass	67.32	65.37	182.3	943.00
Climax grass	19.94	24.22	216.80	56.00
E. ericoides	5.73	5.82	1903.5	1625.00
F. muricata	3.51	1.35	0.00	0.00
Site B: Camp D1				
Sub-Climax grass	52.05	79.96	46.10	116.60
Helichrysum dregeanum	18.66	0.13	0.00	0.00
Climax grass	11.32	1.83	442.30	1.88
Trichodiadema pomeridianum	9.16	0.43	32.00	4.30
Eberlanzia ferox	3.28	0.18	142.80	0.00
Pentzia incana	2.00	14.13	0.00	380.00
F. muricata	0.00	2.41	6.50	16.30
Camp M1				
Sub-Climax grass	74.28	64.91	121.00	966.30
Climax grass	17.40	17.93	50.00	152.10
P. incana	4.67	7.44	0.00	210.30
F. muricata	3.40	3.78	34.75	7.20
H. dregeanum	2.38	0.14	0.00	0.00
T. pomeridianum	2.12	1.16	14.70	6.45

On Site B, where fistula diet sampling took place during the end of March 1990, most of the phenophases for the different plant components were at a peak. Although Site A and Site B are 4 km apart, and the cycles at a peak, the diet selected by the animals on the two sites do not differ much (See Table 17). This infers that phenology did have an influence on the choice of diet selected on Site B, because the cycles were at a peak, but the opposite is also true for Site A. There is a tendency that the animals select Palatable Shrubs in substantial quantities even if the occurrence is very limited. This means that the intake ratio of Palatable Shrubs is much larger than its occurrence ratio. The pressure on this component was thus high.

5.7.4 Summary of Phenology.

From the phenological data of the 18 species studied, there was a strong tendency for the species, in the same Groups, to have similar phenological cycles. It also appeared that phenophases of the different species did not have an effect on diet selection in January 1990 (Site A) and in March 1990 (Site B), although the phenologic cycles were at different stages.



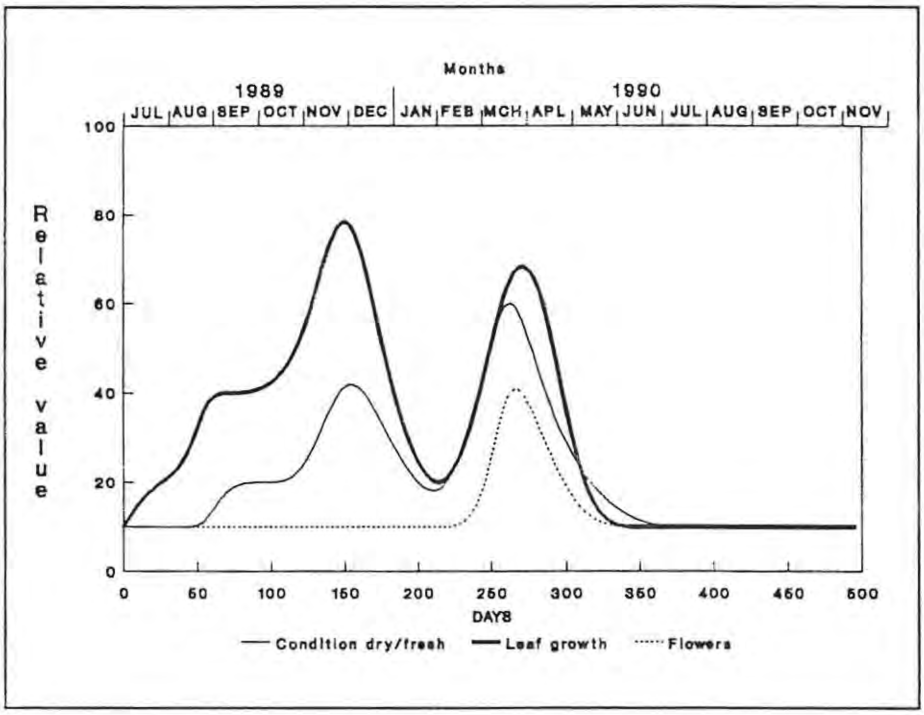


Figure 24 *The march of the phenology of* **Aristida congesta** *during the observation period of 500 days.*

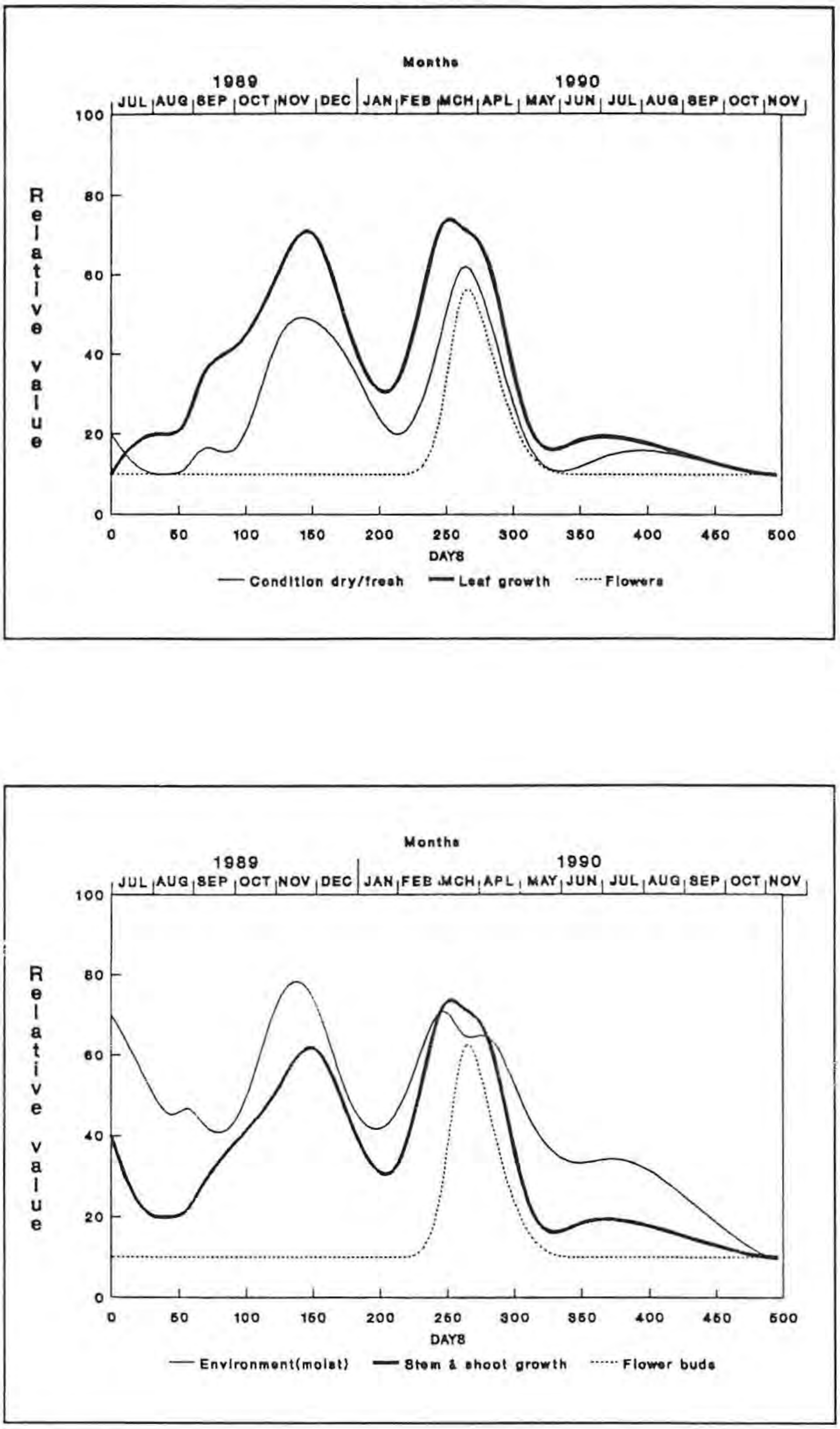
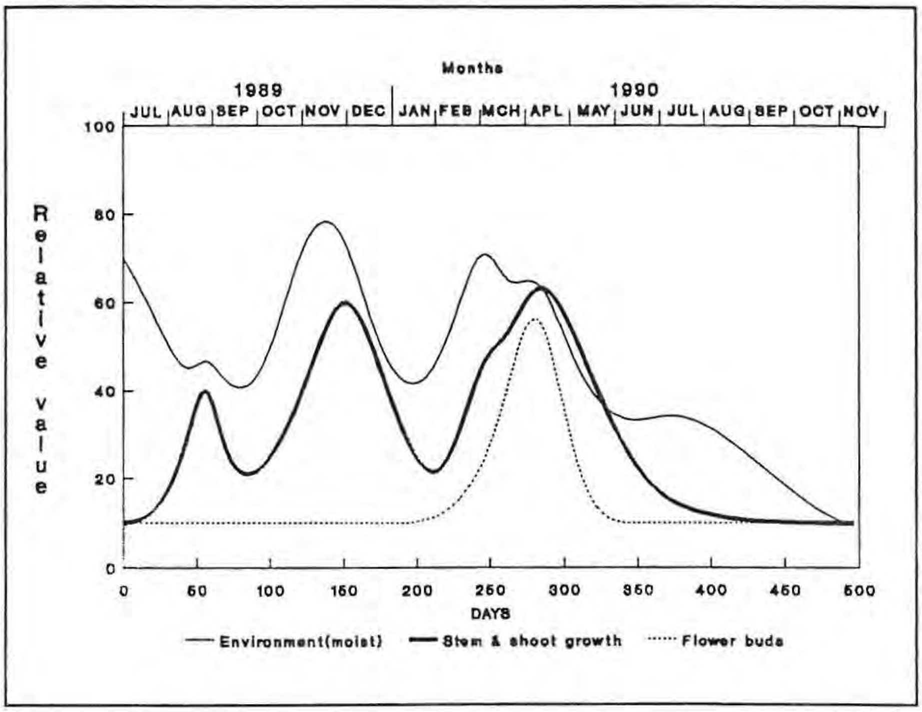


Figure 25 *The march of the phenology of Eragrostis lehmanniana during the observation period of 500 days.*



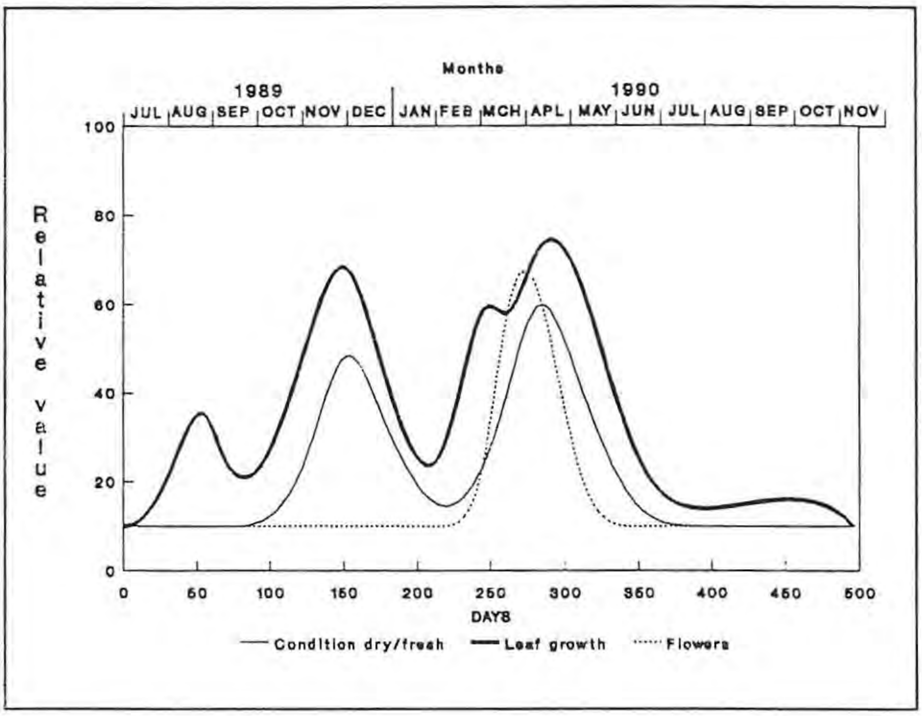
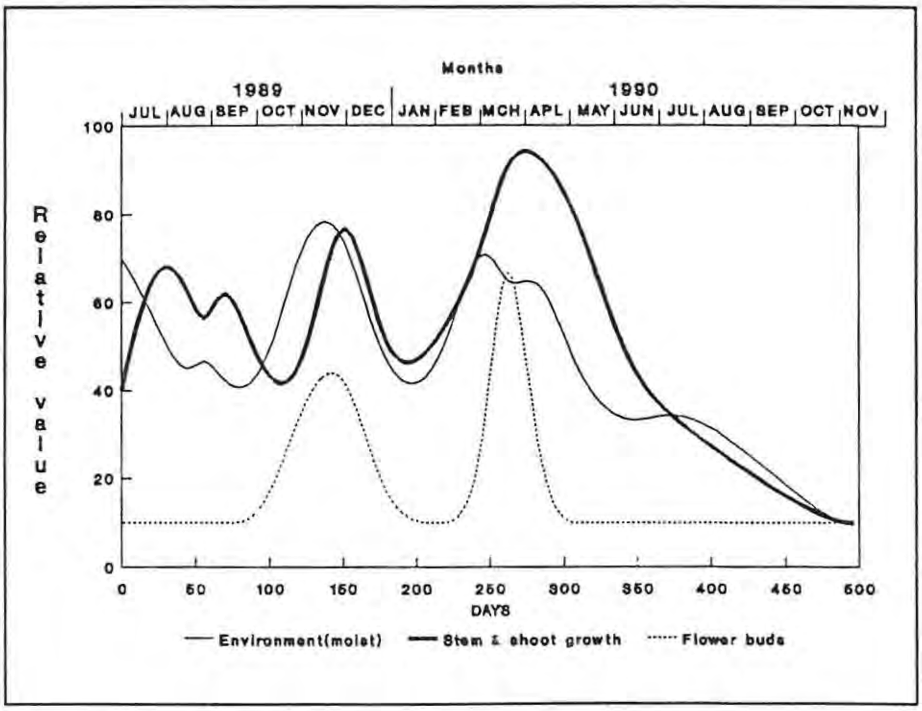


Figure 26 *The march of the phenology of Sporobolus fimbriatus during the observation period of 500 days.*



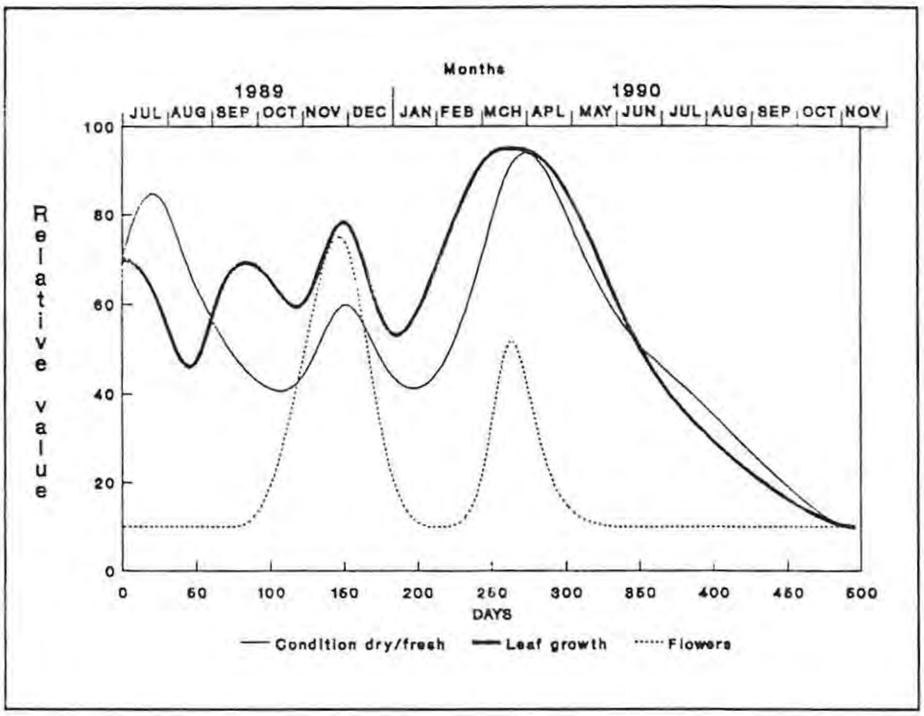
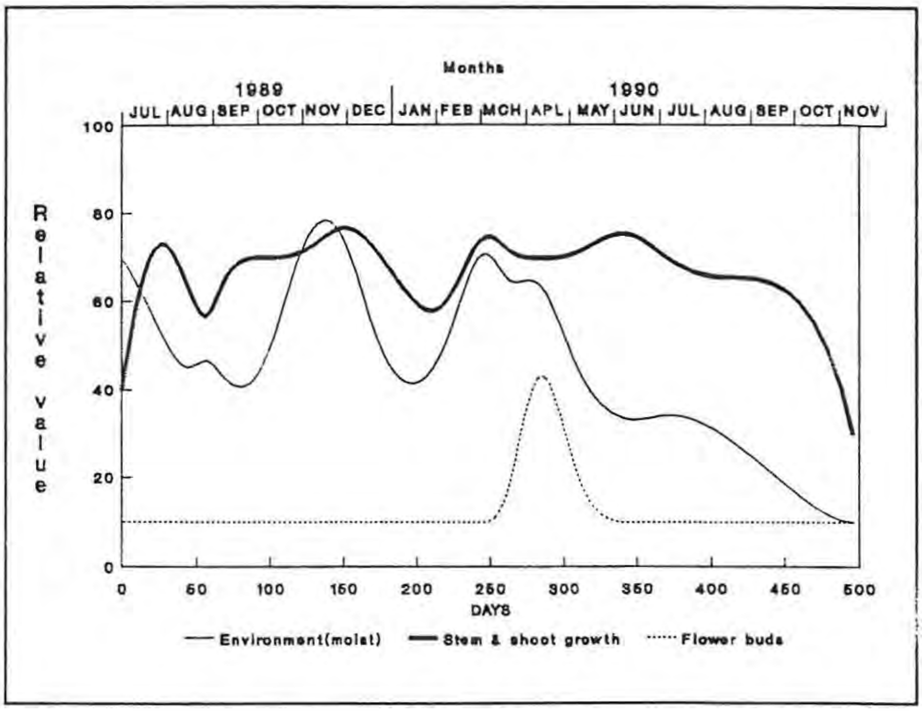


Figure 27 *The march of the phenology of* ***Phymaspermum parvifolium*** *during the observation period of 500 days.*



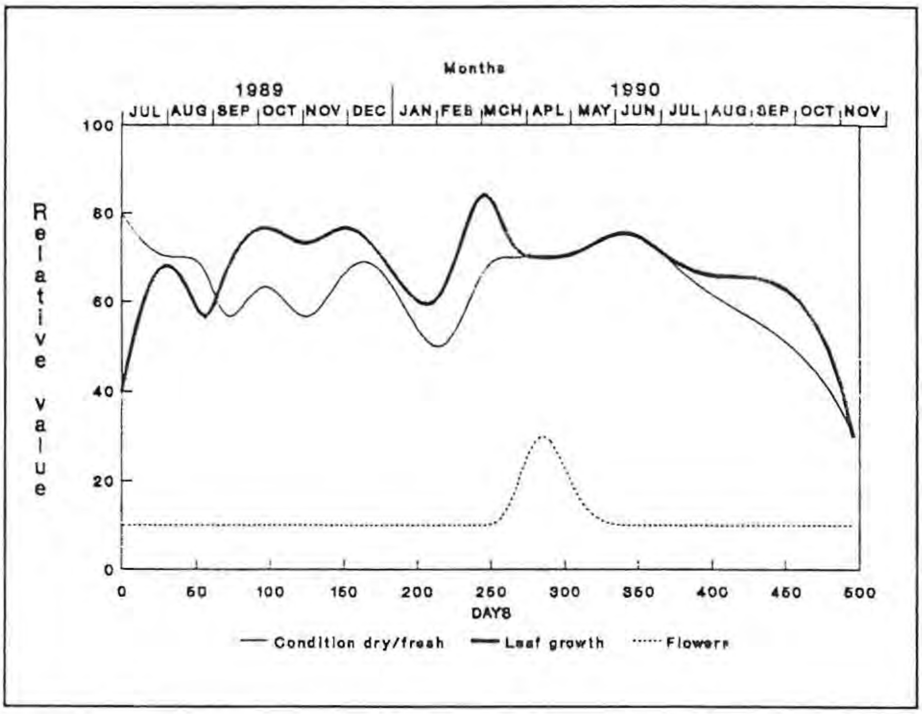
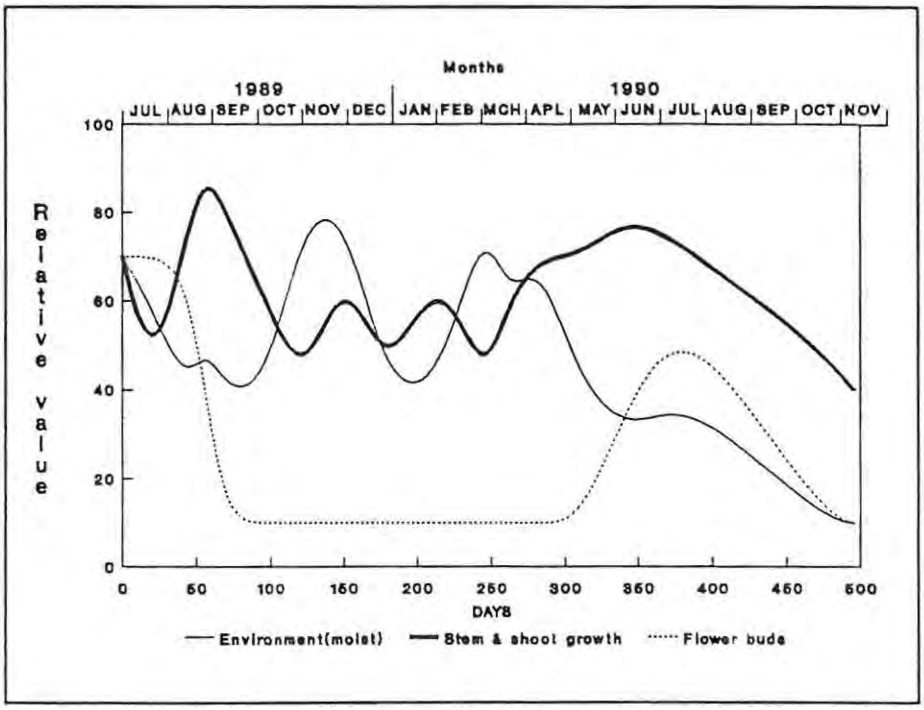


Figure 28 *The march of the phenology of Eriocephalus ericoides during the observation period of 500 days.*



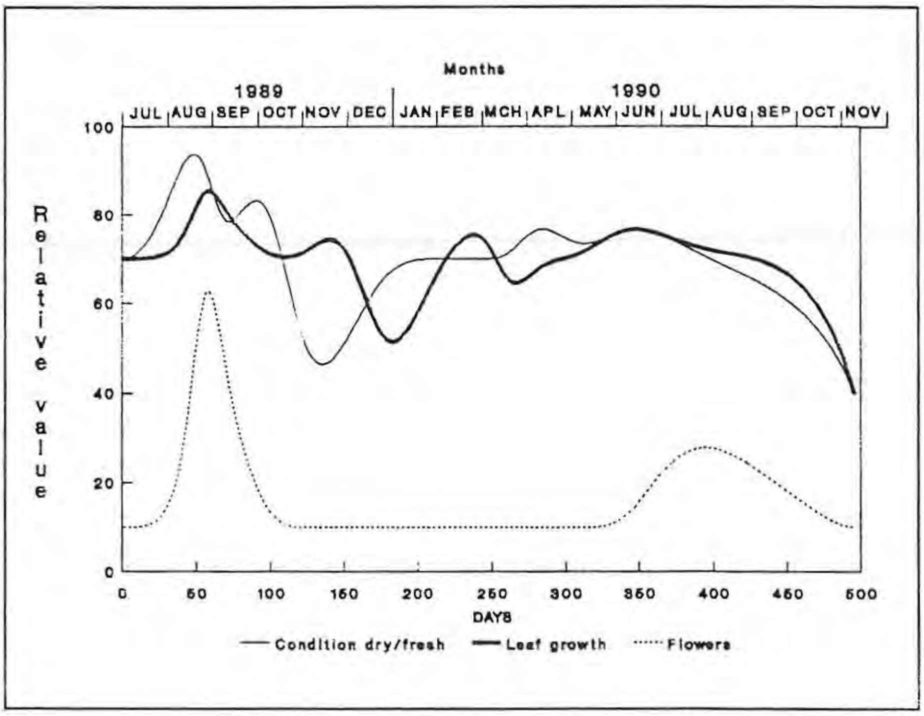


Figure 29 *The march of the phenology of Pteronia tricephala during the observation period of 500 days.*

5.8 SOIL ANALYSIS.

According to Figures 10 and 11 it is clear that the vegetation is by no means homogeneous. This uneven distribution could be explained on the basis of microtopographical differences resulting in differences in soil moisture content with accompanying stimulation of certain plant species - especially grasses. On the other hand, differences in soil characteristics could also result from microtopographical differences leading to differences in accumulation of sediments in parts and the removal of finer soil particles from the slightly higher areas. Such soil differences - leading to differences in soil moisture, wilting point, soil texture and structure etc. - would also be reflected in differences in phytomass or plant production (see Appendix D, Tables D1 to D4), apart from the higher palatability of plants. In order to find a reason for vegetation patterning - and consequently also area and spot selective grazing - soil was sampled in most and least grazed areas for chemical and physical analysis.

5.8.1 Method.

Soil samples were taken in two areas per camp. The first was located in the area where the animals grazed most (High) frequently during the periods of observation and the second in the area grazed least (Low) or not grazed at all. A line (cord), with knots every 1 m, was placed on the ground and a soil sample taken every two metres apart as indicated by the knots. Ten soil samples were taken on this line in every area selected.

At each sampling point on this line two samples were taken with a soil auger at depths of 0 - 5 cm and 5 - 15 cm yielding 40 samples per Site and 160 samples in total. A composite sample (Piper, 1951) was compounded from all the samples of the same depth for the same area. These compound samples, 16 in total for the four camps, were analyzed for a variety of elements and various soil characteristics according the Handbook of Standard Soil Testing Methods for Advisory Purposes, (Anon,1990). The analyses were performed by the Chemistry Section of the Grootfontein Agricultural Research Institute, Middelburg CP.

5.8.2 Results and Conclusions.

Table 18 reflects the results of the analyses. The results can be correlated with the soil types of the two Sites A and B, namely a Hutton and a Mispah respectively. The conductivity (mS/m) of the soils were never more than 57 (Table 18). According to de Kock (unpub.) this indicates that brackishness of soils could not have an effect on plant growth. The pH of the soils varied between 5.2 and 7.3. Usually a high pH reduces the accessibility for plant nutrients. Another element, Na (sodium), if abundant in the soil, can cause difficulty for a plant to absorb water and plant nutrients. In all the Camps, however, this status was low.

From Table 18 no conclusive evidence from a particular soil property, or properties, could be extracted that would indicate definite differences between High-and Low-frequented areas.

5.8.3 Summary of Soil Analysis.

No positive evidence could be found that indicated that differences in soil, between High- and Low-occupation areas, had an influence on the vegetation pattern, or, for that matter, on the grazing pattern.

Table 18 *The chemical and physical properties of soils, at two depths, of the High- and Low- time-frequented areas in Sites A and B.*

Camp	mS/m	SAR me/kg	pH	Na mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	P mg/kg	Zn mg/kg	CEC	F.Cap %	W.Pn %	Moi %	SG	Clay %	Silt %	Sand %	OM %	N mg/kg
High: Site A																			
DA 0-5 cm	42	0.36	5.3	10	776	582	465	10	1.1	7	9	5	4	1.4	14	6	20	4	700
DA 5-15 cm	32	0.53	5.2	10	796	726	352	6	0.9	9	11	6	5	1.4	17	8	24	5	560
Low : Site A																			
DA 0-5 cm	42	0.22	5.6	8	933	684	398	4	0.3	9	9	6	3	1.4	16	7	23	4	616
DA 5-15 cm	40	0.56	5.6	17	1183	1069	269	2	0.4	11	11	8	4	1.1	24	7	30	5	615
High : Site A																			
MA 0-5 cm	41	0.47	6.1	7	844	525	398	10	0.6	6	6	5	2	1.4	11	5	15	3	362
MA 5-15 cm	36	0.39	5.5	10	874	610	309	11	0.9	8	9	5	3	1.4	13	7	20	4	438
Low : Site A																			
MA 0-5 cm	43	0.28	6.1	10	1050	659	263	2	0.5	7	8	5	3	1.3	12	5	18	3	379
MA 5-15 cm	49	0.66	6.1	17	1170	789	201	3	0.4	9	9	10	4	1.3	15	11	26	4	462
High : Site B																			
DB 0-5 cm	54	0.69	5.7	7	897	291	401	6	1.2	9	9	5	4	1.5	15	13	27	4	672
DB 5-15 cm	49	0.35	6.5	10	2476	352	468	14	0.9	13	12	8	4	1.3	27	11	38	6	785
Low : Site B																			
DB 0-5 cm	47	0.35	7.3	17	6700	345	381	7	0.2	14	13	9	4	1.3	33	9	42	6	754
DB 5-15 cm	32	0.69	5.7	10	1260	318	188	6	0.6	10	9	5	4	1.4	19	9	28	4	473
High : Site B																			
MB 0-5 cm	43	0.52	5.7	10	990	274	360	14	1.1	8	9	5	4	1.4	14	9	23	3	443
MB 5-15 cm	40	0.42	5.7	10	1444	468	3088	15	1.1	12	14	8	7	1.2	23	13	36	5	766
Low : Site B																			
MB 0-5 cm	57	0.52	5.8	13	1428	344	290	6	0.6	11	12	6	5	1.4	22	11	33	4	352
MB 5-15 cm	38	0.47	5.7	17	2584	642	444	5	0.6	17	18	15	4	1.2	40	13	53	7	675

Explanation: mS/m = Milli Siemans/metre F.Cap = Field Capacity mg/kg = Milligram/Kilogram
OM = Organic Matter S AR = Sodium Absorption Ratio W.pnt = Wilting Point
me/kg = Milli equivalents/Kilogram SG = Specific gravity
CEC = Cation Exchange Capacity

5.9 MICROTOPOGRAPHY MAPPING:

As microtopography could possibly had an effect on vegetation patterning and consequently influencing the grazing pattern, this aspect was also investigated.

5.9.1 Method.

The Shokkisha electronic theodolite (Figure 30), was used in conjunction with a Digital Terrain Modelling-program (Model Maker) to log and print out the microtopographical data of the experimental camps.

Figure 30 *The Shokkisha electronic theodolite that was used to log the microtopographical data of the camps.*

These data were then transferred to the Surfer-program to produce a contour map of the microtopography of the different camps and to provide an oblique view of the terrain. Contour intervals were set at 0.2 m intervals on the electronic memory module.

To log the data two workers were employed to walk through the camps placing the reflecting prism staff on a systematic grid pattern which provided a very accurate and systematic coverage of the terrain. A third person operated the stationary theodolite work station. The fact that the camps were already gridded out with 1.8 m droppers, made the grid-logging of the topographical measurements (vertical and horizontal angles, and distance) a relatively easy task.

For each of camps DA and MA, (Site A), 156 placement points were logged. For camps DB and MB (Site B), 133 points were logged. This apparatus is extremely accurate and was ideally suited for the compilation of the microtopographical maps. Generally 3 hours were required to complete a microtopographical survey per camp.

5.9.2 Results and Discussion.

5.9.2.1 Site A.

The microtopography for both the camps (DA and MA) are displayed in Figure 31. The difference between the highest part and the lowest part of Camp DA is 4 m and the slope is from right to left. In Camp MA it is 3 m and the slope is also from right to left. In both instances the slope is over a distance of 200 m. This gives DA a slope of 2% and for MA a slope of 1.5%. The direction of drainage is from right to left. In both camps no unusual microtopographical features that might have had an influence on the vegetation composition or patterning, and grazing pattern of the animals, could be detected.

5.9.2.2 Site B.

Figure 32 depicts the microtopography for Camps DB and MB. The difference between the lowest parts and the highest parts are 5.6 m for DB and 6.8 m for MB. The increase in slope is over a distance of 400 m providing an average slope of 1.6%. At the end of the upper parts of the camps the slope increases towards a nearby hill. In could be expected that after a rapid thunder storm water would flow through these camps, taking some of the topsoil with it. This probably accounts for the shallowness of the soil as it eroded away over very many years.

5.9.3 Summary of Microtopography.

On Sites A and B, no unusual microtopographical features, were in evidence that could have an influence on the vegetation composition or patterning or on the grazing pattern of the animals.

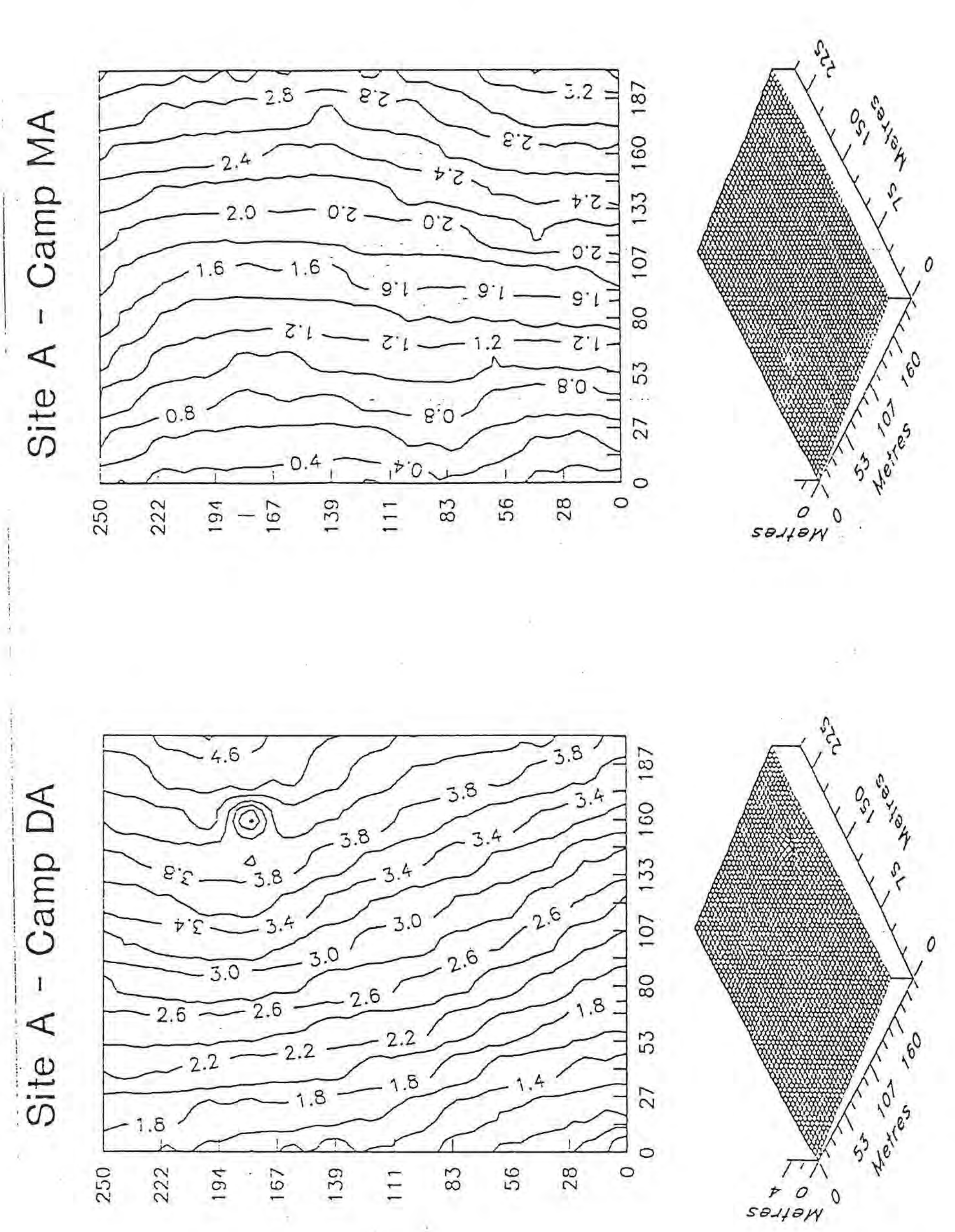
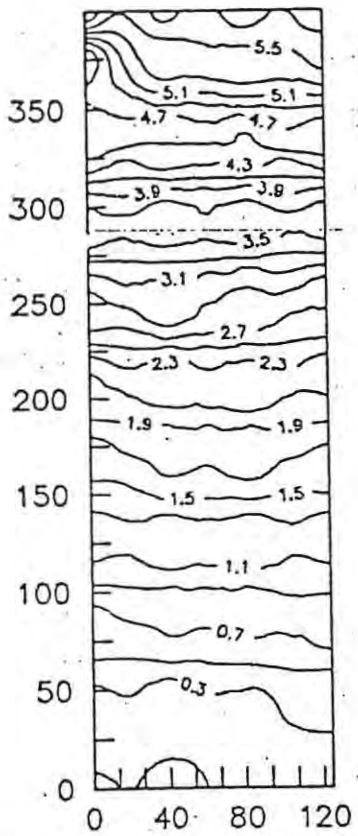
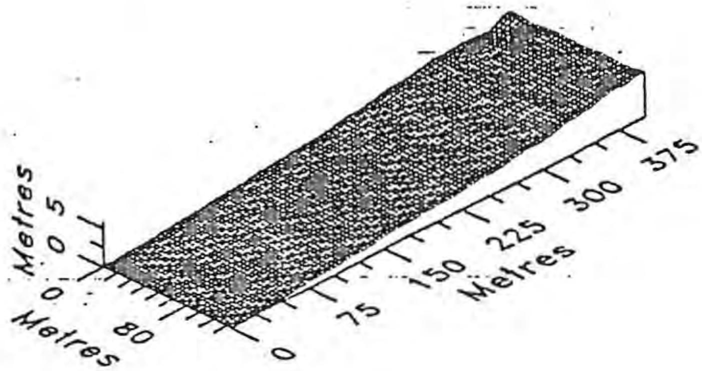


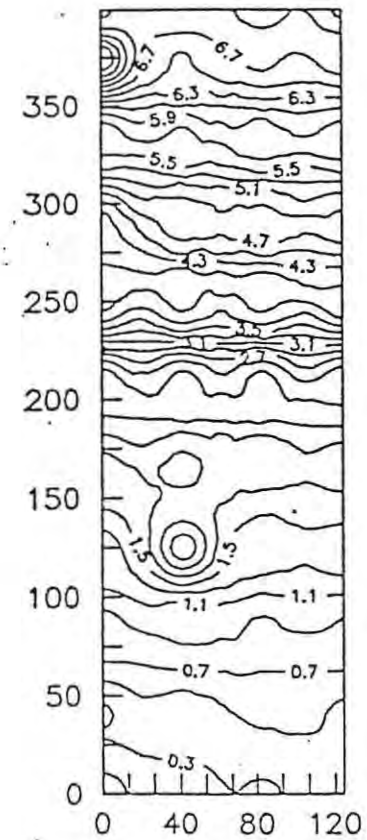
Figure 31 *A contour map, with 0.2 m height intervals, of the microtopography of Camps DA and MA, and orthographic views of the terrain.*

Site B - Camp DB





Site B - Camp MB



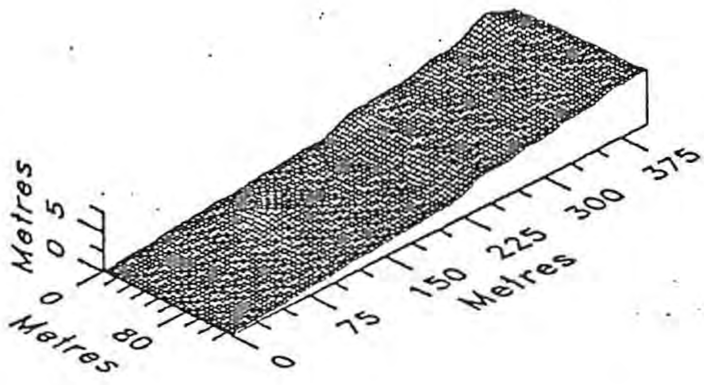


Figure 32 *A contour map, with 0.2 m height intervals, of the microtopography of Camps DB and MB, and orthographic views of the terrain.*

5.10 AERIAL PHOTOGRAPHY:

5.10.1 Method.

The aerial-balloon photography method, as described by Roux, Du Plessis & Botha (1984), was used to photograph a selected veld area in a camp from a height of approximately 80 m. Figure 33 shows the apparatus before launching.

Figure 33 *The aerial-balloon photography apparatus before launching.*

This cheap method is ideally suited for the study of surface features such as bare areas, plant distribution patterns and density, and the formation of foot-paths (sheep tracks). For this study, however a single photo only was taken above the drinking trough of camp MA to illustrate foot-paths, vegetation patterning, texture, and density. As surface topography was already adequately covered by the contour maps (Figures 31 & 32) this photography was not exploited further for this study. It appears, however, to be a very useful tool to be exploited in vegetation studies.

5.10.2 Results and Discussion.

Figure 34 depicts the vegetation texture and formation of tracks radiating from the drinking trough. The larger part of the vegetation in Figure 34 is composed by ***Eriocephalus ericoides*** (17.06%), ***Eragrostis lehmanniana*** (9.09%), ***E. curvula var. conferta*** (8.42%), ***Aristida diffusa*** (4.25%) and ***Pteronia tricephala*** (2.31%). The average diameters for these species, as determined by Roux & Roux (1989), are respectively 16.5 cm, 8.5 cm, 32.8 cm, 35.3 cm and 50.4 cm.

It appears that there are prominent tracks that radiate from the trough. Some of the footpaths are more prominent than others and can be regarded to be the primary routes to the trough. This is typical of all the other camps. It can be reasoned that the placing of a watering point, the number of watering points, and the dimensions (area and shape) of a camp, could have a marked effect on the movement of sheep as well as track formations. A single trough occurred in each of the experimental camps.

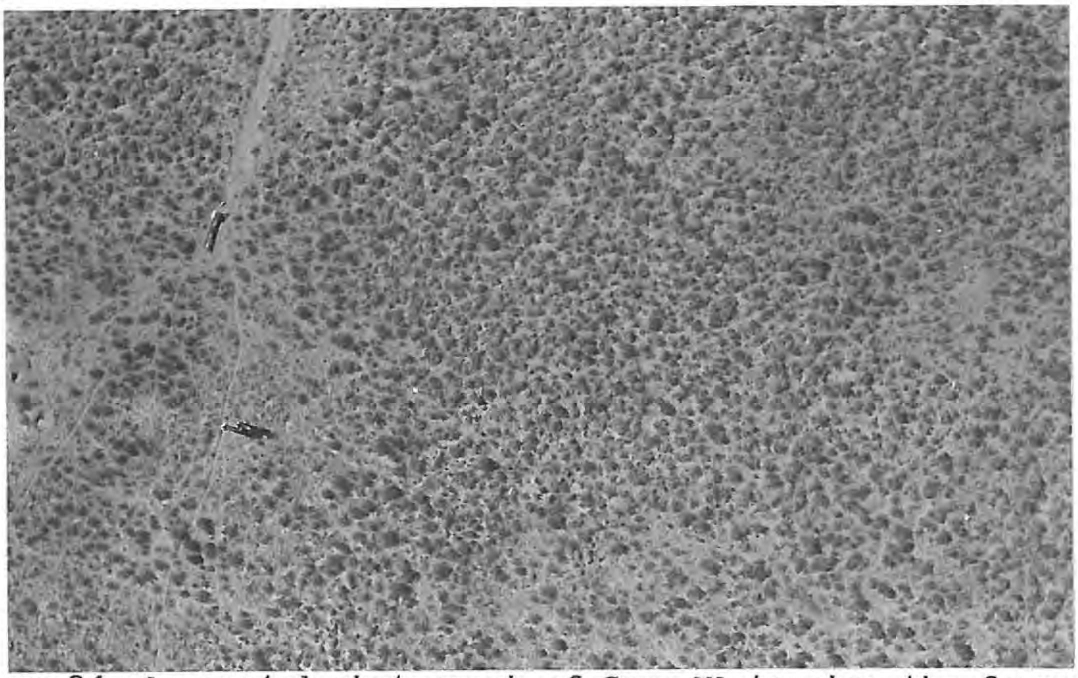


Figure 34 *An aerial photograph of Camp MA to show the formation of tracks near a watering point. (Scale 1 : 3800)*

5.10.3 Summary of Aerial Photography.

This simple technique appeared to be very useful in studying the formation of sheep tracks. The results have e.g. shown that the position of watering troughs in a camp have an influence on the movement of sheep as tracks radiate from a trough (see Fig. 34).

CHAPTER 6

SUMMARY

6.1 PROCEDURES and CONCLUSIONS.

An investigation into the influence of the composition of mixed Karoo vegetation on the grazing habits of sheep (Dorper and Merino wethers) was carried out. In this study, four camps, each 5 ha in size and on two different localities, were used in this investigation. Special attention was given to the movement of stock in relation to vegetation patterning. Various techniques were employed in this study.

The descending-point method of vegetation survey was used to determine the vegetation composition. Each camp was subdivided into small grid-blocks in order to trace the movement of the sheep, and to determine the time occupied per grid-block, by the sheep in relation to the vegetation composition (per grid-block) and grazing capacity. Observations were made at 15 minute intervals during the day-time. The near exact grazing patterns could be determined in this fashion. The actions of the sheep i.e. grazing, urinating, drinking water, standing still or lying down were recorded.

The results have shown that Dorpers avoided grazing in more than 50% of Camp DA. This was largely due to the abundance of *Aristida diffusa* in certain parts of the camp. The Merinos in Camp MA utilized (70%) a larger part of their camp. On the other hand it was found that with the Merinos there were more periods of high intensity grazing on certain areas than for the Dorpers; this possibility indicated a great inclination to spot selective grazing or also a greater selectivity. The longest average time the Dorpers grazed on a particular area in Camp DA was 13 minutes against the 25 minutes of the Merinos. The average time the Dorpers grazed, per day, during the observation period was 525 minutes. This period consisted of two, approximately equal grazing periods; one in the morning (of 240 minutes) and one in the afternoon (of 285 minutes).

The average time the Merinos grazed in Camp MA was 555 minutes/day. This total time consisted of four grazing periods; two in the morning (165 and 75 minutes respectively) and two in the afternoon (180 and 135 minutes respectively).

The average walking distance for a Dorper (Camp DA) was 1.8 km/day and for the Merinos 2.75 km/day. This is a difference of nearly one kilometre, even though the difference in grazing time was only 30 minutes.

In Camp DB the longest period of grazing a particular area by the Dorpers never exceeded 18 minutes and that for the Merinos (Camp MB) this figure was as high as 36 minutes on certain spots. The average grazing time for the Dorpers was 465 minutes (255 minutes in the morning and 210 in the afternoon). The average grazing time for the Merinos was 570 minutes. This consisted of three periods in the morning (75, 45 and 105 minutes respectively) and two periods in the afternoon (60 and 285 minutes respectively). The average grazing distance for the Dorpers was 2.23 km/day and for the Merinos 3.5 km/day. In all cases thus appeared that Merinos walked greater distances than the Dorper, and that their grazing periods varied from 4 to 5 as against the two of the Dorper.

A correlation matrix was created for each of the four camps, as well as for the grid-blocks in Low- and High- time-occupation areas. The variables in the matrix were time, vegetation composition and grazing capacity. The relationship among these variables was established.

The correlation analysis showed that there was a significant tendency for the Dorpers in Camp DA to avoid grazing in areas where *Aristida diffusa* occured abundantly. For the Merinos in Camp MA, the occurrence of Climax grass correlated significantly positive ($r = 0.31$) with time occupation in "prime" spots (High-occupation grid-blocks). It was also evident that no Unpalatable Shrubs were found in these spots. For Camp DB there were no significant correlations between the vegetation variables and time spent grazing or not grazing in certain areas. In Camp MB it was clear that there was a high correlation ($r = 0.626$) between Time (Ti) spent grazing and the occurrence of Climax Grass (CG) in the high-occupation grid-blocks. In this particular camp there was also a tendency for the Merinos to avoid areas where ***A. diffusa*** was abundant.

The phytomass in the Low- and High- time-occupation areas was determined; it was thus possible to determine whether there were differences in the phytomass as well as in the composition of the vegetation on a mass basis.

In Camp DA ***Eriocephalus ericoides*** contributed to 65% (1857.75 kg/ha) to the total mass clipped in the High time-occupation area, and ***Aristida diffusa***, 81.3% (2639.5 kg/ha) to the total phytomass in the Low time-occupation areas. In Camp MA, ***E. ericoides*** was the main contributor to the total phytomasss for the High (67%) as well a for the Low (38%) time-occupation areas. In the Low time-occupation areas, ***Pteronia tricephala*** (an Unpalatable Shrub) contributed the second most to the total phytomass (36%). The results for this camp indicates that ***A. diffusa*** and ***P. tricephala*** may be singled out as the main reason for the Merinos not grazing in areas where one, or both, of these species were abundant.

In Camp DB, ***E. spinescens*** was the most abundant on both the High- and-Low areas, contributing to 34% of the total phytomass in both instances. ***Sporobolus fimbriatus*** (a very palatable grass species) formed 18.4% of the total phytomass in the High time-occupation area. In Camp MB, ***E. spinescens*** contributed to 39.6% of the total phytomass in the High-occupation area and ***A. diffusa*** 36% in the Low-occupation area.

The particular diet selection of the Dorpers and Merinos were also determined on the Low- and-High time-occupation areas by making use of the oesophageal fistula technique.

Although there is a difference in the vegetation composition in all the High- and-Low occupation areas, there was a tendency for the sheep to select the same type of diets on these areas. On Site A (Camp DA and MA) the Dorpers and Merinos preferred to select Sub-Climax Grass spp., ***E. ericoides*** and Climax Grass as the major part of their diets. On Site B (Camp DB and MB) the Dorpers as well as the Merinos selected Sub-Climax grass, Climax Grass, *Pentzia incana* and *Felicia muricata* as the largest portion of their diets on the High-and-Low occupation-areas.

Due to the possibility that the phenological stage of a plant might influence the diet selection of sheep, nine grasses and nine karoo bushes were scored for phenological stage over a period 500 days. Phenographs were constructed from the suitably quantified data.

The results showed that phenophases, of the different plants, did not have an influence on the diet selection by sheep during the sampling periods; However, this does not mean that phenophases do not have an influence on diet selection, e.g. a fresh sprouting grass against a dry grass in winter. There was a strong tendency for the species in the same groups to have similar phenological cycles.

Soil samples collected on the Low- and High- time-occupation areas were analyzed in an attempt to establish further reasons for vegetation patterning and consequently also area and spot selective grazing.

From the results no evidence could be extracted that had any indication that soil had any effect on vegetation patterning, and consequently also on grazing patterns.

The microtopography of the four camps, determined by means of an electronic theodolite, was mapped in order to determine if microtopography had any effect on vegetation patterning, and consequently also on the grazing pattern.

No evidence was found that microtopography had influenced the general vegetation patterning or grazing pattern.

Balloon aerial photography was used to photograph a selected veld area in one camp to observe such features as bare areas, plant distribution patterns, and vegetation texture, and sheep-track formation.

The results of this photography have shown that the placing of drinking troughs in a camp have an influence on the movement of sheep as well as track formation.

6.2 CONCLUSIONS:

From the results obtained, the following main conclusions were drawn:

1. Area selective grazing, to a considerable degree, did take place in the small camps grazed by the Dorper and Merino wethers.

2. Species selective grazing did occur within areas occupied by the sheep (high time-occupation area).

3. Species selective grazing did take place in areas not readily frequented by the sheep (low time-occupation area).

4. Those areas in camps covered mainly by climax and sub-climax grass species were those primarily selected for grazing. There was a strong tendency for the animals to avoid areas in camps where ***Aristida diffusa*** or unpalatable shrubs were abundant.

5. The phenological stages of the plant species, did not have a detectable influence on choice of diet selected during the sampling period.

6. There was little or no correlation between the botanical composition of fistula samples and area selective grazing.

7. The distances travelled in the camps by the sheep differed considerably; for Dorpers the average distance was 2 km/day and for Merinos 3.1 km/day.

8. From the point of view of the management of stock and veld it appear that under "normal" stocking rates selective grazing cannot be successfully eliminated in small camps. A "normal" stocking rate can be regarded as the observance of the carrying capacity that exists between upper and lower limits, that when applied in practice does not have a detrimental effect on the vegetation over the long term. According to Danckwerts (1989) carrying capacity describes the productivity of the vegetation in terms of the number of animals that can be run on an area of land without detriment to the vegetation and soil and

that the grazing animals can be maintained in a productive state.

9. There was no indication from the soil sample analyses that soil played a role in vegetation patterning or selective grazing in the four camps studied.

10. The techniques applied to determine botanical composition, phytomass, phenological cycles, selective grazing and movement of sheep, were regarded to be successful and can be recommended for application under similar circumstances.

11. It can be finally concluded that the set hypothesis viz. that area- patch- and species selective grazing are prevalent in small grazing camps under "normal" stocking densities, and that different breeds of stock (Dorper and Merino sheep) have different grazing patterns and selections of diet, has not been refuted. Thus, area selective grazing and selective grazing can take place in small camps where the vegetation is not uniform.

It must be clearly understood that the results as obtained in this project cannot be summarily extrapolated or generalised as each different type of vegetation could yield different results. However, the basic result, i.e. that selective grazing does take place in small camps, could apply almost generally in view of the heterogeneity of Karoo vegetation and different palatabilities.

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APPENDIX A

The following checklist is for species encountered during the study period in the two Sites A and B. Thirty-six of the species were not recorded during the descending-point surveys and were collected in the different camps. The species were matched classified at the Grootfontein Herbarium. If it was not possible to identify a particular species at this herbarium, it was referred to the National Herbarium, Pretoria, for identification.

The checklist shows the Family and Genus. Next to the Family name there is the code number of the PRECIS (Pretoria National Herbarium Computerized Information System) (Gibbs Russell, Welman, Retief, Immelman, Germishuizen, Pienaar, Van Wyk & Nicholas, 1987).

Family, Genus and Species
ACANTHACEAE (7980000)
Blepharis capensis (L.f.) Pers
B. villosa (Nees) C.B. CL.
AIZOACEAE (2382000)
Galenia procumbens L.f.
G. sarcophylla Fenzl
Limeum aethiopicum Brum.
Plinthus karooicus Verdoorn
ASTERACEAE (8729000)
Berkheya annectens Harv.
Chrysocoma tenuifolia Berg.
Dimorphotheca zeyheri Sond.
Eriocephalus ericoides (L.f.) Druce
E. spinescens Burch.
Felicia fascicularis DC.
F. filifolia (Vent.) Burtt Davy
F. muricata (Thunb.) Kuntze forma.
Gazania linearis (Thunb.) Druce

Family, Genus and Species
Geigeria ornativa O.Hoffm.
Helichrysum dregeanum Sond. & Harv.
H. lucilioides Less.
H. rutilans (L) D. Don
Hertia pallens (DC.) Kuntze
Osteospermum leptolobum (Harv.) T. Norl.
Pentzia globosa Less
P. incana (Thunb.) Kuntze forma.
P. lanata Hutch.
Phymaspermum parvifolium (DC.) Benth.& Hook. F.
Pteronia glauca Thunb.
P. glomerata L.f.
P. sordida N.E.Br.
P. tricephala DC.
Pterothrix spinescens DC.
Rosenia humilis (Less.) Bremer
Arctotheca calendula (L) Levyns
Ursinia nana DC.
BRASSICACEAE (2863000)
Lepidium devaricatum Ait.
CAMPANULACEAE (86440000)
Lightfootia tenella Lodd.
CHENOPODIACEAE (2214000)
Salsola calluna Dregé
COMMELINACEAE (0893000)
Commelina africana L.
CYPERACEAE (0452000)
Mariscus capensis (Steud.) Schrad.
EUPHORBIACEAE (4286000)
Euphorbia chamaesyce Ait.

Family, Genus and Species

FABACEAE (3443000)

Indigofera alternans DC.
Lessertia pauciflora Harv.
Medicago laciniata L.
Melolobium microphyllum Eckl.& Zeyh.

LABIATEA (7210000)

Salvia verbenaca L.
Stachys rugosa Ait.

LILIACEAE (0942000)

Protasparagus suaveolens Burch.

MESEMBRYANTHEMACEAE (2405001)

Delosperma tuberosum Schwant.
Eberlanzia ferox (L) Schwant.
Ruschia unidens (Haw.) Schwant.
Trichodiadema pomeridianum L. Bol.

OXALIDACEAE (3935000)

Oxalis depressa Eckl.& Zeyh.

POACEAE (9900010)

Aristida congesta Roem.& Schult
A. diffusa Trin.
Cymbopogon plurinodis (Stapf) Stapf ex Burtt Davy
Cynodon incompletus Nees
Digitaria eriantha Steud.
Enneapogon desvauxii Beauv.
E. scoparius Stapf
Eragrostis bergiana (Kunth) Trin.
E. bicolor Nees
E. curvula (Schrad.) Nees
E. curvula var. conferta Nees
E. lehmanniana Nees

Family, Genus and Species
E. obtusa Munro ex Fical. & Hiern
Heteropogon contortus (L.) Roem. & Schult.
Panicum stapfianum Fourc.
Schismus barbatus (Loefl. ex L.) Thell.
Sporobolus discosporus Nees
S. fimbriatus Nees
Stipagrostis obtusa (Del.) Nees
Tetrachne dregei Nees
Themeda triandra Forsk.
Tragus koelerioides Aschers.
RUBIACEAE (8119000)
Nenax microphylla (Sond.) Salter
SANTALACEAE (2096000)
Thesium hystrix A.W.Hill
SCROPHULARIACEAE (7460000)
Aptosimum procumbens (Lehm)
Sutera pinnatifida Kuntze
Walafrida geniculata (L.f.) Rolfe
W. saxatilis (E.Mey.) Rolfe
SOLANACEAE (7377000)
Lycium cinereum Thunb. (Sens. Lat.)
STERCULIACEAE (5044000)
Hermannia coccocarpa Kuntze
H. pulchella L.f.
THYMELIACEAE (5429000)
Gnidia polycephala (C.A.Mey.) Gilg
ZYGOPHYLLACEAE
Zygophyllum incrustatum E.Mey.

APPENDIX B

Tables B1 to B4 show the complete results of the different variables (time, plant species and grazing capacity) for every grid-block in the four experimental camps Site A; Camps DA and MA, and Site B: Camps DB and MB).

No : Grid-bock Number (as represented in Figure 14 and 15).
The variables are:
Ti : Time of grazing in this block (minutes)
SG : Sub-Climax Grass
CG : Climax Grass
Ad : ***Aristida diffusa***
PG : Pioneer Grass
Ps : Palatable shrubs
LPS :Less Palatable Shrubs
Ee : ***Eriocephalus ericoides***
Es : ***E. spinescens***
US : Unpalatable Shrubs
Geo: Geophytes
OTHE: Other species
SSU/ha, and Ha/SSU : Grazing Capacity

Table B1 *The variables for time, plant species and grazing capacity for every grid-block in Camp DA.*

No	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha	Ha/SSU
1	0	1	0	0	12	2	2	3	0.14	7.39
2	0	4	0	0	12	0	2	2	0.21	4.73
3	1	7	0	3	6	1	1	2	0.35	2.85
4	1	3	1	6	7	1	1	1	0.36	2.75
5	1	5	1	4	8	0	0	2	0.35	2.85
6	1	3	0	0	6	0	0	11	0.16	6.22
7	1	10	0	2	4	0	0	4	0.39	2.57
8	7	6	0	0	0	0	0	14	0.24	4.22
9	5	0	7	0	2	0	0	11	0.35	2.85
10	0	6	0	1	8	4	0	1	0.26	3.81
11	1	5	3	2	7	0	0	3	0.38	2.66
12	1	6	0	2	4	3	4	1	0.34	2.96
13	1	4	0	9	5	0	2	0	0.44	2.27
14	1	8	0	3	2	1	5	1	0.43	2.34
15	1	9	1	0	7	0	0	3	0.35	2.85
16	1	9	0	3	4	0	1	3	0.40	2.49
17	5	8	2	3	4	0	0	3	0.44	2.27
18	9	2	6	0	3	0	0	9	0.36	2.75
19	0	5	1	2	7	0	1	4	0.31	3.20
20	1	5	3	9	2	0	0	1	0.55	1.80
21	1	3	2	8	4	3	0	0	0.44	2.27
22	1	1	0	11	6	0	2	0	0.41	2.41
23	1	2	6	6	4	0	2	0	0.54	1.85
24	1	5	7	6	1	0	1	0	0.64	1.56
25	1	10	0	7	2	0	1	0	0.53	1.89
26	5	5	3	2	8	0	0	2	0.38	2.66
27	13	8	4	0	2	0	0	6	0.44	2.27
28	0	6	0	4	4	1	1	4	0.35	2.85
29	1	4	1	5	6	1	1	2	0.36	2.75
30	1	1	0	12	5	2	0	0	0.41	2.41
31	1	1	0	15	2	0	2	0	0.52	1.94
32	1	7	4	6	1	0	1	1	0.58	1.73
33	1	11	5	3	0	0	1	0	0.64	1.56
34	1	7	1	5	4	1	2	0	0.45	2.21
35	1	12	1	3	2	0	1	1	0.52	1.94
36	5	12	1	3	2	0	1	1	0.52	1.94
37	0	9	0	0	6	1	2	2	0.34	2.96
38	1	3	0	10	4	2	0	1	0.41	2.41
39	1	5	1	11	1	2	0	0	0.53	1.89
40	1	3	1	9	3	1	2	1	0.45	2.21
41	1	2	13	2	1	0	2	0	0.71	1.42
42	1	4	6	6	2	0	2	0	0.59	1.69
43	1	7	2	6	4	0	0	1	0.49	2.04
44	1	9	2	2	1	1	0	5	0.44	2.27
45	5	2	0	0	0	0	0	18	0.14	7.39
46	5	3	1	2	6	3	0	5	0.25	4.01
47	0	4	0	6	8	1	0	1	0.34	2.96
48	1	0	0	12	7	1	0	0	0.39	2.57
49	1	3	0	8	5	2	2	0	0.39	2.57
50	1	1	0	11	3	0	5	0	0.45	2.21
51	1	9	1	10	0	0	0	0	0.60	1.65
52	1	5	1	13	0	0	1	0	0.59	1.69
53	1	4	0	11	5	0	0	0	0.47	2.15
54	5	7	1	6	2	0	0	4	0.45	2.21
55	9	0	0	8	8	4	0	0	0.29	3.48

Table B1 continue

No	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha	Ha/SSU
56	5	0	0	9	6	4	1	0	0.33	3.07
57	1	0	0	13	3	2	2	0	0.44	2.27
58	1	2	1	13	3	0	1	0	0.52	1.94
59	1	2	0	8	5	1	3	1	0.38	2.66
60	1	4	0	13	1	0	2	0	0.54	1.85
61	1	8	0	8	0	0	2	2	0.52	1.94
62	1	4	0	15	1	0	0	0	0.57	1.76
63	9	10	1	6	1	0	0	2	0.53	1.89
64	9	1	0	7	5	1	5	1	0.35	2.85
65	5	1	0	9	6	2	2	0	0.36	2.75
66	1	0	0	11	5	1	2	1	0.39	2.57
67	1	0	3	11	2	1	3	0	0.52	1.94
68	1	8	0	9	1	0	2	0	0.54	1.85
69	1	6	0	12	0	0	0	2	0.54	1.85
70	1	4	4	10	0	0	1	1	0.60	1.65
71	1	2	1	15	0	0	2	0	0.58	1.73
72	5	2	1	2	6	1	1	2	0.22	4.64
73	5	2	1	0	14	1	1	1	0.19	5.37
74	5	5	1	0	7	0	2	2	0.26	3.81
75	1	1	0	12	5	0	2	0	0.44	2.27
76	1	3	1	12	2	0	2	0	0.53	1.89
77	1	6	0	1	6	4	2	1	0.29	3.48
78	1	6	0	9	4	0	1	0	0.48	2.09
79	1	5	0	9	1	0	4	1	0.49	2.04
80	1	3	0	7	4	0	3	2	0.37	2.69
81	3	6	2	0	4	1	5	2	0.38	2.66
82	5	0	0	7	8	5	0	0	0.26	3.81
83	5	3	0	1	11	2	2	1	0.21	4.73
84	1	1	0	1	12	1	5	0	0.20	5.03
85	1	3	0	0	10	1	3	2	0.19	5.14
86	5	4	0	1	9	0	4	2	0.26	3.81
87	2	5	0	0	11	0	3	1	0.25	4.01
88	3	7	0	4	4	0	5	0	0.43	2.34
89	1	4	0	4	11	0	1	0	0.30	3.33
90	9	6	0	0	7	0	6	1	0.31	3.20
91	5	3	0	6	6	3	1	1	0.33	3.07
92	5	5	0	4	4	1	2	2	0.33	3.03
93	5	1	0	1	12	3	0	3	0.14	7.39
94	5	2	0	0	9	4	4	1	0.19	5.37
95	5	3	0	6	3	0	6	2	0.39	2.57
96	7	8	0	0	9	0	3	0	0.33	3.07
97	5	4	0	2	8	0	4	2	0.29	3.48
98	2	5	0	1	10	0	3	1	0.27	3.64
99	9	5	0	2	7	0	3	2	0.30	3.38
100	5	2	0	1	12	1	4	0	0.21	4.73
101	5	8	0	0	8	1	2	1	0.31	3.20
102	5	3	0	4	7	1	2	2	0.28	3.53
103	9	3	1	3	9	2	2	0	0.30	3.33
104	9	11	1	0	3	0	3	2	0.44	2.27
105	9	4	0	6	6	1	2	1	0.36	2.75
106	9	6	0	6	4	0	4	0	0.44	2.27
107	5	4	0	8	7	0	1	0	0.40	2.49
108	9	8	0	0	7	0	3	2	0.33	3.07
109	1	5	2	5	6	1	1	0	0.43	2.34
110	1	2	0	7	6	3	2	0	0.34	2.96
111	9	1	0	0	15	2	2	0	0.14	7.39
112	17	3	0	0	8	3	3	3	0.20	5.03
113	7	4	0	0	8	4	4	0	0.24	4.22

Table B1 continue

No	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha	Ha/SSU
114	5	4	0	0	13	0	3	0	0.22	4.46
115	9	7	0	0	7	0	5	1	0.33	3.07
116	5	9	0	2	5	0	2	2	0.39	2.57
117	13	5	0	0	9	0	5	1	0.27	3.64
118	1	3	0	0	10	1	5	1	0.22	4.46
119	1	4	0	0	10	0	4	2	0.24	4.22
120	9	6	0	0	10	3	1	0	0.25	4.01
121	13	2	0	0	9	3	5	1	0.20	5.03
122	7	2	0	0	15	0	1	2	0.15	6.76
123	5	8	0	0	5	2	4	1	0.34	2.96
124	5	1	0	0	9	2	7	1	0.20	5.03
125	5	7	1	1	6	0	5	0	0.39	2.57
126	9	3	0	6	8	1	1	1	0.33	3.07
127	1	7	1	0	8	2	2	0	0.33	3.07
128	1	5	1	3	6	1	4	0	0.38	2.66
129	3	7	0	0	11	0	1	1	0.27	3.64
130	3	5	0	0	6	2	4	2	0.26	3.88
131	1	6	0	0	4	3	3	4	0.27	3.64
132	1	3	1	0	8	1	6	1	0.27	3.64
133	1	7	1	3	6	0	3	0	0.41	2.41
134	1	8	0	2	4	0	5	2	0.41	2.46
135	5	8	0	4	2	1	2	2	0.41	2.44

Table B2 *The variables for time, plant species and grazing capacity for every grid-block in Camp MA.*

No	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha	Ha/SSU
1	0	7	2	0	7	1	1	2	0.42	2.37
2	0	3	1	0	6	6	4	0	0.30	3.34
3	0	2	0	3	3	1	3	7	0.29	3.40
4	0	2	0	1	4	0	7	6	0.30	3.34
5	0	2	0	0	6	2	7	3	0.27	3.72
6	0	3	1	0	6	5	2	3	0.27	3.72
7	0	2	0	0	5	6	4	3	0.22	4.48
8	0	6	0	0	4	6	4	0	0.35	2.90
9	0	6	0	0	2	0	4	7	0.34	2.94
10	0	5	5	2	2	2	3	1	0.59	1.70
11	0	7	3	1	3	2	3	1	0.53	1.89
12	0	4	2	1	3	1	4	4	0.40	2.49
13	0	3	0	1	7	1	4	4	0.28	3.52
14	0	4	0	1	6	1	5	3	0.33	3.03
15	0	1	0	0	8	3	6	2	0.22	4.48
16	2	3	0	0	7	3	5	2	0.27	3.72
17	2	5	0	0	10	2	2	1	0.28	3.52
18	3	4	1	0	8	1	6	0	0.36	2.77
19	0	3	3	8	2	1	3	0	0.62	1.61
20	0	3	2	2	7	1	5	0	0.42	2.37
21	0	2	6	0	1	2	8	1	0.56	1.79
22	0	5	0	2	3	2	5	3	0.39	2.56
23	0	3	1	0	5	5	6	0	0.33	3.03
24	2	5	1	0	7	1	3	3	0.35	2.90
25	2	3	1	0	5	4	4	3	0.30	3.34
26	2	7	0	0	5	1	6	1	0.41	2.46
27	6	6	0	0	7	0	6	1	0.38	2.66
28	0	1	7	4	0	0	7	1	0.68	1.47
29	0	6	4	0	6	0	3	1	0.51	1.95

Table B2 continue

No	Ti	SG	CG	Ad	PG	US	Fe	OTHE	SSU/Ha	Ha/SSU
30	0	5	0	2	4	2	6	1	0.41	2.46
31	0	5	0	3	3	2	5	2	0.42	2.37
32	0	4	0	0	5	1	9	1	0.36	2.77
33	3	5	0	0	7	3	4	1	0.31	3.18
34	2	2	0	0	7	2	3	5	0.20	4.92
35	6	3	1	1	5	1	9	0	0.41	2.46
36	6	7	1	2	8	1	1	0	0.44	2.29
37	0	0	8	5	3	0	4	0	0.68	1.47
38	0	4	6	0	3	1	3	3	0.54	1.84
39	0	9	0	1	5	0	3	2	0.45	2.21
40	0	4	0	0	5	4	5	2	0.30	3.34
41	2	3	0	0	5	3	7	2	0.30	3.34
42	4	4	0	0	5	4	4	3	0.28	3.52
43	2	4	0	0	6	0	8	2	0.35	2.90
44	6	5	0	0	4	1	7	3	0.36	2.77
45	2	7	0	4	1	0	6	2	0.53	1.89
46	0	0	8	4	1	0	5	2	0.67	1.50
47	0	4	4	6	1	0	4	1	0.65	1.54
48	0	7	1	2	1	0	7	2	0.53	1.89
49	2	4	0	1	6	3	4	2	0.31	3.18
50	4	1	0	0	7	4	4	4	0.19	5.18
51	6	4	0	0	1	9	2	4	0.25	3.94
52	2	4	0	0	6	3	4	3	0.28	3.52
53	4	2	0	4	8	0	6	0	0.38	2.66
54	2	4	0	3	3	0	6	4	0.41	2.46
55	0	1	7	5	4	0	0	3	0.60	1.66
56	2	6	0	2	6	0	5	1	0.42	2.37
57	2	3	0	0	7	1	8	1	0.31	3.18
58	2	5	0	0	1	3	6	4	0.34	2.94
59	2	4	0	0	5	4	5	2	0.30	3.34
60	2	3	0	0	5	1	8	3	0.31	3.18
61	2	7	0	0	4	0	8	1	0.44	2.29
62	2	4	0	0	8	0	4	4	0.28	3.52
63	0	2	0	5	4	0	5	4	0.39	2.56
64	1	2	12	0	3	0	2	1	0.74	1.35
65	2	10	0	1	4	0	5	0	0.51	1.95
66	1	5	4	0	2	0	6	3	0.53	1.89
67	2	1	1	0	6	1	8	3	0.30	3.34
68	2	2	1	0	4	3	6	4	0.30	3.34
69	2	6	0	1	4	1	4	4	0.38	2.66
70	2	4	0	0	7	1	3	4	0.26	3.79
71	2	5	1	0	7	2	4	1	0.36	2.77
72	1	6	0	2	6	0	3	3	0.39	2.56
73	1	3	10	1	1	0	3	2	0.73	1.38
74	2	13	1	0	2	0	3	1	0.59	1.70
75	1	0	7	1	3	1	8	0	0.57	1.74
76	2	1	2	0	8	2	4	3	0.28	3.52
77	2	5	0	0	9	0	5	1	0.33	3.03
78	0	3	0	0	6	1	6	4	0.28	3.52
79	0	3	2	0	8	0	4	3	0.35	2.90
80	2	8	0	0	7	0	5	0	0.42	2.37
81	4	7	3	1	5	0	2	2	0.51	1.95
82	0	0	10	3	3	0	3	1	0.70	1.44
83	2	5	5	0	3	0	6	1	0.57	1.74
84	2	5	8	0	4	1	2	0	0.65	1.54
85	2	6	3	0	4	0	5	2	0.50	2.01
86	2	4	0	0	9	2	2	3	0.25	3.94
87	0	8	0	0	8	1	0	3	0.35	2.90

Table B2 continue x

No	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha	Ha/SSU
88	1	6	0	1	8	0	4	1	0.38	2.66
89	2	4	1	1	6	0	3	5	0.35	2.90
90	6	7	1	1	5	0	5	1	0.47	2.14
91	0	0	13	0	3	0	3	1	0.74	1.35
92	2	1	7	2	2	0	6	2	0.60	1.66
93	2	3	3	0	4	0	5	5	0.41	2.46
94	2	5	1	2	5	1	6	0	0.45	2.21
95	2	2	3	0	10	2	1	2	0.31	3.18
96	0	4	0	0	13	0	3	0	0.27	3.72
97	4	3	2	0	5	0	8	2	0.41	2.46
98	6	2	5	0	7	0	4	2	0.45	2.21
99	8	5	3	4	6	0	2	0	0.54	1.84
100	1	2	8	5	4	0	0	1	0.68	1.47
101	2	0	10	3	3	0	3	1	0.70	1.44
102	2	8	5	0	3	0	4	0	0.63	1.58
103	2	4	3	0	8	0	3	2	0.41	2.46
104	1	7	2	0	5	2	3	1	0.45	2.21
105	1	4	3	0	7	0	5	1	0.44	2.29
106	8	4	5	0	6	0	5	0	0.53	1.89
107	4	8	2	2	6	0	2	0	0.53	1.89
108	10	1	2	3	9	0	4	1	0.38	2.66
109	2	0	13	3	3	0	1	0	0.80	1.25
110	3	0	13	1	1	0	2	3	0.76	1.32
111	2	0	9	2	2	0	5	2	0.65	1.54
112	2	4	4	1	5	0	5	1	0.51	1.95
113	1	2	5	2	4	0	5	2	0.53	1.89
114	2	2	5	2	3	0	5	3	0.53	1.89
115	8	6	4	2	3	0	2	3	0.56	1.79
116	2	5	3	0	7	0	4	1	0.45	2.21
117	8	7	3	3	4	0	1	2	0.56	1.79
118	10	1	11	3	3	0	1	1	0.74	1.35
119	18	0	12	0	1	0	5	2	0.73	1.38
120	10	2	8	4	2	0	1	3	0.67	1.50
121	8	4	1	1	5	0	3	2	0.32	3.08
122	4	2	8	2	2	0	5	1	0.67	1.50
123	2	3	6	1	6	0	4	0	0.56	1.79
124	10	8	2	2	5	0	3	0	0.54	1.84
125	1	4	4	3	7	0	2	0	0.53	1.89
126	10	1	3	3	6	0	4	3	0.42	2.37
127	10	2	13	2	1	0	2	0	0.85	1.18
128	25	2	12	0	2	0	3	1	0.76	1.32
129	16	4	5	1	3	0	3	2	0.52	1.93
130	10	0	9	1	3	0	6	1	0.63	1.58
131	6	2	8	0	5	0	2	3	0.56	1.79
132	2	2	4	2	3	0	5	2	0.47	2.12
133	14	3	3	3	2	0	6	3	0.51	1.95
134	10	6	2	4	2	0	1	4	0.51	1.97
135	20	5	5	0	3	0	5	2	0.56	1.79

Table B3 *The variables for time, plant species and grazing capacity for every grid-block in Camp DB.*

No	Ti	SG	CG	AD	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
1	2	0	3	0	4	3	5	1	0	1	0	0.25	3.93
2	4	4	0	0	7	3	2	0	0	0	1	0.23	4.40
3	4	1	0	0	5	5	0	4	1	1	0	0.25	3.93
4	2	3	0	0	2	3	2	1	1	2	3	0.24	4.15

Table B3 continue

No	Ti	SG	CG	AD	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
5	2	0	0	0	9	1	3	1	2	0	1	0.16	6.26
6	1	0	0	0	5	4	3	2	0	0	3	0.16	6.26
7	0	0	7	0	6	0	3	1	0	0	0	0.38	2.65
8	0	1	3	0	2	3	6	0	1	1	0	0.30	3.39
9	0	0	1	5	3	0	6	1	1	0	0	0.30	3.39
10	0	0	0	10	2	0	3	1	0	0	1	0.36	2.75
11	0	2	3	6	2	0	2	1	0	0	1	0.43	2.32
12	6	0	2	0	3	2	4	3	0	3	0	0.23	4.40
13	4	0	2	0	2	0	6	2	1	0	4	0.21	4.67
14	5	1	1	2	2	0	3	4	1	2	1	0.28	3.55
15	5	0	0	5	4	1	2	4	1	0	0	0.31	3.24
16	1	0	1	3	2	1	5	3	2	0	0	0.31	3.24
17	2	0	0	0	11	2	1	1	1	1	0	0.15	6.84
18	6	0	0	0	6	7	0	0	0	2	2	0.17	5.77
19	6	0	0	0	8	5	1	0	0	2	1	0.15	6.84
20	2	0	0	0	11	4	0	1	0	0	1	0.15	6.84
21	1	1	0	2	7	3	1	1	0	0	2	0.21	4.67
22	1	0	2	0	5	1	7	0	1	0	1	0.20	4.99
23	1	1	1	2	10	1	0	1	1	0	0	0.25	3.93
24	2	0	3	0	4	0	10	0	0	0	0	0.20	4.99
25	0	1	0	5	4	0	1	6	0	0	0	0.32	3.10
26	0	0	0	3	4	1	6	1	0	2	0	0.19	5.35
27	1	0	0	8	4	1	3	1	0	0	0	0.32	3.10
28	14	0	3	0	1	0	10	2	0	0	1	0.23	4.40
29	7	2	1	4	2	0	6	2	0	0	0	0.31	3.24
30	6	1	0	3	6	2	2	1	2	0	0	0.28	3.55
31	7	0	0	1	4	1	8	0	0	2	1	0.12	8.41
32	1	0	0	1	3	3	9	1	0	0	0	0.16	6.26
33	0	0	0	0	7	5	3	0	0	0	2	0.15	6.84
34	2	2	0	1	4	7	0	0	0	1	2	0.25	3.93
35	4	1	0	3	5	6	1	0	0	1	0	0.27	3.73
36	3	1	0	1	8	3	1	1	1	0	1	0.21	4.67
37	1	0	0	0	6	4	1	3	0	0	3	0.17	5.77
38	1	0	0	0	7	2	5	1	1	0	1	0.15	6.84
39	1	2	3	3	5	1	1	1	0	0	1	0.36	2.75
40	1	0	6	0	2	5	3	0	0	0	1	0.39	2.56
41	0	0	0	1	5	2	4	2	1	1	1	0.19	5.35
42	0	0	0	4	5	0	2	5	0	1	0	0.25	3.93
43	2	0	2	5	0	2	4	2	0	0	2	0.35	2.86
44	18	0	4	0	0	0	10	2	0	0	1	0.27	3.73
45	8	0	1	1	0	0	10	4	0	0	1	0.20	4.99
46	3	1	1	3	4	5	1	2	0	0	0	0.32	3.10
47	2	0	3	1	1	4	5	3	0	0	0	0.32	3.10
48	2	3	2	0	4	3	5	0	0	0	0	0.28	3.55
49	0	2	0	4	5	3	2	0	1	0	0	0.31	3.24
50	0	3	0	0	1	8	2	0	0	1	2	0.27	3.73
51	1	1	0	0	4	4	3	2	1	0	2	0.21	4.67
52	2	0	0	1	8	4	0	3	0	1	0	0.20	4.99
53	1	0	0	0	6	0	4	2	3	0	2	0.19	5.35
54	0	0	0	0	8	1	7	1	0	0	0	0.11	9.49
55	1	1	0	0	7	1	3	4	0	0	1	0.17	5.77
56	1	2	3	1	4	4	1	0	1	1	0	0.36	2.75
57	2	3	0	0	5	1	5	1	0	0	2	0.19	5.35
58	0	0	0	1	7	1	1	5	1	1	0	0.21	4.67
59	2	2	1	6	1	0	6	0	1	0	0	0.36	2.75
60	14	1	4	1	1	0	4	3	1	1	1	0.36	2.75
61	6	1	2	0	2	1	9	1	0	1	0	0.21	4.67
62	0	0	2	2	4	0	5	4	0	0	0	0.27	3.73

No	Ti	SG	CG	AD	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
63	3	0	7	3	3	0	4	0	0	0	0	0.44	2.25
64	10	1	2	1	3	1	8	0	1	0	0	0.25	3.93
65	7	2	1	0	6	2	3	0	1	0	2	0.23	4.40
66	0	2	0	2	2	4	1	1	1	3	1	0.28	3.55
67	0	2	0	0	5	2	3	5	0	0	0	0.23	4.40
68	0	0	0	3	8	3	0	2	1	0	0	0.25	3.93
69	0	1	0	0	7	6	0	2	1	0	0	0.24	4.15
70	0	0	0	0	4	4	2	2	3	0	2	0.24	4.15
71	1	0	0	1	5	3	0	3	1	1	3	0.21	4.67
72	1	1	4	0	4	1	4	1	0	0	2	0.30	3.39
73	2	0	2	2	2	1	8	0	0	0	2	0.23	4.40
74	4	0	0	0	4	6	4	2	1	0	0	0.21	4.67
75	12	3	0	2	3	0	4	3	1	0	1	0.28	3.55
76	12	1	0	1	5	0	3	6	0	0	1	0.21	4.67
77	9	0	6	0	5	0	2	4	0	0	0	0.38	2.65
78	0	2	2	2	1	4	5	1	0	0	0	0.34	2.98
79	4	0	3	4	0	0	10	0	0	0	0	0.31	3.24
80	14	0	4	0	3	3	6	0	1	0	0	0.31	3.24
81	7	0	1	0	5	2	5	1	0	1	2	0.16	6.26
82	1	0	0	0	7	3	5	1	0	1	0	0.13	7.55
83	0	1	0	0	5	4	6	1	0	0	0	0.17	5.77
84	0	0	0	4	6	2	2	2	0	0	1	0.24	4.15
85	0	0	0	5	2	2	2	4	0	0	2	0.30	3.39
86	0	0	0	0	6	3	1	0	3	1	3	0.20	4.99
87	1	1	0	1	9	0	4	1	0	0	1	0.15	6.84
88	1	1	2	1	4	1	3	0	1	1	3	0.25	3.93
89	6	1	2	0	2	3	6	1	0	1	1	0.24	4.15
90	6	0	0	0	3	1	6	5	0	2	0	0.16	6.26
91	14	1	0	0	9	0	1	3	1	0	2	0.17	5.77
92	12	0	2	0	6	4	2	0	2	0	1	0.27	3.73
93	10	0	3	0	2	1	5	3	0	0	3	0.25	3.93
94	1	0	3	3	2	0	4	2	0	1	2	0.31	3.24
95	5	0	3	3	1	0	8	0	0	2	0	0.28	3.55
96	10	0	1	0	2	2	7	3	1	1	0	0.21	4.67
97	0	0	0	0	4	4	6	1	1	0	1	0.17	5.77
98	0	0	0	0	3	8	2	1	0	0	3	0.20	4.99
99	0	2	0	0	6	4	3	2	0	0	0	0.21	4.67
100	0	0	0	9	5	1	0	1	0	0	1	0.35	2.86
101	0	0	0	4	8	4	0	0	0	0	1	0.24	4.15
102	0	0	0	1	8	1	2	2	0	0	3	0.15	6.84
103	0	1	0	0	6	3	1	3	0	0	3	0.19	5.35
104	1	2	3	1	6	0	0	3	0	1	1	0.32	3.10
105	6	2	1	0	4	0	3	4	1	1	1	0.25	3.93
106	8	1	3	0	5	1	5	1	0	0	1	0.25	3.93
107	3	2	0	0	5	1	4	2	0	0	3	0.17	5.77
108	4	0	2	0	6	2	3	1	0	1	2	0.20	4.99
109	4	1	1	0	5	4	1	3	1	0	1	0.27	3.73
110	2	3	0	0	4	0	6	3	1	0	0	0.23	4.40
111	3	1	0	7	1	1	6	0	1	0	0	0.34	2.98
112	4	1	0	6	5	0	2	1	1	1	0	0.31	3.24
113	0	0	1	0	9	0	2	1	2	2	0	0.19	5.35
114	0	1	1	0	3	0	5	5	1	1	0	0.24	4.15
115	0	1	0	1	7	4	1	1	0	0	2	0.20	4.99
116	0	0	0	13	0	1	1	2	0	0	0	0.47	2.12
117	0	0	0	8	1	2	2	2	1	0	1	0.38	2.65
118	0	0	0	0	9	2	2	2	0	1	1	0.13	7.55
119	0	1	0	1	8	1	3	3	0	0	0	0.19	5.35
120	1	0	0	4	3	0	1	4	1	2	2	0.27	3.73

Table B3 continue

No	Ti	SG	CG	AD	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
121	4	0	2	0	7	0	0	5	1	1	1	0.25	3.93
122	5	0	6	0	1	1	7	1	0	1	0	0.35	2.86
123	2	0	0	0	7	2	6	1	0	0	1	0.12	8.41
124	0	0	0	0	6	1	9	1	0	0	0	0.11	9.49
125	1	0	3	0	2	1	2	6	0	2	1	0.30	3.39
126	0	0	1	0	4	1	4	4	2	1	0	0.24	4.15
127	4	1	1	3	3	2	4	2	0	0	1	0.28	3.55
128	10	0	3	1	1	0	9	2	1	0	0	0.28	3.55
129	0	1	0	1	5	0	6	1	2	0	1	0.20	4.99
130	0	1	1	2	3	1	1	2	2	3	1	0.30	3.39
131	0	0	0	5	5	1	3	2	1	0	0	0.28	3.55
132	0	0	0	6	2	5	2	1	0	1	0	0.32	3.10
133	0	3	0	1	2	2	2	2	0	2	3	0.24	4.15
134	0	0	0	0	9	3	2	1	1	0	1	0.16	6.26
135	0	1	0	0	8	5	1	1	1	0	0	0.21	4.67
136	0	3	0	1	7	2	0	3	0	0	1	0.25	3.93
137	1	2	0	2	6	1	1	2	3	0	0	0.31	3.24
138	2	1	2	1	2	3	4	1	2	0	1	0.32	3.10
139	0	1	4	0	4	2	2	2	2	0	0	0.38	2.65
140	0	0	0	0	6	0	8	1	1	0	1	0.12	8.41
141	0	3	0	0	4	0	3	2	1	0	4	0.21	4.67
142	2	1	1	3	3	0	6	3	0	0	2	0.28	3.62
143	2	1	2	0	5	2	4	1	1	1	0	0.25	3.93
144	3	1	1	0	1	2	9	0	2	1	0	0.23	4.40

Table B4 *The variables for time, plant species and grazing capacity for every grid-block in Camp DB.*

No	Ti	SG	CG	Ad	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
1	2	3	0	0	6	3	2	1	1	1	0	0.26	3.79
2	2	0	0	1	4	4	3	2	1	1	1	0.23	4.27
3	2	0	0	12	2	0	2	0	0	0	1	0.44	2.26
4	2	0	0	6	0	0	5	4	0	2	0	0.32	3.09
5	2	0	0	4	7	1	1	2	1	0	1	0.28	3.59
6	0	0	0	1	9	1	0	3	1	0	2	0.20	4.89
7	0	0	0	2	8	0	2	2	1	0	2	0.20	4.89
8	2	0	0	0	6	1	6	1	1	1	1	0.15	6.89
9	2	0	0	2	4	2	8	1	0	0	0	0.19	5.27
10	2	1	0	1	6	0	6	3	0	0	0	0.19	5.27
11	2	0	0	0	4	1	6	2	0	2	2	0.13	7.68
12	2	0	1	4	3	2	5	2	0	0	0	0.31	3.24
13	6	0	0	2	2	1	7	5	0	0	0	0.23	4.27
14	8	0	0	1	4	0	7	3	1	1	0	0.19	5.27
15	8	0	0	0	7	2	6	2	0	0	0	0.15	6.89
16	6	1	0	1	0	1	12	1	1	0	0	0.20	4.89
17	2	0	0	1	8	3	1	1	3	0	0	0.26	3.79
18	2	0	0	0	8	1	4	2	1	0	1	0.16	6.25
19	2	1	0	7	2	3	0	3	1	0	0	0.44	2.26
20	2	0	0	6	5	1	2	2	0	0	1	0.31	3.24
21	0	0	0	1	6	0	0	4	2	3	1	0.23	4.27
22	0	0	0	0	7	0	2	4	3	0	1	0.23	4.27
23	0	1	0	0	7	1	3	2	2	1	0	0.22	4.56
24	2	0	0	2	7	1	0	2	3	1	1	0.28	3.59
25	2	0	0	0	7	2	5	3	0	0	0	0.16	6.25
26	2	1	2	5	4	0	2	2	1	0	0	0.41	2.42
27	2	1	2	1	4	0	4	3	1	1	0	0.31	3.24
28	1	3	6	0	1	1	5	0	0	0	1	0.46	2.19

No	Ti	SG	CG	Ad	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
29	8	0	0	3	5	2	6	1	0	0	0	0.22	4.56
30	14	0	0	0	9	1	7	0	0	0	0	0.10	9.95
31	12	0	0	1	6	0	4	4	2	0	0	0.23	4.27
32	12	0	0	0	6	1	7	2	0	1	0	0.13	7.68
33	2	0	0	0	6	4	5	0	2	0	0	0.20	4.89
34	2	1	0	0	3	4	2	0	1	2	4	0.20	4.89
35	0	0	0	4	3	2	1	3	2	1	1	0.34	2.96
36	0	1	0	2	4	1	3	2	2	0	2	0.28	3.59
37	2	2	0	1	5	2	1	2	3	1	0	0.32	3.09
38	1	0	0	0	6	0	2	3	2	3	1	0.19	5.27
39	0	1	0	0	7	0	1	5	0	1	2	0.19	5.27
40	2	0	0	1	7	0	2	5	1	0	1	0.22	4.56
41	2	0	0	9	2	0	3	1	2	0	0	0.43	2.34
42	2	0	0	6	4	0	1	4	1	0	1	0.35	2.83
43	2	1	1	1	4	0	5	4	1	0	0	0.28	3.59
44	1	1	7	0	2	0	4	1	0	0	2	0.44	2.26
45	1	0	0	3	6	0	5	2	0	1	0	0.20	4.89
46	6	0	0	0	9	2	3	2	0	0	1	0.15	6.89
47	20	0	0	2	4	2	5	1	2	0	1	0.25	4.01
48	12	3	0	0	8	0	4	1	1	0	0	0.22	4.56
49	5	2	0	0	5	4	1	0	5	0	0	0.35	2.83
50	6	2	0	0	7	4	0	1	0	1	2	0.22	4.56
51	2	0	0	0	4	3	1	0	4	1	4	0.25	4.01
52	0	1	0	0	4	0	0	2	7	0	3	0.35	2.83
53	2	1	0	0	6	5	2	2	0	1	0	0.22	4.56
54	2	2	0	2	3	2	1	4	3	0	0	0.38	2.61
55	1	1	0	0	7	0	0	0	4	3	2	0.23	4.27
56	2	1	0	2	7	2	0	4	1	0	0	0.29	3.41
57	2	0	0	7	4	1	3	1	0	0	1	0.32	3.09
58	2	1	0	6	4	0	2	2	0	0	2	0.32	3.09
59	2	0	0	4	5	0	1	5	0	1	1	0.28	3.59
60	1	1	7	0	2	1	4	0	2	0	0	0.50	1.99
61	0	0	4	4	3	0	4	0	0	0	2	0.38	2.61
62	2	0	0	0	9	0	5	0	2	0	1	0.15	6.89
63	16	0	0	2	4	1	3	4	3	0	0	0.31	3.24
64	10	0	0	0	5	0	9	1	1	1	0	0.13	7.68
65	8	0	0	0	8	5	2	1	0	0	1	0.17	5.72
66	6	0	0	0	5	4	2	1	1	1	3	0.19	5.27
67	2	1	0	6	5	0	2	1	0	0	2	0.31	3.24
68	2	1	0	1	7	2	1	0	3	1	1	0.26	3.79
69	2	1	0	0	9	2	2	2	0	0	1	0.17	5.72
70	0	1	0	3	6	0	1	1	2	2	1	0.28	3.59
71	1	1	0	1	6	2	4	1	1	0	1	0.22	4.56
72	2	1	0	1	8	0	4	3	0	0	0	0.19	5.27
73	2	2	0	6	4	0	3	1	1	0	0	0.37	2.72
74	2	0	1	8	2	0	3	3	0	0	0	0.41	2.42
75	2	0	1	6	4	0	3	3	0	0	0	0.35	2.83
76	1	1	8	1	2	1	3	1	0	0	0	0.53	1.88
77	0	3	1	7	4	0	1	1	0	0	0	0.44	2.26
78	6	0	0	4	8	0	4	1	0	0	0	0.22	4.56
79	14	1	0	0	10	0	2	2	0	0	2	0.15	6.89
80	8	0	0	1	2	0	11	1	2	0	0	0.19	5.27
81	6	3	0	0	3	1	5	0	2	3	0	0.25	4.01
82	6	0	0	1	4	2	8	0	1	0	1	0.17	5.72
83	0	1	0	9	1	1	2	0	1	1	1	0.43	2.34
84	0	0	0	8	4	0	0	3	0	0	2	0.37	2.72
85	1	1	0	1	6	1	4	2	1	0	1	0.22	4.56
86	0	1	1	0	4	0	4	1	3	0	3	0.26	3.79

Table B4 continue

No	Ti	SG	CG	Ad	PG	LPS	Geo	Es	PS	US	OTHE	SSU/Ha	Ha/SSU
87	0	1	1	0	2	6	2	3	2	0	0	0.35	2.83
88	2	1	0	0	2	0	4	5	2	1	2	0.25	4.01
89	2	0	0	1	8	1	3	1	1	0	2	0.17	5.72
90	2	3	0	3	2	1	0	4	1	0	3	0.37	2.72
91	2	2	0	9	1	0	3	1	0	0	1	0.43	2.34
92	0	0	3	4	0	0	6	1	0	1	2	0.35	2.83
93	0	1	0	9	4	0	0	1	1	0	1	0.43	2.34
94	8	0	0	2	7	0	4	3	0	0	1	0.19	5.27
95	14	1	0	3	8	0	1	4	0	0	0	0.26	3.79
96	8	2	1	1	1	2	7	2	0	1	0	0.28	3.59
97	0	1	1	0	8	4	2	0	1	0	0	0.25	4.01
98	0	1	0	0	1	6	1	3	2	1	2	0.31	3.24
99	2	1	0	5	4	2	1	3	0	1	0	0.34	2.96
100	2	1	0	6	1	0	1	3	2	0	3	0.40	2.51
101	0	0	0	4	5	0	5	0	3	0	0	0.29	3.41
102	2	1	1	0	9	1	1	1	2	1	0	0.25	4.01
103	2	0	1	0	8	1	1	1	3	2	0	0.25	4.01
104	4	0	0	2	6	2	4	0	2	0	1	0.23	4.27
105	2	0	0	1	6	0	4	4	0	1	1	0.17	5.72
106	2	0	2	4	3	0	3	3	2	0	0	0.40	2.51
107	2	0	3	1	4	1	2	5	1	0	0	0.37	2.72
108	4	0	8	3	1	0	3	0	0	1	1	0.53	1.88
109	0	4	2	2	2	0	5	2	0	0	0	0.38	2.61
110	2	0	0	5	3	0	4	3	0	0	2	0.28	3.59
111	3	2	1	1	3	0	6	1	2	1	0	0.29	3.41
112	25	1	2	0	4	1	3	1	1	0	4	0.26	3.79
113	0	4	3	0	2	2	2	3	1	0	0	0.44	2.26
114	0	3	0	1	7	1	0	0	3	1	1	0.31	3.24
115	0	2	1	2	3	5	1	1	1	0	1	0.37	2.72
116	0	0	0	6	6	0	2	1	1	1	0	0.31	3.24
117	2	0	0	8	2	0	2	3	1	0	1	0.40	2.51
118	0	1	0	3	5	2	1	1	3	0	1	0.34	2.96
119	3	1	4	1	3	1	2	1	1	1	2	0.38	2.61
120	14	1	0	3	4	3	3	2	0	0	1	0.28	3.59
121	4	0	0	4	4	1	2	3	2	0	1	0.32	3.09
122	2	1	1	8	4	0	0	2	0	0	1	0.43	2.34
123	7	1	3	8	0	0	2	1	2	0	0	0.56	1.78
124	10	0	9	0	5	0	1	2	0	0	0	0.52	1.94
125	5	0	7	4	0	0	2	1	0	2	1	0.53	1.88
126	1	0	4	6	2	2	1	1	0	0	1	0.49	2.05
127	8	1	0	8	0	1	4	1	1	0	1	0.41	2.42
128	36	1	7	0	4	0	1	1	2	1	0	0.50	1.99
129	0	0	5	0	2	1	4	4	0	0	1	0.38	2.61
130	0	1	2	0	5	5	3	1	0	0	1	0.30	3.37
131	0	0	0	0	6	7	1	2	0	1	1	0.22	4.49
132	0	1	0	0	8	2	0	1	4	0	1	0.28	3.59
133	0	3	0	1	7	1	2	1	2	0	0	0.29	3.41
134	2	0	0	3	5	0	3	3	1	1	1	0.25	4.01
135	2	0	6	0	4	1	0	4	1	1	1	0.46	2.17
136	3	0	0	1	3	2	5	2	0	2	2	0.17	5.72
137	2	1	0	3	7	0	1	2	2	0	1	0.29	3.41
138	2	1	0	8	1	0	0	4	0	0	3	0.41	2.42
139	4	0	2	9	1	0	2	2	1	0	0	0.50	1.99
140	3	1	8	2	0	0	1	3	1	1	0	0.61	1.65
141	2	0	4	1	6	1	0	5	0	0	0	0.38	2.61
142	1	2	2	6	3	0	0	3	0	0	1	0.46	2.19
143	2	0	0	6	1	0	4	4	2	0	0	0.38	2.61
144	30	5	0	1	0	0	5	2	2	0	2	0.35	2.83

APPENDIX C

The correlation matrixes for the four camps on Sites A and B. (See Tables C1 to C12).

Correlation matixes for:

Site A: Camp DA

Total blocks, 135
Low time-occupation blocks (n=54)
High time-occupation blocks (n=12)

Camp MA

Total blocks, 135
Low time-occupation blocks (n=28)
High time-occupation blocks (n=10)

Site B: Camp DB

Total blocks, 144
Low time-occupation blocks (n=31)
High time-occupation blocks (n=15)

Camp MB

Total blocks, 144
Low time-occupation blocks (n=46)
High time-occupation blocks (n=25)

n=Sample size

Explaination of the Tables:

VARIABLES	Ti (Time in minutes)
Ti	1.0000 = r (correlation coefficient) 0.0000 = significance level (P)

Note

P < 0.001(***) significance level is between 0.0000 and 0.001
P < 0.01 (**) significance level is between 0.001 and 0.01
P < 0.05 (*) significance level is between 0.01 and 0.05
P ≥ 0.05 (NS) significance level is equal or greater than 0.05

Table C1 *Correlation matrix for all the blocks (n=135) in Camp DA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Unpalatable Shrubs (US),* ***Eriocephalus ericoides*** *(Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.0210 1.0000	-0.0896 0.3182	-0.3766 0.0000	0.2563 0.0000	0.1446 0.0000	0.1832 0.0000	0.1635 0.0000	-0.3642 0.0000
SG	-0.0210 1.0000	1.0000 0.0000	-0.0090 1.0000	-0.2845 0.0000	-0.3096 0.0000	-0.3395 0.0000	-0.0647 0.9995	0.1001 0.0391	0.3096 0.0000
CG	-0.0896 0.3182	-0.0090 1.0000	1.0000 0.0000	-0.0302 1.0000	-0.3457 0.0000	-0.2241 0.0000	-0.2217 0.0000	0.1109 0.0016	0.4853 0.0000
Ad	-0.3766 0.0000	-0.2845 0.0000	-0.0302 1.0000	1.0000 0.0000	-0.5335 0.0000	-0.0982 0.0620	-0.2755 0.0000	-0.4113 0.0000	0.6615 0.0000
PG	0.2563 0.0000	-0.3096 0.0000	-0.3457 0.0000	-0.5335 0.0000	1.0000 0.0000	0.2823 0.0000	0.2192 0.0000	-0.1307 0.0000	-0.8070 0.0000
US	0.1446 0.0000	-0.3395 0.0000	-0.2241 0.0000	-0.0982 0.0620	0.2823 0.0000	1.0000 0.0000	-0.0031 1.0000	-0.1516 0.0000	-0.4107 0.0000
Ee	0.1832 0.0000	-0.0647 0.9995	-0.2217 0.0000	-0.2755 0.0000	0.2192 0.0000	-0.0031 1.0000	1.0000 0.0000	-0.2792 0.0000	-0.2344 0.0000
OTHE	0.1635 0.0000	0.1001 0.0391	0.1109 0.0016	-0.4113 0.0000	-0.1307 0.0000	-0.1516 0.0000	-0.2792 0.0000	1.0000 0.0000	-0.2948 0.0000
SSU/Ha	-0.3642 0.0000	0.3096 0.0000	0.4853 0.0000	0.6615 0.0000	-0.8070 0.0000	-0.4107 0.0000	-0.2344 0.0000	-0.2948 0.0000	1.0000 0.0000

Table C2 *Correlation matrix for the Low time-occupation blocks (n=54) in Camp DA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Unpalatable Shrubs (US),* ***Eriocephalus ericoides*** *(Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.1860 1.0000	0.1839 0.0121	0.4377 0.0000	-0.5736 0.0000	-0.2325 0.0000	0.0359 1.0000	-0.2269 0.0001	0.5418 0.0000
SG	-0.0186 1.0000	1.0000 0.0000	-0.0333 1.0000	-0.4803 0.0000	-0.2807 0.0000	-0.2271 0.0001	-0.1927 0.0046	0.2565 0.0000	0.1542 0.1751
CG	0.1839 0.0121	-0.0333 1.0000	1.0000 0.0000	-0.1904 0.0060	-0.3057 0.0000	-0.2188 0.0002	0.0023 1.0000	-0.1853 0.0104	0.5649 0.0000
Ad	0.4377 0.0000	-0.4803 0.0000	-0.1904 0.0060	1.0000 0.0000	-0.4565 0.0000	-0.0670 1.0000	0.0079 1.0000	-0.5683 0.0000	0.4865 0.0000
PG	-0.5736 0.0000	-0.2807 0.0000	-0.3057 0.0000	-0.4565 0.0000	1.0000 0.0000	0.2635 0.0000	-0.0798 0.9999	0.2875 0.0000	-0.8606 0.0000
US	-0.2325 0.0000	-0.2271 0.0001	-0.2188 0.0002	-0.0670 1.0000	0.2635 0.0000	1.0000 0.0000	0.0209 1.0000	-0.1071 0.9612	-0.3966 0.0000
Ee	0.0359 1.0000	-0.1927 0.0046	0.0023 1.0000	0.0079 1.0000	-0.0798 0.9999	0.0209 1.0000	1.0000 0.0000	-0.2717 0.0000	0.0023 1.0000
OTHE	-0.2269 0.0001	0.2565 0.0000	-0.1853 0.0104	-0.5683 0.0000	0.2875 0.0000	-0.1071 0.9612	-0.2717 0.0000	1.0000 0.0000	-0.5401 0.0000
SSU/Ha	0.5418 0.0000	0.1542 0.1751	0.5649 0.0000	0.4865 0.0000	-0.8606 0.0000	-0.3966 0.0000	0.0023 1.0000	-0.5401 0.0000	1.0000 0.0000

Table C3 *Correlation matrix for the High time-occupation blocks (n=12) in Camp DA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Unpalatable Shrubs (US),* ***Eriocephalus ericoides*** *(Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.2263 0.8064	-0.2425 0.7354	-0.3335 0.2993	0.1236 0.9964	-0.4306 0.0602	0.1795 0.9464	0.6136 0.0007	-0.4424 0.0477
SG	-0.2263 0.8064	1.0000 0.0000	0.5937 0.0012	-0.2721 0.5893	-0.6411 0.0003	-0.6999 0.0000	-0.0377 1.0000	0.4560 0.0361	0.7117 0.0000
CG	-0.2425 0.7354	0.5937 0.0012	1.0000 0.0000	0.0917 0.9997	-0.5095 0.0109	-0.3830 0.1425	-0.3453 0.2546	0.2108 0.8641	0.6455 0.0002
Ad	-0.3335 0.2993	-0.2721 0.5893	0.0917 0.9997	1.0000 0.0000	-0.4048 0.0977	0.0670 1.0000	-0.4341 0.0563	-0.1449 0.9876	-0.4528 0.0386
PG	0.1236 0.9964	-0.6411 0.0003	-0.5095 0.0109	-0.4048 0.0977	1.0000 0.0000	0.5795 0.0018	0.0084 1.0000	-0.5908 0.0013	-0.9231 0.0000
US	0.4306 0.0602	-0.6999 0.0000	-0.3830 0.1425	0.0670 1.0000	0.5795 0.0018	1.0000 0.0000	-0.3658 0.1878	-0.3303 0.3123	-0.6791 0.0001
Ee	0.1795 0.9464	-0.0377 1.0000	-0.3453 0.2546	-0.4341 0.0563	0.0084 1.0000	-0.3658 0.1878	1.0000 0.0000	0.1872 0.9305	-0.1883 0.9281
OTHE	0.6136 0.0007	0.4560 0.0361	0.2108 0.8641	-0.1449 0.9876	-0.5908 0.0013	-0.3303 0.3123	0.1872 0.9305	1.0000 0.0000	0.3461 0.2516
SSU/Ha	-0.4424 0.0477	0.7117 0.0000	0.6455 0.0002	0.4528 0.0386	-0.9231 0.0000	-0.6791 0.0001	-0.1883 0.9281	0.3461 0.2516	1.0000 0.0000

Table C4 *Correlation matrix for all the blocks (n=135) in Camp MA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG), **Aristida diffusa** (Ad), Pioneer Grass (PG), Unpalatable Shrubs (US), **Eriocephalus ericoides** (Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000	-0.0657	0.3052	0.0233	-0.1577	-0.2124	-0.1232	-0.0768	0.2899
	0.0000	0.9991	0.0000	1.0000	0.0000	0.0000	0.0000	0.9071	0.0000
SG	-0.0657	1.0000	-0.4980	-0.1984	0.1247	-0.0434	-0.1059	-0.1430	-0.1565
	0.9991	0.0000	0.0000	0.0000	0.0000	1.0000	0.0078	0.0000	0.0000
CG	0.3052	-0.4980	1.0000	0.2393	-0.5037	-0.3793	-0.3014	-0.2718	0.8849
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ad	0.0233	-0.1984	0.2393	1.0000	-0.3623	-0.3228	-0.2185	-0.1238	0.4472
	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PG	-0.1577	0.1247	-0.5037	-0.3623	1.0000	0.0942	-0.0901	-0.1082	-0.6328
	0.0000	0.0000	0.0000	0.0000	0.0000	0.1470	0.2957	0.0037	0.0000
US	-0.2124	-0.0434	-0.3793	-0.3228	0.0942	1.0000	0.0196	0.1084	-0.5422
	0.0000	1.0000	0.0000	0.0000	0.1470	0.0000	1.0000	0.0035	0.0000
Ee	-0.1232	-0.1059	-0.3014	-0.2185	-0.0901	0.0196	1.0000	-0.0269	-0.2523
	0.0000	0.0078	0.0000	0.0000	0.2957	1.0000	0.0000	1.0000	0.0000
OTHE	-0.0768	-0.1430	-0.2718	-0.1238	-0.1082	-0.1082	-0.1084	1.0000	-0.4147
	0.9071	0.0000	0.0000	0.0000	0.0037	0.0035	1.0000	0.0000	0.0000
SSU/Ha	0.2899	-0.1565	0.8849	0.4472	-0.6328	-0.5422	-0.2523	-0.4147	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table C5 *Correlation matrix for the Low time-occupation blocks (n=28) in Camp MA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Unpalatable Shrubs (US),* ***Eriocephalus ericoides*** *(Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000 0.0000	0.0132 1.0000	-0.1631 0.7858	-0.0754 1.0000	0.2014 0.3660	0.1971 0.4110	-0.0800 1.0000	0.0040 1.0000	-0.1984 0.3965
SG	0.0132 1.0000	1.0000 0.0000	-0.4135 0.0000	-0.3150 0.0022	0.2213 0.1943	-0.0131 1.0000	-0.3515 0.0003	-0.0720 1.0000	-0.1178 0.9929
CG	-0.1631 0.7858	-0.4135 0.0000	1.0000 0.0000	0.3787 0.0000	-0.5782 0.0000	-0.3432 0.0004	-0.1062 0.9984	-0.3699 0.0001	0.8681 0.0000
Ad	-0.0754 1.0000	-0.3150 0.0022	0.3789 0.0000	1.0000 0.0000	-0.5724 0.0000	-0.4061 0.0000	-0.1528 0.8718	-0.1802 0.6028	0.6227 0.0000
PG	0.2014 0.3660	0.2213 0.1943	-0.5782 0.0000	-0.5724 0.0000	1.0000 0.0000	0.3240 0.0013	-0.2029 0.3508	0.0498 1.0000	-0.7290 0.0000
US	0.1971 0.4110	-0.0131 1.0000	-0.3432 0.0004	-0.4061 0.0000	0.3240 0.0013	1.0000 0.0000	0.0297 1.0000	-0.2596 0.0399	-0.4956 0.0000
Ee	-0.0800 1.0000	-0.3515 0.0003	-0.1062 0.9984	-0.1528 0.8718	-0.2029 0.3508	0.0297 1.0000	1.0000 0.0000	-0.0378 1.0000	-0.1191 0.9918
OTHE	0.0040 1.0000	-0.0720 1.0000	-0.3699 0.0001	-0.1802 0.6028	0.0498 1.0000	-0.2596 0.0399	-0.0378 1.0000	1.0000 0.0000	-0.4716 0.0000
SSU/Ha	-0.1984 0.3965	-0.1178 0.9929	0.8681 0.0000	0.6227 0.0000	-0.7290 0.0000	-0.4956 0.0000	-0.1191 0.9918	-0.4716 0.0000	1.0000 0.0000

Table C6 *Correlation matrix for the High time-occupation blocks (n=10) in Camp MA, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Unpalatable Shrubs (US),* ***Eriocephalus ericoides*** *(Ee), Other Species (OTHE) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	US	Ee	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.0817 0.9998	0.3701 0.2990	-0.4185 0.1636	-0.3996 0.2099	1.0000 0.0000	0.0647 1.0000	-0.1140 0.9976	0.2962 0.5921
SG	-0.0817 0.9998	1.0000 0.0000	-0.7169 0.0003	0.0240 1.0000	0.4403 0.1201	1.0000 0.0000	-0.3705 0.2975	0.2182 0.8794	-0.6151 0.0043
CG	0.3701 0.2990	-0.7169 0.0003	1.0000 0.0000	0.0045 1.0000	-0.7271 0.0002	1.0000 0.0000	-0.0123 1.0000	-0.4786 0.0660	0.9647 0.0000
Ad	-0.4185 0.1636	0.0240 1.0000	0.0045 1.0000	1.0000 0.0000	-0.2206 0.8731	1.0000 0.0000	-0.4951 0.0498	-0.0341 1.0000	0.2091 0.9023
PG	-0.3996 0.2099	0.4403 0.1201	-0.7271 0.0002	-0.2206 0.8731	1.0000 0.0000	1.0000 0.0000	-0.1677 0.9709	0.4704 0.0754	-0.8196 0.0000
US	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000	1.0000 0.0000
Ee	0.0647 1.0000	-0.3705 0.2975	-0.0123 1.0000	-0.4951 0.0480	0.1677 0.9709	1.0000 0.0000	1.0000 0.0000	-0.2395 0.8155	-0.0795 0.9998
OTHE	-0.1140 0.9976	0.2182 0.8794	-0.4786 0.0660	-0.0341 1.0000	0.4704 0.0754	1.0000 0.0000	-0.2395 0.8155	1.0000 0.0000	-0.5304 0.0262
SSU/Ha	0.2962 0.5921	-0.6151 0.0043	0.9647 0.0000	0.2091 0.9023	-0.8196 0.0000	1.0000 0.0000	-0.0795 0.9998	-0.5304 0.0262	1.0000 0.0000

Table C7 *Correlation matrix for all the blocks (n=144) in Camp DB, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo),* ***Eriocephalus spinescens****, Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.0371 1.0000	0.2988 0.0000	-0.1906 0.0000	-0.2298 0.0000	-0.1982 0.0000	0.3476 0.0000	0.0780 0.7882	-0.0312 1.0000	0.0121 1.0000	-0.0299 1.0000	0.0309 1.0000
SG	-0.0371 1.0000	1.0000 0.0000	-0.1245 0.0000	-0.0873 0.2896	-0.0533 1.0000	0.0610 0.9999	-0.1444 0.0000	-0.0490 1.0000	0.0091 1.0000	0.0350 1.0000	0.0889 0.2160	0.1487 0.0000
CG	0.2988 0.0000	-0.1245 0.0000	1.0000 0.0000	-0.1457 0.0000	-0.3448 0.0000	-0.1900 0.0000	0.2711 0.0000	-0.1110 0.0003	-0.1208 0.0000	-0.0343 1.0000	-0.1720 0.0000	0.5532 0.0000
Ad	-0.1906 0.0000	-0.0873 0.2896	-0.1457 0.0000	1.0000 0.0000	-0.3162 0.0000	-0.2122 0.0000	-0.1156 0.0000	-0.0055 1.0000	-0.1051 0.0026	-0.1180 0.0000	-0.2097 0.0000	0.5936 0.0000
PG	-0.2298 0.0000	-0.0533 1.0000	-0.3448 0.0000	-0.3162 0.0000	1.0000 0.0000	0.1299 0.0000	-0.4657 0.0000	0.0399 1.0000	0.1064 0.0016	-0.1329 0.0000	-0.0130 1.0000	-0.5442 0.0000
LPS	-0.1982 0.0000	0.0610 0.9999	-0.1900 0.0000	-0.2122 0.0000	0.1299 0.0000	1.0000 0.0000	-0.3096 0.0000	-0.3167 0.0000	-0.0544 1.0000	0.0365 1.0000	0.0523 1.0000	-0.1137 0.0001
Geo	0.3476 0.0000	-0.1444 0.0000	0.2711 0.0000	-0.1156 0.0000	-0.4657 0.0000	-0.3096 0.0000	1.0000 0.0000	-0.1806 0.0000	-0.0639 0.9993	-0.0882 0.2469	-0.2729 0.0000	-0.0867 0.3180
Es	0.0780 0.7882	-0.0490 1.0000	-0.1110 0.0003	-0.0055 1.0000	-0.0399 1.0000	-0.3167 0.0000	-0.1806 0.0000	1.0000 0.0000	-0.0245 1.0000	0.0841 0.4578	-0.0474 1.0000	0.0266 1.0000
Ps	-0.0312 1.0000	0.0091 1.0000	-0.1208 0.0000	-0.1051 0.0026	0.1064 0.0016	-0.0544 1.0000	-0.0639 0.9993	-0.0245 1.0000	1.0000 0.0000	0.0358 1.0000	-0.0326 1.0000	0.0268 1.0000
US	0.0121 1.0000	-0.0350 1.0000	-0.0343 1.0000	-0.1180 0.0000	-0.1329 0.0000	0.0365 1.0000	-0.0882 0.2469	0.0841 0.4578	0.0358 1.0000	1.0000 0.0000	-0.0088 1.0000	-0.0886 0.2312
OTHE	-0.0299 1.0000	0.0889 0.2160	-0.1720 0.0000	-0.2097 0.0000	-0.0130 1.0000	0.0523 1.0000	-0.2729 0.0000	-0.0474 1.0000	-0.0326 1.0000	-0.0088 1.0000	1.0000 0.0000	-0.2633 0.0000
SSU/Ha	0.0390 1.0000	0.1487 0.0000	0.5532 0.0000	0.5936 0.0000	-0.5442 0.0000	-0.1137 0.0001	-0.0867 0.3180	0.0266 1.0000	0.0268 1.0000	-0.0886 0.2312	-0.2633 0.0000	1.0000 0.0000

Table C8 *Correlation matrix for the Low time-occupation blocks (n=31) in Camp DB, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo),* ***Eriocephalus spinescens****, Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.0791 1.0000	-0.1071 0.9975	-0.0267 1.0000	0.0480 1.0000	-0.2526 0.0243	-0.3008 0.0013	0.1859 0.4237	-0.0039 1.0000	0.2253 0.0961	0.2473 0.0322	-0.1174 0.9903
SG	-0.0791 1.0000	1.0000 0.0000	0.0651 1.0000	-0.3658 0.0000	-0.0605 1.0000	-0.0505 1.0000	0.2351 0.0604	0.2604 0.0158	-0.2308 0.0743	0.1485 0.8581	-0.0607 1.0000	-0.1735 0.5785
CG	-0.1071 0.9975	0.0651 1.0000	1.0000 0.0000	-0.1647 0.6886	0.0055 1.0000	-0.3686 0.0000	0.1805 0.4905	0.1859 0.4237	0.3622 0.0000	0.6361 0.0000	-0.2442 0.0381	0.0342 1.0000
Ad	-0.0267 1.0000	-0.3658 0.0000	-0.1647 0.6886	1.0000 0.0000	-0.5098 0.0000	-0.2311 0.0732	-0.3150 0.0005	-0.0310 1.0000	-0.2330 0.0667	-0.1103 0.9961	-0.2141 0.1571	0.8936 0.0000
PG	0.0480 1.0000	-0.0605 1.0000	0.0055 1.0000	-0.5098 0.0000	1.0000 0.0000	-0.0605 1.0000	-0.1454 0.8821	-0.2930 0.0022	-0.0014 1.0000	-0.1587 0.7585	-0.1070 0.9976	-0.7126 0.0000
LPS	-0.2526 0.0243	-0.0505 1.0000	-0.3686 0.0000	-0.2311 0.0732	-0.0605 1.0000	1.0000 0.0000	-0.0945 0.9997	-0.3281 0.0002	-0.1244 0.9789	-0.3083 0.0008	0.1660 0.6737	-0.1314 0.9590
Geo	-0.3008 0.0013	0.2351 0.0604	0.1805 0.4905	-0.3150 0.0005	-0.1454 0.8821	-0.0945 0.9997	1.0000 0.0000	0.0867 0.9999	0.0995 0.9993	0.0893 0.9999	-0.3044 0.0011	-0.2669 0.0108
Es	0.1859 0.4237	0.2604 0.0158	0.1859 0.4237	-0.0310 1.0000	-0.2930 0.0022	-0.3281 0.0022	0.0867 0.9999	1.0000 0.0000	-0.1560 0.7870	0.1135 0.9940	-0.0670 1.0000	0.1405 0.9155
Ps	-0.0039 1.0000	-0.2308 0.0743	0.3622 0.0000	-0.2330 0.0667	-0.0014 1.0000	-0.1244 0.9789	0.0995 0.9993	-0.1560 0.7870	1.0000 0.0000	0.3404 0.0001	0.0849 1.0000	-0.0260 1.0000
US	0.2253 0.0961	0.1485 0.8581	0.6361 0.0000	-0.1103 0.9961	-0.1587 0.7585	-0.3083 0.0008	-0.0893 0.9999	0.1135 0.9940	0.3404 0.0001	1.0000 0.0000	0.1365 0.9373	0.0555 1.0000
OTHE	0.2473 0.0322	-0.0607 1.0000	-0.2442 0.0381	-0.2141 0.1571	-0.1070 0.9976	0.1660 0.6737	-0.3044 0.0011	-0.0670 1.0000	0.0849 1.0000	0.1365 0.9373	1.0000 0.0000	-0.2338 0.0642
SSU/Ha	-0.1174 0.9903	-0.1735 0.5785	0.0342 1.0000	0.8936 0.0000	-0.7126 0.0000	-0.1314 0.9590	-0.2669 0.0108	0.1405 0.9155	-0.0260 1.0000	0.0555 1.0000	-0.2338 0.0642	1.0000 0.0000

Table C9 *Correlation matrix for the High time-occupation blocks (n=15) in Camp DB, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG), Aristida diffusa (Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo), Eriocephalus spinescens, Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000	0.0206	0.1164	-0.1478	-0.0543	-0.0408	-0.0616	-0.1227	0.1224	0.0489	0.1341	0.0662
	0.0000	1.0000	0.9979	0.9816	1.0000	1.0000	1.0000	0.9965	0.9966	1.0000	0.9921	1.0000
SG	0.0206	1.0000	-0.4980	0.7050	0.2346	-0.2980	-0.3347	0.1426	0.1625	-0.0162	0.1096	-0.0160
	1.0000	0.0000	0.0018	0.0000	0.6523	0.2805	0.1407	0.9864	0.9608	1.0000	0.9989	1.0000
CG	0.1164	-0.4980	1.0000	-0.4393	-0.2282	0.1040	0.0818	-0.3174	-0.1957	0.0073	0.2815	0.7852
	0.9979	0.0018	0.0000	0.0106	0.6916	0.9993	1.0000	0.1980	0.8613	1.0000	0.3656	0.0000
Ad	-0.1478	0.7050	-0.4393	1.0000	-0.2616	-0.4059	0.0933	0.2787	0.1412	0.0211	-0.1428	0.0590
	0.9816	0.0000	0.0106	0.0000	0.4825	0.0264	0.9998	0.3807	0.9875	1.0000	0.9863	1.0000
PG	-0.0543	0.2346	-0.2282	-0.2616	1.0000	0.2766	-0.7153	-0.0470	0.3033	-0.2619	0.1444	-0.1543
	1.0000	0.6523	0.6916	0.4825	0.0000	0.3930	0.0000	1.0000	0.2558	0.4804	0.9849	0.9739
LPS	-0.0408	-0.2980	0.1040	0.4059	0.2766	1.0000	-0.0347	-0.6312	0.6071	0.0642	-0.1625	0.0435
	1.0000	0.2805	0.9993	0.0264	0.3930	0.0000	1.0000	0.0000	0.0000	1.0000	0.9608	1.0000
Geo	-0.0616	-0.3347	0.0818	0.0933	-0.7153	-0.0347	1.0000	-0.2957	-0.0809	0.1004	-0.4590	-0.1697
	1.0000	0.1407	1.0000	0.9998	0.0000	1.0000	0.0000	0.2917	1.0000	0.9995	0.0060	0.9461
Es	-0.1227	0.1426	-0.3174	0.2787	-0.0470	-0.6312	-0.2957	1.0000	-0.5104	0.1448	0.2445	-0.1545
	0.9965	0.9864	0.1980	0.3807	1.0000	0.0000	0.2917	0.0000	0.0012	0.9845	0.5902	0.9736
Ps	0.1224	0.1625	-0.1957	0.1412	0.3033	0.6071	-0.0809	-0.5104	1.0000	0.2568	-0.2438	0.0948
	0.9966	0.9608	0.8613	0.9875	0.2558	0.0000	1.0000	0.0012	0.0000	0.5125	0.5945	0.9998
US	0.0489	-0.0162	0.0073	0.0211	-0.2619	0.0642	0.1004	0.1448	0.2568	1.0000	-0.1785	0.1680
	1.0000	1.0000	1.0000	1.0000	0.4804	1.0000	0.9995	0.9845	0.5125	0.0000	0.9228	0.9497
OTHE	0.1341	0.1096	-0.2815	-0.1428	0.1444	-0.1625	-0.4590	0.2445	-0.2438	-0.1785	1.0000	-0.3556
	0.9921	0.9989	0.3656	0.9863	0.9849	0.9608	0.0060	0.5902	0.5945	0.9228	0.0000	0.0900
SSU/Ha	0.0662	-0.0160	0.7852	0.0599	-0.1543	0.0435	-0.1697	-0.1545	0.0948	0.1680	-0.3556	1.0000
	1.0000	1.0000	0.0000	1.0000	0.9739	1.0000	0.9461	0.9736	0.9998	0.9497	0.0900	0.0000

Table C10 *Correlation matrix for all the blocks (n=144) in Camp MB, for the variables Time in minutes (Ti), individual counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo),* ***Eriocephalus spinescens****, Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000 0.0000	0.0853 0.3887	0.0759 0.8684	-0.1615 0.0000	0.0144 1.0000	-0.0800 0.6905	0.2434 0.0000	-0.0631 0.9995	-0.0296 1.0000	-0.0765 0.8483	-0.0274 1.0000	-0.0764 0.8518
SG	0.0853 0.3887	1.0000 0.0000	0.0284 1.0000	-0.1072 0.0012	-0.1646 0.0000	0.0473 1.0000	-0.1121 0.0002	-0.1506 0.0000	0.1156 0.0000	-0.0377 1.0000	-0.0269 1.0000	0.2359 0.0000
CG	0.0759 0.8684	0.0284 1.0000	1.0000 0.0000	-0.0977 0.0278	-0.3651 0.0000	-0.1420 0.0000	-0.0809 0.6412	-0.0869 0.3085	-0.1863 0.0000	-0.0140 1.0000	-0.1032 0.0050	0.6643 0.0000
Ad	-0.1615 0.0000	-0.1072 0.0012	-0.0977 0.0278	1.0000 0.0000	-0.4457 0.0000	-0.3479 0.0000	-0.2054 0.0000	0.0371 1.0000	-0.2421 0.0000	-0.2394 0.0000	-0.0534 1.0000	0.5259 0.0000
PG	0.0144 1.0000	-0.1646 0.0000	-0.3651 0.0000	-0.4457 0.0000	1.0000 0.0000	0.1063 0.0017	-0.1648 0.0000	-0.0625 0.9997	0.0893 0.2005	-0.0247 1.0000	-0.0845 0.4354	-0.6585 0.0000
LPS	-0.0800 0.6905	0.0473 1.0000	-0.1420 0.0000	-0.3479 0.0000	0.1063 0.0017	1.0000 0.0000	-0.1100 0.0004	-0.1997 0.0000	0.0414 1.0000	0.0145 1.0000	0.0385 1.0000	-0.1982 1.0000
Geo	0.2434 0.0000	-0.1121 0.0002	-0.0809 0.6412	-0.2054 0.0000	-0.1648 0.0000	-0.1100 0.0004	1.0000 0.0000	-0.1728 0.0000	-0.2240 0.0000	-0.0604 0.9999	-0.2613 0.0000	-0.3996 0.0000
Es	-0.0631 0.9995	-0.1506 0.0000	-0.0869 0.3085	0.0371 1.0000	-0.0625 0.9997	-0.1997 0.0000	-0.1728 0.0000	1.0000 0.0000	-0.1672 0.0000	-0.0518 1.0000	-0.0780 0.7874	0.0063 1.0000
Ps	-0.0296 1.0000	0.1156 0.0000	-0.1863 0.0000	-0.2421 0.0000	0.0893 0.2005	0.0414 1.0000	-0.2240 0.0000	-0.1672 0.0000	1.0000 0.0000	0.1239 0.0000	0.0973 0.0309	0.0005 1.0000
US	-0.0765 0.8483	-0.0377 1.0000	-0.0140 1.0000	-0.2394 0.0000	-0.0247 1.0000	0.0145 1.0000	-0.0604 0.9999	-0.0518 1.0000	0.1239 0.0000	1.0000 0.0000	0.1077 0.0010	-0.1711 0.0000
OTHE	-0.0274 1.0000	-0.0269 1.0000	-0.1032 0.0050	-0.0534 1.0000	-0.0845 0.4354	0.0385 1.0000	-0.2613 0.0000	-0.0780 0.7874	0.0973 0.0309	0.1077 0.0010	1.0000 0.0000	-0.1067 0.0015
SSU/Ha	-0.0764 0.8518	0.2359 0.0000	0.6643 0.0000	0.5259 0.0000	-0.6585 0.0000	-0.1982 0.0000	-0.3996 0.0000	0.0063 1.0000	0.0005 1.0000	-0.1711 0.0000	-0.1067 0.0015	1.0000 0.0000

Table C11 *Correlation matrix for the Low time-occupation blocks (n=46) in Camp MB, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo),* ***Eriocephalus spinescens,*** *Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000 0.0000	-0.1175 0.9389	-0.2347 0.0006	0.2412 0.0003	-0.0990 0.9962	-0.0573 1.0000	0.0667 1.0000	-0.1606 1.0000	0.0728 0.2773	0.0728 1.0000	-0.1018 0.9937	-0.0019 1.0000
SG	-0.1175 0.9383	1.0000 0.0000	0.2000 0.0172	-0.2372 0.0005	-0.0538 1.0000	0.1892 0.0418	-0.1475 0.4987	-0.1892 0.0419	0.1720 0.1437	-0.1721 0.1423	-0.2383 0.0004	0.3338 0.0000
CG	-0.2347 0.0006	0.2000 0.0172	1.0000 0.0000	-0.2628 0.0000	-0.2119 0.0059	0.1598 0.2902	0.3000 0.0000	0.1155 0.9517	-0.2177 0.0034	-0.2227 0.0021	-0.1064 0.9863	0.2925 0.0000
Ad	0.2412 0.0003	-0.2372 0.0005	-0.2628 0.0000	1.0000 0.0000	-0.4963 0.0000	-0.2992 0.0000	-0.0428 1.0000	0.0696 1.0000	-0.3203 0.0000	-0.1340 0.7439	-0.0849 0.9999	0.5967 0.0000
PG	-0.0990 0.9962	-0.0538 1.0000	-0.2119 0.0059	-0.4963 0.0000	1.0000 0.0000	-0.0700 1.0000	-0.1809 0.0783	-0.3062 0.0000	0.0694 1.0000	0.0538 1.0000	-0.1026 0.9927	-0.7560 0.0000
LPS	-0.0573 1.0000	0.1892 0.0418	0.1598 0.2902	-0.2992 0.0000	-0.0700 1.0000	1.0000 0.0000	-0.1337 0.7497	-0.1518 0.4202	-0.1999 0.0174	-0.1358 0.7137	-0.1521 0.4162	0.0399 1.0000
Geo	0.0643 1.0000	-0.1475 0.4987	0.3000 0.0000	-0.0428 1.0000	-0.1809 0.0783	-0.1337 0.7497	1.0000 0.0000	-0.0255 1.0000	-0.2962 0.0000	-0.1196 0.9233	-0.2078 0.0086	-0.1673 0.1914
Es	0.0667 1.0000	-0.1892 0.0419	0.1155 0.9517	0.0696 1.0000	-0.3062 0.0000	-0.1518 0.4202	-0.0255 1.0000	1.0000 0.0000	-0.3019 0.0000	0.0321 1.0000	-0.0508 1.0000	0.1007 0.9948
Ps	-0.1606 0.2773	0.1720 0.1437	-0.2177 0.0034	-0.3203 0.0000	0.0694 1.0000	-0.1999 0.0174	-0.2962 0.0000	-0.3090 0.0000	1.0000 0.0000	0.0906 0.9994	0.3217 0.0000	0.0221 1.0000
US	0.0728 1.0000	-0.1721 0.1423	-0.2227 0.0021	-0.1340 0.7439	0.0538 1.0000	-0.1358 0.7137	-0.1196 0.9233	0.0321 1.0000	0.0906 0.9994	1.0000 0.0000	-0.0683 1.0000	-0.3208 0.0000
OTHE	-0.1018 0.9937	-0.2383 0.0004	-0.1064 0.9863	-0.0849 0.9999	-0.1026 0.9927	-0.1521 0.4162	-0.2078 0.0086	-0.0508 1.0000	0.3217 0.0000	-0.0683 1.0000	1.0000 0.0000	-0.1171 0.9416
SSU/Ha	-0.0019 1.0000	0.3338 0.0000	0.2925 0.0000	0.5967 0.0000	-0.7560 0.0000	0.0399 1.0000	-0.1673 0.1914	0.1007 0.9948	0.0221 1.0000	-0.3208 0.0000	-0.1171 0.9416	1.0000 0.0000

Table C12 *Correlation matrix for the High time-occupation blocks (n=25) in Camp MB, for the variables Time in minutes (Ti), counts of Sub-Climax Grass (SG), Climax Grass (CG),* ***Aristida diffusa*** *(Ad), Pioneer Grass (PG), Less Palatable Shrubs (LPS), Geophytes (Geo),* ***Eriocephalus spinescens****, Palatable Shrubs (PS), Unpalatable Shrubs (US), Other Species (Othe) and Grazing Capacity (SSU/ha).*

	Ti	SG	CG	Ad	PG	LPS	Geo	Es	Ps	US	OTHE	SSU/Ha
Ti	1.0000 0.0000	0.4334 0.0000	0.6265 0.0000	-0.3394 0.0025	-0.0931 0.9998	0.0165 1.0000	-0.3358 0.0030	-0.1699 0.7969	0.2927 0.0225	0.0829 1.0000	0.3029 0.0143	0.4107 0.0001
SG	0.4334 0.0000	1.0000 0.0000	0.1309 0.9818	-0.1263 0.9880	-0.2417 0.1630	-0.1571 0.8882	-0.1370 0.9699	-0.1673 0.8175	0.1641 0.8424	0.0724 1.0000	0.2332 0.2138	0.3723 0.0004
CG	0.6265 0.0000	0.1309 0.9818	1.0000 0.0000	-0.2162 0.3453	-0.1499 0.9262	-0.0810 1.0000	-0.3382 0.0026	-0.2198 0.3137	0.2192 0.3188	0.4205 0.0000	0.0404 1.0000	0.5812 0.0000
Ad	-0.3394 0.0025	-0.1263 0.9880	-0.2162 0.3453	1.0000 0.0000	-0.4688 0.0000	-0.1004 0.9995	-0.1901 0.6046	0.3325 0.0035	-0.0072 1.0000	-0.3057 0.0125	-0.0117 1.0000	0.5037 0.0000
PG	-0.0931 0.9998	-0.2417 0.1630	-0.1499 0.9262	-0.4688 0.0000	1.0000 0.0000	-0.0377 1.0000	-0.3155 0.0079	-0.1810 0.6964	-0.3679 0.0006	-0.2361 0.1954	-0.0827 1.0000	-0.6230 0.0000
LPS	0.0165 1.0000	-0.1571 0.8882	-0.0810 1.0000	-0.1004 0.9995	-0.0377 1.0000	1.0000 0.0000	0.1441 0.9490	-0.0618 1.0000	-0.2462 0.1398	-0.0448 1.0000	0.0325 1.0000	-0.1459 0.9428
Geo	-0.3358 0.0030	-0.1370 0.9699	-0.3382 0.0026	-0.1901 0.6046	-0.3155 0.0079	0.1441 0.9490	1.0000 0.0000	-0.1764 0.7401	0.0007 1.0000	0.3455 0.0018	-0.3542 0.0012	-0.4303 0.0000
Es	-0.1699 0.7969	-0.1673 0.8175	-0.2198 0.3137	0.3325 0.0035	-0.1810 0.6964	-0.0618 1.0000	-0.1764 0.7401	1.0000 0.0000	-0.0610 1.0000	-0.1564 0.8922	-0.1705 0.7920	0.1574 0.8865
Ps	0.2927 0.0225	0.1641 0.8424	0.2192 0.3188	-0.0072 1.0000	-0.3679 0.0006	-0.2462 0.1398	0.0007 1.0000	-0.0610 1.0000	1.0000 0.0000	0.0235 1.0000	-0.0596 1.0000	0.4670 0.0000
US	0.0829 1.0000	0.0724 1.0000	0.4205 0.0000	-0.3057 0.0125	-0.2361 0.1954	-0.0448 1.0000	0.3455 0.0018	-0.1564 0.8922	0.0235 1.0000	1.0000 0.0000	-0.3441 0.0020	0.0791 1.0000
OTHE	0.3029 0.0143	0.2332 0.2138	0.0404 1.0000	-0.0117 1.0000	-0.0827 1.0000	0.0325 1.0000	-0.3542 0.0012	-0.1705 0.7920	-0.0596 1.0000	-0.3441 0.0020	1.0000 0.0000	0.0646 1.0000
SSU/Ha	0.4107 0.0001	0.3723 0.0004	0.5812 0.0000	0.5037 0.0000	-0.6230 0.0000	-0.1459 0.9428	-0.4303 0.0000	0.1574 0.8865	0.4670 0.0000	0.0791 1.0000	0.0646 1.0000	1.0000 0.0000

APPENDIX D

Tables D1 to D4 show the differences in phytomass (kg/ha), on a species basis for the High-and Low-occupation areas in the four camps DA, MA, DB and MB.

Table D1 *The phytomass for camp DA, expressed in Kg/ha dry matter, to show the difference between the localities where the animals (Dorpers) prefered to graze (High) and not to graze (Low).*

GROUP	SPECIE	High	Low
		Kg/ha	Kg/ha
1	*Aristida congesta*	22.75	29.00
2	*Tragus koelerioides*	25.50	6.00
3	*Aristida diffusa*	5.30	2639.50
3	*Eragrostis lehmanniana*	84.00	8.30
3	*Eragrostis obtusa*	0.00	0.30
4	*Eragrostis curvula var. conferta*	0.00	28.50
4	*Sporobolus fimbriatus*	375.75	0.00
4	*Themeda triandra*	44.30	0.00
5	*Felicia muricata*	14.00	0.00
5	*Phymaspermum parvifolium*	43.00	15.80
5	*Plinthus karooicus*	0.00	14.00
5	*Salsola calluna*	21.80	7.80
5	*Trichodiadema pomeridianum*	6.80	10.50
5	*Walafrida geniculata*	9.80	0.00
6	*Eriocephalus ericoides*	1857.75	241.50
6	*E. spinescens*	46.75	53.75
6	*Pentzia globosa*	34.75	0.00
6	*P. incana*	16.50	0.00
7	*Lycium cinereum*	0.00	25.75
7	*Pteronia glauca*	108.00	0.00
7	*P. tricephala*	60.00	84.25
7	*Rosenia humilis*	49.50	13.25
7	*Thesium hystrix*	0.00	36.00
7	*Walafrida saxatilis*	1.00	0.00
8	*Salvia verbenaca*	3.00	0.00
	Totaal	2830.25	3241.20

1:Pioneer grass (annual)
2:Pioneer grass(perennial)
3:Sub-climax grass
4:Climax grass
5:Palatable shrubs
6:Less palatable shrubs
7:Unpalatable shrubs
8:Ephemerals

Table D2 *The phytomass for camp MA, expressed in Kg/ha dry matter, to show the difference between the localities where the animals (Merino's) have preffered to graze (High) and not to graze (Low).*

GROUP	SPECIES	High	Low
		Kg/ha	Kg/ha
1	*Aristida congesta*	459.30	1.25
2	*Tragus koelerioides*	6.30	17.75
3	*Aristida diffusa*	106.80	833.50
3	*Eragrostis lehmanniana*	75.50	54.00
4	*E. curvula var. conferta*	97.00	56.00
4	*Sporobolus fimbriatus*	26.25	0.00
4	*Tetrachne dregei*	59.30	0.00
4	*Themeda triandra*	34.25	0.00
5	*Phymaspermum parvifolium*	0.00	4.50
5	*Trichodiadema pomeridianum*	0.00	0.30
6	*Eriocephalus ericoides*	1903.50	1625.00
6	*Pentzia globosa*	0.00	9.00
6	*P. incana*	0.00	18.75
7	*Lycium cinereum*	80.50	36.25
7	*Pteronia glauca*	0.00	85.75
7	*P. tricephala*	0.00	1528.00
7	*Walafrida saxatilis*	0.75	27.00
	Totaal	2849.45	4296.75

1:Pioneer grass (annual)
2:Pioneer grass(perennial)
3:Sub-climax grass
4:Climax grass
5:Palatable shrubs
6:Less palatable shrubs
7:Unpalatable shrubs

Table D3 *The phytomass for camp DB, expressed in Kg/ha dry matter, to show the difference between the localities where the animals (Dorpers) have preffered to graze (High) and not to graze (Low).*

GROUP	SPECIES	High	Low
		Kg/ha	Kg/ha
1	*Aristida congesta*	23.30	34.00
2	*Sporobolus ludwigii*	0.00	80.00
2	*Tragus koelerioides*	51.00	113.00
3	*Aristida diffusa*	28.80	75.70
3	*Eragrostis lehmanniana*	14.00	39.50
3	*E. obtusa*	3.30	1.40
4	*E. curvula var. conferta*	8.30	0.13
4	*Sporobolus fimbriatus*	434.00	1.75
5	*Felicia muricata*	6.50	16.30
5	*Hermannia coccocarpa*	0.30	0.33
5	*Limeum aethiopicum*	1.30	0.50
5	*Osteospermum leptolobum*	52.00	20.50
5	*Phymaspermum parvifolium*	102.00	161.00
5	*Plinthus karooicus*	0.13	0.50
5	*Salsola calluna*	0.00	7.00
5	*Trichodiadema pomeridianum*	32.00	4.30
5	*Walafrida geniculata*	9.40	36.00
6	*Eriocephalus ericoides*	66.00	175.00
6	*E. spinescens*	817.00	747.00
6	*Helichrysum lucilioides*	0.00	13.30
6	*Pentzia globosa*	369.50	62.00
6	*P. incana*	0.00	380.00
7	*Chrysocoma tenuifolia*	0.30	10.50
7	*Dimorphotheca zeyheri*	0.00	0.13
7	*Eberlanzia ferox*	142.80	0.00
7	*Lycium cinereum*	25.80	0.00
7	*Pteronia glomerata*	0.00	29.80
7	*Rosenia humilis*	44.00	39.80
7	*Thesium hystrix*	34.60	60.30
7	*Walafrida saxatilis*	0.00	0.25
8	*Berkheya annectens*	0.00	0.10
8	*Blepharis villosa*	1.30	0.00
8	*Commelina africana*	4.10	0.00
8	*Gazania linearis*	1.10	0.00
8	*Indigofera alternans*	0.60	0.88
8	*Lepidium africanum*	0.00	0.25
9	*Euphorbia chamaesyce*	0.10	6.90
10	*Moraea polystachya*	1.30	0.00
10	*Mariscus capensis*	77.8	18.30
	Totaal	2352.63	2136.42

1:Pioneer grass (annual)
2:Pioneer grass (perennial)
3:Sub-climax grass
4:Climax grass
5:Palatable shrubs
6:Less palatable shrubs
7:Unpalatable shrubs
8:Ephemerals
9:Xerophytes
10:Geophytes

Table D4 *The phytomass for camp MB, expressed in Kg/ha dry matter, to show the difference between the localities where the animals have preffered to graze (High) and not to graze (Low).*

GROUP	SPECIES	High	Low
		Kg/ha	Kg/ha
1	*Aristida congesta*	98.75	43.80
2	*Tragus koelerioides*	123.50	81.00
3	*Aristida diffusa*	66.75	955.80
3	*Enneapogon scoparius*	0.00	10.50
3	*Eragrostis lehmanniana*	47.75	0.00
3	*E. obtusa*	6.50	21.75
4	*E. curvula var. conferta*	50.00	23.30
4	*Sporobolus fimbriatus*	0.00	128.80
5	*Delosperma tuberosum*	13.50	0.00
5	*Felicia muricata*	34.75	7.20
5	*Hermannia coccocarpa*	0.38	0.00
5	*Phymaspermum parvifolium*	152.30	107.50
5	*Salsola calluna*	0.00	6.50
5	*Trichodiadema pomeridianum*	14.70	6.45
5	*Walafrida geniculata*	73.50	8.00
6	*Eriocephalus ericoides*	216.50	42.80
6	*E. spinescens*	807.00	747.00
6	*Helichrysum lucilioides*	30.50	15.50
6	*Pentzia globosa*	84.30	34.00
6	*P. incana*	0.00	210.30
7	*Eberlanzia ferox*	19.25	2.00
7	*Lycium cinereum*	83.75	0.00
7	*Pteronia glomerata*	12.50	0.00
7	*Thesium hystrix*	36.30	155.80
8	*Blepharis villosa*	0.50	0.00
8	*Indigofera alternans*	0.00	0.90
8	*Oxalis depressa*	0.00	0.50
9	*Asclepias sp.*	0.00	0.30
9	*Euphorbia chamaesyce*	0.00	1.10
9	*Ruschia unidens*	0.00	0.10
10	*Mariscus capensis*	55.3	37.80
11	*Seedlings*	6.5	5.30
	Totaal	2034.78	2654.00

1:Pioneer grass (annual)
2:Pioneer grass (perennial)
3:Sub-climax grass
4:Climax grass
5:Palatable shrubs
6:Less palatable shrubs
7:Unpalatable shrubs
8:Ephemerals
9:Xerophytes
10:Geophytes

APPENDIX E

Tables E1 to E3 contain the quantified phenological data for the species that were scored during the course of this study.

P = The different items that were scored
P1 = Environmental condition
P2 = Plant condition
P3 = Stem and shoot growth
P4 = Leaf growth
P5 = Flower buds
P6 = Flowers

Table E1 *The quantified phenological data for the different species over a period of 500 days.*

SPECIES		*Aristida congesta*						*Tragus koelerioides*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	10	10	10	10	10	70	10	10	10	10	10
25JUL89	18	60	10	20	20	10	10	60	10	10	10	10	10
16AUG89	40	40	10	20	20	10	10	40	10	10	10	10	10
01SEP89	56	50	10	40	40	10	10	50	10	10	10	10	10
15SEP89	70	40	20	40	40	10	10	40	20	40	40	10	10
11OCT89	96	40	20	40	40	10	10	40	20	40	40	10	10
08NOV89	124	80	20	50	50	10	10	80	20	40	50	10	10
05DEC89	151	80	50	80	95	10	10	80	50	70	80	10	10
02JAN90	179	40	30	40	40	10	10	40	20	40	40	70	90
07FEB90	215	40	10	10	10	10	10	40	20	20	40	10	10
08MAR90	244	80	40	40	40	40	10	80	50	70	70	10	10
26MAR90	262	60	70	70	70	60	50	60	70	70	70	70	70
17APL90	284	70	40	70	70	10	30	70	50	40	40	40	40
14MAY90	311	40	20	10	10	10	10	40	40	40	40	40	70
19JUN90	347	30	10	10	10	10	10	30	10	10	10	10	10
31JUL90	390	40	10	10	10	10	10	40	10	10	10	10	10
22OCT90	472	10	10	10	10	10	10	10	10	10	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10
SPECIES		*Aristida diffusa*						*Eragrostis lehmanniana*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	10	10	10	10	10	70	20	40	10	10	10
25JUL89	18	60	10	20	20	10	10	60	10	20	20	10	10
16AUG89	40	40	10	20	20	10	10	40	10	20	20	10	10
01SEP89	56	50	10	40	40	10	10	50	10	20	20	10	10
15SEP89	70	40	20	40	40	10	10	40	20	30	40	40	10
11OCT89	96	40	20	40	40	10	10	40	10	40	40	10	10
08NOV89	124	80	20	50	50	10	10	80	50	50	60	10	10
05DEC89	151	80	50	70	80	80	40	80	50	70	80	10	10
02JAN90	179	40	40	40	40	40	80	40	40	40	40	10	10
07FEB90	215	40	30	20	40	10	10	40	10	20	20	10	10
08MAR90	244	80	10	30	40	10	10	80	40	80	80	10	10
26MAR90	262	60	60	60	60	40	20	60	70	70	70	80	70
17APL90	284	70	50	50	70	40	40	70	50	70	70	40	40
14MAY90	311	40	30	40	40	10	40	40	10	10	10	10	10
19JUN90	347	30	30	20	30	10	10	30	10	20	20	10	10
31JUL90	390	40	10	10	10	10	10	40	20	20	20	10	10
22OCT90	472	10	10	10	10	10	10	10	10	10	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10
SPECIES		*Eragrostis obtusa*						*Digitaria eriantha*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	10	10	10	10	10	70	10	10	10	10	10
25JUL89	18	60	10	10	10	10	10	60	10	20	20	10	10
16AUG89	40	40	10	10	10	10	10	40	10	20	20	10	10
01SEP89	56	50	10	10	10	10	10	50	10	20	20	10	10
15SEP89	70	40	10	10	10	10	10	40	10	20	20	10	10
11OCT89	96	40	10	10	10	10	10	40	10	20	20	10	10
08NOV89	124	80	20	40	50	10	10	80	20	40	40	10	10
05DEC89	151	80	50	70	80	10	10	80	60	70	80	40	20
02JAN90	179	40	10	10	10	10	10	40	30	40	40	10	10
07FEB90	215	40	20	40	10	10	10	40	10	10	10	10	10
08MAR90	244	80	50	70	70	10	10	80	10	30	30	10	10
26MAR90	262	60	70	70	70	40	40	60	50	70	70	40	40
17APL90	284	70	70	70	70	60	50	70	70	80	95	40	95
14MAY90	311	40	30	30	30	10	40	40	50	70	70	20	40
19JUN90	347	30	10	10	10	10	10	30	20	40	40	10	10
31JUL90	390	40	10	10	10	10	10	40	10	10	10	10	10
22OCT90	472	10	10	10	10	10	10	10	10	10	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10

Table E2 *The quantified phenological data for the different species over a period of 500 days.*

SPECIES		*Eragrostis curvula*						*Sporobolus fimbriatus*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	10	10	10	10	10	70	10	10	10	10	10
25JUL89	18	60	10	10	10	10	10	60	10	10	10	10	10
16AUG89	40	40	10	20	20	10	10	40	10	20	30	10	10
01SEP89	56	50	10	30	30	10	10	50	10	50	40	10	10
15SEP89	70	40	20	40	40	40	10	40	10	20	20	10	10
11OCT89	96	40	20	40	40	10	10	40	10	20	20	10	10
08NOV89	124	80	30	50	50	10	10	80	20	40	50	10	10
05DEC89	151	80	70	95	95	70	50	80	60	70	80	10	10
02JAN90	179	40	40	40	40	10	10	40	30	40	40	10	10
07FEB90	215	40	10	10	20	10	10	40	10	10	10	10	10
08MAR90	244	80	40	40	70	10	10	80	20	50	70	20	10
26MAR90	262	60	40	40	70	10	10	60	40	50	50	40	70
17APL90	284	70	40	40	50	10	10	70	70	70	80	70	70
14MAY90	311	40	20	20	20	10	10	40	40	50	70	10	10
19JUN90	347	30	10	10	10	10	10	30	10	20	20	10	10
31JUL90	390	40	10	10	10	10	10	40	10	10	10	10	10
22OCT90	472	10	10	10	10	10	10	10	10	20	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10

SPECIES		*Themeda triandra*						*P. parvifolium*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	10	10	10	10	10	70	70	40	70	10	10
25JUL89	18	60	10	20	20	10	10	60	95	70	70	10	10
16AUG89	40	40	10	30	30	10	10	40	70	70	40	10	10
01SEP89	56	50	10	40	50	10	10	50	60	50	50	10	10
15SEP89	70	40	40	40	50	10	10	40	50	70	70	10	10
11OCT89	96	40	20	40	40	10	10	40	40	40	70	10	10
08NOV89	124	80	20	40	50	10	10	80	40	40	50	40	50
05DEC89	151	80	60	80	95	60	50	80	70	95	95	50	95
02JAN90	179	40	40	40	60	10	20	40	40	40	40	10	10
07FEB90	215	40	10	10	10	10	10	40	40	50	70	10	10
08MAR90	244	80	10	20	40	10	10	80	70	70	95	10	10
26MAR90	262	60	95	95	95	40	40	60	95	95	95	95	70
17APL90	284	70	80	80	80	50	50	70	95	95	95	10	20
14MAY90	311	40	70	70	70	50	50	40	70	80	80	10	10
19JUN90	347	30	10	20	20	10	10	30	50	40	50	10	10
31JUL90	390	40	10	10	10	10	10	40	40	30	30	10	10
22OCT90	472	10	10	10	10	10	10	10	10	10	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10

SPECIES		*Eriocephalus ercoides*						*E.spinescens*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	80	40	40	10	10	70	95	40	70	10	10
25JUL89	18	60	70	80	70	10	10	60	95	80	60	10	10
16AUG89	40	40	70	70	70	10	10	40	70	70	70	10	10
01SEP89	56	50	70	50	50	10	10	50	70	50	50	10	10
15SEP89	70	40	50	70	70	10	10	40	40	40	70	10	10
11OCT89	96	40	70	70	80	10	10	40	70	70	80	90	10
08NOV89	124	80	50	70	70	10	10	80	40	40	50	40	40
05DEC89	151	80	70	80	80	10	10	80	70	80	80	40	70
02JAN90	179	40	70	70	70	10	10	40	60	50	70	10	10
07FEB90	215	40	40	50	50	10	10	40	40	50	70	10	10
08MAR90	244	80	70	80	95	10	10	80	70	40	70	10	10
26MAR90	262	60	70	70	70	10	10	60	70	70	70	70	40
17APL90	284	70	70	70	70	60	40	70	95	95	95	10	10
14MAY90	311	40	70	70	70	10	10	40	70	60	70	10	10
19JUN90	347	30	80	80	80	10	10	30	80	80	80	10	10
31JUL90	390	40	60	60	60	10	10	40	80	70	70	10	10
22OCT90	472	10	50	70	70	10	10	10	50	50	70	10	10
15NOV90	496	10	30	30	30	10	10	10	40	30	30	10	10

Table E3 *The quantified phenological data for the different species over a period of 500 days.*

SPECIES		*Pentzia globosa*						*Pentzia incana*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	40	40	70	10	10	70	40	40	60	10	10
25JUL89	18	60	30	40	40	10	10	60	60	70	80	10	10
16AUG89	40	40	50	70	70	10	10	40	50	70	70	10	10
01SEP89	56	50	30	40	40	10	10	50	40	40	40	10	10
15SEP89	70	40	40	20	40	10	10	40	20	40	40	10	10
11OCT89	96	40	40	60	60	10	10	40	30	40	40	10	10
08NOV89	124	80	20	40	40	10	10	80	30	40	40	10	10
05DEC89	151	80	70	80	80	95	40	80	40	60	70	40	10
02JAN90	179	40	50	50	70	20	70	40	40	50	50	50	40
07FEB90	215	40	40	40	40	10	10	40	40	50	70	10	10
08MAR90	244	80	40	80	80	10	10	80	40	80	80	10	10
26MAR90	262	60	95	95	95	70	70	60	40	40	40	60	10
17APL90	284	70	95	95	95	60	95	70	50	70	80	40	10
14MAY90	311	40	40	40	40	10	60	40	30	40	40	10	30
19JUN90	347	30	30	10	20	10	10	30	10	10	10	10	10
31JUL90	390	40	10	10	10	10	10	40	10	10	10	10	10
22OCT90	472	10	10	20	20	10	10	10	10	10	10	10	10
15NOV90	496	10	10	10	10	10	10	10	10	10	10	10	10
SPECIES		*Pteronia glauca*						*Pteronia glomerata*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	60	70	70	10	10	70	60	70	70	70	10
25JUL89	18	60	60	70	70	10	10	60	70	40	70	70	10
16AUG89	40	40	40	40	50	20	10	40	95	70	70	70	10
01SEP89	56	50	50	70	80	70	10	50	95	90	90	40	80
15SEP89	70	40	50	70	70	50	10	40	70	80	80	10	40
11OCT89	96	40	40	60	70	40	60	40	95	60	70	10	10
08NOV89	124	80	40	40	70	10	10	80	40	40	70	10	10
05DEC89	151	80	40	40	40	10	10	80	50	70	80	10	10
02JAN90	179	40	40	70	70	10	10	40	70	40	40	10	10
07FEB90	215	40	70	40	70	10	10	40	70	70	70	10	10
08MAR90	244	80	70	40	50	10	10	80	70	40	80	10	10
26MAR90	262	60	50	50	70	10	10	60	70	60	60	10	10
17APL90	284	70	70	70	70	10	10	70	80	70	70	10	10
14MAY90	311	40	70	70	70	10	10	40	70	70	70	10	10
19JUN90	347	30	60	50	50	10	10	30	80	80	80	40	10
31JUL90	390	40	40	40	40	10	10	40	70	70	70	60	40
22OCT90	472	10	40	40	40	10	10	10	60	50	70	10	10
15NOV90	496	10	30	10	10	10	10	10	40	40	40	10	10
SPECIES		*Pteronia tricephala*						*Rosenia humelis*					
DATE	DAY	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
07JUL89	1	70	95	80	80	10	10	70	95	40	70	95	30
25JUL89	18	60	95	80	80	10	10	60	95	70	70	95	40
16AUG89	40	40	50	70	70	10	10	40	70	40	40	95	40
01SEP89	56	50	70	80	80	40	10	50	95	80	80	95	60
15SEP89	70	40	80	70	70	95	10	40	50	70	90	10	10
11OCT89	96	40	50	70	70	40	40	40	40	40	70	10	10
08NOV89	124	80	70	80	95	20	20	80	40	40	70	10	10
05DEC89	151	80	80	40	40	10	10	80	50	70	80	10	10
02JAN90	179	40	80	70	80	10	10	40	40	40	70	10	10
07FEB90	215	40	70	70	70	10	10	40	40	40	40	10	10
08MAR90	244	80	95	70	70	10	10	80	50	50	50	10	10
26MAR90	262	60	95	70	70	10	10	60	70	70	70	10	10
17APL90	284	70	95	70	70	10	10	70	70	70	80	10	10
14MAY90	311	40	95	70	70	10	10	40	70	80	95	95	10
19JUN90	347	30	80	60	70	10	10	30	70	80	80	95	10
31JUL90	390	40	70	50	50	30	10	40	70	70	70	50	50
22OCT90	472	10	70	40	40	70	10	10	40	40	40	10	10
15NOV90	496	10	50	40	50	40	40	10	30	10	10	10	10