

# Habitat selection and population dynamics of selected herbivores on Sondela Nature Reserve, Limpopo

by

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Submitted in fulfilment of part of the requirements for the degree of  
*Magister Scientiae* in Wildlife Management

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February 2003



**Habitat selection and population dynamics of selected herbivores on Sondela  
Nature Reserve, Limpopo**

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## ACKNOWLEDGEMENTS

Many thanks to the Centre for Wildlife Management for making the project possible at all – Prof Van Hoven, Ben and Liset in particular.

To Dr Mike Van Der Linde for making statistics sound easy...

To 'Lena, Ian, Danielle and Simone for making Sondela such a special place.

For the completion of this manuscript I thank my husband, Greg, for his unwavering support, my dearest friends Nicky and Liesl for believing it possible, my parents for giving me the opportunity and my daughter Zoë for sleeping long enough to allow me to finish.

## ABSTRACT

The first part of this thesis investigates the habitat selection of the following herbivores on Sondela Nature Reserve, Limpopo: zebra; impala; giraffe; kudu; blue wildebeest; blesbok; gemsbok and eland.

The main findings indicated that the majority of the species studied congregated in the large grassland community *Chloris virgata* - *Cynodon Dactylon* during the summer season. As this area is already low on surface cover and sensitive to erosion, it is recommended that management use appetite stimulating licks in under utilised areas during summer to attract these species.

The second part of this thesis explores the population dynamics of the following herbivores on Sondela: zebra; impala; kudu; giraffe and blue wildebeest.

The most important findings showed that the populations of all the species has been through a rapid growth phase, with all the herds showing a large percentage of young animals. This leaves the population vulnerable to diseases affecting young animals.

Furthermore, the sex ratios of zebra, kudu and giraffe indicate that there are too few female animals for optimum production.

## INTRODUCTION

The management of a game ranch should be conducted under sound ecological principles involving both conservation and preservation (Bothma, 1996). One of the most important aspects is to understand the behaviour and dynamics of the populations on a ranch in order to manage them better.

## HABITAT SELECTION

The objectives of conducting this study were to:

1. Determine the preferred habitat of the following herbivores:
  - Impala, *Aepyceros melampus*
  - Burchell's zebra, *Equus burchellii*
  - Blue wildebeest, *Connochaetes taurinus*
  - Blesbok, *Damaliscus pygargus phillipsi*
  - Gemsbok, *Oryx gazella*
  - Giraffe, *Giraffa camelopardis*
  - Kudu, *Tragelaphus strepsiceros*
  - Eland, *Taurotragus oryx*
2. Determine if the preferred habitat of the aforementioned herbivores changes with the seasons
3. Plot the movements of each species
4. Give management recommendations using the results

## POPULATION DYNAMICS

The six objectives of the survey were to:

1. Determine the sex ratio of the following herbivores
  - Impala, *Aepyceros melampus*
  - Burchell's zebra, *Equus burchellii*
  - Blue wildebeest, *Connochaetes taurinus*
  - Giraffe, *Giraffa camelopardis*
  - Kudu, *Tragelaphus strepsiceros*

2. Determine the age structure of the selected animals
3. Determine if the herd sizes of the selected animals change with the seasons
4. Make management recommendations using results

#### Location and site

Sandile National Park is situated in the north-eastern part of the Free State province and is bounded by the Orange River to the north and the Orange River to the south. The area is a typical semi-arid savanna environment.

Sandile National Park is a typical savanna environment with a mix of open grassy areas and wooded areas. The vegetation is a mix of open grassy areas and wooded areas. The area is a typical semi-arid savanna environment.

Some of the key findings of the study are that the population of the group and the herd sizes of the selected animals change with the seasons. The study also found that the age structure of the selected animals is skewed towards younger animals.

#### Variables

The study investigated the following variables: herd size, age structure, and seasonal changes. The study also investigated the relationship between these variables and the environment.

The study found that the population of the group and the herd sizes of the selected animals change with the seasons. The study also found that the age structure of the selected animals is skewed towards younger animals. The study also found that the relationship between these variables and the environment is complex.

## THE STUDY AREA

### INTRODUCTION

#### Location and size

Sondela Nature Reserve is situated between latitude  $24^{\circ} 50' 40''$  and  $24^{\circ} 55' 40''$  S, and longitude  $28^{\circ} 21' 35''$  and  $28^{\circ} 27' 04''$  E in the Limpopo Province of South Africa. The closest town is Bela-Bela, which is 7 km away (Figure 1).

Sondela Nature Reserve is part of Adinvale (Pty) Ltd. Adinvale has a wide range of land uses which include game ranching, domestic farming and tourism. The largest land use zones are Sondela Nature Reserve at 1410 ha, a cattle ranch at 2260 ha and a bushcamp at 370 ha. The cattle ranch lies adjacent to Sondela Nature Reserve, while the bushcamp lies on the opposite side of the N1 highway (Figure 2).

Sondela Nature Reserve is part of the RCI timeshare group and has 50 chalets with six beds in each. The activities on offer include horse riding, mountain biking, game drives, archery and clay pigeon shooting. The majority of guests visiting Sondela Nature Reserve are South African.

#### Vegetation

Acocks (1998) classified this region as the boundary of the Springbok Flats Turf Thornveld (Veld Type 12) and the Sourish Mixed Bushveld (Veld Type 19), while according to Low and Rebelo (1996), Sondela occurs on the boundary of the Clay Thorn Bushveld (Vegetation Type 14) and the Mixed Bushveld (Vegetation Type 18).

The vegetation of the reserve was classified by van Wijk (1996) by means of the Braun-Blanquet method (Werger 1974). The whole farm was classified into five communities, two of which have two sub-communities each, and one which has one sub-community with three variations (Figure 3). For the purpose of the study, only the communities on the Nature Reserve needed to be included (Table 1).

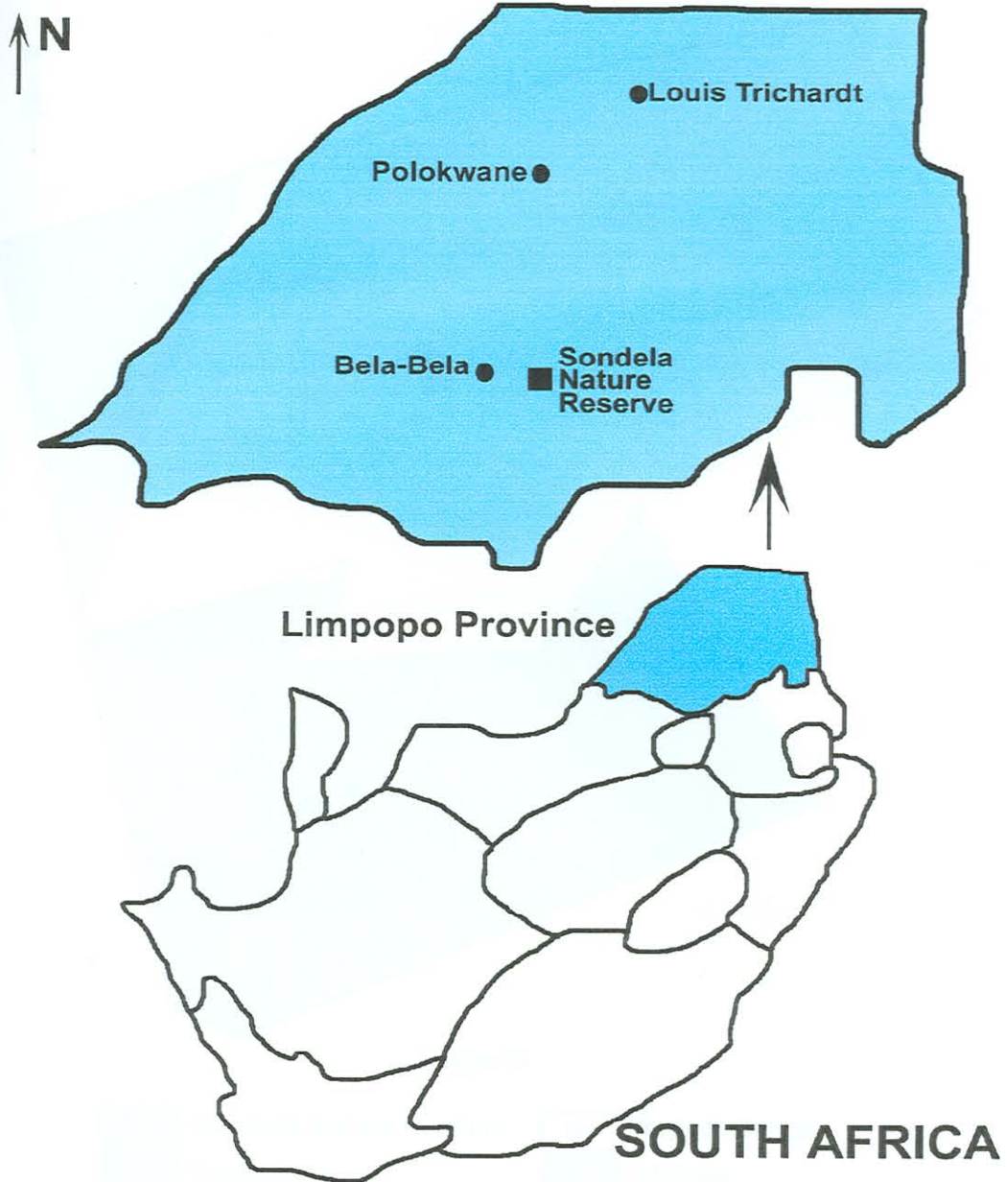
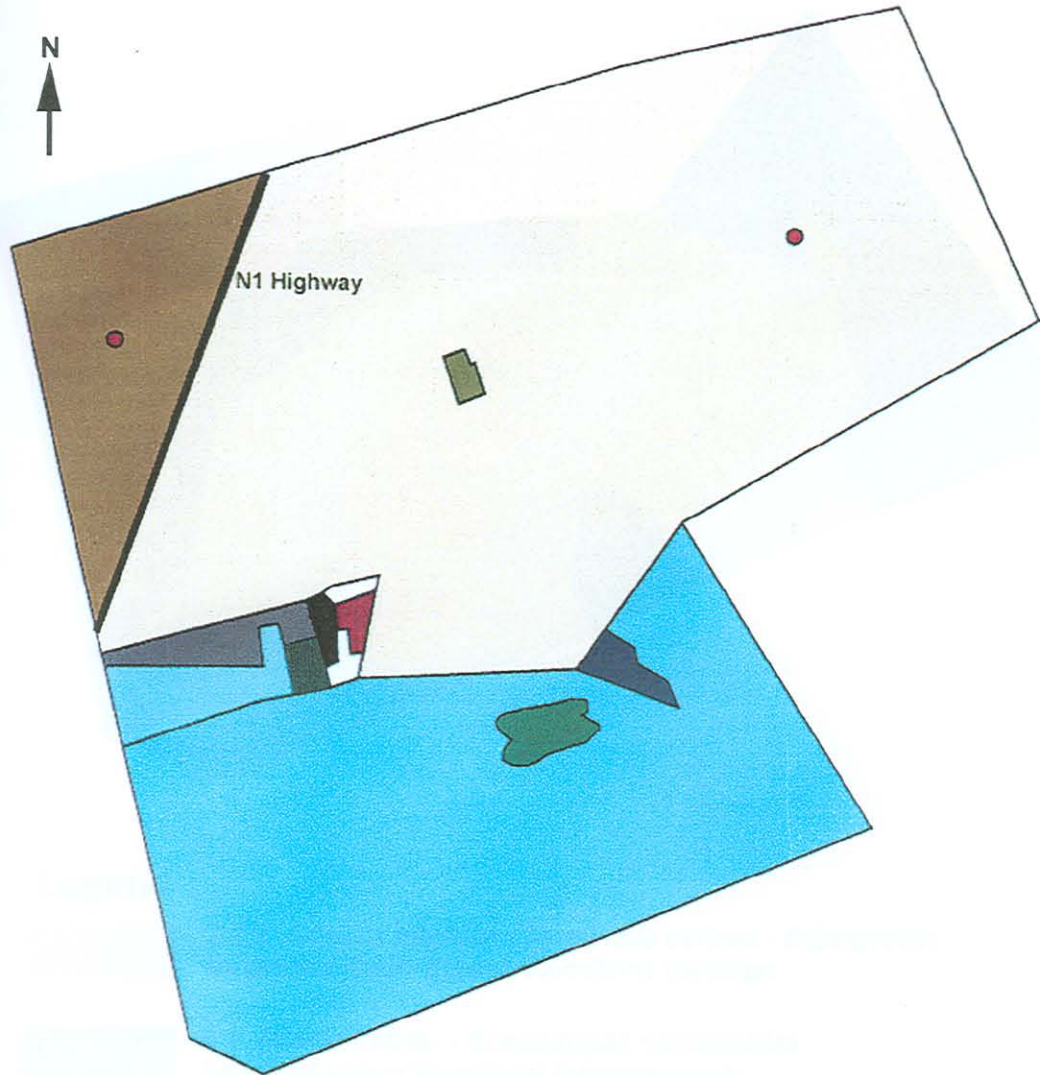


Figure 1: Map indicating the location of Sondela Nature Reserve



Legend














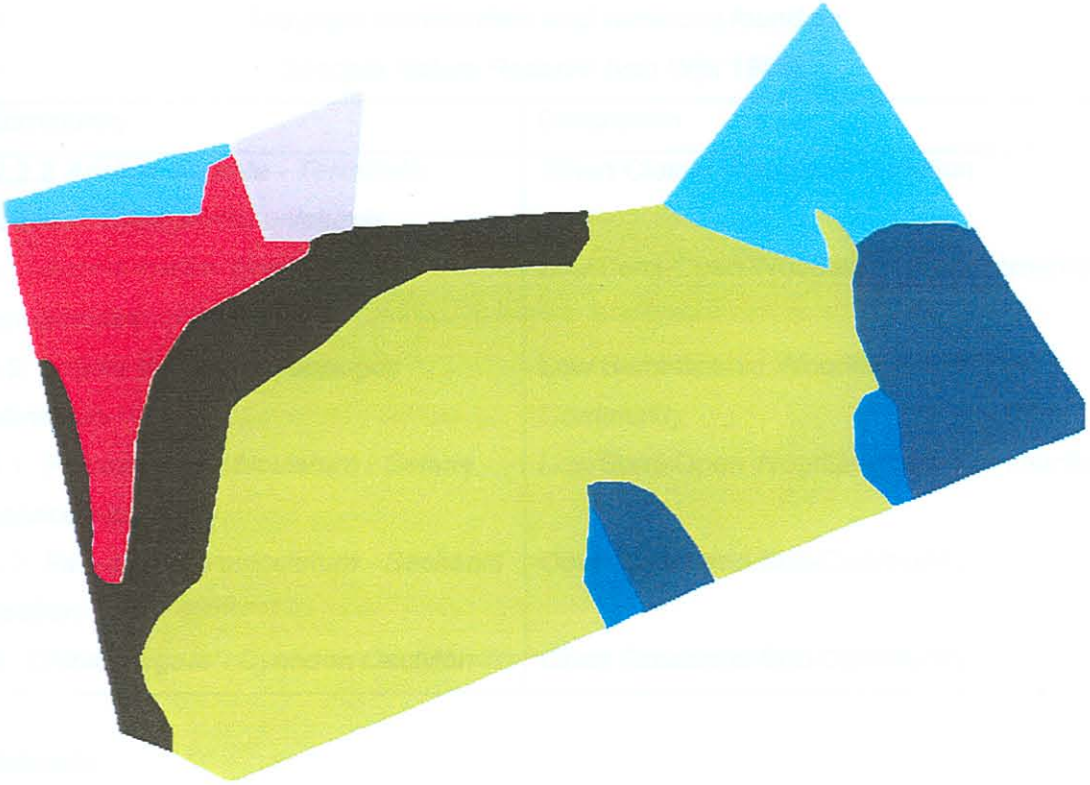
	Sondela Nature Reserve		Tented Camps
	Chalets		Stables
	Springbok Camp		Polocrosse Fields
	Cattle Ranch		Cultivated Land
	Cattle Kraal		Reception and Farmyard
	Old Hunting Camp		Vineyards
	Staff Accommodation		

Figure 2: The land use zones of Adinvale





### Legend







-  2.2.2 *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* Short Closed Woodland Variation
-  4.1 *Acacia tortilis* - *Enneapogon cenchroides* Low Semi-open Woodland Subcommunity
-  4.2 *Acacia tortilis* - *Cymbopogon plurinodis* Low Semi-sparse Woodland Subcommunity
-  5.1 *Paspalum scrobiculatum* - *Setaria sphacelata* Low Semi-open Woodland Subcommunity
-  5.2 *Paspalum scrobiculatum* - *Sesbania sesban* Open Grassland Subcommunity
-  6. *Chloris virgata* - *Cynodon dactylon* Open Grassland Community

Figure 3: Plant communities found on Sondela Nature Reserve

**Table 1**

*The plant communities and variations found on  
Sondela Nature Reserve (van Wijk 1996).*

Community	Description
2.2.2 <i>Aristida stipitata</i> - <i>Terminalia sericea</i> - <i>Stipagrostis uniplumis</i>	Short Closed Woodland Variation
4.1 <i>Acacia tortilis</i> - <i>Enneapogon cenchroides</i>	Low Semi-Open Woodland Sub-Community
4.2 <i>Acacia tortilis</i> - <i>Cymbopogon plurinodis</i>	Low Semi-Sparse Woodland Sub-Community
5.1 <i>Paspalum scrobiculatum</i> - <i>Setaria sphacelata</i>	Low Semi-Open Woodland Sub-Community
5.2 <i>Paspalum scrobiculatum</i> - <i>Sesbania sesban</i>	Open Grassland Sub-Community
6. <i>Chloris virgata</i> - <i>Cynodon Dactylon</i>	Open Grassland Sub-Community

## Animals

At present there is a wide variety of ungulates on Sondela, including:

Blesbok, *Damaliscus pygargus phillipsi*  
 Impala, *Aepyceros melampus*  
 Giraffe, *Giraffa camelopardis*  
 Gemsbok, *Oryx gazella*  
 Eland, *Taurotragus oryx*  
 Blue wildebeest, *Connochaetes taurinus*  
 Waterbuck, *Kobus ellipsiprymnus*  
 Burchell's zebra, *Equus burchellii*  
 Kudu, *Tragelaphus strepsiceros*  
 Red hartebeest, *Alcelaphus buselaphus*

There are no large predators on Sondela and no members of the big five, but the following smaller predators are found:

Black-backed jackal, *Canis mesomelas*

Brown hyaena, *Hyaena brunnea*

Caracal, *Felis caracal*

Aardvark, *Orycteropus afer*

## **Topography**

Sondela ranges in altitude from 1120 m above sea level in the south, to 1200m above sea level in the North-west. The surface is predominantly flat with a mean slope of 3.3°. There are no perennial water sources and no major drainage lines on the farm.

## **Climate**

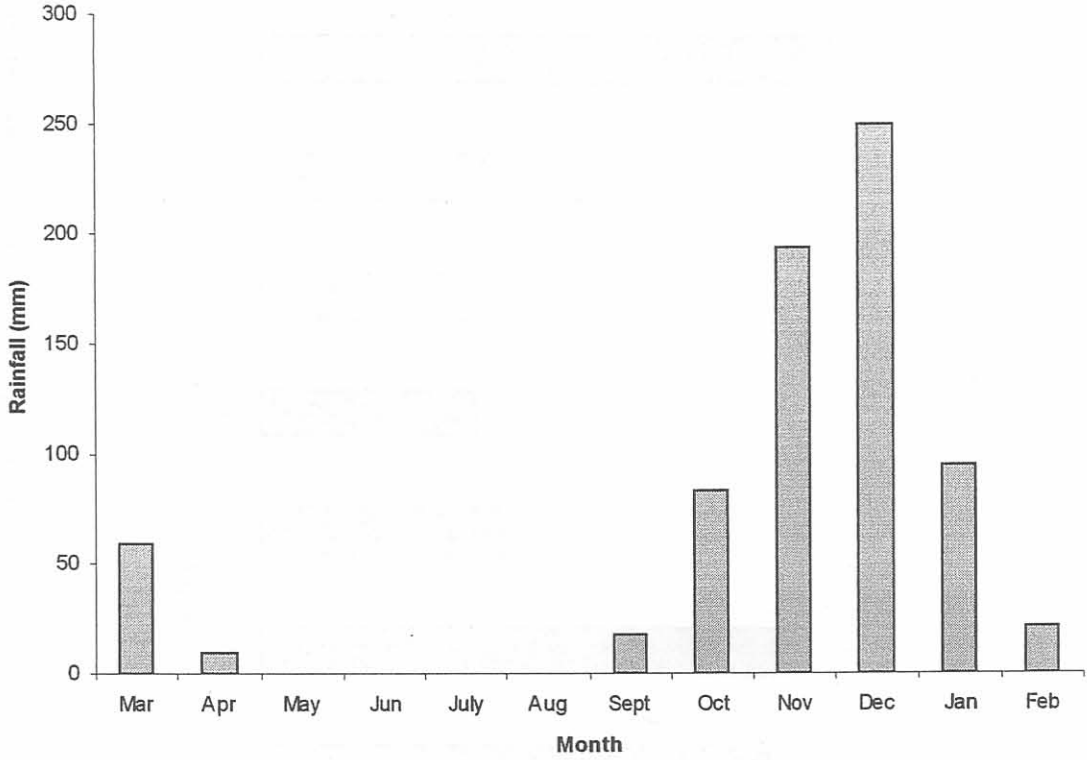
Sondela falls into the Southern Savanna biome and is subjected to a typical unimodal subtropical Savanna climate with a single summer rainy season. Climatic data was obtained from the Towoomba Weather Station (station number 0589 / 5941; longitude 24° 54` S; latitude 28° 20` E; 1120m above sea level), 4 km west of Sondela.

The rainfall is erratic and varies from year to year. The average rainfall in this area is 61 mm for the period March 1998 to February 1999. The wet season stretches from October to April, with November and December being the wettest months with measurements of 193.5 mm and 248.4 mm respectively. The dry season stretches from May to September (Figure 4).

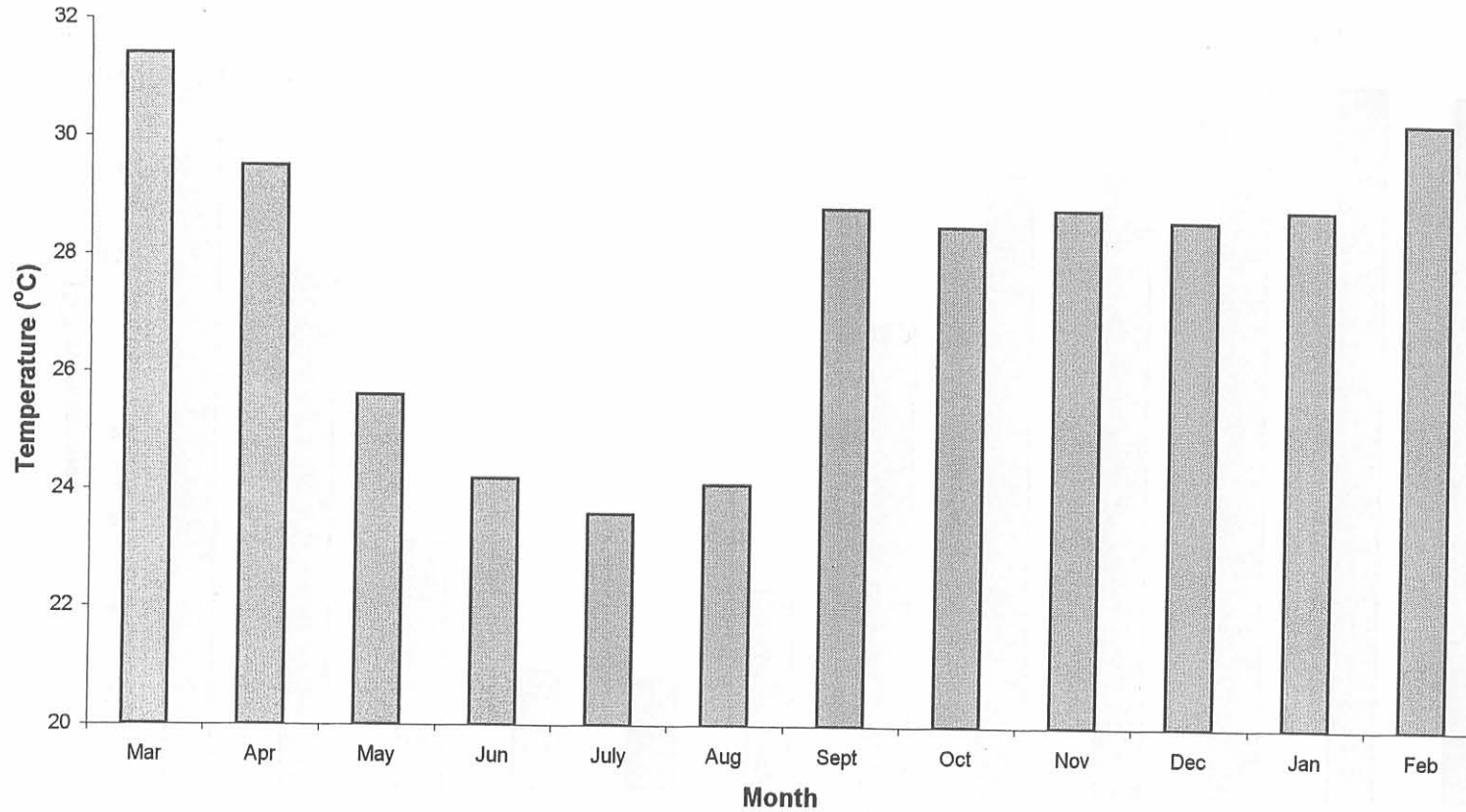
The average maximum yearly temperatures measured on Sondela is 28° Celsius (Figure 5), while the average minimum yearly temperature measured on Sondela is 11° Celsius (Figure 6). Extreme temperatures are not uncommon and can reach 30° Celsius in summer and drop to as low as 2° Celsius in winter.

## **Geology**

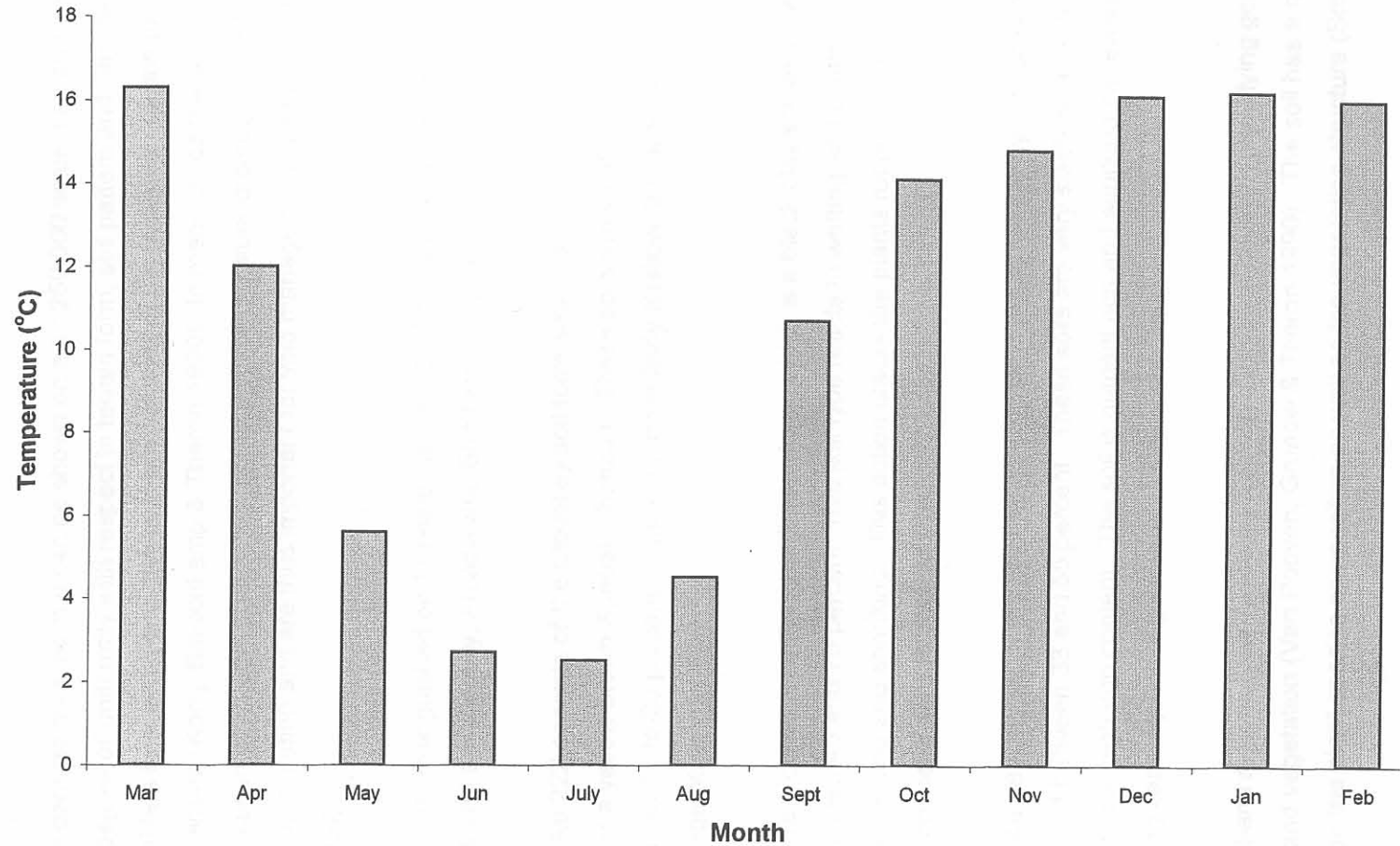
There is one major rock type found on Sondela Nature Reserve and this type forms part of the Karoo Sequence. This type is known as the Letaba formation, which has a sedimentary column of volcanic rock and sandstone and an igneous column of basalt and pyroclasts. The result of this parent rock is shallow, high clay, nutrient rich soils.



**Figure 4.** Monthly rainfall for Sondela Nature Reserve from 1999 to 2000 as determined from the data of the Towoomba weather station, number: 0589594 1; Latitude: 2454; Longitude: 2828; Height: 1143m ASL (Weather Bureau, unpublished)



**Figure 5.** Monthly maximum temperature for Sondela Nature Reserve from 1999 to 2000 as determined from the data of the Towoomba weather station, number: 0589594 1; Latitude: 2454; Longitude: 2828; Height: 1143m ASL (Weather Bureau, unpublished)



**Figure 6.** Monthly minimum temperature for Sondela Nature Reserve from 1999 to 2000 as determined from the data of the Towoomba weather station, number: 0589594 1; Latitude: 2454; Longitude: 2828; Height: 1143m ASL (Weather Bureau, unpublished)

## Landtypes and soils

A land type denotes an area that can be shown on a 1 : 250 000 scale map and displays a marked degree of uniformity with respect to terrain form, soil pattern and climate. One land type differs from another in terms of one or more of the following: terrain form, soil pattern or climate (Kooij, Bredenkamp & Theron 1990). In many cases these categories give an indication of nutrient status and patterns of soil moisture drainage and soil moisture accumulation and are thus important for veld management (Van Rooyen & Theron 1996).

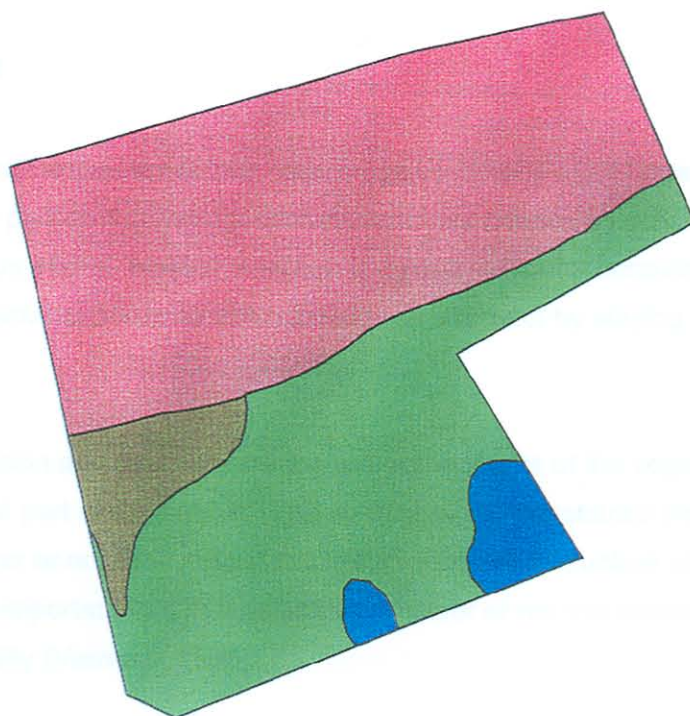
The land types distinguished on Sondela are Ae 222, Ea 1 and Ae 18, while the three soil types found are Clovelly, Arcadia and Shortlands (Figure 7).

Land type Ae 222 consists of the Clovelley soil form, which is comprised of an Orthic A horizon over a yellow-brown Apedal B horizon. These soils are sandy loam soils with a clay content of 15 to 20 percent. This soil form is fairly shallow, but does support sourveld vegetation.

Land type Ea 1 consists of the Arcadia soil form, which is a black clay soil with clay content between 45 and 70 percent. This soil type reacts to wetting and drying by continuous swelling and shrinking. This action cracks the plants roots and thus vegetation on these soils is often stunted.

Land type Ae 18 consists of the Shortlands soil form. These red sandy clay soils have a clay content of between 33 and 55 percent. These soils are very stable against erosion, stabilized by the high iron content. The soil is nutrient rich and supports sweetveld with high carrying capacity under good rainfall (Macvicar 1991).

In the semi-arid regions there is usually a strong correlation between underlying geology, soil types and vegetation (Van Rooyen, Grunow & Theron 1990). The soil has a major influence on the plant species composition as well as the vegetation structure (Schmidt 1992).



**Legend**

-  Avalon soil form
-  Clovelly soil form
-  Arcadia soil form
-  Shortlands soil form

**Figure 7:** Soil types found on Sondela Nature Reserve



## HABITAT SELECTION

### INTRODUCTION

A feature of African ungulates is their wide range of morphological diversity. This causes resource partitioning through dietary, and thus habitat, selection (Owen-Smith 1985, In: Fabricius 1989). Habitat selection is a combination of behavioural phenomena involving stimuli and response to which individuals will react by staying or leaving (Van Rooyen 1990).

Species composition and structure are the two components of the vegetation, which form an important part of the habitat. The species which constitutes the vegetation will determine whether or not the food source is sufficient. The structure of the vegetation plays an equally important role in determining whether or not the habitat is suitable e.g. shelter and visibility (Vermaak 1996).

The kinds of food eaten by animals of any one species are not fixed and differ in relative abundance both spatially and temporally. The benefits and costs of feeding on particular food types depends on phenotypic features of the herbivore, as well as environmental circumstances. Benefits depend on nutrient yields, which are influenced by the digestive system (Owen-Smith 1996). All these factors create a feeding style which is the most important factor in determining the habitat selected by any ungulate (Jarman 1977, In: Van Rooyen 1990).

Animals not only show preferences for different habitats by shelter and diet, but also for topographical features such as slopes or areas of differing soil slopes or level territory or different soils. (Bell 1971; Bothma & Van Rooyen 1989; Novellie 1990)

A sound knowledge of the habitat requirements of ungulates within a game reserve is imperative for the formulation of management policies (Funston 1992).

## Methods

### Collection of data

The method used in this study is the same as used by Vermaak (1996).

The homogenous vegetation units in this reserve were determined by Van Wijk (1996) and a grid was superimposed over this map. Each grid square was 1 km by 1 km (100 m by 100 m on the ground) and was allocated a reference number. The survey was conducted from March 1998 to March 1999.

The study area was surveyed at least twice a week, in the mornings and afternoons, from vehicles, hides and on foot. The route taken was fixed and covered all vegetation types. The animals were observed by means of binoculars.

When an animal was observed it was first established which species it was and then the time, date, grid reference, size of the group and environmental variables were recorded.

The following data were recorded at each sighting on a sightings sheet (Appendix 1):

### Distance from water

The distance from water was measured as follows:

- 0 - 100 m
- 100 - 200 m
- 200 - 500 m
- > 500 m

### Erosion

The erosion was categorised as follows:

- slight / none = no erosion or very small bare areas with no cover
- Moderate = low plant cover and large amounts of bare areas.

### Landscape position

- Plains = large, relatively flat areas
- Drainage areas = areas around waterholes

### Rock cover

The rock cover was described in percentage as follows:

- 0 - 25%
- >26%

### Vegetation cover

The cover of the vegetation was measured in percentage and split into classes for the different vegetation layers (Table 2).

**Table 2**  
*Classes of cover for different vegetation layers*

Tree layer	Class 1	Class 2	Class 3	Class 4
Herbaceous layer	0 - 50%	51 - 70%	71 - 85%	86% +
Shrub layer (<2m)	0 - 2.5%	2.6 - 10%	11 - 15%	16% + 21%
Tree layer (2 - 6m)	0 - 2.5%	2.6 - 5%	6 - 20%	11% +
Tree layer (>6m)			10%	

### Herbaceous height

The grass height was classed as:

- Short (0 - 200 mm)
- Medium (> 200mm)

### Animals

The following data was recorded for each species observed:

- Species
- Association with other species (i.e. If another species was within 100m of the observed species, the species were known as associating with one another.)
- Activities
  - Grazing = half or more of the group is grazing
  - Drinking = at least one animal is drinking
  - Resting = half or more of the group is lying down or standing still

- Flight = the group is fleeing from a disturbance
- Moving = the group is moving to another area, not because of a disturbance
- Mating = at least two individuals are mating
- Mock fighting = at least two individuals are mock fighting

## Statistical Analysis

### Frequency Histograms

Frequency histograms were constructed to illustrate the number of observations (dependent axis) against the habitat variables, i.e. erosion or grass height. The preferences for each habitat variable were tested for significance using the Chi-square test. The value of  $X^2$  is the measure of magnitude of the discrepancies between the observed and expected frequencies and is calculated by the equation:  $X^2 = (O - E)^2 / E$ , where O = observed values and E = expected values. The null hypothesis assumes that there was no significant preference for any habitat variables. If the value of  $X^2$  exceeds the decided significance level, then the null hypothesis is rejected (Snedecor & Cochran 1989). A significant difference level of 5% ( $P=0.05$ ) was accepted.

### Correspondence Analysis

The correspondence analysis was used to show the preferred plant communities of each herbivore species, as well as to illustrate each species relationship with other species. The correspondence analysis is much the same as the  $X^2$  test in that it measures the difference that the data shows from the null hypothesis.

The end result of the correspondence analysis is a graphical display of the correlation between the two variables, i.e. species and community. The principle behind this analysis is to maximise inertia, which is a squared distance measure, and thus find the measurement from the hypothesis.

## RESULTS AND DISCUSSION

### Frequency Histograms

#### Zebra

In summer ( $\chi^2=81$ ,  $P<0.05$ ,  $df=1$ ) and spring ( $\chi^2=70.56$ ,  $P<0.05$ ,  $df=1$ ) it was found that zebra significantly preferred less eroded areas. The same trend was followed for winter, while in autumn the zebra were found to frequent more eroded areas (Figure 8a). The relationship between these preferences and the season of the year was found to be significant:  $\chi^2=103.86$ ,  $P<0.05$ ,  $df=3$ .

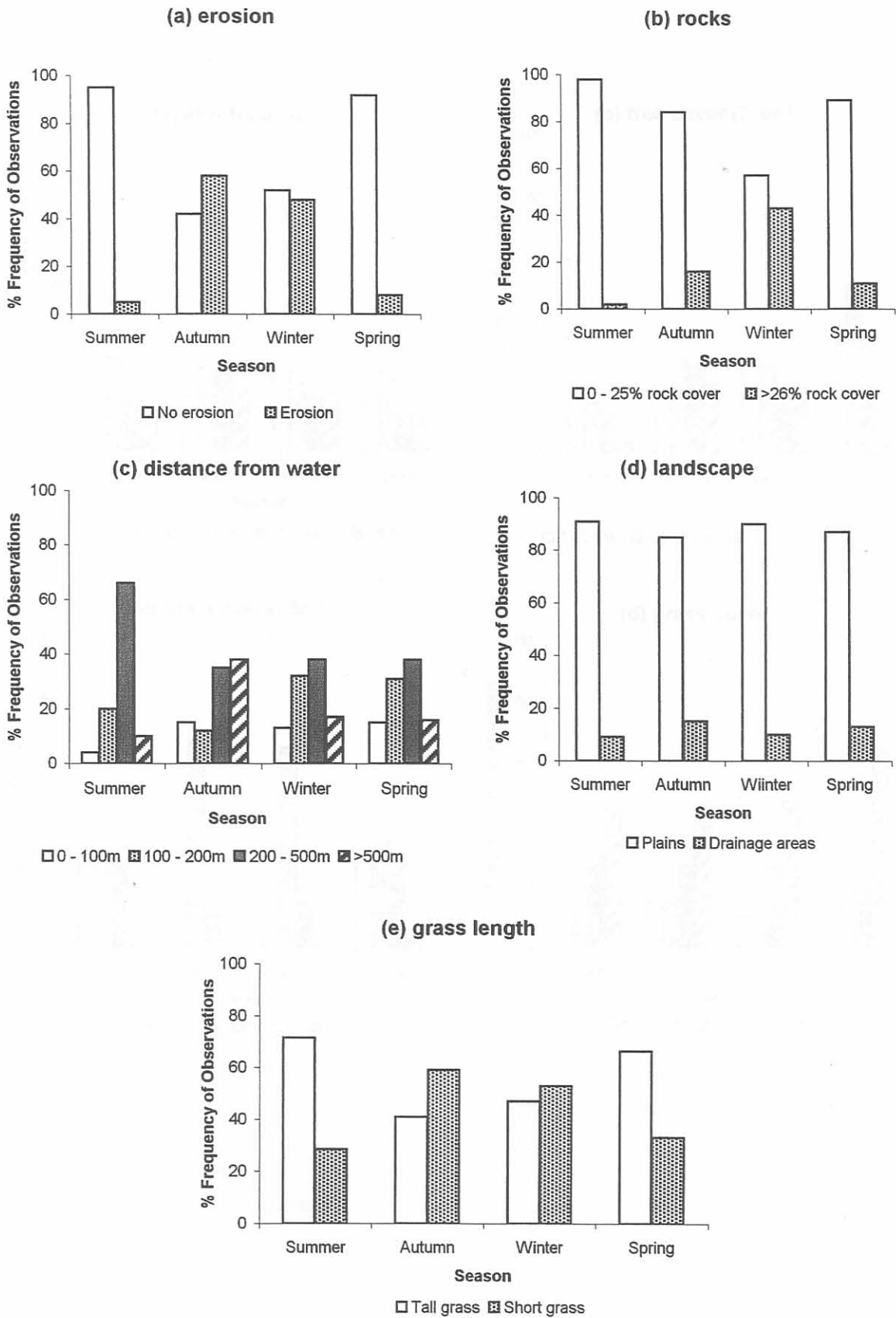
In all four seasons it was found that zebra preferred areas which were less rocky. They spent 84% of their time in less rocky areas in autumn, 89% in spring and 57% in winter (Figure 8b).

Zebra tended to remain 200 to 500 m distance from water in summer ( $\chi^2=91$ ,  $P<0.05$ ,  $df=3$ ), which was significantly different from other observations, no significant preferences were found over the other seasons (Figure 8c), although a relationship did exist between their preference to water and the time of year ( $\chi^2=51.698$ ,  $P<0.05$ ,  $df=9$ ).

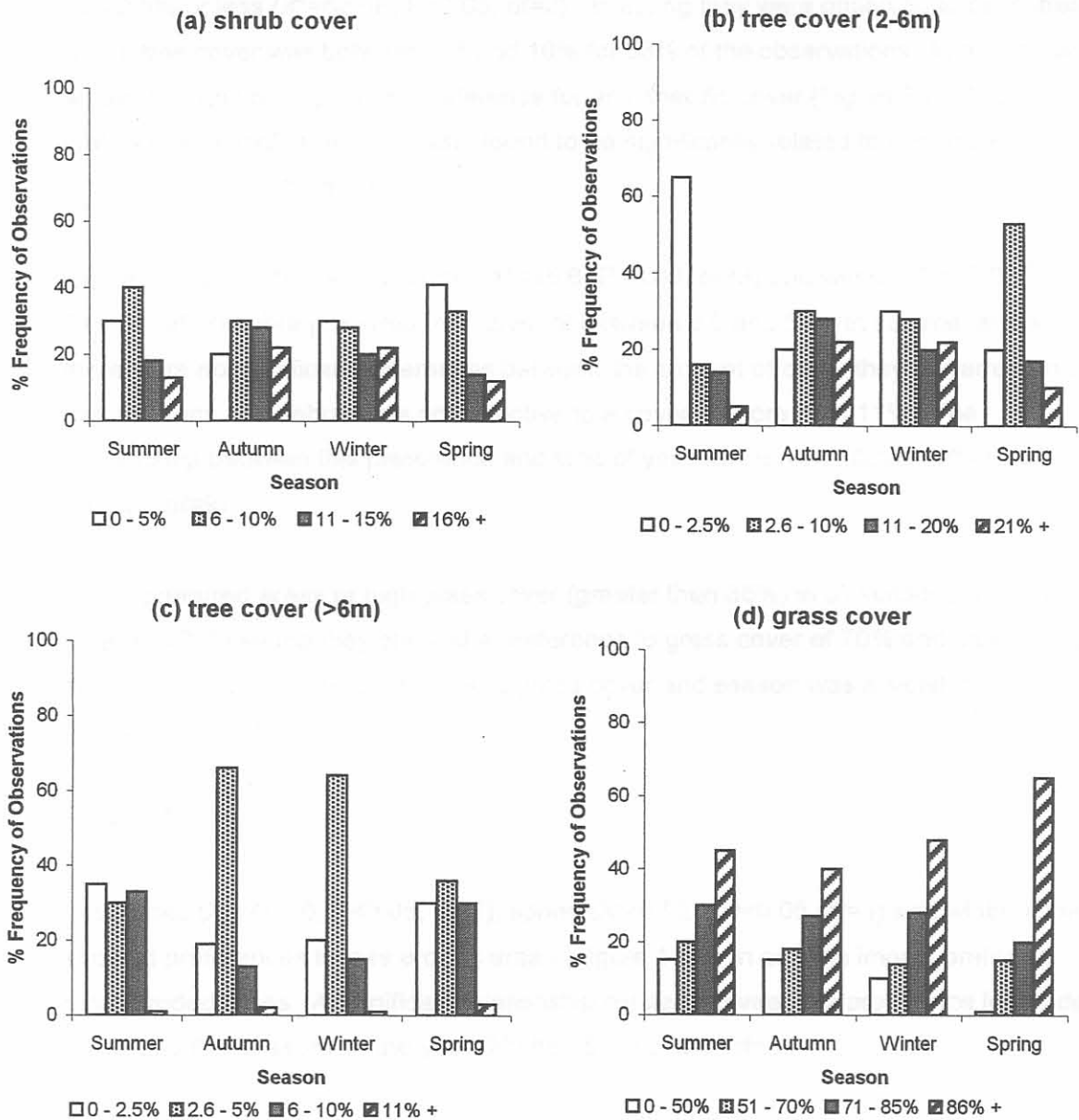
Figure 8d shows that zebra significantly preferred plain type areas to drainage areas in all the seasons, 91% of the time in summer and more than 85% in the other seasons.

Zebra preferred tall grass predominantly in summer ( $\chi^2=18.49$ ,  $P<0.05$ ,  $df=1$ ) and spring ( $\chi^2=10.61$ ,  $P<0.05$ ,  $df=1$ ), they preferred short grass 53% of the time in winter and 59% of the time in autumn (Figure 8e). The relationship between this preference and the seasons of the year was a significant one ( $\chi^2=10.170$ ,  $P<0.05$ ,  $df=3$ ).

In summer and spring, zebra tended to spend more time in areas where the shrub cover was less than 10% (Figure 9a). In winter and autumn they showed no significant preference to areas with more or less shrub cover. The preference towards shrub cover was correlated with the time of the year:  $\chi^2=42.519$ ,  $P<0.05$ ,  $df=9$ .



**Figure 8.** Seasonal frequency distribution of zebra in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grasslength



**Figure 9.** Seasonal frequency distribution of zebra in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

Zebra were observed significantly in summer to be in areas where the tree cover (2-6m) was 2.5% or less ( $\chi^2=88.08$ ,  $P<0.05$ ,  $df=3$ ). In spring they were observed to be in areas where tree cover was between 2.6 and 10% for 53% of the observations. In autumn and winter they had no significant preference for any specific cover (Figure 9b). The preference towards tree cover was found to be significantly related to the time of year ( $\chi^2=102.22$ ,  $P<0.05$ ,  $df=9$ ).

Figure 9c illustrates that in autumn ( $\chi^2=95.6$ ,  $P<0.05$ ,  $df=3$ ) and winter ( $\chi^2=87.06$ ,  $P<0.05$ ,  $df=3$ ) zebra preferred tree cover of between 2.6 and 5%. In summer and spring there were no significant differences between the amount of cover they preferred. In all four seasons, the zebra were not selective to a cover of more than 11%. The relationship between this preference and time of year was not significant ( $\chi^2=15.987$ ,  $P>0.05$ ,  $df=9$ ).

Zebra preferred areas of high grass cover (greater than 85%) in all seasons of the year (Figure 9d). In spring they showed a preference to grass cover of 70% and more. The correlation between the preference to grass cover and season was a significant one:  $\chi^2=32.79$ ,  $P<0.005$ ,  $df=9$ .

### Impala

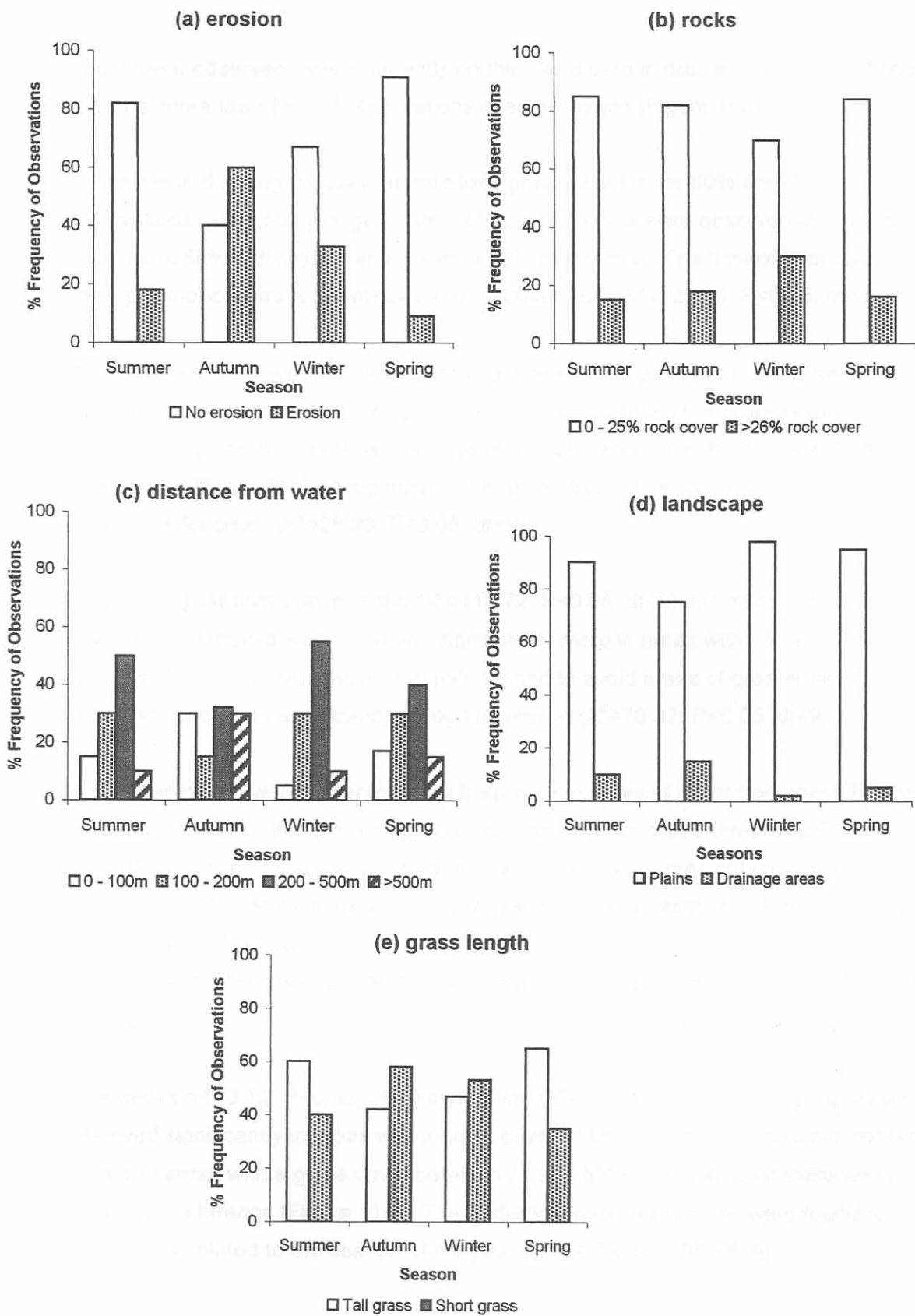
In summer ( $\chi^2=40.96$ ,  $P<0.05$ ,  $df=1$ ), spring ( $\chi^2=67.24$ ,  $P<0.05$ ,  $df=1$ ) and winter impala showed preferences to less eroded areas (Figure 10a). In autumn impala preferred more eroded areas. A significant relationship existed between the preference for eroded areas and the seasons of the year ( $\chi^2=86.75$ ,  $P<0.005$ ,  $df=3$ ).

Figure 10b illustrates that in all four seasons impala were observed more in less rocky areas, for more than 75% of observations each time.

Impala were observed at all four distances from water during all four seasons, with a slightly higher preference to remain a distance of 200 to 500m from water in winter ( $\chi^2=101$ ,  $P<0.05$ ,  $df=3$ ), summer and spring (Figure 10c).

The time of the year was a factor in this preference and a significant relationship exists between the two ( $\chi^2=33.80$ ,  $P<0.05$ ,  $df=9$ ).





**Figure 10.** Seasonal frequency distribution of impala in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grass length

Impala were observed more frequently on the plains than in drainage areas for all four seasons, more than 75% of observations in each season (Figure 10d).

In summer and spring impala preferred long grass to short, for 60% and 65% of observations respectively (Figure 10e). In autumn impala were observed in areas of short grass 58% of the time, and in winter 53% of the time. The time of year influences these preferences, as is shown by the Chi-square test:  $X^2=12.704$ ,  $P<0.05$ ,  $df=3$ .

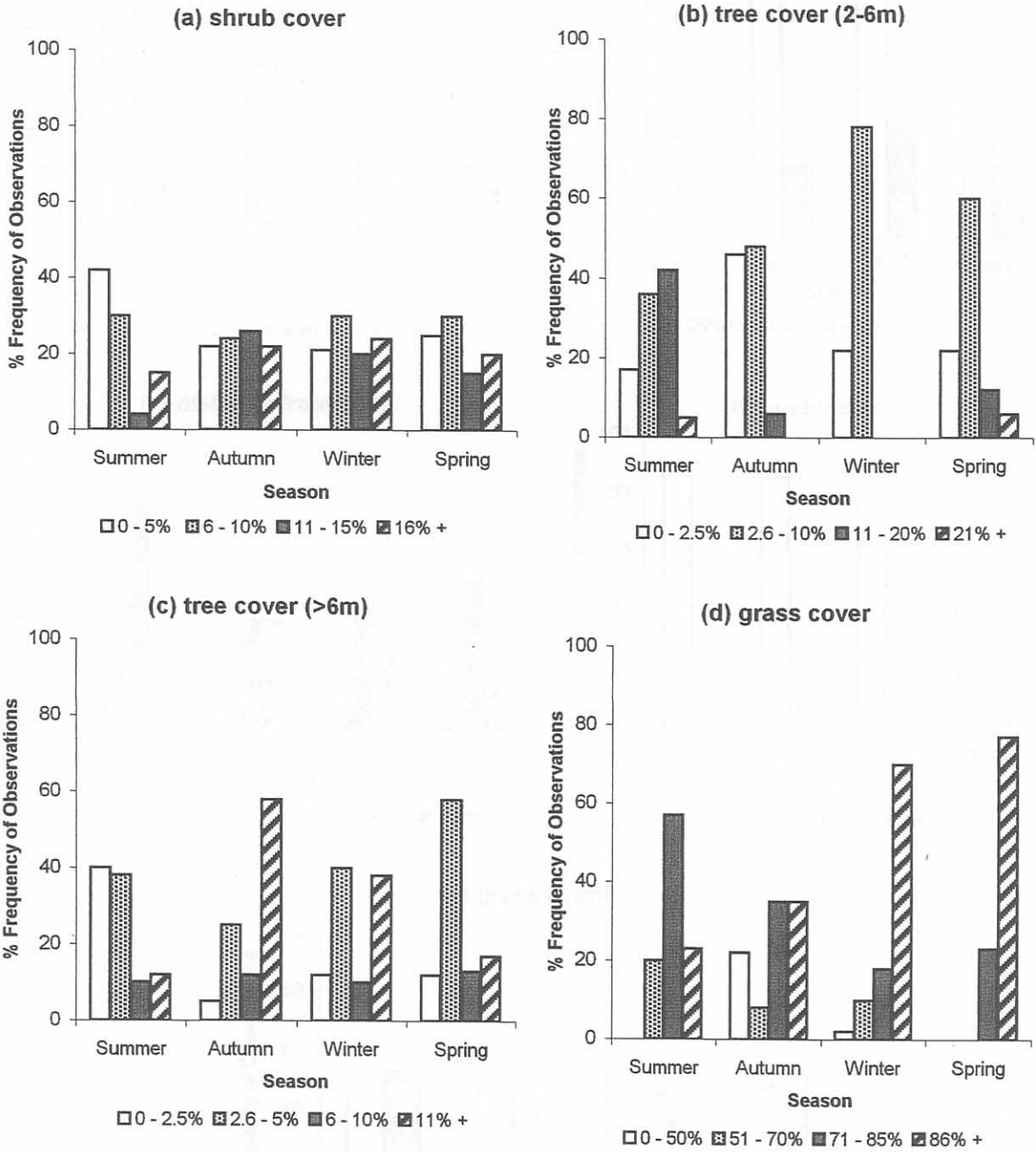
Impala showed no particular preferences for areas with high or low shrub cover in winter, spring or autumn. In summer impala were found 42% of the time in areas with less than 5% cover and only 4% of observations were in areas where shrub cover was between 11 and 15% (Figure 11a). A significant correlation existed between seasons and preference for cover ( $X^2=26.26$ ,  $P<0.05$ ,  $df=9$ ).

Figure 11b illustrates that in winter ( $X^2=112.72$ ,  $P<0.05$ ,  $df=3$ ) and spring ( $X^2=70.56$ ,  $P<0.05$ ,  $df=3$ ) impala were observed significantly more in areas with a tree (2-6m) cover of 2.6 to 10%. In all four seasons impala tended to avoid areas of greater tree cover. This preference was significantly related to season ( $X^2=78.32$ ,  $P<0.05$ ,  $df=9$ ).

In summer impala were observed most frequently in areas of lower tree cover (between zero and 2.6%). In spring the most observations were for a tree cover of 2.6 to 5% cover (Figure 11c). In autumn impala were seen mostly in areas of high tree cover (more than 11%), while in winter they were seen most frequently in areas of 2.6 to 5% and more than 11% cover.

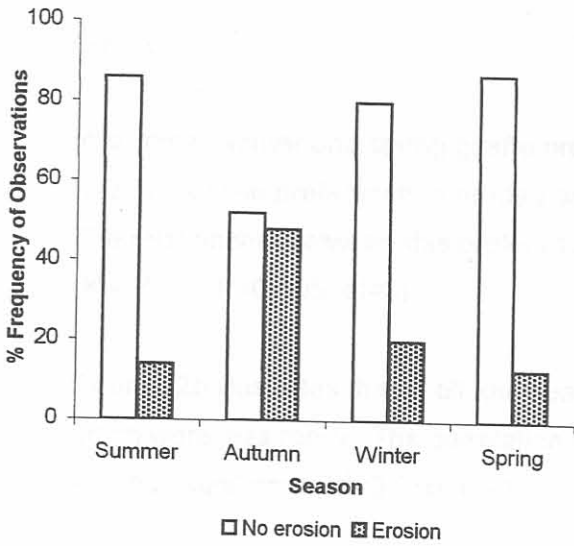
The preference for cover was significantly related to the seasons of the year ( $X^2=25.12$ ,  $P<0.05$ ,  $df=9$ ).

In winter ( $X^2=113.12$ ,  $P<0.05$ ,  $df=3$ ) and spring ( $X^2=108.32$ ,  $P<0.05$ ,  $df=3$ ) impala were observed significantly in areas with a grass cover of 86% or more. In summer impala preferred areas with a grass cover between 71 and 85% and in autumn there was no particular preference (Figure 11d). The preferences for grass cover were found to be significantly related to the season of the year ( $X^2=34.14$ ,  $P<0.05$ ,  $df=9$ ).

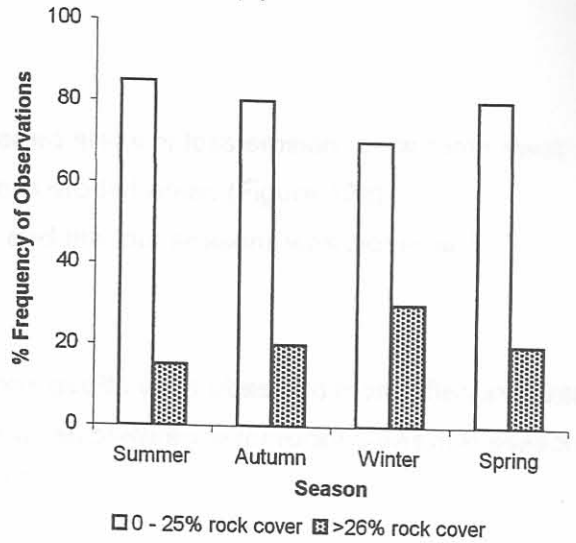


**Figure 11.** Season frequency distribution of impala in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

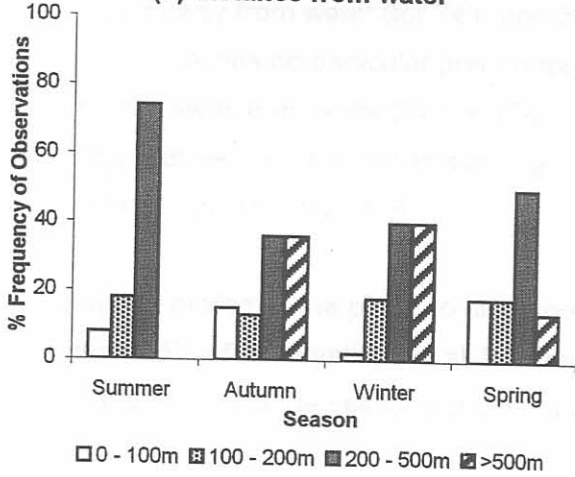
(a) erosion



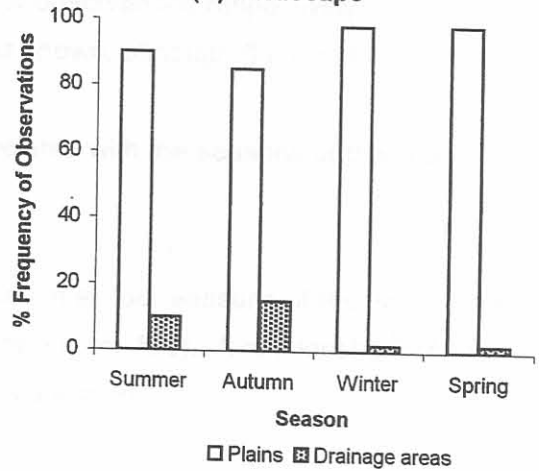
(b) rocks



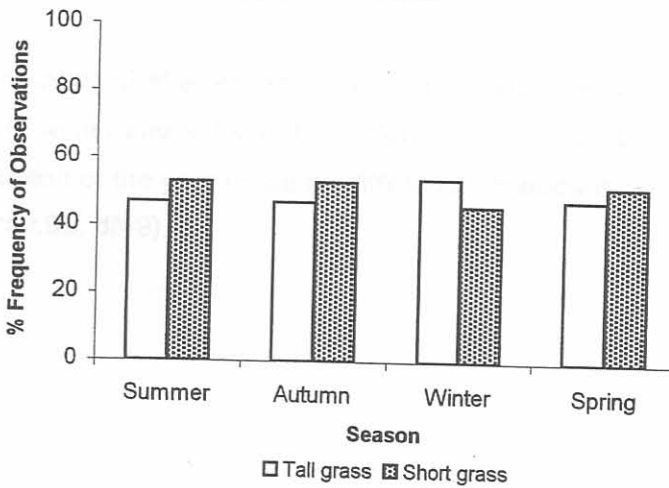
(c) distance from water



(d) landscape



(e) grass length



**Figure 12.** Season frequency distribution of giraffe in relation to (a) erosion, (b) rocks, (c) water (d) landscape and (e) grass length

## Giraffe

In summer, winter and spring giraffe preferred areas of less erosion. In autumn there was no definite preference to eroded or less eroded areas (Figure 12a).

The relationship between this preference and the four seasons was significant ( $\chi^2=20.37$ ,  $P<0.005$ ,  $df=3$ ).

Figure 12b illustrates that in all four seasons giraffe were observed more often in areas which were less rocky. The correlation between preference for rocky areas and seasons was not significant ( $\chi^2=3.956$ ,  $P>0.05$ ,  $df=3$ ).

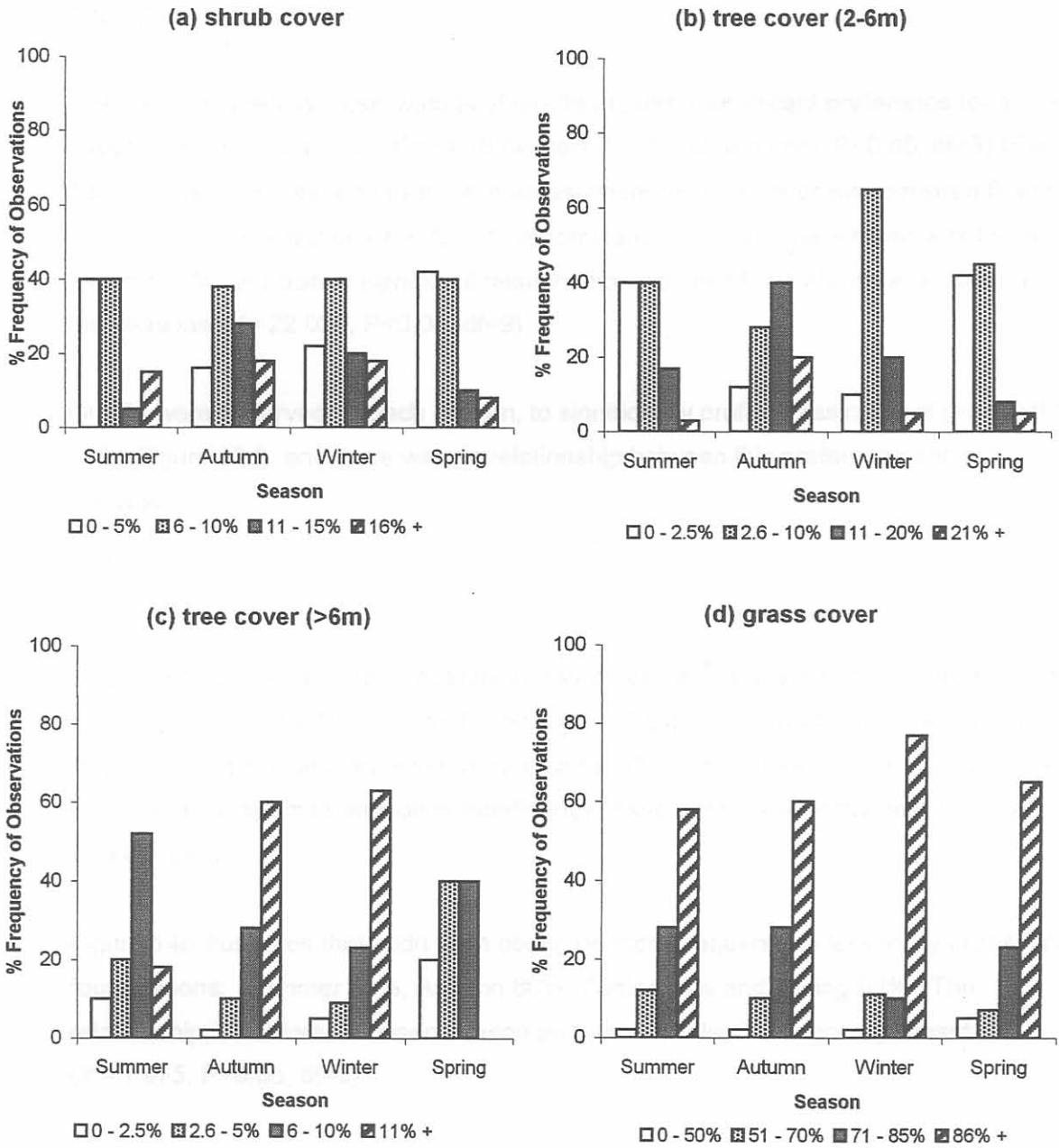
In summer ( $\chi^2=109.56$ ,  $P<0.05$ ,  $df=3$ ) and spring giraffe spent most time around 200 to 500m away from water (for 74% and 50% of observations respectively), while in the other seasons no particular preference was shown, although the trend was to areas further away from water (Figure 12c).

The preference for water was strongly correlated with the seasons of the year ( $\chi^2=26.107$ ,  $P<0.05$ ,  $df=9$ ).

Giraffe preferred the plains to drainage areas in all four seasons of the year for more than 85% of observations in all four seasons (Figure 12d). A relationship between this preference and the seasons could not be established.

Figure 12e illustrates that in all four seasons giraffe showed no significant preference to length of grass, nor was there a correlation between this preference and the seasons.

In summer and spring giraffe preferred shrub cover which was between zero and 10% (Figure 13a). In winter and autumn the preference was towards areas of 6 to 10% cover. The season of the year made no difference towards the giraffe's preferences ( $\chi^2=15.606$ ,  $P>0.05$ ,  $df=9$ ).



**Figure 13.** Seasonal frequency distribution of giraffe in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

Giraffe were observed in summer and spring mainly in areas where the tree cover (<6m) was between zero and 10% (Figure 13b). In winter the number of observations ( $\chi^2=90$ ,  $P<0.05$ ,  $df=3$ ), was significantly for the category 2.6 to 10%. The time of year played an important role in these preferences and the relationship was significant ( $\chi^2=39.321$ ,  $P<0.05$ ,  $df=9$ ).

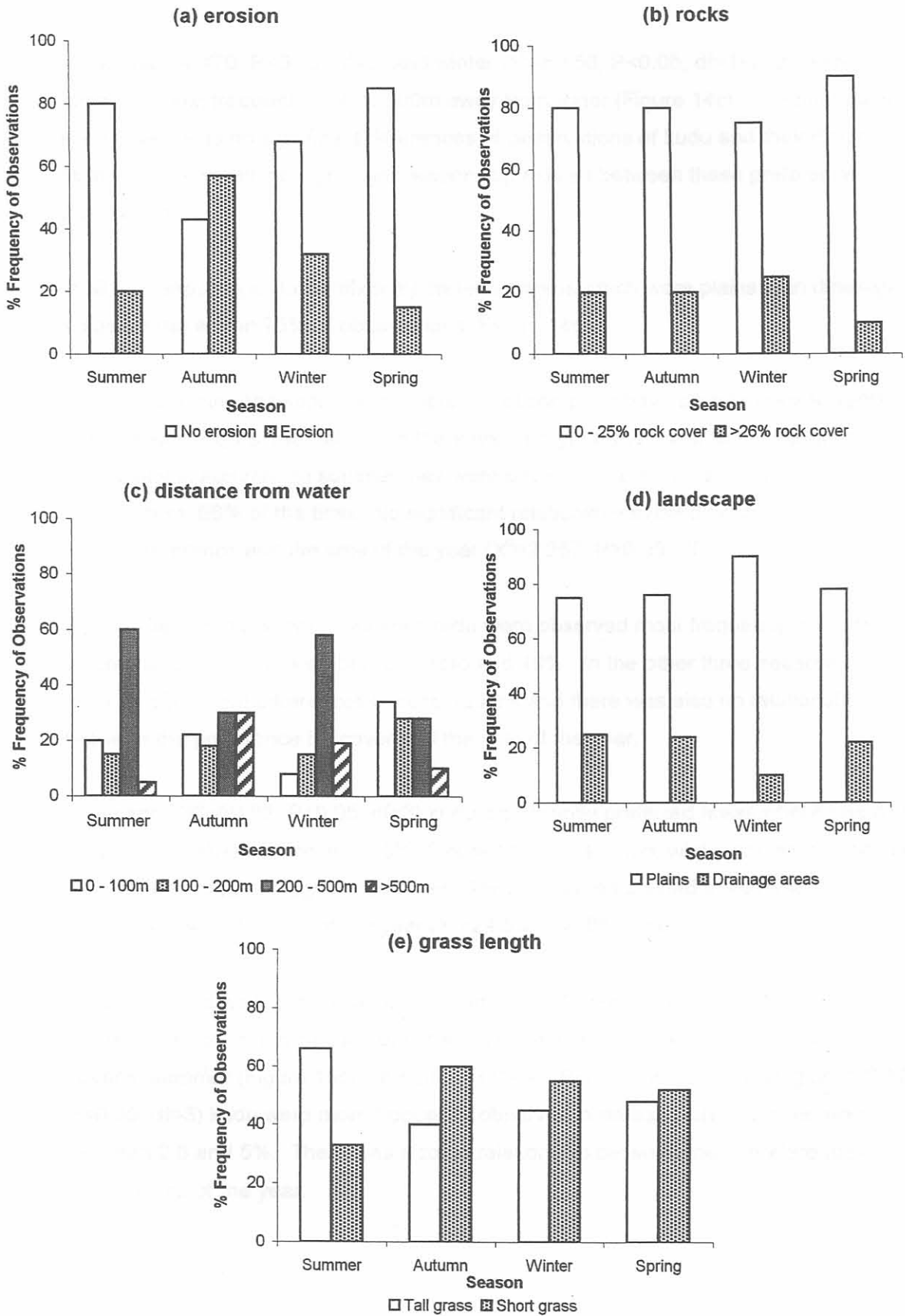
In winter and autumn, observations of giraffe proved a significant preference for a tree cover of greater than 11% ( $\chi^2=84.16$  (winter),  $\chi^2=79.52$  (autumn),  $P<0.05$ ,  $df=3$ ) (Figure 13c). In summer they tended to be in areas where the tree cover was between 6 and 10%, while in spring they were found predominantly in areas where cover was between 2.6 and 10%. A positive significant relationship was seen for preference of cover and the seasons ( $\chi^2=22.029$ ,  $P<0.05$ ,  $df=9$ ).

Giraffe were observed, in each season, to significantly prefer grass cover of greater than 85% (Figure 13d), and there was no relationship between this preference and the time of the year.

#### Kudu

Kudu were observed more frequently in less eroded areas in summer ( $\chi^2=36$ ,  $P<0.05$ ,  $df=1$ ), spring ( $\chi^2=49$ ,  $P<0.05$ ,  $df=1$ ) and winter (Figure 14a). Kudu were seen more frequently in highly eroded areas in autumn for 57% of the observations. The behaviour of kudu with respect to erosion is significantly linked to the time of the year ( $\chi^2=10.21$ ,  $P<0.05$ ,  $df=3$ ).

Figure 14b illustrates that kudu were observed more frequently in less rocky areas for all four seasons: Summer 80%, Autumn 80%, Winter 75% and Spring 90%. The relationship, therefore, between season and habitat selection is not significant ( $\chi^2=1.975$ ,  $P>0.05$ ,  $df=3$ ).



**Figure 14.** Seasonal frequency distribution of kudu in relation to (a) erosion, (b) rocks, (c) water, (d) landscape, (e) grass length



In summer ( $\chi^2=70$ ,  $P<0.05$ ,  $df=3$ ) and winter ( $\chi^2=60.56$ ,  $P<0.05$ ,  $df=1$ ) kudu were observed most frequently 200 to 500m away from water (Figure 14c). In autumn and spring there was no significant differences of observations of kudu and their distances from water. Overall, no significant relationship existed between these preferences and the seasons.

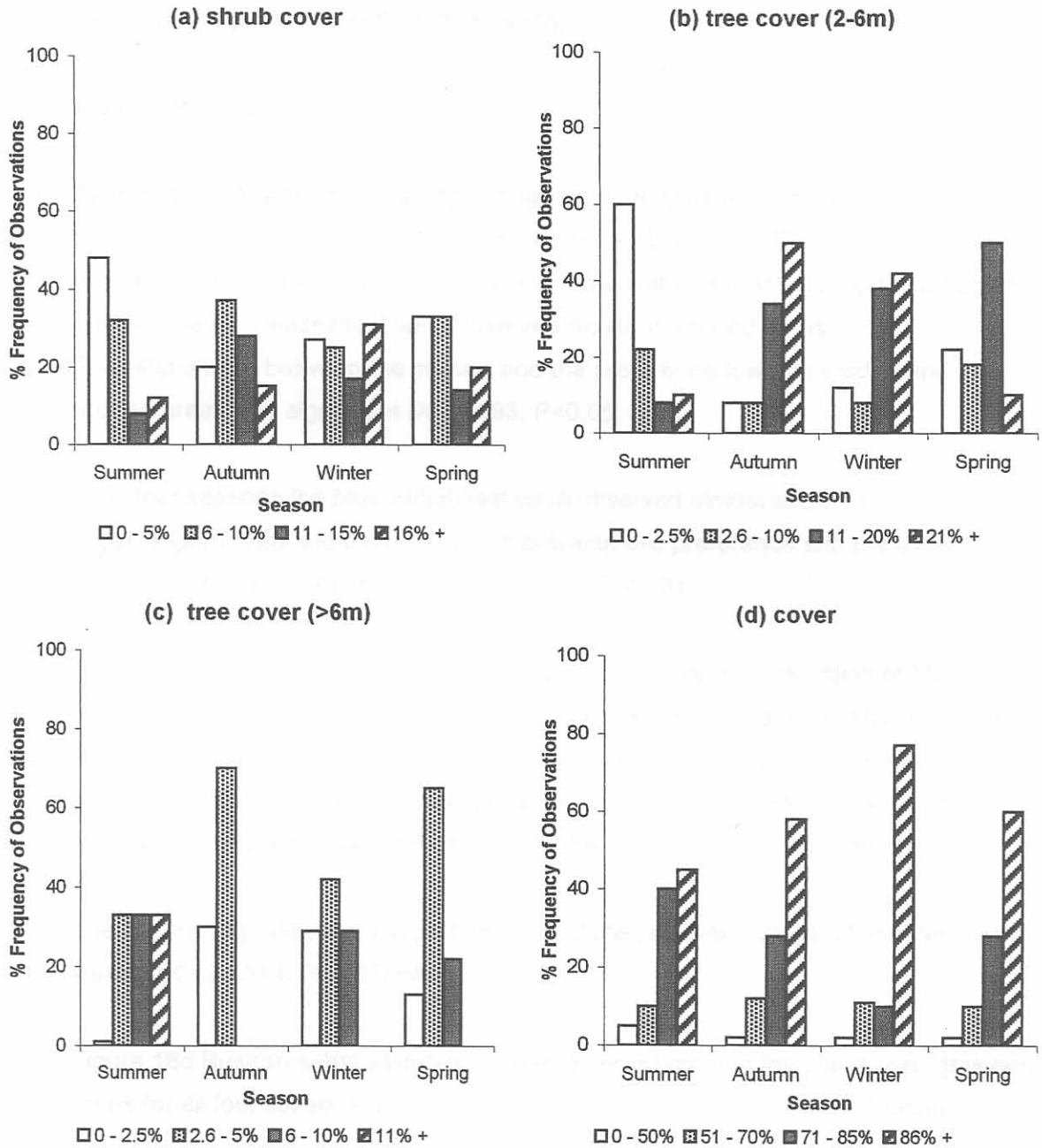
In all four seasons kudu significantly preferred areas which were plains than drainage areas for more than 75% of observations (Figure 14d).

In autumn, winter and spring, kudu were not observed to have a preference towards grass length (Figure 14e), although there was a slight trend towards shorter grass, particularly in autumn. In summer they were observed more frequently in areas with longer grass, 66% of the time. No significant relationship existed between the grass length preference and the time of the year ( $\chi^2=2.257$ ,  $P>0.05$ ,  $df=3$ ).

Figure 15a illustrates that in summer kudu were observed most frequently in areas where the shrub cover was between zero and 10%. In the other three seasons there were no significant differences in observations and there was also no relationship between the preference for cover and the time of the year.

In summer ( $\chi^2=69.92$ ,  $P<0.05$ ,  $df=3$ ) kudu significantly preferred areas where tree cover (2-6m) was between zero and 2.5% (Figure 15b). In autumn, winter and spring the trend was towards areas of higher tree cover. These preferences had a significant relationship with the time of the year ( $\chi^2=24.85$ ,  $P<0.05$ ,  $df=9$ ).

In summer and winter, there were no significant differences in observations of kudu in areas of tree cover (>6m), although there were almost no observations for zero to 2.5% cover in summer (Figure 15c). In autumn ( $\chi^2=82$ ,  $P<0.05$ ,  $df=3$ ) and spring ( $\chi^2=70.12$ ,  $P<0.05$ ,  $df=3$ ) kudu were more frequently observed in areas where the cover was between 2.6 and 5%. There was also no relationship between these preferences and the seasons of the year.



**Figure 15.** Seasonal frequency distribution of kudu in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

In all four seasons, kudu were observed most frequently in areas where grass cover is greater than 85% (Figure 15d). In summer they were also observed frequently where grass cover was between 71 and 85%. The time of the year did not significantly affect the preferences ( $\chi^2=14.865$ ,  $P>0.05$ ,  $df=9$ ).

#### Blue wildebeest

Blue wildebeest were observed spending significantly more time in less eroded areas in summer ( $\chi^2 = 64$ ,  $P<0.05$ ,  $df=1$ ) and spring ( $\chi^2 = 63.21$ ,  $P<0.05$ ,  $df=1$ ) (Figure 16a). In winter the differences in observations were only slight, with 61% in eroded areas. In autumn the blue wildebeest were observed mostly in eroded areas.

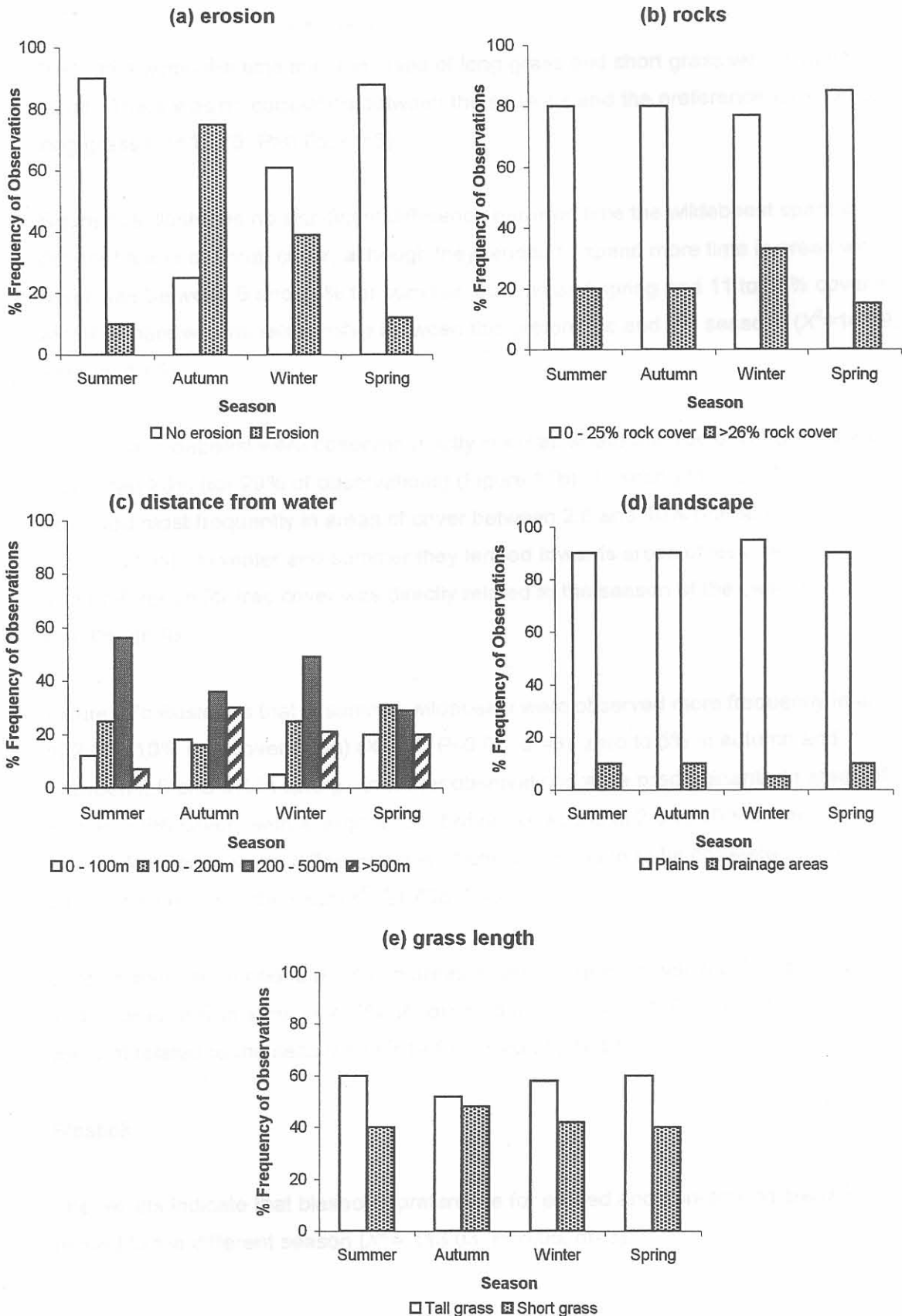
The relationship between the season and the preference towards eroded and non-eroded areas was significant ( $\chi^2=68.93$ ,  $P<0.05$ ,  $df=3$ ).

In all four seasons the blue wildebeest were observed almost exclusively in less rocky areas (Figure 16b) and the relationship between this preference and the different seasons was not significant ( $\chi^2= 3.569$ ,  $P>0.05$ ,  $df=3$ ).

In spring and autumn there was no significant difference in observation of blue wildebeest and the distances they kept to water, although in autumn the trend was further from water (Figure 16c). In summer and winter the wildebeest remained 200 to 500m away from the nearest water point for 56% and 49% of the observed time respectively and this was significant ( $\chi^2=62.84$  (summer),  $\chi^2=39.68$  (spring),  $P<0.05$ ,  $df=3$ ).

The relationship between this preference and the seasons was correlated, although weakly ( $\chi^2=21.514$ ,  $P<0.05$ ,  $df=9$ ).

Figure 16d illustrates that wildebeest were observed more in the plains than drainage areas for all four seasons (for more than 89% of observations in each season).



**Figure 16.** Seasonal frequency distribution of blue wildebeest in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grass length

16e). In autumn the time spent in areas of long grass and short grass were almost equal. There was no correlation between the seasons and the preference for short or long grass ( $X^2=1.275$ ,  $P>0.05$ ,  $df=3$ ).

Figure 17a illustrates no significant difference between time the wildebeest spent in different areas of shrub cover, although they tended to spend more time in areas where cover was between 6 and 10% for summer, autumn and spring and 11 to 15% cover in winter. There was no relationship between this preference and the seasons ( $X^2=14.69$ ,  $P<0.05$ ,  $df=9$ ).

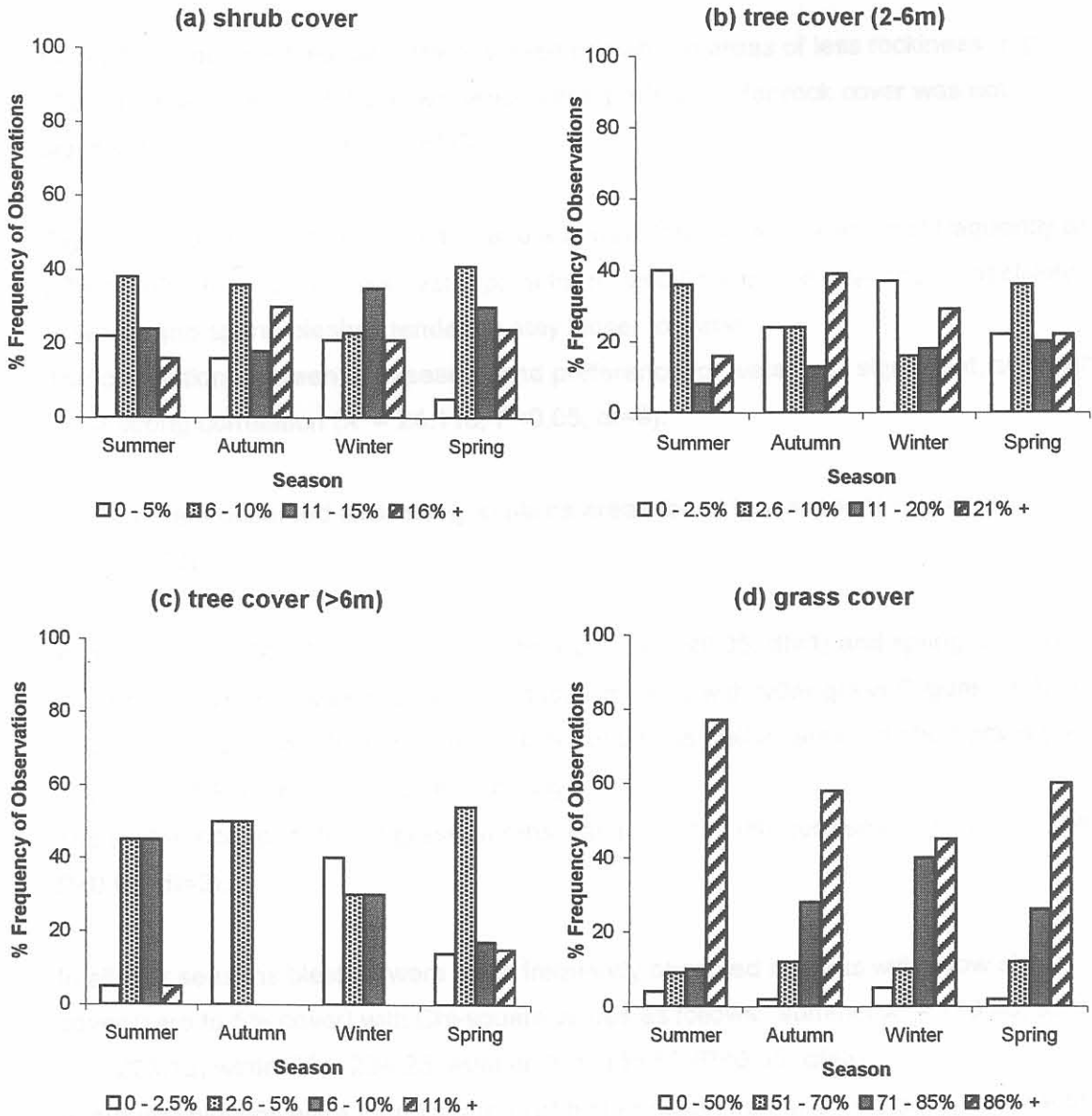
In autumn wildebeest were observed mostly in areas where the tree cover (2-6m) was more than 20% (for 29% of observations) (Figure 17b). In spring the wildebeest were observed most frequently in areas of cover between 2.6 and 10% (for 36% of observations). In winter and summer they tended towards areas of less tree cover. The preference for tree cover was directly related to the season of the year ( $X^2=21.263$ ,  $P<0.05$ ,  $df=9$ ).

Figure 17c illustrates that in summer wildebeest were observed more frequently in areas of 2.6 to 10% tree cover (>6m) ( $X^2=64$ ,  $P<0.05$ ,  $df=3$ ), zero to 5% in autumn and between 2.6 and 5% in spring. In winter observations were predominantly in areas of zero to 2.5% cover, with a large amount of observations at 2.6 to 10% cover. The preference towards different areas of cover was found to be correlated to the different seasons of the year ( $X^2=21.438$ ,  $P<0.05$ ,  $df=9$ ).

Blue wildebeest tended to remain in areas where the grass cover was higher (Figure 17d), particularly in summer (76% of observations,  $X^2=145.04$ ,  $P<0.05$ ,  $df=3$ ) and this was not related to the seasons ( $X^2=12.979$ ,  $P>0.05$ ,  $df=9$ ).

#### Blesbok

The results indicate that blesbok's preference for eroded and non-eroded areas is related to the different season ( $X^2 = 113.03$ ,  $P<0.05$ ,  $df=3$ ).



**Figure 17.** Season frequency distribution of blue wildebeest in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

In the warmer seasons blesbok were observed exclusively in areas of less erosion (Summer:  $X^2 = 96.04$ ; Spring:  $X^2 = 96.04$ ,  $P < 0.05$ ,  $df=1$ ), while in autumn and winter they were observed more frequently in eroded areas (Figure 18a).

For all four seasons blesbok were observed primarily in areas of less rockiness (Figure 18b) and the relationship between season and preference for rock cover was not significant ( $X^2 = 5.353$ ,  $P > 0.05$ ,  $df=3$ ).

Figure 18c illustrates that in summer and autumn blesbok were seen most frequently at 200 to 500m from the nearest water point for 52 and 61% of observations respectively. In winter and spring blesbok tended to stay closer to water.

The correlation between the seasons and preference for water was significant, although not a strong correlation ( $X^2 = 24.116$ ,  $P < 0.05$ ,  $df=9$ ).

Blesbok were observed exclusively in plains areas for all four seasons of the year (Figure 18d).

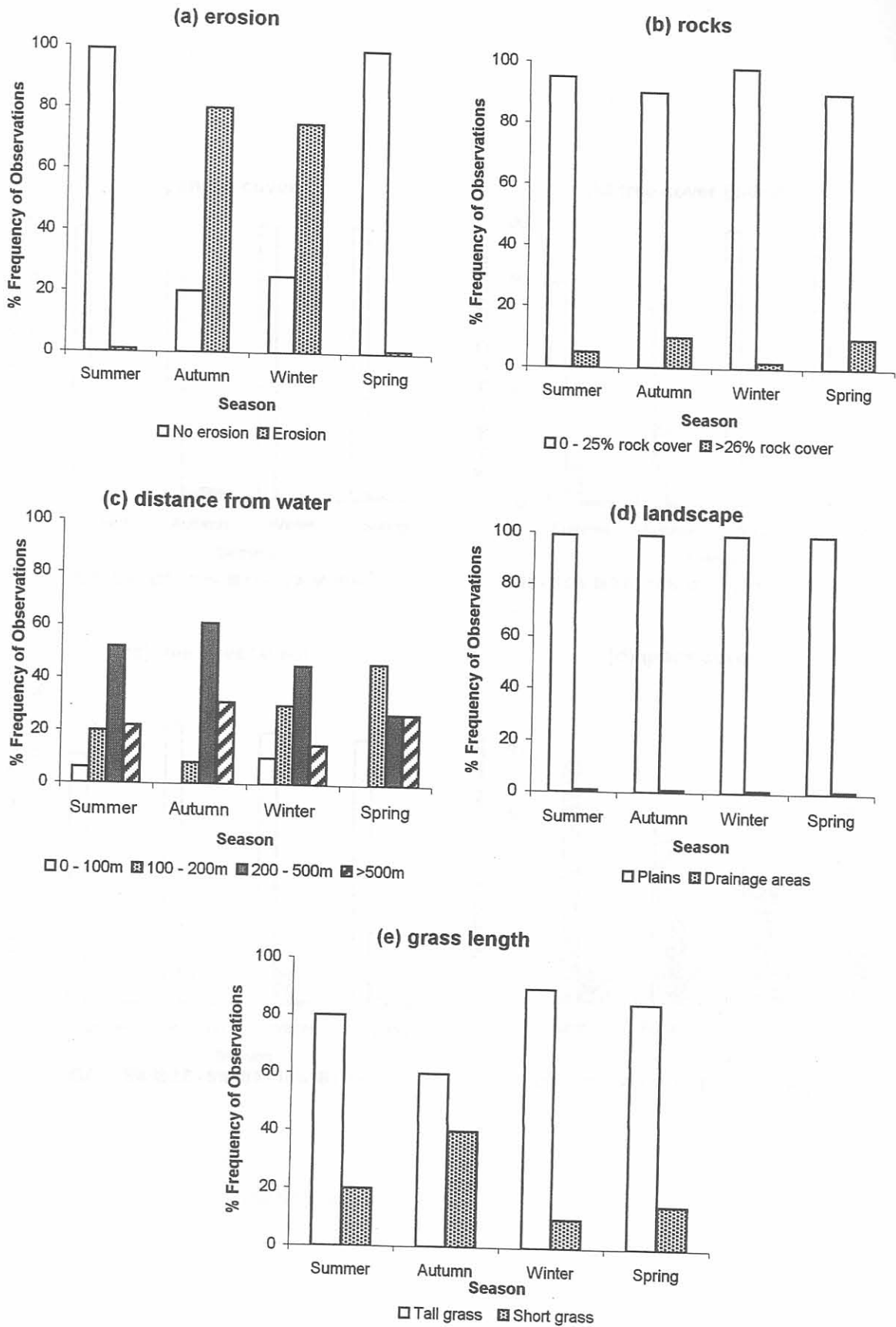
In summer ( $X^2 = 36$ ,  $P < 0.05$ ,  $df=1$ ), winter ( $X^2 = 64$ ,  $P < 0.05$ ,  $df=1$ ) and spring ( $X^2 = 49$ ,  $P < 0.05$ ,  $df=1$ ) blesbok were observed mostly in areas with taller grass (Figure 18e). In autumn blesbok spent time in areas of taller grass, as well as areas of short grass (for 62% and 38% of observations respectively).

The preference for differing grass lengths was related to different seasons ( $X^2 = 12.526$ ,  $P < 0.05$ ,  $df=3$ ).

In all four seasons blesbok were more frequently observed in areas with a low shrub cover (zero to 5% cover) with Chi-square values as follows: summer  $X^2 = 170.46$ , spring  $X^2 = 223.12$ , winter  $X^2 = 284.25$ , autumn  $X^2 = 118.88$  ( $P < 0.05$ ,  $df=3$ ).

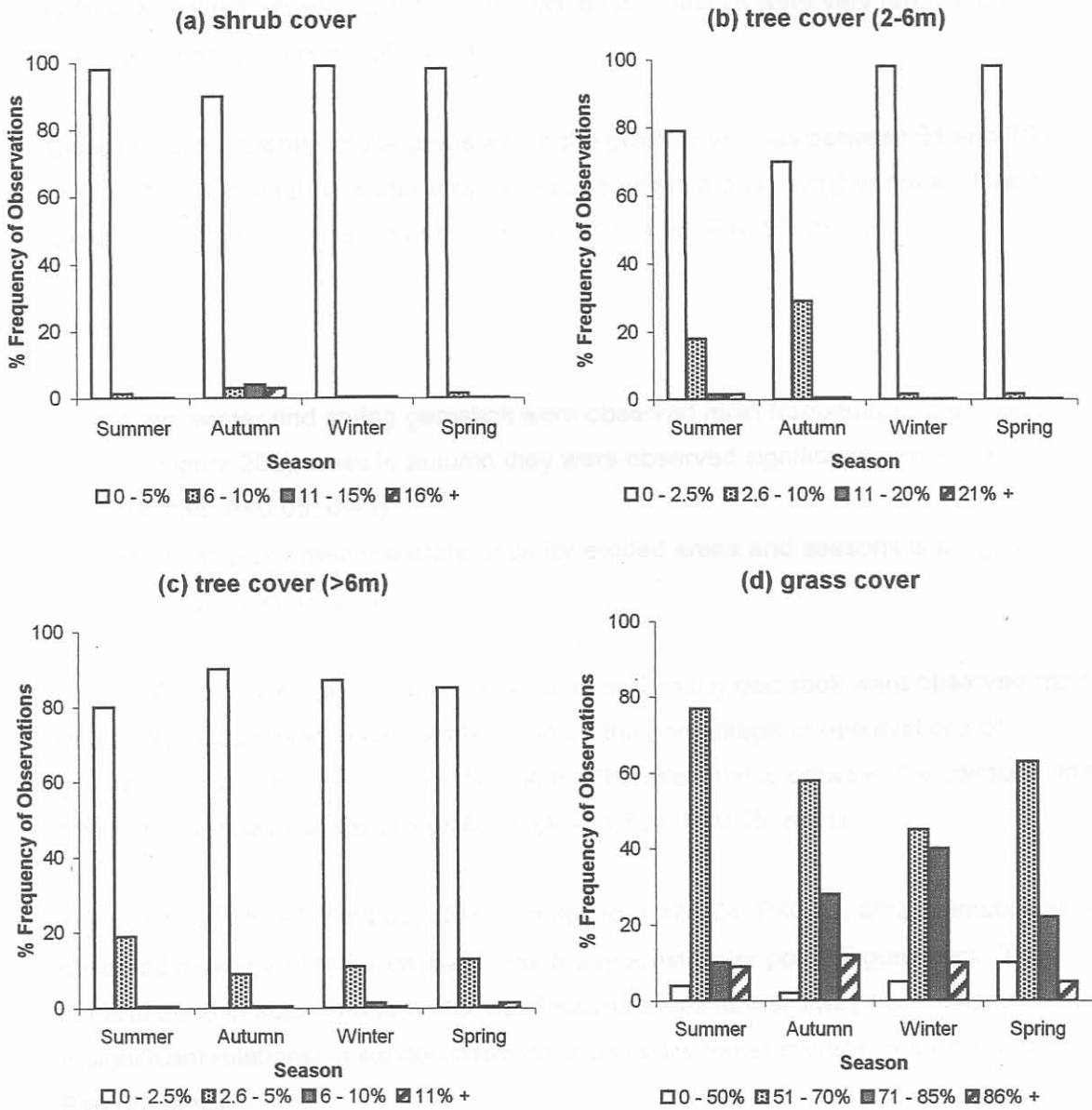
In autumn blesbok were found in areas of higher cover, but for a very small percent of observations (Figure 19a).

Figure 19b illustrates that in winter and spring blesbok were observed more frequently in areas of low tree cover (2-6m), between zero and 2.5% cover.



**Figure 18.** Seasonal distribution of blesbok in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grass length





**Figure 19.** Seasonal frequency distribution of blesbok in relation to (a) shrub cover, (b) tree cover (2 - 6m), (c) tree cover (>6m) and (d) grass cover

2.6 and 10%, but still primarily in areas of lower cover.

In all four seasons blesbok were observed in areas (>6m), with a cover of zero to 5%, with all  $\chi^2$  values exceeding 170 for  $P<0.05$ ,  $df=3$ . Blesbok were very rarely found in areas exceeding 5% cover (Figure 19c).

Blesbok predominantly chose areas where the grass cover was between 51 and 70% (Figure 19d), although in winter they were observed in areas of higher cover. Grass cover preference was not related to season ( $\chi^2 = 4.56$ ,  $P>0.05$ ,  $df=6$ ).

### Gemsbok

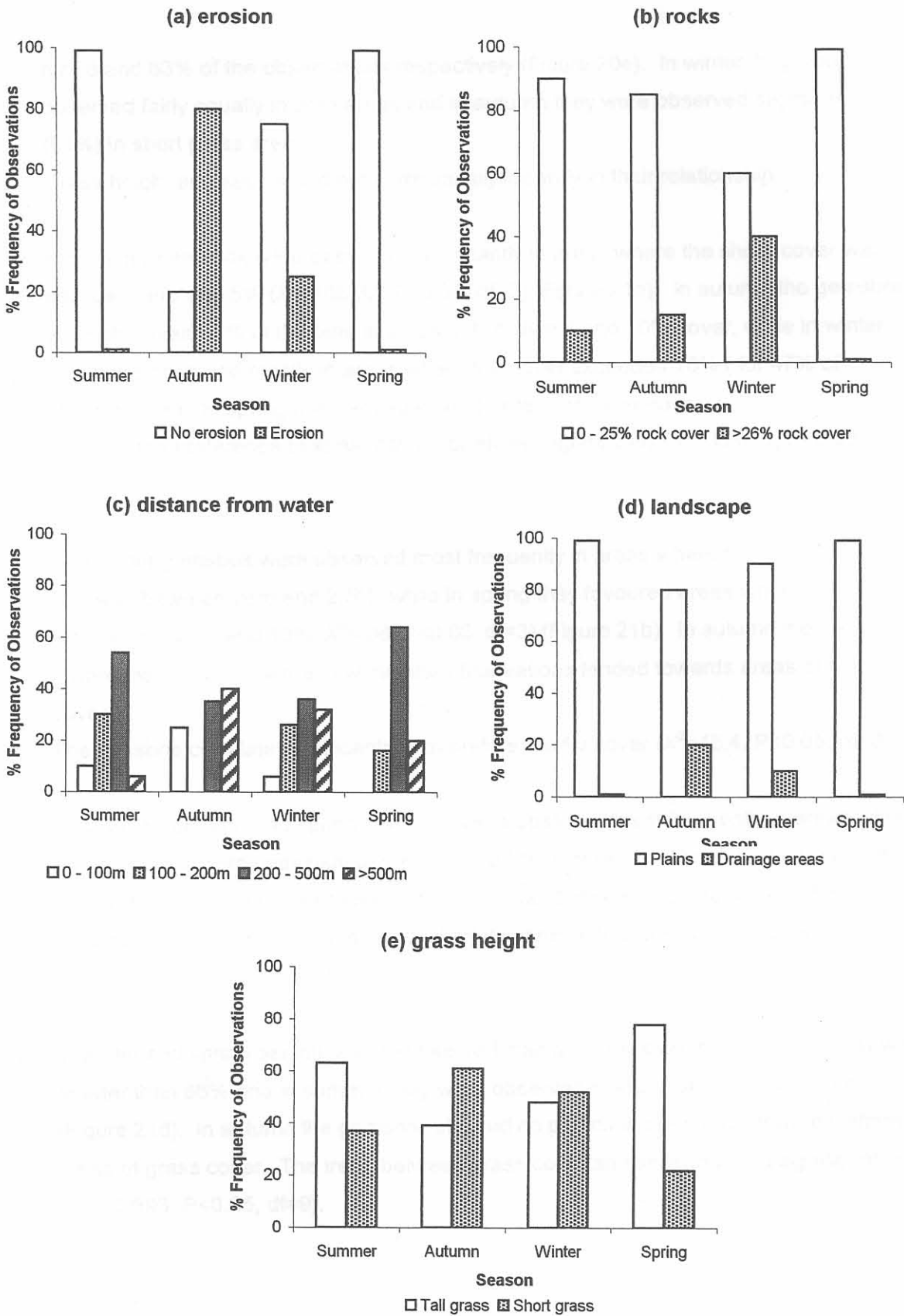
In summer, winter and spring gemsbok were observed most frequently in areas of little erosion (Figure 20a), while in autumn they were observed significantly more in eroded areas ( $\chi^2=36$ ,  $P<0.05$ ,  $df=1$ )

The relationship between the preference for eroded areas and seasons is a significant one ( $\chi^2=42.34$ ,  $P<0.005$ ,  $df=3$ ).

Figure 20b illustrates that in summer, autumn and spring gemsbok were observed more frequently in less rocky areas, while in winter, the percentage of observations of gemsbok in rocky areas was slightly higher. The relationship between the seasons and preference for rocky areas is significant ( $\chi^2=11.801$ ,  $P<0.05$ ,  $df=1$ ).

In summer ( $\chi^2=58.08$ ,  $P<0.05$ ,  $df=3$ ) and spring ( $\chi^2=65.04$ ,  $P<0.05$ ,  $df=3$ ) gemsbok were observed mostly 200 to 500m away from the nearest water point (Figure 20c). The general trend in autumn and winter was towards areas further away from water. A significant relationship existed between season and water preferences ( $\chi^2=18.9$ ,  $P<0.05$ ,  $df=3$ ).

Figure 20d illustrates that in all four seasons gemsbok preferred plains areas to drainage areas. The relationship between the seasons and landscape type was not a significant one.



**Figure 20.** Seasonal distribution of gemsbok in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grass length

for 78 and 63% of the observations respectively (Figure 20e). In winter they were observed fairly equally in both areas and in autumn they were observed slightly more (61%) in short grass areas.

Grass height and season did not correlate significantly in their relationship.

In summer gemsbok were observed significantly in areas where the shrub cover was between zero and 5% ( $X^2=108.32$ ,  $P<0.05$ ,  $df=3$ ) (Figure 21a). In autumn the gemsbok were observed 57% of the time in areas of between 6 and 10% cover, while in winter they were observed mostly in areas where the cover exceeded 16% (for 47% of observations). In spring they tended towards areas of lower cover.

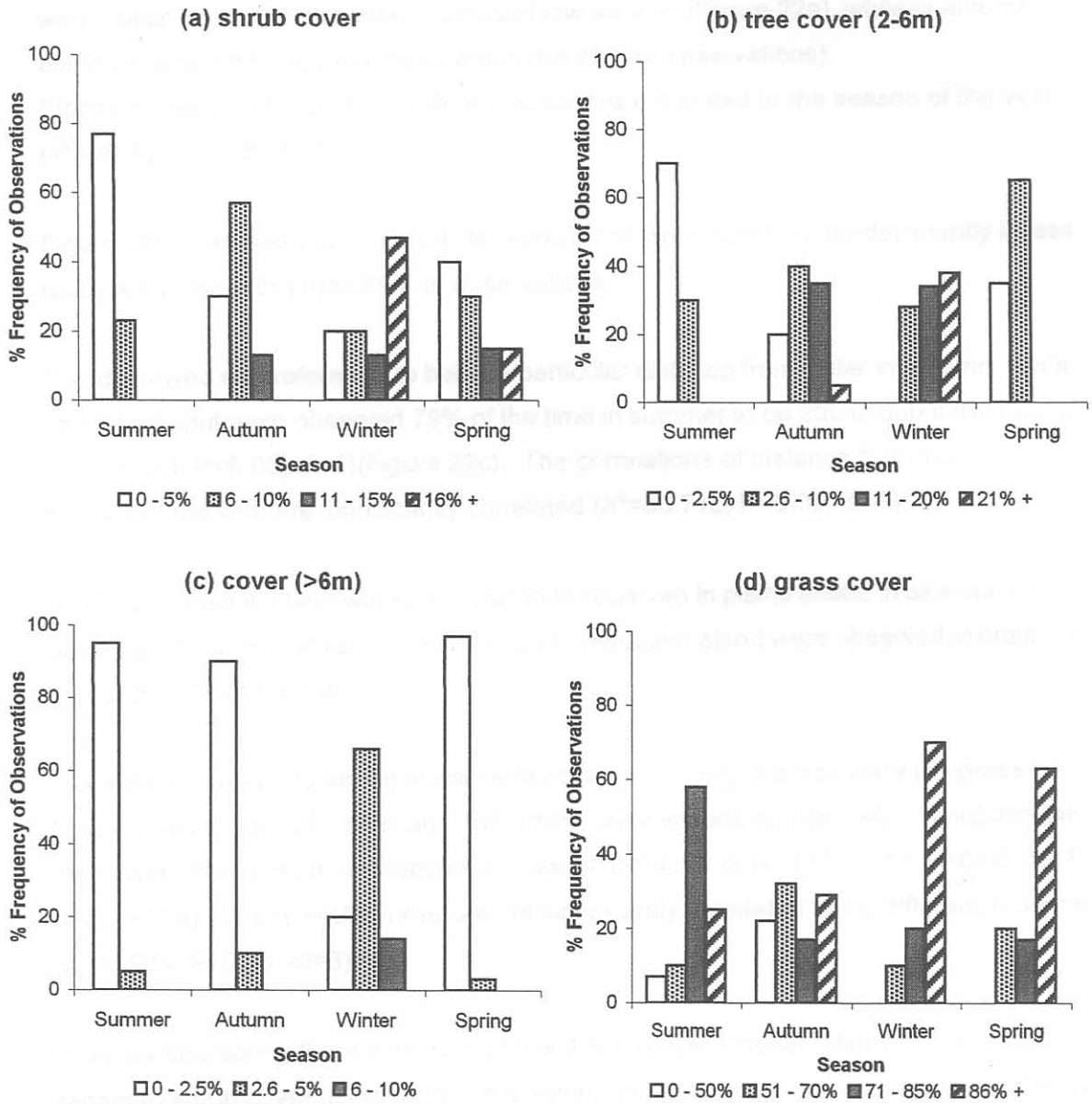
Season and preference to shrub cover correlated significantly ( $X^2=36.671$ ,  $P<0.05$ ,  $df=9$ ).

In summer gemsbok were observed most frequently in areas where the tree cover (2-6m) was between zero and 2.5%, while in spring they favoured areas where the cover was between 2.6 and 10% ( $X^2=68$ ,  $P<0.05$ ,  $df=3$ ) (Figure 21b). In autumn the trend was towards lower cover, while in winter the observations tended towards areas of higher cover.

The seasons correlate significantly with preference for cover ( $X^2=45.4$ ,  $P<0.05$ ,  $df=3$ ).

In summer, autumn and spring gemsbok were observed most frequently in areas where the tree cover (>6m) was between zero and 2.5% (Figure 21c). In winter they were most frequently observed in areas where the cover was between 2.6 and 5% (for 66% of observations). There was no significant relationship between season and preference for cover.

In winter and spring gemsbok were observed mainly in areas where the grass cover was greater than 86% and in summer they were observed in areas of 71 to 85% cover (Figure 21d). In autumn the gemsbok showed no particular preference towards different areas of grass cover. The trend between grass cover and season was a significant one ( $X^2=23.693$ ,  $P<0.05$ ,  $df=9$ ).



**Figure 21.** Seasonal frequency distribution of gemsbok in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover

## Eland

In summer ( $\chi^2=86.67$ ,  $P<0.05$ ,  $df=1$ ), spring ( $\chi^2=84.01$ ,  $P<0.05$ ,  $df=1$ ) and winter eland were observed most frequently in areas of low erosion (Figure 22a), while in autumn eland were found mostly in eroded areas (for 72% of observations).

Elands preference for areas of different erosion is correlated to the season of the year ( $\chi^2=39.33$ ,  $P<0.05$ ,  $df=3$ ).

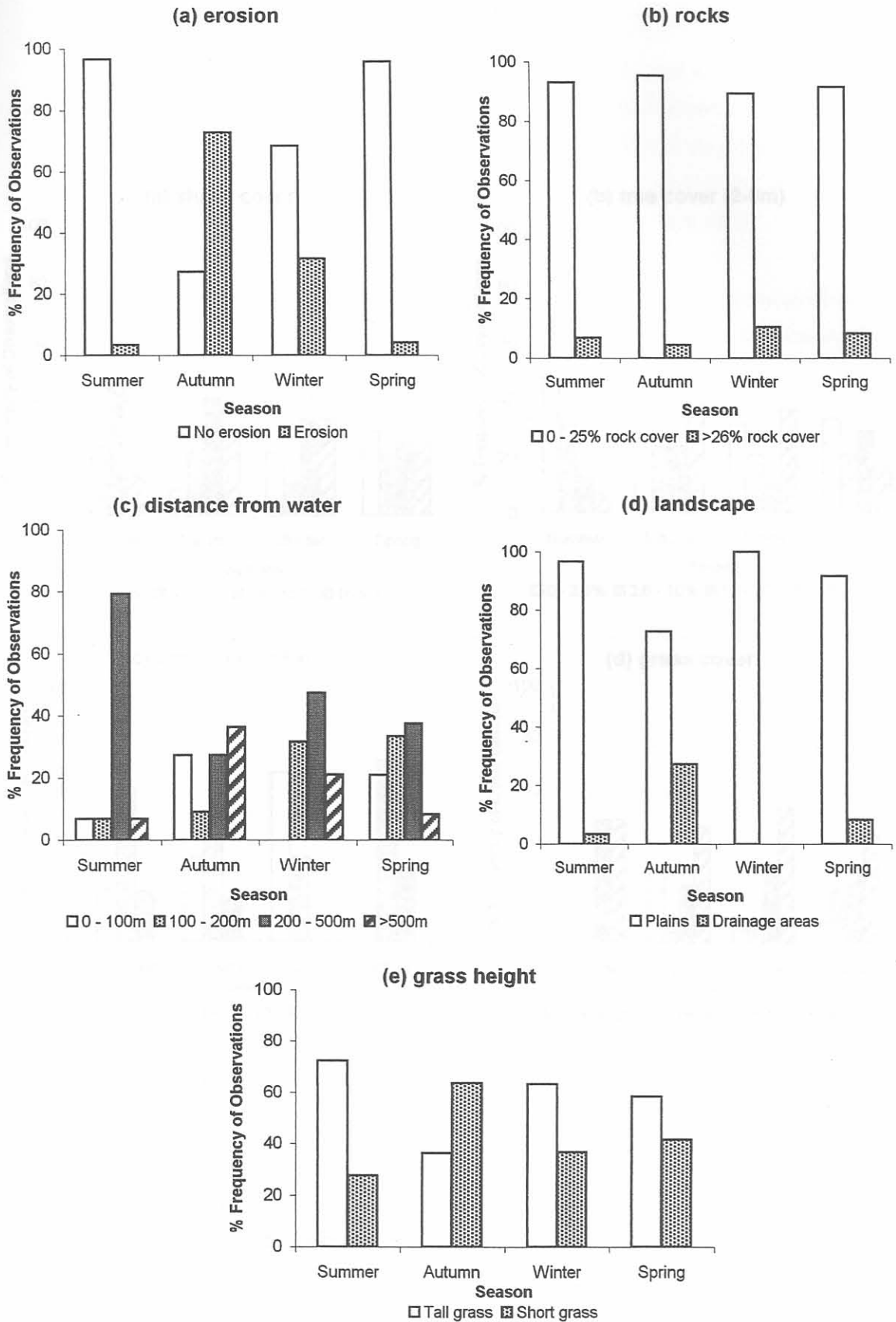
Figure 22b illustrates that in all four seasons eland were observed predominantly in less rocky areas, for more than 89% of observations.

Eland showed no preference to being a particular distance from water in autumn, winter and spring, but were observed 79% of the time in summer to be 200 to 500m from water ( $\chi^2=157.28$ ,  $P<0.05$ ,  $df=3$ )(Figure 22c). The correlations of distance from water and season of the year are significantly correlated ( $\chi^2=30.712$ ,  $P<0.05$ ,  $df=9$ ).

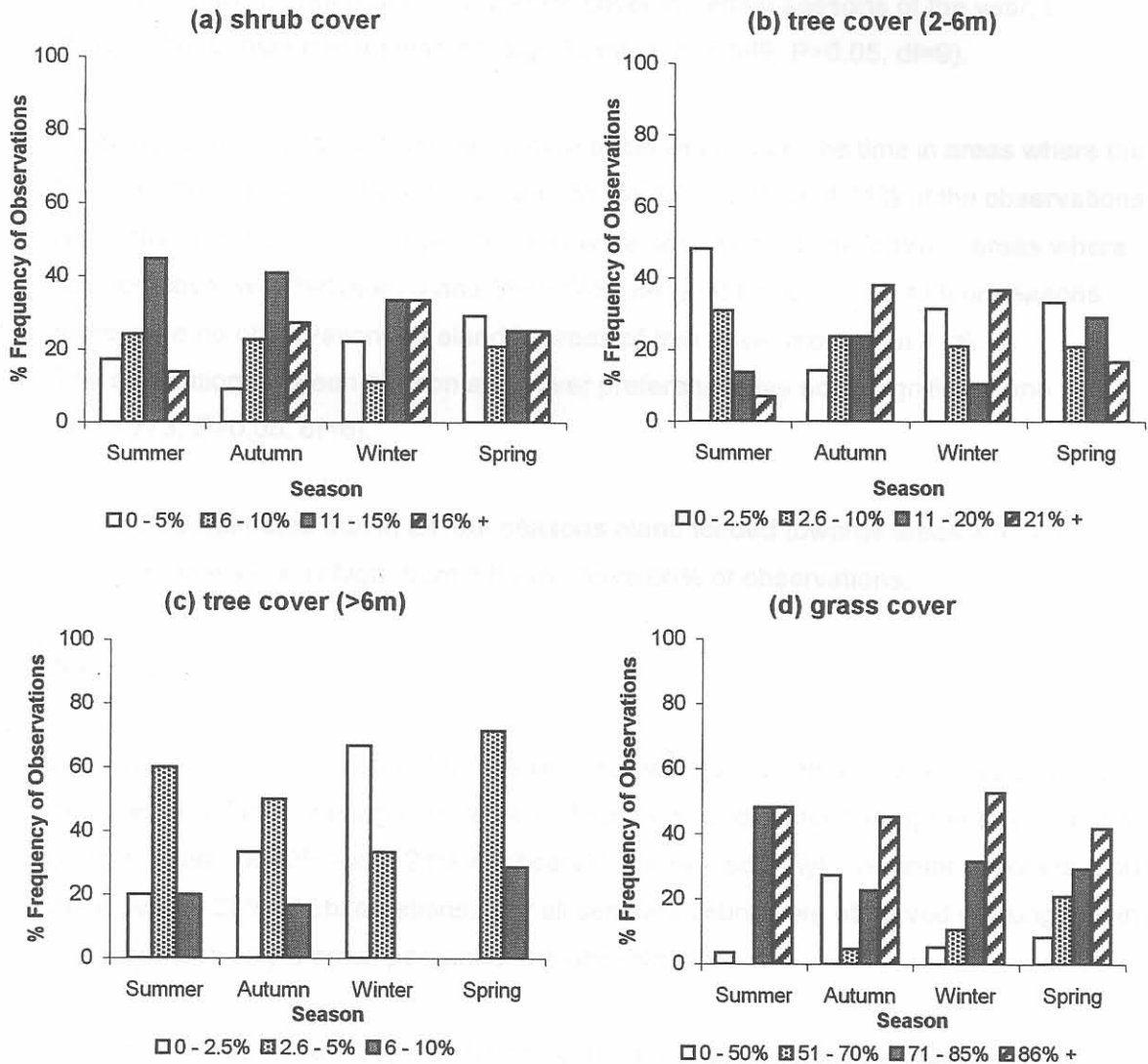
In all four seasons eland were predominantly observed in plains areas, in all seasons the observations were above 70% (Figure 22d). In autumn eland were observed in drainage areas for 27% of the time.

In summer, winter and spring eland were observed mostly in areas where the grass height was tall, for 72%, 63% and 58% of the observations respectively. In autumn the eland were observed more frequently in areas of shorter grass ( $\chi^2=7.441$ ,  $P<0.05$ ,  $df=1$ ) (Figure 22e). These preferences are not significantly correlated to the different seasons ( $\chi^2=6.924$ ,  $P>0.05$ ,  $df=3$ ).

In winter and spring there was no significant difference of observations of eland with regard to shrub cover (Figure 23a). In summer and autumn eland were observed slightly more in areas where the shrub cover was between 6 and 10% (for 44% and 40% of observations respectively). There was no significant correlation between the preferences for shrub cover and the seasons of the year ( $\chi^2=7.183$ ,  $P>0.05$ ,  $df=9$ ).



**Figure 22.** Seasonal frequency distribution of erland in relation to (a) erosion, (b) rocks, (c) water, (d) landscape and (e) grass height



**Figure 23.** Seasonal frequency distribution of eland in relation to (a) shrub cover, (b) tree cover (2-6m), (c) tree cover (>6m) and (d) grass cover



Figure 23b illustrates that in summer eland tended towards areas where the tree cover (2-6m) was lower (between zero and 10%). In autumn eland preferred areas of slightly higher tree cover, while in winter they preferred either very low or very high cover. Despite the slight preferences for specific cover in certain seasons of the year, the relationship between them was not significant ( $\chi^2=15.089$ ,  $P>0.05$ ,  $df=9$ ).

In spring, autumn and summer eland were observed most of the time in areas where the tree cover (>6m) was between 2.6% and 5% for 60%, 50% and 71% of the observations respectively (Figure 23c). In winter eland were observed mainly (66%) in areas where the tree cover was between 0 and 5% ( $\chi^2=55.84$ ,  $P<0.05$ ,  $df=3$ ). In all four seasons there were no observations of eland in areas of tree cover more than 11%.

The correlation between season and cover preference was not a significant one ( $\chi^2=5.773$ ,  $P>0.05$ ,  $df=6$ ).

Figure 23d illustrates that in all four seasons eland tended towards areas where the grass cover was fairly high, from 51% to above 86% of observations.

### Activities

Zebra were observed grazing for 92% of observations in summer, 52% in autumn, 46% in winter and 74% in spring (Figure 24a). In autumn and winter they spent a fair amount of time resting (for 25% and 21% of observations respectively). In winter zebra were on the move for 25% of observations. For all seasons zebra were observed drinking and in flight, but with only a small percent of the observations.

Impala were observed mostly whilst grazing or browsing, the highest number of observations being in summer (74% of observations) and decreasing in frequency from spring to winter to autumn (Figure 24b). Impala were observed both resting and in flight for all the seasons of the year, but were only observed mating and mock fighting in autumn, when they did most of their movement as well.

In all four seasons giraffe were either grazing or browsing when observed, with all observations exceeding 75% (Figure 25a). Giraffe were observed mock fighting in both autumn and spring and were in flight more in those months as well.

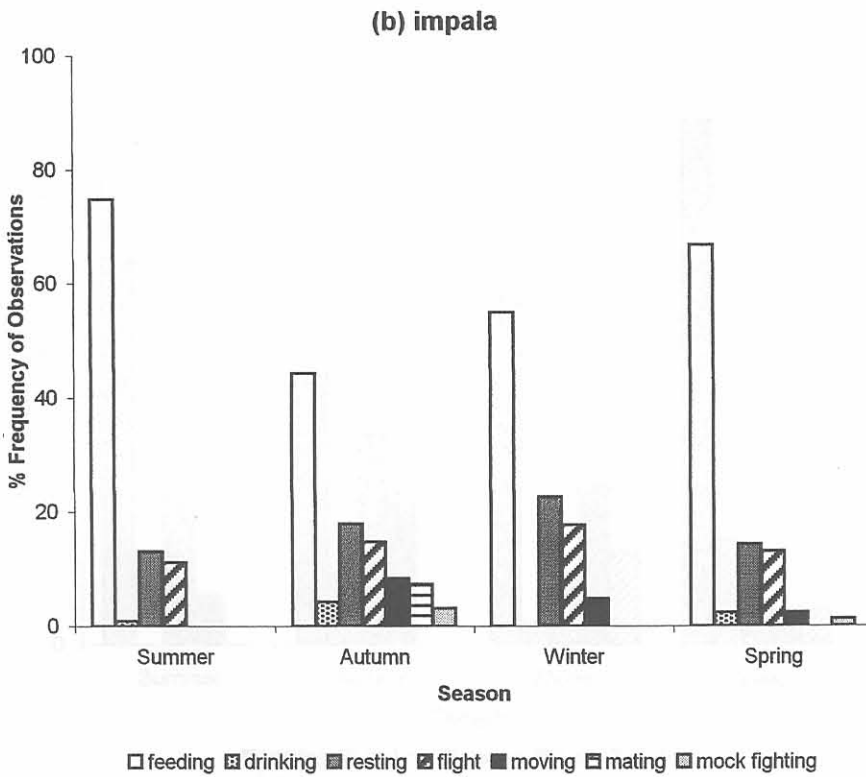
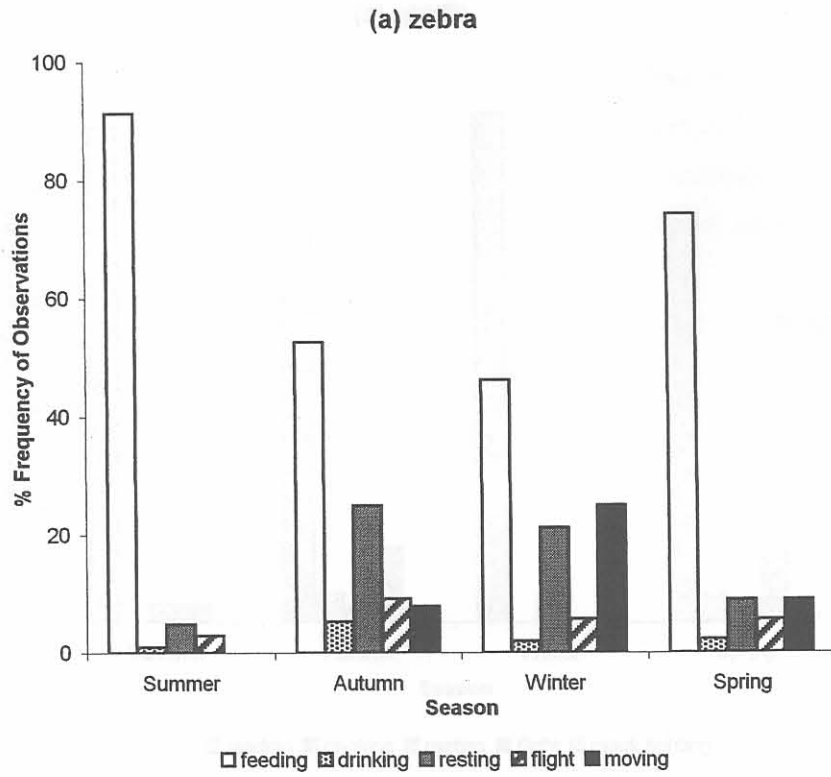


Figure 24. Seasonal frequency distribution of (a) zebra and (b) impala, showing activity

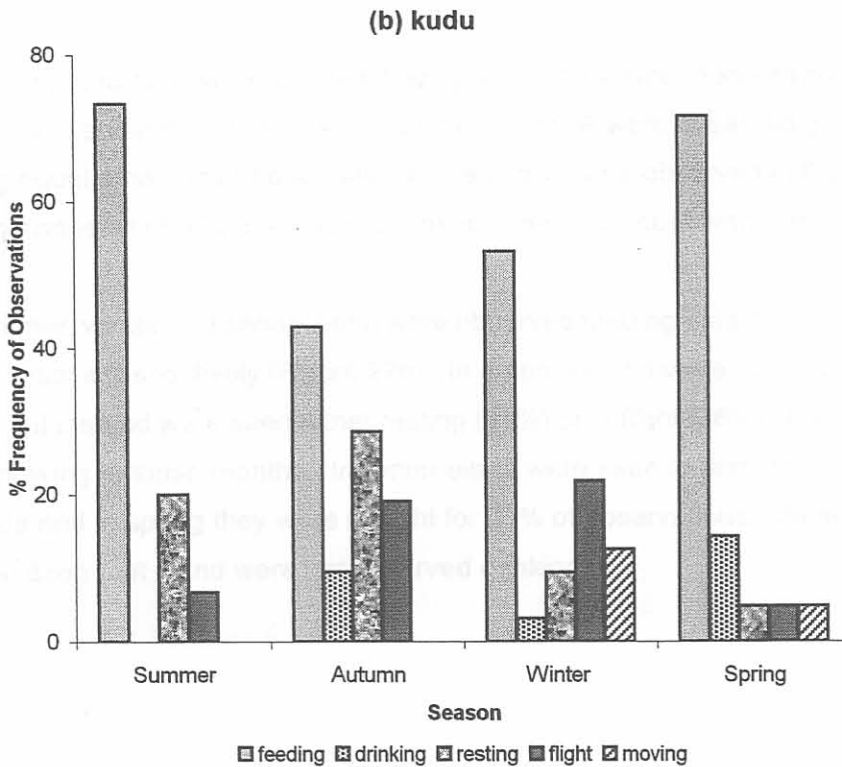
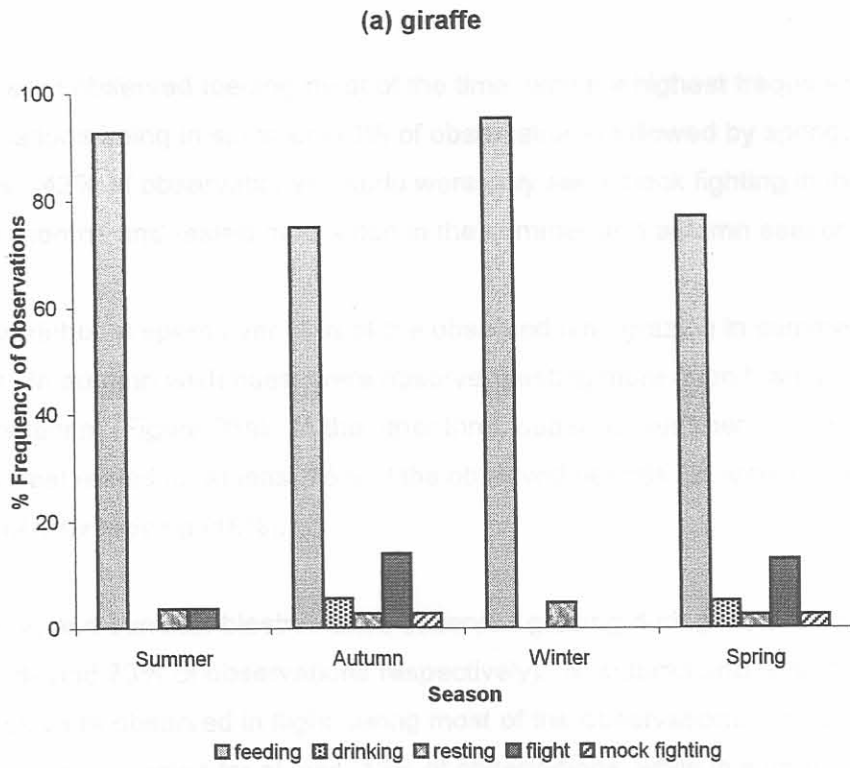


Figure 25. Seasonal frequency distribution of (a) giraffe and (b) kudu, showing activity

Kudu were observed feeding most of the time, with the highest frequency of observations being in summer (73% of observations) followed by spring, winter and autumn (42% of observations). Kudu were only seen mock fighting in the spring and winter months and rested most often in the summer and autumn seasons (Figure 25b).

Blue wildebeest spent over 60% of the observed time grazing in summer, spring and winter. In autumn wildebeest were observed resting more often than grazing (for 53% of observations) (Figure 26a). In the other three seasons, summer, winter and spring, blue wildebeest rested for at least 16% of the observed periods. In winter blue wildebeest did most of their moving (18%).

In spring and summer blesbok were observed grazing during most of the observations (for 93% and 73% of observations respectively). In autumn and winter, however, blesbok were observed in flight during most of the observations. In autumn, winter and spring blesbok rested for at least 13% of observations, while in summer they did not rest much (Figure 26b).

In summer gemsbok were spotted grazing 77% of the time, decreasing to 57% in spring and 38% in autumn (Figure 27a). In winter gemsbok were observed grazing and resting during equal amounts of observations. Gemsbok were observed in flight mostly in spring and least of all in summer. Gemsbok were only observed drinking in autumn.

In summer, winter and spring eland were observed feeding during 79%, 68% and 54% of observations respectively (Figure 27b). In autumn eland were very rarely seen grazing (9%), but instead were seen either resting (31%) or in flight (36%). They also did most of their moving in these months. In winter eland were seen to rest for quite considerable periods and in spring they were in flight for 29% of observations. Winter was also the only season that eland were not observed drinking.

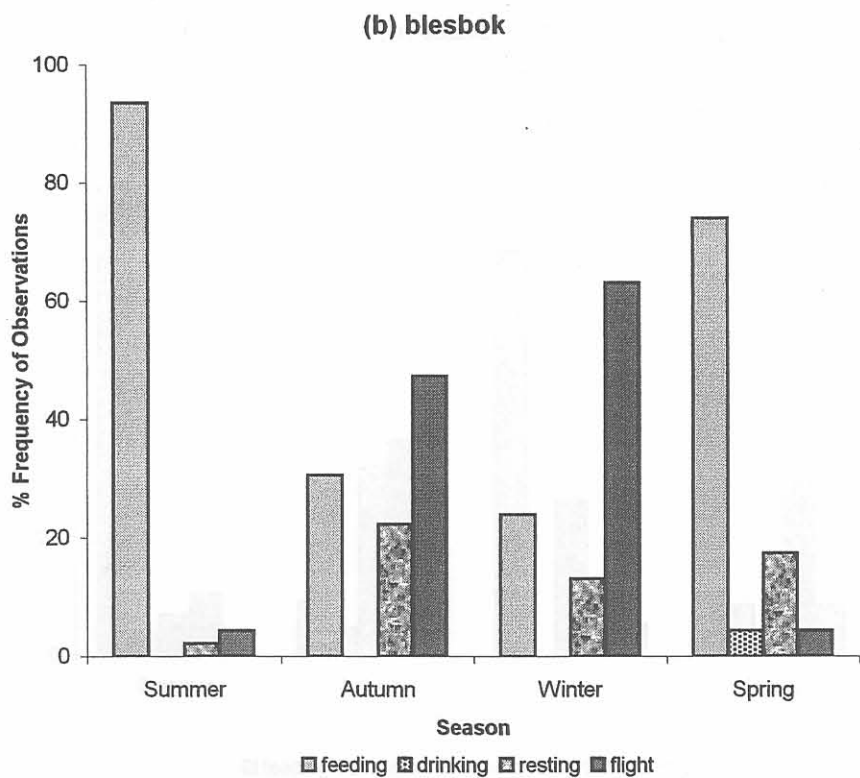
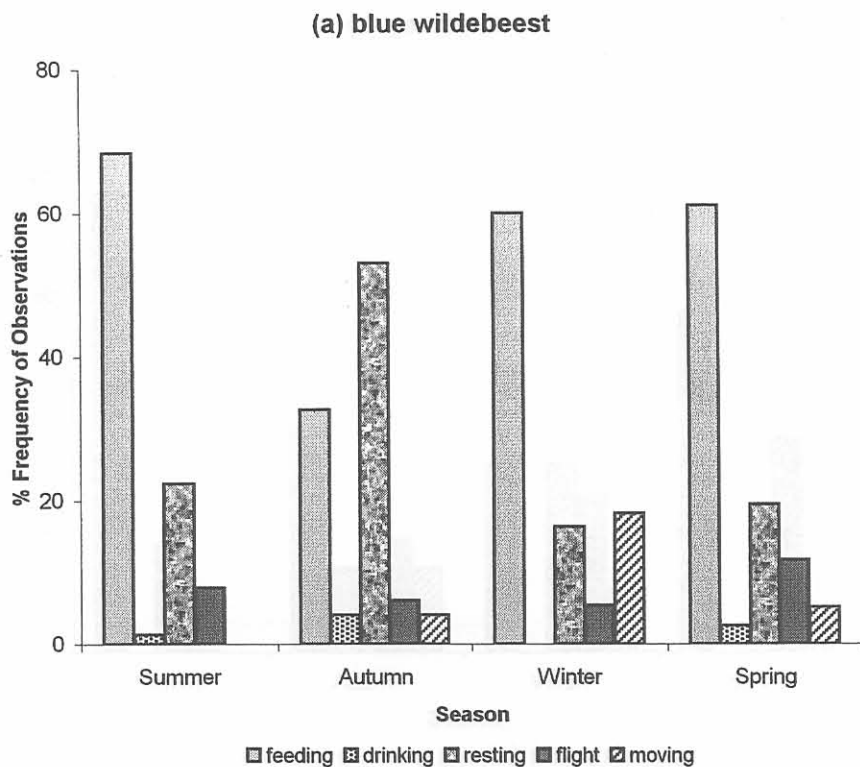


Figure 26. Seasonal frequency distribution of (a) blue wildebeest and (b) blesbok, showing activity

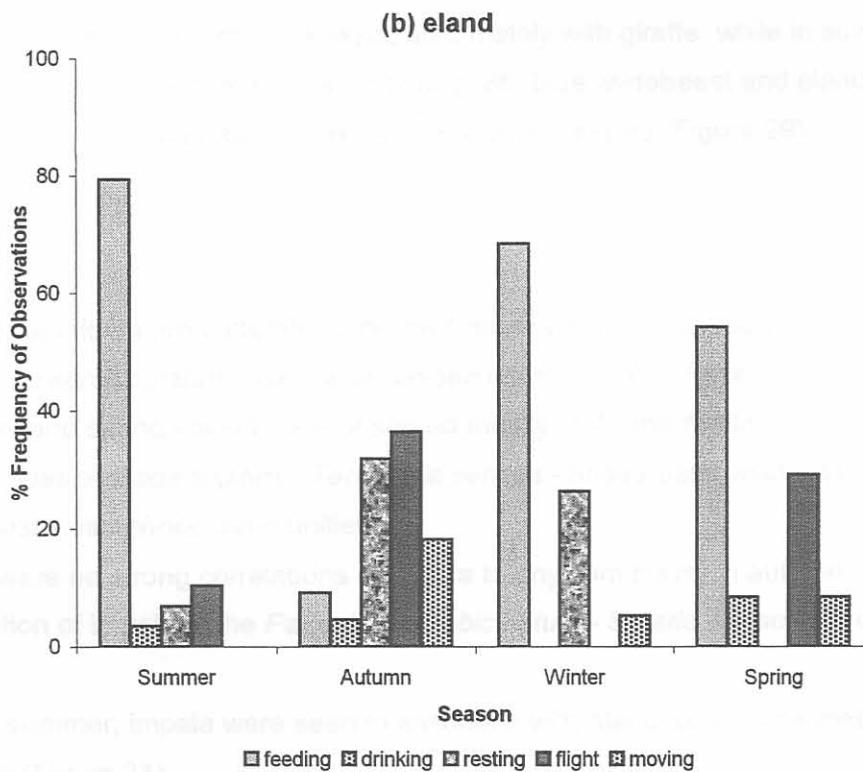
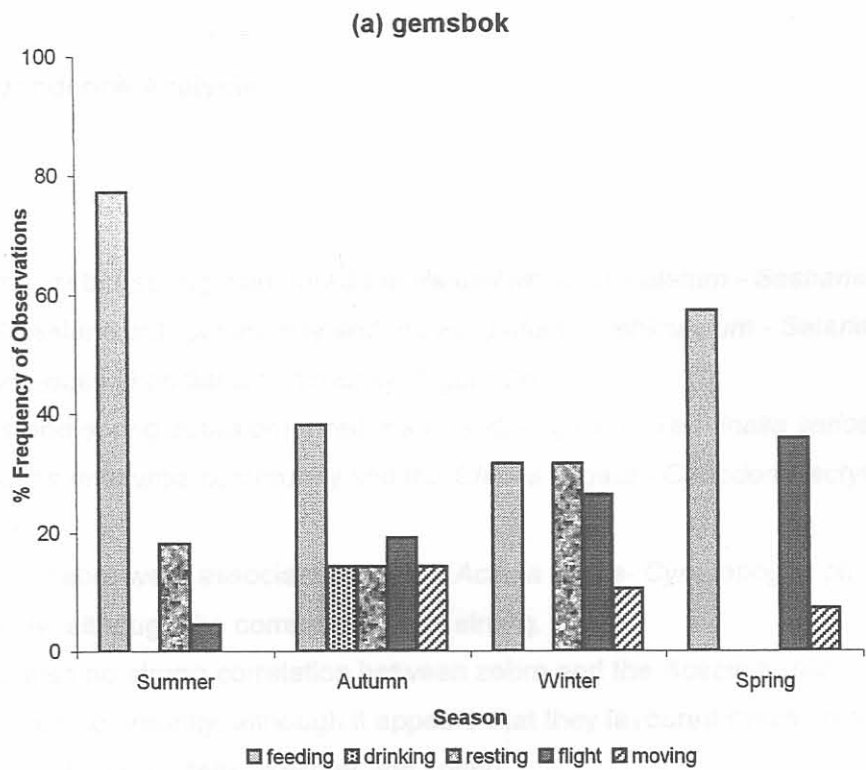


Figure 27. Seasonal frequency distribution of (a) gemsbok and (b) eland, showing activity

## Correspondence Analysis

### Zebra

In summer zebra strongly favoured the *Paspalum scrobiculatum* - *Sesbania sesban* Open Grassland sub-community and the *Paspalum scrobiculatum* - *Setaria sphacelata* Low Semi-open Woodland community (Figure 28).

In winter and spring zebra preferred the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* community and the *Chloris virgata* - *Cynodon Dactylon* community.

In autumn zebra were associated with the *Acacia tortilis*- *Cymbopogon plurinodis* community, although the correlation is not strong.

There is also no strong correlation between zebra and the *Acacia tortilis*- *Enneapogon cenchroides* community, although it appears that they favoured these areas more in summer and autumn than in winter and spring.

In winter and spring zebra were associated mainly with giraffe, while in summer they were observed more frequently associating with blue wildebeest and eland. In autumn zebra had no particular association with any other species (Figure 29).

### Impala

In summer impala are correlated with the *Chloris virgata* - *Cynodon dactylon* and *Paspalum scrobiculatum* - *Sesbania sesban* communities (Figure 30).

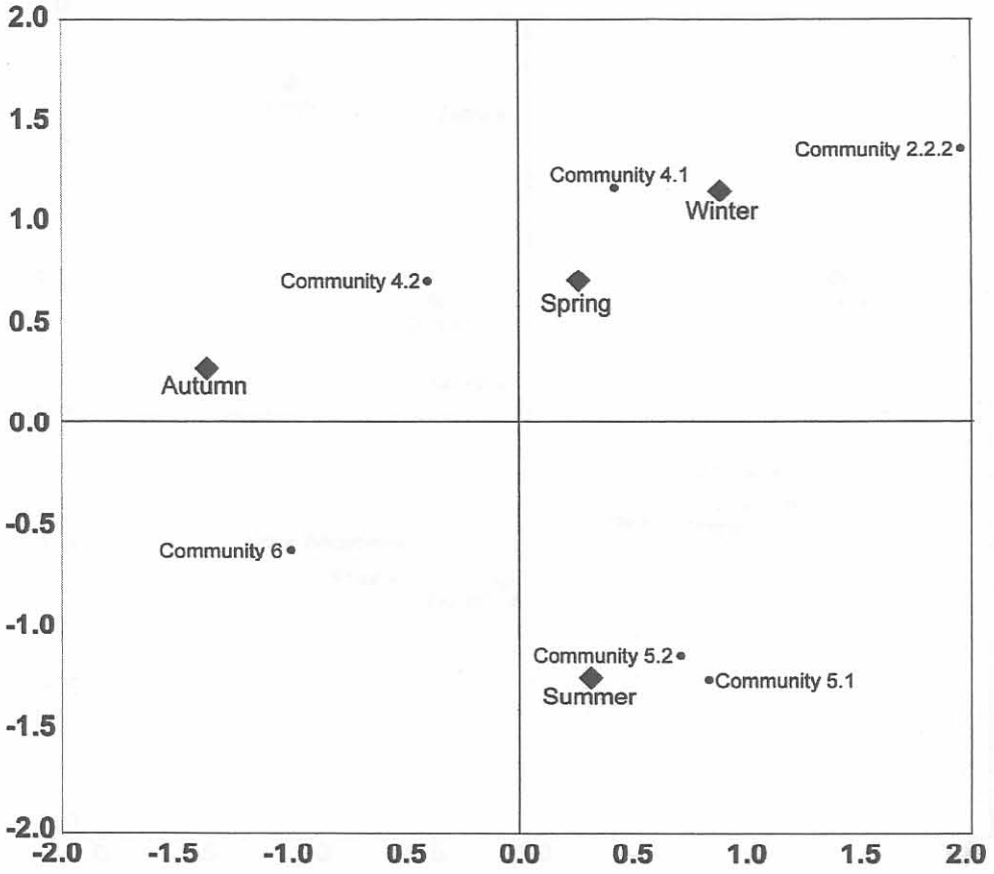
In winter and spring impala were observed mostly in *Acacia tortilis*- *Enneapogon cenchroides*, *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis*, *Acacia burkei* - *Eragrostis tricophora* communities.

There were no strong correlations of impala to any community in autumn, or any correlation of impala to the *Paspalum scrobiculatum* - *Setaria sphacelata* community.

During summer, impala were seen to associate with eland, blue wildebeest, kudu and blesbok (Figure 31).

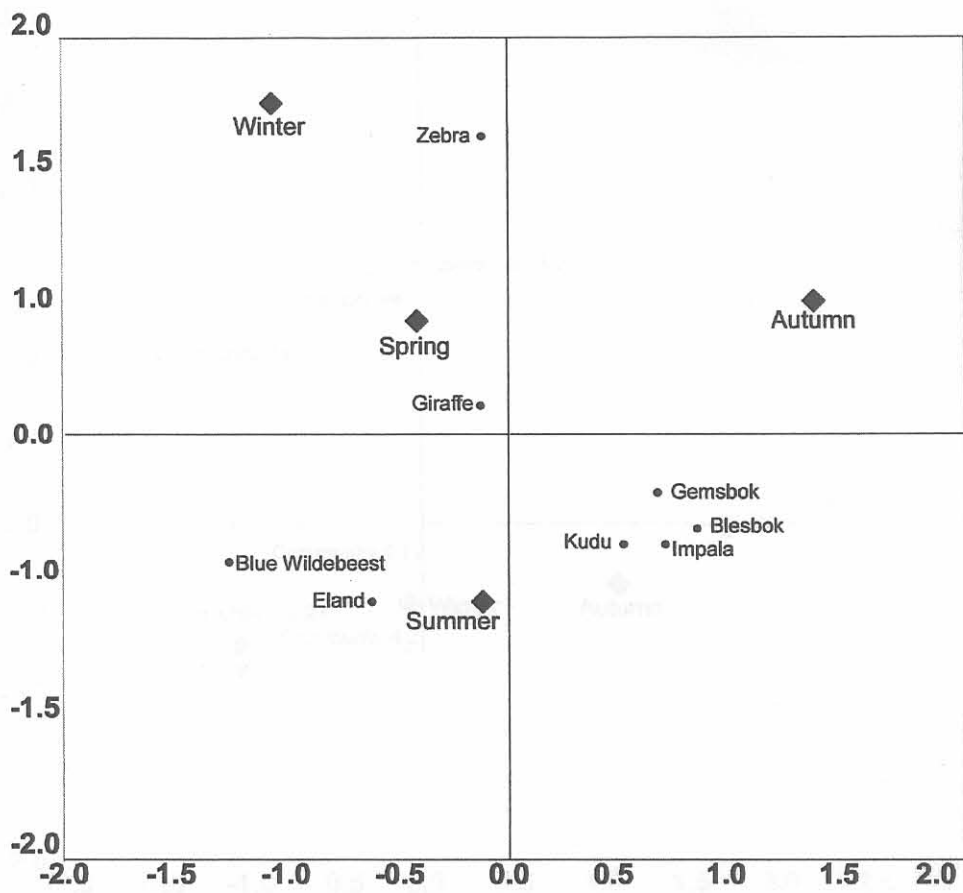
In winter and spring impala were found to associate mostly with other impala.

In autumn there was no particular species that impala associated with.

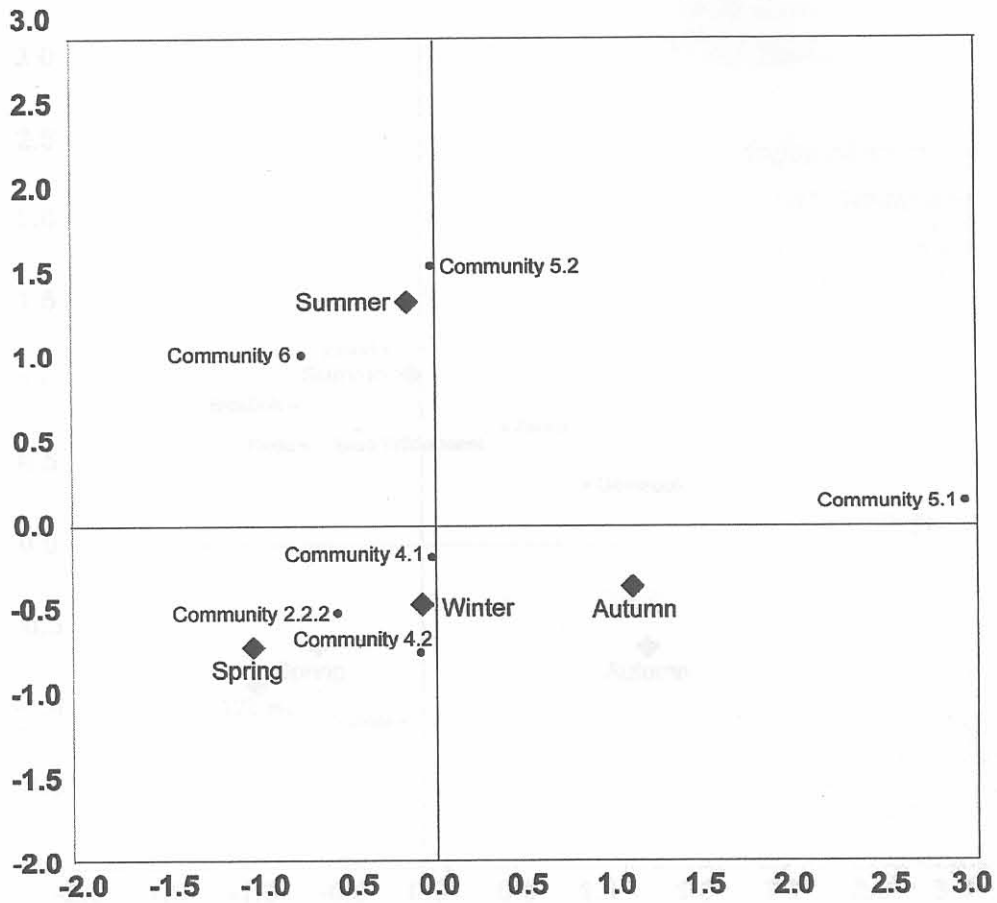


**Figure 28:** Correspondence analysis showing the plot of season versus plant community for zebra





**Figure 29:** Correspondence analysis showing the plot of season versus association for zebra



**Figure 30:** Correspondence analysis showing the plot of season versus plant community for impala

Giraffe

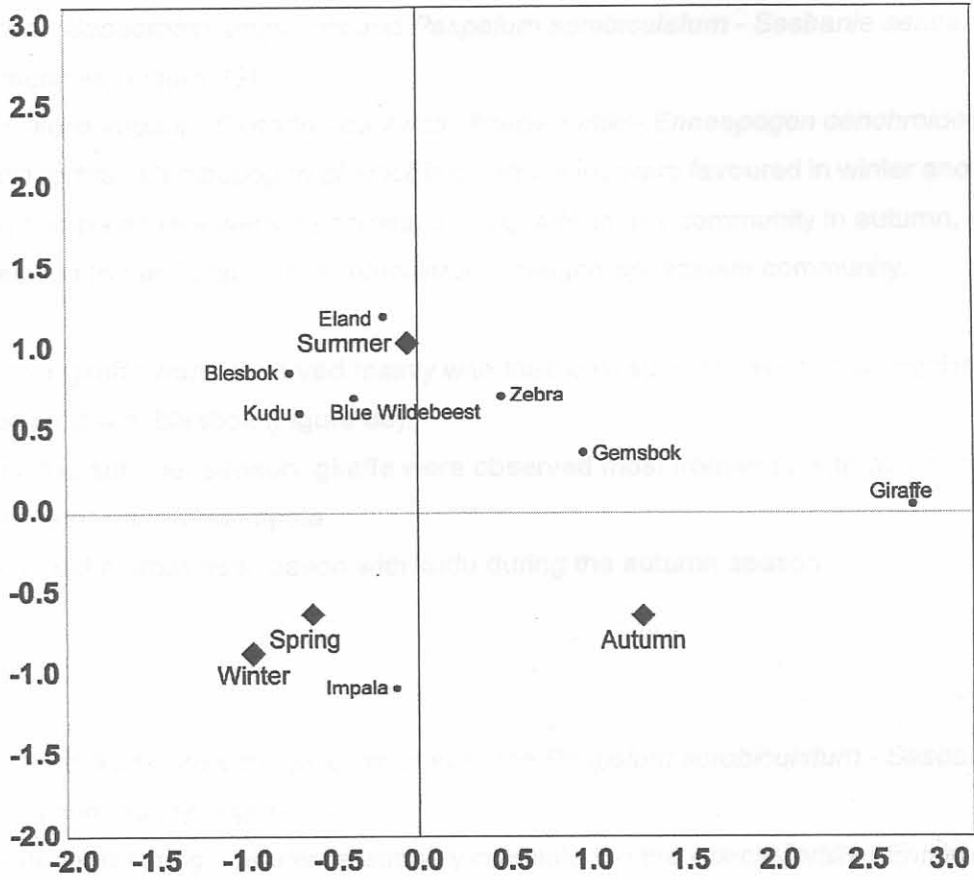


Figure 31: Correspondence analysis showing the plot of season versus association for impala

## Giraffe

In summer giraffe were observed predominantly in the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* and *Paspalum scrobiculatum* - *Sesbania sesban* communities (Figure 32).

The *Chloris virgata* - *Cynodon dactylon*, *Acacia tortilis*- *Enneapogon cenchroides* and *Acacia tortilis* - *Cymbopogon plurinodis* communities were favoured in winter and spring. As with impala there were no correlation of giraffe to any community in autumn, and no correlation to the *Paspalum scrobiculatum* - *Setaria sphacelata* community.

In winter giraffe were observed mainly with their own species, while in spring they were associated with blesbok (Figure 33).

During the summer season, giraffe were observed most frequently with gemsbok, blue wildebeest, eland and impala.

Giraffe had a small association with kudu during the autumn season.

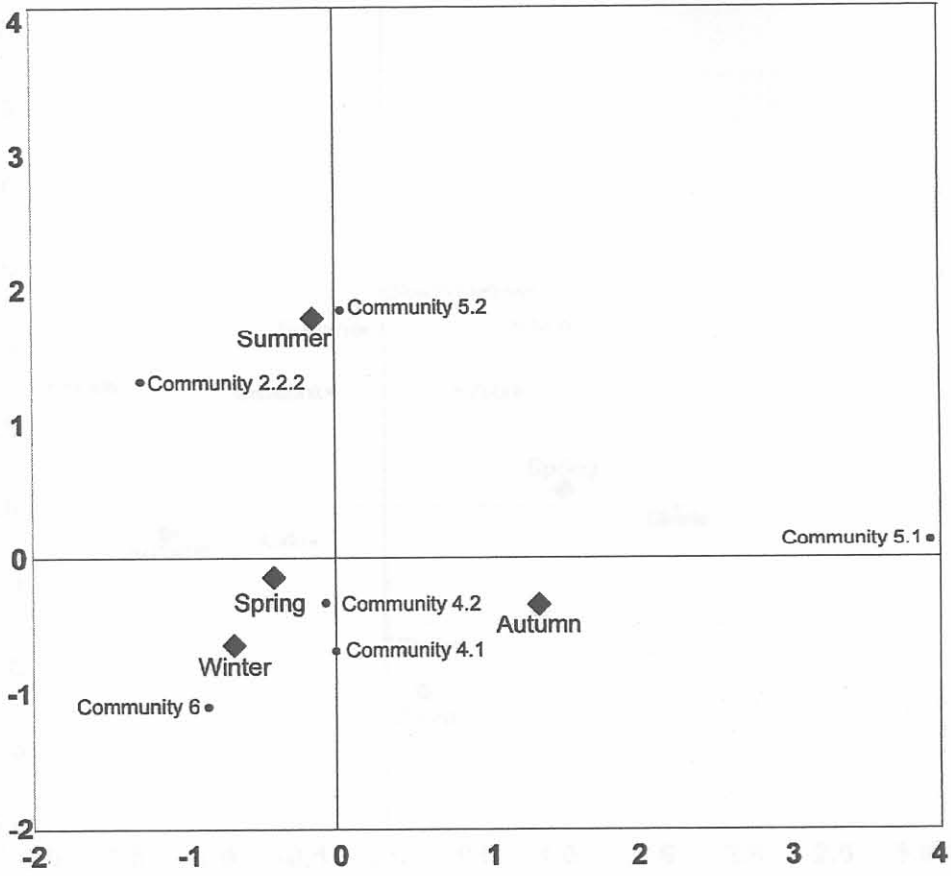
## Kudu

In summer kudu are strongly correlated to the *Paspalum scrobiculatum* - *Sesbania sesban* community (Figure 34).

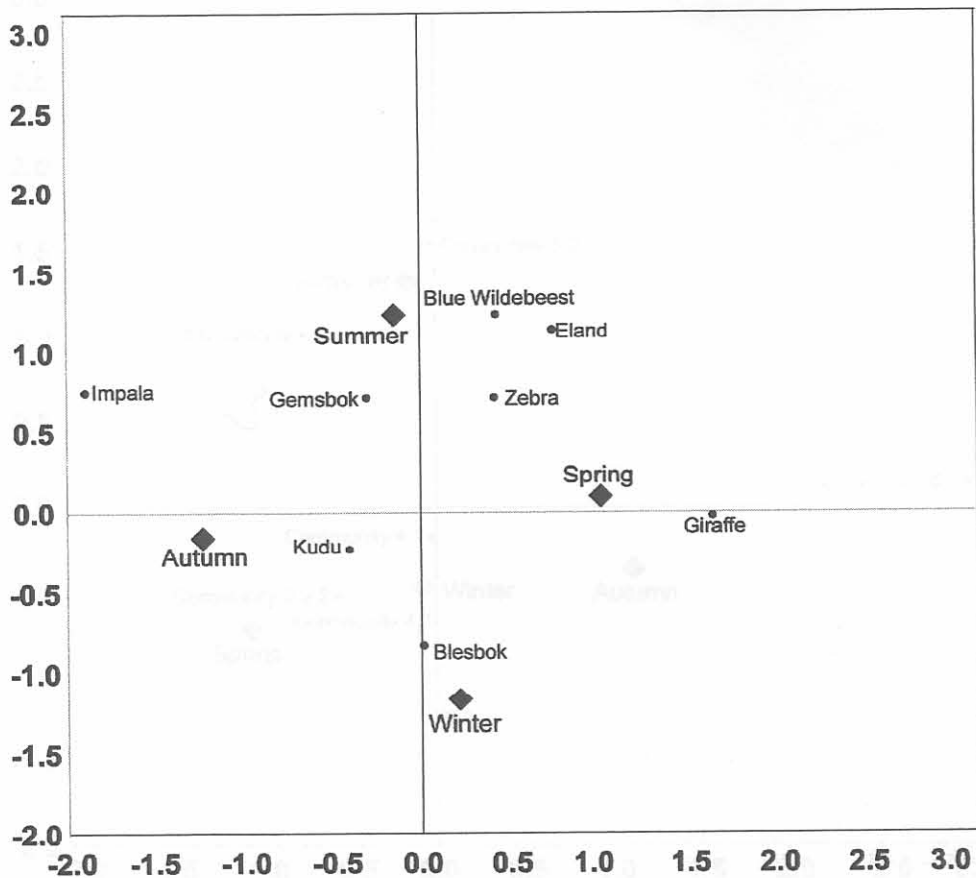
In winter and spring, kudu were strongly correlated to the *Acacia tortilis* - *Enneapogon cenchroides* community and weakly correlated to the *Acacia tortilis* - *Cymbopogon plurinodis* community.

In autumn kudu were associated with the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* communities, although the correlation is not strong.

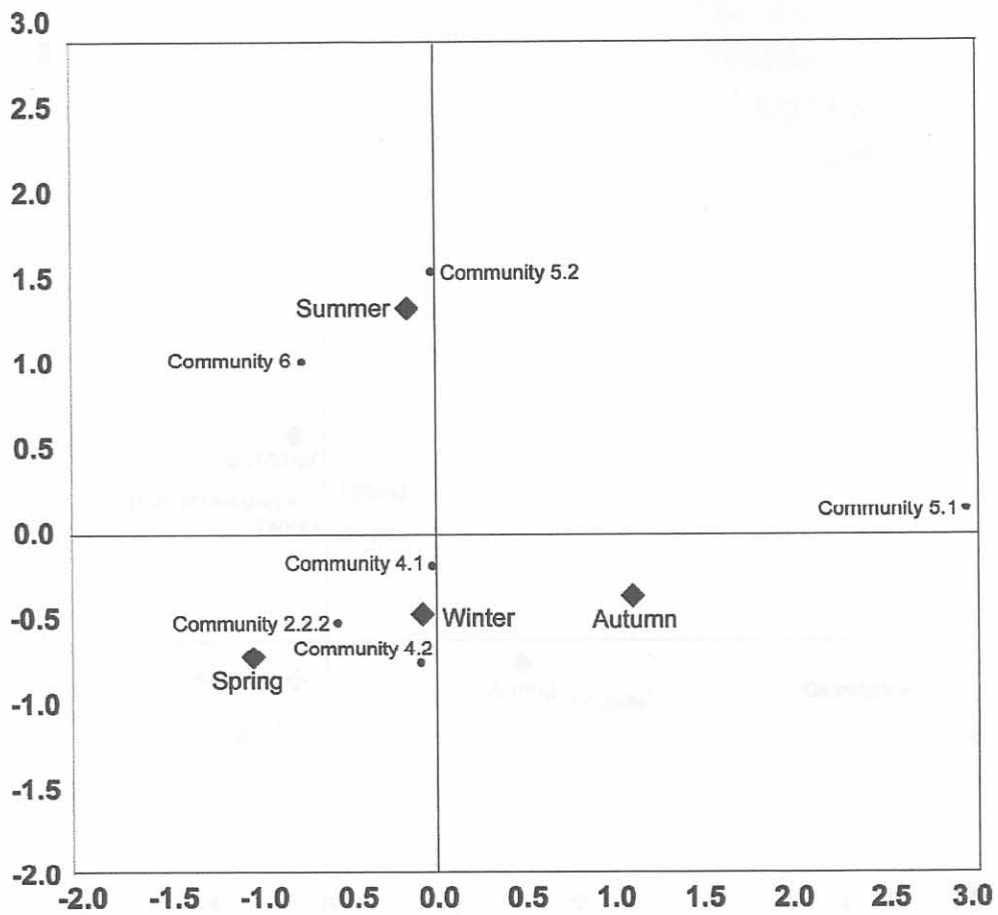
Kudu were observed mostly with other kudu during autumn and winter. During spring they were strongly associated with giraffe and had a weak association with gemsbok. During summer kudu were seen associating with blue wildebeest, zebra, impala and eland (Figure 35).



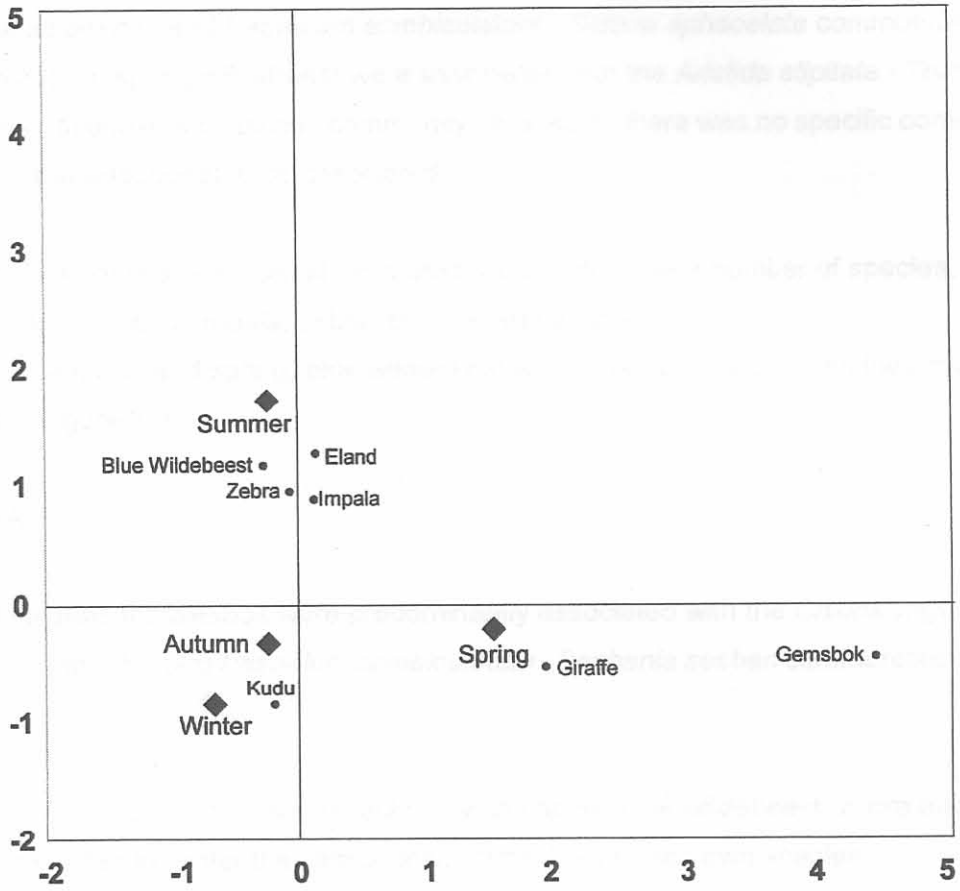
**Figure 32:** Correspondence analysis showing the plot of season versus plant community for giraffe



**Figure 33:** Correspondence analysis showing the plot of season versus association for giraffe



**Figure 34:** Correspondence analysis showing the plot of season versus plant community for kudu



**Figure 35:** Correspondence analysis showing the plot of season versus association for kudu



## Blue wildebeest

In summer and winter blue wildebeest were associated with the *Paspalum scrobiculatum* - *Sesbania sesban* and *Paspalum scrobiculatum* - *Setaria sphacelata* communities (Figure 36). In spring wildebeest were associated with the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* community. In autumn there was no specific community to which the wildebeest were associated.

During summer blue wildebeest were associated with quite a number of species, namely; kudu, eland, impala, zebra, blesbok and giraffe.

In winter, autumn and spring, blue wildebeest were observed mostly with their own species (Figure 37).

## Blesbok

In all four seasons blesbok were predominantly associated with the *Chloris virgata* - *Cynodon dactylon* and *Paspalum scrobiculatum* - *Sesbania sesban* communities (Figure 38).

During summer blesbok were associated with impala, blue wildebeest, zebra and gemsbok, while in winter they associated primarily with their own species.

During spring they were associated with eland, and had weak associations with giraffe and kudu for the same season (Figure 39).

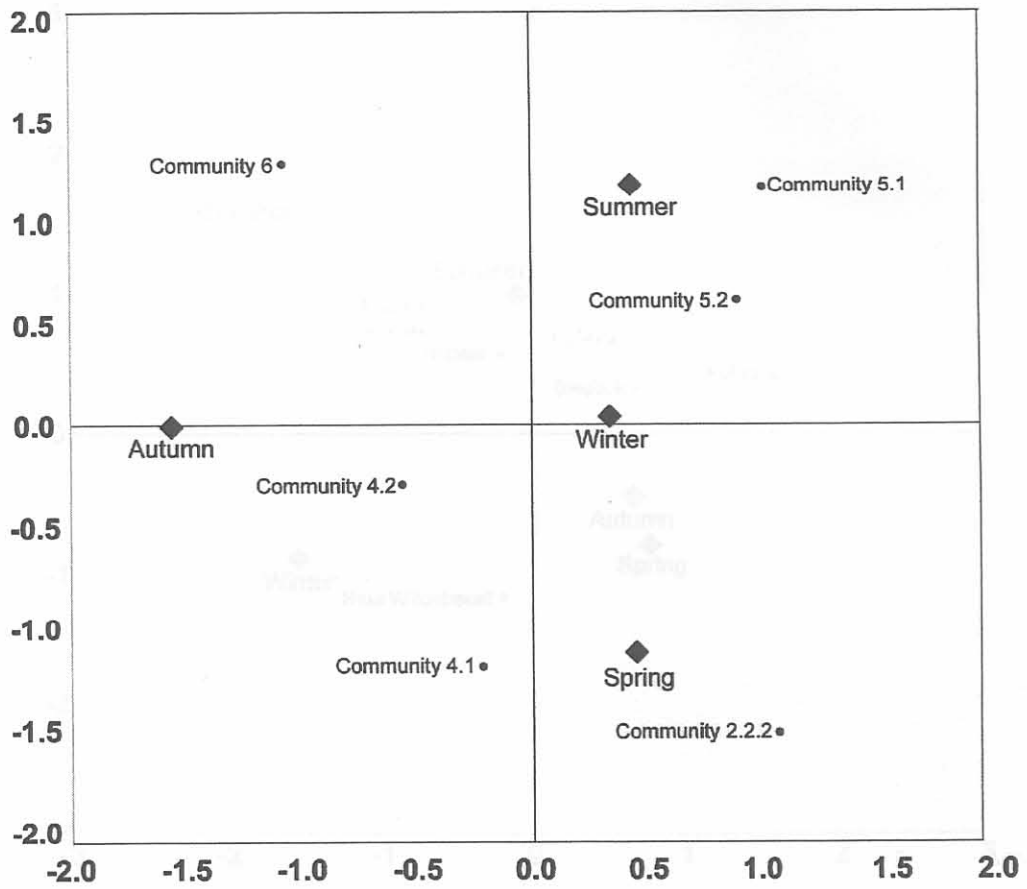
## Gemsbok

In winter gemsbok were observed mostly in the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis*, *Paspalum scrobiculatum* - *Setaria sphacelata* and *Acacia tortilis* - *Cymbopogon plurinodis* communities (Figure 40).

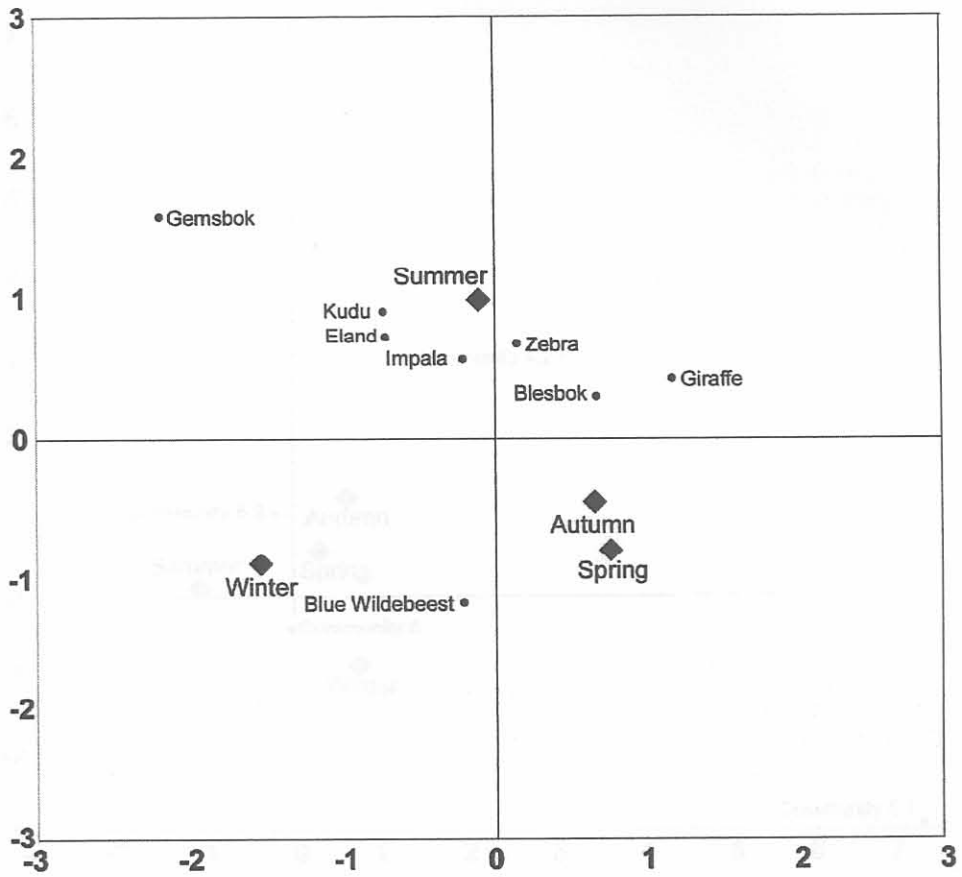
In summer gemsbok were strongly correlated with the *Chloris virgata* - *Cynodon dactylon* community.

In autumn and spring gemsbok were associated with the *Acacia tortilis* - *Enneapogon cenchroides* community.

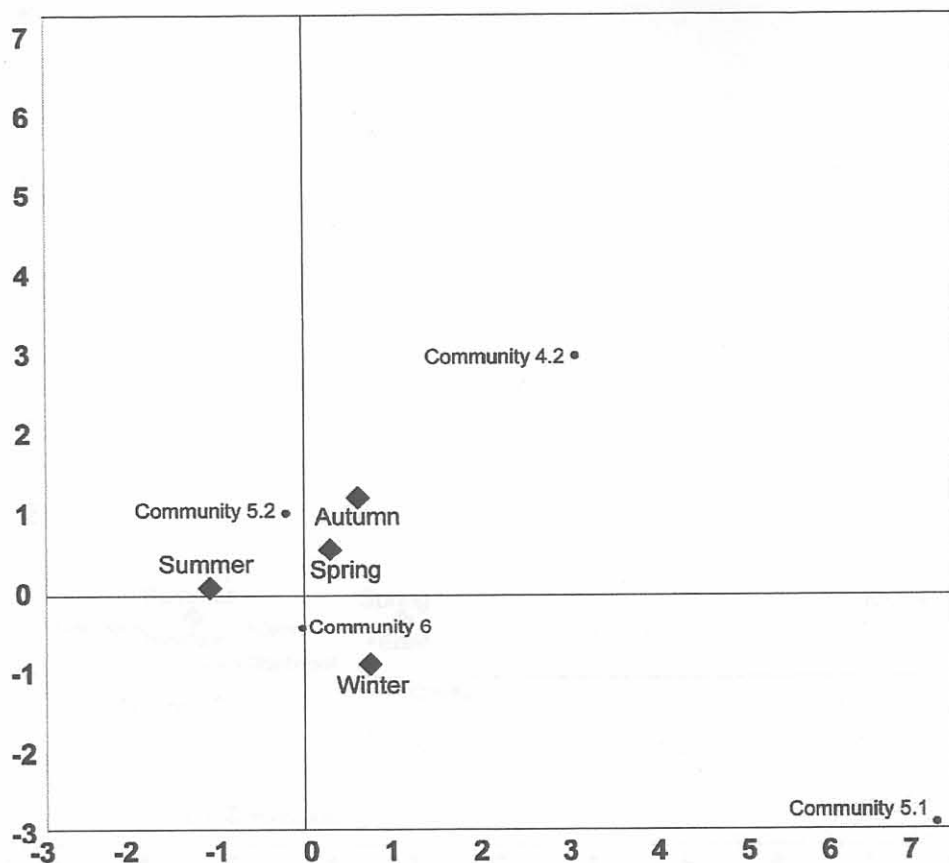
Figure 36: Correspondence plot showing the relationship between plant communities and blue wildebeest.



**Figure 36:** Correspondence analysis showing the plot of season versus plant community for blue wildebeest



**Figure 37:** Correspondence analysis showing the plot of season versus association for blue wildebeest



**Figure 38:** Correspondence analysis showing the plot of season versus plant community for blesbok

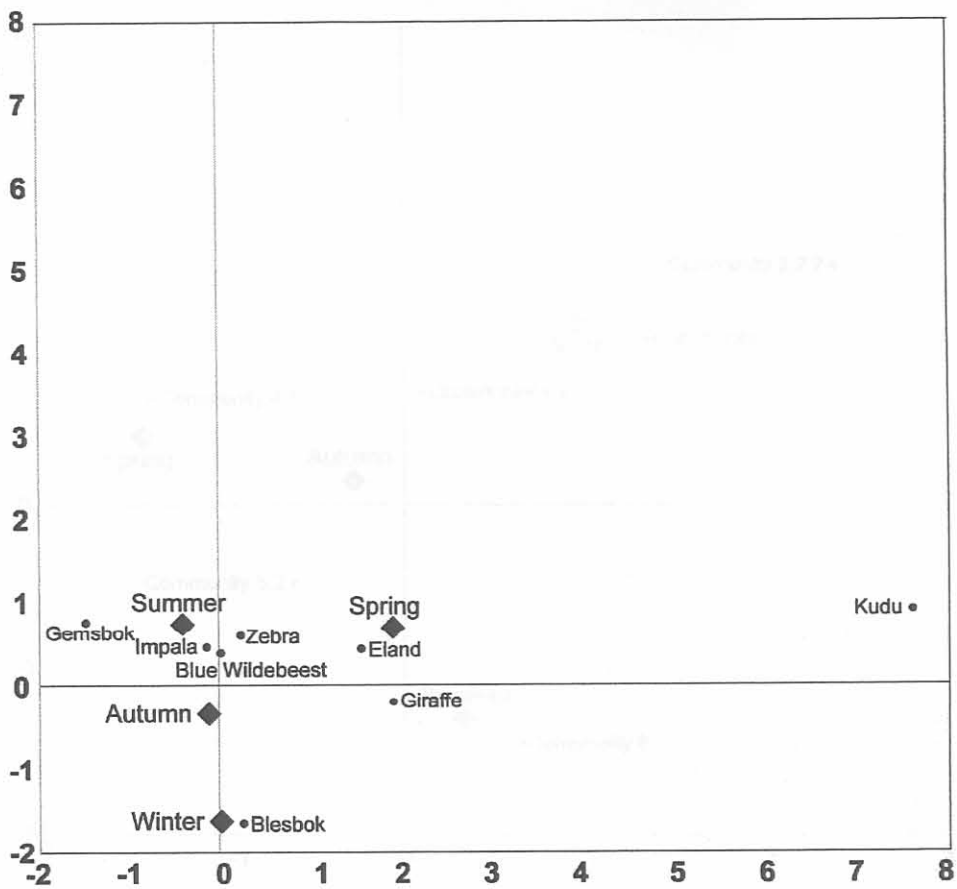
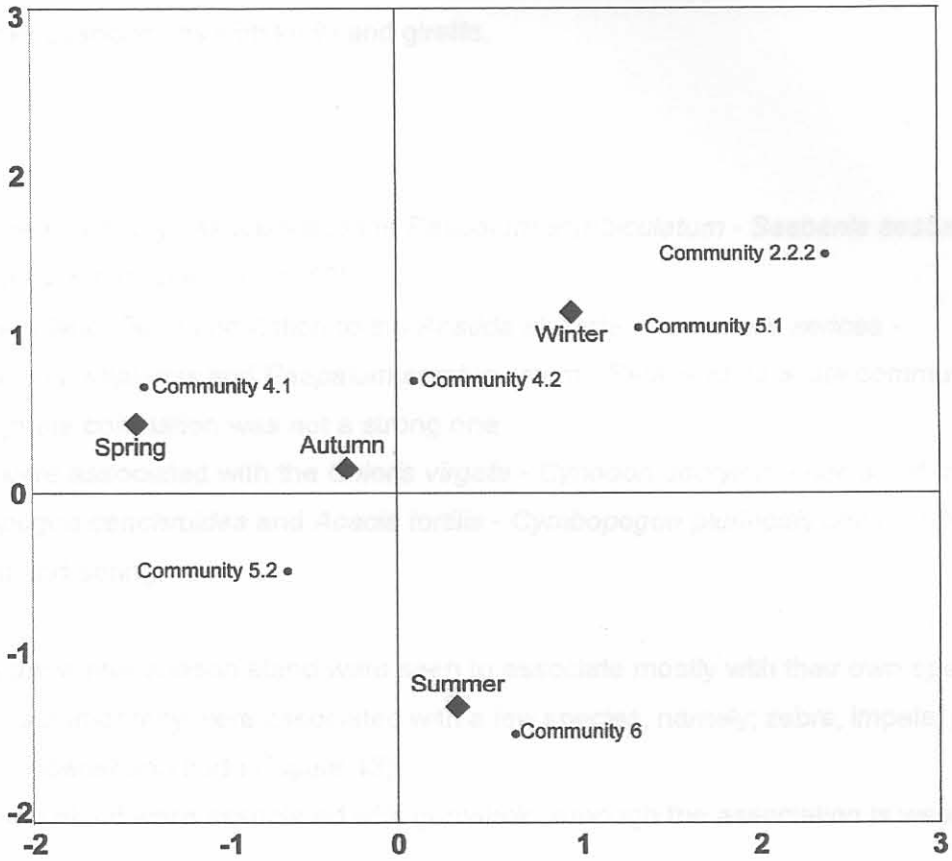


Figure 39: Correspondence analysis showing the plot of season versus association for blesbok



**Figure 40:** Correspondence analysis showing the plot of season versus plant community for gemsbok

During winter gemsbok kept mainly to themselves, while in summer they associated with impala, blue wildebeest and blesbok (Figure 41).

During autumn they had a weak association with eland and in the spring season they had weak associations with kudu and giraffe.

## Eland

Eland were strongly associated to the *Paspalum scrobiculatum* - *Sesbania sesban* community in summer (Figure 42).

In winter eland had a correlation to the *Aristida stipitata* - *Terminalia sericea* - *Stipagrostis uniplumis* and *Paspalum scrobiculatum* - *Setaria sphacelata* communities, although the correlation was not a strong one.

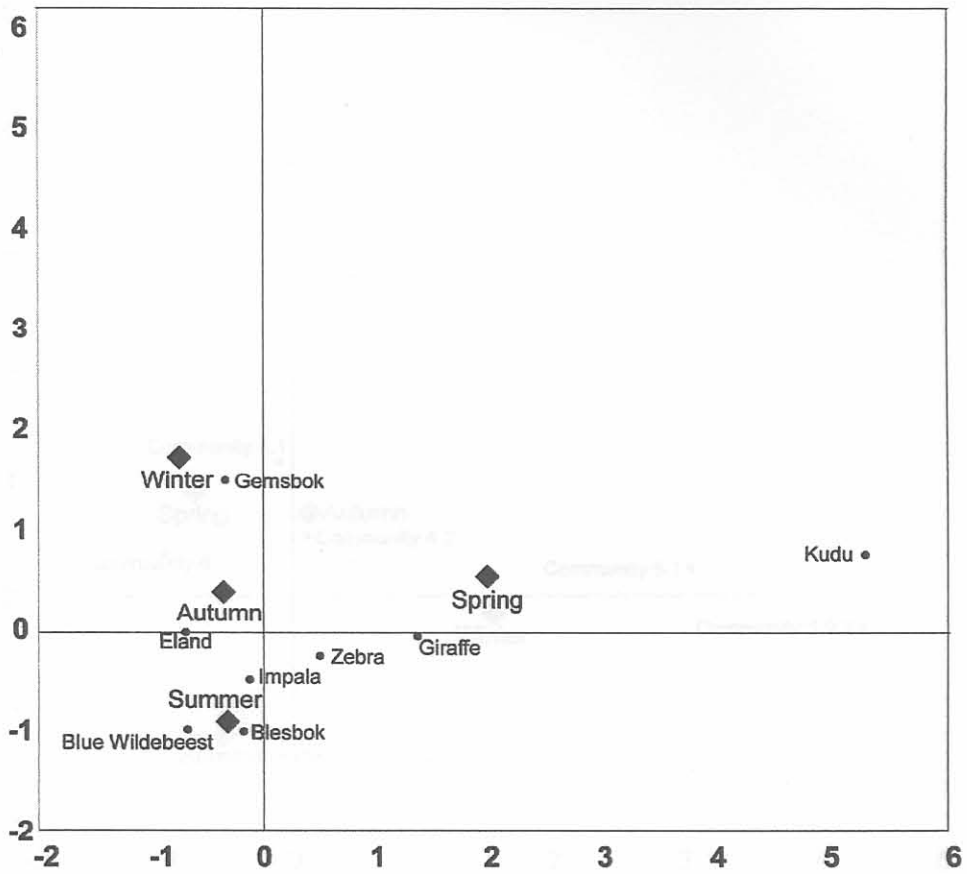
Eland were associated with the *Chloris virgata* - *Cynodon dactylon*, *Acacia tortilis* - *Enneapogon cenchroides* and *Acacia tortilis* - *Cymbopogon plurinodis* communities in autumn and spring.

During the winter season eland were seen to associate mostly with their own species while in summer they were associated with a few species, namely; zebra, impala, giraffe, blue wildebeest and kudu (Figure 43).

In autumn eland were associated with gemsbok, although the association is weak.

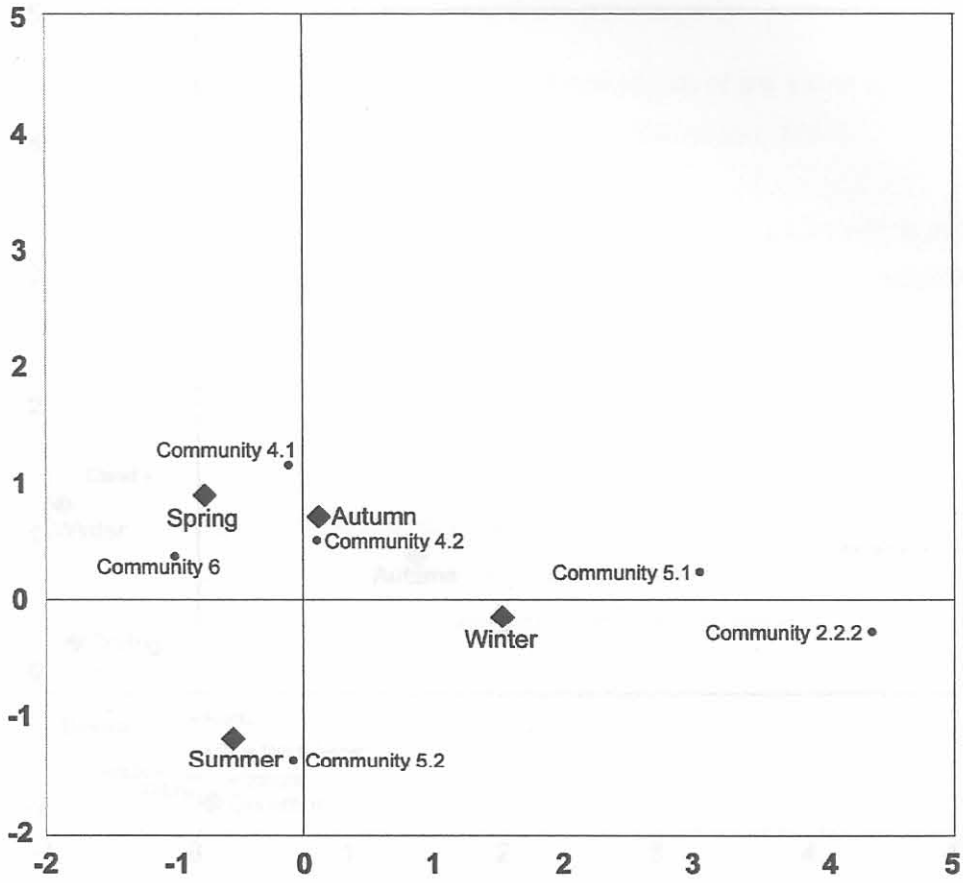
## MANAGEMENT RECOMMENDATIONS

During autumn and into winter quite a few species congregate in the *Chloris virgata* - *Cynodon dactylon* community. It may be beneficial to place licks with appetite stimulants in the other communities to attract the game and prevent overgrazing of the grassland. Overgrazing can lead to erosion, which is not easily managed.



**Figure 41:** Correspondence analysis showing the plot of season versus association for gemsbok

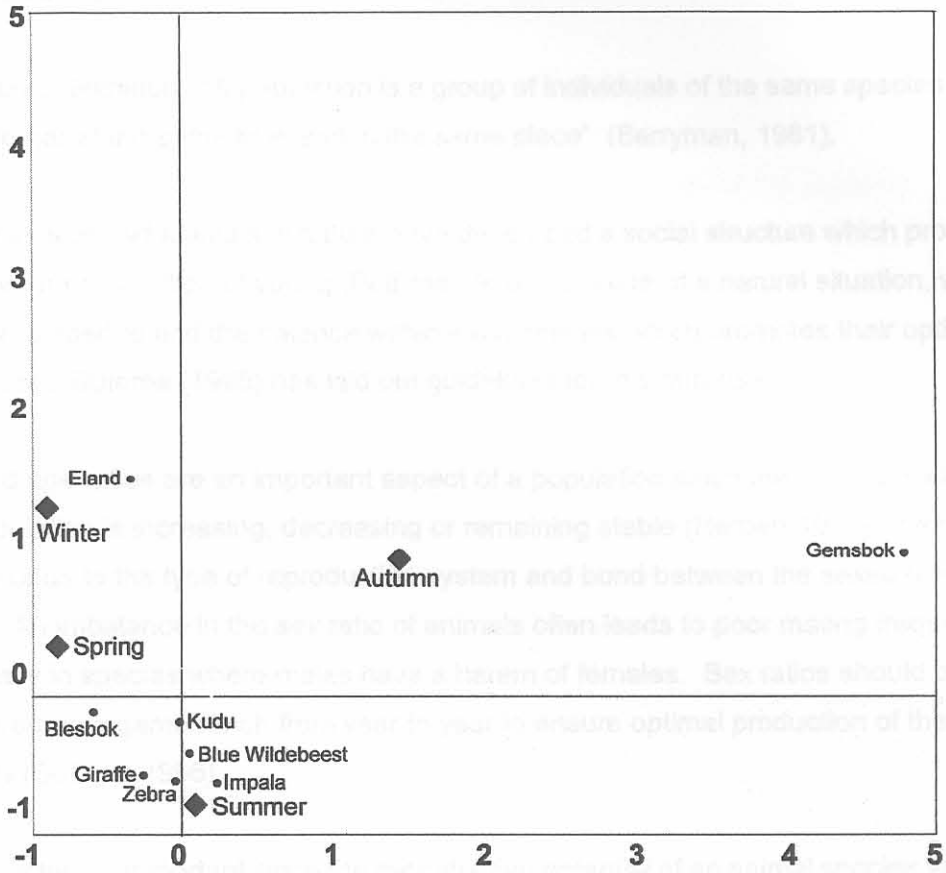




**Figure 42:** Correspondence analysis showing the plot of season versus plant community for eland

POPULATION DYNAMICS

INTRODUCTION



**Figure 43:** Correspondence analysis showing the plot of season versus association for eland

## POPULATION DYNAMICS

### INTRODUCTION *This study are as follows:*

Population, definition: "A population is a group of individuals of the same species which live together at the same time and in the same place" (Berryman, 1981).

Populations of wild animals in nature have developed a social structure which promotes the optimum production of young (Bothma 1996). Outside of a natural situation, wildlife managers need to find the balance within each species which promotes their optimum production. Bothma (1996) has laid out guidelines for this purpose.

Sex and age ratios are an important aspect of a population since they indicate whether the population is increasing, decreasing or remaining stable (Herbert 1970). Sex ratio corresponds to the type of reproduction system and bond between the sexes (Leuthold 1997). An imbalance in the sex ratio of animals often leads to poor mating frequency, especially in species where males have a harem of females. Sex ratios should be monitored on a game ranch from year to year to ensure optimal production of the animals (Bothma 1996).

Age structure is important since the reproductive potential of an animal species varies in accordance with age. The maintenance of a healthy age structure in a population is essential (Bothma 1996).

The function of animal populations is to ensure maximum productivity and performance (Bothma 1996).

There are three potential problems which require management of populations:

Conservation - increase populations which are decreasing

Harvesting - to obtain a proportion of the population on a long term basis, sustained yield.

Control - too many animals

## OBJECTIVES

The objectives of this study are as follows:

- To determine the sex ratio of the selected animal species
- To determine the age structure of the selected animals.
- To determine if any changes in herd size are apparent throughout the seasons.
- To make management recommendations using the results.

## METHODS

The methods used in this study was sexing and aging animals by means of field observations using binoculars.

The survey took place simultaneously with the habitat selection surveys, with each group of animals being sexed and aged and the information being filled out in an observation sheet (Appendix 2). The age classes which the animals were divided into was:

Juveniles or calves

Sub-adults

Adults

Herd sizes were noted.

Animals were sexed and aged using a number of methods, the differences in sexes primarily determined by:

Horn presence or absence (Van Rooyen 1990)

Horn structure (thickness, rings etc) (Dieckmann 1980; Du Plessis 1968)

Presence or absence of a penile sheath (Dieckmann 1980)

Tail tufts, e.g. blesbok (Du Plessis 1968)

General build (Du Plessis 1990, Smuts 1974)

Colour differences (Du Plessis 1968)

Young calves were especially difficult to sex and the method of Dieckmann (1980) was used, that is to sex the young animals opportunistically, such as when the calf is urinating.

Age classes were assessed by:

Height of animal in comparison with the adults wither (Dieckmann 1980)

Horn development (Hillman 1979)

Colour differences (Dieckmann 1980)

## Results

### Herd Sizes

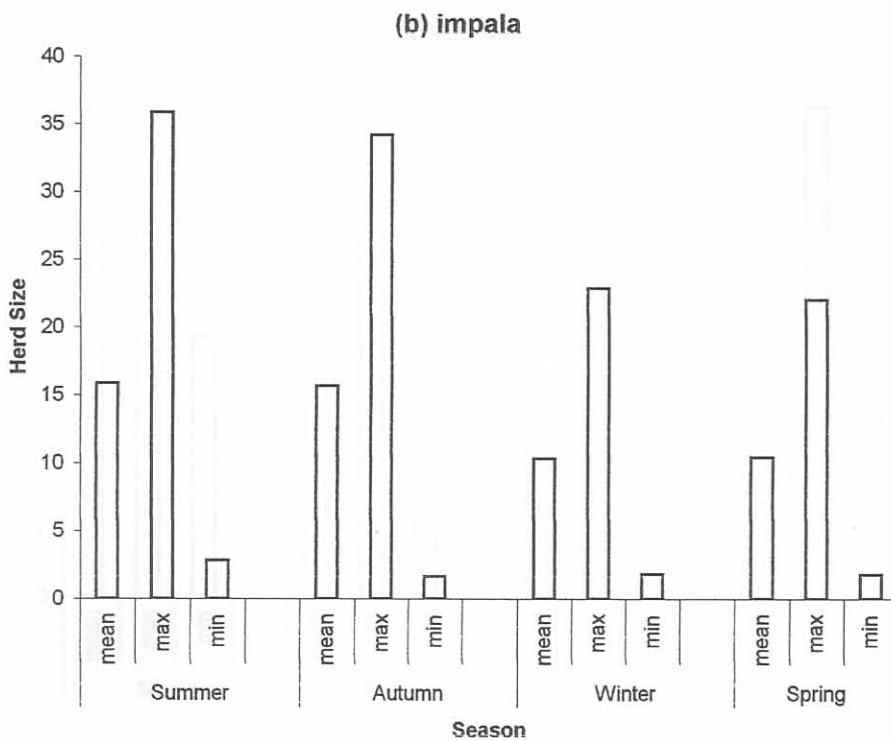
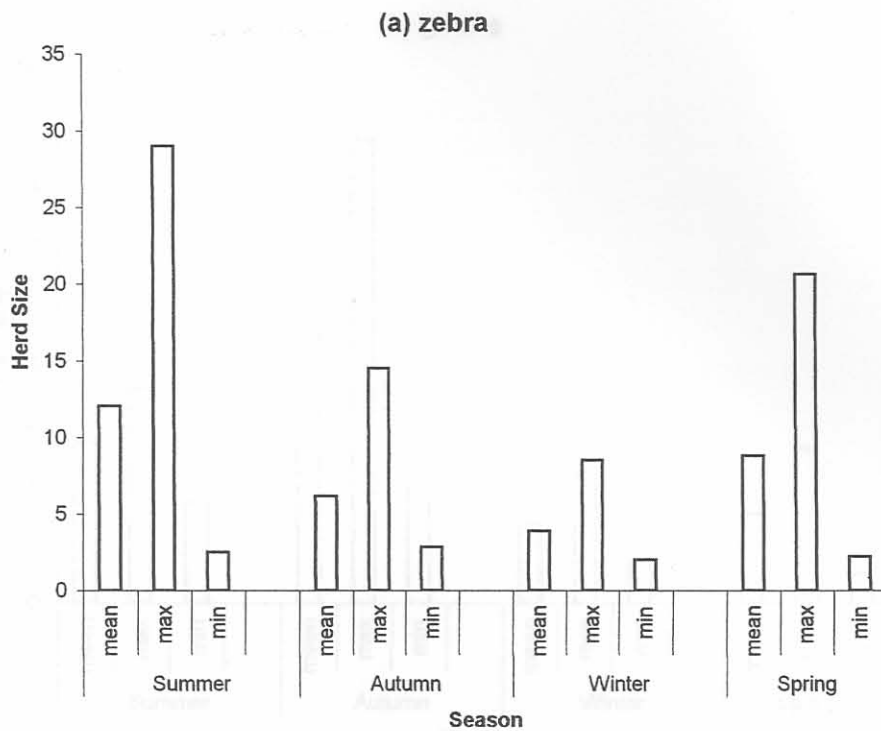
Zebra had the largest herd sizes in summer, with the mean herd size being 12 individuals and the biggest herd totalling near 30 animals (Figure 44a). Herd sizes were also fairly large in spring, but decreased in autumn and even more in winter, with the mean herd size being 3.8 individuals and the largest herd totalling 8.5 zebra.

In summer and autumn impala were observed in the largest herds of the year, with maximums of 35 (mean = 15.8) and 34 (mean=15.6) animals respectively (Figure 44b). In winter and spring these numbers decreased, with winter herd sizes averaging 10.3 and spring averaging 10.4 individuals.

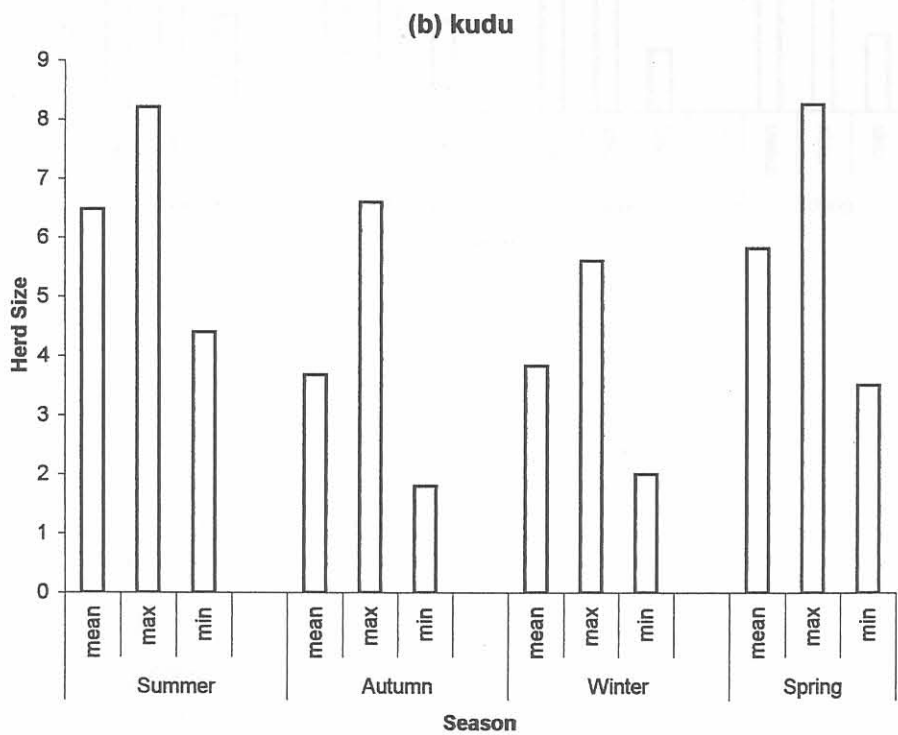
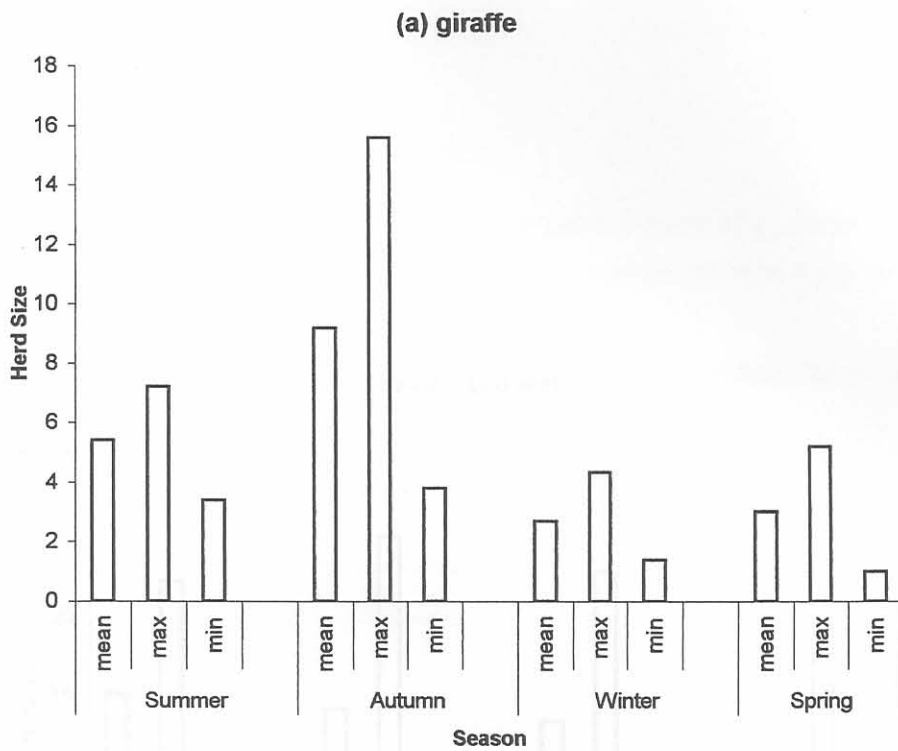
An average of nine giraffe per herd was observed in autumn, with a maximum of 15 giraffe seen in one herd (Figure 45a). The other seasons show markedly less giraffe per herd, in particular winter and spring where herd sizes averages at 2.6 and 3 individuals. The smallest herd sizes were seen in spring, where lone bulls were frequently observed.

The largest congregation of kudu was in the summer and spring seasons, with herds numbering over 8 individuals (Figure 45b). Winter and autumn showed observations of slightly smaller herd sizes. The smallest herd size recorded was in autumn for a group of 2 individuals.

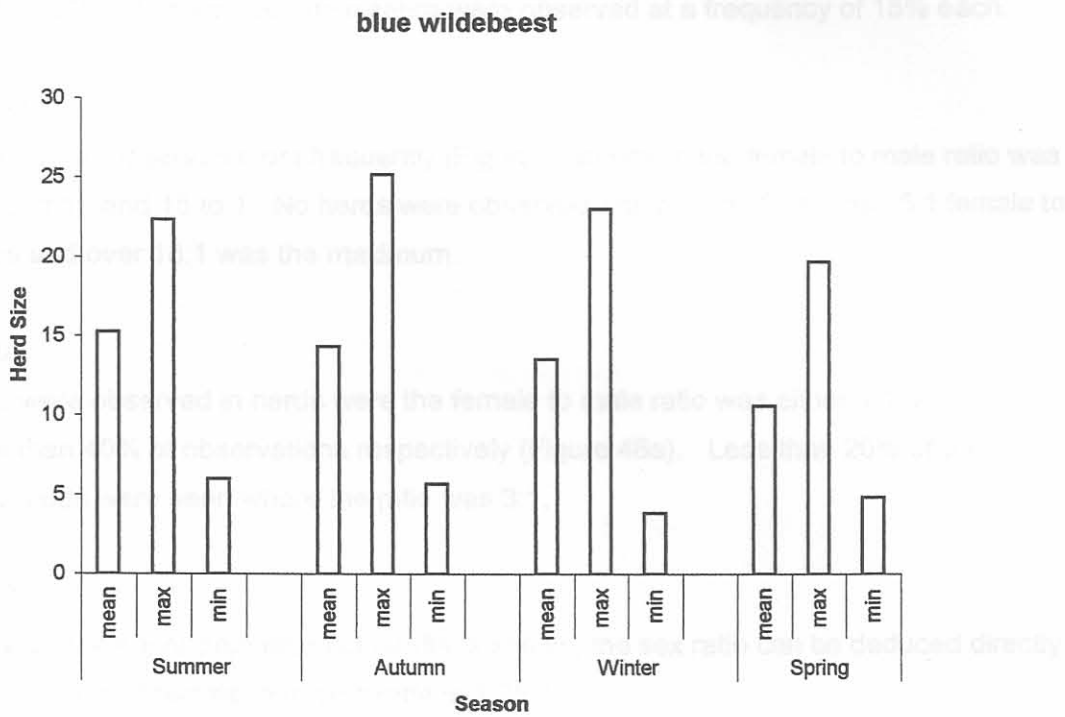
Herd sizes of blue wildebeest were fairly uniform throughout the year, with the highest recorded herd size being in autumn of 25 individuals and the smallest herd being in winter with four individuals (Figure 46).



**Figure 44.** Mean, minimum and maximum herd sizes of (a) zebra and (b) impala over the four seasons



**Figure 45.** Mean, minimum and maximum herd sizes of (a) giraffe and (b) kudu over the four seasons



**Figure 46.** Mean, minimum and maximum herd sizes of blue wildebeest over the four seasons



## Sex Ratio

### *Zebra*

The results of investigating sex ratios of adult zebra (Figure 47a), show that the highest frequency of observations were for a ratio of 1 : 1 female zebra to male zebra, with a frequency greater than 40%.

2 : 1 and 3 : 1 females per male zebra were observed at a frequency of 15% each.

### *Impala*

Impala were observed most frequently (Figure 47b) where the female to male ratio was between 10 and 15 to 1. No herds were observed with a ratio of less than 5:1 female to males and over 18:1 was the maximum.

### *Kudu*

Kudu were observed in herds where the female to male ratio was either 1:1 or 2:1 for more than 40% of observations respectively (Figure 48a). Less than 20% of the time kudu herds were seen where the ratio was 3:1.

### *Giraffe*

Because the entire population of giraffe is known, the sex ratio can be deduced directly. The sex ratio of female to male giraffe is 1.25:1

### *Blue wildebeest*

Blue wildebeest were observed in herds where the female to male ratio was predominantly 7:1 or 8:1 (for more than 30% of observations) (Figure 48b).

## Age Structure

### *Zebra*

As seen in Figure 49a 51% of the zebra population is made up of adult zebra, while 21% and 28% are made up of juveniles and sub adults respectively.

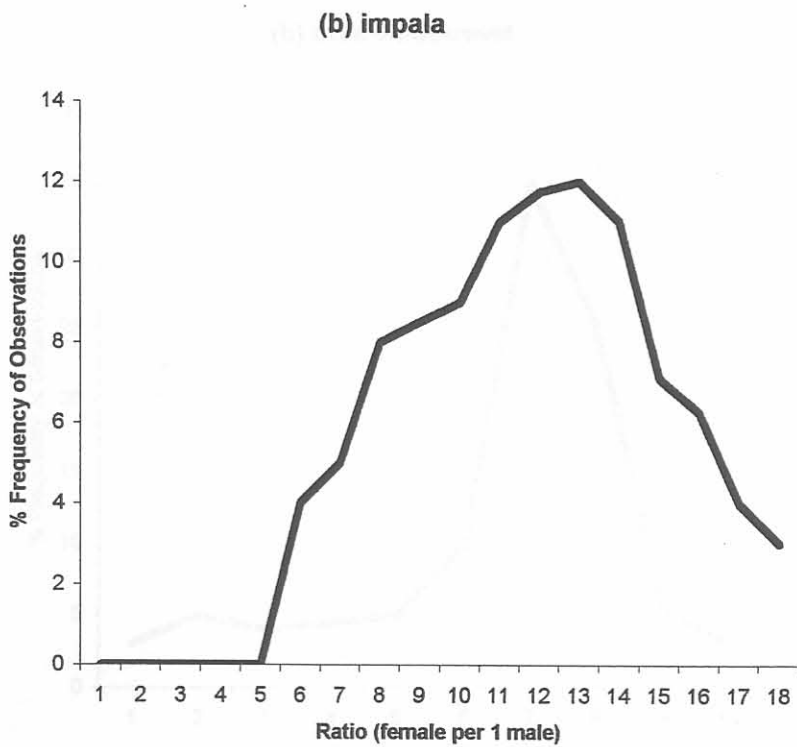
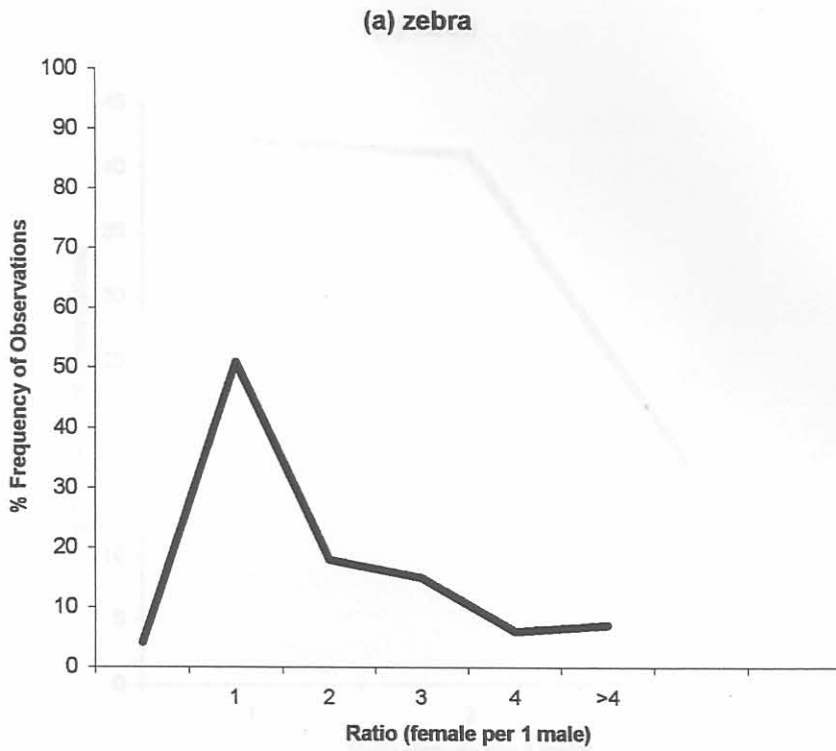


Figure 47. Frequency distribution of sex ratios of (a) zebra and (b) impala

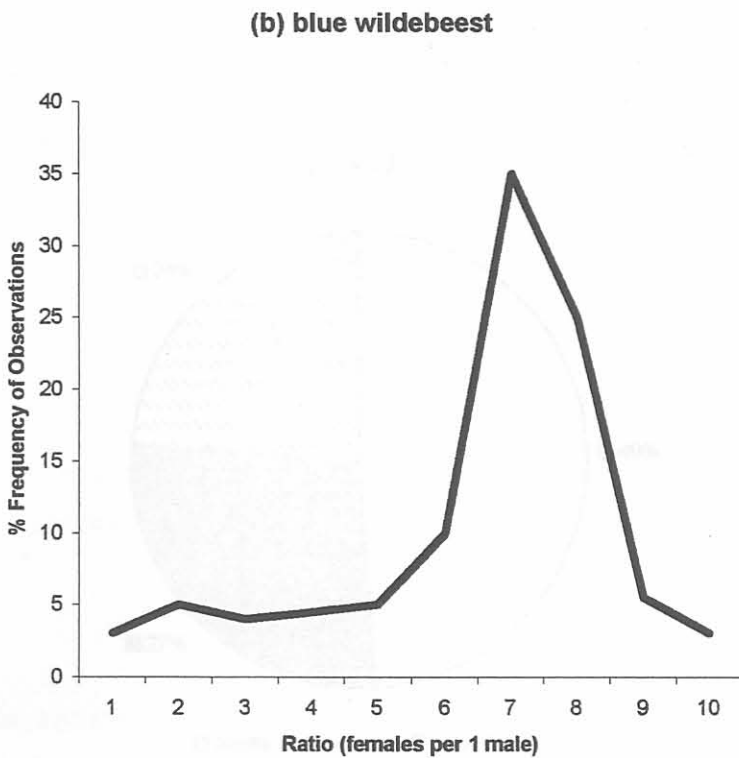
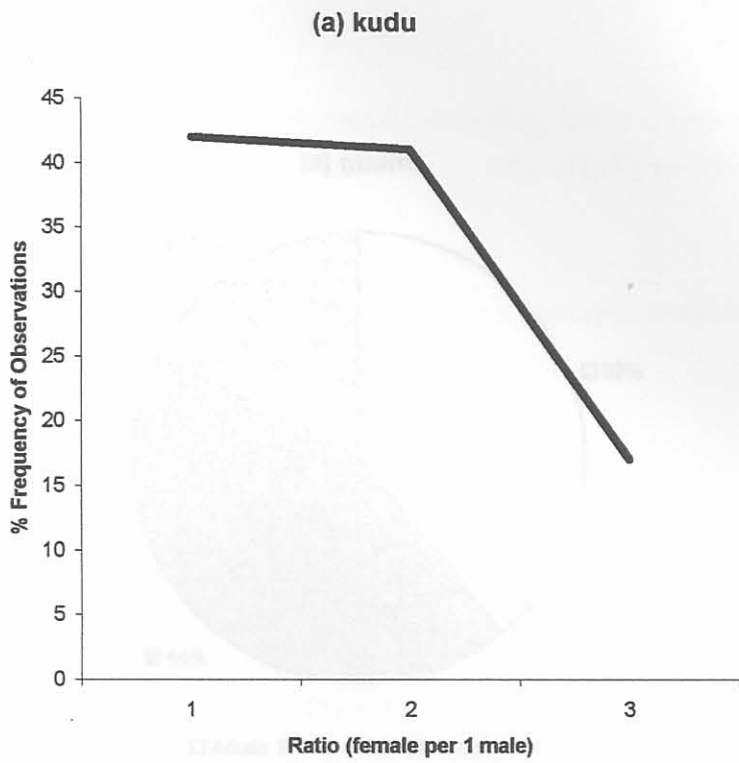
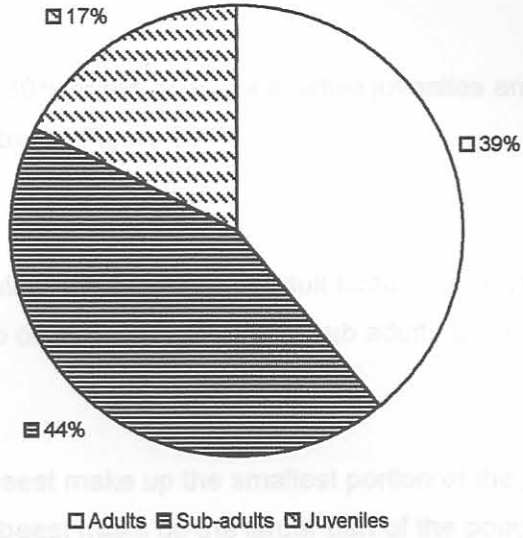


Figure 48. Frequency distribution of sex ratios of (a) kudu and (b) blue wildebeest

(a) giraffe



(b) kudu

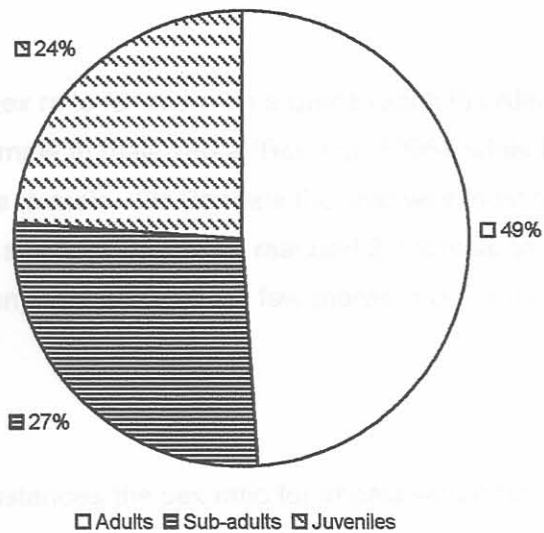


Figure 50. Age structure of (a) giraffe and (b) kudu

### *Impala*

Juvenile impala make up 32% of the impala population, which is very close to the sub adults, who make up 25%. Adult impala make up 43% of the population (Figure 49b).

### *Giraffe*

Adult giraffe make up 39% of the population, while juveniles and sub adults make up 17% and 44% respectively (Figure 50a).

### *Kudu*

49% of the kudu population is made up of adult kudu (Figure 50b) the remaining population is made up of juveniles (24%) and sub adults (27%).

### *Blue wildebeest*

Sub adult blue wildebeest make up the smallest portion of the population with 24%, while adult blue wildebeest make up the larger part of the population, 44%. Juveniles make up 32% of the wildebeest population (Figure 51).

## **Discussion**

### **Sex Ratio**

#### *Zebra*

The recommended sex ratio for zebra on a game ranch in order to have optimum productivity is 6:1 female to male zebra (Bothma, 1996), while in nature, the ratio is closer to 1.5:1 female to male. On Sondela the ratio was most frequently less than even the natural sex ratio, and less frequently reached 3:1 female to male zebra, indicating that there are too many stallions and too few mares in order for production to be optimum.

#### *Impala*

Under natural circumstances the sex ratio for impala would be 1.5 - 2.0 female to male impala, while the recommended ratio is 10 females per one male. On Sondela the ratio is on the recommended and slightly above.

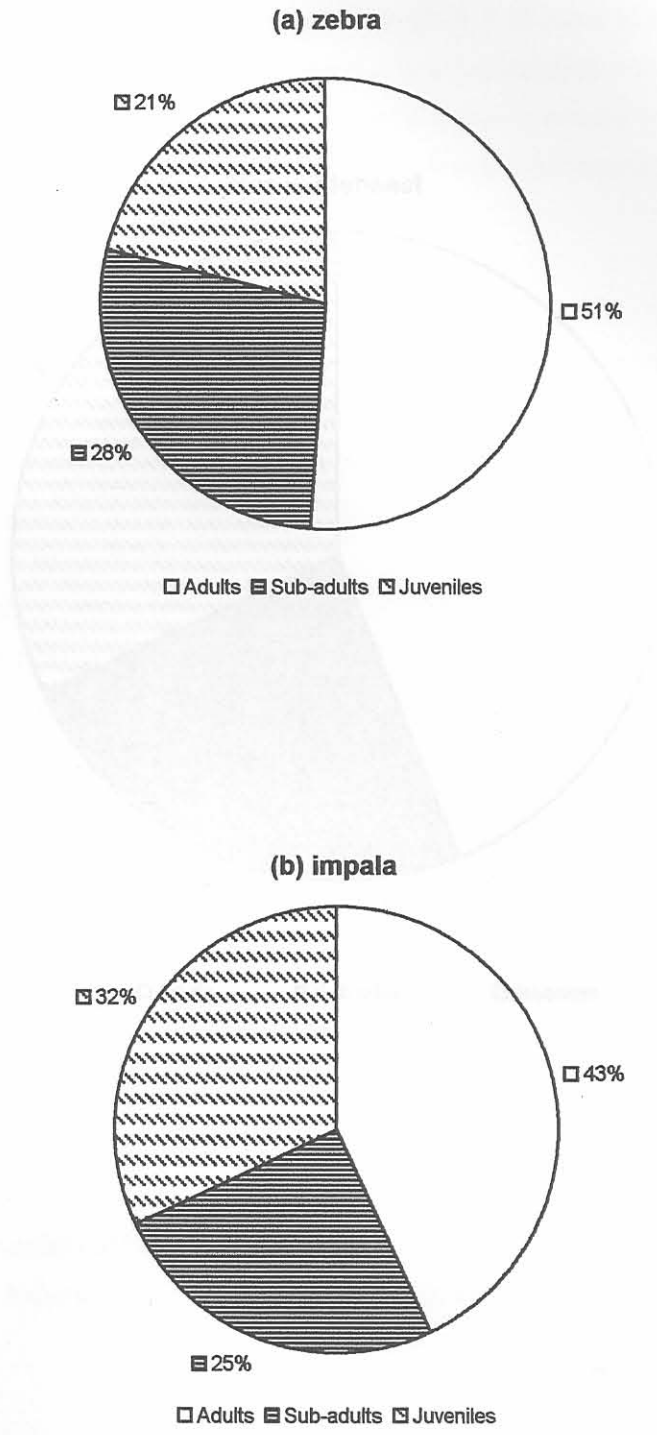
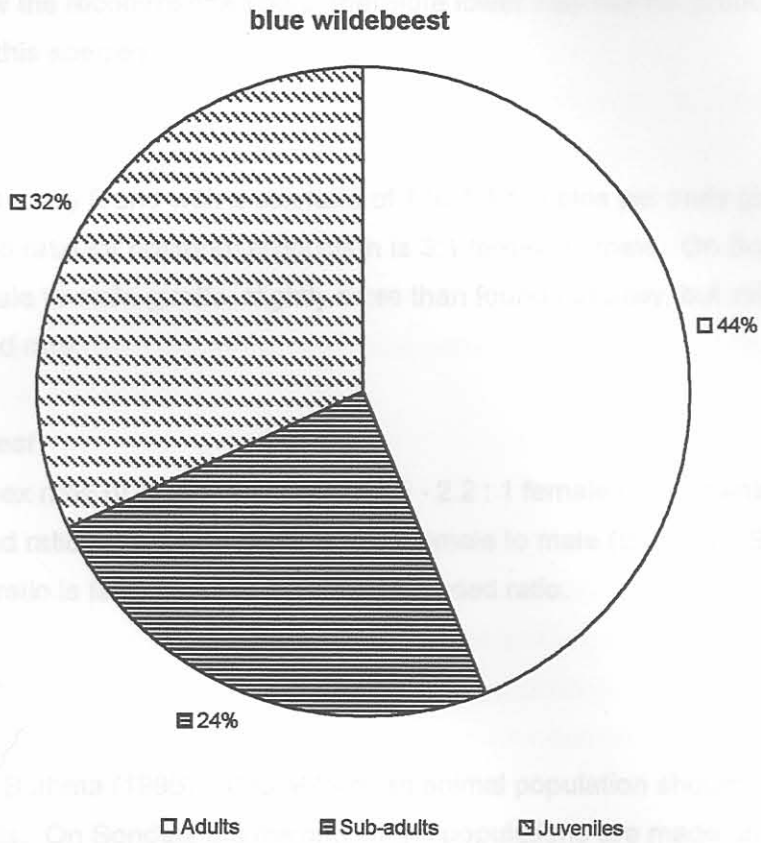


Figure 49. Age structure of (a) zebra and (b) impala



**Figure 51.** Age structure of blue wildebeest

### *Kudu*

The recommended ratio for kudu on a game ranch is 1:10 male to female kudu. Under natural circumstances the ratio is between 1.4 and 1.8 females per male.

On Sondela the ratio is slightly higher than would occur in natural circumstances, but is still well below the recommended ratio, therefore lower than normal production can be expected for this species.

### *Giraffe*

Giraffe are naturally found with a sex ratio of 1 to 1.1 females per male giraffe. The recommended ratio for optimum production is 3:1 female to male. On Sondela the ratio is 1.25:1 female to male giraffe, slightly more than found naturally, but still below the recommended rate.

### *Blue wildebeest*

The natural sex ratio of blue wildebeest is 1.5 - 2.2 : 1 female to male animals, while the recommended ratio for a game ranch is 10:1 female to male (Bothma, 1996). On Sondela the ratio is fairly close to the recommended ratio.

### *Age Structure*

According to Bothma (1996), 30 to 40% of an animal population should be made up of young animals. On Sondela the majority of the populations are made up of young animals, indicating an incredibly fast growth period. This also leaves the population at risk to factors affecting young animals only.

### *Zebra*

The zebra population of Sondela has 49% of its population consisting of sub adult and juvenile zebra, leaving the population at danger to sudden mortalities of the young.

### *Kudu*

The kudu population is made up of 51% of young animals. Should a disease or any other nature affect the young animals, the population will be in serious trouble. 49% of the kudu population is made up of adult kudu the remaining population is made up of juveniles (24%) and sub adults (27%).



### *Giraffe*

Adult giraffe make up 39% of the population, while juveniles and sub adults make up 17% and 44% respectively.

### *Impala*

Juvenile impala make up 32% of the impala population, which is very close to the sub adults, who make up 25%. Adult impala make up 43% of the population.

### *Blue wildebeest*

Sub adult blue wildebeest make up the smallest portion of the population with 24%, while adult blue wildebeest make up the most part of the population, 44%. Juveniles make up 32% of the wildebeest population.

### **Management recommendations**

In order to increase the productivity of zebra, kudu and giraffe on Sondela Nature Reserve, it is necessary to add more females to the existing herds, thus increasing the ratio of female to male animals and increasing the production rate. Impala and blue wildebeest herds on Sondela are close to the recommended rate and productivity should be optimum already.

Most of the herds show a high percentage of juveniles and sub adults in the population, indicating a fast growth period, but which also leaves it very vulnerable should the young be affected by disease or other mortalities. Sondela frequently captures game to be sold at auctions and during any future captures should make sure that mature animals are not removed in excess.

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APPENDIX

Appendix 1. Habitat selection recording sheet

Date:  Time:  Community Grid:

**Species**

**Activities**

Grazing	<input type="text"/>
Drinking	<input type="text"/>
Resting	<input type="text"/>
Flight	<input type="text"/>
Moving	<input type="text"/>
Mating	<input type="text"/>
Fighting	<input type="text"/>

**Association**

<input type="text"/>
<input type="text"/>
<input type="text"/>
<input type="text"/>

**Distance from water**

0 - 100 m	<input type="text"/>
100 - 200 m	<input type="text"/>
200 - 500 m	<input type="text"/>
> 500 m	<input type="text"/>

**Cover**

Tree (>6m)	<input type="text"/>
Tree (2 - 6m)	<input type="text"/>
Shrub (< 2m)	<input type="text"/>
Herbaceous	<input type="text"/>

**Rock cover**

0 - 25%	<input type="text"/>
> 26%	<input type="text"/>

**Erosion**

Slight / none	<input type="text"/>
Moderate	<input type="text"/>

**Landscape**

Plains	<input type="text"/>
Drainage	<input type="text"/>

**Grass height**

Short (0 - 200mm)	<input type="text"/>
Tall (> 200mm)	<input type="text"/>

Adult females	<input type="text"/>
Adult males	<input type="text"/>
Sub adult females	<input type="text"/>
Sub adult males	<input type="text"/>
Juvenile females	<input type="text"/>
Juvenile males	<input type="text"/>

Appendix 2. Population dynamics recording sheet

Date:  Time:  Community Grid:

Species  Herd size

Adult females   
 Adult males

Sub adult females   
 Sub adult males

Juvenile females   
 Juvenile males

Species  Herd size

Adult females   
 Adult males

Sub adult females   
 Sub adult males

Juvenile females   
 Juvenile males

Species  Herd size

Adult females   
 Adult males

Sub adult females   
 Sub adult males

Juvenile females   
 Juvenile males