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FEEDING BIOLOGY OF COMMON AND BLUE DUIKER

A thesis submitted in the fulfilment of

the requirements for the degree of

MASTER OF SCIENCE

of

RHODES UNIVERSITY

by

FREDERICK KIGOZI

December 2000

DECLARATION

I hereby declare that this thesis has not been submitted before to any other university for degree or examination purposes and that it is my original work except for the vegetation surveys at Kasouga and Salem.

Signed by Frederick Kigozi on this twenty-second day of December in the year 2000.

ABSTRACT

The blue duiker, *Philantomba monticola* and common or grey duiker, *Sylvicapra grimmia* represent two of the three duiker genera as well as two of the three species occurring in Southern Africa. The two species have not been adequately studied in their habitats within the Eastern Cape Province of South Africa, and this thesis centres around their biology with focus on diet and dental microwear.

Faecal analysis was used to study the diet of blue duiker at Salem in the Albany district, and of common duiker on two farms, one a predominantly cattle farm at Kasouga and the other a farm for cultivation of chicory at Grants valley, both in the Bathurst district. The validity of faecal analysis was reviewed, and its applicability to blue and common duiker assessed. The method was appropriate for diet analysis of both species, as the common duiker is shy and secretive and the blue duiker is a rare and protected species which does not habituate readily.

Results showed that the blue duiker was mainly folivorous with a seasonally stable diet of 79% dicot foliage and only 17% fruit. Common duiker diet at both study sites comprised mostly dicot foliage, with only two monocotyledonous plant species. Twenty-seven and nineteen plant species were identified in the diets of common duiker at Kasouga and Grants valley respectively and the annual percentage occurrences of dicot foliage in the diets were about 99% at both study sites. The predominantly browsing common duiker, therefore offered negligible competition for food resources to the grazing cattle on Kasouga farm. Both blue and common duiker fed selectively, with approximately one third of the total number of plant

species identified in their diets providing at least 50% of the food eaten annually. *Ehretia rigida* was the most important plant species in the diets of both duiker species.

Chicory, *Chichorium intybus* provided more than one third (35.6%) of the winter diet and a substantial proportion (14.4%) of the spring diet of common duiker at Grants valley, thereby confirming earlier reports of this species feeding on chicory and other cultivated crops. The diet of common duiker at Kasouga did not vary seasonally but that of common duiker at Grants valley did vary and this was attributed to utilisation of chicory.

Results from the dental microwear analyses did not show any significant differences in dental microwear between blue and common duiker, but supported and confirmed that the two were browsing species, characterised by many pits and few scratches on their dental surfaces. A high incidence of pits was found on the dental surfaces of both duiker species, and was attributed to utilisation of fruit in the diet.

TABLE OF CONTENTS

LIST OF FIGURES ... v

LIST OF TABLES ... vi

LIST OF APPENDICES ... vii

ACKNOWLEDGEMENTS ... viii

CHAPTER 1: GENERAL INTRODUCTION. ... 1

1.1 OVERVIEW ... 1

1.2 PREVIOUS STUDIES ... 5

1.3 AIMS ... 6

CHAPTER 2: DIET OF COMMON DUIKER AT KASOUGA FARM. ... 7

2.1 INTRODUCTION ... 7

2.2 MATERIALS AND METHODS ... 12

2.2.1 Study area ... 12

2.2.2 Reference plant collection ... 13

2.2.3 Preparation of plant cuticle reference collection ... 14

2.2.4 Collection of faecal samples ... 14

2.2.5 Preparation of faecal samples for analysis ... 15

2.2.6 Microscopic analysis of faecal material ... 15

2.2.7 Data analyses ... 16

2.2.8 Dietary plant availability ... 16

2.3 RESULTS ... 18

2.3.1 Reference plant collection ... 18

2.3.2 Collection of faecal samples ... 18

Pencil, ink marks and highlighting ruin books for other readers.

Make your own notes. NEVER underline or write in a book.

2.3.3 Dietary analysis 18
2.3.4 Food preference 19
2.4 DISCUSSION 22
2.4.1 Faecal analysis 22
2.4.2 Diet of common duiker at Kasouga farm 24

CHAPTER 3: THE SIGNIFICANCE OF CHICORY TO THE DIET OF COMMON DUIKER. 28
3.1 INTRODUCTION 28
3.2 MATERIALS AND METHODS 31
3.2.1 Study area 31
3.2.2 Preparation for faecal analysis 32
3.2.3 Microscopic analysis of faecal material 32
3.2.4 Data analyses 33
3.3 RESULTS 34
3.3.1 Microscopic analysis of faecal material 34
3.4 DISCUSSION 37
3.4.1 Faecal analysis 37
3.4.2 Diet of common duiker at Grants valley 37

CHAPTER 4: DIET OF BLUE DUIKER AT SALEM. 41
4.1 INTRODUCTION 41
4.2 MATERIALS AND METHODS 44
4.2.1 Study area 44
4.2.2 Preparation for faecal analysis 45

4.2.3 Microscopic analysis of faecal material 45

4.2.4 Data analyses 46

4.2.5 Plant abundance in the field 46

4.3 RESULTS 47

4.3.1 Diet of blue duiker at Salem 47

4.3.2 Food preference 49

4.4 DISCUSSION 51

CHAPTER 5: DENTAL MICROWEAR IN RELATION TO DIET IN BLUE AND COMMON DUIKER. 55

5.1 INTRODUCTION 55

5.2 MATERIALS AND METHODS 58

5.2.1 Sampling of specimens 58

5.2.2 Preparation of dental replicas 59

5.2.3 Scanning electron microscopy (SEM) analysis 60

5.2.4 Data collection and analyses 61

5.3 RESULTS 62

5.3.1 Dental microwear analyses 62

5.4 DISCUSSION 64

CHAPTER 6: GENERAL DISCUSSION AND CONCLUSIONS 68

APPENDICES **73**

REFERENCES **82**

LIST OF FIGURES

FIGURE 1.1: Map showing the geographical distribution of the common duiker, *Sylvicapra grimmia*. (From Skinner and Smithers, 1990). 4

FIGURE 1.2: Map showing the geographical distribution of the blue duiker, *Philantomba monticola*. (From Skinner and Smithers, 1990). 4

FIGURE 2.1: Map showing the geographical location of Kasouga. (Modified from Randell, 1999) 13

FIGURE 3.1: Map showing the geographical location of Grants valley and the three chicory growing districts (Alexandria, Albany and Bathurst) of the Eastern Cape Province of S. Africa. (Modified from Randell, 1999) 31

FIGURE 4.1: Map showing the geographical location of Salem. (Modified from Randell, 1999) 44

FIGURE 5.1: Skulls (A) of blue duiker (left) and common duiker (right) as well as their lower jaws (B) showing the 3 molars and 3 premolars. Note the positioning of the second lower molar in the blue duiker (foreground) and common duiker (background). 59

FIGURE 5.2: Scanning electron micrographs taken from the occlusal surfaces of the second lower molars of common duiker (A) and blue duiker (B). The horizontal arrow indicates a scratch and the vertical arrow a pit. Magnification is 450 X. 63

LIST OF TABLES

Table 2.1: Percentage occurrence of plant species identified in the autumn/winter and spring/summer faecal samples of common duiker at Kasouga farm. 20

Table 2.2: Indices of preference (% consumed / % available) for some (those whose field abundance data were available) of the identified food plants in the seasonal diets of common duiker at Kasouga. Values > 1 indicate preference, while those < 1 show avoidance. 21

Table 3.1: Percentage occurrence of chicory, dicotyledons and monocotyledons in the spring and winter samples of common duiker at Grants valley. 35

Table 3.2: Percentage occurrence of plant species identified in common duiker faecal samples for winter and spring. The plants marked with asterisks (principal items) have a mean percentage greater than 5%. 36

Table 4.1: Percentage occurrence of plant species identified in the spring/summer and autumn/winter faecal samples of blue duiker at Salem. Plants marked with asterisks were consumed in greatest quantities (mean annual % > 6%). 48

Table 4.2: Percentage seasonal occurrence of plant food categories in the diet of blue duiker at Salem. 49

Table 4.3: Indices of preference (% consumed ÷ % available) for some (those identified in the diet and whose field availability data were available) of the plant species identified in the diet of blue duiker at Salem. Values greater than one indicate preference, and those less than one show avoidance. 50

Table 5.1: Numbers, ratios and percentages of pits and scratches on teeth of the blue and common duiker. 62

LIST OF APPENDICES

APPENDIX A: Common and botanical (scientific) names of plants comprising the reference plant collection used for common duiker (*Sylvicapra grimmia*) diet analyses at Kasouga and Grants valley. In brackets ( ) are the local Xhosa common names. 73

APPENDIX B: Common and botanical (scientific) names of plants comprising the reference plant collection used for blue duiker (*Philantomba monticola*) diet analysis at Salem. In brackets ( ) are the local Xhosa common names. 76

APPENDIX C: Information accompanying the blue and common duiker museum specimens, whose second lower molars were used in the dental microwear analyses. 78

APPENDIX D: Scientific names of the animals referred to in the text. 80

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Overview

The duikers are members of the subfamily Cephalophini, which is the largest and least known of all African antelope subfamilies (Wilson, 1996). The lack of information about the biology of the duiker is because most of the approximately 19 species in the taxon are forest dwellers and all are shy and secretive animals (Wilson, 1996; Kingdon, 1997).
Three genera of duiker occur in Southern Africa, and each is represented by a single species (Meester *et al.*, 1986; Skinner and Smithers, 1990). They are, *Philantomba monticola*, the blue duiker; *Cephalophus natalensis*, the red duiker; and *Sylvicapra grimmia*, the common or grey duiker. Two of these, the blue and common duiker are investigated in this study.

The common duiker has the widest distribution of all African antelopes, occurring almost everywhere South of the Sahara (Morris, 1965) (Figure 1.1). Throughout their wide geographical range, bush is an essential habitat requirement of the common duiker (Shortridge, 1934; Dunbar, 1978; Skinner and Smithers, 1990). They are found on the fringes of forested areas, but keep out of forests themselves (Wilson, 1987; Skinner and Smithers, 1990). The wide distribution of common duiker is paralleled by considerable variation in their colour and size (Shortridge, 1934; Wilson, 1987). The colour of the upper parts varies from a greyish-buff to a reddish-yellow colour and the under parts are usually white but may also be tinged red, grey or off-white (Skinner and Smithers, 1990). Common duiker are small antelopes, with males standing approximately 50 to 60 cm at the shoulder, while females may be as much as 20 cm taller (Skinner and Smithers, 1990). Adult males weigh between 15 and 18 kg , while females weigh between 16 and 21 kg (Stuart and Stuart, 1988; Skinner and Smithers, 1990).

Males possess short straight horns between 7.5 cm and 10 cm in length, while females either lack them or have very short stunted horns (Shortridge, 1934; Keymer, 1969; Wilson, 1987; Skinner and Smithers, 1990).

The common duiker is a solitary, secretive and shy species (Wilson and Clarke, 1962; Keymer, 1969; Dunbar and Dunbar, 1979; Boomker, 1981; Wilson *et al.*, 1984; Skinner and Smithers, 1990). The available information about activity patterns of common duiker is contradictory. Skinner and Smithers (1990) state that the common duiker is most active from the late afternoon, extending into the night and again in the morning. On the other hand Keymer (1969) gives the first three hours before sunrise as the period of peak activity, whilst Shortridge (1934) said that common duiker are most active after dusk and during the evening. Randell's (1999) work in the Eastern Cape coastal habitats, indicated that common duiker are most active during the first two to four hours after sunset and that their activity does not increase in the early morning before sunrise.

Many common duiker habitats within its distribution range have been cleared for agriculture and human habitation, however this species seems to adapt well to these changes (Scott, 1991), and in many cases has resorted to utilising cultivated lands as sources of food (Ansell, 1960; Wilson, 1987; Wilson and Roth, 1967; Randell, 1999). An old tale of the Banangwato people in Botswana, which is traced back to the early 1800's during the reign of Chief Khama 1 (Greaves, 1993) points out the co-existence of common duiker and man.

In Southern Africa, blue duiker are confined to a coastal strip along the Eastern Cape, part of the Western Cape and KwaZulu-Natal Provinces (Smithers, 1983; Wilson, 1987; Skinner and Smithers, 1990) (Figure 1.2). They also occur in the west, east and central parts of Africa, but because of their specialised habitat requirements their distribution is discontinuous and patchy (Skinner and Smithers, 1990). The blue duiker is described as a rare species in

South Africa (Crawford, 1984; Smithers, 1986; Bowland,1992) being confined to forests and dense coastal bush (Skinner and Smithers, 1990; Hanekom and Wilson, 1991; Faurie and Perrin, 1993). These habitats provide food as well as primary cover, such that blue duiker seldom venture far from overhead cover and when doing so, transverse open ground rapidly (Skinner and Smithers, 1990; Bowland, 1992; Ross, 1992).

The conservation status of forests and their fauna has often been highlighted because of the threat this fragmented ecosystem faces from human-induced pressures such as overgrazing, bushclearing and invasion by exotic plant species (Geldenhuys and MacDevette, 1989). Though duiker in tropical forests have been described as very resilient to hunting (Robinson and Bodmer, 1999) their status in temperate areas is yet to be established. Forest has been assessed by Rutherford and Westfall (1986) and Lubke and Mckenzie (1996) as the smallest biome in Southern Africa. Bowland (1989) states that the principal threat to blue duiker in South Africa is the destruction and fragmentation of forests.

Blue duiker are the smallest of all the 19 species of African duiker (Wilson, 1996) and the smallest among antelopes in Southern Africa (Meester *et al.*, 1986 Skinner and Smithers, 1990). Adult males stand approximately 30 cm at the shoulder, and weigh about 4 kg, while females are heavier by about 600 g (Skinner and Smithers, 1990). Both sexes carry tiny horns which slope backwards and are often concealed by a tuft of hair (Cillie, 1987; Skinner and Smithers, 1990; Bowland, 1992; Ross, 1992). Blue duiker are most active at dusk and dawn, and spend less than 8 hours a day foraging or patrolling their territories (Skinner and Smithers, 1990; Bowland, 1990, 1992). They seldom move about at night and spend a large portion of daylight hours resting or ruminating (Skinner and Smithers, 1990; Bowland, 1992).

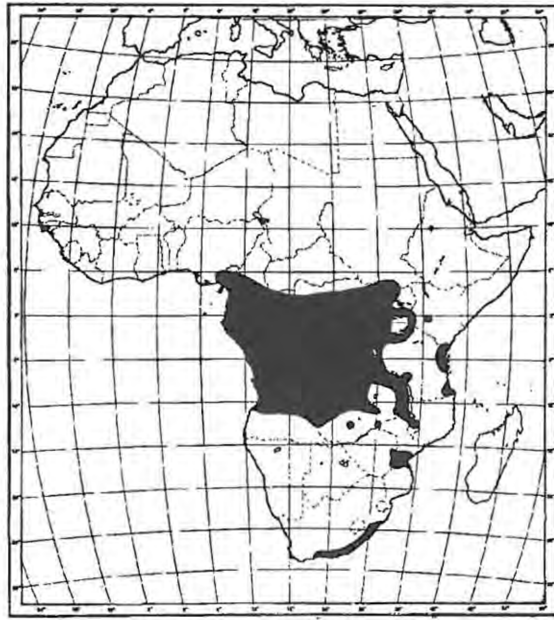

FIGURE 1.2: Map showing the geographical distribution of the blue duiker, *Philantomba monticola*. (From Skinner and Smithers, 1990).

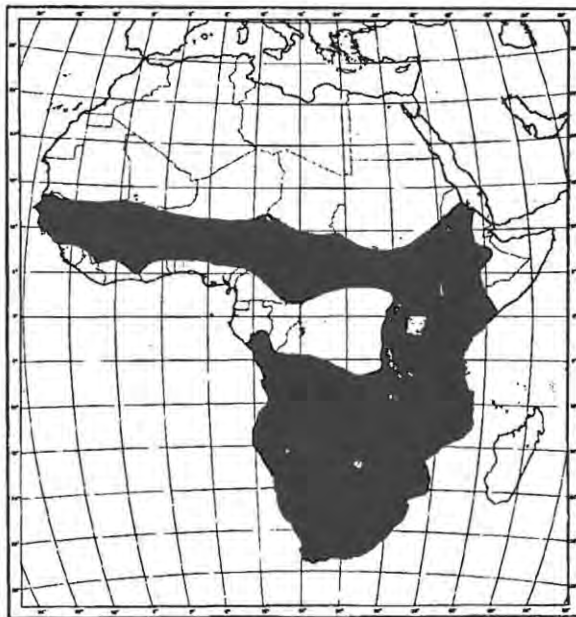

FIGURE 1.1: Map showing the geographical distribution of the common duiker, *Sylvicapra grimmia*. (From Skinner and Smithers, 1990).

1.2 Previous studies

The diets of blue duiker, *Philantomba monticola* and common duiker, *Sylvicapra grimmia* in selected habitats are well documented (Blamey and Jackson, 1956; Wilson and Clarke, 1962; Wilson 1966; Bowland, 1990; Randell, 1999) however, no literature is available about dental microwear in these species. Common duiker are predominantly browsers (Wilson and Clarke, 1962; Keymer, 1969; Boomker, 1981; Skinner and Smithers, 1990). They feed on trees, forbs and shrubs (Hofmann and Stewart, 1972, Dunbar, 1978), bark, roots, flowers, fruits, seeds (Hofmann and Stewart, 1972 Skinner and Smithers, 1990) and cultivated crops (Wilson, 1966; Coetzee, 1979; Skinner and Smithers, 1990; Randell, 1999). Trees, forbs and shrubs are three plant growth forms. Trees are typically considered to comprise plants taller than 3 m and with a single basal trunk, while shrubs are less than 2 or 3 m tall, well branched and possess secondary thickening (are woody), and the forbs are non-woody and usually live for only one or two seasons. However, these terms should be used with caution as a plant that is usually a shrub can grow to be a tree and a plant that is normally a forb can grow into a shrub (Dr D. du Preez, Botany department, University of Port Elizabeth, pers. comm).

Blue duiker browse infrequently, and forage beneath the forest canopy on fallen leaves, fruits and flowers (Skinner and Smithers, 1990, Faurie and Perrin, 1993; Bowland and Perrin, 1998). Leaves and fruits from the canopy are made available to blue duiker through natural senescence, wind fall and by the foraging activities of other animals (Skinner and Smithers, 1990; Faurie and Perrin, 1993).

Child and Riney (1964) investigated dental abnormalities in common duiker, with no mention of tooth wear. Nevertheless, some work has been published about dental wear in relation to diet, in a few antelopes including the common waterbuck, gerenuk, lesser and

greater kudu (Solounias and Hayek, 1993), other bovids such as domestic sheep and goats (Baker *et al.*, 1959 Mainland, 1998), as well as other taxa such as hyrax (Walker *et al.*, 1978), monkeys (Teaford, 1986), small spotted genets, tree civets, suricates and yellow mongoose (Taylor and Hannam, 1987), spotted hyaena, wild dog, grey wolf and cheetah (Van Valkenburgh *et al.*, 1990) as well as the gentle lemur and giant panda (Daegling and Grine, 1994). Most of these studies have illustrated the potential of molar microwear for inference of diet.

The potential for microwear variations on the teeth of blue and common duiker cannot be underestimated, particularly in light of their different habitat requirements (with possible diet differences). Such variation can be a valuable taxonomic tool in identification of skulls, jawbones and loose teeth from carcases of the two species by supplementing the general morphological characteristics. Accurate identification of species is of fundamental importance in ecological monitoring, assessment, impact and conservation work as it often underpins the data from which subsequent analyses and interpretations are made.

1.3 Aims

The objectives of this study are twofold;

1.To analyse the diets of blue and common duiker in three habitats from the Eastern Cape Province of South Africa.

2. To analyse and compare dental microwear of blue and common duiker specimens collected from South Africa, and particularly in the Eastern Cape Province.

CHAPTER 2

DIET OF COMMON DUIKER AT KASOUGA FARM

2.1 Introduction

The process of diet selection by ungulates is fundamental to understanding many aspects of their ecology (Hobbs *et al.*, 1983). Body size and morphology limit the range of foods that ruminants can efficiently eat (Hofmann, 1989), while food selection affects the social structure, patterns of dispersal, and predator avoidance (Jarman, 1974).

In a recent classification of African bovidae, Gagnon and Chew (2000), placed the common duiker in a group devoid of any other duiker species. According to this classification *Sylvicapra grimmia* is a browser with a diet comprising more than 70% dicots, whereas all other cephalophini are frugivores, with a diet of more than 70% fruit. With reference to the feeding styles proposed by Jarman (1974), and in accordance with Skinner and Smither's (1990) description of the diet of common duiker, it would probably be placed in category *a* (Jarman, 1974), with member species predominantly browsers, and taking such items as flowers, twig tips, fruits, seed pods and even bark (Jarman, 1974). Skinner and Smithers (1990) listed tubers and roots in addition to those food items. However, various other strange items like, chickens (Stoneham, 1955), ducklings (Wilson and Clarke, 1962), turkey chicks (Maberly, 1964), guinea fowl, lizard and insect remains (Wilson, 1966), mopane caterpillars (Smithers, 1971), striped mouse (Hofmann, 1973) have also been recorded in the diets of common duiker. Hofmann and Stewart (1972) placed the common duiker in a category of fruit and dicot (tree, shrub or forb) foliage selectors, and all published accounts indicate that common duiker is essentially a selective browser consuming a wide variety of leaves, shoots, flowers, seeds, fruits and roots from numerous dicotyledons (Van der Schijff, 1959; Brynard

and Pienaar, 1960; Wilson and Clarke, 1962; Wilson, 1966; Smithers, 1971; Allen-Rowlandson, 1986; Rowe-Rowe, 1994). With the use of its large mouth and wide maw, common duiker easily bite sizeable chunks of fruit which can be swallowed and latter on ruminated (Wilson, 1987). Utilisation of fruit, a high quality food is important for a small sized antelope like the common duiker (Jarman, 1974). Boomker (1981) suggested that they utilise the lowest level of browse, and this is supported by Furstenburg and Kleynhans (1996), who state that the animals browse mainly below a height of 45 cm from ground level, rarely going up to 60 cm.

In terms of its contribution to the wildlife diversity in the Eastern Cape Province, the common duiker is an important species on many farmlands. However, very little information exists about its diet in these habitats. The greatest value of game animals lies in their utilisation of the harsher environment of the extensive stock-farming areas as well as their ability to endure the competition from domestic stock for food resources (Ferreira and Hoffman, 1999). Farmers in the Eastern Cape are eager to monitor the magnitude of competition that common duiker and other game offer to their livestock with regards to food resources. Furstenburg and Kleynhans (1996) established that minimal competition exists for browse between common duiker and boergoats in the Eastern Cape xerophytic succulent valley bushveld as the preferred feeding height for the two differs considerably.

Hunting for meat of the common duiker is limited in the Eastern Cape, such that land use by farmers, and the impacts on vegetation have a more profound effect on duiker abundance and survival than any other factor.

It is therefore apparent that a study investigating food availability and dietary preference by common duiker at Kasouga will contribute to understanding the effects of land use on duiker populations, and consequently to conservation of the species.

Identifying the diets of animals can be achieved through various methods such as direct observations, analysis of mouth contents, fistula contents, stomach contents and faecal material (Field, 1972; Beukes, 1988; Van Rooyen, 1992; Lewis, 1994; Macleod *et al.*, 1996). These methods are reviewed below in order to ascertain the most appropriate technique for diet analysis in common duiker.

Observations are often restricted to a single animal for just a portion of its grazing time in a limited part of its range (Norbury and Sanson, 1992). The shy nature of common duiker and their habit of being most active at night (Wilson and Clarke, 1962; Keymer, 1969; Dunbar and Dunbar, 1979; Boomker, 1981; Wilson *et al.*, 1984; Skinner and Smithers, 1990) also compound the difficulty of visual observations. Even in situations where a feeding duiker can be spotted from a distance, the bush pockets and, or patches of long grass which they commonly inhabit (Wilson and Roth, 1967; Keymer, 1969; Skinner and Smithers, 1990) impede vision making it difficult to pinpoint the particular plant species being fed on. As an alternative to direct observations in the wild, observations from captive animals can be made, however this alternative was never considered because of the unnatural stress to the subjects, and the practicality of making all food plants available.

Mouth, fistula and stomach contents and faecal analyses are better suited for these shy, secretive and nocturnal species. However, since mouth and fistula content analyses involve handling animals, they are more suitable for tame or easily caught and handled animals (Norbury and Sanson, 1992). Culling for stomach contents analyses would have been a suitable

option, but this necessitates killing of the animals, which raises both ethical and practical constraints. Hunting in the study area is seasonal , and most farmers are not in favour of any form of deviation from this practice.

It therefore emerged that the only viable option was to use faecal analysis, which not only ensured coverage of all seasons but also guaranteed minimum disturbance to the animals.

Faecal analysis has widely been used (Robinson and Stebbings, 1993; Gaylard, 1994; Wrench *et al.*, 1997; Schuette *et al.*, 1998; Perrin and Taolo, 1999) and some authors (Anthony and Smith, 1974) consider it the only feasible method of studying the diets of secretive and shy animals. Common duiker faecal pellets are also easy to locate, identify and collect from the field (Walker, 1981). Compared to other techniques, faecal samples cover a much broader spatial and temporal range of diet (Norbury and Sanson, 1992). The technique also allows practically unlimited sampling and requires lower sample sizes than rumen analysis (Anthony and Smith, 1974).

On the other hand, faecal analysis is also problematic (Gaylard, 1994). Its main disadvantage stems from the discrepancy in the proportions of forage species in the faeces and that consumed, because of differential digestion of plant species (Anthony and Smith, 1974; Gill *et al.*, 1983; Johnson *et al.*, 1983; Stevens *et al.*, 1987; Norbury and Sanson, 1992). Norbury, (1988) and Norbury and Sanson (1992) suggest the use of a correction factor to overcome this problem, but this is based on a questionable assumption that digestion rates are constant among individuals (Gill *et al.*, 1983) and that they remain constant for each species even as diet composition changes.

The other problems inherent in the technique of faecal analysis are in the identification of plant species, and the possible destruction or damage to plant fragments during preparation

(Gaylard, 1994). Norbury (1988) states that only a portion of the plant material (mostly epidermis) bears characteristics that facilitate identification, while Monro (1982) points out that a considerable amount of material examined often turns out to be completely unidentifiable.

Nevertheless, Fitzgerald and Waddington (1979) highlight the occurrence of inadequacies with all other available techniques, such that faecal analysis remains widely used (Perrin and Taolo 1999; Randell, 1999). Furthermore, it has been concluded that digestion does not alter botanical composition significantly (Johnson *et al.*, 1983) and as long as observers have the necessary knowledge and skills to identify plant fragments and quantify them systematically, there should be no lack of confidence in application of faecal analysis to assess diets (Johnson *et al.*, 1983).

The aim of this part of the research was therefore to examine the diet of the common duiker on a livestock farm, so as to contribute to our understanding of the effects of land use on its biology and ecology

2.2 Materials and Methods

2.2.1 Study Area

The study was conducted at Kasouga farm, at Kasouga in the Bathurst district of the Eastern Cape Province of South Africa (Fig. 2.1). The place name is of Gonaque origin and means "place of leopards" (Stirk, 1991). A variety of spellings namely, Gwa Souga, Gasoga and Guasouwga are recorded in history, and the present spelling (Kasouga) has been in use since around 1830 (Stirk, 1991). Kasouga farm is about 5.3 km East and 5.0 km North of the Kariega river mouth at a latitude of 33°38' S, a longitude of 26°44' E, and an altitude of about 105 metres (Anon c, 1975; Anon b, 1976). The farm is managed for cattle ranching, with more than 500 cattle being maintained alongside common duiker, oribi and bushbuck.

The terrain is of low relief and consists of slightly undulating plains (Schulze, 1997). Kasouga has a mean annual precipitation between 600 mm and 800 mm, and receives rainfall all year round. Mean daily temperatures vary between 15° C in winter and 22° C in summer (Schulze, 1997). Kasouga falls in the post-cretaceous calcareous zone (Dyer, 1937) and soils are sandy. Acocks (1975) described the vegetation of the area as coastal forest and thornveld (veld type 1), and a recent vegetation survey (Lubke and McKenzie, 1996; Lubke *et al.*, 1996) indicated a combination of coastal forest and grassland. Randell (1999) recognised *Scutia myrtina*, *Rhus sp*, *Acacia karro* and *Diospyros dichrophylla* as the dominant plant species of the bushes in the area.

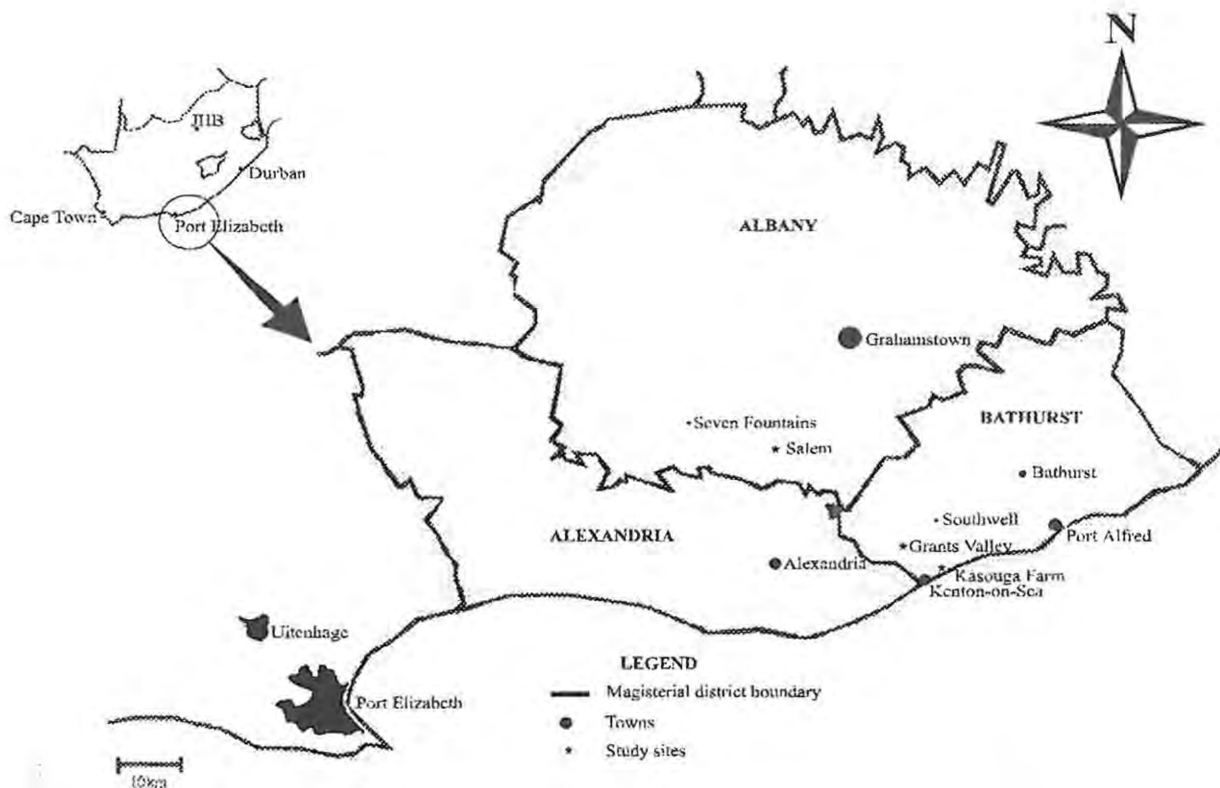

FIGURE 2.1: Map showing the geographical location of Kasouga (Modified from Randell, 1999).

2.2.2 Reference plant collection

A representative collection of vegetation in the study area was made through gathering plant specimens once weekly during the entire study period. Only plant material within reachable height (Not more than 1.5 m above ground level) by an adult common duiker was sampled and recorded. The materials collected included leaves, seeds, fruits, floral parts and roots. These were then pressed prior to identification at the Albany museum herbarium. Thereafter all plant material with the exception of seeds were used to prepare a reference collection of epidermi of plant species found in the study area.

Since common duiker are exclusively browsers, only very rarely eating grass (Wilson and Clarke, 1962; Wilson, 1966; Allen-Rowlandson, 1986), greater emphasis was devoted to collecting dicotyledonous species. The availability of most dicotyledons throughout the year

made their collection in the first months of the study possible. However, the collection of their floral parts and fruits extended for a longer period, since these appeared seasonally.

2.2.3 Preparation of plant cuticle reference collection

A reference collection of plant epidermi was compiled using a method which is a modification from Storr (1961) and McAllister and Bornman (1972). This method which has previously been used with success (Gaylard and Kerley, 1995; Kigozi, 1996) involves cutting the leaves into 15 mm lengths and then boiling them gently in a flask containing 10% nitric acid. The apparatus was set up in a fume cupboard, however, boiling can also be done outside the fume cupboard by simply attaching the flask to a vacuum (Gaylard, 1994; Kigozi, 1996). Depending on the texture of the leaf, the epidermis begun peeling away after 5 to 10 minutes. The leaf material was then washed under running tap water to remove any residual acid, and the cuticle was removed by gently waving the piece of leaf in a beaker of water with a pair of forceps. The cuticle layer was removed from the beaker, lightly stained with haematoxylin and mounted on a microscope slide (Macleod *et al.*, 1996). Photomicrographs were taken of both the adaxial and abaxial surfaces, because of possible cuticular differences between the two (Macleod, 1992).

2.2.4 Collection of faecal samples

Faecal pellets were collected from the study area at least twice a month. Preliminary attempts to age pellets failed, because only day old pellets could be aged with certainty. As a result the twelve samples collected were pooled into two groups, a spring/summer group (September to February) and an autumn/winter group (March to August). The pellets were

then stored in marked plastic bags and frozen until preparation for analysis (Kirchhoff and Larsen, 1998).

2.2.5 Preparation of faecal samples for analysis

A sub-sample of ten randomly selected pellets from each group of faecal samples was broken up using a glass rod and digested in 4 ml concentrated nitric acid over a low heat for approximately 2 minutes (Ferreira and Bigalke, 1987; Gaylard, 1994). This was then made up to 100 ml with distilled water and boiled and stirred for a further few minutes. The resulting sample was allowed to cool then centrifuged for 15 minutes at 2000 RPM, and the supernatant discarded. This process removed most of the leaf mesophyll, facilitating identification whilst keeping the epidermis intact (Gaylard, 1994). The remaining cuticle fragments were stored in 5 ml FAA (25% distilled water, 60% absolute alcohol,10% formalin and 5% glacial acetic acid).

2.2.6 Microscopic analysis of faecal material

The prepared faecal fragments were shaken, a sub-sample (of about 4 drops) drawn with a dropper and placed on a gridded microscope slide and viewed at 400 X magnification. This was repeated six times from each of the pooled samples. According to Dusi (1949), a small fraction of faecal material spread homogeneously under a coverslip contains all food items in the sample.

Plant fragments in the faecal matter were identified with the aid of the plant cuticle reference collection. Cell shapes and sizes, guard cells and stomatal features, presence and appearance of hairs and trichomes as well as cell wall thickness were some of the characteristics used to identify plant fragments. Fragments that did not have sufficient characteristics for identification were coded as unidentified dicotyledons or monocotyledons. Plant fragments that could not be

differentiated at the species level, as was the case with some members of the genus *Rhus* were represented by the generic name followed by *sp* (*Rhus sp*). The first 100 identifiable fragments in each sub-sample were recorded (Ferreira and Bigalke, 1987; Gaylard, 1994; Macleod *et al.*, 1996).The very small unidentifiable fragments were ignored (Gaylard and Kerley, 1995).

2.2.7 Data analyses

The numbers of fragments counted were used to compute percentage occurrences of plant species in the spring/summer and autumn/winter faecal samples. A mean (annual) percentage occurrence for each plant species was also calculated. A t-test was done on the raw data (Zar, 1996) to determine if any seasonal difference existed in occurrence of plant species in the faecal material.

2.2.8 Dietary plant availability

Estimation of food preferences and diet selection involves comparison of the relative abundances of food items available to an animal, with the relative abundances of food items consumed by the animal (Johnson, 1980; Norbury and Sanson, 1992). Random sampling of vegetation in the study area was done during spring/summer and autumn/winter seasons. Only plant material at a height (Not more than 1.5 m above ground level) within reach of the common duiker were taken into account.

Abundances and estimates of percentage cover, in thirty 5 m X 5 m quadrats spread randomly throughout the study area, were recorded. The quadrats were determined by throwing a small stick from various positions within the study site and using its point of landing as the distal left corner of the quadrat. A preference index (PI = [% Consumption] ÷ [% Availability]) (Davies *et al.*, 1986) was calculated to indicate the extent of utilisation of plant species in relation to

their availabilities. A preference index greater than one indicated selection for that species, whereas a value less than one indicated that the item was consumed in proportions less than its abundance in the environment (Kerley, 1990; Macleod *et al.*, 1996).

2.3 Results

2.3.1 Reference plant collection

Seventy two plant species (Appendix A minus chicory) were used in the reference plant collection.

2.3.2 Collection of faecal samples

Most of the common duiker faecal pellets were located within and at the periphery of the bush clumps. Size and shape was used to differentiate common duiker faecal pellets from those of other species in the study area. Although at a glance profound similarities exist between the pellets of common duiker and oribi, the two can be distinguished. The latter are often located in middens (Walker, 1981), and preliminary microscopic examination showed differences. Oribi diet and faecal matter consists mostly of monocotyledons, whilst diet and consequently faecal matter of common duiker is mostly dicotyledonous in composition. Furthermore, when crushed between the fingers, oribi pellets appear more fibrous than those of the duiker.

2.3.3 Dietary analysis

A total of 27 plant species were identified in the pellets of the common duiker at Kasouga farm (Table 2.1). Four of these with a total annual percentage of about 8 % could only be identified as dicotyledons. The t-test showed no significant difference ($P = 0.998$; $df = 52$) in occurrence of plant species between spring/summer and autumn/winter samples. Out of the 27 dietary items, 20 were recorded in both seasons, 4 only occurred in the spring/summer diet, and 3 were confined to the autumn/winter diet (Table 2.1). The total percentages of the 4 plant species

only occurring in the spring/summer and the 3 only present in the autumn/winter diet were 5.4 % and 2.5 % respectively.

Approximately one quarter (23.6 %) of the annual diet of the common duiker was made up *Ehretia rigida*, whilst the same species along with 3 others, *(Dovyalis rotundifolia*, *Diospyros dichrophylla* and *Euclea undulata*) made up 63.6 % and 59.4 % of the spring/summer and autumn/ winter diets respectively.

Two monocotyledons, *Sanseviera hyancithoides* and *Protasparagus densiflorus* with a combined annual percentage of 0.5 % were identified in the diet of the common duiker. The dicotyledonous species identified in the diet of common duiker comprised, 8 forbs, 5 trees and 8 shrubs.

2.3.4 Food preference

The preference indices (Table 2.2) for common duiker show that *Euclea undulata* was the most preferred food item during both spring/summer and autumn/winter seasons. Highly selected species during spring/summer (in descending order of preference) included *Euclea undulata*, *Ehretia rigida*, *Rhus spp* and *Lobelia tomentosa*, while in autumn/winter the sequence was *Euclea undulata*, *Ehretia rigida*, *Lobelia tomentosa* and *Rhus spp*. *Ehretia rigida* is a shrub, *Lobelia tomentosa*, a forb, *Rhus crenata*, *Rhus glauca* and *Rhus incisa*, all shrubs, while *Euclea undulata* is a shrub which can grow into a small tree (Dr. D. du Preez, Botany department, University of Port Elizabeth, pers. comm.). The general trend in preference was a higher preference index during the warmer than the colder months (autumn/winter). *Senecio inaequiedens*, a forb and *Pterocelastrus tricuspidatus* which is a shrub that can grow into a small tree both had a much higher preference index in winter than summer.

Two species (a monocot and shrub) were avoided (PI < 1) during spring/summer as well as autumn/winter seasons.

Table 2.1: Percentage occurrence of plant species identified in the Autumn / Winter and Spring / Summer faecal samples of common duiker at Kasouga farm

Plant species	**March - August (Autumn/Winter)** (n=23)	**September - February (Spring/Summer)**(n=24)	**Annual** (n=27)
Ehretia rigida	27.6	19.6	23.6
Dovyalis rotundifolia	15.0	17.5	16.3
Diospyros dichrophylla (fruit)	9.4	13.8	11.6
Euclea undulata	7.4	12.7	10.0
Lobelia tomentosa	4.7	5.0	4.8
Rhus crenata	7.0	2.7	4.8
Rhus sp	2.4	3.2	2.8
Pterocelastrus tricuspidatus	3.7	2.0	2.8
Unidentified d	5.2	0.3	2.8
Senecio inaequidens	2.7	2.5	2.6
Scutia myrtina	0.7	4.1	2.4
Zanthoxylum capense	1.8	2.7	2.3
Unidentified b	1.8	2.7	2.3
Carissa haematocarpa	3.2	0.7	2.0
Unidentified a	1.5	2.1	1.8
Senecio sp (flower)	-	2.8	1.4
Chrysanthemoides monolifera	-	2.3	1.2
Felicia aethiopica	1.3	0.8	1.1
Unidentified c	1.1	1.0	1.0
Nemesia floribunda	1.3	-	0.7
Trifolium burchellianum	0.9	-	0.5
Rhus glauca	0.5	0.3	0.4
Sanseviera hyancithoides	0.2	0.6	0.4
Rhus sp (fruit)	0.3	0.3	0.3
Wahlenbergia sp	0.3	-	0.2
Protasparagus densiflorus	-	0.2	0.1
Helichrysum odoratissimum (Pollen)	-	0.1	0.1

Table 2.2: Indices of preference (% consumed / % available) for some (those whose field abundance data were available) of the identified food plants in the seasonal diets of common duiker at Kasouga. Values >1 indicate preference, while those <1 show avoidance.

Plant species	Available (%)		Consumed (%)		Preference index	
	A/W (n=18)	S/S (n=18)	A/W (n=18)	S/S (n=15)	A/W (n=18)	S/S (n=15)
Euclea undulata	0.1	0.03	7.4	12.7	74.0	423.3
Ehretia rigida	0.5	0.1	27.6	19.6	55.2	196.0
Rhus sp	0.1	0.03	2.4	3.2	24.0	106.7
Rhus crenata	0.1	0.03	7.0	2.7	70.0	90.0
Lobelia tomentosa	0.1	0.1	4.7	5.0	47.0	50.0
Dovyalis rotundifolia	1.1	0.5	15.0	17.5	13.6	35.0
Felicia aethiopica	0.1	0.03	1.3	0.8	13.0	26.7
Nemesia floribunda	0.1	1.1	1.3	-	13.0	-
Rhus sp (fruit)	0.1	0.03	0.3	0.3	3.0	10.0
Zanthoxylum capense	0.1	0.3	1.8	2.7	18.0	9.0
Diospyros dichrophylla	3.8	1.8	9.4	13.8	2.5	7.7
Pterocelastrus tricuspidatus	0.1	0.5	3.7	2.0	37.0	4.0
Senecio inaequidens	0.1	1.2	2.7	2.5	27.0	2.1
Scutia myrtina	0.2	1.4	0.7	4.1	3.5	2.9
Wahlenbergia sp	0.1	0.03	0.3	-	3.0	-
Trifolium burchellianum	0.6	1.6	0.9	-	1.5	-
Carissa haematocarpa	3.9	1.7	3.2	0.7	0.8	0.4
Sanseviera hyancithoides	4.7	2.7	0.2	0.6	0.04	0.2

Legend

A/W = Autumn/Winter

S/S = Spring/Summer

2.4 Discussion

2.4.1 Faecal analysis

The most readily obtained samples of diets are provided by faeces (Perrin and Taolo, 1999). Common duiker faecal pellets were easily located, identified (Walker, 1981) and collected from the study area. Faecal analysis is non-intrusive and causes minimum disturbance to the common duiker which is a shy and secretive species (Wilson and Clarke, 1962; Dunbar and Dunbar, 1979; Skinner and Smithers, 1990). The faecal samples also covered a broad spatial and temporal range of diets. In addition, the use of faecal samples eliminated the necessity of killing animals to obtain rumen contents. Although rumen samples could be obtained during game hunting, sampling would have been biassed because hunting in the study area is seasonal and restricted.

Microscopic examination of the cellular structure of epidermis of plant species in faeces using characteristic features (like cell shapes, sizes and arrangement, stomata shapes and arrangement, presence or absence of hairs) made it possible to isolate and identify 27 plant species in this study.

Only four of these were not identifiable (beyond being dicotyledons), but were at least differentiable from the monocots. Buys (1990) states that the structural differences between monocots and dicots are very conspicuous. Monocot cells appear in neatly arranged parallel rows, while dicot cellular arrangement is more patterned. Many plant species are difficult to separate at the species level and sometimes at the genus level (Gaylard, 1994). In this study this was encountered with species belonging to the genus *Rhus*. Some plant fragments could not be identified, either as a result of damage during preparation or lack of adequate characteristics for identification. In addition to the above shortcomings of faecal analysis experienced in this study, others that have been cited are as follows.

1. Faecal analysis may reflect plant species consumption inaccurately owing to differential digestibility of different species (Anthony and Smith, 1974; Gill *et al.*, 1983; Norbury and Sanson, 1992). Proportions of plant species consumed may differ from those appearing in the faeces.

2. Species eaten infrequently and in small quantities may be missed completely (Stewart, 1967), whilst woody plants produce more fragments than grasses or forbs (Johnson *et al.*, 1983).

3. Analytical biases (Anthony and Smith, 1974) such as use of only particular structural characteristics (usually the most distinct) when microscopically identifying plant species.

4. Observer training and experience (Johnson *et al.*, 1983). Preparation and analysis of samples is done differently.

To overcome some of these problems, some studies have supplemented faecal analysis with other techniques like rumen sample analysis and field observation (Allen-Rowlandson, 1986; Lewis, 1994; Macleod *et al.*, 1996). Despite these inadequacies, faecal analysis remains widely used (Gaylard, 1994; Wrench *et al.*, 1997; Schuette *et al.*, 1998; Perrin and Taolo, 1999). Anthony and Smith (1974) recommend the technique for studying diets of secretive, shy and nocturnal animals like the common duiker.

Different methods of data presentation illustrate different aspects of diet, while trying to avoid biases owing to inherent inaccuracies of faecal analysis. Frequency of occurrence was used to quantify the plant species identified in the diet of common duiker. This method, which has commonly been used (Anthony and Smith, 1974; Odendaal, 1983; Ferreira and Bigalke, 1987), gives an indication of the importance of each plant species in providing food for the animal.

2.4.2 Diet of common duiker at Kasouga farm

The dominant plant species in the diet of common duiker at Kasouga were *Ehretia rigida* (23.6%), *Dovyalis rotundifolia* (16.3%), *Diospyros dichrophylla* (11.6%) and *Euclea undulata* (10%), while *Rhus spp* (8.3%) and *Lobelia tomentosa* (4.8%) were also eaten in substantial quantities. These food plants made up the principal food items of the animals at Kasouga. Petrides (1975) defines principal food items as those eaten in the greatest proportions. Various botanical surveys of, and in the vicinity of Kasouga (Hutchinson, 1946; Martin *et al.*, 1960; Stirk, 1991; Lubke and McKenzie, 1996; Lubke *et al.*, 1996), list these plant species amongst others as characteristic of coastal habitats. They are all evergreen and *Diospyros dichrophylla* appears to fruit year round, while *Rhus spp* fruit mainly during the winter months, and the flowers of *Lobelia tomentosa* are available throughout the year.

The four dominant food items made a contribution well above half of the diet for the spring/summer (63.6%) and autumn/winter (59.4%) seasons. This demonstrates the selective nature of feeding in the common duiker, which was also shown by Allen-Rowlandson (1986). Hofmann (1973) explains the selectivity in common duiker in terms of its fairly undifferentiated rumen which is poorly adapted to a diverse diet.

According to Keymer (1969), Boomker (1983), Allen-Rowlandson (1986) as well as Skinner and Smithers, (1990), the common duiker is predominantly a browser and has recently (Gagnon and Chew, 2000) been classified likewise. Gagnon and Chew (2000) classified the animal as a browser, with more than 70% of its diet comprising dicots. The results of this study concur with this description of common duiker, as only 0.5% of its diet was monocots, and 11.9% fruit, with the rest (87.6%) dicot foliage.

Out of the 27 plant species identified in the diet of common duiker at Kasouga, only two monocotyledons (*Sanseviera hyancithoides* and *Protasparagus densiflorus*) with an annual

percentage of 0.5% were recorded. Comparatively, Allen-Rowlandson (1986) found common duiker diet to comprise only 0.3% grasses, whilst Wilson and Clarke (1962) sampled grasses from only 4 out of 150 common duiker they studied.

Browsing is advantageous, as dicot foliage contains more protein and soluble carbohydrates than grasses (monocots), and Jarman (1974) stresses the necessity of a small antelope (like the common duiker) with a high metabolism to select highly nutritious food items.

The diet of common duiker at Kasouga did not significantly differ between spring/summer and autumn/winter, as 20 out of the 27 plant food items identified were recorded in both seasons, and the 4 dominant food plants were represented by almost similar percentages (63.6% Vs 59.4%) in these seasons. Furthermore, the total percentages of the 4 plant species only occurring in the spring/summer diets was about 5%, and that of the three species confined to autumn/winter was approximately 3%.

Euclea undulata, Ehretia rigida, Rhus spp and *Lobelia tomentosa* were the four most highly selected plant species for both spring/summer and autumn/winter seasons, and the general trend in preference was a higher index during spring/summer than autumn/winter season. The higher preference indices for the warmer months may be attributed to the lower availability of plant species during spring/summer, and it can also be speculated that the decreased energy demands during the warmer months gives the common duiker more time to devote to selecting preferred food types. It can also be assumed that the high metabolism and resultant raised energy demands during the cold season, does not give the animal much choice, but to possibly eat the first edible species that are encountered whilst foraging. Furthermore, it is also possible that the quality of common duiker's plant foods at Kasouga decreases during the colder, drier winter period, such that the animals become less selective, which is exhibited by lower preference indices for most plant species in their diet. The lowered quality and quantity of

antelope food plants in winter has been mentioned by various authors (Skinner and Smithers, 1990; Owen-Smith, 1998; Winterbach and Bothma, 1998).

Carissa haematocarpa, a shrub and *Sanseviera hyancithoides*, a monocot were avoided (preference index; PI < 1) during both spring/summer and autumn/ winter seasons.

Senecio inaequidens and *Pterocelastrus tricuspidatus* both had a much higher preference index in winter than in summer, and this was more a result of the seasonal difference in their availability rather than their seasonal difference in consumption.

Dyer (1937), Martin *et al.*, (1960), Acocks, (1975), Lubke (1996), Lubke and McKenzie (1996) as well as Randell (1999) have indicated that the bush clumps in the Kasouga area are predominantly made up of dicot species, some of which (like *Ehretia rigida, Dovyalis rotundifolia, Diospyros dichrophylla, Rhus crenata, Rhus glauca* and *Euclea undulata*) were found to be important in the diet of common duiker. Furthermore, most of the common duiker faecal pellets were located within and at the periphery of the bush clumps. This suggests that common duiker spend a considerable amount of time within the bush clumps either feeding or hidden while lying down and ruminating.

In general, my results for percentage occurrence of plant species in the faeces of common duiker, and those for food preference indicated that the most important plant species in the diet of the common duiker at Kasouga were *Euclea undulata* and *Ehretia rigida*.

The effects of ungulates on the composition of plant communities depend on the relative abundance of browsers and grazers, as well as the selectivity of foraging by any given herbivore (Augustine and McNaughton, 1998). The feeding relationship between grazers and browsers of a community is facilitative rather than competitive (Gwynne and Bell, 1968). Kasouga farm is predominantly stocked with cattle alongside common duiker, oribi and

bushbuck. Cattle and oribi (grazers) offer no feeding competition to the common duiker which is mainly a browser. However, bushbuck which are also browsers compete with common duiker for browse, but this competition is limited by the difference in feeding height between the two species (Haschick, 1994). Furstenburg and Kleynhans (1996) assessed integration of duiker, kudu and bushbuck in boergoat production systems in the Eastern Cape valley bushveld, and they established that common duiker rarely feed above 60 cm whereas bushbuck can feed up to height of 130 cm above ground level.

CHAPTER 3

THE SIGNIFICANCE OF CHICORY TO THE DIET OF COMMON DUIKER

3.1 Introduction

South Africa is considered one of the top four chicory producing countries of the world, with an output of approximately 900,000 tons of wet root annually (Randell, 1999). However, the country does not export any chicory, making it one of the top five chicory consumers of the world (Anon a, 1992).

Chicory, *Chichorium intybus* is a perennial plant of the daisy family which is indigenous to North America, but also grown in vast areas of Asia, Europe and Africa. The plant has heads of large, bright blue florets and dandelion-like roots. Its leaves are used in salads and the roasted and pulverised root is used in coffee blends or as a coffee substitute. The practice of adding chicory to coffee began in France during the 17 th century and was enforced during the Napoleonic blockade when the importation of coffee was extremely difficult. This practice continues today, because of the aroma and flavour given to coffee, and the belief that it neutralises the acids and caffeine in coffee (Anon a, 1992).

Commercial growing of chicory in South Africa is restricted to a small section (Alexandria, Albany and Bathurst districts) along the Eastern Cape coast (Anon a, 1992). In these three districts, chicory cultivation has been at the expense of coastal habitats for a number of mammal species like common duiker, oribi and porcupine (Pers. obs). Geist (1974) states that among other ecological parameters, habitat stability influences social behaviour and organisation in ungulates. As a result of destruction of their natural habitats to make way for chicory cultivation, these mammals have resorted to utilising chicory as an alternative and easily accessible source of food. Common duiker have been recorded feeding on chicory for

the past 21 years (Coetzee, 1979), thus confirming earlier reports (Ansell, 1960; Wilson and Roth, 1967) that they are great raiders of cultivated crops. Wilson and Roth (1967) also emphasised the great adaptability of common duiker to human activities. This is further highlighted by an old tale (from early 1800's) of the Bamangwato people in Botswana (Greaves, 1993).

The chicory farmers consider common duiker a major pest, and they assume that the species shows a preference for chicory over natural vegetation (Randell, 1999). However there are no data to verify this. At present chicory farmers are making use of fencing, and to a very limited extent hunting, to deter duiker invasions on their farms. However, Wilson and Roth (1967) expressed reservations about effectiveness of hunting to control common duiker populations. On top of that hunting is also a globally sensitive topic in most habitats. Details obtained from the farmers suggest that hunting of common duiker as a source of meat is limited, although limited poaching occurs (A. Maclachlan , Rhodes University, Grahamstown, S.A, pers. comm.). Most farmers support wildlife conservation in the area, and emphasise the importance of wildlife diversity on their farms (Randell, 1999; A. Maclachlan, pers. comm.).

According to the South African chicory board, rainfall and prevailing weather conditions are the most influential factors affecting cultivation of chicory (Anon a , 1992). Since farmers have no control over these parameters it is imperative that they minimise the loss due to other agents in their control (mammalian pests like the common duiker).

Intensive habitat management requires accurate estimates of the diets of foraging animals (Gill *et al.*, 1983). The aim of this study was thus, to determine the diet of common duiker in a home range bordering chicory fields. An important factor was to determine if

chicory was a principal food item of common duiker at Grants valley. Principal food items are those plant species eaten in the greatest quantities (Petrides, 1975).

The available techniques for assessing the diet of free ranging ungulates were reviewed (see chapter 2), and a decision was made to employ faecal analysis for this study.

3.2 Materials and methods

3.2.1 Study Area

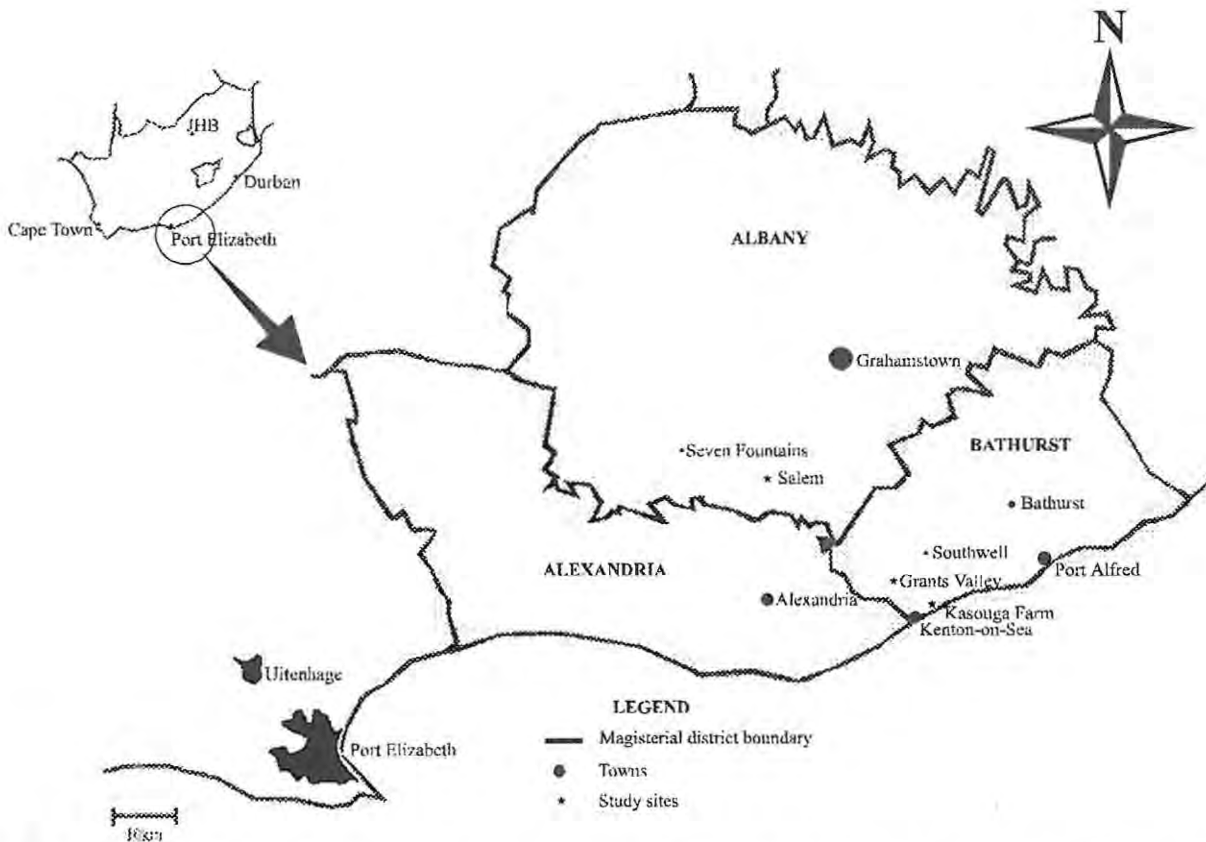

FIGURE 3.1: Map showing the geographical location of Grants valley and the three chicory growing districts (Alexandria, Albany and Bathurst) of the Eastern Cape Province of S. Africa. (Modified from Randell, 1999)

The study was conducted at Grants valley (Fig. 3.1) which is about 2.5 km North and 1.3 km East of Kenton on Sea, at a latitude of 33° 39' S a longitude of 26°41' E and an altitude of about 150 m, in Bathurst district of the Eastern Cape Province of South Africa (Anon c, 1975; Anon b, 1976).

Good rains fall in the area from March to May and again from September to November, (Schulze, 1997) thus making irrigation unnecessary during the nine-month chicory season

(Randell, 1999). Chicory plants germinate at the start of winter (April / May) and are lifted at the end of spring, or the beginning of summer (October - November).

The study site was a farm with chicory fields surrounded by a six-strand barbed wire fence, which provided easy access to the crop for the common duiker.

3.2.2 Preparation for faecal analysis

The technique of faecal analysis for the diet of a herbivore requires collection of plant species in the animal's range. The plant materials gathered are then used to prepare a plant cuticle reference collection. Grants valley and Kasouga are approximately 4 km apart and their vegetation composition is similar (Randell, 1999). Therefore, in addition to chicory root (eaten by common duiker) and leaf all plant species used in the reference plant collection for chapter 2 (Appendix A) were also used here.

Fresh common duiker faecal pellets were collected during winter (July, 1998) and spring (September, 1998). Nine spring samples and thirteen winter samples were collected from chicory fields which common duiker were known to frequent at night. The faecal samples were frozen and latter prepared for microscopic analyses using the methods of Gaylard (1994) (See Chapter 2).

3.2.3 Microscopic analysis of faecal material

Similar procedures and amounts to those described in chapter 2 were applied to common duiker faecal samples from the chicory farm. The primary objective of the study was to determine the importance of chicory in the diet of common duiker, therefore initial identifications were confined to establishing whether a plant fragment in the faecal material was that of chicory, a dicotyledon or a monocotyledon. Seasonal percentages of these three

food types were then computed from the raw data. When these preliminary results indicated that chicory formed a substantial portion of the diet, all samples were re-examined to establish how chicory compared with other individual plant species eaten by common duiker at Grant's valley.

This necessitated identification beyond the broader categories (monocot and dicot) to species level. However, those fragments with a deficiency of characteristics for identification were only coded as unidentified dicots or monocots. Only the first 100 identifiable fragments from each sample were recorded (Ferriera and Bigalke, 1987; Gaylard, 1994; Macleod *et al.,* 1996).

3.2.4 Data analyses

Percentages of occurrence for the food categories and individual plant species were computed from the winter and spring samples. Annual (mean) occurrences were then derived from these data.

A t-test of arcsine transformed data (Zar, 1996) was performed to compare winter and spring utilisation of chicory. Chi-square Goodness of fit test was performed on the frequency data (Zar, 1996) to compare seasonal utilisation of the three food categories.

3.3 Results

3.3.1 Microscopic analysis of faecal material

The winter diet of common duiker at Grants valley comprised 34.8 % chicory, 62.7% dicotyledons and 2.5% monocotyledons (Table 3.1). On the other hand chicory made up only 13.7% of the spring diet, while dicots represented 84.6% of the diet. The t-test showed a significant difference ($P < 0.0001$; df = 8) in seasonal utilisation of chicory, and Chi- square test indicated a significant difference ($P = 0.0002$; df = 2) in seasonal utilisation of dicots, chicory and monocots.

In terms of species composition, a total of 19 plants were identified in the faeces of the animals (Table 3.2). Of these, seventeen occurred in both seasons, and the winter and spring diets differed by a single species (Table 3.2). About 7% of all plant material could not be identified. In winter, chicory and *Ehretia rigida* made up the largest percentages of the diet, whilst *Ehretia rigida* and *Diospyros dichrophylla* made up the highest percentages of the spring diet (Table 3.2). A total of seven species (marked with asterisks), the principal items (Petrides, 1975) made up 85.5% of the winter diet, while the same seven species had a total contribution of 78.6% towards the spring diet. This is more than three-quarters of the food being provided by about one third of the plant species utilised. Apart from chicory, which has a nine month growing season, the rest of the principal food items were available year round, and included three shrubs and two trees.

Sanseviera hyancithoides and *Protasparagus densiflorus* were the only monocots identified in the diet of the common duiker, and each had a contribution of less than 1.5% during both seasons.

Of the plants identified in the faeces of common duiker, 6 were shrubs, 4 were trees, 4 were forbs, 2 were monocots, and 3 could be identified only as dicots. However, these categories

should be viewed with caution, as plants may vary considerably, such that a plant that is usually a shrub grows to be a tree, and a plant that is a forb grows into a shrub, or even a creeper growing like a bush (Dr. D.R du Preez, Botany Department, University of Port Elizabeth, pers. comm).

Table 3.1: Percentage occurrence of chicory, dicotyledons and monocotyledons in the spring and winter faecal samples of common duiker at Grants valley.

Plant type	**Winter** percentage		**Spring** percentage	
	%	(n)	%	(n)
Chicory	**34.8**	(1)	**13.7**	(1)
Dicots	**62.7**	(15)	**84.6**	(15)
Monocots	**2.5**	(2)	**1.7**	(2)

Legend

(n) = Number of species.

Table 3.2: Percentage occurrence of plant species identified in common duiker faecal samples for Winter and Spring. The plants marked with asterisks (principal items) have a mean percentage greater than 5%.

PLANT SPECIES	**WINTER** (n = 18)	**SPRING** (n = 18)	**MEAN** (n = 19)
Chicory - *Chichorium intybus* *	34.8	13.7	24.3
Ehretia rigida *	11.5	16.7	14.1
Diospyros dichrophylla *	10.3	17.3	14.0
Dovyalis rotundifolia *	8.2	15.2	11.7
Rhus sp *	8.3	5.7	7.0
Rhus crenata *	6.2	5.2	5.7
Euclea undulata *	6.2	4.8	5.5
Unidentified dicot b	2.8	5.8	4.3
Scutia myrtina	3.0	2.7	2.8
Unidentified dicot c	-	4.5	2.3
Acacia sp	1.7	1.3	1.5
Lobelia tomentosa	1.2	1.7	1.4
Protasparagus densiflorus	1.3	1.2	1.3
Carissa haematocarpa	0.8	1.3	1.1
Felicia aethiopica	0.7	1.2	0.9
Sanseviera hyancithoides	1.2	0.5	0.8
Unidentified dicot a	0.7	0.3	0.5
Pterocelastrus tricuspidatus	0.5	0.5	0.5
Senecio inaequidens	0.7	-	0.3

3.4 Discussion

3.4.1 Faecal analysis

The technique of microscopic analysis of faeces was first introduced to wildlife research by Storr (1961) and adapted by Stewart (1967, 1971) and Field (1968, 1972) to investigate the diet of wild African ungulates. Currently it is one of the most frequently used techniques (McAllister and Bornman, 1972; Wilson *et al.*, 1977; Ferreira and Bigalke, 1987; Buys, 1990; Macleod *et al.*, 1996; Perrin and Taolo, 1999).

The technique does have limitations (see chapter 2). Noteworthy, however Stewart (1967) found that species eaten infrequently and in small quantities are missed completely, whilst Johnson *et al.*, (1983) revealed that woody plants produce more fragments than grasses or forbs, and that these differences are significant when compared to grasses. Despite these shortcomings, the structural differences between monocots and dicots are very conspicuous (Buys, 1990), thus making the technique suitable for comparative studies (Loggers, 1991). In this study only about 7% of the plant material was unidentifiable and the chicory root cells could easily be identified.

3.4.2 Diet of the common duiker at Grants valley

Results from this study indicated that the diet of the common duiker comprised 34.8% chicory in winter, but this percentage declined to 13.7% in spring. However, these percentages should be viewed with caution as Randell (1999), using feeding trials on a captive common duiker, has shown that the percentage of chicory in the faeces is approximately 21% less than the percentage of chicory eaten by common duiker. Despite this error, results of this study confirm earlier reports of common duiker feeding on cultivated crops (Ansell, 1960; Wilson and Roth, 1967; Skinner and Smithers, 1990) and chicory in particular (Coetzee, 1979;

Randell, 1999). Also evident from the results of this study is the seasonal variation in utilisation of chicory by common duiker.

Common duiker's natural food consists of forbs, shrubs, flowers and fruits (Hofmann and Stewart, 1972; Dunbar, 1978; Wilson, 1966; Skinner and Smithers, 1990), which are in abundance during spring and summer. However, during winter the quality and quantity of these foods decrease (Owen-Smith, 1998; Skinner and Smithers, 1990; Winterbach and Bothma, 1998), compelling the animals to utilise alternative foods such as more fibrous parts of plants (Boomker, 1981) or cultivated crops. It may be suggested that seasonal changes in abundance and quality of the natural food at Grants valley probably explain the change in utilisation of chicory by the common duiker. Intensification of feeding pressure on chicory during winter is made possible by its ready availability and accessibility during that time. Randell (1999) demonstrated that the energy level and water content of a chicory root does not vary between winter and spring, thus ruling out the possibility of these two factors determining seasonal variation in utilisation of chicory. Randell (1999) also established a greater degree of pest (common duiker, oribi, porcupine) damage to chicory during winter months than spring. However, the damage could not be allocated to any of these individual species, since all three exhibit similar types of damage. None of the three feed on chicory leaves, but all dig up the root leaving part of it uneaten and exposed.

In terms of individual plant species eaten by common duiker, results from this study indicated that chicory is the most utilised plant food item during winter, and among the four most eaten plants during spring (Table 3.2). This makes chicory a principal food item (Petrides, 1975) of common duiker at Grants valley. Although this may appear to lend some degree of support to chicory farmers' reports, that common duiker show a preference for chicory over natural vegetation (Randell, 1999), it does not verify these accounts. Norbury and Sanson (1992)

define diet preference as an animal's choice of food from an array of different food items. Consequently a principal food item is different from a preferred food item. Whilst principal food items are those eaten in greatest quantities (Petrides, 1975), preferred foods are those proportionately more frequently eaten by the animal, than they occur in the environment (Johnson, 1980; Chesson, 1983). However, availability data for individual plant species in the study area were not compiled and it was not possible to determine preference indexes for each of the plant food items identified in the diet of common duiker at Grants valley. Nevertheless, the substantial contribution of chicory as a food item, particularly to the winter diet of common duiker may have profound implications for the commercial growing of chicory, especially since other animals also damage the crop. Oribi, porcupine and bushpig also feed on the chicory root, while bushbuck, rabbits, grysbok, springhares, baboons, monkeys, kudu, guinea fowl and Egyptian geese eat the leaves, with the latter causing the most extensive damage (Randell, 1999).

At present chicory farmers use a variety of fencing (netted, electric, barbed wire, veldspan) in an effort to deter common duiker and other problem animals from the chicory fields. Netted fencing is reported to be most effective, followed by electric, then veldspan fencing (Randell, 1999).

The seven principal food items of common duiker at Grants valley (excluding chicory which is an introduced commercial crop) have been described as characteristic flora of the Eastern Cape coastal habitats, and are evergreen and thus available year round (Hutchinson, 1946; Martin *et al.*, 1960; Lubke and McKenzie, 1996; Lubke *et al.*, 1996).

In accordance with previous findings, (Keymer, 1969; Boomker, 1983; Allen-Rowlandson, 1986) the present study indicated that common duiker are predominantly browsers, eating only a very small percentage of monocotyledonous plants. Only two out of the nineteen species

identified were monocotyledons, (*Sanseviera hyancithoides and Protasparagus densiflorus*) and they had a combined annual percentage of about 2% in the diet. Furthermore, results of this study concur with Allen-Rowlandson's (1986) findings that common duiker feed selectively. At Grants valley, this selectivity is exhibited by more than three-quarters of the annual food being derived from only one third of the plant species eaten. Furthermore, out of the nineteen plant species identified, the winter diet had just two of these *Ehretia rigida* and chicory making up 46.3% of the diet, and in spring *Ehretia rigida, Diospyros dichlorophylla* and *Dovyalis rotundifolia* had a total percentage of 49.2% of the diet. However, selection can also be exercised at different scales which include, selection of vegetative zones for feeding sites or selection for specific plant parts (Owen-Smith, 1982). Common duiker feed only on chicory roots, avoiding the leaves. The high degree of selectivity in the common duiker has been attributed to its rumen which is fairly undifferentiated and thus poorly adapted to a diverse diet (Hofmann, 1973). Consequently the animal tends to have localised specialised diets.

In comparison with the diet of neighbouring populations of common duiker at Kasouga the diet of common duiker at Grants valley comprised fewer dietary items (19 vs 27). Although the percentage occurrence of five plant species (*Ehretia rigida, Diospyros dichrophylla, Dovyalis rotundifolia, Euclea undulata, Rhus crenata*) was high in the diets of common duiker at Kasouga and Grants valley, generally these plant species were less prominent in the diet at Grants valley. It is therefore possible that the high representation of chicory in the diet of the common duiker at Grants valley is either a result of its superabundance in the area or its utilisation in preference to the natural vegetation or even a combination of both.

CHAPTER 4

DIET OF BLUE DUIKER AT SALEM

4.1 Introduction

Central to the study of animal ecology and management is the use an animal makes of its environment, particularly the kinds of foods it consumes and the habitats it occupies (Johnson, 1980).
Dietary information has in the past proved useful to our understanding of animal distribution and diversity (Johnson, 1980; Chesson, 1983; McNaughton and Georgiadis, 1986), for investigating interactions within and among species and sexes (Shank,1982; Loggers, 1991), for estimating habitat carrying capacities (Hobbs and Swift, 1985), for devising strategies to manipulate animal populations by vegetation management (Warren *et al.*, 1984) and for determining patch richness in optimal foraging models (Baharav and Rosenzweig, 1985).

Blue duiker feed primarily on freshly fallen leaves and fruit, but also occasionally browse on young shoots (Bowland, 1990; Skinner and Smithers, 1990; Hanekon and Wilson, 1991; Faurie and Perrin, 1993; Bowland and Perrin, 1998). They have also been recorded to feed on flowers (Skinner and Smithers, 1990) and green grass (Blamey and Jackson, 1956). Faurie and Perrin (1993) state that blue duiker have varied food habits throughout their distribution. Dubost (1984) found the blue duiker of Gabon forests to be predominantly frugivorous, while Bowland (1990) found KwaZulu-Natal coastal forest blue duiker to be mainly folivorous. Bowland (1990), cited by Faurie and Perrin (1993) describe Southern African coastal forests as scarce in fruits and very abundant in freshly fallen leaves. In a recent dietary classification scheme for African bovids, blue duiker have been categorised as

frugivores, with a diet of more than 70% fruits and little or no monocots (Gagnon and Chew, 2000).

Blue duiker are small ruminants with high metabolic requirements relative to gut capacities, and are therefore compelled to feed selectively (McNaughton, 1987). Jarman (1974) classified the blue duiker as a very selective browser, picking such items as flowers, twig tips, fruits, seed pods as well as bark, and Bowland (1990) noted that the primary factors determining diet selection in this antelope are nutrient composition and secondary metabolites in the fallen leaves. The fallen leaves from the forest canopy are made available to blue duiker through natural senescence, wind fall and by the foraging activities of animals (Skinner and Smithers, 1990; Faurie and Perrin, 1993). Bowland (1990) monitored potential food availability (leaf fall) seasonally and concluded that coastal forests in KwaZulu-Natal provide a superabundance of food for blue duiker.

In this study, the diet of blue duiker at Salem was determined by means of faecal analysis. However, direct observations in the wild, observations from captive animals or rumen contents analysis (Field, 1972; Beukes, 1988; Van Rooyen, 1992; Lewis, 1994; Macleod *et al.*, 1996) are also possible methods. These were all reviewed (chapter 2) and with regard to blue duiker, the following should be mentioned.

Blue duiker do not habituate readily (Bowland, 1990) making direct observations in the wild problematic. Although, this can be overcome with use of a portable hide, (Bowland, 1990) positive identification of the tree species to which the fallen leaves being fed on originate is difficult. Rumen samples require culling and this was considered unethical because of the rare status of blue duiker (Smithers, 1986; Hanekom and Wilson, 1991). Reliance on animals from accidental deaths was never considered an option because it does not ensure coverage of all

seasons and resultant samples were likely to be too small for any valid qualitative and quantitative analysis. Anthony and Smith (1974) established that 15 faecal samples provided the same precision in predicting dietary composition as 50 rumen samples collected from deer. In light of these considerations, faecal analysis was not only used to ensure minimal disturbance to the subjects in their dense habitats, but also to allow a much broader spatial and temporal range of diet analysis.

Forests and their fauna are under constant pressures from overgrazing, bushclearing and invasion by exotic plant species (Geldenhuys and MacDevette, 1989) and the aim of this part of the research was to examine the diet of the blue duiker in the forests at Salem and therefore contribute to our knowledge and conservation of the coastal forests.

4.2 Materials and methods

4.2.1 Study area

The study was conducted at Salem in the Albany district of the Eastern Cape Province of South Africa. Salem is situated at 33° 28 ′S ; 26° 28 ′E and at an altitude of about 1010 m (Anon c, 1975; Anon b, 1976). The area has a mean annual precipitation between 400 mm and 600 mm, and receives rainfall throughout the year (Schulze, 1997). The mean annual minimum temperature is about 8° C, while the maximum is 28° C (Schulze, 1997). Salem vegetation is a combination of forest and grassland (Acocks, 1975; Lubke, 1996; Lubke and McKenzie, 1996; Lubke *et al.*, 1996). Common plant species in the study area include *Portulacaria afra*, *Euphorbia triangularis* and *Rhus spp.*

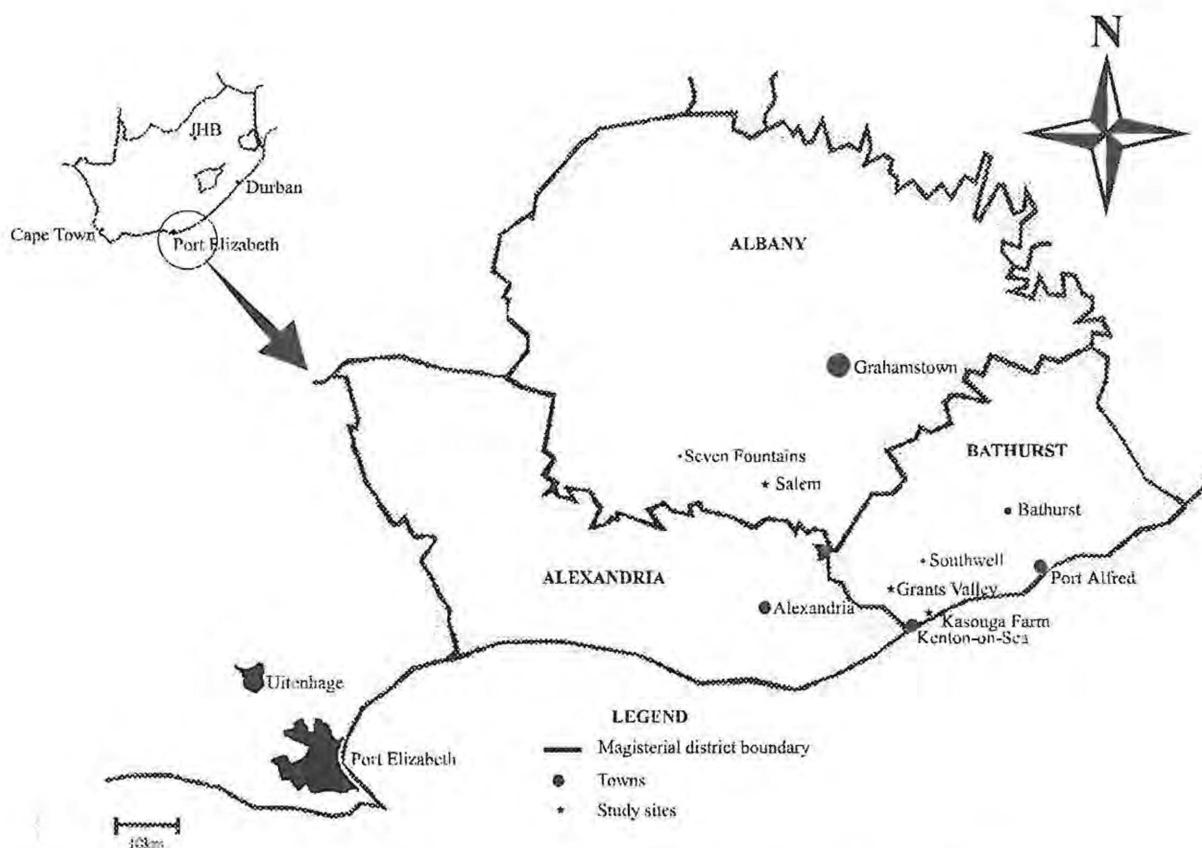

FIGURE 4.1: Map showing the geographical location of Salem. (Modified from Randell, 1999).

4.2.2 Preparation for faecal analysis

A plant cuticle reference collection was compiled following the methods outlined in chapter 2. Fresh, blue duiker faecal pellets were collected each month from August 1998 to July 1999. The faecal samples were stored in marked plastic bags and kept in a freezer until preparation for analysis (Kirchhoff and Larsen, 1998). Preparation of the faecal samples followed the methods described by Ferreira and Bigalke (1987) as well as Gaylard (1994), (see chapter 2). However, since the faeces could not be aged with certainty, the samples were pooled to yield six pooled samples (3 spring/summer and 3 autumn/winter) which were used in the analyses.

4.2.3 Microscopic analysis of faecal material

The pooled samples of prepared faecal material were shaken, a sub-sample (of about 4 drops) drawn with a dropper and placed on a gridded microscope slide and viewed at 400 X magnification. This was repeated six times from each of the pooled samples. Plant species that could not be identified beyond the generic level (such as some *Rhus sp*) were recorded with the name of the genus followed by *sp*. The first 100 identifiable fragments in each sub-sample were recorded (Ferreira and Bigalke, 1987; Gaylard, 1994; Macleod *et al.*, 1996). Fragments containing inadequate characteristics for identification were ignored (Gaylard and Kerley, 1995).

4.2.4 Data analyses

Percentage occurrences of plant species in the spring/summer and autumn/winter faecal samples were computed from the fragment counts. A mean (annual) percentage occurrence of plant species was calculated from all data sets. T-tests of arcsine transformed data (Zar, 1996) were performed to compare utilisation of the food items in spring/summer and autumn/winter seasons.

4.2.5 Plant abundance in the field

Comparison of the relative abundances of food items available to an animal with the relative abundances of food items consumed by the animal gives estimates of food selection and preference (Johnson, 1980; Davies *et al.*, 1986; Norbury and Sanson, 1992).
Fifty quadrats with dimensions of 5 m length by 5 m width, which were randomly spread throughout the study area were sampled for vegetation once during each of the two seasons (summer and winter). In order to determine the position of each quadrat, a small stick was thrown from various positions within the study site and its point of landing was used as the distal left corner of the quadrat. All plant species encountered during the vegetation survey were identified, counted and their relative abundances in the study area calculated. Percentage availabilities of all plant species were calculated from the abundance data.
A preference index (PI = [% consumption] ÷ [% availability]) (Davies *et al.*, 1986) was calculated to indicate the extent of utilisation of plant species in relation to their availabilities. A preference index value greater than one indicated selection for the food item, whereas values less than one meant that the food item was avoided (Kerley, 1990; Gaylard, 1994; Macleod *et al.*, 1996).

4.3 Results

4.3.1 Diet of blue duiker at Salem

A total of 30 plant species were identified in the faeces of the blue duiker from Salem (Table 4.1). One of these with an annual percentage occurrence of 0.7% could only be identified as a dicotyledonous species. All the 30 plant species appeared in the autumn / winter diet, while 29 featured in the spring / summer diet. *Asparagus densiflorus* was the only monocot identified in the faeces, and it was represented by 0.5% and 3.5% in the spring/summer and autumn/winter samples respectively. The t-test showed no significant difference ($P = 1.0$; $df = 58$) between the spring/summer and autumn/winter diets of blue duiker.

Six plant species (marked with asterisks) each had a mean annual percentage occurrence above 6%, and each was represented by more than 5% during the spring /summer and autumn / winter seasons. The total contribution of these six plant species towards the spring / summer diet was 47%, the autumn / winter diet 44% and overall 45.5%. The t- test also showed no significant difference ($P = 0.5859$; $df = 10$) in the occurrence of these six plant species in the spring/summer and autumn/winter faecal samples. From these percentages it appears that approximately half of the diet of blue duiker at Salem was derived from only one-fifth of the plant species comprising its diet. Other important plant species identified in the diet included *Euclea undulata and Schotia afra* each of which provided approximately 5% of the food for each of the seasons. Six out of the thirty food items identified were fruit of different plant species (Table 4.1), and the t-test showed no significant difference ($P = 0.7125$; $df = 10$) in their occurrence in the spring/summer and autumn/winter faecal samples.

Table 4.1: Percentage occurrence of plant species identified in the spring/summer and autumn/winter faecal samples of blue duiker at Salem. Plants marked with asterisks were consumed in greatest quantities (mean annual % > 6%).

PLANT SPECIES	SPRING/SUMMER (n = 29)	AUTUMN/WINTER (n = 30)	MEAN (n = 30)
Rhus crenata *	9	9.5	9.3
Portulacaria afra *	9	8.5	8.7
Ehretia rigida *	7	9	8.0
Scutia myrtina *	8.5	5.5	7.0
Rhus glauca *	7	5.5	6.3
Euphorbia triangularis *	6.5	6	6.2
Rhus sp	5	5.5	5.3
Euclea undulata	5.0	5.5	5.2
Schotia afra	4.5	4.5	4.5
Mimusops caffra fruit	4	3.5	3.7
Rhus sp fruit	2.5	4.5	3.5
Sarcostemma viminale	-	7	3.5
Ehretia rigida fruit	2	3.5	2.7
Scutia myrtina fruit	3	2.5	2.7
Opuntia sp fruit	3.5	1	2.3
Cynanchum capense	3	1.5	2.2
Asparagus densiflorus	0.5	3.5	2.0
Chrysanthemoides monolifera	1.5	2	1.8
Senecio quinquelobus	2	1.5	1.8
Cassine papillosa fruit	2.5	1	1.7
Scutia myrtina flower	2.5	0.5	1.5
Felicia aethiopica	2	1	1.5
Oxalis latifolia	1.5	1	1.3
Rhus incisa	1.5	1	1.2
Olea europaea	1.5	1	1.2
Ptaeroxylon obliquum	2	0.5	1.2
Clutia sp	1	1	1.0
Cotula heterocarpa	1	1	1.0
Commelina africana	0.5	1	0.8
Unidentified dicot a	0.5	1	0.7

The seasonal percentage occurrences of different plant food categories in the diet of blue duiker at Salem are tabulated (Table 4.2). Generally, the annual diet of blue duiker at Salem comprised 17% fruit, 1% flowers, 79% dicot foliage, 1% unidentified dicot material and 2% monocots.

Table 4.2: Percentage seasonal occurrence of plant food categories in the diet of blue duiker at Salem.

PLANT FOOD CATEGORIES	SPRING/ SUMMER		AUTUMN/WINTER		ANNUAL
	%	**(n)**	**%**	**(n)**	**% (n)**
Dicot foliage	79	(20)	79.5	(21)	79.3 (21)
Fruit	17.5	(6)	16	(6)	16.8 (6)
Flowers	2.5	(1)	0.5	(1)	1.5 (1)
Monocot	0.5	(1)	3.5	(1)	2 (1)
Unidentified dicot material	0.5	(1)	1.0	(1)	0.8 (1)

Legend

n = number of plant species.

4.3.2 Food preference

Preference indices for some (those identified in the diet and whose field availability data were available) of the food plant species identified in the diet of blue duiker at Salem are tabulated (Table 4.3). From this, the most highly selected (most preferred) food plant item was fruit of *Cassine papillosa*. Other highly selected food plant species included *Euclea undulata, Rhus glauca, Rhus crenata, Ehretia rigida* and *Euphorbia triangularis*, all of which with the exception of the first one also exhibited a high occurrence in the faecal material. The general trend in preference was a higher selection for individual plant species during summer than in winter. Three plant species, *Asparagus densiflorus, Senecio quinquelobus* and *Oxalis latifolia* were avoided (PI < 1) during both winter and summer, and *Cotula heterocarpa* was avoided during the latter season.

Table 4.3: Indices of preference (% consumed ÷ % available) for some (those identified in the diet and whose field availability data were available) of the plant species identified in the seasonal diet of blue duiker at Salem. Values greater than one indicate preference and those less than one show avoidance.

Plant species	**Available (%)**		**Consumed (%)**		**Preference index**	
	A/W (n=18)	**S/S (n=18)**	**A/W (n=18)**	**S/S (n=17)**	**A/W (n=18)**	**S/S (n=17)**
Cassine papillosa (fruit)	0.13	0.09	1.0	2.5	7.7	27.8
Rhus glauca *	0.51	0.37	5.5	7.0	10.8	18.9
Euclea undulata	0.51	0.37	5.5	5.0	10.8	13.5
Ehretia rigida *	1.03	0.76	9.0	7.0	8.7	9.2
Euphorbia triangularis *	1.28	0.93	6.0	6.5	4.7	7.0
Rhus crenata *	1.67	1.22	9.5	9.0	5.7	7.4
Scutia myrtina *	1.54	1.12	5.5	8.5	3.6	7.6
Opuntia sp (fruit)	0.77	0.56	1.0	3.5	1.3	6.3
Ptaeroxylon obliquum	0.26	1.96	1	1	3.8	0.5
Sarcostemma viminale	0.9	1.12	7.0	-	7.8	-
Schotia afra	1.41	1.04	4.5	4.5	3.2	4.3
Portulacaria afra	3.21	2.33	8.5	9.0	2.6	3.9
Rhus incisa	0.64	0.47	1.0	1.5	1.6	3.2
Olea europaea	0.64	0.47	1.0	1.5	1.6	3.2
Cotula heterocarpa	0.26	1.96	1	1	3.8	0.5
Senecio quinquelobus	2.82	3.17	1.5	2.0	0.5	0.6
Oxalis latifolia	4.88	3.84	1.0	1.5	0.2	0.4
Asparagus densiflorus	5.91	4.1	3.5	0.5	0.6	0.1

Legend

A/W = Autumn / Winter ; S/S = Spring / Summer; * = Principal food items

4.4 Discussion

The merits of faecal analysis have been discussed in chapter 2. However, it must be mentioned that, for a rare and protected species like the blue duiker (Crawford, 1984; Smithers, 1986; Bowland, 1992) the method is appropriate in that it eliminates the need for culling animals to obtain rumen contents. Blue duiker inhabit dense coastal bush and thickly wooded forests (Skinner and Smithers, 1990; Hanekom and Wilson, 1991; Bowland, 1992; Faurie and Perrin, 1993) which makes direct observation difficult. It should also be noted that direct observations make quantification of the food items complicated and their practicality is limited because blue duiker do not habituate readily (Bowland, 1990). Skinner and Smithers (1990), Bowland (1992) as well as Ross (1992) state that blue duiker seldom leave their dense habitats, and when doing so transverse open ground very rapidly. Although Bowland (1990) made use of a portable hide to observe blue duiker while feeding in their habitat, identification of the plant species eaten was often difficult.

Results of this study showed the annual diet of blue duiker at Salem to comprise 17% fruit, 1% flowers, 79% dicot foliage, 1% unidentified dicot foliage and 2% monocots. However, in a recent dietary classification scheme of African bovids (Gagnon and Chew, 2000), blue duiker are categorised as frugivores with a diet of more than 70% fruit and little or no monocots. This classification is paralleled by the findings of Dubost (1984), who established that the blue duiker in the forests of Gabon are predominantly frugivores. Contrary to this, but in support of the current findings, Bowland (1990) found that, in the coastal forests of KwaZulu-Natal, blue duiker are mainly folivorous, with a very small percentage of fruit in their diet. However, Bowland (1990) noted a high preference index for fruit in his subjects, and

Jarman (1974) stresses the importance of energy-rich food items such as fruit, seeds, flowers and new growth for a small antelope with a high metabolism (like the blue duiker). Faurie and Perrin (1993) state that, blue duiker vary their diet throughout their distribution, and that the high degree of folivory is therefore attributable to a scarcity of fruits. The dry, lowland coastal forests (like at Salem) have been described as scarce in fruit and abundant in freshly fallen leaves (Bowland, 1990), whilst in the tropical forests of Gabon, fruit is an abundant and reliable food resource (Dubost, 1984).
Thirty dietary plant species were recorded in the diet of blue duiker at Salem. However, only six of these were consumed in great quantities (more than 6% annually). These plant species, namely *Ehretia rigida, Rhus crenata, Rhus glauca, Scutia myrtina, Portulacaria afra* and *Euphorbia triangularis* comprised the principal food items (Petrides, 1975). Although not equally high in terms of their percentage representation, *Euclea undulata and Schotia afra* were also important food items in the diet of blue duiker at Salem. Each of these two plant species provided approximately 5% of the food in each of the seasons. The principal food plants contributed 47% towards the spring/ summer diet, 44% towards the autumn/winter diet, and were represented by 45.5% in the annual diet. This implies that blue duiker at Salem fed selectively, as approximately half of their diet was derived from only 1/5 of the total plant species eaten. Bowland (1990) as well as Hanekom and Wilson (1991) also found blue duiker to be selective foragers.

There was no seasonal variation in utilisation of the 30 plant species identified in the diet of blue duiker at Salem, neither was there any seasonal variation in utilisation of the six principal food items nor the six fruit species. The spring/summer and autumn/winter diets differed by a single plant species. Since plant species like *Portulacaria afra*, *Euphorbia*

triangularis and *Rhus sp* are dominant among the vegetation of the study area, and together with the rest of the plant species identified, are available throughout the year (Dyer, 1937; Martin *et al.*, 1960; Acocks, 1975; Lubke, 1996), it is possible that food availability rather than quality plays the major role in determining the level of utilisation of particular plant species across seasons at Salem. The importance of both food quality and quantity in determining the seasonal diets of herbivores has been highlighted (Skinner and Smithers, 1990; Owen-Smith, 1998; Winterbach and Bothma, 1998). Within an area covering Salem, different fruiting periods have been given for the six plant species whose fruits appeared in the diet of blue duiker (Martin *et al.*, 1960; R. Ludick, Rhodes University, Grahamtown S.A, pers. comm.). *Ehretia rigida* and *Cassine papillosa* fruit throughout the year, while *Rhus spp* and *Mimusops caffra* fruit mainly during the winter months, and *Opuntia sp* fruit is mostly available during the summer months (Martin *et al.*, 1960; R. Ludick, pers. comm). From this it might be expected that utilisation of fruit by blue duiker at Salem is seasonal but this was not the case. It may be suggested that the occurrence of some of the plant fruit species in the faecal samples was incidental or erroneous, due to the inherent inaccuracies of faecal analysis. To overcome this as well as other problems some studies have supplemented faecal analysis with other techniques like rumen sample analysis and field observation (Allen-Rowlandson, 1986; Lewis, 1994; Macleod *et al.*, 1996), but as mentioned earlier, this was not possible in this study.

Food preference results from this study indicated a higher selection for fruit than any other plant food item. Fruit of the bastard saffron wood tree, *Cassine papillosa,* had the highest preference index. This plant species is listed by Acocks (1975) amongst the trees of less general occurrence in an area covering Salem, but neither Lubke (1996) nor Lubke *et al.*, (1996) mention

this tree species in the vegetation composition of the same area. The rarity of *Cassine papillosa* at Salem was also shown by the vegetation survey which formed part of this study. Percentage availability of *Cassine papillosa* at Salem was only 0.09% during summer, and 0.13% in winter. This implies that *Cassine papillosa* is an important, but scarce food resource for blue duiker at Salem.

As mentioned earlier a higher preference for fruit than any other plant food item was also found by Bowland (1990) in blue duiker inhabiting forests in KwaZulu-Natal. Fruit as well as seeds and flowers are high energy food items, such that Field (1972) and Jarman (1974) mention their importance to a small antelope like the blue duiker.

Blue duiker at Salem had a high preference for five plant species namely, *Euclea undulata, Rhus glauca, Rhus crenata, Ehretia rigida* and *Euphorbia triangularis.* All these are evergreen plant species which characterise the vegetation of Salem (Dyer, 1937; Martin *et al.*, 1960; Acocks, 1975; Lubke, 1996; Lubke *et al.*, 1996). With the exception of *Euclea undulata* these preferred plant species also comprised the principal food items (Petrides, 1975) of blue duiker at Salem. Therefore, the four plant species (*Rhus glauca, Rhus crenata, Ehretia rigida* and *Euphorbia triangularis*) are the most important food plant species of blue duiker at Salem.

Two forbs, *Senecio inaequidens* and *Oxalis latifolia* as well as a monocot, *Asparagus densiflorus* were avoided during both summer and winter, whilst a shrub, *Cotula heterocarpa* was avoided during summer. Bowland (1990) suggested that, nutrient composition and secondary metabolites are the primary factors affecting diet selection or/and avoidance in the blue duiker, but Faurie and Perrin (1993) found no correlation between these factors and food selection.

Jarman (1974) and recently Gagnon and Chew (2000) described blue duiker as utilising little or no monocots at all in their diet, and in this study the low occurrence of monocots in the faecal material along with a low preference index indicative of avoidance, support this description.

CHAPTER 5

DENTAL MICROWEAR IN RELATION TO DIET IN BLUE AND COMMON DUIKER

5.1 Introduction

Variations in dental microwear have yielded insight into a number of oral phenomena such as, occlusal relationships and biomechanics of the jaw (Ryan,1979; Gordon 1984a, 1984b; Robson and Young, 1990; Wilkins and Cunningham, 1993), and dietary habits (Smith 1984; Teaford, 1986; Taylor and Hannam, 1987). Probably the most important aspect of microwear analysis is its application to deduce the diet of extinct and fossil forms (Grine, 1981; 1986; Daegling and Grine, 1987; Van Valkenburgh *et al.*, 1990; Lubell *et al.*, 1994; Waddle, 1988). Dental microwear analysis has focussed on a number of herbivorous taxa such as Primates and Hyracoidea (Walker *et al.*, 1978; Teaford, 1985; Teaford and Robinson, 1989; Teaford and Runestad, 1992), while there have been few studies on ungulates (Solounias and Hayek, 1993; Mainland, 1998). No such study on duiker or any other species of small antelope is documented.

Dental microwear analysis is facilitated by the use of casts and scanning electron microscopy (Murphy, 1982; Roomans, 1984). Analyses range from qualitative to quantitative, and from experimental studies using live animals to comparative studies of museum collections (Teaford, 1988). Teaford and Oyen (1989) state that the process of taking dental impressions from live animals is a difficult one and that it presents problems different from those encountered when working with museum material. However, Teaford and Runestad (1992)

stress the importance of using museum specimens collected from the same area at the same time unless the effects of spatial and temporal variation are being investigated.

The choice of magnification constitutes a sampling strategy. A single micrograph taken at 500 X magnification covers only 0.03 mm² of surface area, whereas 0.4 mm² area is covered by a micrograph taken at 150 X magnification (Gordon, 1988). The principle advantage of higher magnification levels is the enhanced ability to resolve and measure small dimensions (Gordon,1988).

Several microwear features have been correlated with dietary variations (Kay and Covert, 1983; Covert and Kay, 1981; Teaford and Runestad, 1992; Lukacs and Pal, 1993). Gordon (1982) places these features into three categories, striations or scratches, pits and gouges. The distinction between pits and scratches can be made through the use of a cut-off point in the range of length to width ratio (Teaford, 1985; Daegling and Grine, 1994) or, by subjective determination (Grine, 1986). Generally, scratches are linear depressions whose length is always far greater than the breadth (Gordon, 1982). In pits the lengths and breadths do not differ much, and the gouges are usually broader, strongly curved and often S-shaped (Gordon, 1982).

Quantification of these features is more objective (Teaford and Walker, 1984), but is made difficult by factors like irregular tooth surfaces, specimen tilt angle, and obliteration of scratches by subsequent ones (Walker *et al.*, 1978).

Microwear features do not necessarily reflect specific food items, but rather the structural properties of the items or the constituents of the items (Grine, 1986; Teaford and Robinson, 1989). Therefore, foods with similar mechanical properties might be expected to produce similar microwear patterns (Daegling and Grine, 1994). Microwear patterns have been used to

differentiate browsers from grazers (Walker *et al.*, 1978; Teaford, 1985; Mainland, 1998), and frugivores from folivores (Teaford and Walker, 1984; Teaford and Runestad, 1992).

The diet of the blue duiker comprises mainly fallen leaves and fruits (Bowland, 1990; Hanekon and Wilson, 1991). The proportions of these food items in the diet vary. Whereas, Dubost (1984) found a high occurrence of fruit and described the blue duiker as frugivorous, Bowland (1990) considered the blue duiker to be folivorous .

The diet of the common duiker mainly consists of forage of various dicots, twigs, flowers and some fruit (Wilson and Clarke, 1962; Boomker, 1983; Allen- Rowlandson, 1986, Skinner and Smithers, 1990). Gagnon and Chew (2000) state that with the exception of common duiker, all duiker species are frugivorous by definition.

It may be suggested that the diet of the blue and common duiker in the Eastern Cape Province differ in terms of the plant species used and the utilisation of fruit but they are similar in that both feed primarily on the leaves of dicotyledonous plants. The primary aim of this chapter was to compare the dental microwear features of the blue and common duiker and establish if the technique could separate two species with quite similar diets.

5.2 Materials and Methods

5.2.1 Sampling of specimens

Eleven skulls for each of the two duiker species, collected from two matched districts in the Eastern Cape Province of S. Africa, and with the closest possible dates of collection, were used for the study. The specimens were obtained from Amathole Museum and MacGregor Museum mammal collections (Appendix C). This sample size is comparable to the ten used by Teaford (1985), and Daegling and Grine (1994) as well as the twelve of Covert and Kay (1981).

The second lower molars (Skinner and Smithers, 1990) were selected for SEM analysis, because, they are placed between two other molars (Fig. 5.1) and therefore the occlusal function is the same on both sides (Rensberger, 1973; Associate Prof. G. Sanson, Monash University, Australia, Department of Biological Sciences, pers. comm.). They are also thinner than the upper molars and they occlude over the entire surface whereas the uppers have only part of the crown occluded by all the lowers as a result of the overlap (Butler, 1978; G. Sanson, pers. comm.).

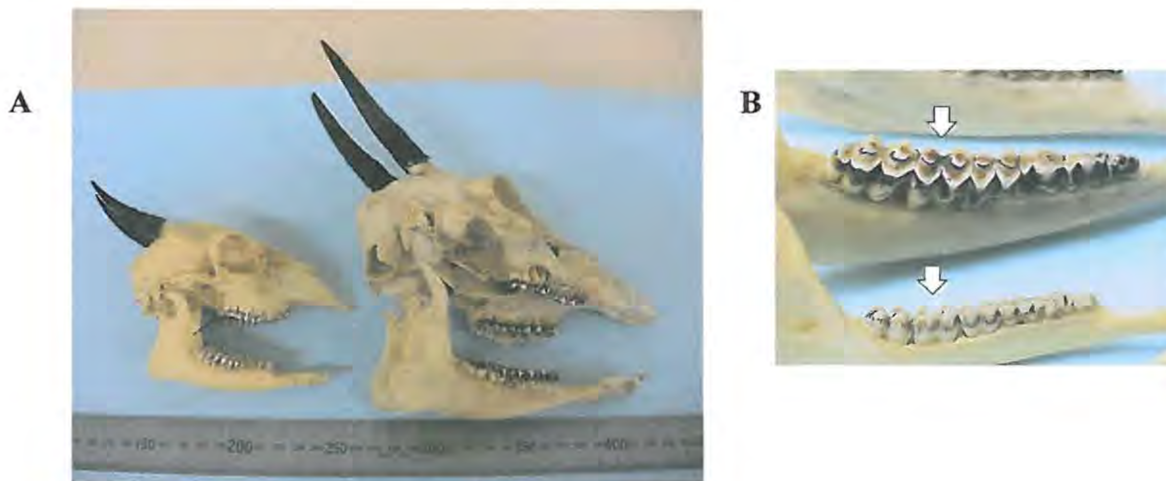

Figure 5.1: Skulls (A) of blue duiker (left) and common duiker (right) as well as their lower jaws (B) showing the 3 molars and 3 premolars. Note the positioning of the second lower molar in the blue duiker (foreground) and common duiker (background).

5.2.2 Preparation of dental replicas

With the use of cotton wool the teeth surface were cleaned with water, then ethanol and finally acetone (Rose, 1983). This frees the surface of any dirt, glue, loose matrix or grease (Rose, 1983). Vigorous scrubbing which may create artefactual scratches was avoided (Telford and Oyen, 1989). After allowing the surface to air dry (Rose, 1983), a thin coating of acetic acid was applied to it, and a wall of Bostik Prestik sticky stuff (Genkem Ltd, England) was built around the tooth. Latex was then poured on top of the acid layer. The acetic acid facilitates rapid and proper setting of the impression material and together with the barrier prevent seepage of the latex (Ryan, 1979).

Preliminary SEM analysis indicated that latex did not pick up the dental impressions, and subsequently its use was abandoned. Moulds of the teeth were then made with a mixture of equal amount of Aquasil smart wetting impression material (S.W.I.M) "base" and Aquasil S.W.I.M " hardener catalyst" (Dentsply / Caulk, Milford DE, USA). As recommended by Rose

(1983) and Dr. J.P. Malan (Dental Surgeon; pers. comm.), the impression material was applied to the teeth surfaces with disposable plastic syringes. Once removed from the teeth the moulds were placed in a dust free environment at room temperature for about 8 hours, in order to permit total degassing (Grine 1986). This is necessary in order to prevent any artefactual pitting (Gordon 1984 c). Initially, epoxy-resin casts were made from the moulds as was the case in several studies (Gordon, 1984 d; Bullington, 1988; Teaford and Runestad, 1992). However, this was discontinued, as a result of failure of the casts to separate cleanly from the moulds, after setting. Rose (1983) states that clean separation is an important requirement for suitability of any casting material, which if not met may result into formation of artefacts. This led to a comparative examination of SEM images of teeth and images of their Aquasil S.W.I.M moulds. Based on the similarity of these images it was decided to use the original Aquasil moulds which once made and allowed time to degass were sputter-coated with gold prior to SEM analysis (Echlin, 1978).

5.2.3 Scanning electron microscopy (SEM) analysis

Approximately two hours after coating the moulds, they were carefully orientated with the long axes of moulds uniformly placed and mounted on marked stubs. Care was taken to avoid any direct contact with the mould surfaces (Rose, 1983).

The moulds were then examined in a Jeol JSM 840 scanning electron microscope. Basic precautions relating to rotation of the image and recording of magnification as proposed by Boyde (1974) were observed, but stereo microscopy was not employed. Teeth were rotated in various positions to have an overview of features, and comparative micrographs were taken (Crompton and Kielan-Jaworowska, 1978). Sets of micrographs at magnifications of 130x and 450x were taken, but only the latter were used for analyses.

5.2.4 Data collection and analyses

Data were collected from eleven micrographs for each of the two duiker species. With the use of a B41420/3 illuminated magnifier all identifiable pits and scratches in an area of 16 cm^2 at the centre of each micrograph (of 450 X magnification) were counted and recorded. Gouges were subsumed as scratches (Grine, 1986). Pits and scratches were identified independently by subjective determination following the method of Gordon (1982), rather than by imposing an arbitrarily set length to width ratio on the features. In order to ensure that features were correctly categorised, only those which could clearly be identified were recorded. It has been stated (Gordon, 1982; Teaford and Walker, 1984.) that, because of the overlap and large numbers of features per field it is not always possible to record every feature. The number of microwear features per field of examination was compared between samples using the Mann-Whitney statistic as well as t- test, and chi-square analysis was used to test for interspecific differences in the proportions of pits and scratches (Zar, 1996).

5.3 Results

5.3.1 Dental microwear analyses

Three types of features; scratches, pits and gouges were identified as occurring on all teeth of the blue and common duiker. Representative images of casts from the teeth of the blue and common duiker are shown in the micrographs (Figs. 5.2 A and B).

The total number and percentages of pits and scratches recorded on the teeth of the blue and common duiker were similar and for both species there were more pits than scratches on the dental surfaces (Table 5.1).

Table 5.1: Numbers, ratios and percentages of pits and scratches on teeth of the blue and common duiker.

Dental features	**Blue duiker** (n = 11)	**Common duiker** (n = 11)
Number of scratches (%)	79 (15%)	84 (14.9%)
Number of pits (%)	449 (85%)	481 (85.1%)
Ratio of Pits : Scratches	5.7 : 1	5.5 : 1
Pits & Scratches / Field (lowest recorded)	9	21
Pits & Scratches / Field (highest recorded)	97	94

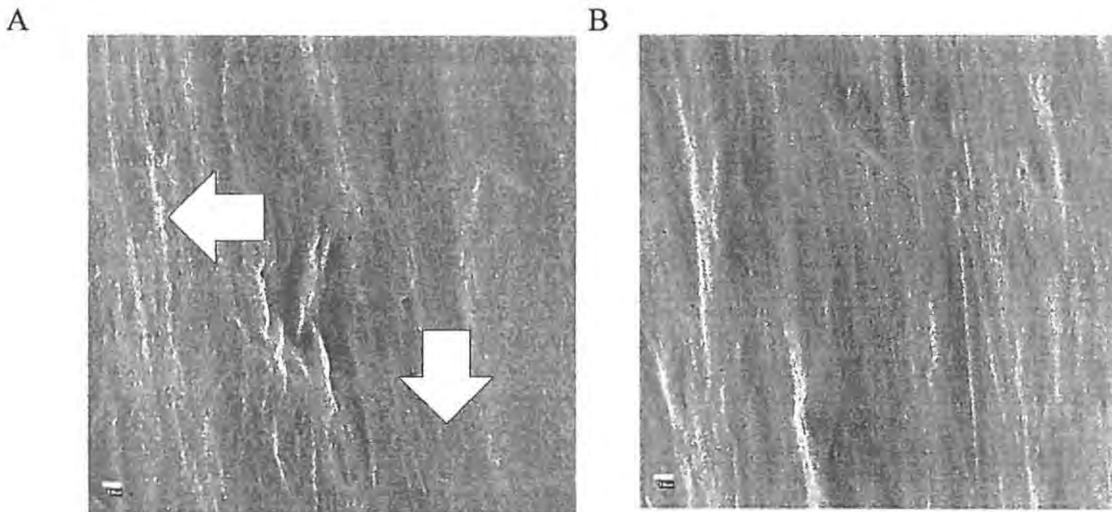

FIGURE 5.2: Scanning electron micrographs taken from the occlusal surfaces of the second lower molars of common duiker (A) and blue duiker (B). The horizontal arrow indicates a scratch and the vertical arrow a pit. Magnification is 450 X.

The chi-square analysis showed no significant interspecific differences in the proportions of pits and scratches on the teeth of both duiker species ($P = 0.96$; $df = 1$).

Interspecific comparison of the number of features per field indicated no significant differences ($P = 0.53$, Mann-Whitney). Intriguingly however, significant intraspecific differences were shown to exist between the various fields of blue duiker ($P < 0.0001$; $df = 10$; t-test) and common duiker ($P < 0.0001$; $df = 10$; t-test).

The lowest recorded number of features in a 16 cm^2 field (from a micrograph of 450 X magnification) on common duiker teeth was 21 as compared to 9 in a similar field on blue duiker teeth. The highest number recorded, in the same fields for common duiker and blue duiker were 94 and 97 respectively (Table 5.1).

5.4 Discussion

In this study casting of the dental impressions was found unnecessary as the SEM images of the moulds and those of the teeth were similar. Grine (1977) states that impression materials like xantopren provide accurate replicas of the surface details of teeth up to magnifications of approximately 2000 X. Grine (1977) however, adds that this neat replication may undergo distortion during the coating process. Aquasil smart wetting impression material used in this study, was sputter-coated with gold, and this did not affect the surface details of the teeth. As a result of the unavoidable damage to specimens, (Ryan, 1979) using teeth in the place of dental impressions was never considered an option in the study.

It is established that the diets of grazers and browsers result in different patterns of molar microwear (Walker *et al.*, 1978; Teaford, 1985; Solounias and Hayek, 1993; Mainland, 1998). Browsers are characterised by many pits and few scratches, while grazers have many scratches and few pits (Solounias and Hayek, 1993). In comparison to a folivorous diet a frugivorous diet results in teeth with a higher density of pits (Teaford and Walker, 1984; Teaford and Runestad, 1992) and the hard fruit eaters have wider pits than the soft fruit eaters (Teaford, 1985; Teaford and Runestad, 1992). Since the diets of blue and common duiker are similar (Boomker, 1981; Wilson, 1966; Allen-Rowlandson, 1986; Bowland, 1990; Bowland and Perrin, 1998) as supported by the diet analyses in chapters 2,3 and 4 it is not surprising that the dental wear on their molar occlusal surfaces is also similar. Both duiker species are predominantly pitted which is characteristic of browsers.
Covert and Kay, (1981) and Peters (1982) attribute the differential wear on teeth of grazers (many scratches and few pits) to the opaline phytoliths in grasses. Baker *et al.*, (1959) and Kay and Covert, (1983) demonstrated that wear caused by the opaline phytoliths and that of gritty

diets are essentially similar. Blue duiker feed on fallen leaves, fruit and flower (Skinner and Smithers, 1990; Faurie and Perrin, 1993; Bowland and Perrin, 1998) which are ingested along with accompanying debris. As a result, it might be expected that blue duiker dental wear would be closer to that of grazers, but the results from the present study suggest that this is not the case. It is possible that utilisation of fruit by both duiker genera explains this. Teaford and Walker, (1984) and Teaford and Runestad (1992) relate a high incidence of pits to a frugivorous diet. It is therefore likely that the dental effects of eating fruits in both duiker genera overshadows any minor feeding habit differences.

The significant intraspecific differences (between similar sites on the molars of the same species) in the number of features per field is interesting. Although every effort was made to ensure that specimens for the study were collected from the same area at the same time, this was not entirely possible. All specimens had been collected from Peddie and King William's Town districts, which are neighbouring jurisdictional areas of the Eastern Cape Province. At the time of collecting the specimens, both these districts were described as having similar vegetation types, which was a combination of valley bushveld and Eastern Province thornveld (Comins,1962; Acocks, 1975). All specimens were collected between 25 May 1948 and 05 April 1949. However, most specimens were collected during autumn and winter (Appendix C). Despite the use of only adult specimens (of unknown ages) in the study, age was not fully controlled for, and therefore may also have been a variable affecting the results. Although the factor of sex is not mentioned anywhere in the literature, in this study only three specimens were of unknown sex, also males and females were spread evenly throughout all categories (species and localities) (Appendix C). Finally, the small number of features in some micrographs may be due to the obliteration of small features by subsequent larger ones.

Identification of features can be achieved by subjective inspection, as was the case in this study, or by using arbitrary dimensional ratios (Grine, 1986). The latter procedure requires the use of a digitizer controlled by computer (Walker, 1984; Teaford and Robinson, 1989; Solounias and Hayek, 1992), and with less precision a dial-equipped caliper (Grine, 1986), or an electronic planimeter (Gordon, 1984 a).

Gordon (1982) postulates that the recognised types of microscopic abrasion features are not intrinsically different, but rather manifestations of different degrees of shear and compression subjected to the agents which produce microwear. According to this view, pits and scratches are found at opposite ends of a continuum of surface wear phenomena, such that the decision about where to make the division is always arbitrary (Gordon 1988). Different cut-off points have been used. Daegling and Grine (1994) defined pits as those features with a length-width ratio of 4:1 or below, while Teaford and Walker (1984) and Teaford (1985) assigned to pits a ratio of 10:1 and anything above to scratches. Subsequent assessment of the features indicated that those features recognised as pits in this study possessed length to width ratios of about 4:1 and below. In an analysis of feature dimension ratios, Solounias and Hayek (1993) concluded that the best diagnostic method of tooth microwear analysis utilizes the number of pits smaller than or equal to the ratio four (length over width), the number of scratches between four and one hundred in length to width ratio, and that of gouges greater than one hundred in length to width ratio.

The data used in this study were from microwear counts. Microwear feature densities and relative abundance have widely been used to detect dietary differences among closely related species (Teaford and Walker, 1984; Teaford and Runestad, 1992; Solounias and Hayek, 1993) however, feature dimensions are also equally important (Gordon, 1982). Robson and Young, (1990) state that microwear feature dimensions rather than feature densities and

relative abundances, may be the most suitable for investigating diet differences of closely related species. However, Teaford and Runestad (1992) describe scratch widths as poor indicators of dietary differences.

To conclude, although the results of this study did not show any significant dental microwear differences between the blue and common duiker, they support and confirm that the two are browsing species, with fruit as part of their diets.

It can also be concluded that a frugivorous diet has a great impact (high incidence of pits) on the dental microwear surfaces in the two duiker genera.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

Hofmann and Stewart (1972) as well as Jarman (1974) placed the common duiker and blue duiker in the same dietary group, that of selective foragers (Jarman, 1974), taking juicy concentrated herbage consisting of fruit and dicot foliage (Hofmann and Stewart, 1972). However, in a recent dietary classification scheme of African bovidae (Gagnon and Chew, 2000), the two duiker species have been described differently and placed in separate groups. Whereas, the results of my study are in agreement with Gagnon and Chew (2000) for the common duiker which are browsers consuming more than 70% dicots, my findings do not agree with their description and consequent classification of the blue duiker. Contrary to Gagnon and Chew (2000), my study has shown that blue duiker consume a far lower percentage (17%) of fruit than that given by Gagnon and Chew (2000) (> 70%) and accordingly blue duiker would not be classified as frugivores. Therefore it would be appropriate to state that blue duiker, in the dry lowland coastal forests (like at Salem), with an abundance of freshly fallen leaves and scarcity of fruit (Bowland, 1990), are predominantly folivores (browsers), whereas those inhabiting tropical rain forests are mainly frugivores (Dubost, 1984). This has been supported by Faurie and Perrin (1993), who state that blue duiker have varied food habits throughout their distribution. The implication of this for the conservation of blue duiker is that the species appears to be able to feed on a range of different food plants. However, the forest patches provide blue duiker with primary cover in addition to food (Skinner and Smithers, 1990; Bowland, 1992) such that the conservation of forest is essential for the existence of the blue duiker.

Blue duiker at Salem exhibited no seasonal variation in utilisation of the broad range of the 30 plant food items occurring in their diet, nor the 6 plant fruit species which were part of the former.

Both blue duiker and common duiker feed selectively (Jarman, 1974; Allen-Rowlandson, 1986; Hanekom and Wilson, 1991) and this has been supported by the results of this study. All dietary analyses indicated that, on average, less than one third of the total number of plant species identified in the diets provided 50% or more of the food eaten.

In accordance with previous reports about common duiker (Keymer, 1969; Boomker, 1983; Allen-Rowlandson, 1986; Skinner and Smithers, 1990), results of the present study showed the animal to be mainly a browser, with only two monocotyledonous plant species (*Sanseviera hyancithoides* and *Protasparagus densiflorus*) identified in the diet at Kasouga and Grants valley farms. The combined annual percentages of the two species were 2% at Grants valley farm and 0.5% at Kasouga farm, and in the latter, food preference results indicated avoidance (preference index < 0.25) for *Sanseviera hyancithoides*.
Kasouga farm is predominantly stocked with cattle (grazers), and the common duiker are unlikely to compete with this domestic herd for food. As Gwynne and Bell (1968) hypothesised, the coexistence of different species (browsers and grazers) may be facilitative rather than competitive.
The diet analyses for common duiker at Kasouga and Grants valley indicated that (with the exception of chicory), *Ehretia rigida, Dovyalis rotundifolia, Diospyros dichrophylla, Rhus crenata, Rhus glauca* and *Euclea undulata* were important food plant species. Various vegetation surveys (Dyer, 1937; Martin *et al.*, 1960; Acocks, 1975; Lubke, 1996; Lubke and

McKenzie, 1996; Lubke *et al.*, 1996) covering an area which includes Kasouga indicate that all these plant species along with other dicots make up the bush clumps, and for this study most of the faecal pellets for common duiker were found within and at the periphery of the bush clumps. These findings suggest that common duiker spend a considerable amount of time inside the bush clumps either feeding or in concealment while lying down and ruminating. Thus the conservation of the bush clumps in the otherwise cleared fields is essential for the maintenance of the common duiker.

The dietary analyses and food preferences for the blue and common duiker, indicated that the most important food plant species was *Ehretia rigida*. Not only was the foliage of this shrub selectively fed on by the blue and common duiker, but its fruit were also an important component of the diets of both species. However, the vegetation surveys conducted indicated that *Ehretia rigida* had a percentage occurrence of between 0.1% and 1.03% throughout the year, meaning that it is an important but scarce food resource that requires proper conservation measures.

The diet of common duiker at Kasouga showed no seasonal variation, but that of common duiker at Grants valley did, and this was attributed to utilisation of chicory.

In the common duiker at Grants valley one of the principal items in their diet (Petrides, 1975) was chicory, *Chichorium intybus* which is a commercial crop grown in three districts along the Eastern Cape coast. The crop provided more than one third (35.6%) of the winter diet and a substantial proportion (14.4%) of the spring diet of the animals. These findings confirm earlier reports of common duiker feeding on cultivated crops (Ansell, 1960; Wilson and Roth, 1967; Skinner and Smithers, 1990) and chicory in particular (Coetzee, 1979; Randell, 1999). In the presence of a large common duiker population (duiker populations in

study area were not established), the substantial contribution of chicory as a food item to the diet of common duiker is suggestive of negative implications for commercial growing of chicory at Grants valley. In order to curtail the loss of income to chicory farmers (due to common duiker and other mammals activities), Randell (1999) proposed a management program involving fencing and modification of the shapes of chicory fields.

Both blue duiker and common duiker had approximately 85% pits and 15% scratches on their dental surfaces. Consequently, the dental microwear results from my study concur with those of Solounias and Hayek (1993), that browsers have many pits and few scratches. Dental microwear differences between browsers and grazers have also been illustrated by Walker *et al.*, (1978), Teaford (1985), as well as Mainland (1998). The high incidence of pits on the dental surfaces of blue duiker and common duiker may be attributed to utilisation of fruit by both species, as Teaford and Walker (1984) and Teaford and Runestad (1992) correlate a frugivorous diet to high occurrence of dental pits.
An assumption that can be proposed from these results, is that differences in dental microwear should exist between the predominantly frugivorous blue duiker in tropical rain forests (Dubost, 1984) and the mainly folivorous blue duiker inhabiting the dry, lowland coastal forests (Bowland, 1990) such as that at Salem in the Eastern Cape.
It appears that while studies of dental microwear may be able to distinguish between diet on a broad scale, they cannot separate species with closely similar diets.

The validity of faecal analysis technique for studying diet, has been challenged on numerous grounds, including differential digestion (Anthony and Smith, 1974; Gill *et al.*, 1983; Johnson *et al.*, 1983; Stevens *et al.*, 1987; Norbury and Sanson, 1992). However, the method

was appropriate for the common duiker which is shy and secretive (Wilson and Clarke, 1962; Dunbar and Dunbar, 1979; Skinner and Smithers, 1990) and blue duiker, a rare and protected species (Crawford, 1984; Smithers, 1986; Bowland, 1992), in that use of faecal samples caused minimal disturbance to the animals, and eliminated the necessity to kill them for rumen contents. The use of faecal matter also allowed diet analyses for all seasons of the year and throughout the home range of the subjects.

APPENDIX A

Common and botanical (scientific) names of the plants comprising the reference plant collection used for common duiker (*Sylvicapra grimmia*) diet analyses at Kasouga and Grants valley. In brackets, ( ) are the local Xhosa common names.

COMMON NAME	SCIENTIFIC NAME
Wolboontjie	*Rhyncosia hirsuta*
Cat-thorn	*Scutia myrtina*
Granny bonnet	*Hermannia althaeoides*
Korantebessie (Intlokolotshane)	*Rhus crenata*
Botterblom	*Gazania linearis*
	Chaemaechrista capensis
Everlasting	*Helichrysum herbacium*
Monkey apple	*Diospyros dichrophylla*
	Falkia canescens
	Eriosema squarrosum
Perdeklou	*Eriospermum brevipes*
Wild clover	*Trifolium burchellianum*
Black eyed susan	*Thunbergia capensis*
Kareeboom	*Rhus incisa*
Wild apricot	*Dovyalis rotundifolia*
Sodom's apple	*Solanum sodomaeodes*
Gonna	*Passerina montana*
Wildemalva	*Abutilon sonneratianum*
Cherry wood	*Pterocelastrus tricuspidatus*
Bitou	*Chrysanthemoides monolifera*
Coast red milkwood	*Mimusops caffra*

	Protasparagus densiflorus
	Commelina africana
	Clutia sp
	Achyranthes indica
Saffron wood	*Cassine crocea*
Monkey rope	*Cynanchum capense*
Bitou	*Haplocarpha lyrata*
Stinkruid	*Cotula heterocarpa*
	Allophylus natalensis
Duermekaarbos	*Ehretia rigida*
Knobwood (Mlungamabele)	*Zanthoxylum capense*
Daisy	*Cenia sericea*
Everlasting	*Helichrysum dregeanus*
Everlasting	*Helichrysum spiralepis*
Mother in law's tongue	*Sanseviera hyancithoides*
Wild lobelia	*Lobelia tomentosa*
	Platycarpha sp
Paint brush	*Haemanthus albiflos*
	Senecio hastulatus
Everlasting (Imphepho)	*Helichrysum odoratissimum*
Canary weed	*Senecio inaequidens*
	Walafrida sp

White milkwood	*Sideroxylon inerme*
Wild grape (Chitibunga)	*Rhoicissus tridentata*
Leeubekkie	*Nemesia floribunda*
Hotnotskool	*Trachyandra affinis*
Everlasting	*Helichrysum felinum*
	Senecio hastulatus

Wild ertjie	*Vigna capensis*
Caper bush	*Capparis sepiaria*
	Tephrosia pallens
Natal guarri	*Euclea natalensis*
Taaibos	*Rhus glauca*
Wild honeysuckle	*Turrea obtusifolia*
Noem noem	*Carrissa haematocarpa*
	Ipomoea ficifolia
Everlasting	*Helichrysum cymosum*
Everlasting	*Helichrysum oreonitens*
Draai bos	*Felicia filifolia*
	Wahlenbergia sp
	Protasparagus densiflorus
	Pavonia praemorsa
	Centella sp
	Selago sp
	Senecio quinquelobus
Parsley fern	*Cheilanthes viviridus*
Bastard saffron wood	*Cassine pappilosa*
Guarri	*Euclea undulata*
	Clutia sp
	Rhynchosia caribaea
Marigold	*Ursinia anethoides*
	Asparagus racemosus

APPENDIX B

Common and botanical (scientific) names of plants comprising the reference plant collection used for blue duiker (*Philantomba monticola*) diet analysis at Salem. In brackets ( ) are the local Xhosa common names.

COMMON NAME	SCIENTIFIC NAME
Cat-thorn	*Scutia myrtina*
Granny bonnet	*Hermannia althaeodes*
Korantebessie (Intlokolotshane)	*Rhus crenata*
Kareeboom	*Rhus incisa*
Wildemalva	*Abutilon sonneratianum*
Bitou	*Chrysanthemoides monolifera*
Coast red milkwood	*Mimusops caffra*
	Protasparagus densiflorus
	Commelina africana
	Clutia sp
Monkey rope	*Cynanchum capense*
Stinkruid	*Cotula heterocarpa*
Duermekaarbos	*Ehretia rigida*
Taaibos	*Rhus glauca*
Everlasting	*Helichrysum oreonitens*
	Centella sp
	Selago sp
	Senecio quinquelobus
Parsley fern	*Cheilanthes viviridus*
Bastard saffron wood	*Cassine papillosa*
Guarri	*Euclea undulata*

	Clutia sp
	Asparagus racemosus
Bloublom bossie	*Felicia aethiopica*
Doringboom	*Acacia karroo*
	Acacia sp
Wildemalva	*Abutilon sonneratianum*
Boerboon	*Schotia afra*
Prickly pear (Tolofiya)	*Opuntia sp*
Melkbostou	*Sarcostemma viminale*
Suring	*Oxalis latifolia*
Spekboom	*Portulacaria afra*
Wild olive	*Olea europaea*
Granny bonnet	*Hermannia althaeodes*
Sneezewood (Umthathi)	*Ptaeroxylon obliquum*
	Senecio quinquilobus
River euphorbia (Intlontlo)	*Euphorbia triangularis*
Kooboo-berry	*Cassine aethiopica*
Tree euphorbia	*Euphorbia tetragona*

APPENDIX C

Information accompanying the blue and common duiker museum specimens whose molars were used in the dental microwear analyses.

Specimen	Catalogue Number	Sex	District of origin	Date collected
Blue duiker	KM 15056	M	King William's Town	25 April 1948
Blue duiker	KM 15060	?	King William's Town	25 May 1948
Blue duiker	KM 15082	F	King William's Town	30 July 1948
Blue duiker	KM 15037	M	King William's Town	27 June 1949
Blue duiker	KM 15055	M	King William's Town	06 May 1948
Blue duiker	KM 15558	?	King William's Town	08 May 1949
Blue duiker	KM 15559	?	King William's Town	27 June 1949
Blue duiker	KM 15052	M	Peddie	04 July 1948
Blue duiker	KM 15053	M	Peddie	01 July 1948
Blue duiker	KM 15062	M	Peddie	04 July 1948
Blue duiker	KM 15081	M	Peddie	19 July 1948
Common duiker	KM 15098	F	King William's Town	02 March 1949
Common duiker	KM 15099	F	King William's Town	05 April 1949
Common duiker	KM 15100	F	King William's Town	07 April 1949
Common duiker	KM 15101	F	King William's Town	17 January 1949
Common duiker	KM 15102	M	King William's Town	17 January 1949
Common duiker	KM 15103	M	King William's Town	09 July 1948
Common duiker	KM 15129	M	King William's Town	16 May 1948
Common duiker	KM 15138	M	Peddie	28 August 1948
Common duiker	KM 15162	M	Peddie	02 August 1948
Common duiker	KM 15163	M	Peddie	08 August 1948
Common duiker	KM 15164	F	Peddie	08 August 1948
Common duiker	MMK/M/175	F	Kimberley	? February 1990
Common duiker	MMK/M/6916	F	Griekwastad	21 May 1991

KEY

MMK McGregor Museum Kimberley (Not used in the analyses)

KM Amathole Museum (Formerly Kaffrarian museum)

? Not given

F Female

M Male

King William's Town (3327 CD) and Peddie (3327 AA) districts are in Eastern Cape Province of South Africa.

Griekwastad (2823 CC) and Kimberley (2824 DB) districts are in Northern Cape Province of South Africa.

APPENDIX D

Scientific names of the animals referred to in the text.

COMMON NAME	SCIENTIFIC NAME
Blue duiker	*Philantomba monticola*
Common duiker	*Sylvicapra grimmia*
Red duiker	*Cephalophus natalensis*
Oribi	*Ourebia ourebi*
Bushpig	*Potamochoerus porcus*
Rabbit	*Pronolagus rupestris*
Grysbok	*Raphicerus melanotis*
Springhare	*Pedetes capensis*
Baboon	*Papio ursinus*
Monkey	*Cercopithecus aethiops*
Greater kudu	*Tragelaphus strepsiceros*
Lesser kudu	*Tragelaphus imberbis*
Suricate	*Suricata suricatta*
Small spotted genet	*Genetta genetta*
Tree civet	*Nandinia binotata*
Yellow mongoose	*Cynictis penicillata*
Gerenuk	*Litocranius walleri*
Common water buck	*Kobus ellipsiprymnus*
Domestic sheep	*Ovis aries*
Cattle	*Bos taurus*
Domestic goat / Boergoat	*Capra hircus*
Spotted hyaena	*Crocuta crocuta*
Wild dog	*Lycaon pictus*
Grey wolf	*Canis lupus*

Cheetah	*Acinonyx jubatus*
Striped mouse	*Rhabdomys pumilio*
Gentle lemur	*Hapalemur griseus*
Giant panda	*Ailuropoda melanoleuca*
Hyrax (Yellow- spotted rock dassie)	*Heterohyrax brucei*
Turkey	*Meleagris gallopavo*
Egyptian goose	*Alopochen aegyptiacus*
Guinea fowl	*Numida meleagris*
Chicken	*Gallus domesticus*
Mopane catterpillars	*Gonimbrasia belina*

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