# SOME ASPECTS OF THE ECOLOGY OF BUSHBUCK

## (*Tragelaphus scriptus* Pallas 1776)

## IN THE SOUTHERN CAPE

by

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## ABSTRACT

The social biology and habitat selection of bushbuck, *Tragelaphus scriptus*, was investigated by radio-tracking five bushbuck in the same area, three males and two females. A large degree of over= lap of home ranges was shown to exist. Evidence is advanced to suggest the existence of a time-mechanism to separate individuals whose home ranges overlap. Subadult males have larger home ranges than females. Crepuscular peaks were exhibited in the activity pattern of the study animals.

Of 1 380 animals observed in this study, 61% occurred singly and 29% in twos. Breeding is probably throughout the year with peaks in the rate of parturition in April, July-August and November.

Bushbuck show a need for canopy cover during the day but will frequent areas with lateral cover or even no cover during the night. Although the indigenous forests are of great importance to bushbuck, evidence was found that they can exist in a very much modified environment such as *Pinus* spp stands.

Bushbuck occur at densities of about 3-5 animals/km$^2$ in the Southern Cape.

They feed on a wide array of food plants but are mostly browsers with grasses constituting only about five per cent of the diet.

A surprisingly high incidence of mushrooms were found in the diet during winter. Some indications exist of the possible presence of sub-optimal feeding conditions during winter.

Information is also presented on nutritional element levels, external parasites and morphological data.

# CHAPTER I

## PREFACE

### 1.1 INTRODUCTION

The herbivores of Africa are one of the better known natural resources of the continent. The diversity of species and adaptations to widely different environmental conditons are unequalled anywhere. It is undoubtedly the single most important attraction for tourists in Central and Southern Africa. The importance of this industry can be gauged by the expenditure of R279 million by foreign tourists in South Africa during 1975 (Anon, 1977). Knobel (1971) goes so far as to say that tourism must be accepted as a very important, if not the most important factor in the economy of a country. He also points out that, by attracting foreign visitors to a country, it develops a better understanding amongst nations, and thus also has an advantage from a political point of view.

The Southern Cape coastal area between the towns of Mossel Bay and Plettenberg Bay is one of the major tourist areas of South Africa. The magnificant beaches are undoubtedly the major attraction in this area. However, the large areas of relatively undisturbed indigenous high-forests are of con= siderable importance, especially since the opening of two hiking trails through these areas. These trails enable people to traverse the forests on foot and enjoy a feeling of solitude - something which has become a rare comodity in our society.

The wildlife in the forests, although fewer in species and numbers than in reserves situated in the savanna biome (Davis, 1962, in Bigalke, 1968), constitutes an important component of the forest ecosystem. Many tourists and hikers take a special interest in the larger wildlife species such as elephant *Loxodonta africana*, leopard, *Panthera pardus*, and bushbuck. Because of the forest environment and their behaviour, these animals are not often seen. However, the mere fact that they are present and signs of them can be found, is a stimulating experience to people who are used to be restricted to their cars in game reserves.

Unfortunately even the indigenous forests can not be termed unspoilt and even less to be complete ecological units. Too much uncontrolled exploitation and clearing of forests have taken place in the past. Man must therefore manage these forests on a scientific basis. This is in fact a pre-requisite for their optimum use and something which can only be achieved if a sound basis of scientific knowledge exists. Consequently research is needed to provide this basic information.

The present investigation must therefore be seen as a contribution to our understanding of the forest ecosystem in its broadest context, and in particular of bushbuck, a small component of this system.

## 1.2 TAXONOMY

The bushbuck, Tragelaphus scriptus, was first described by Pallas in 1776. The type specimen came from Senegal, West Africa.

The classification of the species is as follows (Young, 1962; Ansell, 1968):

| | | |
|---|---|---|
| ORDER | : | Artiodactyla |
| SUBORDER | : | Ruminantia |
| INFRAORDER | : | Pecora |
| SUPERFAMILY | : | Bovoidea |
| FAMILY | : | Bovidae |
| SUBFAMILY | : | Bovinae |
| TRIBE | : | Tragelaphini |
| GENUS | : | Tragelaphus |
| SPECIES | : | scriptus |

Probably owing to their wide distribution in Africa south of the Sahara, and the extreme range of climatic and other environmental conditions under which bushbuck are found, they vary considerably and a large number of subspecies have been described. Nine are recognised by Ansell, (1968): as follows:

T.s. scriptus, from Senegal eastwards to Nigeria and Cameroon and south to the Congo river.

<u>T.s. bor</u>, Chad, Central African Republic, northern Congo, southern Sudan, Uganda and northwestern Kenya.

<u>T.s. decula</u>, northwestern Abyssinian range of the species.

<u>T.s. powelli</u>, Central Abyssinia.

<u>T.s. meneliki</u>, Southern and southeastern Abyssinia and north= western Somalia.

<u>T.s. delamerei</u>, most of Kenya and Tanzania.

<u>T.s. ornatus</u>, Angola, northwestern Botswana, Zambia, south= eastern Congo, Malawi, northern Mocambique and northeastern Rhodesia.

<u>T.s. roualeyni</u>, eastern Botswana, western and southern Rhodesia, Limpopo valley, southern Mocambique, northeastern Zululand and Transvaal lowveld.

<u>T.s. sylvaticus</u>, the South African range of the species except northeastern Zululand and the Transvaal lowveld. Roberts (1951) describes males of this subspecies as being of a dark brown colour, but almost black individuals are encountered locally. According to this author there are no signs of transverse white bands across the body as in <u>T.s. ornatus</u>, and considerably fewer white spots on the body. However, Von Gadow (1970) provides photographic evidence that transverse dorsal white bands do occur, although very infrequently. In the ewes the colour is

fawny, sometimes darkening, with white markings as in the male (Roberts, 1951).

On distributional grounds (fig. 1), animals collected in the present study are referable to T.s. sylvaticus. However, it is unlikely that other subspecies differ significantly in ecology and behaviour, so that the results should not apply only to this subspecies.

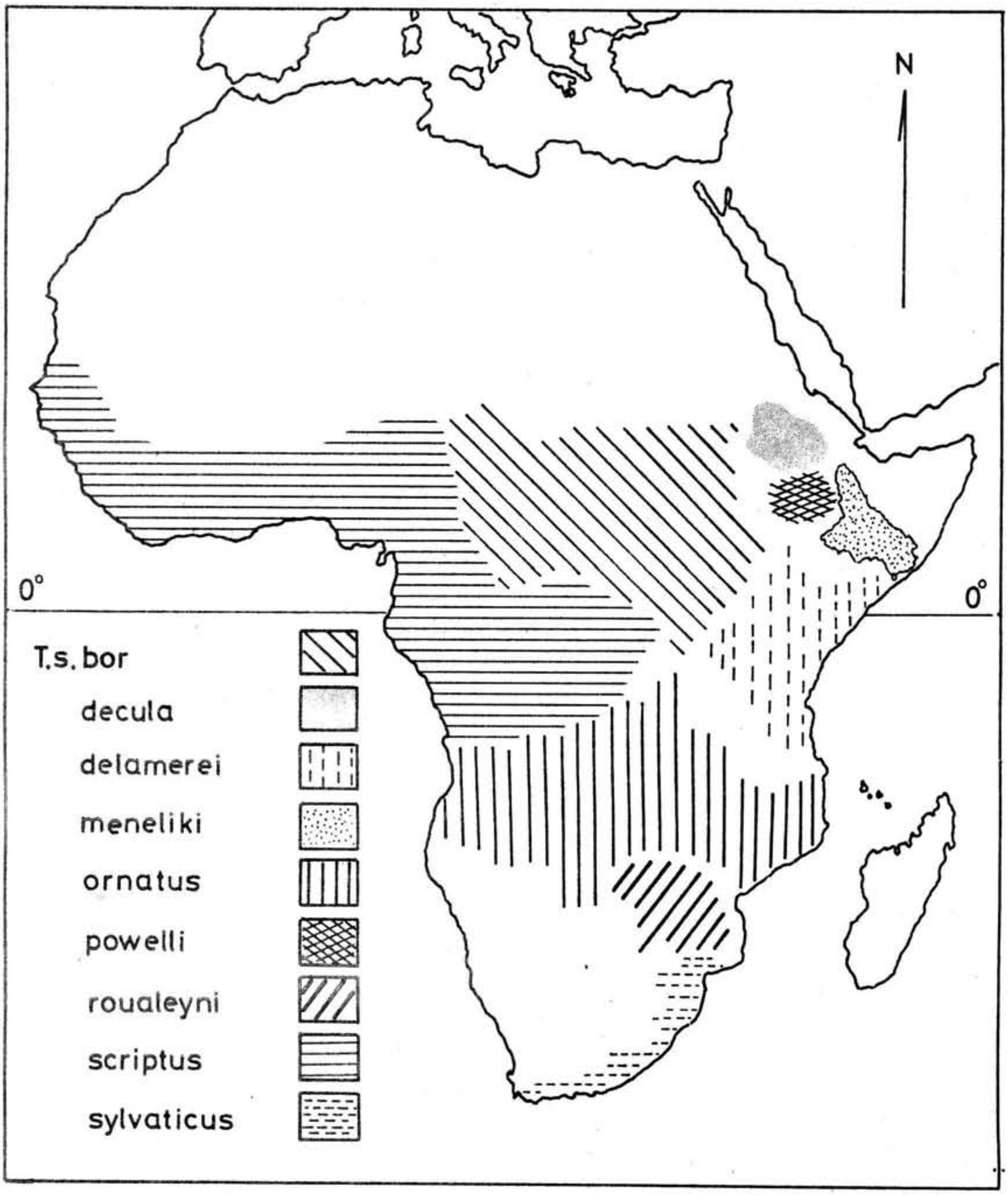


Fig 1 : Distribution of subspecies of <u>Tragelaphus</u> <u>scriptus</u> in Africa (Allsopp, 1969)

## 1.3 DISTRIBUTION

The Strepsicerotini, which is equivalent to the Tragelaphini, were thought to have been distributed throughout Europe, Asia, North Africa and Ethiopian Africa during the Upper Miocene to Recent (Simpson, 1945). However, the supposed trage= laphine fossils from Europe and Asia were recently reclassified and referred to other bovid tribes, mainly Antilopini (Gentry, 1971).

The tribe to which the bushbuck belongs has therefore always been restricted to Africa.

The earliest known fossils of bushbuck, which are not the modern species but may represent an immediate ancestor, come from the Makapansgat Limeworks Grey Breccia near Potgietersrus, which is probably between two and three million years old, and from sediments in East Africa dated about 2,5 million years. In various fossil deposits dating from about one million to 200 000 years ago, fragments that are indistinguishable from modern bushbuck have been found. For instance there are some teeth from Kromdraai and the later Swartkrans breccia (Vrba, pers. comm.). In South African deposits of the late Pleistocene-Holocene (last 200 000 years), T. scriptus, or at least remains that cannot be distinguished from it, is often present. Thus the species has been identified from Klasies River mouth in the southern Cape Province (Klein, 1975). In the vicinity of the present study, at Nelson Bay cave near Plettenberg Bay, bushbuck are absent from fossil assemblages dating from 12 000 to 18 000 years ago, but present thereafter (Klein, 1972). However, this late occurance is in all probability a local event and due to changing environmental conditions peculiar to this locality.

Of the six species of the genus Tragelaphus, greater kudu, T. strepsiceros; lesser kudu, T. imberbis; mountain nyala, T. buxtoni; sitatunga, T. spekei; nyala, T. angasi and T. scriptus, the bushbuck is by far the most widely distributed throughout the Ethiopian region as shown in fig. 1. It is one of the wild ungulate species which has probably suffered least from the impact of modern man on African wildlife. Although it has been reduced in places and has been exterminated where its habitat has been destroyed completely, the species has shown a remarkable ability to survive in areas greatly disturbed by the activities of man. Consequently, its distribution has probably not changed appreciably from that before the advent of the Europeans in Africa.

Du Plessis (1969) writes as follows on the distribution of bushbuck in Southern Africa:

"Owing to incomplete records of past distribution, the widest historical range of the bushbuck will never be known exactly, but wherever it was known to have occurred in the past it is still to be found, even though in more limited numbers. Bryden (1899) writes: 'These antelopes are found in suitable localities throughout South Africa, and, owing to their retiring habits, will be the last to remain'. This statement seems to a large extend to be true, although along the southern Cape coast it does not extend as far west as it used to".

His map of past distribution of bushbuck, shows that they occured westwards along the southern Cape coast as far as the district of Caledon. However, the species still occurs on approximately five per cent of the farms in the Caledon district, and are also found in the districts of Bredasdorp, Montagu, Robertson, Swellendam and Riversdale (Lloyd, 1972). It can therefore be assumed that the past distribution of bushbuck in Southern Africa has not changed significantly during recent times.

## 1.4 MORPHOLOGY

A description of bushbuck can be found in Roberts (1951), Allsopp (1969) and Smithers (1971).

Body, horn, and cranial measurements, as well as gross weight and field dressed weight were recorded for the 14 bushbuck males culled during 1974 and 1975 at Goudveld State Forest. Body measurements, where applicable, were taken between pegs. Field dressed weight was determined following Ansell (1965), except for the kidneys and kidney fat which were not included.

The animals were divided into three broad age classes using the ageing techniques described by Simpson (1974). Be= cause of inexperience with these techniques and the loss of the incisors from many of the mandibles, a finer age classification was not attempted.

Measurements are given in tables 1 to 3. For various reasons not all measurements of all animals were taken or were usuable.

Some of these attributes are compared in table 4 with data available for other bushbuck populations. These comparisons are between males of four to eight years of age. Allthough data from other sources (Roberts, 1951) are also available, these are based on too few animals to allow for meaningful comparisons.

Unfortunately the data in table 4 can not be subjected to statistical analysis because the attribute values of the in= dividual animals are not available. However, it appears as if animals in the southern parts of the range of the species are heavier and taller than those towards the central part of their range. Due to lack of information it was not possible to ascertain whether these morphological differences can be attributed to differences between T.s. sylvaticus and T.s. ornatus, the two subspecies involved.

A mean carcass yield of 55,9 per cent can be derived from the data in table 2. This is within the range of carcass yield figures for African game animals of 50 to 63 per cent (Keep, 1972). The comparable figure for adult nyala males is 57,0 per cent (Keep, 1971) and 57,4 per cent for male eland, Taurotragus oryx (Keep, 1972). These figures show a reasonable degree of uniformity amongst members of the Tragelaphini.

TABLE 1 : Body measurements of 14 bushbuck males

| | BODY MEASUREMENTS (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | TOTAL LENGTH | HEAD & BODY | TAIL | HIND FOOT (c.u.) | EAR | GIRTH | HEIGHT AT WITHERS |
| (a) 2 - 3 years | | | | | | | |
| mean | 138,5 | 118 | - | 31,8 | 14,5 | 79 | 80 |
| range | 129 - 148 | 112 - 124 | - | 29,5 - 34 | 14 - 15 | 78 - 80 | 76 - 84 |
| SD | 13,4 | 8,5 | - | 3,2 | 0,7 | 1,4 | 5,7 |
| n | 2 | 2 | - | 2 | 2 | 2 | 2 |
| (b) 4 - 7 years | | | | | | | |
| mean | 154,5 | 130,4 | 21 | 32,7 | 15,8 | 88,5 | 84,7 |
| range | 135 - 168 | 114 - 140 | 20 - 22 | 28,5 - 37 | 14,5 - 18 | 81 - 96 | 76 - 94 |
| SD | 11,6 | 7,5 | 1,4 | 2,9 | 1,0 | 4,9 | 5,8 |
| n | 11 | 11 | 2 | 11 | 11 | 11 | 11 |
| (c) 9 - 11 years | | | | | | | |
| mean | 141 | 118 | 23 | 31 | 14 | 84 | 81 |
| range | - | - | - | - | - | - | - |
| SD | - | - | - | - | - | - | - |
| n | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

ABLE 2 : Horn measurements and weights of 14 bushbuck males

| | HORN MEASUREMENTS (cm) | | WEIGHTS (kg) | |
|---|---|---|---|---|
| | TOTAL LENGTH ALONG CURVE | TIP TO TIP | GROSS WEIGHT | FIELD DRESSED WEIGHT |
| a) 2 - 3 years | | | | |
| mean | 23,5 | 12,8 | 47,1 | 25,8 |
| range | 22 - 25 | 12,5 - 13 | 46,2 - 48 | 25 - 26,5 |
| SD | 2,1 | 0,4 | 1,3 | 1,1 |
| n | 2 | 2 | 2 | 2 |
| b) 4 - 7 years | | | | |
| mean | 27,8 | 12,8 | 61,7 | 34,5 |
| range | 22,8 - 31 | 9,7 - 14,8 | 50 - 71 | 25 - 41,5 |
| SD | 2,5 | 1,9 | 6,0 | 4,6 |
| n | 11 | 8 | 11 | 11 |
| c) 9 - 11 years | | | | |
| mean | 31 | 13 | 60,5 | 35 |
| range | - | - | - | - |
| SD | - | - | - | - |
| n | 1 | 1 | 1 | 1 |

TABLE 3 : Cranial measurements of 14 bushbuck males (where available)

| | CRANIAL MEASUREMENTS (cm) | | | | | |
|---|---|---|---|---|---|---|
| | TOTAL LENGTH | CONDYLOBASAL LENGTH | MANDIBULAR LENGTH | ZYGOMATIC WIDTH | PALATAL LENGTH | LENGTH OF LOWER TOOTH ROW |
| (a) 2 - 3 years | | | | | | |
| mean | n.a. | n.a. | 18,65 | 9,38 | 7,24 | 6,78 |
| range | - | - | - | 9,31 - 9,45 | - | - |
| SD | - | - | - | 0,10 | - | - |
| n | - | - | 1 | 2 | 1 | 1 |
| (b) 4 - 7 years | | | | | | |
| mean | 24,3 | 23,4 | 18,19 | 9,69 | 8,41 | 6,81 |
| range | 23,6 - 25,1 | 22,6 - 24,3 | 17,3 - 18,7 | 9,3 - 10,1 | 7,23 - 9,02 | 6,46 - 7,10 |
| SD | 0,74 | 0,85 | 0,48 | 0,25 | 0,60 | 0,20 |
| n | 3 | 3 | 11 | 10 | 8 | 10 |
| (c) 9 - 11 years | | | | | | |
| mean | 24,4 | 23,7 | 18,16 | 9,92 | 8,09 | 6,86 |
| range | - | - | - | - | - | - |
| SD | - | - | - | - | - | - |
| n | 1 | 1 | 1 | 1 | 1 | 1 |

TABLE 4 : Comparison of some morphological attributes of bushbuck from various regions

| Attribute | Present study (Southern Cape) | Morris, 1973 (Rhodesia) | Wilson & Child 1964 (Zambia) |
|---|---|---|---|
| Head & body length (cm) | 130,0 | | 127,0 |
| Hind foot (c.u.) (cm) | 32,7 | 35,9 | 30,0 |
| Height at withers (cm) | 84,7 | 74,6 | 70,0 |
| Horn length along curve (cm) | 27,8 | | 25,6 |
| Mandibular length (cm) | 18,2 | | 17,8 |
| Zygomatic width (cm) | 9,7 | | 9,4 |
| Gross weight (kg) | 61,7 | 47,5 | 42,0 |

## 1.5 PREVIOUS WORK

Lönnberg (1905) discusses taxonimic aspects of hair length and records observations on bushbuck behaviour in the Cameroons. Kolbe (1948) notes the occurence of cryptorchidism amongst bushbuck. Verheyen (1955) describes behaviour and comments on territoriality and related aspects, as well as recording general observations on drinking and ecto-parasites. The first detailed ethological study of, amongst others, bushbuck was undertaken by Walther (1964). Wilson and Child (1964) utilized tsetse control records in Rhodesia to collect data on morphology, tooth eruption sequences and group composition.

The first life table for a bushbuck population was pre= pared by Allsopp (1969) in Kenya who also undertook detailed field observations of social biology. Information on growth and development and aspects of reproduction is also given by this author.

Elder and Elder (1970) describe social groupings and primate associations of bushbuck in Botswana. Associations, sex ratios and feeding habits were investigated by Von Gadow (1970) in the same area as the present study. Thomson (1972) discusses distribution and habitat preference within the Victoria Falls National Park. A thorough investigation into growth and condition, ageing, reproductive changes and breeding in a bushbuck population in Rhodesia was undertaken by Morris (1973). Simpson (1974) studied the ecology of bushbuck in Botswana, covering aspects such as feeding habits, growth and ageing criteria, population dynamics, reproduction, habitat preference and inter-specific relationships. Jacobsen (1974) describes feeding habits, social behaviour, home range and territoriality of bushbuck in the Sengwa area, Rhodesia. A study was undertaken by Waser (1975) in Uganda on population density, activity cycles and ranging patterns. Von Ketelhodt (1976) gives information on lambing intervals in captivity.

Reference can also be found to bushbuck in more general works such as Stevenson-Hamilton (1974), Roberts (1951) and Smithers (1971).

Considering the solitary nature of bushbuck and the dense habitat types which it frequents, this list is certainly a fairly impressive one for an African bovid.

## 1.6 AIMS AND OBJECTS OF STUDY

With the exception of Verheyen (1955) all serious studies on bushbuck up to the present time have been undertaken in the Southern Savanna biome (Davis, 1962, in Bigalke, 1968). These study areas are characterised by being relatively undisturbed by the activities of man. With the exception of the short study by Von Gadow (1970), none were located south of the Tropic of Capricorn so that all were undertaken in a tropical or sub-tropical climate.

The present study area is located in the relict forests of the southern Cape where the climate is temperate. It also represents one of the southernmost points of distribution of bushbuck in Africa. However, the most important difference between this and other study areas is the large degree to which the natural environment has been altered by human activity. Man-made exotic pine and eucalypt plantations have to a great extent replaced the original evergreen, broad-leaved, temperate forests. As an indication of just how much of the original indigenous vegetation has been replaced by exotic plantations one may consider land utilisation by the Department of Forestry, as the largest land-owner in the area. The Southern Cape Forest Region of this department comprises 25 400 ha indigenous forests as opposed to 32 800 ha exotic plantations. It can safely be assumed that a large proportion of the plantation area was at one stage also covered by indigenous forests.

It was considered justifiable to undertake another study on bushbuck to determine habitat use in this particular environment. An added incentive for this investigation was the lack of information on food habits of bushbuck under local conditions.

The ready adaptation of the species to the changed environment, holds promise for managing populations on a sustained yield basis. Although few of the local inhabitants exist on a protein-deficient diet, a reasonable market is available for high-quality venison. At present bushbuck carcasses fetch locally between R1-20 and R1-30 per kg (retail) as opposed to R0-90 and R1-00 per kg for beef. Such prices mean that about R40 is realised per adult male carcass. A realistic cropping scheme can therefore provide income for the forest owner, in an area where traditional timber-producing forestry is becoming less and less of an economic proposition, due mainly to spiralling labour costs.

With the loss of the traditional hunting areas in Mocambiqu and Rhodesia to South African hunters, a case can also be made out for commercial "safari-type" hunting. Admittedly this will of necessity be on a small scale, but even so may be of reasonable economic importance to the larger land-owners. Kettlitz (1962, in Ansell, 1968) points out that the species could stand heavy hunting pressure.

It was therefore decided that quantitative data were needed on population densities and age and sex ratios before population manipulation could be initiated. Coupled to population density is home range behaviour, which eventually became the major field of study. Sanderson (1966) states that a study of mammal movement is useful in a control programme and that, regardless of the control method used, the extent of the animal's daily, seasonal and annual movements should be known.

As the work progressed, various other aspects were touched upon. Some of these are merely recorded eg. ecto-parasites, while others, such as associations, have proved to be interesting and valuable from the viewpoint of management.

The overall object of the study was to increase our knowledge of bushbuck in the Southern Cape, with a view to placing the conservation and utilization of the species on a sound basis.

# CHAPTER II

## STUDY AREAS

This investigation was conducted in various study areas in the southern Cape Province of South Africa.

Intensive radio-tracking work was undertaken in an area of about four $km^2$ on Kruisfontein State Forest, approximately six kilometres to the east of the town of Knysna. The grid reference is 34° 02" S and 23° 09" E.

Observations were made over the whole Southern Cape Forest Region. This is an area stretching from the Keurbooms river in the east to the Gouritz river in the west, and between the Outeniqua mountain range in the north and the Indian Ocean in the south. Observations were largely restricted to State Forests in this area, comprising an area of about 1 240 $km^2$. The radio-tracking study area is situated in the southeastern corner of this region.

Track counts were carried out on two individual State Forests within the Southern Cape Forest Region, Goudveld and Gouna. These two State Forests are adjacent to each other and lie about 12 kilometres north of Knysna.

Some observations were also recorded in the Tsitsikamma, a forested area lying between 50 and 100 kilometres east of Knysna.

Observations as well as some track counts were also undertaken in the Goukamma Nature Reserve situated about 17 kilometres west of Knysna.

All study areas excepting the one used for radio-tracking are referred to as the general study area. It comprises therefore the Southern Cape Forest Region, as well as the Tsitsikamma and Goukamma Nature Reserve. Sections 2.1 to 2.4 contain a brief description of this area.

## 2.1 TOPOGRAPHY, GEOLOGY AND SOILS

The topography of the Southern Cape coastal belt may be described as a series of west-east terraces leading step-like from the shores of the Indian Ocean up to the slopes of the barrier range of the Outeniqua-Tsitsikamma mountains.

Four principal topographical zones may be distinguished: the littoral, the lower plateau, the upper plateau and the moun= tains (Von Breitenbach, 1974).

The littoral is the continental margin of a coastal shelf. It varies from a narrow sandy or rocky strip to wide plains, often with lakes or lagoons.

The lower plateau rises as a cliff-faced terrace above the littoral to a height of 150 to 200 m . It extends about 5 to 16 km inland and reaches 200 to 300 m at the foot of the upper plateau.

The upper plateau builds up on the northern margins of the lower plateau and proceeds further inland at a height of 250 to 550 m until it reaches the extensions of the mountain range.

The slopes of the Outeniqua and Tsitsikamma mountains rise from the northern edge of the upper plateau to elavations of 1 200 to 1 500 m .

The mountain slopes and plateau are deeply intersected by ravines, valleys and gorges through which numerous streams and rivers flow to the sea.

The geology of this region is dominated by the Table Mountain sandstone of which the mountains and most of the upper plateau and the eastern portion of the lower plateau are made up. Pre-Cape sediments and granite bosses constitute most of the western portion of the lower plateau. Other formations present in the area include Bokkeveld beds, Enon beds, Knysna beds and the late Quaternary to recent sands (Von Breitenbach, 1974).

The soils of the Southern Cape coastal belt are derived from acid parent rock which are, except for certain shales, poor in mineral nutrients. According to Von Christen (1960, in Von Breitenbach, 1968) the pH range of the root-penetrable topsoils is 4,0 - 5,0 ($H_2O$). The acidity of the parent material is lower.

Except for certain sand and shale soils, the soils are usually shallow and often, because of an impermeable clay sub=stratum, badly drained or seasonally to permanently waterlogged. The basic soil types encountered are sand soils, sandy loam soils, loam soils and clay soils.

## 2.2 CLIMATE

The climate of the Southern Cape coastal belt is called a temperate version of a subtropical one by Von Breitenbach (1968). It is mainly characterised by precipitation which is well distribute throughout the year and by generally mild temperatures.

Mean annual rainfall varies from 700 mm to 1 200 mm . The distribution of the rainfall during the year shows two periods of increased precipitation, both in amount of rain and number of rain days. One peak is between February and April and the other between August and November. The midsummer decrease is less than that during winter.

Snow falls every winter on the higher mountain peaks but does not usually remain there for longer than a few days. Hailstorms and thunderstorms are rare.

The prevailing winds are those from the south-west and south-east. The south-wester is the rain-bearing and more frequent wind.

A special feature of the region is the occurence of hot dry "bergwinds". These north-westerly winds have a highly desiccating effect on the vegetation. Bergwinds occur throughout the year but are more frequent during the winter months. They are frequently followed by rains after the wind direction changes to south-west.

Air temperature shows annual morning (08h00) means of about 17°C at the littoral, and 14,5°C on the upper portions of the plateau and on the mountain slopes. The absolute maxima and minima reached on the forested plateau and lower mountain slopes are about 38°C and 1°C respectively (Von Breitenbach, 1968).

## 2.3 VEGETATION

According to Acocks (1953) two basic indigenous vegetation types are encountered in the area under consideration, Knysna Forests and False Macchia, veld types 4 and 70 respectively.

The Knysna Forests are of a mixed nature and show few pure communities so far as the dominant species are concerned. The forests are composed of about 125 woody species.

Von Breitenbach (1974) recognises eight forest types viz. the very very dry scrub, very dry scrub-forest, dry high-forest, medium-moist high-forest, moist high-forest, wet high-forest, very wet scrub-forest and very very wet scrub. The following descriptions are from this author.

The very very dry scrub is found on littoral dunes and steep escarpments, and on lower northern and western slopes and ridges at medium to high altitudes. These sites are very hot and dry. The scrub is about 2 - 5 m high and consists of groups of shrubs and occasional, stunted and gnarled, bushy trees, with low ground vegetation in the openings between. The shrub flora is rich in species. Among the most common shrubs are *Allophylus decipiens*, *Buddleia saligna*, *Cassine peragua*, *Chrysanthemoides monolifera*, *Colpoon compressum*, *Euclea schimperi*, *Grewia occidentalis* *Maytenus heterophylla* and *Passerina falcifolia*.

The very dry scrub-forest is found on the lowest level portions of the lower plateau, on western and northern slopes and on ridges at low to high altitudes. It is also found on eastern and southern slopes near or at the littoral. These sites are fairly hot and dry with shallow soils. The scrub-forest consists of a dense jungle-like mixture of tall shrubs, 3 - 6 m high, and stunted, bushy trees, 6 - 12 m high. The ground flora is very poor. Abundantly represented as small trees are *Cassine aethiopica* and *C. peragua*. Other tree and shrub species commonly present are *Buddleia saligna*, *B. salviifolia*, *Calodendrum capense*, *Canthuim obovatum*, *Diospyros dichrophylla*, *Fagara davyi*, *Halleria lucida*, *Maytenus acuminata*, *Olea capensis* subsp. *capensis*, *Pterocelastrus tricuspidatus*, *Rhus chirendensis*, *Carissa bispinosa*, *Gonioma kamassi*, *Rhamnus prinoides* and *Rhus tomentosa*.

The dry high-forest is found on lower level portions of the lower plateau and on western and northern slopes. It is also found on ridges at medium to high altitudes, and on eastern and southern slopes at very low altitudes. These sites are moderately hot and dry. The forest is fairly dense and consists of small to medium-tall, often stag-headed trees. The undershrub layer is low and open and a rich ground flora is present. The tree canopy is irregular and generally about 10 - 19 m high. Among the trees forming the main canopy, *Pterocelastrus tricuspidatus* is usually the most frequent. Other common species are *Apodytes dimidiata*, *Canthium obovatum*, *Curtisia dentata*, *Lachnostylis hirta*, *Olinia ventosa*, *Podocarpus falcatus* and

Rapanea melanophloeos. In the lower storey Gonioma kamassi and Olea capensis subsp. capensis occur abundantly. The layer of undershrubs consist mainly of thorny species such as Carissa bispinosa, Maytenus heterophylla and Scutia myrtina. The ground layer is constituted by ferns, grasses and herbs, such as Thelypteris bergiana, Pellaea viridis, Rumohra adiantiformis, Oplismenus hirtellus and Dietes vegeta. Regeneration of the tree species is usually scarce.

The medium-moist high-forest is found on higher level portions of the lower plateau and on lower level portions of the upper plateau. It is also found on western slopes at medium to high altitude. These sites are temperate and fairly humid. The soils have an impenetrable clay substratum resulting in impeded drainage and fairly moist conditions throughout the year. The forest consist of two fairly dense tree strata above a very dense undershrub layer and a generally scanty ground flora. The upper canopy is about 16 - 22 m high and more or less continuous. Most abundant amongst the taller trees is Olea capensis subsp. macrocarpa followed by Podocarpus latifolius. Other dominants are Apodytes dimidiata, Olinia ventosa, Pterocelastrus tricuspidatus and Rapanea melanophloeos. The lower tree storey is about 6 - 12 m high and consists of pole-stage trees of the upper-storey species and of mature trees of a number of under-storey species. Particularly numerous among the under-storey species is Gonioma kamassi. The undershrub layer is about 3 - 6 m high and consists of a dense and continuous thicket of Trichocladus crinitus. Tree regeneration is abundant. This forest type occupies the largest part of the high-forest area, and nearly 40 per cent of the total are of the Southern Cape indigenous forests.

The moist high-forest is found on eastern and southern slopes at medium to high altitudes and on more level portions of the upper plateau. These sites are temperate and humid with badly drained soils. The forest consists of three irregular tree strata, a dense to open undershrub layer and a luxuriant ground flora. The upper canopy is about 20 - 30 m high con= taining species such as Olea capensis subsp. macrocarpa, Podocarpus latifolius, P. falcatus, Apodytes dimidiata, Nuxia floribunda, Ocotea bullata and Rapanea melanophloeos. The intermediate-storey is about 12 - 20 m high and consists of immature trees of upper-storey species, and of intermediate-storey species such as Canthuim obovatum, Cassine papillosa, Curtissia dentata, Platylophus trifoliatus and Pterocelastrus tricuspidatus. The lower-storey is usually 6 - 12 m high and consists of scattered under-storey species. Gonioma kamassi is is abundant and Burchellia bubalina, Canthium mundianum, Diospyros whyteana, Ochna arborea and Halleria lucida are also frequent. The undershrub layer is of variable distribution, height and density and consists mostly of Trichocladus orinitus, Cassinopsis ilicifolia and Alsophila capensis. The ground flora consists of dense communities of Plectranthus fruticosus, Piper capense, Blechnum attenuatum, Rumchro adiantiformis, Pteris buchananii and Pteridium aquilinum. Tree regeneration is comparatively scarce.

The wet high-forest is found on level portions of the eastern and southern slopes of the foothills and the upper plateau.

It is also found on steep southern and eastern slopes and in narrow valleys at medium to lower altitudes. These sites are cool and wet. The forest consists of a two-storied stocking of narrow-crowned trees over a dense tree fern storey or a shrub-interspersed ground flora. The canopy height is about 12 - 20 m . It is irregularly broken and consists mostly of Ocotea bullata, Cunonia capensis, Podocarpus latifolius, Gonioma kamassi, Nuxia floribunda and Rapanea melanophloeos. The lower tree storey is about 6 - 12 m high and consists of scattered small trees such as Curtissia dentata, Halleria lucida and Olea capensis. Alsophila capensis is abundant on badly drained sites but is replaced by Sparrmannia africana and various other fern communities on less badly drained soils.

The very wet scrub-forest is found on protected south-western slopes and upper reaches of foothills and on southern and eastern mountain slopes. These sites are very cool and wet with shallow, peaty loam soils. The scrub-forest consists of an open mixture of about 6 - 10 m high. Cunonia capensis is often abundant and usually emerges from the general canopy which consists of Halleria lucida, Ocotea bullata, Platylophus trifoliatus, Podocarpus latifolius, Rapanea melanophloeos and Virgillia oroboides. Common shrubs are Alsophila capensis, and Sparrmannia africana. The luxuriant ground layer consists mainly of tall and dense fern growth such as Blechnum attenuatum, B. capense, B. tabulare, Gleichenia polypodioides and Todea barbara.

The very very wet scrub is found on south-western and higher southern and eastern mountain slopes, and along streambanks in open rocky valleys. These sites are cold, misty and wet. The scrub consists of an open growth of 3 - 5 m high shrubs and small groups of bushy trees over a dense ground layer. Frequent tall shrubs are Berzelia intermedia, Cassine parvifolia, Diospyros glabra, Halleria lucida, Laurophyllus capensis and Sparrmannia africana. Common small trees are Cunonia capensis, Leucadendron eucalyptifolium, Virgillia oroboides and Widdringtonia nodiflora. Dense groups of Brachylaena neriifolia are present along stream= banks. The scrub is often heavily infested by the fern Gleichenia polypodioides.

The False Macchia veld type is largely avoided by bush= buck and not of much consequence to this investigation. Most of this veld type is to-day indistinguishable from the true Macchia or Fynbos. The outstanding characteristic of this veld type is its extreme floristic diversity. The following important families and genera are listed by Acocks (1953):

PROTEACEAE

Protea
Leucadendron
Leucospermum
Serruria
Paranomus and others

ROSACEAE

Cliffortia

BRUNIACEAE

Berzelia
Brunia
Tittmannia and others

ERICACEAE

Erica

Simocheilus

Philippia

Blaeria and others

LEGUMINOSAE

Aspalathus

Podalyria

Cyclopia

Amphithalea and others

RESTIONACEAE

All genera

CYPERACEAE

Tetraria

Ficinia

Chrysithrix and others

GRAMINEAE

Danthonia

Pentaschistis

Ehrharta

Plagiochloa

Lasiochloa and others

GERANIACEAE

Pelargonium

Monsonia and others

HAEMODORACEAE

Wachendorfia

Cyanella

Dilatris and others

LILIACEAE

Ornithogalum

Bulbinella

Dipidax

Lachenalia and others

ORCHIDACEAE

Disa

Acrolophia

Satyrium and others

COMPOSITAE

Metalasia

Ursinia

Othonna

Euryops

Helipterum

Helicrysum

RHAMNACEAE

Phylica

PENAEACEAE

All genera

RUTACEAE

Diosma

Agathosma

Acmadenia

Marcrostylis and others

THYMELEAEACEAE

Gnidia

Passerina

Cryptadenia and others

AIZOACEAE

Acrosanthes

Pharnaceum

Polpoda and others

BORRAGINACEAE

Lobostemon

Echiostachys

COMPOSITAE

Stoebe

Elytropappus

Cullumia

Pteronia

Pentzia

Senecio

Corymbium

Eriocephalus and others

GRUBBIACEAE

Grubbia

AMARYLLIDACEAE

Amaryllis

Nerine

Gethyllis

Hypoxis

Brunsvigia and others

IRIDACEAE

Moraea

Homeria

Gladiolus

Lapeyrousia

Sparaxis

Ixia

VERBENACEAE

Stilbe

Campylostachys

CAMPANULACEAE

Lightfootia

Prismatocarpus

Lobelia

Merciera and others

POLYGALACEAE

Polygala

Muraltia

Mundia

IRIDACEAE

Tritonia

Watsonia

Micranthus

Romulea

Anapalina

Pentamenes

Geissorhiza and others

This veld type is particularly associated with sandstone and nutrient-deficient sandy soils. The low frequency of occurance of grasses is noteworthy. Of importance too is that wetter southern aspects, which are commonly found in this region, would have had a transitional forest climax (Acocks, 1953).

## 2.4 LAND USE

The regional land use pattern can be described as con= sisting of four main components viz.

(i) Protected indigenous high forests with little or no disturbance. This zone is found throughout the region, often as isolated patches.

(ii) Intensively managed exotic pine and eucalypt plantations with a high disturbance factor, but still far below that of agricultural land. This zone is concentrated in the foothills and upper plateau, although fairly large plantations are also found on the lower plateau.

(iii) Agricultural land where both agronomy and grazing are practised. Use of this zone is highly developed. The disturbance factor is very high. This zone is concentrated on the lower plateau.

(iv) Mountain catchment areas which lie north of the first three zones in the Outeniqua-Tsitsikamma mountains. The vegetation covering consists of false macchia and this zone remains practically undisturbed.

This investigation was almost exclusively undertaken in the first two zones which are also the zones apparently preferred by bushbuck.

## 2.5 RADIO-TRACKING STUDY AREA

### 2.5.1 TOPOGRAPHY, GEOLOGY AND SOILS

The study area is situated on the lower plateau at an average height above sea level of 280 m . The plateau is divided into several broad, north-southerly ridges by the valleys of the principal streams. The study area lies to a large extent on one such ridge between the Springfield stream and Witels river. Both streams are perennial. These ridges are further dissected by the valleys of numerous tributaries. The general impression of the topography can be described as gentle undulating.

Table Mountain sandstone, consisting of quartzitic sandstones, forms the basic geological formation. It is partly covered by appreciable layers of sand.

The soil is moderately deep to deep. It consists of grey-brown or brown friable loamy sands or sandy loams. It usually rests upon a yellow-pink to red compact clay (Von Gadow, 1971).

## 2.5.2 CLIMATE

The climate is temperate with mild winters and warm summers. A noteworthy aspect of the climate is the fairly con= stant rate of precipitation throughout the year. Droughts are rare and water can not be seen as the limiting factor to any mammal population in this area. Table 5 gives the monthly distri= bution of rainfall in the vicinity of the study area. The rainfall was measured at Harkerville Forest Station, approximately nine kilometres to the east of the study area and about the same height above sea level.

Frost occurs in lower-lying depressions, but snow is extremely rare, although it has been recorded in the study area. During May to August strong north-westerly bergwinds are experienced. These hot winds greatly reduce the humidity and are invariably followed by periods of cool weather or rain. However, the prevailing winds are those from the south-west and south-east, with the south-wester being the rain-bearing and more frequent wind. Hailstorms are exceptional.

No climatic data, other than the rainfall figures, are available for the study area. However, a general statement from Von Breitenbach (1968) indicates that the maximum and minimum temperatures for the area are 38°C and 1°C respectively with an annual morning (08h00 hrs) mean of 16°C.

TABLE 5 : Monthly distribution of rainfall at Harkerville Forest Station, between 1900 - 1932 and 1956 - 1971, based on records of Department of Forestry (data for 1933 - 1955 is not available).

| MONTH | PRECIPITATION (mm) | % OF TOTAL | SD | NO. OF RAINY DAYS |
|---|---|---|---|---|
| January | 78,6 | 7,8 | 40,8 | 10 |
| February | 74,3 | 7,4 | 43,9 | 9 |
| March | 85,7 | 8,5 | 42,0 | 9 |
| April | 80,1 | 7,9 | 48,8 | 8 |
| May | 88,2 | 8,7 | 60,1 | 8 |
| June | 73,3 | 7,3 | 37,7 | 8 |
| July | 71,6 | 7,1 | 44,5 | 9 |
| August | 92,2 | 9,1 | 40,5 | 9 |
| September | 100,3 | 10,0 | 65,5 | 12 |
| October | 102,7 | 10,2 | 43,0 | 11 |
| November | 76,2 | 7,6 | 46,9 | 9 |
| December | 85,1 | 8,4 | 58,7 | 8 |
| TOTAL | 1 008,3 | 100,0 | | 109 |

## 2.5.3 THE VEGETATION

The vegetation of the study area can be classified physiognomically into seven zones (see fig. 5):

(A) Indigenous broad-leaved evergreen forests.

(B) Immature exotic *Pinus* spp. plantations with a dense herbaceous undergrowth but with the pines forming an over-storey over the undergrowth.

(C) Newly-planted *Pinus* spp.plantations with the young pines being a component of the herbaceous scrub vegetation, about one to two metres high.

(D) Plantation areas which have been clear-felled but have not yet been regenerated, or have been regenerated less than one year ago. These areas have now been invaded by pioneer shrubs. Included into this category are clear-felled areas which will not be regenerated again, and which have been invaded by scrub vegetation.

(E) Mature and some immature *Pinus* spp compartments with very little understorey vegetation.

(F) Open areas covered by shrubs but with a high incidence of graminoids. Of importance here is to note the presence of human habitation and vegetable patches.

(G) Plantation areas of *Eucalyptus* spp of all ages.

All seven zones were covered on foot and an attempt was made to identify and list all the commoner species of each zone. The Forest Research Station, Saasveld, assisted with this re= connaissance survey.

## ZONE A

The indigenous forest zone belongs to veld type 4, Knysna Forests, of Acocks (1953). The greater portion of the forests in the study area belong to the medium-moist high-forest type with lesser areas of wet high-forests along stream beds (Von Breitenbach, 1974).

The following are the commoner species which were identified in this zone:

Over-storey

| Family | Species |
|---|---|
| Podocarpaceae | *Podocarpus falcatus* |
| | *P. latifolius* |
| Lauraceae | *Ocotea bullata* |
| Celastraceae | *Maytenus acuminata* |
| | *M. heterophylla* |
| | *M.peduncularis* |
| | *Pterocelastrus tricuspidatus* |
| | *Cassine crocea* |

| | |
|---|---|
| Icacinaceae | Apodytes dimidiata |
| Flacourtiaceae | Scolopia mundii |
| Oliniaceae | Olinia ventosa |
| Cornaceae | Curtisia dentata |
| Myrsinaceae | Rapanea melanophloeos |
| Ebenaceae | Diospyros whyteana |
| Oleaceae | Olea capensis subsp. macrocarpa |
| Loganiaceae | Nuxia floribunda |
| Apocynaceae | Gonioma kamassi |
| Rubiaceae | Rothmannia capensis |
| | Canthium mundianum |
| | C. obovatum |

Ground Layer

Regeneration of the overstorey species plus:

| | |
|---|---|
| Polypodiaceae | Polystichum sp |
| Cyperaceae | Hypolepis sparsisora |
| | Kobresia lancea |
| | Carex clavata |
| Thymelaeceae | Gnidia denudata |

## ZONE B

The pine stands in this zone vary in age from seven to nine years and have an average height of 10,0 m . They were planted at an espacement of 2,7 m x 2,7 m i.e. 1370 stems per ha.

These trees form an over-storey over the undergrowth which has an average height of 1,5 m . A distinct double storey effect is thus obtained.

The following are the commoner species in this habitat zone:-

<u>Over-storey</u>

| | |
|---|---|
| Pinaceaea | <u>Pinus elliottii</u> |
| | <u>P. radiata</u> |

<u>Ground layer</u>

| | |
|---|---|
| Polypodiaceae | <u>Pteridium aquilinum</u> |
| Gramineae | <u>Paspalum dilatatum</u> |
| | <u>Pennisetum sp</u> |
| | <u>Phalaris sp</u> |
| | <u>Eragrostis sp</u> |
| | <u>Ehrharta racemosa</u> |
| | <u>Afrachneria ampla</u> |
| Cyperaceae | <u>Tetraria involucrata</u> |
| Restionaceae | <u>Restio sp</u> |
| | <u>Elegia sp</u> |
| Proteaceae | <u>Leucadendron eucalyptifolium</u> |
| Bruniaceae | <u>Berzelia intermedia</u> |
| Rosaceae | <u>Rubus sp</u> |
| | <u>Cliffortia graminea</u> |
| | <u>C. odorata</u> |
| | <u>C. tuberculata</u> |

| | |
|---|---|
| Leguminosae | Acacia melanoxylon (regeneration) |
| | A. mearnsii |
| | Psoralea asarina |
| | P. tomentosa |
| Geraniaceae | Pelargonium cordatum |
| Anacardiaceae | Rhus tomentosa |
| Celastraceae | Pterocelastrus tricuspidatus |
| Penaeaceae | Penaea myrtoides |
| Thymelaeaceae | Gnidia denudata |
| | G. juniperifolia |
| Umbelliferae | Centella eriantha |
| Ericaceae | Erica copiosa |
| | E. scriphiifolia |
| | E. speciosa |
| | E. gibbosa |
| Myrsinaceae | Rapanea melanophloeos |
| Ebenaceae | Diospyros glabra |
| Scrophulariaceae | Halleria lucida |
| Rubiaceae | Anthospermum herbaceum |
| Campanulaceae | Lobelia hirsuta |
| Compositae | Helichrysum petiolatum |
| | H. felinum |
| | H. parviflorum |
| | H. capitellatum |
| | Stoebe plumosa |
| | Metalasia muricata |
| | M. gnaphaloides |
| | Hippia frutescens |
| | Peyrousea umbellata |

*Senecio lineatus*

*Ursinia chrysanthemoides*

## ZONE C

This habitat zone consists mostly of a fairly dense indigenous herbaceous vegetation with *Pinus radiata* seedlings interplanted at an espacement of 2,7 m x 2,7 m . These young trees are of about the same height, one to two metres, as the indigenous shrubs and form only a minor component of this zone.

The following are the commoner species in this habitat zone:-

| | |
|---|---|
| Polypodiaceae | *Pteridium aquilinum* |
| Pinaceae | *Pinus radiata* |
| Liliaceae | *Caesia contorta* |
| | *Asparagus thunbergianus* |
| Rosaceae | *Rubus sp* |
| Leguminosae | *Acacia melanoxylon* |
| | *Virgilia oroboides* |
| | *Indigofera flabellata* |
| | *Indigofera sp* |
| Geraniaceae | *Pelargonium cordatum* |
| Anacardiaceae | *Rhus tomentosa* |
| Celastraceae | *Maytenus heterophylla* |

| | |
|---|---|
| | _Pterocelastrus tricuspidatus_ |
| Rhamnaceae | _Phylica cf axillaris_ |
| Oliniaceae | _Olinia ventosa_ |
| Myrtaceae | _Eucalyptus globulus_ |
| Ericaceae | _Erica speciosa_ |
| Myrsinaceae | _Rapanea melanophloeos_ |
| Ebenaceae | _Euclea crispa_ |
| Scrophulariaceae | _Halleria lucida_ |
| Campanulaceae | _Lobelia hirsuta_ |
| Compositae | _Helichrysum petiolatum_ |
| | _H. felinum_ |
| | _Helichrysum sp_ |
| | _Stoebe sp_ |
| | _Metalasia muricata_ |
| | _Peyrousea umbellata_ |

## ZONE D

This habitat zone is devoid of any cover for bushbuck, being a sere in the early successional stages of a pine plantation. The average height of the vegetation is less than 0,25 m . The area had been prepared for artificial regeneration with _P.radiata_ by slashing the remaining debris after clear-felling of the mature _P.pinaster_ stand had been completed in February 1973. The debris was thrown into rows and pits hoed at an espacement of 2,7 m x 2,7 m prior to planting. The actual planting operation was carried out during the course of this project. This zone could also therefore be called a P.radiata compartment on a site quality I site (i.e. the best site index for a stand) with an age of nil years.

The following are the commoner species in this habitat zone (P.radiata seedlings excluded):-

| | |
|---|---|
| Polypoideaceae | Pteridium aquilinum |
| Graminae | Andropogon appendiculatus |
| | Stenotaphrum glabrum |
| | Phalaris sp |
| | Pentaschistis angustifolia |
| | Cynodon sp |
| Iridaceae | Aristea ensifolia |
| | Watsonia sp |
| Rosaceae | Cliffortia stricta |
| | C. tuberculata |
| Leguminosae | Acacia melanoxylon |
| | A. mearnsii |
| | Aspalathus laricifolia |
| Celastraceae | Pterocelastrus tricuspidatus |
| Rhamnaceae | Phylica cf axillaris |
| Penaeaceae | Penaea ovata |
| Myrtaceae | Eucalyptus globulus |
| Umbelliferae | Centella erianthe |
| Myrsinaceae | Rapanea melanophloeos |
| Loganiaceae | Nuxia floribunda |
| Scrophulariaceae | Halleria lucida |

| | |
|---|---|
| Campanulaceae | Lobelia hirsuta |
| Compositae | Helichrysum petiolatum |
| | H. parviifolium |
| | Metalasia muricata |
| | M. gnaphaloides |
| | Senecio lineatus |
| | S. ilicifolius |
| | S. subcanescens |
| | Chrysanthemoides monolifera |
| | Osteospermum junceum |
| | Ursinia chrysanthemoides |

## ZONE E

The main characteristics of this zone are the complete dominance by P.radiata and P.pinaster trees and the sparse under= growth, both in species diversity and density. The trees vary in age from 18 to 53 years of age, and the average stand heights vary between 20,0 m and 45,0 m .

The following are the more common species of this habitat zone:

Over-storey

| | |
|---|---|
| Pinaceae | Pinus radiata |
| | P. pinaster |

Ground Layer

| | |
|---|---|
| Polypodiaceae | Blechnum attenuatum |
| Pinaceae | Pinus radiata |
| Myricaceae | Myrica serrata |
| Rosaceae | Rubus sp |
| Leguminosae | Acacia melanoxylon |
| | A. mearnsii |
| Rutaceae | Agathosma ovata |
| Celastraceae | Pterocelastrus tricuspidatus |
| Rhamnaceae | Scutia myrtina |
| Penaeaceae | Penaea ovata |
| Myrtaceae | Eucalyptus diversicolor |
| Myrsinaceae | Rapanea melanophloeos |
| Ebenaceae | Diospyros glabra |
| Scrophulariaceae | Halleria lucida |
| Campanulaceae | Lobelia hirsuta |
| Compositae | Helichrysum petiolatum |
| | Helichrysum sp |
| | Crysanthemoides monolifera |

ZONE F

This zone is restricted to an area of about 10 ha surrounding the houses of seven employees of the Department of Forestry. Besides the vegetable patches, which are probably the greatest attraction for bushbuck in this habitat zone, the area is to a large extent covered by graminioids without any canopy cover and little lateral cover. Of these Pennisetum sp and Stenotaphrum glabrum are the more conspicuous. The presence of a fair amount of standard 1,2 m fences is to be noted.

## ZONE G

Eucalyptus diversicolor is by far the dominant gum species in this habitat zone. The average age of the stands is 55 years and the average height is 36,0 m. The ground flora is sparse and is often covered by a heavy litter fall from the dominant trees. This zone is mostly present in the form of narrow gum-belts.

The following are the more common species of the ground flora:-

| | |
|---|---|
| Pinaceae | Pinus radiata |
| Leguminosae | Acacia melanoxylon |
| | A. mearnsii |
| Anacardiaceae | Rhus lucida |
| Celastraceae | Maytenus acuminata |
| | Pterocelastrus tricuspidatus |
| Icacinaceae | Apodytes dimidiata |
| Myrtaceae | Eucalyptus diversicolor (regeneration) |
| Myrsinaceae | Rapanea melanophloeos |
| Oleaceae | Olea capensis subsp. capensis |
| Scrophulariaceae | Halleria lucida |

### 2.5.4 LAND USE

By far the greater portion of the radio-tracking study area is utilized by exotic plantations for the production of saw logs. The main species used are P.radiata and P.elliottii which are managed on a rotation of 35 years. The main management activities, besides clear-felling and regeneration, are regular pruning up to about 12 years of age and thinnings at 10, 15 and 20 years of age. The nature of these activities is such that operations will be highly intensive in a particular stand for a short period of time, after which the stand will lie undisturbed for a relatively long period.

The indigenous forest patches in the study area are classified as protection forests and no operations take place in them.

# CHAPTER III

## FOOD HABITS AND NUTRITION

All investigators who have studied the food habits of bushbuck (Wilson and Child, 1964; Von Gadow, 1970; Simpson, 1974; Jacobsen, 1974) agree that the species is mainly a browser but will occasionally consume a certain amount of grass. When analysing the stomach contents of 29 animals, Simpson (1974) found that several stomachs had a high proportion of grass (maximum approximately 90 per cent). He also found traces of grass in 55 per cent of the stomachs examined. Jacobsen (1974) found that green grass was preferred to dry grass in his study area in Rhodesia.

The investigation by Von Gadow (1970) was mainly undertaken at Saasveld, approximately 50 km west of Knysna in very much the same type of environment as the present study. He stated that shoots and leaves of trees and shrubs, herbs and ferns seem to provide the greater part of the diet of bushbuck. In addition he observed that certain amounts of young grass, Oplismenus hirtellus, as well as other Gramineae and also Cyperaceae were consumed.

In contrast to the feeding preferences of bushbuck, nothing is known about the nutritional characteristics of its diet. These aspects were therefore briefly investigated in conjunction with a study of the food habits of the species under local conditions.

## 3.1 METHODS

Samples of 400 - 500 ml were randomly collected from the rumen contents of 25 bushbuck males obtained at Goudveld and Gouna State Forests during the period June and July 1975 and 1976. The samples were preserved in a mixture of 70 per cent alcohol (70%): 30 per cent formalin (40%). They were subsequently washed through a series of five test sieves (BS. 410), of aperture size 5,60 mm to 1,70 mm. For ocular identification based on gross morphological features it was found most practical to use the residue left on the 3,35 mm mesh as the fragments on the smaller mesh sizes were too small to allow for positive identification. When in doubt, fragments were compared with mounted specimens in the herbarium of the Forest Research Station, Saasveld.

All 25 samples were examined to identify as far as possible the food plants in each. Sixteen samples collected in 1976 were also analysed quantitatively by spreading the material evenly over the bottom of a basin and placing a 100 point grid over the basin. Using a 2 x magnifying glass the fragments underneath each point of the grid were then assigned to the taxa, Dicotyledoneae, Monocotyledoneae, Basidiomycetes or Filicinae. Each fragment was also classified as being a leaf or shoot/twig. Where possible leaf size was classified according to the system of Moll *et al* (1976). Leaves were grouped as being ericoid (about $9^{-1} \times 25$ mm²), leptophyllous (about 25 mm²), nanophyllous (about $9 \times 22$ mm²), or microphyllous (about $9^2 \times 25$ mm²). This was accomplished by comparing leaves found in the rumen contents with drawings to full scale of these four categories of leaves. Although Moll et al (1976) made provision for smaller and larger categories of leaves, none were found in the samples.

There is some doubt as to whether the percentage com= position of food plant species in ungulate rumen contents differs significantly for fractions of different minimum particle size. Dirschl (1962) maintains that quantitative analysis can be restricted to relatively large plant fragments without loss of accuracy, while Bergerud and Russell (1964) differ. This problem was not investigated in the present study. However, it is believed to be of little significance because quantitative analysis was based on such broad categories. This also justifies the use of the relatively large 3,35 mm mesh.

In determining the nutritional characteristics of the diet various analyses were carried out. First, rumen content samples were obtained for the determination of the proportions of volatile fatty acids (V F A) in the rumen fluid. Samples of about 500 g were taken from five males collected during July 1974 at Goudveld State Forest and frozen within three hours after an animal was shot. The molar proportions of the V F A were determined by gas chromatography of the strained rumen liquor. These analyses were undertaken by the Faculty of Agriculture, University of Stellenbosch, who also determined the pH value and the percentage dry matter of each sample.

Secondly, similar rumen content samples were obtained from eight of the males collected during 1975. These plus the five samples of 1974 were subjected to a Weende-analysis to deter= mine the levels of crude protein, ether extract, crude fibre, ash and N F E in the rumen contents.

Thirdly, thirty-one bushbuck liver samples were collected from the animals culled at Goudveld and Gouna State Forests during 1974, 1975 and 1976. An additional sample was obtained from an adult male at Lottering State Forest in the Tsitsikamma area. All samples were preserved in 5% analytical formalin and forwarded to the Regional Veterinary Laboratory of the Department of Agricultural Technical Services at Stellenbosch for analysis. The concentration of four essential elements, copper, iron, zinc and manganese was determined in all samples and the level of magnesium and potassium in 15 of them.

## 3.2 RESULTS

A mean number of six identifiable plant species was present per rumen content sample, with a range of between one and fifteen. Due to differential digestibility and the relatively crude method of analysis, these figures must represent minimum numbers of food plants only. In a number of instances a species could only be identified to family level. However, a total of 47 food plants could be identified to at least generic level.

A list of the food plants is given in table 6 and the frequency of each in the total sample indicated. A few records based on field observations during the present study are also included. In order to present as complete a picture as possible of the food plants of the species under local conditions, it was decided to include the results of Von Gadow (1970) in this table. However, since his results are based on observations, no percentage occurance figures are available for those species. The table shows that at least 70 food plants are utilised by bushbuck in the forest environment of the Southern Cape.

Fig. 2(a) indicates the percentages of dicotyledons (browse), monocotyledons, fungi and ferns in the diet of 16 animals based on point sampling of the rumen content. The frequencies of these and some other classes in the 25 rumens are shown in table 7. In fig. 2(b) the percentages of leaves, shoots/twigs and other plant parts (buds, seed, roots) are shown.

The classification of leaves into size classes gave the following results:-

| Size Class | : | Ericoid | Leptophyllous | Nanophyllous | Microphyllous |
|---|---|---|---|---|---|
| % occurance (n = 114) | : | 17 | 30 | 32 | 21 |

The molar proportions of the V F A, the pH value and the percentage dry matter (DM) of the five rumen contents samples collected during July 1974 are shown in table 8. Comparable figures on VFA proportions in white-tail deer, *Odocoileus virginianus*, mule deer, *Odocoileus hemionus*, and pronghorn antelope *Antilocapra americana*, are presented in Table 9.

The results of the proximate (Weende) analysis of 13 rumen samples are given in table 10. Comparative figures for giraffe, *Giraffa camelopardalis*, in the Eastern Transvaal lowveld, (Hall - Martin and Basson, 1975) are also shown.

In table 11 the levels of six essential elements in bushbuck liver samples are shown.

The equivalent values in the one sample from the Tsitsi= kamma area are as follows:-

| Cu | Fe | Zn | Mn | Mg | K |
|---|---|---|---|---|---|
| 89 | 530 | 116 | 11 | 515 | 319 |

TABLE 6 : Food plants of bushbuck in the Southern Cape (* = identified in rumen content; ** = observed in present study; others based on observations by Von Gadow (1970)

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| <u>TREES</u> | | |
| Oliniaceae | | |
| <u>Olinia ventosa</u> * | 9 | 36 |
| Leguminosae | | |
| <u>Acacia melanoxylon</u> * | 9 | 36 |
| Scrophulariaceae | | |
| <u>Halleria lucida</u> * | 6 | 24 |
| Pinaceae | | |
| <u>Pinus spp.</u> * | 5 | 20 |
| Lauraceae | | |
| <u>Ocotea bulata</u> * | 4 | 16 |
| Rubiaceae | | |
| <u>Canthium mundianum</u> * | 4 | 16 |
| <u>C. obovatum</u> * | 3 | 12 |
| <u>Canthium spp.</u> * | 1 | 4 |
| <u>Rothmannia capensis</u> * | 2 | 8 |
| <u>Burchellia bubalina</u> * | 1 | 4 |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| Celastraceae | | |
| Maytenus peduncularis * | 4 | 16 |
| M. heterophylla * | 1 | 4 |
| Pterocelastrus tricuspidatus * | 2 | 8 |
| Cassine papillosa * | 2 | 8 |
| Cassine spp. * | 2 | 8 |
| C. parvifolia * | 1 | 4 |
| C. aethiopica * | 1 | 4 |
| Apocynaceae | | |
| Gonioma kamassi * | 3 | 12 |
| Icacinaceae | | |
| Apodytes dimidiata * | 2 | 8 |
| Oleaceae | | |
| Olea capensis * | 2 | 8 |
| Fabaceae | | |
| Virgillia oroboides * | 2 | 8 |
| Tiliaceae | | |
| Sparrmannia africana * | 1 | 4 |
| Ochnaceae | | |
| Ochna arborea * | 1 | 4 |
| Flacourtiaceae | | |
| Scolopia mundii * | 1 | 4 |
| Scolopia spp. * | 1 | 4 |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| Loganiaceae | | |
| _Nuxia floribunda_ * | 1 | 4 |
| Cunoniacea | | |
| _Platylophus trifoliatus_ | | |
| Euphorbiaceae | | |
| _Lachnostylis hirta_ | | |
| Anacardiaceae | | |
| _Rhus chirendensis_ | | |
| Aquifoliaceae | | |
| _Ilex mitis_ | | |
| SHRUBS | | |
| Penaeceae | | |
| _Penaea_ spp. * | 4 | 16 |
| Euphorbiaceae | | |
| _Andrachne ovalis_ | 3 | 12 |
| _Clutia affinis_ | | |
| _C. pulchella_ | | |
| Capparidaceae | | |
| _Maerua racemulosa_ * | 2 | 8 |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| Rhamnaceae | | |
| *Phyllica spp.* * | 2 | 8 |
| *Rhamnus prinoides* | | |
| Rutaceae * (no further identification possible). | 1 | 4 |
| *Agathosma* spp * | 1 | 4 |
| Ericoid-like sp. * | 1 | 4 |
| Leguminosae | | |
| *Psoralea pinnata* | | |
| Phytolaccaceae | | |
| *Phytolacca americana* | | |
| Rosaceae | | |
| *Rubus* sp. | | |
| *Cliffortia odorata* ** | | |
| Solanaceae | | |
| *Physalis peruviana* | | |
| *Solanum nigrum* | | |
| Compositae | | |
| *Chrysanthemoides monolifera* | | |
| *Vernonia mespilifolia* | | |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| HERBS AND FORBS | | |
| Umbelliferae | | |
| *Centella erianthe* * | 7 | 28 |
| *C. virgata* * | 1 | 4 |
| Rubiaceae | | |
| *Carpacoce spermacocea* * | 7 | 28 |
| Compositae * (no further identification possible) | 5 | 20 |
| *Helichrysum felinum* ** | | |
| *Helichrysum spp.* * | 4 | 16 |
| *Senecio* sp. * | 2 | 8 |
| *Conyza* sp. * | 1 | 4 |
| *Athanasia* sp * | 1 | 4 |
| *Osteospermum junceum* ** | | |
| *Othonna* sp. | | |
| Labiatae | | |
| *Stachys aethiopica* * | 2 | 8 |
| *S. hispida* | | |
| *Plectranthus fruticosus* * | 1 | 4 |
| Cyperaceae * (no further identification possible) | 2 | 8 |
| Iridacea * (no further identification possible) | 1 | 4 |
| *Dietes vegeta* | | |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| Polygonaceae | | |
| Rumex sagittatus | | |
| Polygonum serrulatum | | |
| | | |
| FERNS | | |
| | | |
| Polypodiacae | | |
| Blechnum capense * | 1 | 4 |
| Blechnum spp. * | 3 | 12 |
| Polypodium ensiforme * | 1 | 4 |
| Adiantum aethiopicum * | 1 | 4 |
| Pteridium aquilinum * | 1 | 4 |
| Hypolepis sparsisora | | |
| Pellaea viridis | | |
| Lonchitis stenochlamys | | |
| Pteris buchananii | | |
| Polystichum ammifolium | | |
| Asplenium rutaefolium | | |
| Cyatheaceae | | |
| Alsophila capensis | | |

| SPECIES | FREQUENCY (n=25) | % |
|---|---|---|
| <u>OTHERS</u> | | |
| Monocotyledon * (no further identification possible). | 8 | 32 |
| Graminae * (no further identification possible). | 4 | 16 |
| <u>Oplismenus hirtellus</u> | | |
| Agaricaceae | | |
| <u>Russula</u> sp * | 1 | 4 |
| Other fungi, predominantly mushrooms * | 8 | 32 |
| Loranthaceae | | |
| <u>Viscum</u> sp. * | 1 | 4 |

TABLE 7 : Frequency of certain food plant categories in 25 bushbuck rumens

| FOOD PLANT CATEGORY | FREQUENCY (n=25) | % |
|---|---|---|
| A. | | |
| Dicotyledons (browse) | 24 | 96 |
| Monocotyledons | 14 | 56 |
| Fungi | 10 | 40 |
| Ferns | 9 | 36 |
| B. | | |
| Trees | 21 | 84 |
| Herbs and forbs | 17 | 68 |
| Shrubs | 11 | 44 |
| Ferns | 9 | 36 |
| Grasses | 4 | 16 |
| Others | 11 | 44 |

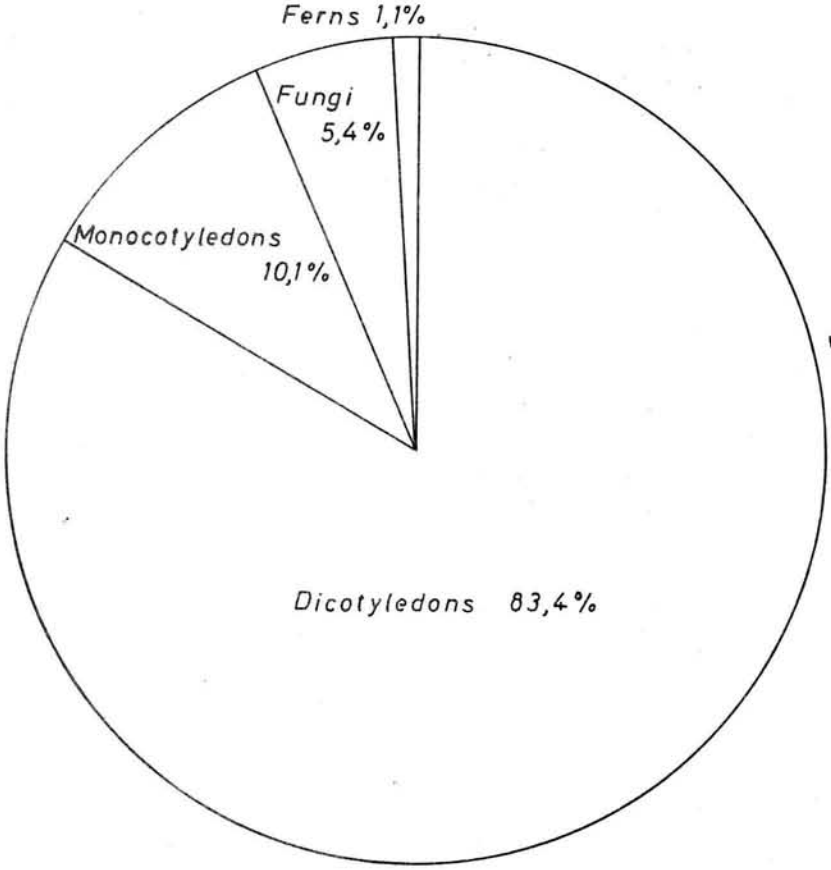


Fig 2:(a) Composition of the diet of 16 bushbuck males from analysis of rumen contents.

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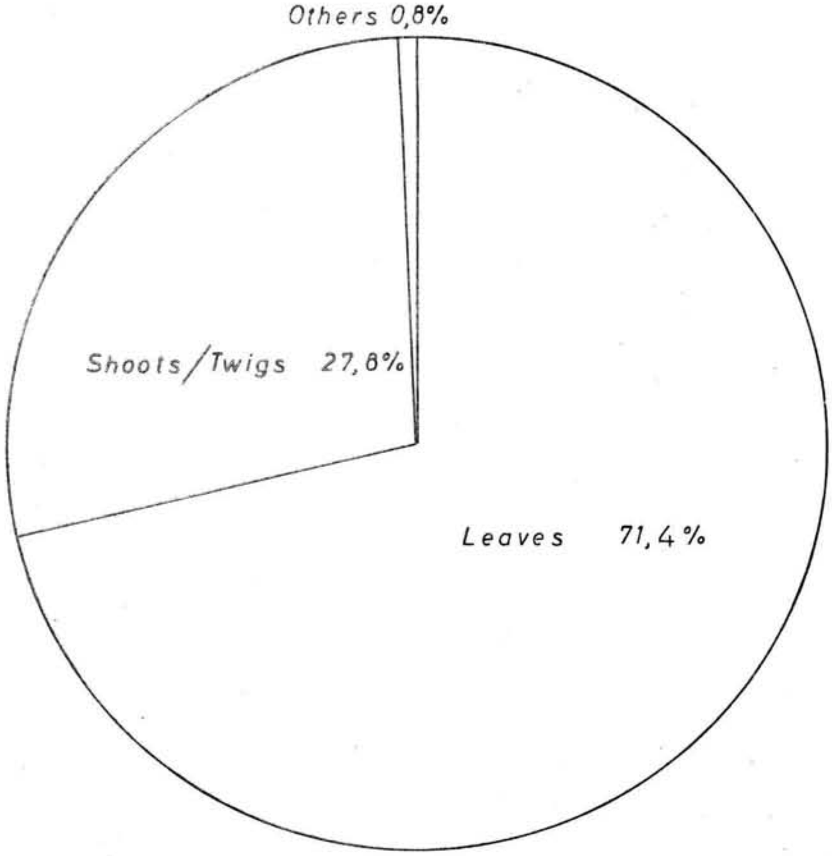



Fig 2:(b) Proportion of leaves, shoots twigs and other plant parts

TABLE 8 : Proportions of volatile fatty acids and other rumen content data from five bushbuck

| SAMPLE NO. | RUMEN CONTENTS | | VOLATILE FATTY ACID (Molar percent) | | |
|---|---|---|---|---|---|
| | DM % | pH | Acetic | Propionic | Butyric |
| 1 (1974) | 14,75 | 5,50 | 68,5 | 22,1 | 9,4 |
| 2 (1974) | 15,33 | 5,55 | 74,8 | 16,1 | 9,1 |
| 3 (1974) | 14,62 | 5,55 | 73,8 | 18,0 | 8,2 |
| 4 (1974) | 18,91 | 5,65 | 75,3 | 16,3 | 8,4 |
| 5 (1974) | 20,45 | 5,55 | 76,8 | 15,7 | 7,5 |
| MEAN | 16,81 | 5,56 | 73,8 | 17,6 | 8,5 |
| SD | 2,69 | 0,05 | 3,2 | 2,6 | 0,8 |

TABLE 9 : Molar proportions of V F A in white-tail deer, mule deer and pronghorn antelope (Nagy *et al*, 1967; Short *et al*, 1969; Ullrey *et al*, 1964; Ullrey *et al*, 1967; Ullrey *et al*, 1968; Nagy, and Williams, 1969; all *in* Bailey and Nagy, 1969).

| SPECIES | VOLATILE FATTY ACID (Molar per cent) | | |
|---|---|---|---|
| | Acetic | Propionic | Butyric |
| mule deer | 69 | 17 | 10 |
| mule deer | 66 | 20 | 11 |
| white-tail deer | 56 | 27 | 12 |
| white-tail deer | 73 | 16 | 9 |
| white-tail deer | 68 | 17 | 15 |
| white-tail deer | 68 | 18 | 14 |
| white-tail deer | 71 | 16 | 13 |
| pronghorn antelope | 70 | 16 | 9 |
| MEAN | 67,6 | 18,4 | 11,6 |
| SD | 5,2 | 3,7 | 2,3 |

TABLE 10 : Chemical composition of the rumen contents of bushbuck males and giraffe

| SAMPLE | COMPOSITION ON A DRY MATTER BASIS | | | | | |
|---|---|---|---|---|---|---|
| | DM % | CRUDE PROTEIN % | ETHER EXTRACT % | CRUDE FIBRE % | ASH % | NFE % |
| 1 (1974) | 14,75 | 19,99 | 8,40 | 24,24 | 9,72 | 37,65 |
| 2 (1974) | 15,33 | 18,26 | 12,33 | 30,76 | 10,90 | 27,75 |
| 3 (1974) | 14,62 | 18,80 | 9,50 | 29,59 | 10,03 | 32,08 |
| 4 (1974) | 18,91 | 14,69 | 9,39 | 32,16 | 8,69 | 35,07 |
| 5 (1974) | 20,45 | 15,94 | 11,22 | 28,54 | 9,29 | 35,01 |
| 1 (1975) | 14,94 | 20,69 | 10,64 | 20,53 | 13,39 | 28,76 |
| 2 (1975) | 16,58 | 16,70 | 12,77 | 30,87 | 10,16 | 29,50 |
| 3 (1975) | 13,72 | 20,53 | 11,78 | 28,87 | 10,15 | 28,67 |
| 4 (1975) | 16,10 | 16,24 | 10,95 | 30,53 | 9,16 | 33,12 |
| 5 (1975) | 13,76 | 19,03 | 10,77 | 27,19 | 10,69 | 32,32 |
| 6 (1975) | 16,08 | 20,43 | 7,98 | 30,47 | 10,37 | 30,75 |
| 7 (1975) | 22,26 | 15,03 | 11,51 | 28,93 | 8,96 | 35,57 |
| 8 (1975) | 14,89 | 19,32 | 10,43 | 29,06 | 10,56 | 30,61 |
| MEAN | 16,34 | 18,13 | 10,59 | 28,60 | 10,16 | 32,07 |
| SD | 2,63 | 2,15 | 1,44 | 3,13 | 1,19 | 3,08 |
| Giraffe (Hall-Martin and Basson, 1975), mean for June - July | - | 16,44 | 5,19 | 24,77 | 17,10 | - |

TABLE 11 : The level of six essential elements in bushbuck liver samples

| | ELEMENT LEVELS (p.p.m. Dry basis) | | | | | |
|---|---|---|---|---|---|---|
| | Cu | Fe | Zn | Mn | Mg | K |
| | 209 | 301 | 116 | 9 | 435 | 530 |
| | 66 | 315 | 113 | 10 | 450 | 440 |
| | 111 | 345 | 122 | 10 | 410 | 390 |
| | 111 | 316 | 116 | 10 | 410 | 450 |
| | 115 | 286 | 112 | 11 | 415 | 440 |
| | 124 | 416 | 133 | 8 | 355 | 300 |
| | 73 | 577 | 105 | 8 | 325 | 345 |
| | 93 | 535 | 121 | 8 | 360 | 320 |
| | 84 | 518 | 117 | 8 | 390 | 485 |
| | 68 | 336 | 109 | 8 | 360 | 415 |
| | 133 | 276 | 121 | 7 | 390 | 555 |
| | 128 | 287 | 107 | 12 | 480 | 675 |
| | 125 | 309 | 139 | 8 | 390 | 485 |
| | 172 | 310 | 125 | 7 | 365 | 345 |
| | 138 | 462 | 107 | 8 | - | - |
| | 135 | 436 | 107 | 10 | - | - |
| | 330 | 445 | 89 | 8 | - | - |
| | 533 | 363 | 93 | 6 | - | - |
| | 255 | 310 | 92 | 9 | - | - |
| | 66 | 318 | 105 | 7 | - | - |
| | 66 | 303 | 122 | 8 | - | - |
| | 29 | 320 | 98 | 9 | - | - |
| | 130 | 421 | 97 | 8 | - | - |
| | 99 | 288 | 106 | 8 | - | - |
| | 114 | 429 | 95 | 7 | - | - |
| | 144 | 239 | 124 | 7 | - | - |
| | 135 | 367 | 98 | 8 | - | - |
| | 109 | 446 | 114 | 8 | - | - |
| | 90 | 324 | 102 | 11 | - | - |
| | 127 | 327 | 82 | 8 | - | - |
| | 139 | 348 | 116 | 8 | - | - |
| MEAN | 137 | 364 | 110 | 8,5 | 395 | 441 |
| SD | 93,5 | 83,2 | 13,1 | 1,4 | 41,7 | 102,2 |

## 3.3 DISCUSSION

This study confirms the findings of other workers (Wilson and Child, 1964; Von Gadow, 1970; Simpson, 1974; Jacobsen, 1974) that bushbuck are mainly browsers but will occasionally consume a certain amount of grass. Ninety-six per cent of all rumens analysed in this study contained browse, constituting approximately 83 per cent of the diet. Dividing browse into the components, trees, shrubs and herbs/forbs (table 7) shows that the first and last classes are considerably more frequently consumed than shrubs. This is probably due to availability in the forest environment, where all animals were collected. As was described in chapter II, most forest types have a sparse shrub-layer but there is often a fairly dense ground-layer. Where a shrub-layer does occur, it often consists of *Trichocladus crinitus* only. This species is totally unpalatable to bushbuck. No signs of browsing were ever observed on it nor was it found in any rumen content sample.

In contrast to Simpson (1974) who found traces of grass in 55 per cent of the stomachs he examined, only 16 per cent of the stomachs in the present investigation contained grass. In all probability this is simply s reflection of availability in the two habitats involved. The study area of Simpson (1974) was situated in the Southern Savanna biome, known for its abundance of grass species, while the Forest biome in the present study has relatively few species. The importance of grass in the local diet is even less than this figure indicates. Monocotyledons comprise 10 per cent (fig. 2a) of the diet but the category in= cludes families like Cyperaceae and Iridaceae. Graminae probably do not constitute more than half of this fraction. One can therefore assume that grasses form about 5 per cent of the diet.

A surprisingly high incidence of mushrooms was found in the rumens. Forty per cent of all stomachs had some signs of them and the point sampling showed that they comprise about 5 per cent of the diet, i.e. the same proportion as grass. However, since all rumen content samples were collected during winter, which coincides with the fruiting period of most of the local mushroom species, the proportion is probably lower during other seasons.

Traces of ferns were found in 36 per cent of the stomachs but their relative importance seems to be low as they comprise only about one per cent of the diet.

The use of the frequency method to evaluate the diet of an animal has serious limitations. The true importance of the various food items can not be established because it is not possible to determine the relative proportion of each food plant in the diet. However, the frequency method requires less time than any other method (Englund, 1965). It was unfortunately not possible to use any of the other methods of analysis in the present investigation as too few identifiable food particles were present in each stomach.

The percentage values shown opposite food plants in table 6 must therefore be seen as indications of relative importance only. Serious discrepencies between these values and the relative importance of food plants do occur. For instance the high fre= quency of *Pinus* spp. is not a reflection of the true position, as in each rumen concerned, only one, or at the most, two, dry pine needles were found. In all probability these were con= sumed while they were lying on some other food plant being eaten.

On the other hand the high frequency of *Acacia melanoxylon* was expected and agrees with impressions based on general obser= vations in the field. The same applies to *Ocotea bullata*.

On the whole the list of food plants does provide an indication of their relative importance and forms a basis for more detailed work in the future.

The diet of a browser contains considerable quantities of carbohydrates. These are broken down by rumen micro-organisms into mainly acetic, propionic and butyric acids, the so-called volatile fatty acids (McDonald *et al*, 1969). The total amount and relative proportions of these VFA are important to a ruminant as it derives up to 80 per cent of its energy from them (Olson, 1969 *in* Baily and Nagy, 1969). The relative proportions of acetic and propionic acids in the rumen fluid are of special interest as they reflect the nutritional quality of the food intake. Production of a high level of propionic acid is favoured by a high level of protein intake, a high rate of food fermentation in the rumen and by fine grinding of the forage (Moir, 1965;

Meyer _et al_, 1965 _in_ Bailey and Nagy 1969). On the other hand a diet with a high roughage or fibre content and low in concen= trates will result in a high level of acetic acid. Since propionic acid is utilised more efficiently than other VFA, it is to the advantage of the animal to have a higher propionic production in the rumen.

The results of this investigation indicate a relatively high level of acetic acid in the rumen of bushbuck. The ratio of acetic to propionic acid is 4,2 which is higher than the mean value of 3,7 for the deer and antelope in table 9. These animals were reported to be in normal condition. It is quite close to the mean value of 4,4 for deer in poor condition given by the same authors. The mean values of the pH, dry matter percentage and the proportions of VFA correspond fairly closely to the values of these parameters in mule deer during winter and early spring (Short _et al_, 1966). At that time they feed on range forage that is dormant and has a high dry matter level.

It appears therefore that the diet of bushbuck in the Southern Cape has a high roughage content during winter and that the rate of fermentation in the rumen at this time is probably slow. This may indicate the presence of sub-optimal feeding conditions with the accompanying greater expenditure of energy on feeding activity. However, without a more detailed investigation this must be viewed as speculation only.

The low pH values found in this study may have been significant because Hungate (1966, in Bailey and Nagy, 1969) states that cellulose digestion cannot occur below a pH value of 5,5. However, these low pH values are probably due to the long time lapse between death of the animals and freezing of the rumen contents samples. Once the animal is dead, rumen absorption of VFA stops while the micro-organisms continue to produce VFA, thereby lowering the pH (Olsen, 1969 in Bailey and Nagy, 1969).

Commenting on the results of the proximate analysis of rumen samples of giraffe, Hall-Martin and Basson (1975) state that such studies "..... are of limited practical value in terms of studying food in relation to maintenance and production requirements". Van der Merwe (1970) discusses this method of analysis and points out various short-comings.

Two differences between the results of the proximate analysis of the bushbuck and giraffe rumen content samples are worth mentioning. One is the fairly high level of ether extract in the bushbuck samples which may indicate a high-energy level of nutrition. However, the high value may be due to colour pigments, alkaloids, volatile oils, resins and waxes which have no nutritional value (Van der Merwe, 1970). This is partly confirmed by a number of food plants in its diet which are thought to contain high levels of volatile oils. These include members of the Rubiaceae, Umbelliferae, Oliniaceae, Compositae and Euphorbiaceae, which are all to some extent aromatic. Un= fortunately, no results of analyses in this connection are available.

The other difference is the low level of ash in the bush=buck samples. However, Van der Merwe (1970) states that in plant matter the level of ash has little if any significance from a nutritional point of view, because of its extreme variability both in quantity and composition.

Du Toit _et al_ (1940; _in_ Van der Merwe, 1970) remark that browse normally has a higher mineral element content than grass and shows considerably less seasonal variation. The temperate climate and constant rate of precipitation should make this statement even more valid in the Southern Cape area. The nutritional element levels shown in table 11 can therefore be viewed as a general indication of what levels to expect locally in bushbuck.

Stindt _et al_ (1967; _in_ Louw, 1969) indicate an apparent deficiency during winter in protein, phosphorous and cobalt in grass of the Knysna forests and an excess of iron. During summer a deficiency in protein, calcium, phosphorous and cobalt and an excess of iron is reported by these authors. Examples of cobalt and copper deficiencies in the Western and Southern Cape are cited by Van der Merwe, (1970).

Unfortunately the levels of phosphorous and cobalt in the liver samples were not determined. However, the mean copper value of 137 p.p.m. is within the acceptable level of 100 to 400 p.p.m. for domestic bovids (Van der Merwe, 1970). It is also well above the mean level in grysbuck, _Raphicerus melanotis_, steenbuck, _Raphicerus campestris_, and grey duiker _Sylvicapra grimmia_ in the Western Cape. Values of 50 p.p.m. (Stellenbosch), 24 p.p.m. (Darling) for grysbuck and 27 p.p.m. for steenbuck (Darling) and 19 p.p.m. for grey duiker (Darling) are cited by Manson (1974). The range of copper values for bushbuck is from 29 p.p.m. to 533 p.p.m. with 10 values, or 32 per cent, below the lower limit of 100 p.p.m. The levels of the other elements do not differ appreciably from those for the above three species, which were found to be within acceptable limits (Zumpt, pers. comm.; in Manson, 1974).

The single sample from the Tsitsikamma area shows a copper value below 100 p.p.m. and a fairly high magnesium level of 515 p.p.m.

Little else can be said of these results, besides pointing to the high frequency of low copper values. This is influenced not only by the food plants, but also by certain disease conditions and age of the animal (Van der Merwe, 1970).

# CHAPTER IV

## HABITAT SELECTION

The timber-growing industry in South Africa is often accused of destroying wildlife habitat when afforesting new areas. Very little research into this allegation has ever been undertaken. It appears to be founded mainly on general impressions and casual observations, although there can be no denial that at least some wildlife species are adversely affected by afforestation.

The data obtained from the radio-tracking study allowed an in= vestigation into the habitat selection of bushbuck in an area which has largely been changed by afforestation with *Pinus* spp and *Eucalyptus* spp. Some interesting facts came to light on the relationships between bushbuck and these exotic habitats.

## 4.1 METHODS

As explained in more detail above (section 2.5.3.) the vegetation of the radio-tracking study area can be divided into seven categories. In order to evaluate the use made by the study animals of each vegetation zone, a vegetation map was prepared (fig. 5). All locations of each animal were put onto tracing paper and superimposed on the vegetation map. The procedures involved in determining these locations are described in chapter V. Locations were separately designated as day or night locations. The number of locations per vegetation zone during the day, at night and for day and night together, were expressed as proportions. The area of each vegetation zone within each modified minimum home range (MMHR) was determined by planimeter and also expressed as a proportion of the total MMHR area of each animal. A definition of MMHR is given in section 5.3.2.

These proportions of locations of animals within certain habitat zones and proportions of each zone of the MMHR of an animal, correspond to a set of utilization-availability data of its habitat for each animal. The hypothesis that bushbuck utilize such habitat category in exact proportion to its occurence in their MMHRs can therefore be tested by means of the chi-square technique. The observed locations of an animal are compared with the "expected" locations for each habitat category in calculating a test statistic which is approximately chi-square distributed (Neu et al., 1974). Due to the nature of the data (being derived from the behaviour and ecology of the species and as such not subject to rigid laws and principles), it is felt reasonable to consider deviations from a 90% probability level to be significant.

It is desirable to draw conclusions as to which habitat zones are creating statistical significance in the chi-square statistic. For this purpose, individual confidence intervals may be constructed for each theoretical proportion of occurrence of the multinomial distribution in order to determine whether expected values of occurrence lie within the magnitude of the significant effects. One important adjustment, however, is the use of the Bonferroni normal statistic when constructing these confidence intervals. According to Miller (1966) the Bonferroni t statistic is to be favoured when comparisons between sample values and hypothesized values are to be made.

The use of the Bonferroni t statistic adjusts the level of significance of the confidence intervals. When estimating a single parameter, the probability of obtaining an incorrect interval estimate is controlled at a level of significance, $\alpha$. The resulting interval estimate is termed a $(1 - \alpha)$ 100 per cent confidence interval. However, when estimating two or more parameters simultaneously, the probability that any one interval estimate is incorrect increases beyond $\alpha$ and is partially dependent upon the number of simultaneous estimates being made (Hopkins and Gross, 1970, <u>in</u> Neu <u>et al</u>, 1974). In order to bind the probability error rate at $\alpha$, a scaling down of the significance level of each estimate is required. This is achieved by using the Bonferroni t statistic. The resulting interval estimates are then termed a $(1 - \alpha)$ 100 per cent family of confidence intervals with a $(1 - \alpha)$ confidence coefficient.

The form of the confidence interval is as follows:

$$\bar{P}_i - t_{\left(\frac{1-\alpha}{2k}\right)}\sqrt{\frac{\bar{P}_i(1-\bar{P}_i)}{n}} \leqslant P_i \leqslant \bar{P}_i + t_{\left(\frac{1-\alpha}{2k}\right)}\sqrt{\frac{\bar{P}_i(1-\bar{P}_i}{n}}$$

where:-

$\bar{P}_i$ = proportion of locations in the $i$ th habitat category

$n$ = sample size

$k$ = number of simultaneous estimates being made i.e. seven

$\alpha$ = 0,1

Interpolation of the standard t tables were used to arrive at an approximation of the Bonferroni t statistic. According to Miller (1966) this will suffice for most applications of this method.

The hypothetical occurrence of bushbuck in each habitat category as shown by the confidence interval is then compared with the expected occurrence. Expected occurrence values above the confidence interval indicates a significant selection against a habitat category and vice verca.

In addition to the above method employing the Bonferroni t statistic, a preference index was also calculated for each vege= tation zone and for each animal. This index is expressed as the quotient of the proportion of locations per zone and the proportion of the MMHR occupied by that zone. Non-selection is therefore indicated by unity values while values above unity indicate selection for and values below unity selection against a zone.

## 4.2 RESULTS

The determined (obs) and expected (exp) locations of each animal per vegetation zone are shown in tables 12 - 16.

Goodness-of-fit comparisons as shown by the chi-square values in table 17 indicate that significant differences are present between the determined and expected locations in the various vegetation zones for all the animals with the exception of the day locations of female B and the night locations of the same animal and male D.

To determine which of the individual comparisons are responsible for the significant chi-square values, confidence intervals were constructed and compared with the expected occurrence values as explained previously. These confidence intervals are shown in tables 12 - 16 and significant selections for or against a habitat zone are indicated. Table 18 was constructed in the same way and is an analysis of the mean values of all five animals. By way of illustration the situation in zone F in the latter table is explained. During the whole diel period one can expect that 0,112 of all locations are in zone F. The confidence interval of the actual locations is between 0,053 and 0,145. This interval includes the expected proportion and hence no significant selection for or against zone F is demonstrated.

TABLE 12 : Locations of female B per vegetation zone (* = selection against; ** = selection for).

| VEGETATION ZONES | AREA (HA) | PROPORTION OF TOTAL MMHR | NUMBER OF LOCATIONS | | | | | | PROPORTION OF LOCATIONS IN EACH ZONE | | | CONFIDENCE INTERVAL ON PROPORTION OF LOCATIONS IN EACH ZONE (90% FAMILY CONFIDENCE COEFFICIENT) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 4,4 | 0,301 | 3 | 5 | 5 | 8 | 8 | 14 | 0,187 | 0,200 | 0,174 | -0,016-0,390 | 0,039-0,361 | 0,064-0,284* |
| B | 4,0 | 0,274 | 1 | 4 | 6 | 7 | 8 | 13 | 0,063 | 0,240 | 0,174 | -0,063-0,189* | 0,068-0,412 | 0,064-0,284 |
| C | 1,4 | 0,096 | 4 | 2 | 1 | 2 | 5 | 4 | 0,250 | 0,040 | 0,109 | 0,025-0,475 | -0,039-0,119 | 0,019-0,199 |
| D | 3,0 | 0,206 | 3 | 3 | 8 | 5 | 14 | 9 | 0,187 | 0,320 | 0,304 | -0,016-0,390 | 0,132-0,508 | 0,171-0,437 |
| E | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| F | 1,8 | 0,123 | 5 | 2 | 5 | 3 | 11 | 6 | 0,313 | 0,200 | 0,239 | 0,072-0,554 | 0,039-0,361 | 0,115-0,363 |
| G | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TOTAL | 14,6 | 1,000 | 16 | 16 | 25 | 25 | 46 | 46 | 1,000 | 1,000 | 1,000 | | | |

TABLE 13 : Locations of sub-adult ram C per vegetation zone (* = selection against; ** = selection for)

| VEGETATION ZONES | AREA (HA) | PROPORTION OF TOTAL MMHR | NUMBER OF LOCATIONS | | | | | | PROPORTION OF LOCATIONS IN EACH ZONE | | | CONFIDENCE INTERVAL ON PROPORTION OF LOCATIONS IN EACH ZONE (90% FAMILY CONFIDENCE COEFFICIENT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 9,7 | 0,063 | 4 | 5 | 4 | 4 | 8 | 9 | 0,049 | 0,073 | 0,058 | 0,003-0,095 | 0,004-0,142 | 0,020-0,096 |
| B | 75,5 | 0,493 | 57 | 4 | 22 | 27 | 79 | 68 | 0,695 | 0,400 | 0,577 | 0,596-0,794 ** | 0,271-0,529 | 0,496-0,658 ** |
| C | 10,6 | 0,069 | 3 | 6 | 1 | 4 | 4 | 9 | 0,037 | 0,018 | 0,029 | -0,004-0,078 | -0,017-0,053 * | 0,002-0,056 * |
| D | 28,9 | 0,188 | 5 | 15 | 25 | 10 | 30 | 26 | 0,061 | 0,455 | 0,219 | 0,010-0,112 * | 0,324-0,586 ** | 0,151-0,287 |
| E | 3,8 | 0,025 | 6 | 2 | 1 | 1 | 7 | 3 | 0,073 | 0,018 | 0,051 | 0,017-0,129 | -0,017-0,053 | 0,015-0,087 |
| F | 16,5 | 0,108 | 2 | 9 | 1 | 6 | 3 | 15 | 0,024 | 0,018 | 0,022 | -0,009-0,057 * | -0,017-0,053 * | -0,002-0,046 * |
| G | 8,2 | 0,054 | 5 | 4 | 1 | 3 | 6 | 7 | 0,061 | 0,018 | 0,044 | 0,010-0,112 | -0,017-0,053 * | 0,010-0,078 |
| TOTAL | 153,2 | 1,000 | 82 | 82 | 55 | 55 | 137 | 137 | 1,00 | 1,00 | 1,00 | | | |

TABLE 14 : Locations of adult ram D per vegetation zone (* = selection against; ** = selection for)

| VEGETATION ZONES | AREA (HA) | PROPORTION OF TOTAL MMHR | NUMBER OF LOCATIONS | | | | | | PROPORTION OF LOCATIONS IN EACH ZONE | | | CONFIDENCE INTERVAL ON PROPORTION OF LOCATIONS IN EACH ZONE (90% FAMILY CONFIDENCE COEFFICIENT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 7,0 | 0,127 | 12 | 8 | 18 | 12 | 32 | 20 | 0,197 | 0,198 | 0,199 | 0,097-0,297 | 0,117-0,279 | 0,139-0,259 |
| B | 22,8 | 0,414 | 34 | 25 | 30 | 38 | 65 | 66 | 0,558 | 0,330 | 0,404 | 0,434-0,682 ** | 0,234-0,426 | 0,330-0,478 |
| C | 1,9 | 0,036 | 3 | 2 | 6 | 3 | 9 | 6 | 0,049 | 0,066 | 0,056 | -0,005-0,103 | 0,015-0,117 | 0,021-0,091 |
| D | 12,2 | 0,222 | 10 | 14 | 21 | 20 | 36 | 36 | 0,164 | 0,231 | 0,223 | 0,071-0,257 | 0,145-0,317 | 0,160-0,286 |
| E | 2,0 | 0,036 | 1 | 2 | 2 | 3 | 3 | 6 | 0,016 | 0,022 | 0,019 | -0,015-0,047 | -0,008-0,052 | -0,002-0,040 |
| F | 7,5 | 0,136 | 1 | 8 | 12 | 12 | 14 | 22 | 0,016 | 0,132 | 0,087 | -0,015-0,047 * | 0,063-0,201 | 0,044-0,130 * |
| G | 1,6 | 0,029 | - | 2 | 2 | 3 | 2 | 5 | - | 0,022 | 0,012 | - | -0,008-0,052 | -0,004-0,028 * |
| TOTAL | 55,0 | 1,000 | 61 | 61 | 91 | 91 | 161 | 161 | 1,000 | 1,001 | 1,000 | | | |

TABLE 15 : Locations of female E per vegetation zone (* = selection against; ** = selection for)

| VEGETATION ZONES | AREA (HA) | PROPORTION OF TOTAL MMHR | NUMBER OF LOCATIONS | | | | | | PROPORTION OF LOCATIONS IN EACH ZONE | | | CONFIDENCE INTERVAL ON PROPORTION OF LOCATIONS IN EACH ZONE (90% FAMILY CONFIDENCE COEFFICIENT) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 19,5 | 0,172 | 28 | 21 | 28 | 21 | 56 | 43 | 0,229 | 0,228 | 0,224 | 0,155–0,303 | 0,155–0,301 | 0,173–0,275 ** |
| B | 48,3 | 0,425 | 61 | 52 | 50 | 52 | 112 | 106 | 0,500 | 0,406 | 0,448 | 0,412–0,588 | 0,320–0,492 | 0,388–0,508 |
| C | 5,8 | 0,051 | 4 | 6 | 7 | 6 | 16 | 13 | 0,033 | 0,057 | 0,064 | 0,002–0,064 | 0,017–0,097 | 0,034–0,094 |
| D | 14,1 | 0,124 | 14 | 15 | 16 | 15 | 28 | 31 | 0,115 | 0,130 | 0,112 | 0,059–0,171 | 0,071–0,189 | 0,074–0,150 |
| E | 4,0 | 0,035 | 3 | 4 | - | 5 | 6 | 9 | 0,025 | - | 0,024 | -0,002–0,052 | - | 0,005–0,043 |
| F | 14,1 | 0,124 | 10 | 15 | 20 | 15 | 28 | 31 | 0,082 | 0,163 | 0,112 | 0,034–0,130 | 0,099–0,227 | 0,074–0,150 |
| G | 7,8 | 0,069 | 2 | 8 | 2 | 9 | 4 | 17 | 0,016 | 0,016 | 0,016 | -0,006–0,038 * | -0,006–0,038 * | 0,001–0,031 * |
| TOTAL | 113,6 | 1,000 | 122 | 122 | 123 | 123 | 250 | 250 | 1,000 | 1,000 | 1,000 | | | |

TABLE 16 : Locations of adult male F per vegetation zone (* = selection against; ** = selection for)

| VEGETATION ZONES | AREA (HA) | PROPORTION OF TOTAL MMHR | NUMBER OF LOCATIONS | | | | | | PROPORTION OF LOCATIONS IN EACH ZONE | | | CONFIDENCE INTERVAL ON PROPORTION OF LOCATIONS IN EACH ZONE (90% FAMILY CONFIDENCE COEFFICIENT) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 35,0 | 0,201 | 11 | 20 | 3 | 15 | 14 | 35 | 0,113 | 0,039 | 0,080 | 0,051–0,175 * | -0,004–0,082 * | 0,041–0,119 * |
| B | 64,6 | 0,371 | 25 | 36 | 20 | 28 | 45 | 65 | 0,258 | 0,260 | 0,259 | 0,172–0,344 * | 0,163–0,357 * | 0,195–0,323 * |
| C | 7,4 | 0,042 | 5 | 4 | 4 | 3 | 9 | 7 | 0,052 | 0,052 | 0,052 | 0,008–0,096 | 0,003–0,101 | 0,020–0,084 |
| D | 24,5 | 0,140 | 19 | 14 | 38 | 11 | 57 | 24 | 0,196 | 0,493 | 0,328 | 0,118–0,274 | 0,382–0,604 ** | 0,260–0,396 ** |
| E | 15,3 | 0,088 | 26 | 8 | 5 | 7 | 31 | 15 | 0,268 | 0,065 | 0,178 | 0,181–0,355 ** | 0,010–0,120 | 0,122–0,234 ** |
| F | 17,1 | 0,098 | 4 | 9 | 2 | 8 | 6 | 17 | 0,041 | 0,026 | 0,034 | 0,002–0,080 * | -0,009–0,061 * | 0,008–0,060 * |
| G | 10,4 | 0,060 | 7 | 6 | 5 | 5 | 12 | 11 | 0,072 | 0,065 | 0,069 | 0,021–0,123 | 0,010–0,120 | 0,032–0,106 |
| TOTAL | 174,3 | 1,000 | 97 | 97 | 77 | 77 | 174 | 174 | 1,000 | 1,000 | 1,000 | | | |

TABLE 17 : Chi-square values of goodness-of-fit comparisons between determined and expected locations in each habitat zone for the study animals

($P_{0,10} = 10,64$; $P_{0,05} = 12,59$; $P_{0,01} = 16,81$)

| BUSHBUCK | CHI-SQUARE VALUES | | |
|---|---|---|---|
| | DAY | NIGHT | TOTAL |
| Female B | 9,55 NS | 4,90 NS | 11,69 * |
| Sub-adult male C | 28,31 * | 31,18 * | 20,36 * |
| Adult male D | 15,01 * | 8,40 NS | 14,92 * |
| Female E | 11,99 * | 14,75 * | 16,48 * |
| Adult male F | 52,89 * | 83,56 * | 88,98 * |
| Mean (table 18) | 6,22 NS | 10,86 * | 6,19 NS |

TABLE 18 : Mean proportions of locations of all five bushbuck per vegetation zone
(* = selection against; ** = selection for)

| VEGE= TATION ZONES | MEAN AREA (HA) | PROPORTION OF MEAN MMHR | MEAN NUMBER OF LOCATIONS | | | | | | MEAN PROPORTION OF LOCATIONS | | | CONFIDENCE INTERVAL ON MEAN PROPORTION OF LOCATIONS (90% FAMILY CONFIDENCE COEFFICIENT) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DAY | | NIGHT | | TOTAL | | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL |
| | | | OBS | EXP | OBS | EXP | OBS | EXP | | | | | | |
| A | 15,1 | 0,148 | 11,6 | 11,2 | 11,6 | 11,0 | 23,6 | 22,8 | 0,155 | 0,147 | 0,147 | 0,074-0,236 | 0,067-0,227 | 0,092-0,202 |
| B | 43,0 | 0,421 | 35,6 | 31,8 | 25,6 | 31,2 | 61,8 | 64,6 | 0,415 | 0,327 | 0,373 | 0,305-0,525 | 0,221-0,433 | 0,298-0,448 |
| C | 5,4 | 0,053 | 3,8 | 4,0 | 3,8 | 4,0 | 8,6 | 8,2 | 0,084 | 0,047 | 0,062 | 0,022-0,146 | -0,001-0,095 | 0,025-0,099 |
| D | 16,5 | 0,162 | 10,2 | 12,2 | 21,6 | 12,0 | 33,0 | 24,8 | 0,145 | 0,326 | 0,237 | 0,066-0,224 | 0,220-0,432 ** | 0,171-0,303 ** |
| E | 5,0 | 0,049 | 7,2 | 3,8 | 1,6 | 3,6 | 9,4 | 7,6 | 0,076 | 0,021 | 0,054 | 0,017-0,135 | -0,011-0,053 | 0,019-0,089 |
| F | 11,4 | 0,112 | 4,4 | 8,4 | 8,0 | 8,4 | 12,4 | 17,2 | 0,095 | 0,108 | 0,099 | 0,029-0,161 | 0,038-0,178 | 0,053-0,145 |
| G | 5,6 | 0,055 | 2,8 | 4,2 | 2,0 | 4,0 | 4,8 | 8,4 | 0,030 | 0,024 | 0,028 | -0,008-0,068 | -0,011-0,059 | 0,002-0,054 * |
| TOTAL | 102,0 | 1,000 | 75,6 | 75,6 | 74,2 | 74,2 | 153,6 | 153,6 | 1,000 | 1,000 | 1,000 | | | |

The results from use of the Bonferroni t statistic are confusing with no clear trends visible. The most consistent result is the significant selection against Eucalyptus areas shown by three of the study animals during either day or night periods or during the whole diel period. Since the home range of female B did not include Eucalyptus areas it can be said that 75% of the study animals avoided these areas.

Two of the bushbuck show a significant selection for recently clear-felled plantation areas during the night period. Two animals show a significant selection against and two a significant selection for immature pine plantations with a dense undergrowth during the day period. The most confusing result is the significant selection against indigenous forests exhibited by two of the bushbuck.

However, when combining the results as in table 18 a goodness-of-fit comparison shows that a significant difference between determined and expected occurrences is only present during the night period. This significant difference is caused entirely by a preference for recently clear-felled areas. Although not resulting in significant chi-square values, the significant preference for this zone is also shown during the whole diel period. Similarly failing to contribute to a significant chi-square value, is a significant selection against Eucalyptus area when looking at the summed locations for the whole diel period.

The results of the second method of analysis, the con= struction of preference indices, are shown in table 19.

An analysis of variance was conducted on the preference indices values in table 19 and the results are given in table 20.

The analysis of variance indicates no significant difference amongst the preference indices for the different vege= tation zones and during day, night and the whole day periods at a 5% level of significance. However, at a 10% level of significance a significant difference is found between both the vegetation zones and between the interaction factor vegetation zones X period.

Due to the low number of replications (n = 5) and the nature of the data it is considered reasonable to adopt the 10% level of significance instead of the usual 5% level.

The preference indices for all five bushbuck were summed per vegetation zone and the mean of the sums for the three periods was calculated for each vegetation zone. The differences between the various means were determined and tested for significance by means of the Least Significance Difference, LSD (Snedecor and Cochran, 1967). Table 21 gives the summed values and their means and table 22 gives the differences between the means. Significant differences are indicated with an asterisk.

TABLE 19 : Preference indices of all five study bushbuck

| VEGETATION ZONE | PERIOD | LACTATING EWE | YOUNG RAM C | ADULT RAM D | ADULT EWE E | ADULT RAM F |
|---|---|---|---|---|---|---|
| A | NIGHT | 0,98 | 1,16 | 1,69 | 1,49 | 0,19 |
| | DAY | 0,89 | 0,78 | 1,29 | 1,39 | 0,56 |
| | TOTAL | 0,94 | 0,92 | 1,52 | 1,45 | 0,40 |
| B | NIGHT | - | 0,81 | 0,71 | 0,79 | 0,70 |
| | DAY | 1,79 | 1,41 | 1,47 | 1,12 | 0,70 |
| | TOTAL | 0,81 | 1,17 | 1,02 | 0,97 | 0,70 |
| C | NIGHT | - | 0,26 | 2,19 | 1,35 | 1,24 |
| | DAY | 1,34 | 0,54 | 0,92 | 0,73 | 1,24 |
| | TOTAL | 0,61 | 0,42 | 1,67 | 1,01 | 1,24 |
| D | NIGHT | 1,53 | 2,42 | 1,06 | 1,27 | 3,52 |
| | DAY | 0,23 | 0,32 | 0,81 | 0,89 | 1,40 |
| | TOTAL | 0,94 | 1,16 | 0,96 | 1,08 | 2,34 |
| E | NIGHT | - | 0,72 | 0,61 | - | 0,74 |
| | DAY | - | 2,92 | 0,44 | 0,80 | 3,05 |
| | TOTAL | - | 2,04 | 0,56 | 0,43 | 2,02 |
| F | NIGHT | 1,38 | 0,17 | 0,99 | 1,36 | 0,27 |
| | DAY | 1,68 | 0,22 | - | 0,74 | 0,42 |
| | TOTAL | 1,51 | 0,20 | 0,59 | 1,00 | 0,35 |
| G | NIGHT | - | 0,33 | 0,76 | 0,14 | 1,08 |
| | DAY | - | 1,13 | - | 0,26 | 1,20 |
| | TOTAL | - | 0,81 | 0,45 | 0,20 | 1,15 |

TABLE 20 : Analysis of variance of preference indices

| SOURCE OF VARIANCE | SS | df | MS | F |
|---|---|---|---|---|
| total | 48,61 | 104 | | |
| period | 0,02 | 2 | 0,01 | 0,02 NS |
| vegetation zone | 6,03 | 6 | 1,01 | 2,46 NS (* P 0,10) |
| interaction | 7,82 | 12 | 0,65 | 1,59 NS (* P 0,10) |
| exp. error | 34,73 | 84 | 0,41 | |

TABLE 21 : Summed values of preference indices per vegetation zone

| VEGETATION ZONE | SUMMED VALUES OF PREFERENCE INDICES | | | |
|---|---|---|---|---|
| | DAY | NIGHT | TOTAL | MEAN |
| A | 4,91 | 5,51 | 5,23 | 5,22 |
| B | 6,49 | 3,01 | 4,67 | 4,72 |
| C | 4,77 | 5,04 | 4,95 | 4,92 |
| D | 3,65 | 9,80 | 6,48 | 6,64 |
| E | 7,21 | 2,07 | 5,05 | 4,78 |
| F | 3,06 | 4,17 | 3,65 | 3,63 |
| G | 2,59 | 2,31 | 2,61 | 2,50 |

TABLE 22 : Differences between means of summed preference indices values given in table of different vegetation zones (LSD = 2,086)

| COMPARISON BETWEEN VEGETATION ZONES | DIFFERENCES BETWEEN MEAN VALUES IN TABLE |
|---|---|
| AB | 0,50 |
| AC | 0,30 |
| AD | 1,42 |
| AE | 0,44 |
| AF | 1,59 |
| AG | 2,72 * |
| BC | 0,20 |
| BD | 1,92 |
| BE | 0,06 |
| BF | 1,09 |
| BG | 2,22 * |
| CD | 1,72 |
| CE | 0,14 |
| CF | 1,29 |
| CG | 2,42 * |
| DE | 1,86 |
| DF | 3,01 * |
| DG | 4,14 * |
| EF | 1,15 |
| EG | 2,28 * |
| FG | 1,13 |

Significant differences between the mean summed preference indices are shown in six cases. (The last mentioned area in each case is less preferred than the first mentioned area):-

(i) between indigenous forest and Eucalyptus areas.

(ii) between newly regenerated pine areas and Eucalyptus areas.

(iii) between clear-felled areas and open areas with a high incidence of graminioids.

(iv) between recently clear-felled areas and Eucalyptus areas.

(v) between immature pine stands with dense undergrowth and Eucalyptus areas.

(vi) between mature pine stands with little undergrowth and Eucalyptus areas.

These results indicate very clearly the degree to which Eucalyptus areas are avoided by bushbuck. With the exception of open graminioid areas all the other vegetation zones have significantly higher mean preference values than the Eucalyptus areas.

The only comparison which proved significant and which did not include Eucalyptus areas, was between the open clear-felled areas with fairly abundant forbs and shrubs and the open graminioid areas.

Although not statistically significant, the following interesting differences also came to light.

(a) With the exception of adult male F, all the animals showed higher preference indices for the indigenous forest during the night than during the day.

(b) Again with the exception of adult male F (who showed no change in its preference index) all the animals exhibited higher preference indices for immature pine stands with a dense undergrowth during the day than during the night.

(c) All five bushbuck showed higher preference indices for recently clear-felled areas during the night than during the day.

The above observations may explain, partially at least, the significant interaction found between vegetation zones and the period of observation.

From table 21 it is clear that, on the average, recently clear-felled areas are the most highly selected for during the night, followed by the indigenous forest and recently regenerated pine areas. On the average all other vegetation zones are selected against. Similarly mature pine stands are most strongly selected for during the day (however, this is entirely due to the high indices for males C and F only, the other animals showing a preference against this zone) followed by immature pine stands with a dense undergrowth. A slight indication is shown that bushbuck move out of the indigenous forest by day, having a mean preference index of $\frac{4,91}{5} = 0,98$. Recently regenerated pine stands occupy a similar position with a mean value of 0,95. All other vegetation zones are selected against during the day.

## 4.3 DISCUSSION

The use of the Bonferroni t statistic has not proved to be very satisfactory and has yielded inconclusive results. This may be largely due to insufficient sampling. It remains, however, an interesting technique and one which should be kept in mind when analysing utilization-availability data. In this study, the use of the preference index method provided more useful and conclusive results.

The most striking aspect of habitat selection which came to light under these particular conditions is the degree to which certain types of exotic pine stands are preferred by bushbuck. On the other hand the extreme avoidance of *Eucalyptus* stands is highlighted. It has the lowest preference index value of all types of vegetation and is the only zone which is significantly selected against when considering all five bushbuck together (table 18). This, admitedly expected, result points clearly to the fact that the forest owner should think twice before planting *Eucalyptus* spp in an area where he wishes to conserve the bushbuck population. In all probability this avoidance of gum stands is linked to the lack of undergrowth, and hence food plants, usually associated with *Eucalyptus* compartments in the Southern Cape.

The importance of canopy cover for bushbuck during the hours of daylight is illustrated by the low preference index values in table 21 for the "open" zones C and D, which are devoid of any significant canopy cover, although zone C has some lateral cover.

Thomson (1972) found that canopy cover is an important factor which governs the distribution of bushbuck. He also found that canopy cover should preferably be combined with lateral cover, as in zone A and B in this study, but canopy cover alone is sufficient, as is the case in zones E and G. Lateral cover with= out canopy cover was found to be totally unattractive. Such a situation is present in zone C.

The preference for various habitat zones, of which the cover aspect is one component, may, however, be complicated by a difference in diurnal and nocturnal preferences of bushbuck. Waser (1975) found that the day and night ranges of the individuals in his study were practically non-overlapping. Although a similar tendency was found in the present study it was not as pronounced.

Both zones C and D are favoured during the night but avoided during the day. The degree of this positive selection during the night and avoidance during the day is less marked in zone C. This ties in well with the fact that zone C has con= siderably more vegetative growth, or lateral cover, than zone D. Furthermore the average height of the vegetation in zone C is one to two metres, as opposed to the height of 0,25 m and less in zone D, indicating an absence of even lateral cover in zone D.

The need for canopy cover during the day is similarly shown by the high preference exhibited for the "canopy cover" zones B and E during the day.

As well as the need for canopy cover during the day, the above pattern of selection may also be linked to the feeding habits of bushbuck. Based on field observations it appears that feeding is an important activity in zones C and D. These areas, because of their limited canopy cover, allow more sunlight to reach lower levels. Hence more plant material can be produced at a trophic level utilizable by bushbuck. It appears therefore, that bushbuck seek the shelter of the "canopy cover" zones during the day for cover and other unknown purposes, and move out to the more open and also more productive areas at night for feeding purposes. These latter areas may have some lateral cover or not.

The singular importance of indigenous forest for bushbuck is clearly shown by the preference indices values. If those of the adult ram F, are ignored, the indigenous forest zone is the only one which is preferred both by day and night. This implies that all the requirements of cover, and food plants are met in this zone, in contrast with the other zones where movement from one to the other are apparently necessary. It should be kept in mind though that the exotic zones can all be grouped together as one "exotic" zone in contrast to the "indigenous" zone. In such a case it appears quite possible for a bushbuck to exist in an entirely "exotic" zone, although it is of course mainly the arboreal component of such a zone which is exotic. The movements of the sub-adult ram C, appear to approximate such a situation. Although he did frequent indigenous forest areas, the area of indigenous forest in his home range made up only some six per cent of his total MMHR. The selection of adult ram F, against indigenous forest, although 20 per cent of his MMHR was made up by that zone, may be another indication of such a situation.

The available evidence therefore points to a rejection of the accusation that afforestation *per se* will eliminate all wildlife from an area. Provided that afforestation is with *Pinus* spp and that normality is striven for i.e. an even age-class distribution, there is no reason to assume that the bushbuck population will suffer as a result, or at the very worst, not be able to survive.

# CHAPTER V

# SOCIAL BIOLOGY

## 5.1 GENERAL

The aspects of social biology which were investigated in this study are home range behaviour, associations and sex ratio.

Smith (1966) defines the home range of an animal as the area over which it habitually travels while engaged in its usual activities. The size is a variable quantity, but is of great importance in determining population density if the degree of overlap of home ranges is known.

The nature of the home range will also give an indication of the habitat requirements of the species.

A knowledge of all the facets of home range behaviour should be of advantage in any programme which entails the manipulation of a population as the disrupting effect of removal of individuals can then be better evaluated.

Of particular importance is also the part which home range behaviour occupies in the social organisation of a species. Especially in a species such as bushbuck, which is claimed by some authors (Verheyen, 1955; Jarman, 1973; Jacobsen, 1974) to be territorial, while others (Allsopp, 1969; Leuthold, pers. comm., in Jarman, 1973) state that it is non-territorial, a study of home range behaviour may help to throw some light on this problem.

When studying social organisation, it is also necessary to determine what associations occur between animals belonging to various sex and age groups, and how frequent they are. This subject is also associated with home range behaviour as the various associations of animals may exhibit different home range behaviour.

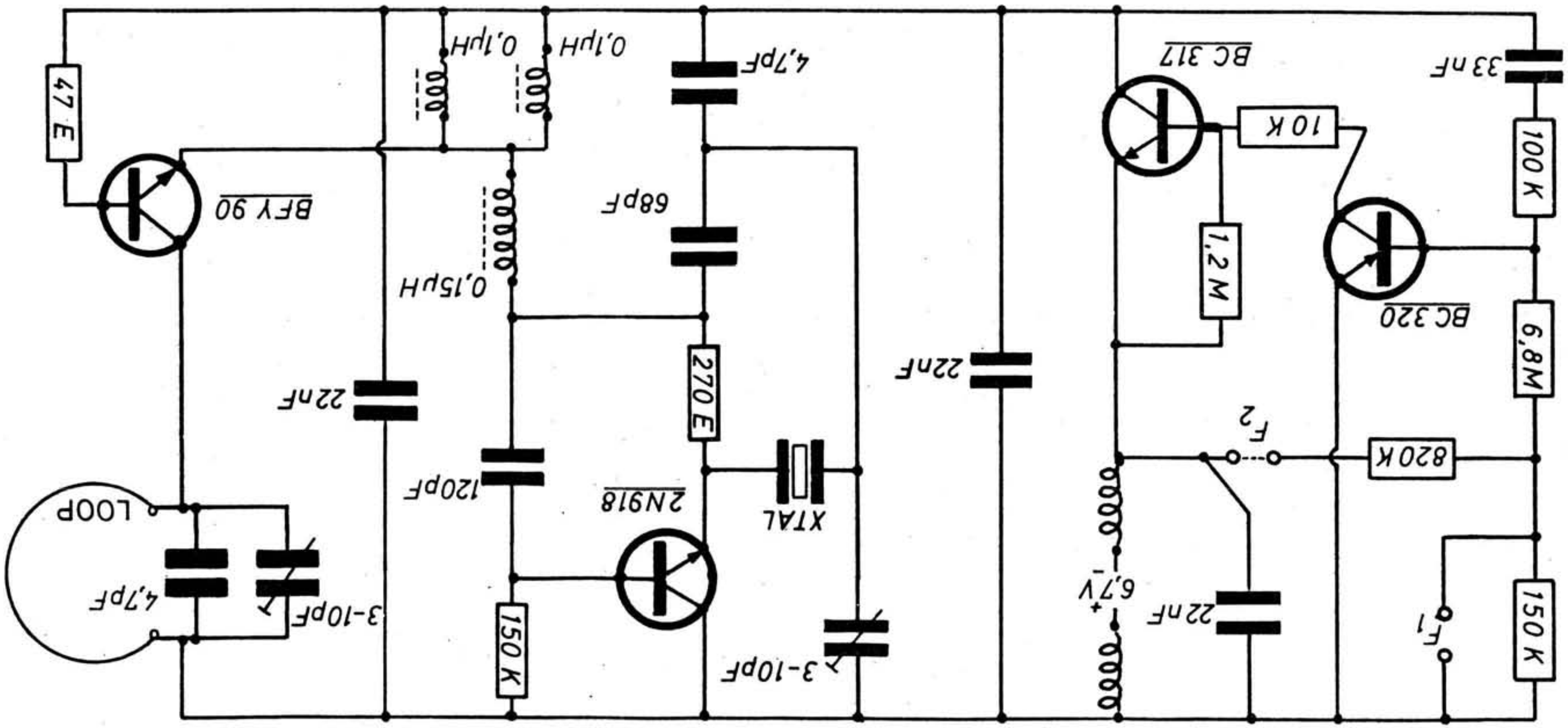
## 5.2 METHODS

### 5.2.1 INSTRUMENTATION

The dense habitat occupied by bushbuck and their un= obtrusive behaviour makes continous direct observation of limited value as a method of study. Radio-tracking appeared therefore to be the obvious technique for the project. The equipment was designed and built by the Division of Electronic Instrumentation, National Research Institute for Electrical Engineering, C.S.I.R. The basic design was similar to the original apparatus used by Anderson and De Moor (1971) with some modifications and improve= ments. A description after Potgieter (1973) of the equipment used in this study, is given below.

The transmitter consists of a cristal controlled colpitts oscillator followed by an antenna driver in the common base mode. The cristal is a 5th overtone type, of which the series resonance is used. To avoid coupling as far as is possible, screened commercial microchokes are used as inductors. Pulsing is achieved by interrupting the voltage supply to both stages. A loop antenna is used and this plus an internal capacitor form the tank circuit of the driver transistor. A circuit with complimentary transistors are used in order to break the circuit completely during the relatively long period when the transmitter is cut off between pulses. The power source consists of five Mallory nickel-cadmium type RM12R batteries. The circuit diagram of the transmitter is given in fig. 3.

FIG 3 : CIRCUIT DIAGRAM OF TRANSMITTER



The transmitter and pulser consist of a printed circuit board 57 x 13 mm, mounted in a tin container on the one side of the loop. This is mounted on the top part of the collar with the set of batteries on the bottom part. Everything is sealed with fibre-glass against climatic interference. The top and bottom halves of the collar are built separately and are con= nected with Sterkolite bands. This is done with bolts and nuts to allow for easy fitting to the animal in the field.

The transmitter is tuned in before being fitted to the animal, as opposed to the earlier equipment where the tuning-in had to be done after fitting.

The whole transmitter with loop and batteries weighed 450 g. Two bushbuck were collected to obtain neck measurements and the fibre-glass collar was moulded to fit the contours of the neck. It was therefore unable to turn and there was no danger of slipping down with the risk of the animal having to carry the transmitter underneath its neck. This reduces its height above ground level and hence its transmitting range. Similar pre-shaped collars were used by Manson (1974) in a study on Cape grysbuck.

The receiving equipment consists of a double Yagi-antenna and a portable receiver. The Yagi-antenna consists of a tuned half-wave dipole with a single reflector on the back side. Because the directional sensitivity of such an antenna exhibits a broad maximum, use was made of a double Yagi. After the direction of the maximum has been roughly determined, the two

Yagis are put out of phase (so that their signals when mixed tend to cancel each other). In this position a sharp nil with good definition indicates the direction of the transmitter.

The block diagram of the receiver is given in fig. 4. A cascade FET-stage feeds from the antenna into the FET-mixer, and from there through a 10,7 $MH_z$ - cristal filter to a wide-band amplifier with automatic gain control. This is followed by a single tuned L.C. circuit, the secondary of which feeds a product detector. Here a 10,7001 $MH_z$ local oscillator is mixed to give an audible beat to the received pulse, followed by an amplifier. Automatic gain control is achieved by using the audio tone as the control signal. The audio-amplifier feeds a built-in loudspeaker as well as earphones.

The main oscillator consists of two identical stages, each capable of handling ten channels by means of a 10-way switch. The geometry of the lay-out prevents the accommodation of twenty channels on two switches in one oscillator circuit, hence the necessity for two oscillators working alternatively. Each channel switch has an eleventh position which activates the other circuit and switches off its own. The oscillators are connected with a cable to the source of the FET-mixer by means of a 50-Ohm turn on the oscillator coil.

The equipment, consisting of six transmitters, a receiver and a double Yagi-antenna, was received during July 1973.

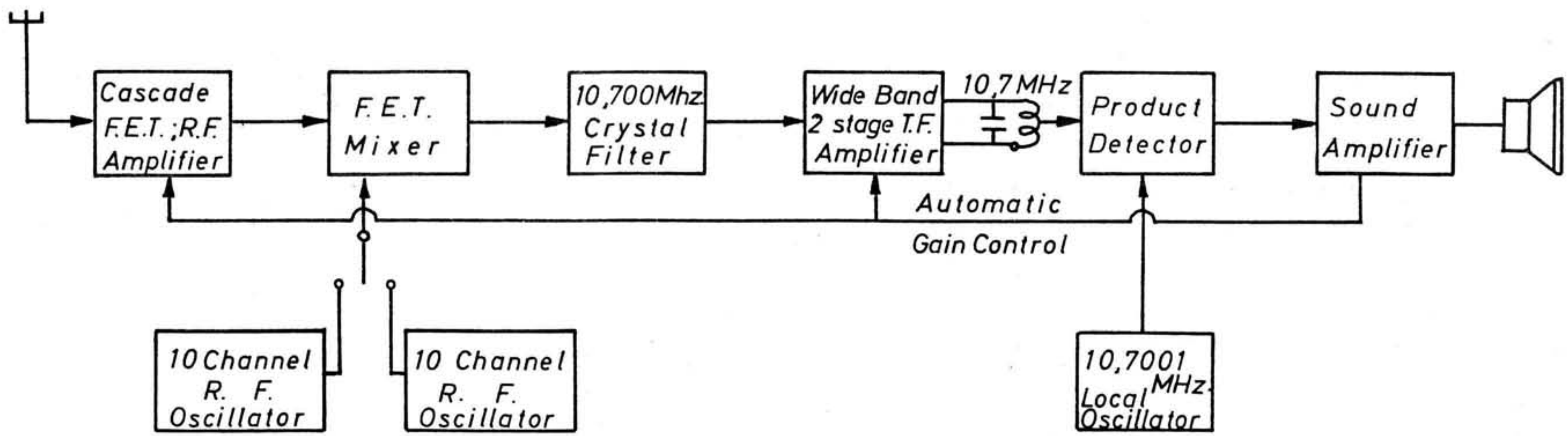



FIG 4 : BLOCK DIAGRAM OF RECEIVER

## 5.2.2 CAPTURE TECHNIQUE

Capture of bushbuck commenced on 6th August 1973. Nylon drop nets with a 15 cm mesh, total length 400 m, and 300 m white plastic hessian were used.

The most important consideration was found to be a thorough study of the capture site and proper siting of the nets and plastic. Capture in a large homogenous stand of indigenous forest proved to be extremely time-consuming and generally un= successful. On the other hand, capture in smallish, isolated indigenous forest patches, with well-established game tracks into the surrounding vegetation, proved to be fairly simple and generally successful. This can probably be attributed to the fact that, in the case of small forest patches, a large percentage of the forest boundary is surrounded by nets and hessian. In addition beaters can cover most of the remaining perimeter. Consequently the probability of chasing any enclosed animal into the nets is greatly increased.

The nets and hessian were strung up in the form of a rough funnel. It was a simple matter to put them up in the forest since adequate hook-up points were available from which to suspend them. After some practice the beaters could erect all the plastic and nets and be ready for the drive within one-and-a-half hours.

The enclosed area was then driven by 20 to 30 beaters. It was found to be important to keep as straight a line as possible during the drive since this prevented bushbuck from breaking back through the line of beaters to a large extent. One person with a whistle was placed in the middle of the line. He regulated the speed of the drive by means of a system of signals.

At the nets four to five men concealed themselves. As soon as a bushbuck ran into the nets, they converged onto the animal and held it down, covering its eyes with a black cloth, until the transmitter was fixed.

On the first day one female was caught. Immediately after capture this animal was injected intramuscularly with 30 mg Rompun (Xylazine hydrochloride) as a sedative. She died approximately ten hours after capture. A thorough post-mortem revealed positive signs of muscular dystrophy (over-straining disease).

No sedatives were used during following captures and no further losses were experienced. Emphasis was placed on handling the animal as little and for as short a period as possible while fixing the transmitter. The animals were all released within ten minutes after capture. Five animals were thus successfully captured and fitted with transmitters between August 1973 and January 1974. Further information is given in table 23.

TABLE 23 : List of bushbuck captured and channels assigned

| ANIMAL | DATE OF CAPTURE | CHANNEL |
|---|---|---|
| Adult male | 9 August 1973 | D |
| Lactating female | 10 August 1973 | B |
| Young female | 10 August 1973 | E |
| Sub-adult male | 19 December 1973 | C |
| Adult male | 18 January 1974 | F |

## 5.2.3 TRACKING TECHNIQUE

Tracking commenced on 23rd August 1973, allowing the animals a period of two weeks to settle down and resume their normal behaviour patterns. An attempt was made to track individuals for one 24 hour period continuously during each week. Tracking was done entirely by triangulation. Locations were ordinarily taken every one to three hours throughout a 24-hour period. Since only one antenna and receiver was available at the start, bearings had first to be taken from one position. The antenna was then dismantled, transported to the next position, erected and the second set of bearings taken. As the animal could have moved a certain distance in the intervening interval, the technique has a potential for a fairly large degree of inaccuracy.

The straightline distance between the stations from which bearings were taken was about 0,5 km. This relatively short distance was necessitated by the topography.

During October 1973 another receiver and antenna were obtained and tracking with the two sets of receiving equipment commenced on the 1st November 1973. The additional apparatus eliminated the time-consuming process of dismantling and erecting the antenna as well as the need to travel between the receiving points.

Initially one person was stationed at each receiver and antenna, these being put up semi-permanently, and bearings were taken every half-an-hour and verified by two-way radio. As a consequence, the efficiency of the system was greatly improved. About three to four times as many locations were determined as previously. This was achieved with considerably less strain on the operators and with far less risk of inaccuracy caused by movement of the animals between bearings.

The system was further improved by stationing two persons at each station and extending the period of observation from one 24-hour period at a time to five such periods in succession. A tent was provided at each station where the off-duty operator could sleep. A reasonable amount of information was thus obtained in a relatively short period of time.

## 5.2.4 OBSERVATIONS

At the beginning of 1972 observation forms were distributed to all forest stations in the Southern Cape Forest Region. Respondents were asked to enter information on sex, association, age and time and date of observation on the forms. Information was also obtained from the Tsitsikamma area. Some data collected by staff of the Indigenous Forest Office at Saasveld in the Southern Cape between 1970 and 1972 were also used.

Most forms were completed by qualified foresters and augmented by observations of foremen and labourers.

The only aspect of the form where confusion was possible, was the question as to when an animal is to be recorded as "young". Therefore, in the present study a young animal was classified as having a rufous pelage and being of slighter built than an adult female. However, the over-riding criterion given to the field staff was that the animal must obviously still be young to be recorded as such. This arbitrary classification allows an unknown proportion of young animals to be recorded as adults. Although not satisfactory, this was considered to be the only practical means of achieving a degree of uniformity in the recording of observations by numerous people with widely different standards of education.

## 5.3 RESULTS

### 5.3.1 TRACKING SUCCESS

A total of 609 hours were spent on actual tracking of the five radio-tagged animals. The tracking was done during 29 sorties between 23rd August 1973 and 1st February 1974. Table 24 gives a breakdown of the dates and duration of each tracking period as well as the number of locations determined for each animal during each period.

The transmitter on the lactating female B, ceased functioning between 9th October 1973 and 18th October 1973, thereby yielding a transmitter life-time of two months. This animal was re-captured on 29th April 1974 and the transmitter removed. Between 14th November 1973 and 26th November 1973 the transmitter on the adult ram D, dropped off the animal. On 12th December 1973 this transmitter was recovered within a radius of 40 m from its position as determined by radio. It was still transmitting and appeared to be in good condition with very little sign of wear. At that stage the transmitter had been in use for four months. Signals could not be received from the young female E, after 30th November 1973, yielding a transmitter life of three-and-a-half months.

The two males C and F were only tracked for a relatively short period and information on the transmitter life is not available. However, the indications were that C lasted for only one month whereas F was still transmitting when the field work was terminated.

TABLE 24 : Tracking periods and number of locations of five bushbuck

(* B = lactating ewe, C = sub-adult ram, D = adult ram, E = young ewe, F = adult ram)

| TRACKING PERIODS | | NUMBER OF LOCATIONS | | | | |
|---|---|---|---|---|---|---|
| DATE | DURATION (hrs) | B * | C * | D * | E * | F * |
| 23/24.8.1973 | 20 | 5 | – | 5 | 5 | – |
| 4/5.9.1973 | 6 | 2 | – | 3 | – | – |
| 19/20.9.1973 | 20 | 6 | – | 9 | 10 | – |
| 24/25.9.1973 | – | – | – | 1 | 1 | – |
| 26/27.9.1973 | 23 | 9 | – | 11 | 10 | – |
| 27/28.9.1973 | 20 | 7 | – | 14 | 15 | – |
| 3/4.10.1973 | 18 | 11 | – | 12 | 13 | – |
| 9/10.10.1973 | 20 | 6 | – | 12 | 12 | – |
| 18/19.10.1973 | 21 | – | – | 12 | 13 | – |
| 1/2.11.1973 | 21 | – | – | 33 | 25 | – |
| 8/9.11.1973 | 22 | – | – | 24 | 25 | – |
| 14/15.11.1973 | 21 | – | – | 25 | 28 | – |
| 26/27.11.1973 | 24 | – | – | – | 26 | – |
| 27/28.11.1973 | 24 | – | – | – | 20 | – |
| 28/29.11.1973 | 24 | – | – | – | 25 | – |
| 29/30.11.1973 | 25 | – | – | – | 22 | – |
| 10/11.12.1973 | 12 | – | – | – | – | – |
| 31.12.1973/1.1.1974 | 24 | – | 29 | – | – | – |
| 1/2.1.1974 | 24 | – | 11 | – | – | – |
| 2/3.1.1974 | 24 | – | 27 | – | – | – |
| 3/4.1.1974 | 24 | – | 12 | – | – | – |
| 21/22.1.1974 | 24 | – | 5 | – | – | 21 |
| 22/23.1.1974 | 24 | – | 18 | – | – | 26 |
| 23/24.1.1974 | 24 | – | 20 | – | – | 21 |
| 24/25.1.1974 | 24 | – | 8 | – | – | 22 |
| 28/29.1.1974 | 24 | – | 7 | – | – | 10 |
| 29/30.1.1974 | 24 | – | – | – | – | 23 |
| 30/31.1.1974 | 24 | – | – | – | – | 23 |
| 31.1/1.2.1974 | 24 | – | – | – | – | 28 |
| TOTAL | 609 | 46 | 137 | 161 | 250 | 174 |

## 5.3.2 SIZE AND SHAPE OF HOME RANGES

The study of mammal movements, with particular emphasis on home ranges, has been reviewed by Sanderson (1966). He suggests that the sizes and shapes of species home ranges have little significance in themselves and that effort should be directed towards ecological studies. However, Craighead et al (1973) refute this. They state that the biological needs of an animal are related to a specific land area and to the capacity of that area to support the animal. Accordingly it is important to retain the area concept and to relate it to the biological requirements of the individual.

It is felt that both schools of thought have merit. The necessity for deriving meaningful ecological answers from a study of home ranges is clear. However, the importance which the size concept and habitat selection, coupled with social behaviour, have with regard to the dynamics and density of a population can not be denied. The geographical aspects of home range behaviour must therefore be seen in combination with the ecological framework into which the species fits. With this in view various parameters of their home ranges were determined for the five study animals.

Numerous methods have been developed to arrive at an estimation of home range size and shape (Sanderson, 1966; Harvey and Barbour, 1965; Hayne, 1969). When all these methods are considered it is felt that only two are applicable to this study viz. the "minimum home range" (MHR) and "modified minimum home range" (MMHR) methods. This is borne out by the fact that practically all African workers (Leuthold, 1971; Goddard, 1967; Hitchins, 1971; Cumming, 1971; Douglas-Hamilton, 1971; De Moor and Steffens, 1971) have used the MHR method.

The MHR method consists of representing the home range as a polygon resulting from connecting the outermost points at which an individual animal was located. Logically it follows that if an infinite number of locations were available, this method would yield an accurate delineation of the true home range.

The MMHR method is included here as a few divergent locations were obtained for some animals. These appear to be mere excursions outside the true home range, of the type termed "periodic exploratory journeys" by Ewer (1968). Similar be= haviour was observed by Jacobsen (pers. comm.) and also for impala by Jarman (1970) and for southern reedbuck by Jungius (1971). By including these divergent locations when determining the MHR the area of the home range is artificially enlarged. However, in the fairly homogenous habitat of the study area, it is extremely difficult to eliminate these locations objectively. The MMHR has provided a ready solution for this problem.

Harvey and Barbour (1965) originally devised this method because the MHR method normally probably included areas which are not frequented by the animal due to insufficient locations being known. However, in addition it is as stated above, a useful method to eliminate divergent locations objectively.

With this method, the range length was first determined, being the two points of detection farthest apart i.e. the same parameter as the "home range major axis" of Marchinton and Jeter (1967). One-fourth of this distance was then used in determining the outer boundaries of the home range. That is, if the two outer points were a greater distance apart than one-fourth the range length, they were not directly connected. Instead, the boundary line was drawn from one of these points to the next outermost point that was no more distant than one-fourth the range length. Points of detection that fell further than one-fourth the range length from any other point were excluded from the main home range area. These points were connected to the nearest point with a straight line and were considered to be exploratory journeys outside the true home range. The break-even point, one-fourth the range length, was used to define divergent locations, as opposed to the range length as used by Harvey and Barbour (1965). The latter used trapping data in their study. Hence a considerably lower number of locations per individual animal were used. Under such conditions the use of range length would readily identify divergent locations. Few locations are available and the probability of a true exploratory journey being detected in this way, appears to be reasonable. However with the more numerous tracking data of the present study, the probability increases that the use of the range length will mask exploratory journeys. Thus for example a study of the scatter diagram of locations of female E in fig. 8 clearly shows the presence of exploratory journey(s) into the indigenous forests to the south of the study area. However, if the range length was used to exclude divergent locations, none of these exploratory journeys would have been identified as such. Consequently it was decided to use one-fourth the range length for this purpose, which follows naturally from the system of determination of the boundary of the MMHR. Only in the instance of female B, was an arbitrary boundary determined at one point. This was done because it was clear that the objective method would in that case yield an obviously wrong picture of the home range boundary. This was an exceptional case though and it is believed that in most of the other instances a reasonably reliable estimate of the true size of the home range was obtained by means of the MMHR method.

The use of one-fourth the range length to determine the boundary of the MMHR is debatable. Admittedly this is an arbitrary figure. However, using the range length was unacceptable as explained earlier. For the same reason it was not considered advisable to use half the range length or longer. Being then left with half the range length or less, it seemed reasonable for the sake of objectivity, to use half of this distance i.e. one fourth of the range length. The fact remains though that this is an objective method without which one would either have to use the obviously incorrect MHR method, or rely on completely arbitrary boundaries.

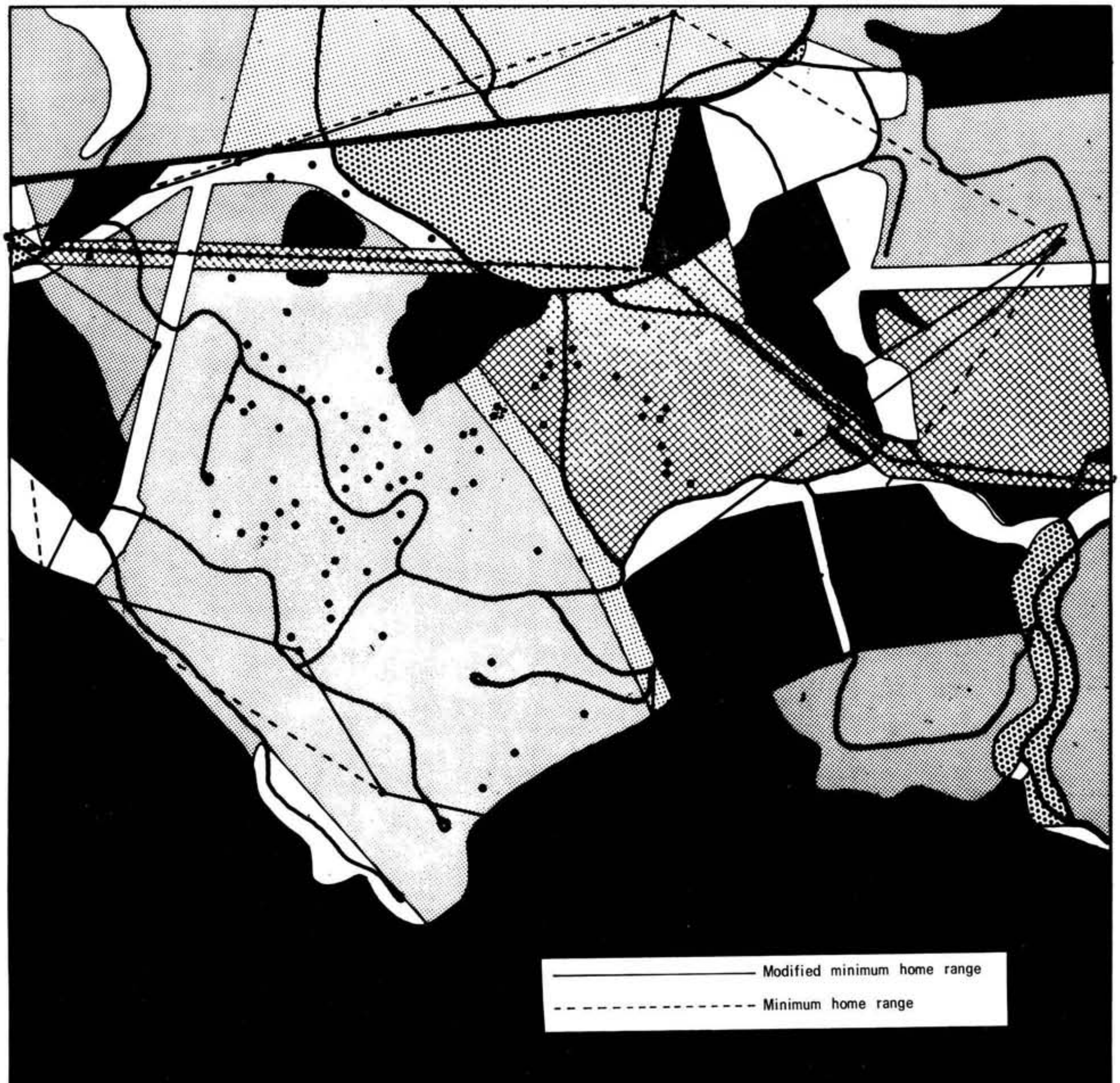
A compensating polar planimeter was used to determine all areas.

Table 25 presents the sizes of the home ranges of the bushbuck studied. Figs 5 - 9 show the home ranges as MHR, MMHR and a scatter-diagram of locations.

Two further measures of home range size were calculated and details are given in table 26. The home range major axis (HRMA) is a line segment formed by connecting the two locations of the animal, obtained at any time during the study, that are the greatest distance apart. The home range minor axis (HRmA) is a line segment perpendicular to the major axis and connecting the boundaries of the MHR at its widest point (Marchinton and Jeter, 1967).

From Figs 5-9 it will be clear that the shapes of the home ranges are irregular. No tendency towards any of the regular geometric patterns is apparent.

Fig 5 : Home range of female B




KRUISFONTEIN
Bushbuck Study Area

VEGETATION ZONES

A B C D E F G

Fig 6 : Home range of Sub-Adult Male C

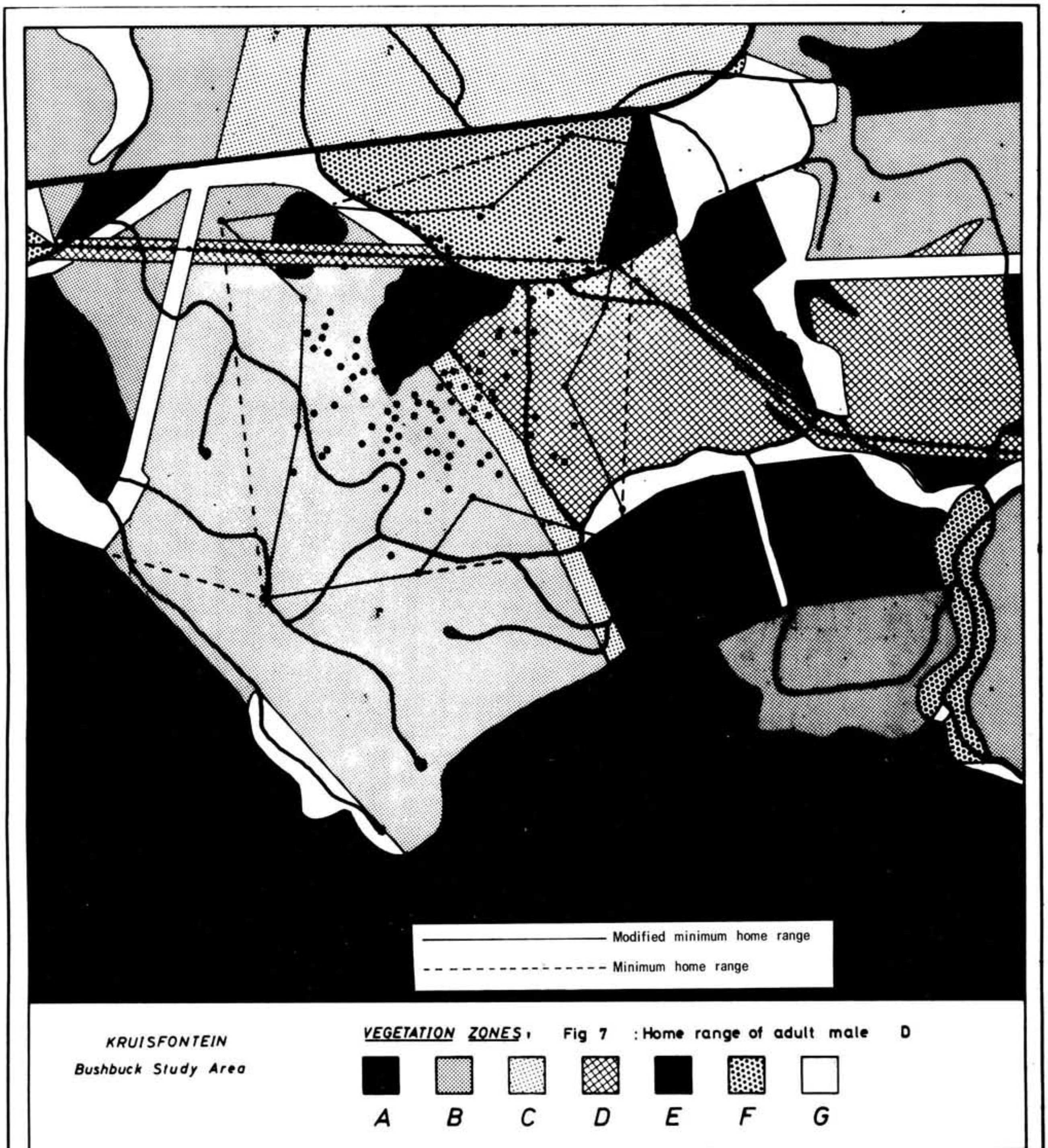



Fig 7 : Home range of adult male D

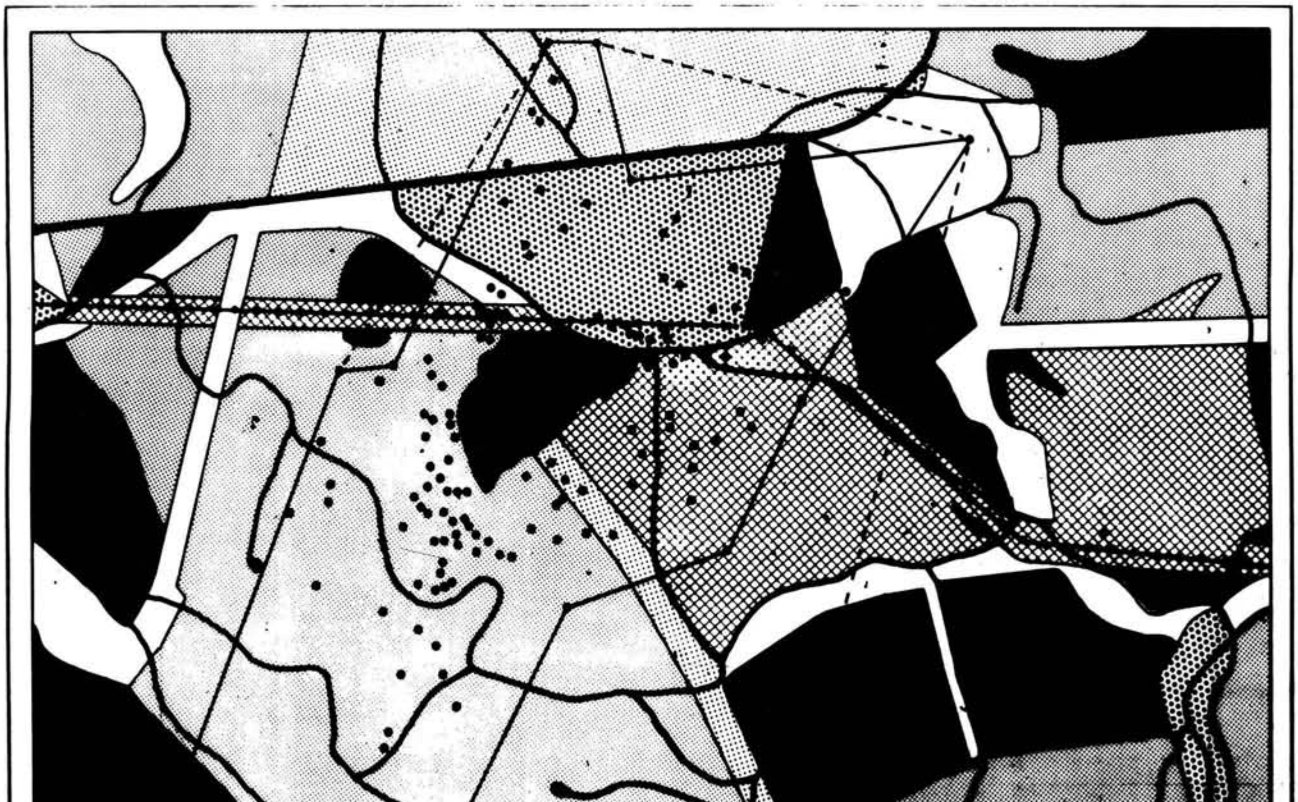



Fig 8 : Home rdnge of female E

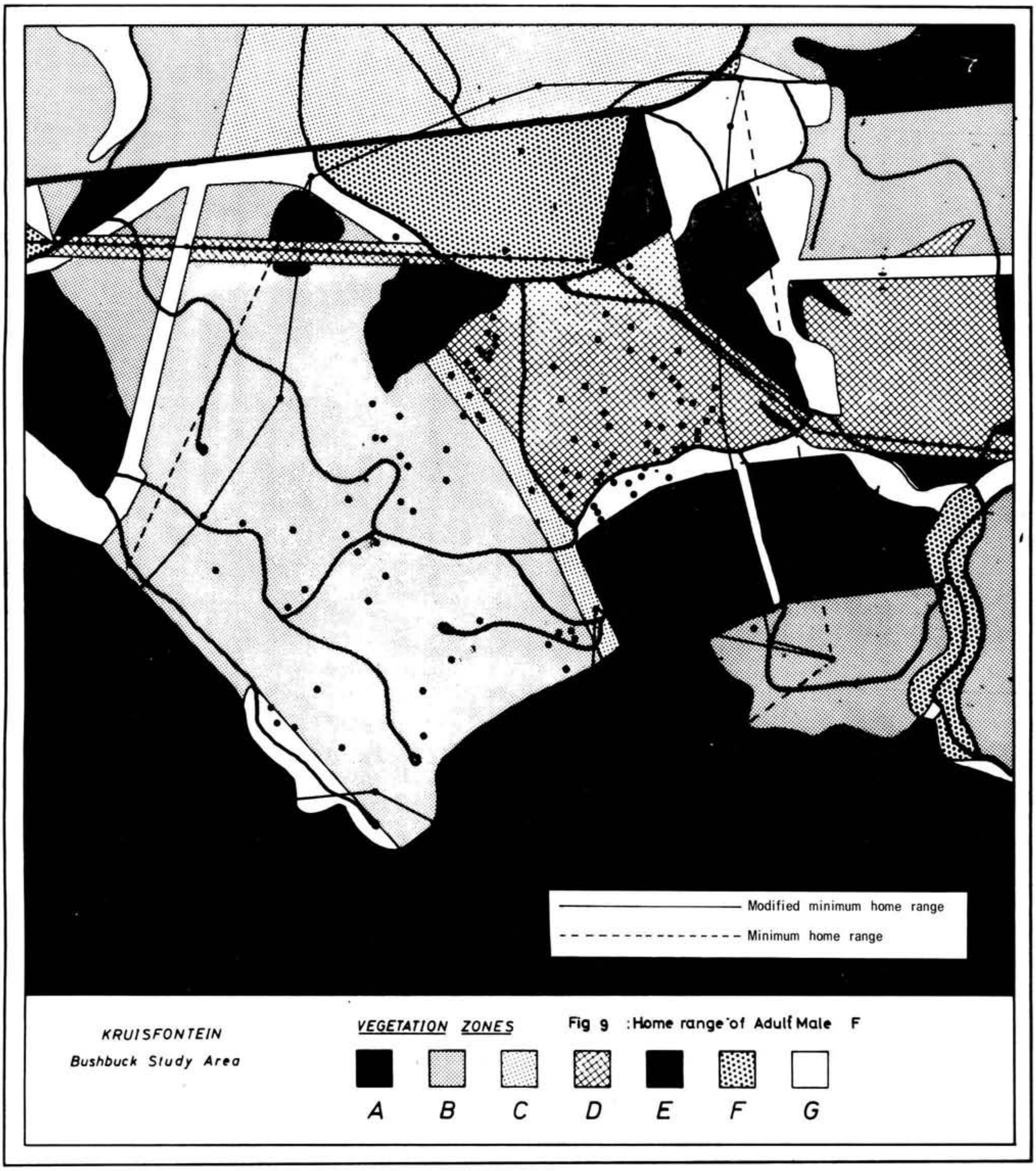



Fig 9 : Home range of Adult Male F

TABLE 25 : Size of home ranges of five bushbuck

| ANIMAL | SIZE OF HOME RANGE (ha) | |
|---|---|---|
| | MHR | MMHR |
| Lactating ewe B | 54,4 | 14,6 |
| Subadult ram C | 225,6 | 153,2 |
| Adult ram D | 76,5 | 55,0 |
| Young ewe E | 259,0 | 113,6 |
| Adult ram F | 224,8 | 174,3 |
| Mean | 168,1 | 102,1 |
| Confidence interval (P=0,95): | ± 118,1 | ± 83,0 |

TABLE 26 : Length of home range major and minor axes

| ANIMAL | HRMA (m) | HRmA (m) |
|---|---|---|
| Lactating ewe B | 1 160 | 775 |
| Subadult ram C | 2 784 | 1 488 |
| Adult ram D | 1 308 | 1 092 |
| Young ewe E | 2 718 | 1 332 |
| Adult ram F | 2 324 | 1 524 |
| Mean | 2 058 | 1 242 |
| Confidence interval (P=0,95): | ± 963 | ± 388 |

## 5.3.3 OVERLAPPING OF HOME RANGES

The degree of overlapping of the home ranges of these five animals is high, as can be seen from fig 10 and the data presented in table 27.

Especially striking is the high degree of overlap between the home ranges of the three male bushbuck. A mean of 65% of the home range of a male is overlapped by that of another male. This percentage refers only to the overlap between two specific individual males. When the overlap of all three males are considered together a mean overlap area of 53 ha exists between them. It comprises 42% of the mean male MMHR area. For a species which is considered by some (Verheyen, 1955; Jarman, 1973; Jacobsen, 1974) to be territorial this is certainly a very large degree of overlap.

However, it must be borne in mind that the tracking period of male D stopped 37 days before tracking of males C and F started. This may have had an influence on the degree of overlap, the extent of which is impossible to ascertain, however.

It is interesting to note that the sum of the MMHR areas of all five animals is 510,7 ha. However, if the locations of all five animals were regarded as being that of a single individual a MMHR area of 228,4 ha is arrived at. This again indicates a high degree of overlap.

The mean overlapping percentage derived from table 27 is 60%. This refers to the mean overlap between two specific individuals. Since the home ranges of more than two animal may and do overlap, it represents the minimum degree of overlap only.

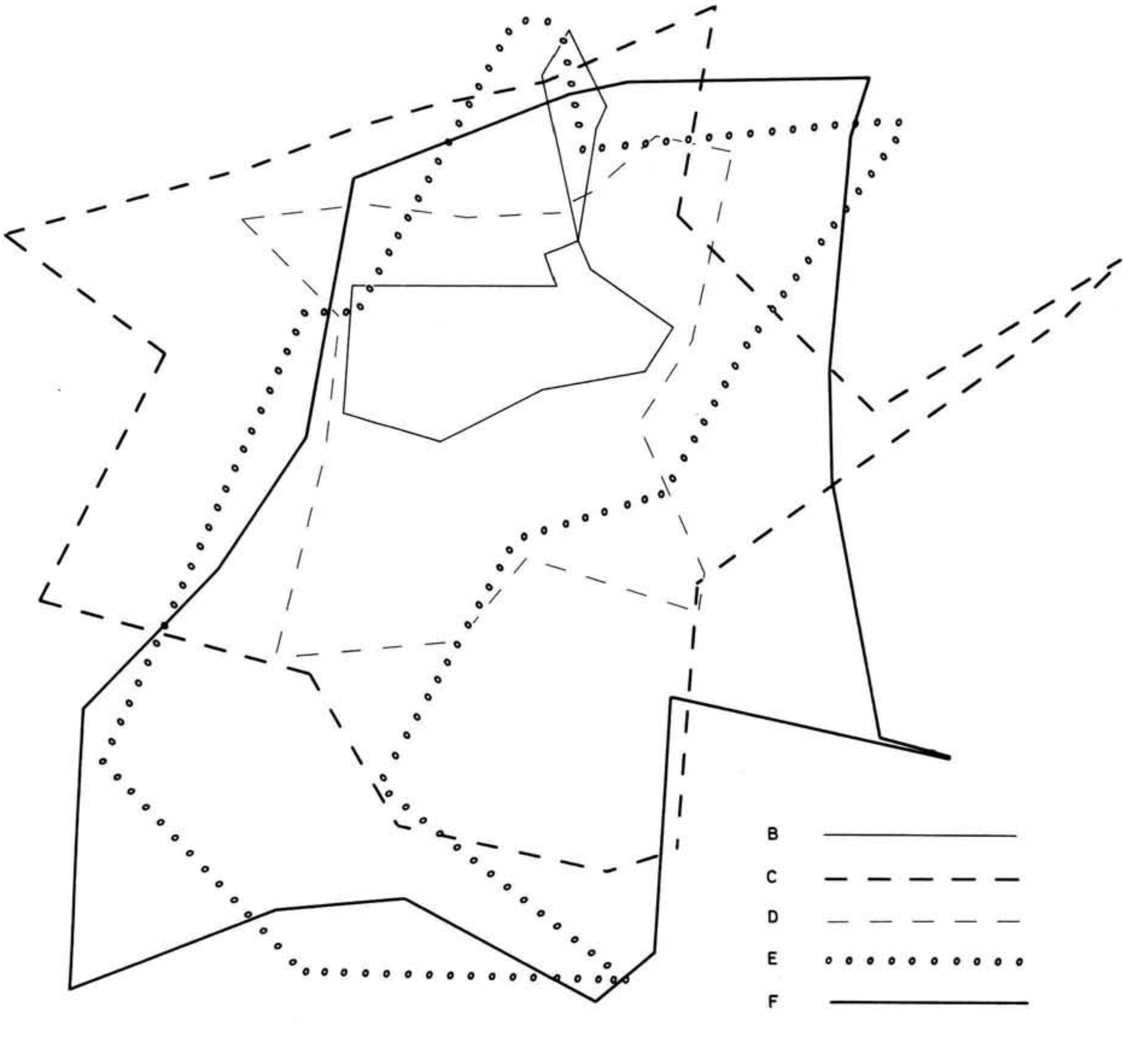



Fig 10 : Modified minimum home ranges of five bushbuck showing the degree of overlap

TABLE 27 : Overlapping of home ranges

| OVERLAPPING AREA OF MMHR (ha) | | | | | | | | | | OVERLAPPING AREA AS % OF THE MMHR AREA OF: | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B+C | B+D | B+E | B+F | C+D | C+E | C+F | D+E | D+F | E+F | B | C | D | E | F |
| 14,5 | | | | | | | | | | 99,3 | 9,5 | | | |
| | 12,7 | | | | | | | | | 87,0 | | 23,1 | | |
| | | 13,8 | | | | | | | | 94,5 | | | 12,1 | |
| | | | 13,6 | | | | | | | 93,2 | | | | 7,8 |
| | | | | 53,0 | | | | | | | 34,5 | 96,3 | | |
| | | | | | 71,9 | | | | | | 46,9 | | 63,2 | |
| | | | | | | 110,0 | | | | | 71,8 | | | 63,0 |
| | | | | | | | 48,7 | | | | | 88,5 | 42,2 | |
| | | | | | | | | 53,3 | | | | 96,9 | | 30,5 |
| | | | | | | | | | 98,4 | | | | 86,6 | 56,4 |

## 5.3.4 MOVEMENT PATTERN

The attribute by which one component of activity, move= ment, was analysed, was the distance covered per time unit in m/hour i.e. speed of movement. Due to the irregular times of plotting it was felt that by converting total minimum distance travelled to speed (actually minimum speed, because the straigh-line distance is used), some bias would be eliminated.

For each period of plotting, all locations were divided into day and night locations. The point of division used was sunrise and sunset. The total minimum distance travelled during each day and each night period was determined. This distance was divided by the time interval during which each distance was covered. In this way a series of activity data was obtained for each animal for each period of observation on a day and night basis. Table 28 illustrates the data obtained in this manner. The observation period 28/29.11.1973 was not used in these cal= culations because of one very divergent location. As the accuracy of this point was very doubtful and would distort the whole movement picture, it was decided to exclude that set of observations from the calculations.

The t-test (Snedecor and Cochran, 1967) was conducted on the sets of day and night observations to test for a signifi= cant difference between day and night movements. The results are given at the bottom of table 28.

TABLE 28 : Movement data of five bushbuck

| OBSERVATION PERIOD | ACTIVITY OF ANIMALS (m/h) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | B | | C | | D | | E | | F | |
| | DAY | NIGHT | DAY | NIGHT | DAY | NIGHT | DAY | NIGHT | DAY | NIGHT |
| 19/20.9.1973 | 156 | 45 | - | - | 138 | 236 | 142 | 290 | - | - |
| 26/27.9.1973 | 70 | 58 | - | - | 82 | 89 | 281 | 128 | - | - |
| 27/28.9.1973 | 272 | 115 | - | - | 142 | 204 | 206 | 87 | - | - |
| 3/4.10.1973 | 138 | 98 | - | - | 215 | 224 | 128 | 171 | - | - |
| 9/8.10.1973 | - | - | - | - | 142 | 187 | 80 | 195 | - | - |
| 18/19.10.1973 | - | - | - | - | 51 | 120 | 64 | 218 | - | - |
| 1/2.11.1973 | - | - | - | - | 63 | 289 | - | - | - | - |
| 8/9.11.1973 | - | - | - | - | 49 | 331 | 82 | 270 | - | - |
| 14/15.11.1973 | - | - | - | - | 72 | 118 | 100 | 186 | - | - |
| 26/27.11.1973 | - | - | - | - | - | - | 326 | 459 | - | - |
| 27/28.11.1973 | - | - | - | - | - | - | 291 | 135 | - | - |
| 28/29.11.1973 | - | - | - | - | - | - | - | - | - | - |
| 29/30.11.1973 | - | - | - | - | - | - | 92 | 361 | - | - |
| 31.12.1973/1.1.1974 | - | - | 174 | 169 | - | - | - | - | - | - |
| 1/2.1.1974 | - | - | 297 | - | - | - | - | - | - | - |
| 2/3.1.1974 | - | - | 344 | 233 | - | - | - | - | - | - |
| 3/4.1.1974 | - | - | 297 | 26 | - | - | - | - | - | - |
| 21/22.1.1974 | - | - | - | - | - | - | - | - | 102 | 76 |
| 22/23.1.1974 | - | - | 114 | 160 | - | - | - | - | 138 | 205 |
| 23/24.1.1974 | - | - | 290 | 104 | - | - | - | - | 209 | 169 |
| 24/25.1.1974 | - | - | 112 | 87 | - | - | - | - | 130 | 310 |
| 28/29.1.1974 | - | - | 319 | 69 | - | - | - | - | 228 | - |
| 29/30.1.1974 | - | - | - | - | - | - | - | - | 170 | 110 |
| 30/31.1.1974 | - | - | - | - | - | - | - | - | 268 | 322 |
| 31.1./1.2.1974 | - | - | - | - | - | - | - | - | 258 | 647 |
| Mean | 159,0 | 79,0 | 143,4 | 121,1 | 106,0 | 188,7 | 162,9 | 227,3 | 187,9 | 262,7 |
| Conf. Limits | ±133,6 | ±52,4 | ±79,1 | ±64,9 | ±43,3 | ±63,3 | ±64,7 | ±74,0 | ±51,9 | ±178,6 |
| t-test (P=0,95) | 2,05* | | 3,01** | | 2,64** | | 1,53 ns | | 1,12 ns | |

Both the adult rams and the young ewe exhibit a higher nocturnal activity, although this was only significant in the case of male D. Both the sub-adult ram and the lactating ewe were significantly more active during the day.

To allow a more detailed investigation of the movement pattern of these animals the data in table 28 were grouped into smaller time units. The diel period was split into four-hour components and the average value of the activity parameter was calculated for each four-hour period.

Fig. 11 gives a graphic representation of the information thus obtained. The data are presented on a percentage basis to allow direct comparison. It will be noticed that only limited data were available for the lactating ewe. The above data were used to construct fig. 12 which shows an average activity pattern based on the mean values of the five individuals.

An analysis of variance was done on the activity data used to construct fig. 11 and the results are shown in table 29. Significant differences on a 95 per cent confidence level were found to exist between the mean distances moved during the various four-hour periods.

The data in table 28 were used to calculate a mean minimum distance moved in a diel period. As with the data in table 28 this attribute is subject to a certain amount of experimental error because of inconsistant frequency of obtaining radio locations. The data for each animal are portrayed in table 30.

Fig 11:
Frequency of movement activity of five bushbuck

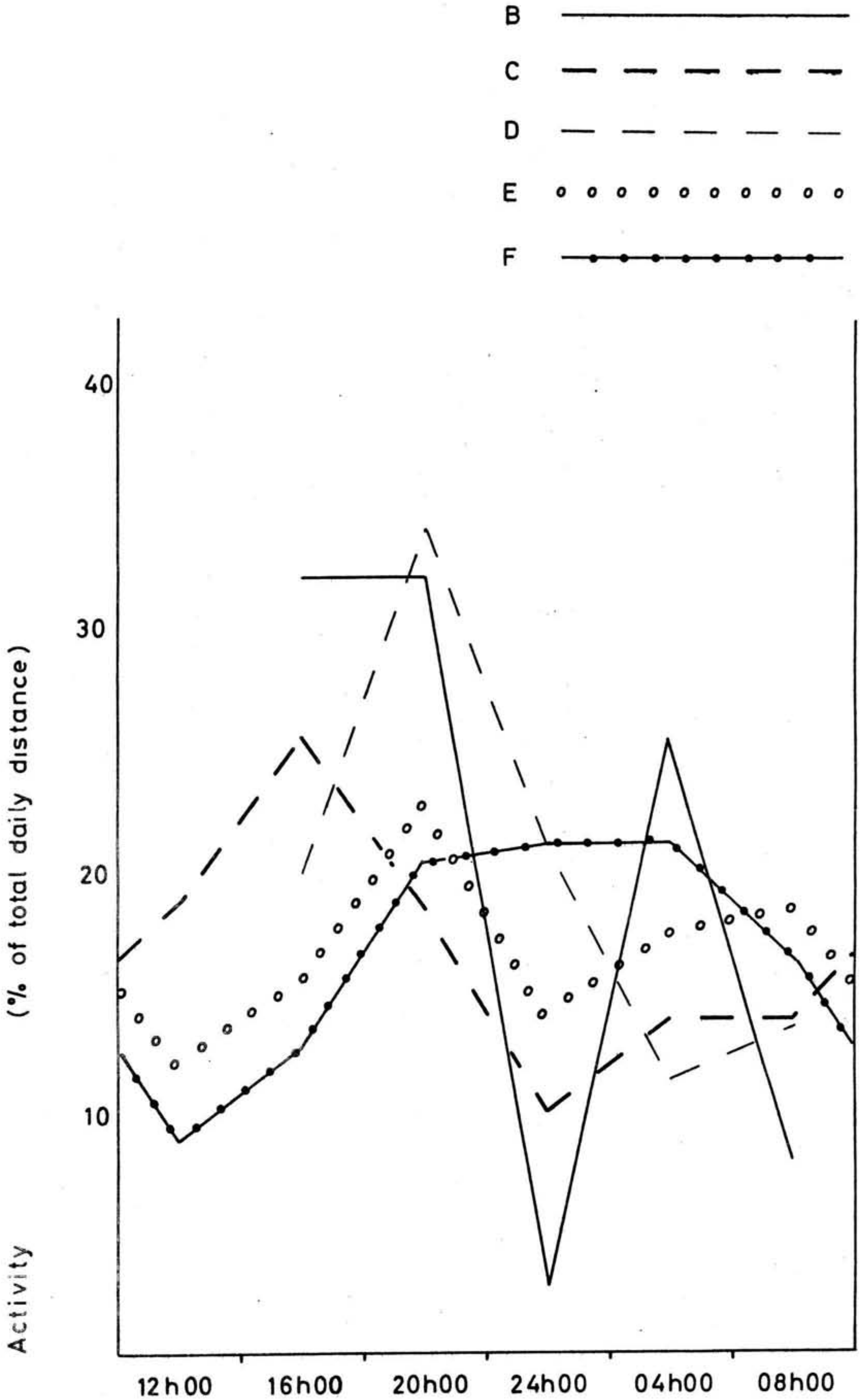


Fig 12:
Frequency of the average movement activity pattern of bushbuck

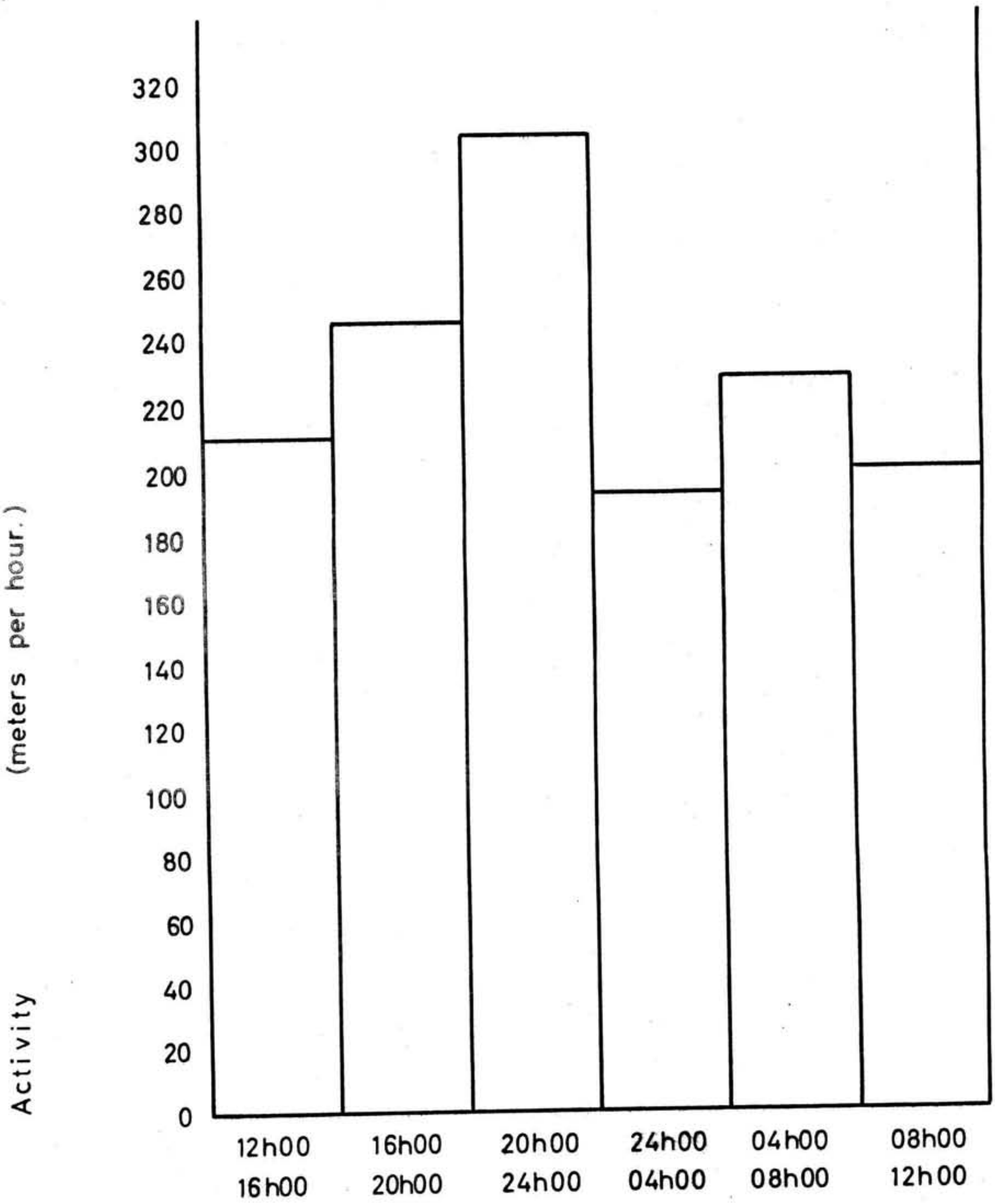


TABLE 29 : Analysis of variance of mean distances moved by five bushbuck during six 4-hour periods

| SOURCE OF VARIATION | SS | df | MS | F |
|---|---|---|---|---|
| Total | 1 504,9 | 27 | | |
| Between periods | 577,4 | 5 | 115,5 | 2,74 * |
| Exp. error | 927,5 | 22 | 42,2 | |

TABLE 30 : Mean distance moved in diel period by each animal

| ANIMAL | MEAN MINIMUM DISTANCE COVERED IN DIEL PERIOD (m) |
|---|---|
| Lactating ewe B | 2855 ± 2223 |
| Sub-adult ram C | 3347 ± 1223 |
| Adult ram D | 3534 ± 1279 |
| Ewe E | 4685 ± 1665 |
| Adult ram F | 5043 ± 2836 (P = 0,95) |

The above data are comparable with those obtained for white-tailed deer, an animal of somewhat similar habitat, but larger (Marchinton and Jeter, 1967). The mean minimum distance covered in a diel period was 2 494 m (six individual deer were involved), as opposed to 3 891 m in this study.

## 5.3.5 ASSOCIATIONS

Initially returns of observation forms were fairly good. However, these soon dwindled to those of the really interested foresters only. Nonetheless, a total of 1 380 useful observations were recorded.

The data, grouped by month, are given in table 31. Forty-four per cent of all observations were recorded at Goudveld State Forest and since this could perhaps distort the results, data from all other areas together are presented separately in table 32. No significant difference are apparent between the two tables, although the proportion of solitary males in table 31 is somewhat higher than in table 32.

These tables show a high percentage of solitary males and solitary females. However, the ratio between solitary males and solitary females in both tables differs significantly from an even ratio. The chi-square values are 44,29 and 10,23 for the ratios in tables 31 and 32 respectively ($t_{0,05} = 3,84$).

The statistical significance of the differences between the frequencies of the various associations containing two or more adult animals was tested, i.e. MM, FF, MF, MFF, MFY and others.

BLE 31 : Associations of bushbuck, by month, in the Southern Cape (No. indicates total number of animals in an association; M = male, F = female, Y = young)

| | JAN. | | FEB. | | MARCH | | APRIL | | MAY | | JUNE | | JULY | | AUG. | | SEPT. | | OCT. | | NOV. | | DEC. | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % |
| | 60 | 45 | 75 | 49 | 57 | 40 | 37 | 36 | 47 | 35 | 33 | 42 | 30 | 26 | 25 | 27 | 28 | 37 | 31 | 30 | 41 | 36 | 53 | 40 | 517 | 38 |
| | 8 | 6 | 6 | 4 | 8 | 6 | 6 | 6 | 12 | 9 | 4 | 5 | 16 | 14 | 8 | 9 | 2 | 3 | 6 | 6 | 6 | 5 | 6 | 5 | 88 | 6 |
| | 35 | 27 | 36 | 23 | 37 | 26 | 32 | 31 | 35 | 26 | 19 | 24 | 20 | 17 | 18 | 20 | 18 | 24 | 23 | 22 | 19 | 16 | 32 | 24 | 324 | 23 |
| | 8 | 6 | 6 | 4 | 14 | 10 | 6 | 6 | 4 | 3 | 6 | 8 | 4 | 4 | 10 | 11 | 2 | 3 | 10 | 10 | 10 | 9 | 2 | 1 | 82 | 6 |
| | 10 | 8 | 14 | 9 | 8 | 6 | 14 | 13 | 22 | 16 | 6 | 8 | 18 | 16 | 12 | 13 | 16 | 21 | 12 | 11 | 10 | 9 | 26 | 19 | 168 | 12 |
| F | 3 | 2 | 3 | 2 | 12 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 8 | 3 | 3 | 3 | 4 | 0 | 0 | 3 | 3 | 3 | 2 | 39 | 3 |
| | 0 | 0 | 10 | 6 | 4 | 3 | 4 | 4 | 6 | 4 | 6 | 8 | 8 | 7 | 10 | 11 | 0 | 0 | 4 | 4 | 6 | 5 | 6 | 5 | 64 | 5 |
| Y | 0 | 0 | 3 | 2 | 3 | 2 | 3 | 3 | 6 | 4 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 0 | 0 | 30 | 2 |
| | 2 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 11 | 1 |
| HER | 6 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 4 | 6 | 5 | 3 | 3 | 3 | 4 | 15 | 14 | 12 | 10 | 6 | 5 | 57 | 4 |
| TAL | 132 | 100 | 155 | 100 | 143 | 101 | 103 | 100 | 136 | 100 | 78 | 100 | 114 | 100 | 92 | 100 | 75 | 100 | 104 | 100 | 114 | 100 | 134 | 101 | 1380 | 100 |

TABLE 32 : Associations of bushbuck, by month, in the Southern Cape except Goudveld State Forest
(No. per month indicates total number of animals in an association)

| | JAN. | | FEB. | | MARCH | | APRIL | | MAY | | JUNE | | JULY | | AUG. | | SEPT. | | OCT. | | NOV. | | DEC. | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % |
| | 26 | 39 | 38 | 46 | 30 | 35 | 14 | 25 | 30 | 30 | 24 | 39 | 21 | 25 | 11 | 23 | 12 | 39 | 14 | 26 | 12 | 35 | 21 | 30 | 253 | 33 |
| M | 2 | 3 | 6 | 7 | 4 | 5 | 0 | 0 | 8 | 8 | 4 | 7 | 10 | 12 | 2 | 4 | 0 | 0 | 0 | 0 | 4 | 12 | 4 | 6 | 44 | 6 |
| | 17 | 25 | 20 | 25 | 25 | 29 | 18 | 32 | 30 | 30 | 15 | 24 | 14 | 16 | 11 | 23 | 4 | 13 | 11 | 20 | 5 | 15 | 16 | 22 | 186 | 24 |
| F | 6 | 9 | 6 | 7 | 10 | 12 | 4 | 7 | 4 | 4 | 6 | 10 | 2 | 2 | 8 | 17 | 2 | 6 | 4 | 7 | 4 | 12 | 2 | 3 | 58 | 8 |
| F | 8 | 12 | 8 | 10 | 6 | 7 | 12 | 22 | 18 | 18 | 4 | 7j | 16 | 19 | 4 | 8 | 10 | 32 | 6 | 11 | 2 | 6 | 18 | 25 | 112 | 14 |
| FF | 0 | 0 | 3 | 4 | 9 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 10 | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 3 | 4 | 27 | 3 |
| Y | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 7 | 4 | 4 | 4 | 7 | 4 | 5 | 6 | 13 | 0 | 0 | 2 | 4 | 2 | 6 | 4 | 6 | 32 | 4 |
| TY | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 6 | 6 | 0 | 0 | 3 | 4 | 3 | 6 | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 18 | 2 |
| | 2 | 3 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 7 | 1 |
| HER | 6 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 6 | 7 | 3 | 6 | 0 | 0 | 15 | 27 | 3 | 9 | 3 | 4 | 39 | 5 |
| TAL | 67 | 100 | 82 | 100 | 86 | 100 | 56 | 100 | 100 | 100 | 61 | 100 | 85 | 100 | 48 | 100 | 31 | 100 | 55 | 100 | 34 | 101 | 71 | 100 | 776 | 100 |

Table 33 presents the result of such an analysis of variance on the frequencies in table 32.

The results indicate significant differences between the frequencies of these associations. Linear combinations (Snedecor and Cochran, 1968) were used to compare the frequencies of specific associations. No significant difference on a 95 per cent confidence level could be detected between the frequencies of MM and FF associations ($t = 0,62$). Nonwithstanding this non-significance the absence of the MM association from observations during three months is considered to be of importance.

A significant t-value of 2,42 ($P < 0,05$) was found when comparing the frequencies of the MF association and the second commonest adult associations, FF. This shows that the MF association is the most common adult association.

The frequencies in table 31 are essentially similar to those in table 32, with the exception that the mean frequencies of the MM and FF associations are equal. A similar analysis of variance was conducted on the frequencies and yielded equivalent results as for table 32.

A comparison of frequencies of associations from other published studies is presented in table 34. They agree reasonably well.

TABLE 33 : An analysis of variance on the frequencies of all associations in table 32 containing two or more adults

| Source of variation | df | SS | MS | F |
|---|---|---|---|---|
| Total | 71 | 1 832,72 | | |
| Between associations | 5 | 468,11 | 93,62 | 4,53** |
| Exp. error | 66 | 1 364,61 | 20,68 | |

TABLE 34 : Frequencies of associations of bushbuck in this study and other published work, expressed as percentages of total number of animals observed

| SOURCE | ASSOCIATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | M | MM | F | FF | MF | MFF | FY | OTHERS |
| Present study, n=1380 | 38 | 6 | 23 | 6 | 12 | 3 | 5 | 7 |
| Present study excluding Goudveld observations, n=776 | 33 | 6 | 24 | 8 | 14 | 3 | 4 | 8 |
| Bourlière & Verschuren, 1960, n=52 (Congo) | 29 | 0 | 38 | 4 | 15 | 0 | 12 | 2 |
| Walther, 1964, n=35 (Uganda) | 31 | 0 | 43 | 0 | 0 | 0 | 17 | 9 |
| Wilson & Child, 1964, n=74 (Zambia) | 37 | 1 | 35 | 6 | 19 | 0 | 0 | 2 |
| Allsopp, 1969, n=642 (Kenya) | 28 | 5 | 24 | 5 | 8 | 4 | 15 | 11 |
| Elder & Elder 1970, n=232 (Botswana) | 27 | 4 | 25 | 6 | 11 | 0 | 8 | 19 |

The combined frequencies of solitary males and solitary females in the seven sets of data in table 34 are 61%, 57%, 67%, 74%, 72%, 52% and 52% respectively. The MF association is in all instances the most frequent of those involving two or more adult animals. The relatively high incidence of the female-young (FY) association recorded in four of the study areas (Bourlière and Verschuren, 1960; Walther, 1964; Allsopp, 1969; Elder and Elder, 1970) can probably be attributed to two main factors. One is that observations could have been undertaken during a period following a peak in parturition, resulting in a higher than average frequency of this association. The other likely reason lies in different interpretations of the age class 'young'. The frequencies of all associations containing a young animal in the various studies are therefore not comparable as the authors do not define their 'young' category.

The male-two female (MFF) association was not observed by four of these investigators (Bourlière and Verschuren, 1960; Walther, 1964; Wilson and Child, 1964; Elder and Elder, 1970). The highest frequency for the association, 4 per cent, was found in Kenya by Allsopp (1969).

The observation forms provided no information on population structure because of the difficulty of determining age under field conditions.

## 5.3.6 SEX RATIO

The population sex ratios derived from all observation forms, and from those excluding Goudveld State Forest, are given in table 35. Other published data are also included for comparison.

Where possible the chi-square test was carried out to test for a significant departure from parity in the various sex ratios. The population sex ratio in this study which was based on all observations, was found to be significantly in favour of males. No significant difference was found in the sex ratio when the Goudveld observations were excluded. Observations were intensive at Goudveld and may have resulted in recording of some individuals more than once. If there was a difference in the average visibility (chances of seeing) of males and females, the calculated sex ratio may be distorted from repeatedly seeing the same animals.

This aspect was investigated by calculating the sex ratio for the first 100 animals observed at Goudveld, the first 200 animals, and so on until the total number observed was reached. The sex ratios of the individual groups of 100 animals each were also determined. These ratios are shown in table 36. Deviations from an even sex ratio were tested for significance and the results shown in the same table.

The first 200 observations yielded sex ratios which do not differ significantly from parity. However, the sex ratios based on between 300 and 578 observations are significantly un= even in favour of males.

TABLE 35 : Population sex ratios of present study and other published work (* and ** = significant difference from an even sex ratio at 95 and 99 percent confidence levels respectively, NS = no significant difference)

| SOURCE | POPULATION SEX RATIO (MALES PER 100 FEMALES) | $X^2$ | n |
|---|---|---|---|
| Southern Cape, present study | 126 | 18,10 ** | 1327 |
| Southern Cape, excluding Goud= veld State Forest | 108 | 1,13 NS | 747 |
| Allsopp, 1969 (Kenya) | 89 | 0,24 NS | 66 |
| Bourlière & Verschuren, 1960 (Congo) | 75 | 0,82 NS | 44 |
| Dasmann & Mossman, 1962 (Rhodesia) | 48 | 4,57 * | 37 |
| Dasmann & Mossman, 1962 (Rhodesia) | 43 | 14,08 ** | 87 |
| Elder & Elder, 1970 (Botswana) | 101 | 0,01 NS | 167 |
| Jacobsen, 1974 (Rhodesia) | 120 | - | not given |
| Mentis, 1970 (Umfolozi, Natal) | 67 | 138,22 ** | 3535 |
| Morris, 1973 (Rhodesia) | 89 | 1,70 NS | 530 |
| Morris, 1973 (Rhodesia 1965-1972) | 78 | * (given by author) | not given |
| Simpson, 1974 (Rhodesia) | 66 | - | not given |
| Thomson, 1972 (Rhodesia) | 94 | 0,16 NS | 161 |
| Walther, 1964 (Uganda) | 58 | 2,13 NS | 30 |
| Wilson & Child, 1964 (Zambia) | 111 | 0,22 NS | 74 |

TABLE 36 : Sex ratio of bushbuck population at Goudveld State Forest ((a) sex ratio of each group of 100 observations (b) sex ratio based on cumulative observations)

| NUMBER OF ANIMALS | CUMULATIVE NUMBER | SEX RATIO (a) (Males/100 Females) | SEX RATIO (b) (Males/100 Females) |
|---|---|---|---|
| first 100 observed | 100 | 138 NS | 138 NS |
| second 100 observed | 200 | 117 NS | 127 NS |
| third 100 observed | 300 | 163 * | 138 * |
| fourth 100 observed | 400 | 186 ** | 148 ** |
| fifth 100 observed | 500 | 170 ** | 153 ** |
| last 78 observed | 578 | 169 * | 155 ** |

## 5.4 DISCUSSION

Allsopp (1969) studied bushbuck in Nairobi National Park, Kenya. He determined the size of home ranges using the MHR method, based on visual observations of animals, and arrived at mean home range sizes of 0,25 ha for females, 0,56 ha for adult males and 2,01 ha for sub-adult males. Working on bushbuck in Ruwenzori National Park, Uganda, Waser (1975) used the same method and determined mean home range sizes of 11,8 ha for females and 19,8 ha for adult males. One sub-adult male in his study occupied a range of 35,2 ha. These figures contrast strongly with mean MMHR figures of 64,1 ha for females, 114,7 ha for adult males and 153,2 ha for the one sub-adult male, deter= mined in this study. However, Waser (1975) points out that his home range sizes should be viewed as under-estimates, due to the limited length of the study and the possibility that some animals may have travelled more widely at night.

In chapter VI on population density it is said that the density of the bushbuck population in this study area appears to be lower than in those populations situated in the savanna biome. It is also generally recognised that the productivity of the forest biome is considerably lower than that of the savanna biome (Estes, 1974). This fact presumably explains the lower population density and therefore also the larger size of the home ranges. Because of the low productivity of their habitat animals are forced to move over a large area to satisfy their requirements of food, resulting in these large home ranges.

Spinage (1974) suggests that size of territory is de= pendent upon the pressure of competition rather than upon size itself i.e. there is no universal optimum territory size. The results of this study and those of Allsopp (1969), Jacobsen (1974) and Waser (1975) partially support this hypothesis. In the latter study the mean home range size was 17 ha with a population density of 26 animals/km² as opposed to 102 ha and 3,0 animals/km² in the present study. Jacobsen (1974) determined a home range size of 5,7 ha for males at a density of 66,7 animals/ km² and Allsopp (1969) a home range size of approximately 1,0 ha at a density of 30,1 animals/km². As competition can be viewed as a function of density a considerable increase in home range size is apparent with a decrease in competition. The relationship follows a negative exponential curve when the values of all four studies are used, but is negatively linear when the study of Jacobsen (1974), with an exceptionally high population density, is ignored (fig 13). Besides supporting the hypothesis of Spinage (1974) these figures may also explain why such widely different values for the size of home ranges of bushbuck are published. However, the large differences in the environmental conditions of the study areas introduce many unknown factors, such as nutritional quality of the forage, which make comparisons risky.

It is noteworthy that there is a rather similar relation= ship between the size of home ranges of females, adult males and sub-adult males in the present study and those of Allsopp (1969) and Waser (1975). The figures of Allsopp (1969) give a ratio of

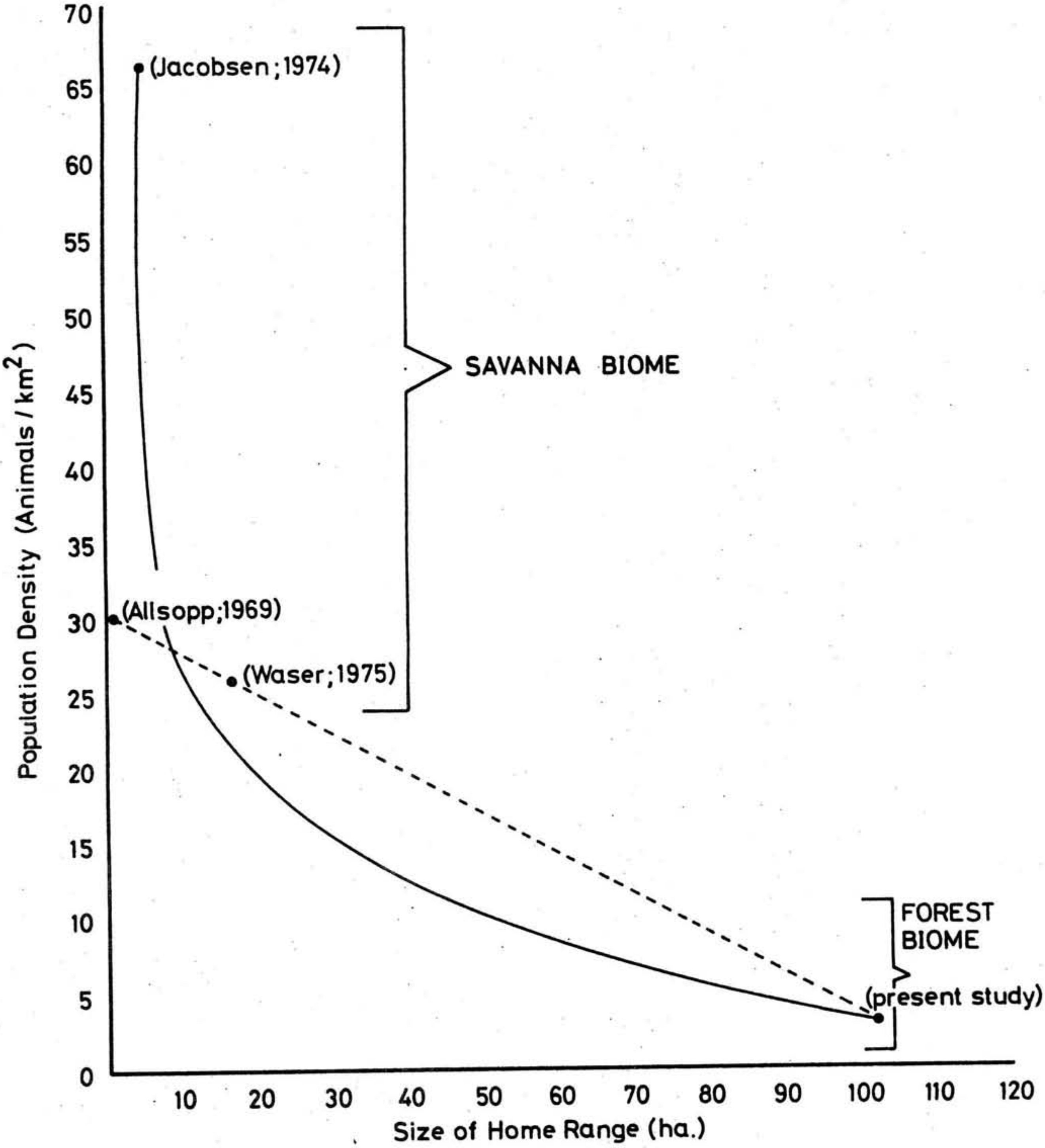



Fig 13: Changes in size of home range with variation in population density

1 : 2,2 : 4,0 and those of Waser (1975) one of 1 : 1,7 : 3,0, whereas in this study the ratio is 1 : 1,8 : 2,4. The home ranges of adult males are thus roughly twice as large as those of females. However, the very small home range of the lactating female B, has probably resulted in a lower than normal mean home range size for females in the present study. The tendency is nevertheless clear for adult males to have larger home ranges than females and for sub-adult males to have larger home ranges than adult males.

It is interesting to note that the study of Leuthold (1974) yields an equivalent ratio of 1 : 1,2 : 1,4 for lesser kudu in Tsavo National Park, Kenya.

The consistently higher figure for sub-adult males is no doubt attributable to dispersal movements (Jewell, 1966). The animals would be moving over a much larger area than the home range they finally inhabit. The same phenomenon was observed in young waterbuck, _Kobus defassa_, females by Spinage (1974). The ratios further indicate that females are generally more sedentary than both adult and sub-adult males.

The small home range of the lactating female B, can pro= bably be attributed to the 'Abliege' behaviour of bushbuck (Walther, 1964; Ewer, 1968). During the period when the young lies down and is only visited by the mother for feeding, it can reasonably be assumed that the movement of the female will be restricted. The same striking reduction in size of home range for lactating females was shown by feral hogs, Sus scrota (Kurz and Marchinton, 1972) and less clearly by white-tailed deer (Marchinton and Jeter, 1967). It should be borne in mind, however, that the actual size of the MMHR of female B is probably an under-estimate of the size of the true home range. This is due to the small number of locations (n = 46) for this animal.

The movement patterns of the five bushbuck studied yielded some interesting information. Especially intriguing is the fact that three animals, both adult males and the young female, were more active at night, while two, the sub-adult male and the lactating female, showed significantly higher diurnal activity.

In the case of the lactating female, the diurnal movement pattern can possibly be accounted for by the suckling or feeding behaviour, or both, of the young of this female. Thomson (1972) stated that feeding of the young is mainly confined to the night hours and therefore the female might be expected to do most of her own feeding, and hence to move most, during the day. Similar re= sults were obtained by Marchinton and Jeter (1967) for a white-tailed deer, although the effect of parturition on movement was not consistent for all females in their study.

There is no such ready solution to account for a similar pattern in the sub-adult male. A possible explanation may lie in the fact that the home range of this animal overlaps 63 per cent of the home range of the adult male F. Avoidance action of some kind may be necessary on the part of the sub-adult male.

No significant difference could be detected between the diurnal and nocturnal activity of the adult male F, although the latter was the highest. The home range of the sub-adult ram also overlaps 96 per cent of the home range of the adult ram D. The latter moves significantly more at night than by day. Consequently the adoption of a diurnal movement pattern by the sub-adult male will, partially at least, assist in avoiding conflict situations with both the adult males.

On the above hypothesis it would be difficult to explain the fact that the two adult males, whose home ranges overlap to a large extent, both show a preference for nocturnal movement, although only significantly so in the case of male D. One could hypothesize, however, that conflict situations which may arise between these two males as a result of similar movement patterns over more or less the same area partially fullfill the needs of the male competitive function (Ewer, 1968).

A more plausible explanation of the preference for nocturnal movement is its survival value for bushbuck under local conditions. Night hunting is apparently practised to a limited extent only in this area and since man is probably the main local predator, the adoption of nocturnal habits will tend to increase the life expectancy of the average individual. Morris (1973) also observed that after the commencement of shooting of bushbuck in his study area, the animals reacted by reducing their diurnal activity. Wilson and Roth (1967) found a similar pronounced shift towards nocturnal activity in grey duiker in reaction to excessive hunting pressure.

All five animals exhibit clear crepuscular peaks of activity, as was also found for bushbuck in Uganda by Waser (1975). Movement is at its highest shortly after dusk and declines sharply after midnight. A lesser peak occurs before dawn which continues till fairly late in the morning. Movement is least in the late-night period between midnight and 04h00.

There are slight differences in the times at which the peaks occur as determined by Waser (1975) and found in this study. This can be partially attributed to the fact that the Uganda study was done during the winter months, whereas most of the present study was carried out during summer with consequent differences in the times of sunrise and sunset. This effect is clearly shown by the earlier winter peak, 18h00 - 20h00, in Uganda as compared with the later summer peak, 20h00 - 24h00, in the Southern Cape. The sun set at about 19h30 in the latter instance and at about 18h00 during the Uganda study.

The salient aspect which emerges from the investigation of associations is the emphasis on the solitary nature of bushbuck social organisation. Of the 1 380 animals that were recorded, 61 per cent occurred singly and 29 per cent occurred in twos, leaving only 10 per cent in associations of three or more. The findings of Bourlière and Verschuren (1960), Walther (1964), Wilson and Child (1964), Allsopp (1969) and Elder and Elder (1970) are all in reasonable agreement with these figures.

Considering the proportion of solitary animals and assuming an even sex ratio, which is known (table 35) to exist within the population portrayed in table 32, it appears that a greater proportion of all male animals are solitary than is the case amongst females. Conversely, females apparently associate more freely with other individuals than males. In this regard it is interesting to note that in table 32 the association FF of two females was always present throughout the year and that the frequency of this association rose during August to as high as 17 per cent. The association MM of two males on the other hand was not observed during three months of the year. This in= dication of a tendency to social cohesion amongst females is seen as the first sign of female group formation amonst the members of the genus, culminating in average harem herd sizes of five animals in mountain nyala (Brown, 1969) and up to about twelve animals in kudu (Bigalke, 1958), This view is supported by Leuthold (1974) who suggests that group structure is similar in all Tragelaphus species, but with decreasing group sizes from greater kudu/mountain nyala through leseer kudu/nyala and sitatunga to bushbuck.

The male-female association MF was found in this study, as well as all other investigations (table 34), to be the most frequent of those involving two or more adult animals. Estes (1974) states that there is evidence of relatively weak pair bonds and a corresponding tendency to form groups in some of the solitary antelopes, including bushbuck. Allsopp (1969) found that the male-female association is not a permanent relationship but usually lasts only a few days. It comprises 12 per cent of the total number of animals recorded in the present investigation and has the highest frequency of all associations of two animals or more. The solitary male, solitary female and male-female associations together account for 73 per cent of all observations in this study and similarly 63 per cent of all observations by Elder and Elder (1970), 91 per cent of all observations by Wilson and Child (1964), 82 per cent of all observations by Bourlière and Verschuren (1960) and 60 per cent of all obser= vations by Allsopp (1969). From these figures it is clear that the solitary males and females, and the male-female association must play an important role in the social organisation of the species.

Since solitary males and females are so frequently encountered, it seems likely that pairs are mainly mating associations. If this assumption is correct, one would expect their incidence to be correlated with peaks in reproductive activity.

The gestation period of bushbuck is approximately six months (Allsopp, 1969; Mentis, 1972). Very young animals should there= fore be seen between six and, say, eight months after mating periods. From fig. 14 it can be seen that the frequency of the male-female association has three peaks viz. in April - May, September and December. The frequencies in all three cases fall outside the confidence interval (P = 0,95) of the mean frequency value and can therefore be considered to be of significance. This would mean that the combined frequencies of those associations including a young animal (it was called a 'lamb' on the observation form) should peak in the periods October - January, March - May and June - August. With the exception of the period March - May

Fig 14:
*Variation in occurance of MF and FY + MFY + Y associations in the Southern Cape .*

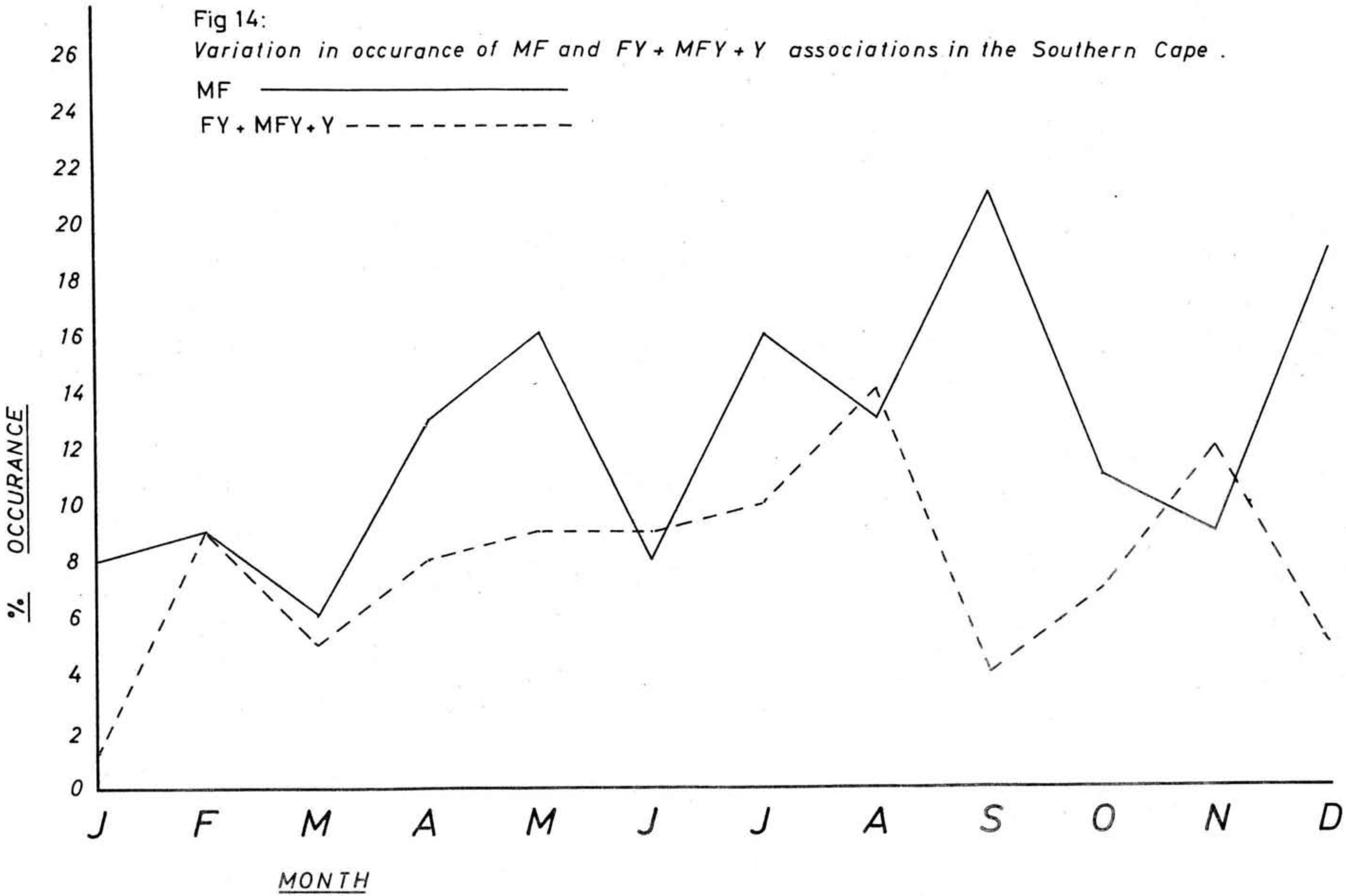
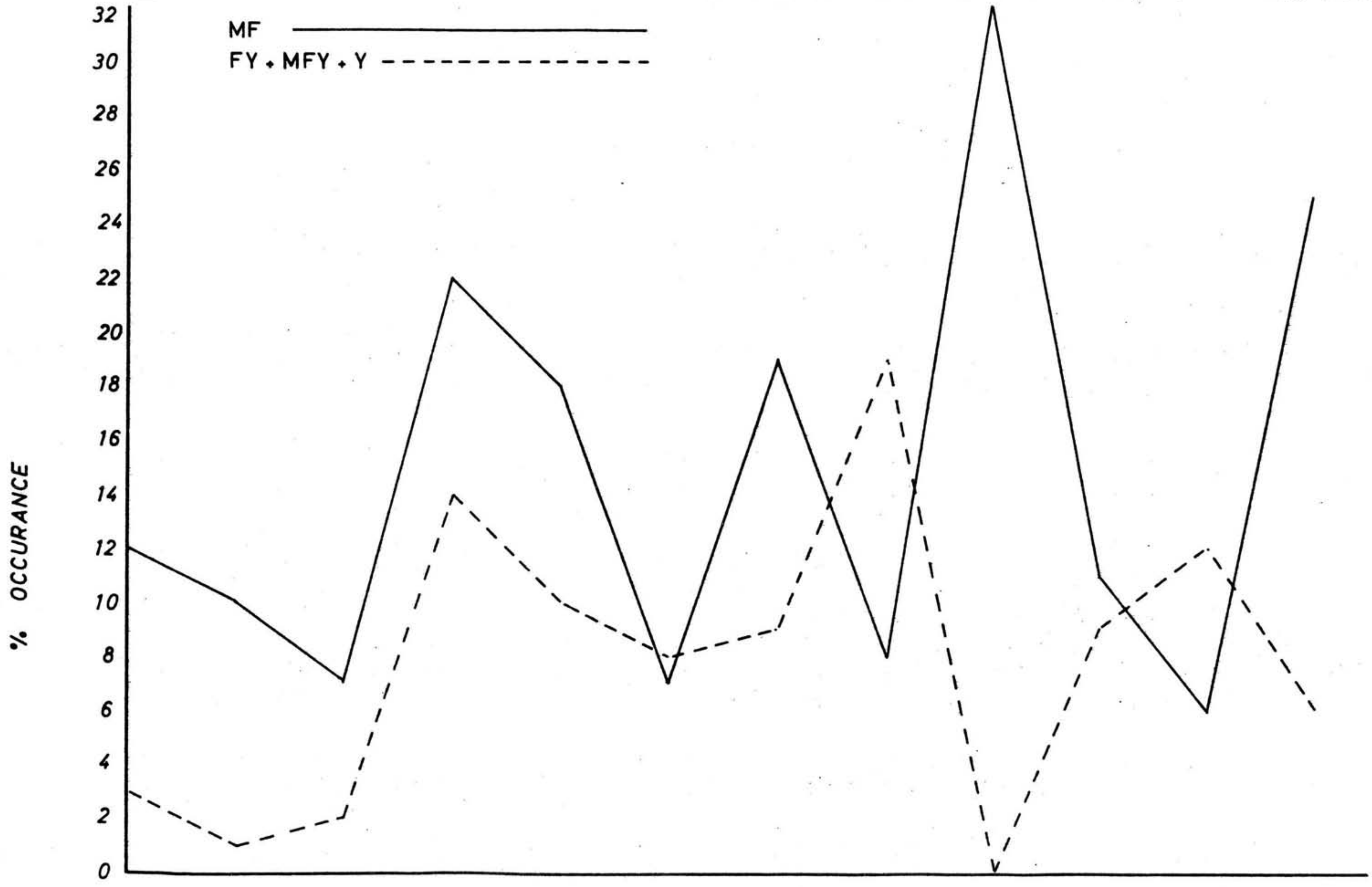


*FIG 15* : *Variation in occurance of MF and FY + MFY + Y associations in the Southern Cape (Goudveld S.F. excluded.)*



these peaks are indeed present (fig. 14) although only the frequencies during August and November fall outside the confidence interval (P = 0,95) of the mean frequency value.

Data from which observations in Goudveld State Forest are excluded, are presented in fig. 15. The pattern in the frequency distribution of the male-female association is similar, but more pronounced. All three the predicted peaks in the frequency of associations containing a young animal, are present. The chance of arriving at these results by coincidence is so small (probability = 0,08), that it can be discounted.

A minor peak in July in the frequency of the male-female association are shown in both figures. However, the correlation with those associations containing a young animal is not consistent. As such this does not fit the hypothesis advanced here and this peak must therefore remain unexplained.

Although these peaks in natality can tentatively be assumed to be real, it should be noted that the frequency of the male-female association never drops below siz per cent for any one month. Both figures 14 and 15 show that young animals are similarly found throughout the year, with the lowest depression in January. This may be correleted with the low frequency of the male-female association in June. Smithers (1971) suggests that young are dropped in Botswana throughout the year; with the majority arriving in the period November - June. In Rhodesia, Morria (1973) similarly found that bushbuck breed throughout the year but he detected a peak in the lambing rate in October - November, whereas in Kenya (Allsopp, 1969) peaks exist in April and November. In the Kruger National Park, South Africa, young lambs have been recorded during July, October and November (Pienaar, 1963). Allsopp (1969) using the figures of Wilson and Child (1964), shows that peaks also exist in April and December in Rhodesia. Thomson (1972) observed young from August until November in Rhodesia with the largest number being recorded in late October.

The peaks described by the above authors all apply to populations in areas where definite dry and wet seasons exists. Most of them fall to a greater or lesser degree within the rainy season. As shown in section 2.5.2 rainfall is evenly distributed throughout the year in the present study area. The nutritional quality of the vegetation can therefore be expected to show little seasonal variation. Consequently one would expect natality to remain fairly constant throughout the year. The fact that it apparently does not, indicates the interaction of other factors as well. However, no research results are available on annual growth patterns in the local vegetation and correlations of these with peaks in natality can therefore not be excluded. Furthermore, it must be borne in mind that these latter peaks in the present study are based on indirect indices with resultant limitations. Considerably more research is needed to confirm or disprove their existence.

As stated earlier (section 5.1) controversy still exists on whether or not territoriality exists amongst bushbuck males. A prerequisite for territoriality is the defence by a male of a defined area against intrusion by another (Ewer, 1968). This implies that the home range of a male, or at least a portion of it, will be utilized exclusively by that particular male. No other male will be allowed into this area, although females move around at will.

Jarman (1973) speculates that bushbuck is territorial, but that the type of territoriality only excludes other males of a comparable social standing, that is, mainly other territorial males. Young males may be tolerated in the territory, but are subordinate to the territorial male.

However, Jacobsen (1974) found a considerable overlap in the home ranges of bushbuck.

Similarly it is evident from the results of radio-tracking in the present study, that at least between adult male and sub-adult male, male and female, and female and female, no form of "home range exclusiveness" exists.

The two adult males in the project were not tracked simultaneously. A break of 37 days exists between the closest tracking period of these two animals. However, both were seen together on occassion, and a male which appeared to be adult male D, was still observed in his originally determined home range during the tracking period of adult male F. The overlap of their home ranges, shown in fig. 10, may therefore be considered real with some confidence.

Leuthold (1974) in a study on lesser kudu, postulates that in the case of adult males there may be a considerable, if not complete, overlap of home ranges. He suggests that this overlap in space may be compensated for by some degree of separation in time. Leyhausen (1964) came to a similar con= clusion after his study on the domestic cat.

The tracking data of adult male F, and sub-adult male C, whose MMHR's overlap more than 60 per cent (see table 27), provide evidence to support this theory of spatial separation by a time mechanism in bushbuck as well. Two examples may be cited.

On 22/23 January 1974 both animals were to a large extent in one anothers' home ranges. However, their home ranges for that day were entirely separated from each other; the closest distance was approximately 240 m .

In the following 24 hour period, 23/24 January, the areas occupied overlapped even more, and the animals even showed an overlap of home ranges for that day. However, this did not result in any contact with one another because of a separation in time. In this case the adult male utilized the overlapping area during the day while it was used at night by the sub-adult male.

Similarly, while the home ranges of adult male D, and female E, did overlap to a certain degree, for example on 14 November 1973, they were using directly opposite portions at the same time. During that 24 hour period the female visited zone F during the night, probably to browse in the garden patches, while the male stayed around the edges of the indigenous forest in zones B, C and D. During the following morning they moved around in essentially the same area of indigenous forest but later moved away in opposite directions.

On the other hand, the same male and female appeared to have stayed together during nearly the whole 24 hour period of 8/9 November 1973. Similarly adult male F, and sub-adult male C, simultaneously frequented more or less the same general areas on 24/25 January 1974. Both animals as well as the adult ram D, were actually seen walking and feeding together between 06h00 and 07h00 on 25 January 1974. No signs of antagonism between the three animals were observed. This observation was made in vegetation zone D which was mostly used for feeding. Allsopp (1969) observed a similar tolerance between males when feeding, especially in the absence of oestrus females.

It is of interest at this stage to note that Walther (1964) in his study on captive Tragelaphines states that bushbuck avoid each other except during the rut.

Some evidence therefore exists to indicate that bushbuck are not territorial, but that they probably avoid each other by means of a time mechanism. Estes (1974) also speculates that the Tragelaphines may prove to be non-territorial and suggests rather the existence of a male rank-hierarchy system. Some preliminary evidence is advanced by Jacobsen (1974) that such a system is actually present amongst male bushbuck. This is further sup= ported by the work of Allsopp (1969) and Thomson (1972) who noted a pronounced tolerance between males of all age groups when not associating with a female.

Reviewing the available information it appears then that the social organization of bushbuck is fairly loose. The species is solitary for the greater part, with females associating more freely with each other than is the case amongst males. Males and females roam over one anothers' home ranges at will. Con= flict situations between males are apparently avoided either by a time mechanism and/or by a male rank-hierarchy system. Relatively weak pair bonds are formed, presumably for mating purposes. According to Allsopp (1969) this bond is of short duration and is defended by the male. These male-female associations are formed throughout the year, resulting in lambs being dropped at any time, although peaks are present.

Eight of the fifteen sex ratios listed in table 35 indicate no significant deviation from an even ratio. Two of the sex ratios could not be tested for significance because their sample sizes are not given. Of the five which do indicate a significant difference, two (Dasmann and Mossman, 1962) are based on such small samples (n = 37 and n = 87) that not much reliance can be placed on them. Another two of these ratios (Mentis, 1970; Morris, 1973) are based on shot specimens, not sighting records. As one often hears from hunters that it is easier to shoot bushbuck ewes than rams, this could possibly have had an influence on the sex ratios obtained in this manner.

The four ratios mentioned above, showing a significant difference from an even sex ratio, all indicated a preponderence of females. However, the fifth significant sex ratio, that of the present study, show significantly more males. As explained in section 5.3.6 it was thought that the large number of observations recorded on Goudveld State Forest may have been responsible for the uneven ratio. The sex ratios of table 36, based on cumulative number of observations (b), support this hypothesis. With the exception of the first ratio, all succeeding ratios indicate increasing numbers of males. This seems to indicate that males have a higher visibility than females under the heavily forested conditions at Goudveld. With the same individuals being repeatedly recorded this will have a cumulative effect on the sex ratio. This is further supported by the fact that, when dividing observations into those in exotic plantations and those in indigenous forests, an even sex ratio ($X^2$ = 0,21; n = 174) is found in the open plantation area but a highly significant ratio ($X^2$ = 20,26; n = 263) in the indigenous forests.

The explanation for this lies perhaps partially in the greater mobility of males. From table 30 it can be shown that they move about five per cent more per diel period than females. However, probably more important is that they move over a 50 per cent larger area than females (table 25). In the relatively open plantation areas these difference may not be of undue importance, but it will certainly increase the chances of observing a male in the dense indigenous forests. In addition the larger body size, coupled to the presence of horns, should make it easier to observe a male.

It is concluded therefore that the population sex ratio of bushbuck in the study area does not differ significantly from parity. A similar situation apparently exists in most other populations as stated above. As the foetal sex ratio is also even (Mentis, 1972) there is apparently no difference in the mortality rate of the sexes. This is in agreement with the prediction of Estes (1974) that an adult sex ratio close to parity is typical of a solitary species, since juveniles of both sexes presumably face much the same risks after the female-young bond has been severed.

# CHAPTER VI

## POPULATION DENSITIES

The Department of Forestry has in recent years adopted a more enlightened policy towards wildlife conservation. Instead of total preservation, the departmental policy now makes provision for active wildlife management, including the manipulation of population densities.

As a result of this change in policy it has become essential to obtain more detailed knowledge of the densities of the major wildlife species on State Forests. Handy expressions such as "common, abundant, scarce, extremely rare" are of little use when decisions regarding the manipulation of the population density of a species must be taken.

This short section therefore attempts to arrive at:

(a) some objective indication of the population densities at which bushbuck may be found in the Southern Cape, and

(b) a practical method of determining these densities.

## 6.1 METHODS

Two techniques were used. The first was based on information derived from the radio-tracking study. All five tracked animals lived in the same area. This area could be accurately determined. It was also thought that a reasonable idea could be formed of the total number of bushbuck in this area. Consequently a density estimate was possible.

The second method entailed the use of track counts in the area in which radio-tracking had been carried out. The track counts were later extended to Goudveld and Gouna State Forests, and for a short period also to the Goukamma Nature Reserve.

Tyson (1959) attempted to model the counts of tracks as a function of numbers of deer, and so obtain an estimator of density. The following condensed description of the model is given by Giles (1969):

"Assume that:

(i) Deer bed in essentially the same place on successive days.

(ii) Nightly activity is confined to a 'range' of travel, D.

Now, imagine a circle of diameter, D, measured in kilometres, defined in the middle of homogenous deer habitat. Let there be N deer bedding in the circule, each of which has produced two tracks on the perimeter of the circle during the preceding night (activity period). This restriction further clarifies the definition of D. The activity of each deer has been idealized and the activity path has been modified into a straight line extending in some arbitrary direction from his bedding spot. Thus, D is half the average linear distance travelled by a deer during the activity period. Note that in this interpretation the assumption that the deer returns to the previous bedding spot is a convenience but is not necessary to the model. For each such track on the circle, there will be a track produced by a deer bedded outside the circle. Therefore, the following quantities can be written:

(i) Total tracks = 4 N

(ii) Total Deer = N

(iii) Area of circle = $\frac{\pi D^2}{4}$

(iv) Circumference of circle = $\pi D$

Thus, tracks per kilometre, t, = $\frac{4N}{\pi D}$

hence, deer per km², Y, = $\frac{4N}{\pi D}2$ = $\frac{t}{D}$

Giles (1969) states that the formula seems to have at least approximate validity, and allows a density interpretation of the index of track counts.

The simplicity of this model makes it attractive from a management point of view, which is the motivation for this study.

The first assumption for the application of this model viz. bedding in the same place on successive days, is not necessary but merely a convenience, as pointed out by Giles (1969).

The problem posed by the second assumption, viz. con= finement of nightly travel to a specified range of travel, is more real. Tyson (1959) states that the most probable source of error in the track count technique is in the method of arriving at this, as he termed it, "average daily range". At that time radio-tracking apparatus was not available and the determination of the "average daily range" was very difficult. However, the information obtained from the radio-tracking data of five bushbuck, has made it possible to find a reasonable approximation to this parameter.

The daily home ranges of all the animals were deter= mined for all those 24 hour periods during which 15 or more locations were made of a specific animal. These daily home ranges were then used to determine an "average theoretical circular daily home range". The diameter of such a home range was viewed as being the "average daily range" of bushbuck in the study area under the specific local conditions at the time.

This distance was assumed to be covered during two activity periods, since as already shown bushbuck are mainly crepuscular. Track counts were therefore ideally undertaken during the late morning to early-afternoon period i.e. between the peaks of activity.

The technique followed in undertaking the track counts can briefly be summarized as follows. The total distance of roads in the radio-tracking study area, 14 kilometer, was divided into 200 m strips. Each strip was given a number. A 20% random sample of these numbers was drawn before each of the four track counts that were undertaken in the area. The strips with the corresponding numbers were then carefully covered on foot and the number of fresh sets of tracks which crossed the road noted. An attempt was made to record only tracks made during the previous 24 hours. The road intensity in the area is approximately 6 ha/km.

In the other areas where the track counts were under= taken, only a fraction of the total distance of roads were thus enumerated, due to the demands on time and manpower which a full enumeration would entail. At Goudveld State Forest 10 kilometre, or six per cent, of the total distance of roads were thus covered and at Gouna State Forest 16 kilometre, or 13 per cent. The percentage sampling at Goukamma Nature Reserve could unfortunately not be determined. Road intensities at Goudveld and Gouna State Forests are about 34 ha/km and 50 ha/km respectively.

## 6.2 RESULTS

Five bushbuck were tracked for various periods of time in the study area. During the period of field work and while under= taking capture operations, another four bushbuck were observed to reside in the same general area.

The five tracked animals covered an area of 228 ha. The home ranges of the other four animals were not known, although they were seen on a few occasions in the area. Two of them were actually captured in an indigenous forest patch, more or less in the centre of the study area. Considering the home ranges of the tracked animals, one can expect the total area inhabited by these nine animals to be about 300 ha. This gives a density figure of 3,0 bushbuck/$km^2$.

If the home ranges of the other four animals are un= expectently divergent from those of the tracked animals, the total area covered by the nine animals may be as much as, say, about 400 ha. In such a case the density drops to 2,3 bushbuck/$km^2$.

A prerequisite for the use of the track count method to estimate population density was a knowledge of the value of D, the "average daily range". To determine this distance the size of the average daily home range must be known.

On 22 occasions an animal was located 15 times or more during one continuous 24 hour period. The size of the daily home ranges were determined by planimeter for all these periods

TABLE 37 : Mean daily home range of bushbuck

| ANIMAL | DATE | DAILY HOME RANGE (ha) |
|---|---|---|
| adult ram D | 1.11.1973 | 27 |
| adult ram D | 8.11.1973 | 16 |
| adult ram D | 14.11.1973 | 8 |
| ewe E | 27.9.1973 | 22 |
| ewe E | 1.11.1973 | 16 |
| ewe E | 8.11.1973 | 25 |
| ewe E | 14.11.1973 | 13 |
| ewe E | 26.11.1973 | 30 |
| ewe E | 27.11.1973 | 68 |
| ewe E | 28.11.1973 | 51 |
| ewe E | 29.11.1973 | 11 |
| sub-adult ram C | 31.12.1973 | 14 |
| sub-adult ram C | 2.1.1974 | 96 |
| sub-adult ram C | 22.1.1974 | 18 |
| sub-adult ram C | 23.1.1974 | 28 |
| adult ram F | 21.1.1974 | 6 |
| adult ram F | 22.1.1974 | 12 |
| adult ram F | 23.1.1974 | 45 |
| adult ram F | 24.1.1974 | 54 |
| adult ram F | 29.1.1974 | 27 |
| adult ram F | 30.1.1974 | 96 |
| adult ram F | 31.1.1974 | 54 |
| Mean | | 33,5 |
| SD | | 26,4 |

Using the figure of 33,5 ha in table 37, a value of 650 m can be calculated for D, the "average daily range". If the figure of 168,1 ha of the MHR in table 25 is used, a D value of 1 463 m is arrived at. Finally, using the MMHR area of 102,1 ha in the same table, a D value of 1 140 m can be determined.

The results of the track counts in the radio-tracking study area are given in table 38.

The mean value determined from table 38 is 3,2 sets of tracks/km. Using the formula of Tyson (1959) the following densities can then be calculated:

$$Y = \frac{t}{D} \qquad (t = 3,2)$$

$$= 4,9 \text{ animals/km}^2 \qquad (D = 0,65)$$

$$\text{or } 2,2 \text{ animals/km}^2 \qquad (D = 1,46)$$

$$\text{or } 2,8 \text{ animals/km}^2 \qquad (D = 1,14)$$

The results of the track counts in the various other areas are given in tables 39 and 40.

Density figures can be computed for the results of the track counts in tables 39 and 40 on the same basis as for those in table 38.

In table 41 a summary is provided of all the density values determined in this study. For purposes of comparison, density figures of other published work are presented in table 42.

TABLE 38 : Results of track counts in radio-tracking study area

| DATE WHEN COUNT WAS DONE | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14.1.1974 | | 15.1.1974 | | 18.1.1974 | | 31.1.1974 | |
| STRIP NO | SETS OF TRACKS | STRIP NO | SETS OF TRACKS | STRIP NO | SETS OF TRACKS | STRIP NO | SETS OF TRACKS |
| 7 | - | 4 | - | 10 | 1 | 4 | - |
| 19 | - | 7 | - | 12 | 1 | 6 | - |
| 29 | - | 24 | 1 | 14 | 1 | 8 | - |
| 31 | - | 26 | 1 | 15 | 3 | 18 | - |
| 33 | 1 | 34 | 1 | 25 | 1 | 21 | 3 |
| 35 | 1 | 39 | - | 28 | 2 | 26 | - |
| 37 | - | 43 | 1 | 30 | 1 | 30 | - |
| 43 | 1 | 44 | - | 31 | - | 35 | - |
| 47 | 1 | 49 | 2 | 33 | - | 36 | 3 |
| 50 | 2 | 52 | - | 41 | - | 40 | - |
| 56 | 1 | 57 | - | 58 | - | 43 | - |
| 61 | - | 62 | - | 63 | - | 51 | 1 |
| 63 | - | 64 | 1 | 64 | 2 | 59 | 1 |
| 70 | 3 | 67 | - | 70 | 1 | 63 | - |
| Tracks/km 3,6 | | 2,1 | | 4,3 | | 2,9 | |

TABLE 39 : Results of track counts at Goudveld State Forest during the period 1974 - 1976

| PERIOD | TRACK COUNTS (Sets of tracks/km) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PINE PLANTATION | | | INDIGENOUS FOREST | | | TRANSITIONAL | |
| | 1974 | 1975 | 1976 | 1974 | 1975 | 1976 | 1975 | 1976 |
| January | - | - | - | - | - | - | - | - |
| February | - | - | 1,3 | - | - | - | - | 7,5 |
| March | - | - | 3,8 | - | - | 6,9 | - | 10,0 |
| April | - | 4,4 | - | - | 10,0 | 3,8 | 2,5 | 5,0 |
| May | - | 4,4 | 5,0 | 9,0 | 7,5 | 2,5 | 1,3 | 10,0 |
| June | 9,0 | 2,5 | 3,8 | 14,0 | 8,8 | 8,8 | 3,8 | 11,3 |
| July | 1,7 | 1,8 | 1,3 | 4,5 | 8,8 | 5,6 | 2,5 | 5,0 |
| August | 2,5 | - | 6,9 | 1,0 | 10,0 | 8,1 | - | 15,0 |
| September | 1,3 | 5,0 | 8,8 | 2,3 | 10,0 | 11,3 | 2,5 | 17,5 |
| October | 1,2 | 4,4 | 3,8 | 3,0 | 5,0 | 10,0 | - | 12,5 |
| November | 1,2 | - | 2,5 | 3,0 | 2,5 | 8,8 | - | 7,5 |
| December | - | 1,3 | - | - | 8,8 | - | 1,3 | - |
| MEAN | 2,8 | 2,6 | 3,7 | 5,3 | 7,9 | 6,6 | 1,5 | 10,1 |
| SD | 3,1 | 2,0 | 2,7 | 4,6 | 2,6 | 3,6 | 1,4 | 4,1 |

TABLE 40 : Results of track counts at Gouna State Forest and Goukamma Nature Reserve during the period 1974 - 1976

| PERIOD | TRACK COUNTS (Sets of tracks/km) | | | | | | |
|---|---|---|---|---|---|---|---|
| | PINE PLANTATION | | INDIGENOUS FOREST | | | TRANSITIONAL | GOUKAMMA |
| | 1975 | 1976 | 1974 | 1975 | 1976 | 1974 | 1974 |
| January | - | 8,6 | - | - | 9,4 | - | - |
| February | - | 7,0 | - | - | 12,3 | - | - |
| March | - | 8,9 | - | - | 7,4 | - | - |
| April | - | - | 22,5 | - | - | 15,0 | - |
| May | - | 3,8 | 1,4 | - | 9,2 | 5,0 | - |
| June | - | 5,3 | 5,0 | - | 5,7 | 15,0 | - |
| July | - | - | 2,0 | - | - | 6,7 | - |
| August | - | 4,1 | - | - | 2,5 | - | 2,5 |
| September | 5,8 | 12,5 | - | 9,0 | 5,4 | - | 3,8 |
| October | 5,8 | 7,9 | - | 6,8 | 7,7 | - | 3,3 |
| November | 4,4 | 7,9 | - | 4,7 | 9,6 | - | 1,3 |
| December | 9,3 | - | - | 5,6 | - | - | 1,9 |
| MEAN | 6,3 | 7,3 | 7,7 | 6,5 | 7,7 | 10,4 | 2,6 |
| SD | 2,1 | 2,7 | 10,0 | 1,9 | 2,9 | 5,3 | 1,0 |

TABLE 41 : Calculated densities of local bushbuck populations

| AREA | POPULATION DENSITY OF BUSHBUCK (Animals/km²) | | |
|---|---|---|---|
| | D = 0,65 | D = 1,14 | D = 1,46 |
| Kruisfontein Study Area | 4,9 | 2,8 | 2,2 |
| Goudveld, plantation 1974 | 4,3 | 2,5 | 1,9 |
| Goudveld, forest 1974 | 8,2 | 4,7 | 3,6 |
| Goudveld, plantation 1975 | 4,0 | 2,3 | 1,8 |
| Goudveld, forest 1975 | 12,2 | 6,9 | 5,4 |
| Goudveld, transitional 1975 | 2,3 | 1,3 | 1,0 |
| Goudveld, plantation 1976 | 5,7 | 3,3 | 2,5 |
| Goudveld, forest 1976 | 10,2 | 5,8 | 4,5 |
| Goudveld, transitional 1976 | 15,5 | 8,9 | 6,9 |
| Goukamma Nature Reserve 1974 | 4,0 | 2,3 | 1,8 |
| Gouna, forest 1974 | 11,9 | 6,8 | 5,3 |
| Gouna, transitional 1974 | 16,0 | 9,1 | 7,1 |
| Gouna, forest 1975 | 10,0 | 5,7 | 4,5 |
| Gouna, plantation 1975 | 9,7 | 5,5 | 4,3 |
| Gouna, forest 1976 | 11,9 | 6,8 | 5,3 |
| Gouna, plantation 1976 | 11,2 | 6,4 | 5,0 |
| Kruisfontein Study Area (not track counts) | 2,3 - 3,0 | | |

TABLE 42 : Bushbuck population densities from published records

| SOURCE | POPULATION DENSITY (Animals/km²) |
|---|---|
| Kenya (Foster & Coe, 1968) | 0,07 - 0,14 |
| Congo (Bourlière, 1965) | 0,09 |
| Uganda (Petrides & Swank, 1965) | 0,04 |
| Uganda (Field & Laws, 1970) | 0 - 0,74 |
| Uganda (Field & Laws, 1970) | 2,75 |
| Rhodesia (Jacobsen, 1974) | 66,7 |
| Uganda (Waser, 1975) | 9,0 |
| Uganda (Waser, 1975) | 26,0 |
| Botswana (Simpson, 1974) | Average population density 10,9. Densities in certain localities of 20,6 - 43,3 are also given by the author |

TABLE 43 : Calculated mean bushbuck population densities in indigenous forest, pine plantation and the transitional area using D = 1,14

| AREA | PINE PLANTATION | INDIGENOUS FOREST | TRANSITIONAL AREA |
|---|---|---|---|
| Goudveld 1974 | 2,5 | 4,7 | - |
| Goudveld 1975 | 2,3 | 6,9 | 1,3 |
| Goudveld 1976 | 3,3 | 5,8 | 8,9 |
| Gouna 1974 | - | 6,8 | 9,1 |
| Gouna 1975 | 5,5 | 5,7 | - |
| Gouna 1976 | 6,4 | 6,8 | - |
| MEAN | 4,0 | 6,1 | 6,4 |
| SD | 1,9 | 0,9 | 4,5 |

TABLE 44 : Calculated bushbuck population densities during summer and winter in plantation, forest and transitional area using D = 1,14

| AREA | PINE PLANTATION | | INDIGENOUS FOREST | | TRANSITIONAL AREA | |
|---|---|---|---|---|---|---|
| | SUMMER | WINTER | SUMMER | WINTER | SUMMER | WINTER |
| Goudveld 1974 | 1,1 | 3,2 | 2,6 | 5,4 | - | - |
| Goudveld 1975 | 1,7 | 2,7 | 4,8 | 8,1 | 0,4 | 1,8 |
| Goudveld 1976 | 2,5 | 3,8 | 5,6 | 5,9 | 8,2 | 9,3 |
| Gouna 1974 | - | - | - | 6,8 | 9,1 | - |
| Gouna 1975 | 5,7 | 5,1 | 5,0 | 7,9 | - | - |
| Gouna 1976 | 7,1 | 5,6 | 8,1 | 5,0 | - | - |
| MEAN | 3,6 | 4,1 | 5,2 | 6,5 | 5,9 | 5,6 |
| SD | 2,6 | 1,2 | 2,0 | 1,3 | 4,8 | 5,3 |

The mean population densities (using D = 1,14) in pine plantation, indigenous forest and the transitional area between the two, are shown in table 43.

A comparison between the data in table 43 shows that the mean population density in indigenous forests is significantly higher than that in pine plantations ($t = 2{,}52$; $P < 0{,}05$).

The data on population densities (again using D = 1,14) were also divided into summer and winter records. Summer is defined as the period October to March and winter as April to September. The results of this analysis are presented in table 44.

The data in table 44 were similarly analysed to test for a significant difference between the mean summer and winter population densities. The difference between the mean summer and winter densities in pine plantations yielded a t-value of 0,35 ($P > 0{,}05$), and the equivalent t-values for the indigenous forest, transitional area and all zones together are 1,31; 0,08 and 0,66 respectively. All are well below the 95 per cent confidence limit. The comparison between summer densities in the pine plantations and indigenous forests gave a t-value of 1,09 ($P > 0{,}05$) and between winter density in the pine plantations and summer density in the indigenous forests a t-value of 1,10 ($P > 0{,}05$).

The only significant differences found were between the winter densities of pine plantations and indigenous forests, and between the summer density in pine plantations and winter den= sity in the indigenous forests. The two t-values are respectively 3,17 and 2,40 which are significant at the 95 per cent level.

An overall mean population density of 5,8 bushbuck/km$^2$ can be determined from all the various density figures arrived at in this study.

## 6.3 DISCUSSION

On comparison with the more recent and detailed work of Simpson (1974) and Waser (1975) the population density of bushbuck in the Southern Cape appears to be lower than in the above studies. Both these studies were executed in the Southern Savanna biome (Davis, 1962, in Bigalke, 1968) whereas the present study area is situated in the Forest biome. Since it is generally recognised that the productivity of the forest biome is considerably lower than that of the Savanna biome (Estes, 1974), the higher population density of bushbuck in the latter must be expected, although the present study area has been modified by man.

Unfortunately the density figures arrived at in this study can not by any means be considered very accurate. The value of 3,0 bushbuck/km² determined by the first method for the Kruisfontein study area, is considered to be the best estimate for that area. The three density values determined by means of the track counts all differ from it to a greater or lesser degree. Of them the density figure calculated on the basis of the MMHR area (D = 1,14), agrees best with the value of 3,0 bushbuck/km², viz. 2,8 bushbuck/km² i.e. a difference of seven per cent.

However, the use of a D value based on the MMHR and MHR areas is not strictly in agreement with the theory of the model proposed by Tyson (1959). His model is based on the daily movement of an animal, not its total range as in the case of the MHR and MMHR.

The theoretically correct D value to use is therefore the one based on the daily home ranges (D = 0,65). However, this value yields a density figure of 4,9 bushbuck/km² which is 63 per cent higher than the assumed correct value of 3,0 bushbuck/km².

The disturbing fact remains therefore that, although theoretically incorrect, the density estimate based on the MMHR area appears to yield the more correct figure.

At this stage it may be usefull to refer to the work of Anderson (1953) on a roe-deer, Capreolus capreolus, population at the Game Biology Station of Kalø in Denmark. It was decided to remove all the old stock of roe-deer from the estate and replace them with new stock. Before the removal commenced, the total roe-deer population was estimated at about 70 animals. When the shooting stopped, 213 roe-deer had been shot, with about four or five still alive. There were three times more roe-deer than were estimated by the staff.

It should be borne in mind that,

(a) bushbuck and roe-deer are ecologically very similar animals, and

(b) the research workers at Kalø certainly had a better knowledge of their roe-deer population than can be said of the present study.

Considering the above facts one should perhaps be less dismayed with the inconclusive results obtained with the track counts at this stage. Even if it does prove impossible to use track counts as a technique of arriving at actual population density, these counts have a definite value as an index of relative abundance. This follows naturally since animals must leave tracks (distinct or not) wherever they walk and, provided sampling is adequate, a count of such tracks should relate to the relative abundance of the species in question. The investigation by Tyson (1959) has in fact shown that a definite relationship exists between deer tracks across roads and population density. Harlow and Downing (1967) also found the use of track counts a practical technique but time-consuming, because of the demands on sufficient sampling intensity.

The analysis of the data in table 43 again emphasizes the importance of indigenous forests to bushbuck. The density in this zone was shown to be 34 per cent higher than that in pine plantation areas. It was stated (section 4.3) that indigenous forest is the only habitat zone which is preferred both by day and by night by bushbuck in contrast to pine plantations and other habitats. Since bushbuck have evolved in adaptation to closed environments, of which the indigenous forests in the study area are a good example, this is to be expected as the animals should find optimal living conditions in this zone and consequently the highest population density is found here. What precisely the food and cover factors are that make indigenous forests superior to other habitats has yet to be determined.

The only seasonal trends detected were significant differences between the winter population densities in the pine plantations and indigenous forests and between the summer density in pine plantations and winter density in indigenous forests. These differences are no doubt largely a reflection of the proven preference by bushbuck for indigenous forests. However, in the case of the difference between winter densities in pine plantations and indigenous forests, it can not be excluded that it is, partially at least, the result of a seasonal movement out of the pine plantations into the indigenous forests. It could also be attributed to a reluctance to leave the indigenous forest during the winter. No obvious explanation is available to account for this behaviour. One possibility is that, because of the slightly lower rainfall and desicating bergwinds during winter, the food plants in the more exposed plantation areas may be less palatable than those in the relatively moist indigenous forest. Therefore those animals which often leave the indigenous forest during summer to feed in the plantation will do this less frequently in winter. Similarly those individuals whose home ranges are mainly in the plantation areas will more often enter the indigenous forest to feed.

Jacobsen (1974) presents evidence of seasonal movement in a bushbuck population which is probably related to abundance or scarcity of food. A similar indication of seasonal movement was found by Thomson (1972). However, the lack of a distinctive growing season in the present study area makes it difficult to come to a similar conclusion without more information on local plant growth patterns.

# CHAPTER VII

## EXTERNAL PARASITES

In conjunction with the collection of various other samples of 14 bushbuck during the winter of 1974 and 1975, skin samples were collected for the identification of arthropod parasites.

This was done purely because the Department of Entomology at the South African Institute for Medical Research offered this identification service (Ledger, 1973) and hence the additional information could be obtained with very little effort. The results are presented for record and comparison purposes.

## 7.1 METHODS

Two pieces of skin, 10 cm x 10 cm each, were cut from each animal. The exact locality of each sample was dictated by obvious parasite concentrations or patches of bare skin where the possibility of finding mites was higher.

The samples were preserved in 70% alcohol and sent to the abovementioned institution for identification.

## 7.2 RESULTS

The tick and lice species found on the 14 animals are listed in table 45. None of the parasites were new records for bushbuck. A list of all arthropod parasites identified on bushbuck in Southern Africa by the above institution is given in table 46.

TABLE 45 : External parasites found on bushbuck at Goudveld State Forest

| SAMPLE | TICKS | LICE |
|---|---|---|
| 1 (1974) | Ixodes pilosus | Damalinia sp. nymphs |
| | | Linognathus sp. nymphs |
| 2 (1974) | I. pilosus | D. anectens |
| 3 (1974) | I. pilosus | D. anectens |
| | | Linognathus sp nymphs |
| 4 (1974) | I. pilosus | D. anectens |
| | | Linognathus sp. nymphs |
| 5 (1974) | I. pilosus | D. anectens |
| 1 (1975) | Ixodes sp. | D. natalensis |
| | Rhipicephalus sp. | |
| 2 (1975) | I. pilosus | D. natalensis |
| 3 (1975) | Rhipicephalus sp. | D. natalensis |
| 4 (1975) | Ixodes sp. | D. natalensis |
| 5 (1975) | Ixodes sp. | D. natalensis |
| 6 (1975) | I. pilosus | D. natalensis |
| 7 (1975) | Ixodes sp. | D. natalensis |
| 8 (1975) | Ixodes sp. | D. natalensis |
| 9 (1975) | Ixodes sp. | Linognathus tragelaphi |

TABLE 46 : List of arthropod parasites from bushbuck in Southern Africa (S.A. Institute for Medical Research)

LICE

Damalinia (D.) natalensis Emerson 1963 - Trichodectidae, Ischnocera

D. (Tricholipeurus) annectens Hopkins 1943 - Trichodectidae

Linognathus fractus Ferris 1932 - Linognathidae, Anoplura

L. tragelaphi Fiedler & Stampa 1965 - Linognathidae

FLEAS

Echidnophaga larina Jordan & Rothschild - Pulicidae

Ctenocephalides felis (Bouché) - Pulicidae

FLIES

Hippobosca fulva Austen - Hippoboscidae

Lipoptena hopkinsi Bequaert - Hippoboscidae

L. paradoxa Newstead - Hippoboscidae

L. sepiacea Speiser - Hippoboscidae

MITES

Sarcoptes spp.

TICKS

<u>Argas reflexus</u>

<u>Amblyomma compressum</u>

<u>A. hebraeum</u>

<u>A. variegatum</u>

<u>Boophilus decoloratus</u>

<u>Haemaphysalis aciculifer</u>

<u>H. hoodi</u>

<u>H. l.leachi</u>

<u>H. parmata</u>

<u>H. silacea</u>

<u>Hyalomma truncatum</u>

<u>Ixodes cumulatimpunctatus</u>

<u>I. evansi</u>

<u>I. lewisi</u>

<u>I. moreli</u>

<u>I. muniensis</u>

<u>I. pilosus</u>

<u>I. pseudorasus</u>

<u>I. rotundal</u>

<u>I. ugandanus</u>

<u>Rhipicephalus appendiculatus</u>

<u>R. bursa</u>

<u>R. complanatus</u>

<u>R. cuspidatus</u>

<u>R. evertsi</u>

<u>R. humeralis</u>

<u>R. burti</u>

R. maculatus

R. masseyi

R. mühlensi

R. neavi

R. vitens

R. oculatus

R. pravus

R. punctatus

R. sanguineus

R. senegalensis

R. s. simus

R. sulcatus

R. tricuspis

R. ziemanni

## 7.3 DISCUSSION

The Department of Entomology of the S.A. Institute for Medical Research comments as follows on the identifications:

"Bushbuck are usually found to harbour those species of ticks and lice that were identified. The lice have no effect on the health of the animal, unless they occur abundantly on a very young animal. The tick Ixodes pilosus is one of the 12 species of Ixodes that has been implicated as a vector of tick paralysis in man. It is quite common, and besides being a parasite of various wild ungulates, it also occurs on domestic bovids and occasionally on man".

From this it is clear that the parasites identified have no special significance at this stage, and the information presented here serves merely as a record to which can be added in future as the opportunity and need arise.

## SUGGESTIONS FOR FURTHER RESEARCH

On completion of this study it became evident than certain avenues of research could fruitfully be pursued further. Since these ideas may be of use to some they are briefly listed here:-

(a) The social organisation of the bushbuck is still not clearly understood. Some biologists believe that the species is territorial while others speculate that a male rank-hierarchy system may be present. Obviously a thorough and intensive study of the social behaviour of the species under natural conditions is urgently required.

(b) An attempt was made in this study to determine whether there are any peaks in the local rate of birth. However, the investigation was based on indirect evidence. If the local population is to be managed scientifically on any scale, this aspect should be researched in depth as it has an obvious bearing on various management activities.

(c) Although track counts hold promise as a management tool to determine the density of bushbuck populations, the method needs a lot of refinement. Other indirect methods, like pellet counts, also need looking at. This is something which is of importance to wildlife managers and which has a potential for wide practical application.

(d) Habitat selection in an area which was largely afforested with *Pinus* spp was looked at in this study. However, the area involved was only about four $km^2$ and may not have been as representative as one would like. An investigation into habitat selection on a regional basis may prove very interesting. Track or pellet counts may prove useful in such a study.

(e) The concentration of volatile fatty acids in the strained rumen liquor, combined with an analysis of the available browse, may throw light on what time of the year, if any, bushbuck live under sub-optimal conditions. Such a study should be combined with a thorough investigation into the feeding habits of bushbuck. This is a field of study of which little is known of the local bushbuck population and, as far as the nutritive characteristics of its food go, of the species in general.

(f) It was not possible to investigate age structure and population dynamics in the present study. This is a serious draw-back from a management point of view. Information will have to be collected on this aspect if intensive management of the local population is contemplated.

The above suggestions highlight only some of the more obvious and important deficiencies in our knowledge of bushbuck in the Southern Cape. It is to be hoped that at least some of these subjects will be investigated in the near future.

# REFERENCES


Acocks, J.P.H. 1953. Veld types of South Africa. Botanical Survey Memoir No. 28. Government Printer, Pretoria.

Anderson, J. 1953. Analysis of a Danish roe-deer population. Dan. Rev. Game Biol. 2, 131 - 155.

Anderson, F. 1971. Design of radio-tracking systems used in South Africa and problems encountered in their application. Proc. symp. Biotel. C.S.I.R., Pretoria.

Anderson, F. and P.P. de Moor. 1971. A system for radio-tracking monkeys in dense bush and forest. J. Wildl Mgmt. 35(4) : 636 - 643.

Anon. 1977. The 1975/76 annual report of the Department of Tourism, South Africa. Government Printe Pretoria.

Allsopp, R. 1969. The population dynamics and social biology of bushbuck (<u>Tragelaphus scriptus</u> Pallas). M.Sc. Thesis, Univ. Nairobi.

Ansell, W.F.H. 1965. Standardisation of field data on mammals. Zool. Afr. 1 (1) : 97 - 113.

Ansell, W.F.H. 1968. Preliminary identification manual for African mammals. 8. Artiodactyla. Smithsonian Institution, Washington.

Bailey, J.A. and J.G. Nagy. 1969. Recent advances in wildlife nutrition. Graduate seminar in wildlife biology, Colorado State University.

Bergerud, A.T. and L. Russell. 1964. Evaluation of rumen food analysis for Newfoundland caribou. J. Wildl. Mgmt. 28(4) : 809 - 814.

Bigalke, R. 1958. What animal is it? Van Schaik, Pretoria.

Bigalke, R.C. 1968. Evolution of mammals on southern continents. III The contemporary mammal fauna of Africa Quart. Rev. Biol. 43(3) : 265 - 300.

Bourlierè, F. 1965. Densities and biomasses of some ungulate populations in eastern Congo and Rwanda, with notes on population structure and lion/ungulate ratio. Zool. Afr. 1, 199 - 207.

Bourlierè, F. and J. Verschuren. 1960. Introduction à l'écologie des Ongules du parc national Albert. Inst. des Parcs Nat. du Congo et du Ruanda-Urundi, Bruxelles, Vol. 1.

Brown, L.H. 1969. Observations on the status, habitat and behaviour of the mountain nyala *Tragelaphus buxtoni* in Ethiopia. Mammalia 33, 545-597.

Cochran, W.W. and R.D. Lord. 1963. A radio-tracking system for wild animals. J. Wildl. Mgmt. 27(1) : 9 - 24.

Craighead, J.J.; Craighead, F.C. jr.; Ruff, R.L. and B.W. O'Gara. 1973. Home ranges and activity patterns of non-migratory elk of the Madison drainage herd as determined by biotelemetry. Wildl. Monogr. No. 33.

Cumming, D.H.M. 1971. Radio-tracking of warthog; some results and their bearing on studies of game-tsetse fly relationships. Proc. symp. Biotel. C.S.I.R., Pretoria.

Dasmann, R.F. and A.S. Mossman. 1962. Abundance and population structure of wild ungulates in some areas of Southern Rhodesia. J. Wildl. Mgmt. 26(3): 262 - 268.

De Moor, P.P. and F.E. Steffens. 1971. The territorial behaviour of vervet monkeys (Cercopithecus aethiops) as revealed by radio-tracking. Proc. symp. Biotel., C.S.I.R., Pretoria.

Dirschl, H.J. 1962 Sieve mesh size related to analysis of antelope rumen contents. J. Wildl. Mgmt. 26(3) : 327 - 328.

Douglas-Hamilton, L. 1971. Radio-tracking of elephant. Proc. symp. Biotel., C.S.I.R., Pretoria.

Du Plessis, S.F. 1969. The past and present geographical distributio of the perissodactyla and artiodactyla in Southern Africa. M.Sc. Thesis, Univ. Pretoria.

Elder, W.H. and N.L. Elder. 1970. Social groups and primate associations of the bushbuck (Tragelaphus scriptus). Mammalia 34(3) : 356 - 362.

Ellis, R.J. 1964. Tracking racoons by radio. J. Wild. Mgmt. 28(2) : 363 - 368.

Englund, J. 1965. Studies on food ecology of the red fox (Vulpes v.) in Sweden. Viltrevy 3(4) : 377 - 485.

Estes, R.D. 1974. Social organisation of the African bovids, in The behaviour of ungulates and its relation to management Vol. 1. Geist, V and F. Walther (eds) I.U.C.N. Publ. New Ser. 24(1) : 166 - 205.

Ewer, R.F. 1968. Ethology of mammals. Logos Press. London.

Field, C.R. and R.M. Laws. 1970. The distribution of the larger herbivores in the Queen Elizabeth National Park, Uganda. J. appl. Ecol. 7, 273-294.

Foster, J.B. and M.J. Coe. 1968. The biomass of game animals in Nairobi National Park 1960-66. J. Zool. (Lond.) 155, 413 - 425.

Gentry, A.W. 1971. The earliest goats and other antelopes from the Samos Hipparion fauna. Bull. Brit. Mus. Nat. Hist. 20(6): 229 - 296

Giles, R.H. (ed) 1969. Wildlife management techniques. The Wildlife Society, Washington.

Goddard, J. 1967. Home range, behaviour and recruitment rates of two black rhinoceros populations. E. Afr. Wildl. J. 5, 133 - 150.

Hall-Martin, A.J. and W.D. Basson. 1975. Seasonal chemical com= position of the diet of Transvaal lowveld giraffe. J.sth. Afr. Wildl. Mgmt. Ass. 5(1) : 19 - 21.

Harlow, R.F. and R.L. Downing. 1967. Evaluating the deer track census method used in the Southeast. Southeast Assoc. Game and Fish Comm. 21st annual Conf. Proc.: 39 - 41.

Harvey, M.J. and R.W. Barbour. 1965. Home range of Microtus orchrogaster as determined by a modified minimum area method. J. Mamm. 46(3) : 398 - 402.

Hayne, D.W. 1949. Calculation of size of home range. J. Mamm. 30(1) : 1 - 19.

Hitchins, P.M. 1971. Preliminary findings in a radio telemetric study on the black rhinoceros in Hluhluwe game reserve Zululand. Proc. symp. Biotel., C.S.I.R., Pretoria.

X Jacobsen, N.H.G. 1974. Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengw valleys, Rhodesia. J. sth, Afr. Wildl. Mgmt. Ass. 4(2) : 75 - 93.

Jarman, M.V. 1970. Attachment to home area in impala. E. Afr. Wildl. J. 8 : 198 - 200.

Jarman, P.J. 1973. The social organisation of antelope in relation to their ecology. Behaviour XLVIII (3 - 4) : 215 - 267.

Jewell, P.A. 1966. The concept of home range in mammals. Symp. zool. Soc. Lond. 18 : 85 - 109.

Jungius, H. 1971. The biology and behaviour of the reedbuck (Redunca arundinum Boddaert 1785) in the Kruger National Park. Mammalia Depicta, Paul Parey, Hamburg.

Keep, M.E. 1971. Some parasites and pathology of the nyala (Tragelaphus angasi) and its potential value as a ranch animal. Lammergeyer 13 : 45 - 54.

Keep, M.E. 1972. The meat yield, parasites and pathology of eland in Natal. Lammergeyer 17 : 1 - 9.

Klein R.G. 1975. Middle stone age man-animal relationships in Southern Africa : Evidence from Die Kelders and Klasies river mouth. Science 190 : 265 - 267.

Klein, R.G. 1972. The late quaternary mammalian fauna of Nelson Bay cave (Cape Province, South Africa). Its implications for megafaunal extinctions and environmental and cultural change. Quaternary Research 2 : 135 - 142.

Knobel, R. 1971. Certain aspects of tourism in relation to wildlife and nature conservation. Proc. Sarccus Symp: Nature Conservation as a form of land use. Gorongosa National Park, Mocambique.

Kolbe, F.F. 1948. The bushbuck - a scientific note. African Wild Life 1(5) : 9.

Kurz, J.L. and R.L. Marchinton. 1972. Radiotelemetry studies of feral hogs in South Carolina. J. Wildl. Mgmt. 36(4) : 1240 - 1248.

Ledger, H.P. 1963. Animal husbandry research and wildlife in East Africa. E. Afr. Wildl. J. 1: 18 - 29.

Ledger, J.A. 1973. The Department of Entomology at the South African Institute for Medical Research: an identification centre for the arthropod parasites of vertebrates in Africa south of the Sahara. J. sth. Afr. Wildl. Mgmt. Ass. 3(2): 115 - 118.

Leuthold, W. 1974. Observations on home range and social organisation of lesser kudu, Tragelaphus imberbis (Blyth, 1869), in The behaviour of ungulates and its relation to management. Vol. 1. Geist, V. and F. Walther (eds.) I.U.C.N. Pub. New Ser. 24(1) : 206 - 234.

Leyhausen, P. 1964. The communual organisation of solitary mammals. Symp. zool. Soc. Lond. 14 : 249 -26

Lloyd, P.M. 1972. Mammal survey: Report 1971 - 1972. Unpublished report of the Department of Nature and Enviornmental Conservation of the Cape Provincial Administration, Cape Town.

Lönnberg, E. 1905. On the harnessed antelopes of the Cameroon territory with some remarks on their colour and habits. Arkiv för Zoologi 2(15): 1 - 12.

Louw, G.N. 1969. The nutritive value of natural grazings in South Africa. Proc. S. Afr. Soc. Anim. Prod. (1969): 57 - 61.

Marchinton, R.L. and L.K. Jeter. 1967. Telemetric study of deer movement-ecology in the Southeast. South= east Assoc. Game and Fish Comm., 20 th Ann. Conf. Proc. 1966 : 189 - 206.

Manson, J.A. 1974. Aspekte van die biologie en gedrag van die Kaapse grysbok (Raphicerus melanotis Thunberg). M.Sc. Tesis, Univ. Stellenbosch.

McDonald, P.; Edwards, R.A. and J.F.D. Greenhalgh. 1969. Animal nutrition. Oliver & Boyd, Edinburgh.

Mentis, M.T. 1972. A review of some life history features of the large herbivores of Africa.

Lammergeyer 16 :1 - 89.

Mentis, M.T. 1970. Estimates of natural biomasses of large herbivores in the Umfolozi Game Reserve area. Mammalia 34(3) : 363 - 393.

Miller, R.G. 1966. Simultaneous statistical inferences. McGraw-Hill, New York.

Moll, E.J.; Campbell, B.M. and T.A. Probyn. 1976. A rapid statistical method of habitat classifi= cation using structural and physiognomic characteristics. S.A. Jour. Wildl. Res. 6(1) : 45 - 50.

Morris, N.E. 1973. A preliminary investigation of the bushbuck population in the Matsikite area, and its relevance to tsetse control hunting. M.Sc. Thesis. Univ. Rhodesia.

Neu. C.W., Byers, C.R. and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Mgmt. 38(3) : 541 - 545.

Petrides, G.A. and W.G. Swank. 1965. Population densities and the range-carrying capacity for large mam= mals in Queen Elizabeth National Park, Uganda. Zool. Afr. 1: 209 - 225.

Phillips, J.F.V. 1931. Forest-succession and ecology in the Knysna Region. Botanical Survey Memoir 14. Government Printer, Pretoria.

Pienaar, U. de V. 1963. The large mammals of the Kruger National Park - their distribution and present-day status. Koedoe 6 : 1 - 37.

Potgieter, J.J. 1973. Toerusting vir wildopsporing. Interne ver= slag, Nasionale Navorsingsinstituut vir Elektriese Ingenieurswese, Afdeling Elek= troniese Instrumentasie. W.N.N.R. Pretoria.

Roberts, A. 1951. The mammals of South Africa. Hafner Publ. Co., New York.

Sanderson, G.C. 1966. The study of mammal movements - a review. J. Wildl. Mgmt. 30(1) : 215 - 235.

Short, H.L., Medin, D.E. and A.E. Anderson. 1966. Seasonal variations in volatile fatty acids in the rumen of mule deer. J. Wildl. Mgmt. 30(3) : 466 - 470.

X - Simpson, C.D. 1974. Ecology of the Zambesi valley bushbuck Tragelaphus scriptus ornatus Pocock. Ph.D. Thesis. Texas A & M Univ.

Simpson, G.G. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist. 85 : 1 - 350

Smith , R.L. 1966. Ecology and field biology. Harper & Row, New York.

Smithers, R.H.N. 1971. The mammals of Botswana. Museum Memoir No. 4, National Museums of Rhodesia, Salisbury.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. Iowa State University Press, Ames, Iowa.

Spinage, C.A. 1974. Territoriality and population regulation in the Uganda defassa waterbuck, in The behaviour of ungulates and its relation to management. Vol. 2. Geist, V. and F. Walther (eds.) I.U.C.N. Pub. New Ser. 24(2) : 635 - 643.

Stevenson-Hamilton, J. 1947. Wild life in South Africa. Cassell & Co. Ltd., London.

Thomson, G.R. 1972. The distribution and habitat preference of bushbuck (Tragelaphus scriptus ornatus) within the Victoria Falls National Park. Cert. Field Ecol. Univ. Rhodesia.

Tyson, E.L. 1959. A deer drive vs. track census. Trans. N. Amer. Wildl. Conf. 24: 457 - 464.

Van der Merwe, F.J. 1970. Dierevoeding. Kosmo-uitgewery. Stellenbosch.

Verheyen, R. 1955. Contribution a l'ethologie du Waterbuck Kobus defassa ugandae Neumann et de l'antilo harnachee Tragelaphus scriptus Pallas. Mammalia 19: 309 - 319.

Verts, B.J. 1963. Equipment and techniques for radio-tracking striped skunks. J. Wildl. Mgmt. 27(3): 325 - 339.

Von Breitenbach, F. 1968. Southern Cape indigenous forest managemen manual. Vol. 1 : Foundations of Management, Department of Forestry, Pretoria.

Von Breitenbach, F. 1974. Southern Cape forests and trees. Government Printer, Pretoria.

Von Gadow, K. 1970. Notes on bushbuck. Southern Cape Indigenous Forests yearbook 1969/1970. Department of Forestry, Pretoria.

Von Gadow, K. 1971. Harkerville indigenous forest management plan 1971/1972 - 1980/1981. Department of Forestry, Pretoria.

Von Ketelhodt, H.F. 1976. Observations on the lambing interval of the Cape bushbuck, Tragelaptus scriptus sylvaticus. Zool. Afr. 11(1) : 221 - 222

Walther, F. 1964. Verhaltenstudien an der Gattung Tragelaphus De Blainville, 1816, in Gefangenschaft, unter besonderer Berücksichtigung des Sozialverhaltens. Z. Tierpsychol. 21 (4) : 393 - 467.

Waser, P. 1975. Diurnal and nocturnal strategies of the bushbuck Tragelaphus scriptus (Pallas). E. Afr. Wildl. J. 13 : 49 - 63.

Wilson V.J. and G.F.T. Child. 1964. Notes on bushbuck (Tragelaphus scriptus) form a tsetse fly control area in Northern Rhodesia. Puku 2 : 118 - 128

Wilson, V.J. and H.H. Roth. 1967. The effects of tsetse control operations on common duiker in eastern Zambia. E. Afr. Wildl. J. 5 : 53 - 64.

Young, J.Z. 1962. The life of vertebrates. Clarendon Press, Oxford.