THE CARACAL, *Felis caracal caracal* SCHREBER, 1776, AS PREDATOR IN THE WEST COAST NATIONAL PARK

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Declaration

I, the undersigned hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any University for a degree.

Nico L. Avenant

25/11/93

Date:

"Near or far,

Hidden

To each other linked are,

That that canst not stir a flower

Without troubling of a star"

(The Mistress of Vision)
Francis Thompson (1859 - 1907)

SUMMARY

Small mammals were sampled in eight different plant communities in the West Coast National Park and on two farms adjacent to the Park, and along various slopes in the Postberg Nature Reserve section. *Rhabdomys pumilio* was by far the most abundant species at all sites, although its density varied between plant communities and seasons. Species diversity, absolute and relative density, cover preference and breeding activity of some small mammals and density, group size and habitat preference of the main bird prey species are also discussed.

A low incidence of larger prey, e.g. antelope, hyrax and hares in caracal scats probably reflects their low densities in the study area. Together with caracal, the diet of four other sympatric carnivore species was also examined by analysis of scats collected over a 14-month period in the West Coast National Park. Dietary patterns of all predators studied correlated with fluctuations in densities of main prey species, as well as group size of certain prey species. Food niche widths accordingly changed seasonally, being widest during spring and then contracting gradually towards winter. A considerable amount of food niche overlap existed between carnivore species pairs. The main prey item of all the carnivores examined were rodents (mainly *Rhabdomys pumilio* and *Otomys unisulcatus*), which were utilized heavily throughout the year, despite marked declines in rodent numbers towards winter.

Habitat use by five transmitter-equipped caracal (*Felis caracal* Schreber 1776) indicated that they spent most of their time active in specific areas where highest rodent density and species diversity were found. Males were active for 45-180 min. in a given area (patch) before moving, without stopping, to another patch; females covered their ranges more uniformly in space. The mean home range size (26.97 ± 0.750 km^2) of two males inhabiting the same area, but at different times, was 3.6

times larger than that of each of three females (7.39 ± 1.68 km^2). Home ranges overlapped both within and between sexes. Caracal were mostly nocturnal, but were also active during daytime in the colder winter. No correlation was found between degree of activity and cloud cover, full or dark moon, wind speed, or rain, but a significant correlation existed between degree of activity and temperatures above 22°C or below 20°C. Mean litter size was 2.25 ± 0.96, with kittens staying ca 120 days with their mother in her territory. This four-month period coincided with the time when most springbok were predated on and when the highest stock losses were reported on farms in the surrounding Swartland Divisional Council.

The impact of caracal on introduced springbok at Postberg Nature Reserve section of the West Coast National Park was studied to aid in the decision of whether springbok can be kept in that section of the Park or not. This study contributes to the conservation and control of caracal in the West Coast Strandveld.

OPSOMMING

Getalle van klein soogdiere is gemonster in agt verskillende plantgemeenskappe in die Weskus Nasionale Park, op twee plase aangrensend aan die Park, en teen verskillende hange in die Postberg Natuurreservaat gedeelte van die Park. *Rhabdomys pumilio* was by verre die volopste spesie by alle vangplekke, alhoewel digthede verskil tussen plantgemeenskappe en oor seisoene. Spesiediversiteit, absolute en relatiewe digthede, voorkeure vir skuiling en voortplantingsaktiwiteit van klein soogdiere, asook digthede, groepgroottes en habitatsvoorkeure van die vernaamste voël-prooispesies word ook bespreek.

Lae voorkoms van groter prooi, bv. antilope, dassies en hase in rooikat mis weerspïeel hul lae digthede in die studie area. Die dïeet van vier ander simpatriese roofdiersoorte is saam met die van die rooikat oor 'n 14-maande periode in die Weskus Nasionale Park bestudeer m.b.v. misontledings. Dïeetpatrone van al die roofdiere bestudeer is gekorrelleerd met fluktuasies in digthede van al die hoof prooispesies en met fluktuasies in groepgroottes van sekere prooispesies. Voedselniswydte van hierdie roofdiere verander ook seisoenaal en is die wydste gedurende lente en neem geleidelik af tot en met die winter. 'n Groot mate van voedselnisoorvleueling kom voor tussen die onderskeie roofdierspesiespare. Die hoof prooi item van al die roofdiere bestudeer, was knaagdiere (hoofsaaklik *Rhabdomys pumilio* en *Otomys unisulcatus*) wat in groot getalle reg deur die jaar benut is ten spyte van geweldige afname in muisgetalle voor die winter.

Vyf rooikatte (*Felis caracal* Schreber, 1776), met radio-nekbande voorsien, spandeer meeste van die tyd wanneer aktief is in spesifieke gebiede met hoogste knaagdier-digthede en waar hoogste spesies-diversiteit voorkom. Mannetjies het vir 45-180 minute in so 'n gegewe area (kol) voorgekom voordat hulle feitlik reguit, en sonder om te stop, na die volgende kol beweeg het; wyfies het hul hele loopgebied meer eweredig benut, maar nog steeds meer voorgekom in gebiede met hoër knaagdier-digthede. Die gemiddelde loopgebiedgrootte (26.97 ± 0.750 km^2) van twee mannetjies gevestig in dieselfde gebied op verskillende tye was 3.6 keer groter as die gemiddelde loopgebiedgrootte van drie wyfies (7.39 ± 1.68 km^2). Loopgebiede oorvleuel beide binne en tussen geslagte. Die rooikatte was meestal naglewend, maar was ook bedags aktief, veral gedurende die kouer winter. Geen korrellasie is gevind tussen die mate van aktiwiteit en wolkbedekking, volmaan of donkermaan, windspoed, of reën nie, maar wel tussen die mate van aktiwiteit en temperature bo of onder 20^oC - 22^oC. Die gemiddelde werpselgrootte was 2.25 ± 0.96 en jong katjies bly ongeveer 120 dae by hul ma in haar gebied. Hierdie vier-maande periode kom ooreen met die tyd wanneer daar die meeste op springbokke deur rooikatte gevoed word en wanneer die meeste veeverliese gerapporteer is op plase in die omringende Swartland Afdelingsraad. Die invloed van die rooikat op die eksotiese springbokpopulasie in die Postberg Natuurreservaat-gedeelte van die Park is ook bestudeer om te help met die besluitneming of springbokke in die Postberg-gedeelte van die Weskus Nasionale Park aangehou kan word of nie. Hierdie studie lewer 'n bydrae tot besluitnemings aangaande die bewaring en beheer van rooikatte in die Weskus Strandveld.

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INTRODUCTION

The caracal, *Felis caracal*, Schreber 1776, is the largest of the "small" cats occurring in the Cape Province (Stuart 1982). Males weigh less than 20 kg; females less than 12 kg (Stuart 1982; Smithers 1983; Moolman 1986; Brand 1990). They utilize a very wide prey spectrum, ranging from insects to adult springbok (Palmer & Fairall 1988). Together with their solitary and nocturnal behaviour, this enabled them to survive and have a very wide distribution in Africa. Caracal is present in nearly all habitats all over Africa except in the driest parts of the Sahara and Namib deserts (Smithers 1983; Stuart & Wilson 1988). This cat is rare and endangered in the non-African sector of its range, with one subspecies (*Felis caracal michaëlis*, Hepfner 1945) being listed in the I.U.C.N. Red Data Book of 1969 (Stuart 1982). However, in the Southern African Subregion the caracal is regarded as a major threat to small-stock farmers (Brand 1990).

Despite its wide distribution range and problem animal status, very little research has been done on this cat. Pringle & Pringle (1979) in the Eastern Cape, Grobler (1981) & Moolman (1986) in the Mountain Zebra National Park, Stuart (1982) in the south-western Cape, and Palmer & Fairall (1988) in the Karoo National Park, have reported on the diet of caracal, but no one compared this with seasonal prey availability. Radio tracking has been done by Stuart (1982), Norton & Lawson (1985) in the Stellenbosch mountains, and Moolman (1986). Bernard & Stuart (1987) have reported on the reproduction of *Felis caracal* from the Cape Province, while Brand (1990) did a thorough study on the control of caracal as a problem animal in the Cape Province.

The present study was initiated in order to get a better understanding of the role of the caracal as largest surviving predator in the West Coast Strandveld ecosystem, as exemplified by the West Coast National Park and some of the adjacent farms which served as a representative study area. The study also aimed to get an understanding of especially the dietary interactions (food niche relationship) of some of the more common carnivores in the Park. A further raison d'êtrè was the concern of the Oude Post Syndicate, owners of the Postberg Nature Reserve, that caracal are responsible for the marked decline in springbok numbers since the inception of the West Coast National Park, when control of caracal was terminated.

The aims of this study were to report on the density of caracal in the West Coast National Park as a whole, the Postberg Nature Reserve section, in particular, and to get an idea of densities in the surrounding farming area; home range sizes of male and female caracal, the degree of overlap, use of the home ranges and the related activity cycles; composition of the caracal's diet and seasonal fluctuation therein; food available to caracal and seasonal fluctuations in availability; possible prey preferences; food available and the diet of caracal in the Postberg Nature Reserve, compared to that in other parts of the West Coast National Park and on the surrounding farms; and the food niche partitioning between caracal and other predators in the Park. Provision in the programme was made for determining the impact of caracal on springbok numbers at Postberg.

This study formed part of a bigger study on carnivores in the West Coast National Park, a unique area for predation studies as the small and medium sized carnivores has hardly been touched and the full spectrum is still present (Nel pers.comm.).

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CHAPTER 1

STUDY AREA

A) GEOGRAPHY

The study area (Fig.1.1) included the whole of the West Coast National Park (W.C.N.P.), which incorporates the privately owned Postberg Nature Reserve (P.N.R.), as well as some of the surrounding farms. Centred on *ca* $33^{o}12$'S;$18^{o}08$'E (3317BB and 3318AA), the park covers more than 30 000 ha and is *ca* 80 km north of Cape Town. The Atlantic coastline, Langebaan village, the Darling district and Yzerfontein forms its western, northern, eastern and southern boundaries respectively.

The main study site was the Postberg Nature Reserve (*ca* 2000 ha) on the Langebaan peninsula (Fig.1.2). Topographically, the area consists of low granite hills interspersed with sandy flats, the latter with a few fallow lands. The altitude varies from sea level to 193 m (Vlaeberg).

The W.C.N.P. includes, apart from the Langebaan lagoon with fringing fresh and salt water marshes, consolidated and unconsolidated dunes, a 26 km stretch of beach and one granite outcrop (Seeberg) with its highest point at 131 m a.s.l.

The adjoining farms Seeberg and Mooimaak (on the north-eastern border) consists mainly of sand dunes with the one granite outcrop. The farms Yzerfontein, De la Rey, Blombos and Mooimeisiesfontein adjoins the southern border and also consist of sand dunes comparable to those within the W.C.N.P.. Other farms used on occasion as study areas were inland from and in more mountainous terrain than the W.C.N.P. These latter farms were in a small stock (sheep and goat) area with extensive wheat farming areas stretching from Darling inland. The farms

Figure 1.1: The West Coast National Park on the Cape West Coast. Scale 1:500 000

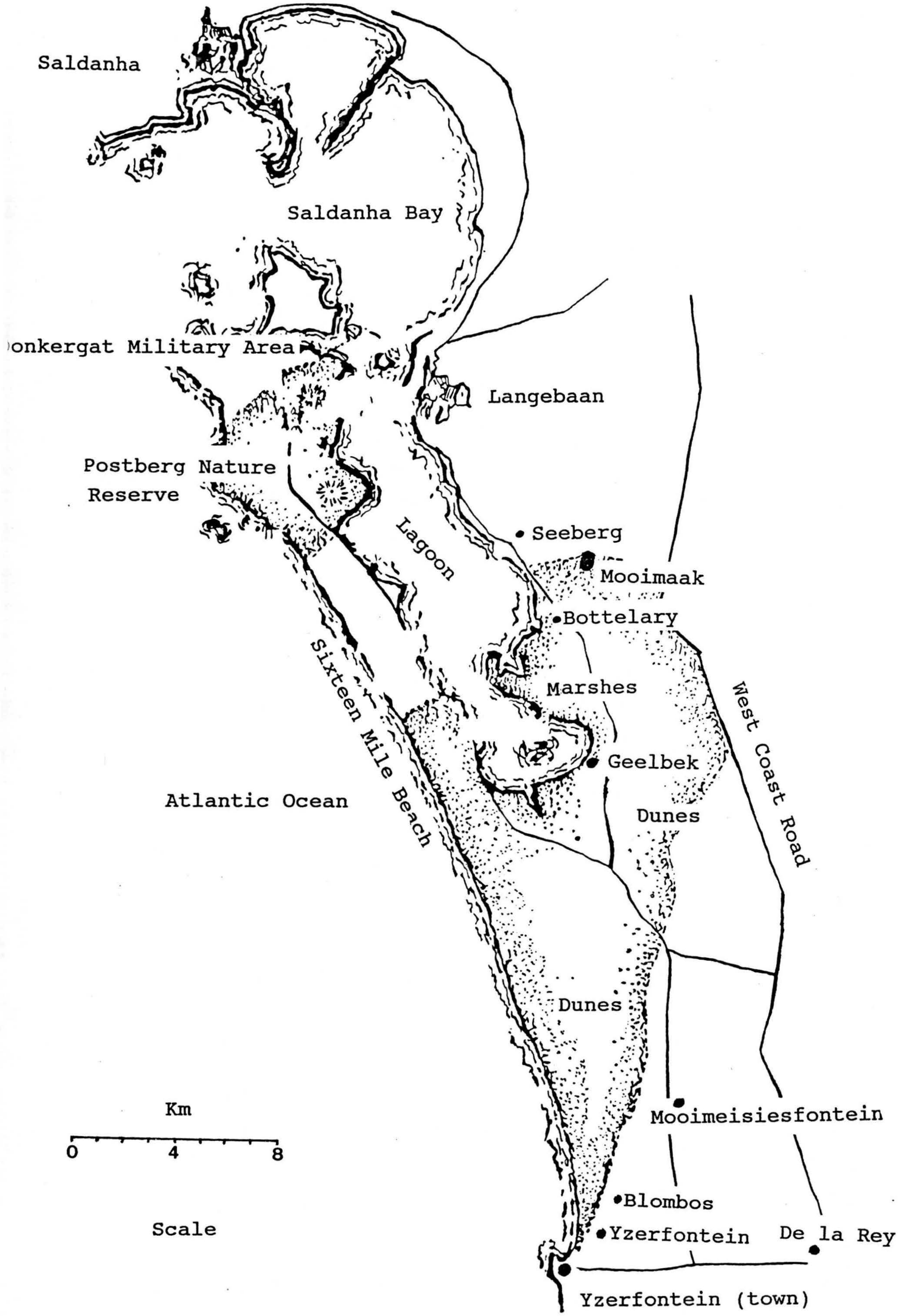

Figure 1.2: The West Coast National Park and some of the surrounding farms.

immediately surrounding the W.C.N.P. still had a 60-90% natural Strandveld vegetation cover, in contrast to those situated further inland.

B) GEOLOGY

The geological framework of the area surrounding the Langebaan lagoon, and therefore the W.C.N.P., is relatively simple. The relief is dominated by dome-like outcrops of the Darling granites, roughly 500 million years old (Leygonie 1974; Kent 1980). The low-lying areas consist mainly of calcrete sheets and unconsolidated sands composed of Quaternary coastal/marine deposits. The geomorphology of the subaerial and submarine terrain results from erosional processes. In the course of the Flandrian transgression (5 000 - 6 000 years ago) much of the seaward extending calcrete sheets and fossil dunes were reworked and removed by wave abrasion and tidal currents as the sea level rose to 3 - 4 m above present. This flooding and scouring of the late Pleistocene coastal dune environment probably reached its peak some 5 000 - 6 000 years ago. Geomorphic evidence suggests a former link between the lagoon and sea at Kraalbaai during the highest stages of this transgression. The subsequent regression reached its present form *ca* 2 000 years ago since when conditions have remained relatively unchanged.

Boucher & Jarman (1977) gave a detailed description of the soil characteristics and classification at different sites throughout the present study area. The richness of phosphate in the soils around the granite outcrops may be the result of large quantities of guano deposited when these were still islands, and may partially account for the richness in vegetation at P.N.R.

C) CLIMATE

(1) Rainfall

The study area falls within the Cape Winter Rainfall Region. The mean annual rainfall (n = 25 years) at Geelbek at the southern end of the lagoon (Fig.1.2) is 270 mm, which is slightly higher than at Langebaan village (253 mm; n = 48 years) (Table 1.1). Although no rainfall data for the main study site, P.N.R. are available, it is probably slightly higher than at Geelbek, due to the much higher granite outcrops (Schaaf pers. comm.; pers. obs.). For Geelbek and Langebaan the mean monthly rainfall for the period May to July is 41 - 45 mm and 5 - 8 mm between December and February (Table 1.1).

Most of the available recent data on the climate in the general area were recorded at Langebaanweg, 20 km north east and inland from Langebaan. Langebaanweg, at 31 m a.s.l., is mostly hotter but also slightly wetter than Langebaan (Schaaf 1991). Mean annual precipitation here for the period 1973 - 1984 was 265 mm, although the mean number of rainy days was higher than at Geelbek or Langebaan village (Table 1.2). Mean monthly rainfall for May to August was 37 - 44 mm, and 5 - 12 mm for December to February. The period March to August has the highest number of foggy days (6 - 8 days per month), while December to February has the highest number of days with clear skies (Table 1.2). Although the W.C.N.P., and especially the P.N.R. is closer to the coast and may have on average more days with fog and cloud cover, the monthly patterns will be much the same as at Langebaanweg (Schaaf pers. comm.).

(2) Temperature and Humidity

Temperature data for Langebaanweg are given in Table 1.3. The mean monthly maximum/minimum temperatures for the period 1973 to 1984 was 23,2°C/11°C, with highest temperatures between December and March and lowest temperatures between June and August. Relative percentage humidity of the air is highest during the late autumn and winter months, corresponding with the period of most fog and rain (Table 1.4).

Closer to the coast, temperatures and air humidity may be slightly lower and higher respectively. Table 1.5 gives data on the climate of Langebaan during 1990 (Schaaf 1991) when most of the field work was done. The annual rainfall was above average, but most rain fell early with very little of the usual succeeding rains. Mean monthly temperatures were within the normal seasonal pattern.

(3) Wind

Winds are predominantly from the south throughout the year, with northerly winds most frequent between May and August (Weather Bureau 1972). At the higher altitudes of Postberg, wind speeds often exceed 10 m/s from both directions .

(D) VEGETATION

The study area falls within the West Coast Strandveld (Veld Type 34b) of Acocks (1975). He described it as containing two variations, namely a dense, dwarf, semi-succulent shrub and the Strandveld proper, an open semi-succulent scrub of fynbos form and intermediate between the Coastal Fynbos and the Succulent Karoo. The succulent shrub components of the

Table 1.1 Mean monthly and annual rainfall (mm) and number of rain days recorded at Langebaan Police Station (33°05'S;18°02'E) at 5 m altitude over 48 years, and at Geelbek farm (33°12'S;18°08'E) at 4 m altitude over 25 years (Weather Bureau 1965).

Month	Geelbek		Langebaan	
	Rainfall	Days	Rainfall	Days
January	6.1	1	5.3	1
February	7.6	2	6.3	1
March	8.1	2	6.4	2
April	18.8	4	22.0	4
May	42.7	6	44.3	7
June	45.2	6	42.3	7
July	40.9	7	43.1	7
August	39.6	6	33.2	7
September	30.7	6	22.5	5
October	15.0	4	13.2	3
November	9.1	2	8.8	2
December	6.1	1	5.7	1
Annual	269.9	47	253.1	47

Table 1.2 Mean monthly rainfall and number of days with rain, fog and cloud cover at Langebaanweg (32°58'S;18°10'E) for the period 1973 - 1984 (Weather Bureau 1988).

Month	Rainfall mm	Days with Rain	Fog	Cloud cover 08:00	14:00	20:00
January	8	2.7	1.7	2.6	2.0	1.8
February	5	2.3	3.0	2.7	1.5	1.5
March	9	2.8	8.0	3.0	1.9	1.3
April	16	4.7	7.7	3.5	2.8	2.5
May	44	8.9	8.4	4.1	3.8	2.6
June	37	8.6	7.7	4.0	3.6	2.1
July	38	8.5	6.1	3.7	3.5	2.1
August	46	9.0	6.3	3.5	3.6	2.2
September	21	7.9	3.3	3.8	3.8	2.5
October	15	5.9	3.0	3.8	3.2	2.7
November	14	5.3	2.0	3.2	2.6	2.4
December	12	4.1	1.9	2.9	1.8	2.0
Annual	265	70.7	59.1	3.4	2.8	2.1

Table 1.3 Mean monthly air temperature (^{O}C) at Langebaanweg ($32^{O}58$ S; $18^{O}10$'E) for the period 1973 - 1984 (Weather Bureau 1988).

Month	Temperature			
	Mean		Frequency (Days)	
			Max:	
	Max	Min	$>30^{O}C$	$<17.5^{O}C$
January	27.5	14.9	6.9	0.0
February	28.0	14.9	8.2	0.0
March	27.0	13.9	7.0	0.2
April	25.0	12.3	5.3	0.9
May	20.9	9.7	0.8	6.9
June	19.1	7.9	0.1	12.9
July	18.4	7.1	0.0	15.5
August	18.6	7.2	0.2	14.3
September	20.2	8.4	0.7	8.4
October	22.7	10.1	3.3	2.5
November	24.8	12.3	3.6	0.3
December	26.3	13.8	5.8	0.0
Annual	23.2	11.0	41.8	61.9

Table 1.4 Relative percentage humidity of the air at Langebaanweg (32°58'S;18°10'E) for the period 1973 - 1984 (Weather Bureau 1988).

Month	Time		
	08:00	14:00	20:00
January	76	44	65
February	83	43	66
March	87	43	71
April	89	48	76
May	90	54	80
June	90	58	84
July	91	57	83
August	91	56	83
September	89	52	77
October	79	47	71
November	73	45	72
December	74	46	69
Annual	84	49	75

Table 1.5 Monthly temperatures and rainfall at Langebaan (33°05'S;18°02'E) during 1990 (Schaaf 1991).

Month	Temperature (°C)		Rainfall (mm)
	Highest	Lowest	Monthly
January	31	15	4.5
February	32	16	4.0
March	33	15	0.0
April	30	14	69.0
May	29	10	78.5
June	25	9	58.5
July	22	8	74.5
August	26	10	24.5
September	29	10	6.0
October	27	11	1.5
November	30	11	4.0
December	31	16	4.5
Annual	33	8	329.5

communities at Langebaan are drought-deciduous, in contrast to the sclerophyllous woody components such as *Euclea racemosa* and *Rhus glauca*. This results in the vegetation showing marked seasonal differences, particularly when the spring annuals are in full bloom. Taylor & Boucher (1973) encountered Coastal Fynbos on less stable recent sand occurring on the eastern side of the lagoon with *Willdenowia striata* and *Eriocephalus racemosus* the fynbos element in the scrub. Cultivated areas occurred on the granite-derived soils around Saldanha Bay. Boucher & Jarman (1977) divided the whole area surrounding the Langebaan Lagoon into different plant communities and described each in detail. These communities were named using differentiating species which were, wherever possible, also conspicuous and related to outstanding habitat features. Table 1.6 lists all 18 communities. The Langebaan peninsula is relatively free of alien plant species, especially perennial alien species. The relatively good state of preservation of the vegetation, the diverse communities which occur because of the variety of habitats present, the scientifically important occurrence of a number of species whose distribution ranges fall within the Park, the presence of remnant tree clumps around the granite boulders, and the limited access to the area recommended it for conservation (Boucher & Jarman 1977).

Within the P.N.R. the different plant communities have the following sizes:

Community:

A - Atriplex-Zygophyllum Dwarf Shrubland - 537 ha

B - Pelargonium-Muraltia Dwarf Shrubland - 11 ha

C - Galenia-Senecio Hillside Closed Dwarf Shrubland - 48 ha

D - Ehrharta-Maurocenia Hillside Dense Shrubland - 215 ha

E - Nenax-Maytenus-Zygophyllum Evergreen Shrubland - 552 ha

Table 1.6. Plant Communities within the Langebaan study area according to Boucher & Jarman (1977).

Coastal-shelf Communities:
- A - *Atriplex-Zygophyllum* Dwarf Shrubland
- B - *Pelargonium-Muraltia* Dwarf Shrubland

Communities on Granite Soils:
- C - *Galenia-Senecio* Hillside Closed Dwarf Shrubland
- D - *Ehrharta-Maurocenia* Hillside Dense Shrubland

Communities on Limestone Soils:
- E - *Nenax-Maytenus-Zygophyllum* Evergreen Shrubland
- F - *Pteronia uncinata* Evergreen Dwarf Shrubland

Communities on Dune Sands:
- G - *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland
- H - *Willdenowia striata* Consolidated-dune Dense Evergreen Restioid Shrubland
- I - *Thamnochortus spicigerus* Dune Dense Tall Restioid Herbland
- J - *Hermannia pinnata* Littoral-dune Dwarf Succulent Shrubland
- K - *Didelta-Psoralea* Littoral-dune Open Grassland
- L - *Metalasia-Myrica* Dune Dense Evergreen Ericoid Shrubland

Marsh Communities:
- Ma - *Juncus kraussii* & *Nidorella-Senecio* Mixed Form
- Mb - *Cliffortia strobilifera*-dominated Form
- Mc - *Typha capensis*-dominated Form
- Md - *Phragmites australis*-dominated Form
- Na - *Limonium-Disphyma* Form
- Nb - *Spartina-Trilochin* Form

F - Pteronia uncinata Evergreen Dwarf Shrubland - 2 ha

G - Maytenus-Kedrostis Consolidated-dune Dense Evergreen Shrubland - 55 ha

I & J - Thamnochortus spicigerus Dune Dense Tall Restioid Herbland & Hermannia pinnata Littoral-dune Dwarf Succulent Shrubland - 137 ha and

Old Lands - 443 ha

The vegetation of the rest of the W.C.N.P. consists mainly of the Communities on Dune Sands, of which communities G, H and L covers by far the largest areas, and the Marsh Communities (variations of communities M & N) all around the lagoon except where a rocky coast occurs.

The adjacent farming area is more or less homogeneous, with vegetation corresponding to that on the sand dunes within the borders of the W.C.N.P., and with plant communities G, H & L dominant. Boucher & Jarman (1977) gave a detailed description of all these communities.

Coastal-shelf Communities

A - *Atriplex-Zygophyllum* Coastal-shelf Dwarf Shrubland

Located on the coastal-boulder shelf, this community is very exposed to salt spray and on-shore winds. Two strata of vegetation can be distinguished above the underlying granite-derived soil: a 5 - 10 cm tall mat-like cover with as chief components the deciduous succulents *Zygophyllum cordifolium*, *Atriplex semibaccata* and *Mesembryanthemum crystallinum*, and a 50 - 100 cm tall upper layer of branched drought-deciduous succulent shrubs represented by the community dominants *Zygophyllum morgsana* and *Senecio floribunda*. Total canopy cover ranges between 30-85 % depending on the extent of grazing by stock in the past.

B - *Pelargonium-Muraltia* Coastal-shelf Dwarf Shrubland

This community occurs on Fernwood Form sandy soil which accumulates at the foot of granite outcrops. It consists of low succulents and dwarf shrubs, 15 - 50 cm tall, and a grassy element in which *Ehrharta calycina* is prominent.

Communities on Granite Soils

The rocks on the granite outcrops support a sparse succulent and bulbous flora which is unique and with a number of endemic species. Weathering products of the granites form a deep, relatively fertile soil, but the low annual rainfall prevents a high primary production.

C - *Galenia-Senecio* Hillside Closed Dwarf Shrubland

This community occupies the steep granitic hill slopes between 3 - 40 m altitude, with a south-easterly aspect. In the understorey is a grassy element and a 15 - 35 cm tall succulent element with *Ehrharta calycina* the dominant species. The upper stratum, 50 cm tall, is dominated by the shrubs *Rhus glauca*, *Zygophyllum morgsana* and *Tetragonia spicata*, with the canopy cover varying between 50 - 75 % during the dry season.

D - *Ehrharta-Maurocenia* Hillside Dense Shrubland

This community occupies the south-eastern to south-western slopes of the granite hillsides, around the bases of granite rock domes where there is relatively more rainfall run-off. It enjoys protection from the northern and north-westerly winds. The community has three strata in its most developed form: the herbaceous layer varies in height between 25 - 50 cm with annuals prevalent during the wetter winter and spring months. The shrub layer, 1.0 - 2.0 m tall, consists of a mixture of leathery-leaved evergreen - and drought-deciduous shrubs. Leathery-leaved evergreen trees, 1.2 - 4.0 m tall, occur in clumps and have a closed canopy. This layer is at some places absent, probably due to removal by man and grazing by goats. During autumn the total canopy cover is 70 - 95 %.

Communities on Limestone Soils

E - *Nenax-Maytenus-Zygophyllum* Limestone Evergreen Shrubland

This community is found on exposed limestone ridges or outcrops on hillslopes that face predominantly south-west, west to north-west, or to the sea, and is exposed to on-shore winds. It is composed of two strata: a 5 - 25 cm high stratum dominated by *Zygophyllum cordifolium* and *Ehrharta calycina*, and an upper stratum (0.8 - 1.2 m) dominated by *Rhus longispina*, *Senecio floribunda* and *Zygophyllum flexuosum*. The vegetation has generally been trampled and grazed heavily by introduced and reintroduced antelope. Annuals are present during winter and spring, especially in the very disturbed areas .

F - *Pteronia uncinata* Limestone Evergreen Dwarf Shrubland

This community is confined to exposed limestone ridge crests on low rises on the lagoon side of the Langebaan peninsula. The very shallow soil probably prevents the *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland community from occurring on these sites in a complete form. The dominance of the 30 - 50 cm tall ericoid shrub, *Pteronia uncinata*, is the most important floristic feature of this community.

Communities on consolidated and unconsolidated dune sands

Most of the isthmus south of Langebaan Lagoon is occupied by coastal dunes of greatly varying elevation and degrees of stabilization by vegetation (Visser & Schoch 1973).

G - *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland

This community generally occupies gullies, lower sides of hill slopes, depressions or shallow drainage lines on stable dunes, with a west or south-west aspect, along the isthmus south of Langebaan Lagoon. The soil belongs to the Fernwood and Mispah Soil Forms and varies in depth, on a limestone base. The *Maytenus-Kedrostis* community generally has a dense single stratum of 1.25 m tall spiny evergreen and drought-deciduous shrubs whose crowns generally interlock. Dwarf shrubs and annuals can be found in openings caused by disturbances such as grazing. The creepers *Kedrostis nana* and *Cynanchum obtusifolium* occur frequently.

H - *Willdenowia striata* Consolidated-dune Dense Evergreen Restioid Shrubland

This community occurs on the consolidated dune sands generally inland of the *Maytenus-Kedrostis* community, on undulating hill slopes, in shallow drainage lines, or on the junction between exposed calcrete and the fixed-dune formations. The soil is deep and generally of the Clovelly Form. The community has a single stratum of vegetation and randomly scattered clumps of *Willdenowia striata*, 1.0 m tall and approximately 1.0 m in diameter, give the community its distinctive restioid character. Canopy cover averages ca 80 %.

I - *Thamnochortus spicigerus* Dune Dense Tall Restioid Herbland

This community marks the division between the consolidated-dune communities and the littoral-dune communities and occurs in scattered patches without any obvious ecological pattern. Larger patches have been mapped, while smaller patches have been incorporated into the communities in which they occur. Dominant species are *Thamnochortus spicigerus*, *Limonium perigrinum* and *Ehrharta calycina*.

J - *Hermannia pinnata* Littoral-dune Dwarf Succulent Shrubland

This community is situated in the dune valleys and slacks and on the exposed ridges of the dune system extending to the south-west on the ocean side of the Langebaan Lagoon. All areas covered by this community are subject to heavy grazing. The soils are deep and sandy, belonging to the Fernwood Form. A 5 - 15 cm tall, dwarf succulent shrub layer and a 30 - 50 cm tall, dwarf shrub and grass layer are distinguishable. The dwarf shrubs are sometimes evergreen or drought-deciduous and succulence is common. The grasses tend towards clumping and annuals are common and may dominate the community during spring and early summer. Mean canopy cover is 60 %, but varies from 30 - 95 % depending on the extent of grazing. Dominant species are *Ehrharta villosa*, *Limonium perigrinum*, *Ehrharta calycina* and *Ruschia geminiflora*.

K - *Didelta-Psoralea* Littoral-dune Open Grassland

This community occupies the undulating crests of the lines of dunes closest to the sea on the isthmus of the Langebaan peninsula. The substratum is typically deep undulating sand (Langebaan Series) that dominates the landscape. Dwarf shrubs and grasses are common: The community is typically open or patchy. In the patches canopy cover varies between 85 - 95%. Dominant species are *Eragrostis cyperoides* and *Senecio elegans*.

L - *Metalasia-Myrica* Dune Dense Evergreen Ericoid Shrubland

This community occurs on the unconsolidated to consolidated shifting dunes to the south and east of the Langebaan lagoon, and is the only community in the study area representative of Acocks's (1975) category of Coastal Fynbos. It occurs on Mispah Form (Kalkbank Series) soils or on deep regic sands. The upper stratum (1.0 - 1.6 m) is formed mainly by the ericoid-leaved *Metalasia muricata* and *Passerina paleacea*. The lower stratum (15 - 25 cm) is formed mainly by *Restio eleocharis*, *Myrica quercifolia* and *Carpobrotus acinaciformis*. This stratum is formed by a mixture of ericoid-leaved, graminoid, resioid and succulent plants. The canopy cover varies between 65 and 85 %.

Marsh Communities

"Marshes are those tracts of soft wet land which are covered wholly or partially with water" (Carpenter 1938). Marsh conditions occur around the whole of the Langebaan lagoon, except where a rocky coast occurs. *Arthrocnemum pillansii* var. *pillansii* is the differential species for the marsh communities in which it is also often the dominant species.

M - *Juncus kraussii* Dense Sedgelands

The *Juncus kraussii* Sedgelands can be subdivided on the basis of dominance in :

a) *Juncus kraussii*-dominated Form
   Nidorella-Senecio Mixed Form

b) *Cliffortia strobilifera*-dominated Form

c) *Typha capensis*-dominated Form

d) *Phragmites australis*-dominated Form

Considerable variation occurs floristically in each of these communities and they are considered to be variations of the *Juncus kraussii* Sedgelands. These communities are restricted mainly to the south-eastern borders of the lagoon where a high freshwater table is present.

a) *Juncus kraussii*-dominated Form: *Juncus kraussii* forms fairly extensive dense stands with *Arthrocnemum pillansii* var. *pillansii* the only accompanying species. The canopy cover of this 60 cm tall spiky stands is very dense (100%).

Nidorella-Senecio Mixed Form: This is probably the more typical form of the *Juncus* Sedgelands, consisting of a mixture of reeds, sedges and shrubs.

b) *Cliffortia strobilifera*-dominated Form: A very similar species composition to the *Juncus kraussii*-dominated Form, but differs in the occurrence of and dominance by 3.0 m tall *Cliffortia strobilifera* individuals.

c) *Typha capensis*-dominated Form: A very similar species composition to the *Juncus* Form, but dense stands of *Typha capensis* individuals reaching 2.0 - 3.0 m in height dominate the community.

d) *Phragmites australis*-dominated Form: *Phragmites australis* (3.5 m tall) can form dense stands with *Scirpus triqueter* as the only accompanying species. These stands usually occur where there is free surface water. In slightly higher lying areas the other species of the *Juncus kraussii*-dominated Form also occur.

N - *Chenolea-Salicornia* Dwarf Succulent Shrubland

This community occurs widely around the Langebaan lagoon in the zone exposed during low tides and flooded during spring tides. It appears mainly as a 5 - 15 cm tall thick mat of scandent divaricate succulents covering 90 - 100% of the substrate. In shallower water, the succulent mat covering the substrate is formed by the 5 - 15 cm tall *Limonium-Disphyma* Form. The *Spartina-Trilochin* Form is about 25 - 35 cm tall and in slightly deeper water forms a pure grassland.

Old Lands

Tilling of the granitic and sandy soils in the general area is practised mainly for wheat production. The sandy soils are often strip-ploughed to reduce wind erosion. Old fallow lands at P.N.R. and in the rest of the W.C.N.P. usually support 1 m tall stands of *Exomis microphylla* var. *axyrioides* with a 10 cm tall understorey of *Atriplex semibaccata*, *Schismus barbatus* and *Pentzia pilulifera*.

(E) FAUNA

Although man has had some influence on the vegetation of this area for a very long time (mainly through grazing and man-made fires to improve grazing) (Hey 1977), most of the area within the W.C.N.P. is still fairly undisturbed as far as the vegetation as well as the natural fauna is concerned. Avery, Rautenbach & Randall (1990) gave an annotated check list of the extinct and recent natural and introduced land mammal fauna of the Park. The whole spectrum of smaller carnivores, as well as their smaller mammalian prey, is still present. Because of the heterogeneity of the study area and influence of man, varying species are present in different numbers in the various habitats.

In 1964, ploughing was stopped on the cultivated fields in the P.N.R. and various previously occurring and exotic game introduced to the area by the Oude Post Syndicate. In 1969 the P.N.R. was proclaimed as the third private nature reserve in the Cape Province. Before this area was incorporated in 1986 into the W.C.N.P. as a contractual Park under management of the National Parks Board, the following numbers of big game were introduced to the *ca* 3 000 ha area (the Donkergat military area was then still a part of Postberg):

15 Blesbok (*Damaliscus dorcas phillipsi*)

6 Bontebok (*Damaliscus dorcas dorcas*)

5 Black wildebeest (*Connochaetes gnou*)

8 Blue wildebeest (*Connochaetes taurinus*)

9 Burchell's zebra (*Equus burchelli*)

10 Eland (*Taurotragus oryx*)

4 Gemsbok (*Oryx gazella*)

5 Kudu (*Tragelaphus strepsiceros*)

32 Mountain reedbuck (*Redunca fulvorufula*)

5 Red hartebeest (*Alcelaphus buselaphus*)

38 Springbok (*Antidorcas marsupialis*)

Most of these species multiplied (Table 1.7) but some of them died out, was shot or resold.

Historical and archaeological evidence suggest that the following species occurred here in earlier times:

Spotted hyaena (*Crocuta crocuta*)

Leopard (*Panthera pardus*)

Lion (*Panthera leo*)

Elephant (*Loxodonta africana*)

Black rhinoceros (*Diceros bicornis*)

Red hartebeest (*Alcelaphus buselaphus*)

Exotic species found in the W.C.N.P. (Avery *et al*. 1990) were Burchell's zebra, black- and blue wildebeest, bontebok, kudu, mountain reedbuck, springbok, house mouse (*Mus musculus*), and the house rat (*Rattus rattus*).

According to the Percy FitzPatric Institute of African Ornithology at the University of Cape Town (unpublished pamphlet), 250 bird species occur in the W.C.N.P., or 28% of the total number of bird species within the Southern African Subregion. The Langebaan lagoon is known internationally for its wader and seabird populations. Although many of the bird species occur only as vagrants, a great variety of species can be seen in the Park, especially during the summer months when local bird populations are supplemented by migrant species of the northern hemisphere.

Branch (1988) listed the reptile species probably present in the study area. Especially the following are frequently seen:

Snakes: Cape cobra (*Naja nivea*)
Puff adder (*Bitis arietans*)
Tree snake (*Dispholidus typus*)
Mole snake (*Pseudaspis cana*)
Skaapsteker (*Psammophylax* sp.)

Lizards: Cape skink (*Mabuya capensis*)
Cape girdled lizard (*Cordylus* sp.)
Gecko (*Pachydactylus labialis*)

Tortoise: Padlopertjie (*Homopus* sp.)
Rooipensie (*Chersina angulata*)

Table 1.7 Counts of the bigger mammals and ostriches present in the West Coast National Park, 1990 - 1991.

	April '90	February '91	November '91
Black wildebeest	2	1	1
Blue wildebeest	83	113	156
Bontebok	29	49	51
Eland	87	95	107
Burchell's zebra	8	7	8
Gemsbok	28	20	19
Kudu	> 12	> 15	> 15
Springbok	80	48	44
Ostrich	>98	132	156

(F) HISTORY

The W.C.N.P. was proclaimed on 30 August 1985. In 1989 the surface area of the W.C.N.P. covered 18 700 ha with 5 700 ha contributed by the Langebaan lagoon, including the intertidal and Admiralty zones, and the islands Schaapen, Malgas, Marcus and Jutten. The total area was subsequently increased by the addition of the farms Geelbek, Bottelary, Seeberg, Schrywershoek, Flamingo Farms, a section of Langefontein, Abrahams Kraal, Wilde Varkens Vallei and the sand dune area of De Hoek, Yzerfontein, Papenkuilsfontein to a total surface area of some 24 000 ha in 1989/1990..

In 1845 five Franschhoek farmers bought the Postberg area. Every year untill 1940, they and their descendants moved here from 15 May to 15 September with *ca* 500 head of cattle, sheep and goat from Franschhoek for winter grazing (Hauman pers.comm.). After 1940 sheep and goat were grazed here throughout the year and wheat was planted. As from 1964, ploughing was stopped and the lands left to recover. The mining of phosphates, grazing, and agricultural and other human activities led to disturbances in parts of the Postberg area. Since 1986 the conservation of the Postberg Nature Reserve has been conducted by contractual agreement between the National Parks Board and the members of the Oude Post Syndicate.

The Donkergat area at the northern extreme of the peninsula was part of the Postberg-area farms until the early 1960's when the South African Defence Force (S.A.D.F.) expropriated this area (Hauman, pers.comm.). Since then, this area has been managed as a conservation area by the S.A.D.F.

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CHAPTER 2

MATERIAL & METHODS

A) PREY AVAILABILITY

To gauge possible prey preferences of caracal, the availability of small antelope, hares, hyraces, rodents and larger birds and mammal & bird carcasses available to scavengers, were determined. No counts were done on smaller bush-preferring birds and reptiles, but their breeding seasons and probable availability were incidentally observed through sighting of new nests, eggs and young; in addition the literature were consulted. Seasonal fluctuations in prey group sizes were also noted together with the diet of some other medium-sized carnivores, apart from caracal, to ascertain possible interspecific interactions, and to help explain the spatial and social behaviour of these other species.

Small antelope, hares & bigger birds:

Steenbok (*Raphicerus campestris*), Grysbok (*Raphicerus melanotis*), Duiker (*Sylvicapra grimmia*), hares (*Lepus capensis* & *Lepus saxatilis*), francolin (*Francolinus capensis* & *Francolinus africanus*), guinea-fowl (*Numida meleagris*) and quail (*Coturnix coturnix*) were counted every month along fixed transects (Fig.2.1) set out at random in predetermined areas representative of the whole W. C. N. P. These counts yielded data on differences in prey densities between plant communities, prey activity patterns, seasonal changes in prey density, times of year when most young of various prey species were seen and seasonal habitat preferences and changes in group size of each species.

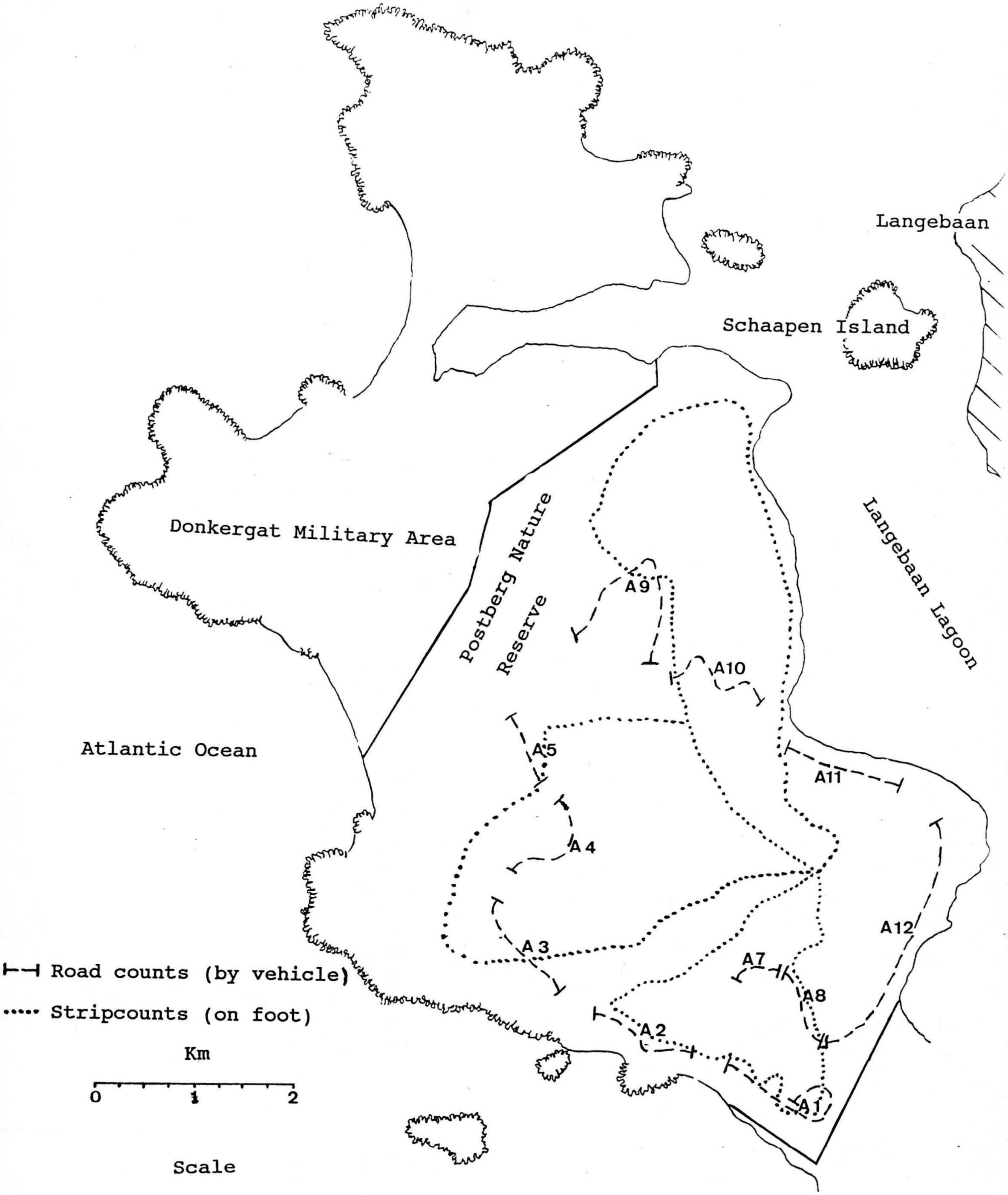

Figure 2.1: Location of Road and Strip counts undertaken at Postberg Nature Reserve during prey availability studies, 1990-1991. For details, see Table 2.1.

Counts were done in three ways: (a) night counts, (b) first light counts and (c) strip counts at starting at one hour after sunrise (Dice 1941; Bothma 1986).

(a) Night counts: these were undertaken with a 300 000 candlepower spotlight over marked distances along narrow gravel roads, from sunset to about 1.5 h thereafter. All night counts were done from the top of a Toyota 4x4 LDV, travelling at a constant speed of *ca* 25 km/h. Due to logistic constraints only one night count was undertaken every month within 3 - 10 days before full moon, when it did not rain, the wind was not stronger than 4 m/s, and the temperature was around the mean for that specific month. Counts were always done in the same direction and at the same speed.

The total area (Table 2.1) of each transect was calculated as follows: Total length of transect x mean width of transect (or mean distance perpendicular from the road). This width (mean distance) differed in the different plant communities, and for each community was estimated by three observers as the mean maximum distance from the road that any of the above mentioned animals could be clearly identified. Although there was a marked seasonal difference in the height and density of the vegetation, this did not have a marked effect on the visibility of these animals in the strips counted at night, and the width for each transect was therefore kept constant throughout the year. The method of Bothma (1986) and Dice (1941) where width was taken as the mean distance over which the animals were sighted, could not be applied as the total distance travelled in each plant community (Table 2.1) was relatively short (min=1.0 km; max=4.7 km) and the number of animals counted, few (0 - 4).

(b) First light counts: These were undertaken on the mornings after night counts, just before sunrise and along the same routes (Fig.2.1; Table 2.1), in the same direction and at a constant speed (30 - 35 km/h). Other constants as far as abiotic factors were concerned were: no rain or fog present, wind not stronger than 4 m/s, and temperatures around the mean for the specific month. Although it was easier to distinguish animals further away from the road during the day, animals clearly outside the width used for night counts were ignored to enable a comparision of night and day counts.

(c) Strip counts: Specific predetermined routes were walked every month at fixed times of the day and the occurrence of prey mapped on photostated 1:40 000 maps during the middle two weeks of each month, starting at precisely 1 h after sunrise and continuing for *ca* 2 hours. These routes traversed all the plant communities at the P.N.R. and took three mornings per month to complete (total length = 19.625 km - Table 2.2). Transects were always walked in the same direction, never against the rising sun, never in rain or fog, with the wind speed less than 4 m/s and with the temperature around the mean for that month. Transect width were taken as the mean distance from the transect line at which individuals of species counted would get startled and flee, or could for *ca* 95% of the time be seen and identified. Estimating these widths was very subjective, but keeping them constant throughout the year minimized errors as the same errors occurred throughout. Seasonal changes in vegetation could be ignored as it made little difference to the widths. The widths differed between the various plant communities (Table 2.2). Guinea-fowl, francolin and quail could only be counted in First light and Strip counts as they usually did not move and could not be seen in the dark.

Hyrax

Hyrax were counted during winter and summer using the Colony plotting Method (R. Davies, in litt.), which is based on the relative constancy of dassie group size. The locations of all dassie groups seen in the P.N.R. (n=16) throughout the study period were mapped. The group sizes of 50% of these groups (n=8; chosen at random) were counted in Nov./Dec.1990 and again in June/July 1991.

Table 2.1 Areas covered during night and first light prey density counts at (A) Postberg and (B) the rest of the West Coast National Park. For location of routes, see Fig.2.1. Plant communities are explained in "Study Area".

Route	Plant community	Length (km)	Width (m)	Area per community sampled (ha)
A 1	I & J	3.2	25	
A 2	I & J	1.5	30	12.5
A 9	A	1.5	20	3.0
A 11	C	1.5	50	7.5
A 12	G	1.0	25	2.5
A 8	D	1.1	25	
A 10	D	1.5	30	7.8
A 4	E	2.0	30	
A 5	E	0.5	10	6.5
A 3	Old Fields	1.3	50	
A 7	Old Fields	0.5	50	9.0
B 15	Na	2.9	50	14.5
B 17	Mb & Mc	1.4	30	4.3
B 16	G	2.1	30	6.2
B 18	H	1.4	20	2.9

Hyrax were counted from a position with an unobstructed view from just before sunrise. Counts took *ca* 30 - 45 min/colony. Only one colony was counted/day and only clear mornings were selected for counts as weather has a profound effect on dassie emergence

(R. Davies, pers.comm.). Hyrax were only present on the granite hills of the P.N.R. and on one small koppie (Seeberg) in the rest of the W.C.N.P. They were only counted in the P.N.R. to obtain density figures and group sizes, which can be compared with hyrax density elsewhere, e.g. in the Karoo National Park where hyrax is a major prey item of caracal (Palmer & Fairall 1987). Single animals (not group-living) were ignored by this method; they comprise less than 2% of the population in the Karoo National Park (R. Davies, pers. comm.).

Rodents

Small mammal trapping was undertaken to determine the diversity of rodents and shrews in different plant communities, and at different altitudes and slopes within the same plant community; to compare species richness within (seasonal) and between different plant communities; to determine habitat preferences, and seasonal fluctuations in density of different species.

Absolute densities of rodents

Absolute densities were determined in four different plant communities (habitats) within the P.N.R.; in two other communities in the rest of the W.C.N.P., and in two communities on adjacent farms (Table 2.3; Fig.2.2). At the six sites within the W.C.N.P., traps were put out during all four seasons, while communities on the farms were sampled only once, during spring 1991. This allowed seasonal comparison of small mammal densities within the communities sampled inside the W.C.N.P. Trapping was done by the Capture, Mark (toe-clipping), Recapture Method (Dice 1941). Fifty Sherman live traps (230 x 90 x 75 mm) were set in a grid (5 lines of 10 traps each) in each community, spaced 10 m apart on each line, with lines also 10 m apart. A mixture of peanut butter, oats, golden syrup and cooking oil was used as bait. Traps were checked and rebaited two or three times a day, depending on the trapping success and the weather conditions (rodents

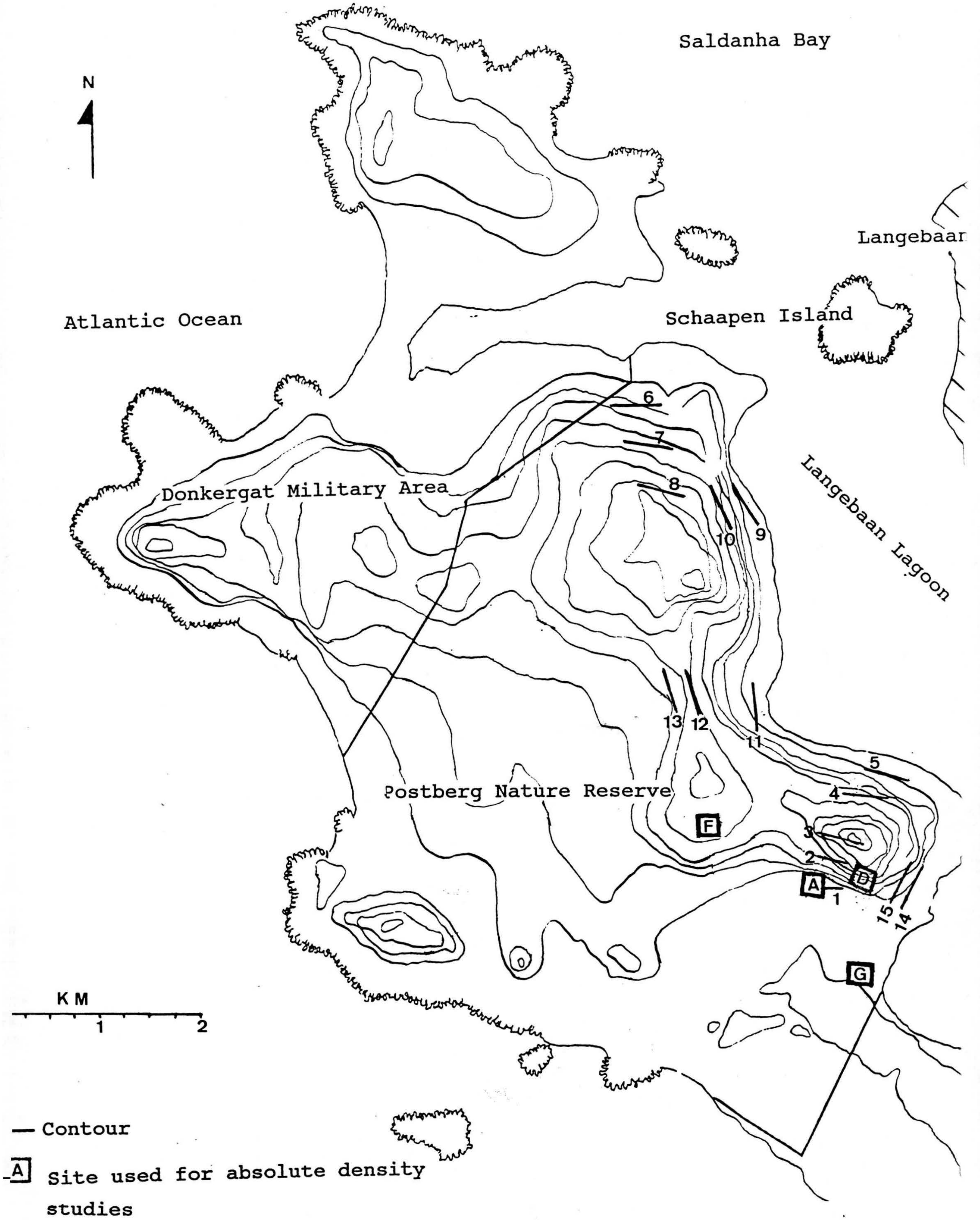

Figure 2.2: Sites at which rodents were trapped at Postberg Nature Reserve, 1990-1991.

died when confined in traps for long periods in cold, wet or very warm weather). Traps were usually checked 2 h after sunrise, at noon, and 1 h before sunset. A trapping session continued until recaptures exceeded 90% of captures for three consecutive times that the traps were checked (Cavallini & Nel 1990).

Rhabdomys pumilio (the most abundant rodent caught) density for each site was calculated as follows: (100 divided by the mean recapture percentage of the last three trap periods) x (the total number of *R. pumilio* caught until then divided by the "Trapping area" - see below). *R. pumilio* mean home range widths in each of the six vegetation types were attained using the longest rectilinear distances between traps in which a *R. pumilio* individual was caught. A distance of half the maximum home range width of the individual with longest rectilinear distance in a particular trapping site during a particular trap session was added to each of the four sides of the 40 m x 90 m plot containing the traps, and this total area taken as the maximum "Trapping area". Although the sizes of home ranges probably varied between the seasons, this method of calculating "Trapping areas" was only done once for each plant community (March 1990) and thereafter only numbers of rodents caught at trap sites were compared between seasons. Trapping sessions at a site lasted for between 5 and 10 days. Immigration, emigration, natality and mortality were not determined. During spring, rodent numbers increased and more young were caught; longer trapping sessions were then needed. During the spring 1990 trapping session in plant community G, the recapture percentage never reached 90% during three consecutive checks of traps within a 10 day trapping session. After 10 days trapping was discontinued as the trapping success was low (max = 46%); density was calculated in the usual way. All trapping within a season was done in as short a time span as possible in order to compare densities between plant communities at more or less the same time. The longest time that elapsed was 34 days from commencement of trapping until the last trap in the last habitat type sampled, was closed.

Table 2.2 Areas covered during strip counts of prey animals in the P.N.R. area of the W.C.N.P. For location of transects see Fig.2.1. For an explanation of the plant communities' see "Study Areas".

Plant community	Transect Length (km)	Width (m)	Area per Community (ha)
A	4.20	50	21.0
C	2.67	60	16.0
D	1.25	40	5.0
E	4.50	60	27.0
G	1.00	40	4.0
I & J	2.13	80	17.0
Old Fields	3.875	100	38.75
Total	19.62		128.75

Table 2.3 Sites at which rodents were trapped in the study area (W.C.N.P. and adjoining farms) to compare their absolute densities in different plant communities. For location of sites at Postberg Nature Reserve see Fig. 2.2.

Site no.	Plant community	Height a.s.l. (m)	Gradient
1	F (P.N.R.)	127	0-15 S
2	D (P.N.R.)	128	0-15 SSW
3	A (P.N.R.)	20	0-30 S
4	G (P.N.R.)	5	0
5	Mc (Marsh)	1	0
6	H (Sanddunes)	20	0
7	G (Farm Yzerfontein)	20	0
8	H (Farm Blombos)	30	0

Otomys unisulcatus, which together with *Rhabdomys pumilio* was the most important rodent prey species in the diet of P.N.R. caracal, was not easily trapped. Their relative densities could only be determined indirectly, and compared, by counting their lodges. According to Vermeulen & Nel (1988), each lodge harbours one *O. unisulcatus* individual on average. *O. unisulcatus* lodges were counted during March (autumn) and September (spring) at the six trapping sites in the W.C.N.P. to compare densities in the various habitat types, and to note seasonal changes in densities.

Relative densities of rodents

Between 25 May and 11 June 1991, 15 trap lines (190 m long, 20 traps/line) were put out at various lower slopes, midslopes, upper slopes and plateaux in communities A, C, D, and E to compare relative rodent densities, species diversity and trapping success at different contours in the P.N.R. area (Fig.2.2; Table 2.4). Traps were spaced 10 m apart on each line and traplines were at least 200 m apart and parallel to each other where possible, along the contours. Trapping was continued until the recapture percentage was >90% during three consecutive checks of traps (see "Absolute densities").

During March 1990 a preliminary trial was run on the southern slope of Konstabel Kop (Plant community A). Ten traps were put out in each transect and a ratio of *ca* 100:50:10 captures was obtained for transects on the lower slope, midslope and upper slope respectively. According to the Chi-Square Goodness-of-Fit Test, eleven *R. pumilio* caught at the bottom slope will be enough for a 100:50:10 ratio to prove significant

Table 2.4 Transects for rodent trapping at various contours in plant communities at the P.N.R. Nature Reserve. For location of transects see Fig. 2.2.
(B = bottom slope; M = midslope; U = upper slope; P = plateau; S = south; N = north; E = east; SE = south east).

Transect no.	Date (1991)	Plant community	Height a.s.l. (m)	Slope and aspect
1	27-29 May	A	20	B S
2	27-29	A	70	M S
3	27-29	A	120	P
4	27-29	A	70	M N
5	27-29	C	20	B N
6	05-08 June	A	20	B N
7	05-08	A	70	M N
8	05-08	A	140	U N
9	05-08	C	10	B E
10	05-08	C	70	M E
11	09-12	E	20	B E
12	09-12	E	100	P
13	09-12	E	70	B W
14	09-12	D	15	B SE
15	09-12	D	70	M SE

differences in densities between trap lines. It was therefore calculated that 20 traps/line should be enough to show significant differences, if any, in rodent densities at different trap lines as an area of at least 0.2 ha (200 m x 100 m) will be covered and more than 20 individuals will get caught at the bottom slopes.

Birds & Reptiles

Breeding seasons for the island-breeding sea birds and the bush-preferring birds as well as the appearance of young, were casually observed.

Reptiles become more active and thus more available to caracal in the warmer summer and autumn months. Their eggs also hatch during this warmer period (Patterson & Bannister 1987).

Carrion

Previous studies indicated that caracal do not scavenge and very seldom return even to its own kills. Nevertheless, all reasonably fresh carcasses of small and big game encountered in the veld were recorded, although they were not searched for on fixed transects. Absolute availability of carrion was thus not established, but revisiting carcasses showed whether caracal or other animals had fed on it. Carcass counts also reflected the seasonal condition and time of highest mortality of possible prey species. Sea birds, e.g. cormorants and kelp gulls, for example have a much higher mortality during their breeding season in summer (Avery & Underhill 1986) than at other times. Monthly counts of sea bird carcasses along "Sixteen mile Beach", the western border of the W.C.N.P., is undertaken by the African Seabird Group (Avery pers.comm.).

Sprinbok

The impact of caracal predation on the declining introduced springbok population at P.N.R. was investigated by counting them at least once a week between February 1990 and March 1991. After that, springbok were counted at least twice a month until December 1991. Additional counts were done at least every second day during the period when most springbok carcasses were found (April-June 1990 & 1991). Springbok were counted from vehicles and on foot with the aid of binoculars, at dawn and before they left the old lands where they had spent the night. The number of groups, group sizes, the sex ratio in groups, age of individuals (estimated from size and horn development - Bothma 1986), and number of young lambs were noted. At the same time the old fields were thoroughly scanned for carcasses. Carcasses were often located by noticing the kelp gulls and pied crows pecking at them. A dead springbok was classified as a caracal kill if there was positive evidence of an attack (Messier, Barrette & Huot 1986), or if signs of haemorrhage and canine or claw wounds were present on the head or neck of the carcass (Gosling 1984; Koehler & Hornocker 1989; Hanekom pers.comm.). Some springbok died of natural causes and were regarded as carrion if found without any sign of having been killed by caracal.

B) DIET

The diet of caracal, small Cape grey mongoose (*Galerella pulverulenta*), water mongoose (*Atilax paludinosus*), yellow mongoose (*Cynictis penicillata*) and wild cat (*Felis lybica*) in the W.C.N.P. was determined through scat analysis, stomach analysis and the location of carcasses eaten by caracal. Although not a 100% accurate reflection of the proportion of food ingested, results of scat analysis proved the most trustworthy of the three in this study as a much bigger sample could be gathered.

Scat Analysis

Different prey items may pass at differnt rates through the gut of a carnivore (Bowland & Bowland 1991) and the same prey individual may, therefore, be represented in more than one scat (Weaver & Hoffman 1979). As the various prey types digest at different rates this causes an under estimation of highly digestible prey, relative to prey leaving a large proportion of indigestable remains (Putman 1984). It is also possible that remnants of three *R. pumilio* individuals (for example) can be present in one caracal scat without the analizer knowing it. The accuracy of ascertaining the diet of a predator by the Percentage of Occurrence or the Percentage of Volume Method is thus debatable. In this study, no one method of presenting results has been considered to reflect accurately the relative importance of the wide variety of prey species of the predators. Results have therefore been presented in a variety of ways (Grobler 1981, Kruuk & Parish 1981, Moolman 1984, Palmer & Fairall 1988,) so that the biases of each method could be studied, and to enable comparison of results with other studies.

Food niche overlap between species pairs was calculated following Pielou (1972).

Collection of scats

All mammalian predator scats found were collected on a monthly basis in four areas: (1) freshwater marshes, (2) sand dunes, (3) P.N.R. and (4) farming areas outside the W.C.N.P. Extensive areas were traversed on foot to obtain a large sample size. Only caracal, Water mongoose, Cape grey mongoose and yellow mongoose scats were encountered in large enough numbers to warrant analyses. Water and yellow mongoose scats were found in specific latrine areas or near their burrows. Scats of Cape grey mongoose and caracal were difficult to find in the dense vegetation. Bat-eared fox (*Otocyon megalotis*) scats were found on the old lands, but were not analyzed for this study. Scats of African wild cat (*Felis lybica*), genets (*Genetta genetta & G. tigrina*) and

Cape fox (*Vulpes chama*) were seldom found due to burying, or the low density of these carnivores in the study area. Scats were in the field identified as belonging to a specific carnivore on the basis of their length, diameter, shape, number of segments in a scat, where and how the scat was deposited, whether it was covered with sand, found near a carcass or a fresh spoor, the type of prey (rodent, bigger mammal, bird, reptile, etc.) apparent from a cursory examination, the way in which the prey had been eaten (e.g. the contents of the scat being finely chewed, showing lots of bones, etc.), the colour of the scat, whether it was single, found among other scats or in a latrine and, if a hair of the predator could immediately be identified on the surface of the scat. The final analysis was done in the laboratory under a stereo-microscope. A scat was regarded as unidentified and discarded if it did not contain any predator hair. As the method of identifying scats by the presence of predator hair is easy, fast and unambiguous and enough scats were collected for significant conclusions, no other method was used.

In the veld, scats were separately put into paper bags and the probable carnivore species responsible, date, habitat type (area), description of the immediate area where collected (e.g. "under bush", "in footpath", "open on rock", etc.), how scat was deposited, buried, lying open or in an obvious latrine, number of sections each scat was found in and number of scats found together, were written on the outside. Scats were air dried for later analysis.

Analysis of scats

In the laboratory, the length and thickness of each dried scat were measured. Scats were teased apart and smaller items (eg. remnants of arthropods, rodent teeth, hair and reptile scales) were identified (to species level where possible) under a stereo microscope (Wild M5D) mostly at 12x magnification. Smaller scats, e.g. those of *G. pulverulenta* and *C.*

penicillata which contained relatively smaller prey species, were also teased apart under a stereo microscope.

Hair, teeth, feathers, remnants of arthropods and reptilian scales were identified by comparing it to a reference sample collected from the study area, specimens in the John Ellerman Museum at Stellenbosch University or the South African Museum in Cape Town. Guard hairs were identified macroscopically by length, colour and colouration (eg. presence of coloured bands), and microscopically (dissecting and electron microscopes) for finer detail of hair structure using the method of Faliu, Lignereux & Barrat (1979). With this method, an imprint of the hair is made in nail varnish and the hair identified as belonging to an individual of a certain species by its scale patterns (Keogh 1983 a & b). Scale patterns of guard hairs are remarkably constant and species-specific (Day 1966; Dreyer 1966; Keogh 1983 a & b). The varnish is thinly spread on a microscopic plate, the hair neatly put on the varnish and again carefully removed after 5 - 8 minutes. This was done by carefully taking the hair at one end and slowly pulling it upwards. As it comes free, the imprint stays behind leaving a clear scale pattern for the whole length of the hair. This scale pattern was compared to that of imprints made of reference material from the museums, as well as to photomicrographs of reference hair (Keogh 1983 a & b).

Stomach analysis

Collection

Only a small number of caracal stomachs (n=7) was available for analysis, too few to reach any conclusions. Almost all these stomachs were collected from caracal caught in traps and were empty stomachs preserved in 10% formalin and provided by Mr. S. Hanekom (Problem animal Control Officer, the then Swartland Divisional Council, C.P.A.). The stomach of only one wild cat, which had probably been run over by a vehicle, was analysed.

Analysis

Both stomach and colon were emptied and their contents separately spread open on a flat surface. It was noted whether the stomachs were full, half full, contained very little material or were empty. The percentage contribution by each different prey item to the volume of the total contents was estimated. Prey species were identified in the same manner as for scats.

Carcasses

Carcasses were not searched for on a regular basis on fixed transects, but were casually observed while doing fieldwork (e.g. prey counts and collecting scats). During 1990, the first year of the study, ca. the same amount of time was spent each month doing fieldwork. The number of carcasses found each season would then indicate the time of year when mortality of certain prey species was highest and whether they had been captured and/or eaten by caracal or any other carnivore.

Throughout the first 13 months of fieldwork, springbok at P.N.R. were counted at least once every week. During the "season" when springbok were most heavily preyed upon, as well as during the main lambing season, counts were done at least every second day to locate carcasses and new-born lambs. To determine whether caracal were preferentially selecting male or female springbok, the sex ratio of the population from which the kills were made was taken into account. To do this, the selection index (H-A)/(H+A) (Fitzgibbon 1990) was used where H is the percentage of springbok of that sex in the sample of hunted animals and A is the proportion of springbok of that sex available to be hunted. A negative value for the selection index reflects an avoidance of springbok of that sex while a positive one reflects a preference. As springbok lambs could get dragged away from the old lands, or got caught by other predators as well, it was difficult to estimate the percentage of lambs taken by caracal although addition of lambs to the population (births) and missing lambs (deaths) were used in food availability studies. The age of all carcasses found were determined (tooth and horn development - Bothma 1986). Only data of springbok definitely killed by caracal were used in the same selection index (Fitzgibbon 1990) as above to determine whether caracal were preferentially hunting springbok of a certain age class. Age classes were taken as: <9 months (sub-adults), <24 months (adults), 24 months and older (older part of the population).

C) RADIO-TELEMETRY

Two male and three female caracal were radio-tracked intermittently over a period of 21 months (April 1990 - December 1991) to determine home range size, territory size and areas of overlap, activity patterns, foraging behaviour and habitat choice, dispersal of young and also to obtain information on the social structure and behaviour of caracal. These results were all correlated to food availability (the density, distribution and size of prey are some of the main factors affecting e.g. the size of caracal territories (Moolman 1986; Brand 1990).

Trapping of caracal

Traps used

Two types of wire mesh box traps were used for trapping caracal. Both types were based on the model of Schellingerhout (1978) which works with a treadle which is connected to the single trap door through a lever action. The main difference between the two types was the way in which the doors closed,

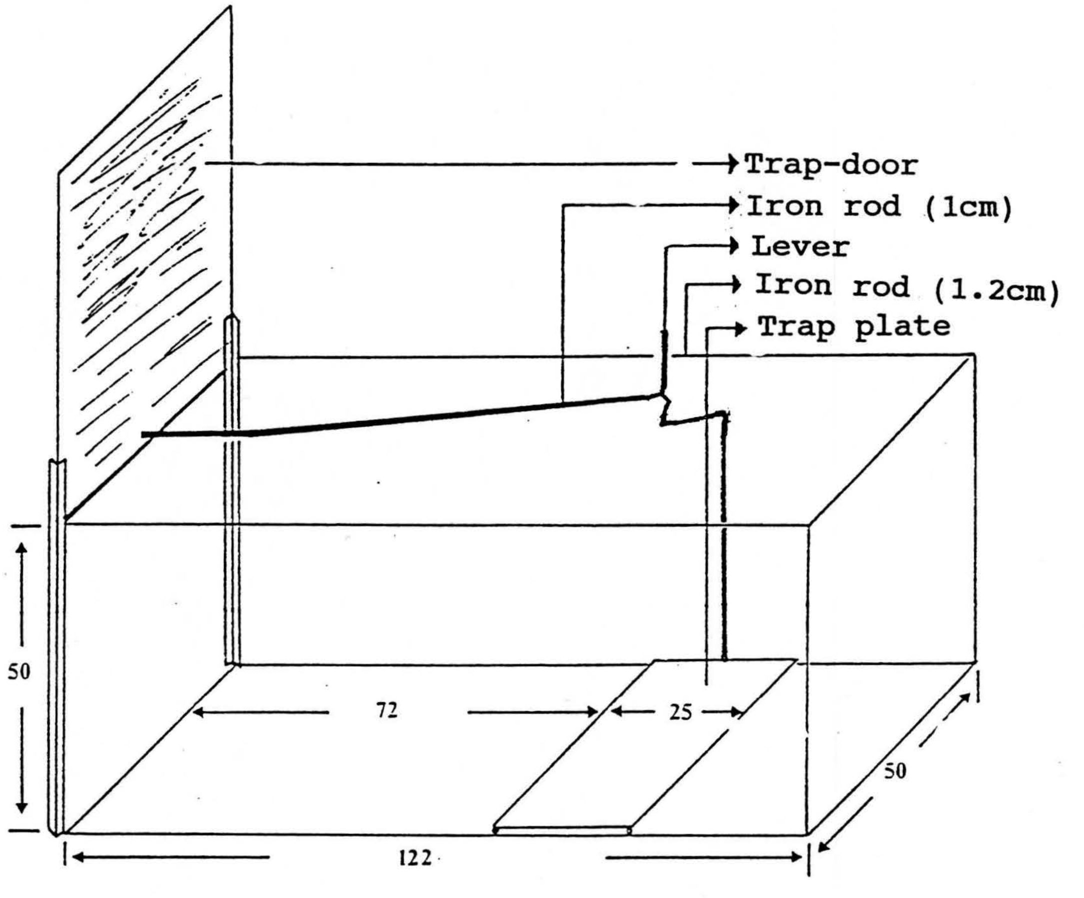

Figure 2.3: Caracal wire mesh box traps as used in this study (Brand 1990) (Measurements in cm).

viz. perpendicular to the ground (Fig.2.3) (Brand 1990) or a door which swings closed (mechanism of Schellingerhout 1978). Four and three of each type of trap respectively were used over a period of 15 months.

Placement of traps

Traps were only put out after a thorough study of the area, and a literature study of methods used previously (Moolman 1986; Brand 1990) and after consulting Problem Animal control officers, Mr.S. Hanekom, Mr. N. Fereira, adjacent farmers, and Mr. Japie Tango. In the study area caracal often used game paths and their scats were frequently collected in such paths at the bottom of slopes, or on paths going over necks. This, together with caracal spoor (especially where going in both directions in a path) served as indicators where traps could be placed. At first, traps were moved to another location immediately after a caracal was caught or after 30 days if there had been no capture. After five caracal were trapped and marked, trapping success improved at the successful sites and from then onwards traps were moved sooner (every 14 days) to another site if nothing had been caught. If a caracal was caught, the traps were set again at that site for an additional 14 days. Traps were also set near (5 - 30 m) springbok and other fresh carcasses, next to the closest footpath leading from the carcass or in the open (but then camouflaged) where a springbok was caught on one of the old fallow lands.

Within the 15-month trapping period, individual traps were moved 25 times to twenty-two different sites at P.N.R., and eight times to seven different sites on the marshes and sand dunes. Six traps were put out at springbok carcasses and once at a fresh grysbok carcass killed and eaten by caracal.

Method

Traps were placed very close to footpaths with the long axis at an angle of 45-90^{0} to the path, with the open end of the trap adjacent to the side of the path (<0.5 m). The most important part of the camouflage of a trap was the covering of the wire floor, as this is the only precaution taken by successful trappers such as Mr. Hanekom and some farmers (Duckitt & Kirsten pers. comm.) when setting caracal traps. The topsoil of the immediate area where the trap was to be set was removed, the trap put down and the soil strewn over the wire floor. Some stones from the immediate area were placed inside. After the bait had been put out at eye level (of the caracal) in the back of the trap, the soil inside the trap was wiped with a small branch and dry leaves, sticks and grass was lightly strewn inside to make it resemble the soil on the outside. A small branch was put inside the cage as a guiding stick to force the caracal to step onto the treadle as the caracal moved towards the bait. The open door, sides and back of the trap were also camouflaged with small branches and the only way the caracal could reach the bait was through the open front. Care was taken that no excess sand, stones or branches could prevent the trap's mechanism from working effectively. Traps were set with bare hands and no gloves were used. All human tracks were wiped with a branch and the dust was thought to mask some of the human smell. Points of unnaturally broken sticks were also covered with soil.

Bait

In this study 12 different types of bait were used. Table 2.5 lists the number of trap nights and how each type of bait was employed. We distinguished between "scent bait" and "visual bait" and experimented with each type alone as well as with food types in combination. For this study, "scent bait" was defined as a "bait without any recognizable form to the caracal, but with an odour that may lure caracal into the trap". "Visual bait" was recognizable objects (eg. carcasses) or something that could attract the caracal's eye even more than the nose (eg. silver strips of fish skin, fish heads or two (one white, one black) fluttering feathers on a string of fishing line). All "Scent baits" were put in a rusted tin with holes in the lid, except for caracal scats and urine which were left on the soil at the back of the cage. The rusted tin hung on the inside of the mesh wire at the back of the cage *ca* 30 cm above the ground (caracal eye level). A mixture of equal parts of cattle blood, fish (entrails, heads and fins) and vide was most often used (Called "Number 9", and is strongly related to the Number 9 bait used by the Department of Nature- and Environmental Conservation of the Cape Provincial Administration (Schellingerhout 1978; Brand & Geldenhuys pers.comm.) which is a mixture of one cup of fish flour, three spoons of rotten meninges and one cup of rotten blood). Fish offal or a liquid fly bait with a strong fishy smell (Pongo Fly Bait) was also used as a "scent bait". The tins were refilled at least every seventh day with fresh bait, although traps were checked at least every second to third day. "Visual bait" (francolin, bush-preferrring birds & bush Karoo rat carcasses, fish skin & heads and crayfish shells) were hung at caracal eye level or left on the ground at the back of the cage (grysbok & skunk carcasses). Two live chickens in a smaller wire mesh cage were put in the back of the caracal traps to provide live bait; a single chicken was less effective as it layed down and remained silent.

Anaesthetizing, Radio collars & Antenna

Caracal caught in traps were anaesthetized with Ketalar (Ketamine HCL, Parker-Davies; 50 mg/ml), with an intra-muscular injection of 0.2 ml/kg body mass. Immobilized animals were sexed and age was calculated from mass, tooth development, tooth wear and head length (Stuart 1982; Brand 1990). Two adult males and three females were radio collared and tracked with a highly directional four element hand-held Yagi antenna. The transmitters were made by Mr.G. van Urk (Potchefstroom University, South Africa) and operated in the 145 - 146 MHz range. A Yaesu FT 290 Mark 1

Table 2.5 Bait used in caracal traps in the W.C.N.P. during this study, from 4 April 1990 to 12 June 1991.

Bait	Trapnights Number (% of total)	Bait placement
SCENT BAIT		
Blood x Fish x Vide ("No.9")	43 (5.79)	Rusted tin on back wire
Fish entrails	20 (2.69)	Rusted tin on back wire
Fly bait	65 (8.75)	Rusted tin on back wire
Fly bait x Meat	50 (6.73)	Rusted tin on back wire
Caracal scats	10 (1.34)	On ground;back of cage
VISUAL BAIT		
Grysbok	7 (0.94)	On ground;back of cage
Francolin (dead) wire	24 (3.23)	Hang head down on back of cage
Bush-prefering bird (dead)	2 (0.27)	As above
Fish skin (silver strips)	11 (1.49)	Hang on fishing-line on back wire
Fish heads	17 (2.29)	As above
Crayfish (shells)	10 (1.34)	As above
Chickens (alive)	17 (2.29)	In wire box;back of cage
SCENT & VISUAL BAIT		
"No.9" & Francolin	70 (9.42)	See text
"No.9" & Rat	13 (1.75)	See text
"No.9" & Feathers	247 (33.24)	See text
"No.9" & Fish skin	6 (0.81)	See text
Fish & Francolin	17 (2.29)	See text
Fly bait & Skunk	9 (1.21)	See text
Fly bait & Francolin	105 (14.13)	See text
TOTAL	743 (100)	

receiver (Yaesu Musen Co., Ltd., Tokyo) was used. The five transmitters were embedded in silicone and fixed to 40 mm wide green and light brown soft and flexible conveyer belt strips. Collars weighed between 240 g and 300 g. All captured caracal were released at the capture site at least five hours after anesthetizing, the same evening or the next morning.

Non-adult caracal were only collared with dull coloured (dark brown, light brown, cream and green) 40 mm wide conveyer belt straps for recognition when seen or recaptured.

Radio-tracking caracal

Caracal were tracked on foot by day and at night with the portable receiver and hand-held antenna. Tracking sessions lasted anything from a single location ("fix") to a 5-day (120 h) continuous session, and tracking was undertaken whenever possible. Table 2.6 gives the number of readings and time span over which each caracal was followed by radio-tracking. During a typical tracking session the position of a single caracal was plotted every 15 min on an enlarged fotostat of a 1:50 000 topographical map, but all other caracal whose signals could be received during that period were also plotted and co-ordinates written down.

Table 2.6 The number of locations (fixes), number of separate days on which caracal were radio-tracked and the time span over which five caracals were radio-tracked in the P.N.R. area of the W.C.N.P.

	Time span	No. readings	No. days
Female no.1	130 days	56	10
Female no.2	491	1114	43
Female no.5	130	530	23
Male no.3	429	589	22
Male no.4	399	435	26
Total	597	2724	124
Mean tracking time per day = 5.5 hours			

Caracal locations were ascertained by triangulation and every fix was plotted from at least two (often more) points between 300 m and 800 m distant from the caracal. I always tried to be down wind and as quiet as possible so as not to disturb the caracal. A grid was drawn on a 1:50 000 topographical map of P.N.R. to form squares 250 x 250 m on the area where radio-telemetry was going to take place. This was enlargened (photostated) to 1:40 000 with longitudinal and latitudinal co-ordinates still 250 m apart. In this way the position of any caracal could be accurately plotted on this scale. On this map, nearest plots could not be closer than 125 m apart, which was accurate enough for the purpose of this study (especially if the comparatively large home range sizes of caracal are taken into account). Co-ordinates of the specific caracal tracked were noted every 15 min and were later assimilated with the computer programme Mcpaal (Microcomputer programs for the analysis of animal locations, Smithsonian Institution, USA). As most of the locations were related to each other, but were not all obtained in long enough continuous sessions (males usually take >6 days to go once around their whole territory and even females do not always sleep in the same spot), only the Minimum Method of Mohr (1947) was used to plot home range areas: "The smallest convex polygon containing all the observed positions, and the area within this polygon is the estimated home range size" (Anderson 1982). This is the method used by Stuart (1982), but differs from the "Method of Anderson" (Anderson 1982) used by Moolman (1986). Moolman (1986) also analyzed his results with the Minimum Method of Mohr (1947) so as to compare his results with those of Stuart (1982) and Norton & Lawson (1985), and his data are thus also comparable with results from this study.

D) STATISTICAL METHODS USED

To see whether *Rhabdomys pumilio* and *Otomys unisulcatus* were distributed uniformly over the different plant communities inside the West Coast National Park, multinomial chi-square tests were done on results of *R. pumilio* caught during summer (the season when most rodents were caught), and counts on *O. unisulcatus* nests in use during both autumn and spring. The same tests were done to determine differences in the distribution of *R. pumilio* between different plant communities in the W.C.N.P. One and two-sided t-tests (Fisher's Exact Test) were done to look for differences in the amount of rodents caught in plant communities G & H in the W.C.N.P. and in the same communities on the farms. To look for differences in small mammal species diversity between the different plant communities, Kruskal-Wallis multiple comparison tests were done on the results obtained for each season.

Multiple comparison t-tests were done on individual prey types (antelope, insects, rodents, carnivores) to see whether they were utilized uniformly by caracal in the four different geographic areas (Postberg Nature Reserve, freshwater marshes, sand dunes of the rest of the W.C.N.P., farms). To look for statistical differences in the use of different prey items by caracal between P.N.R. and the sand dunes of the rest of the W.C.N.P., and between P.N.R. and the farms, Tukey-Kramer t-tests were done.

Two sample t-tests were done on home range areas (Minimum method of Mohr only) to look for differences in home range area size between sexes, and between individuals of the same sex. The mean foraging speed and mean distance covered for individuals of the same sex and for individuals of each sex were used in two sample t-tests for comparison of individuals within sexes and between sexes.
Non-parametric multinomial chi-square tests were done to see whether caracal were as active in all different plant communities and on different contours as expected. To look at caracal presence in this communities and on the different contours, analysis of variance on the original means for multiple means were done.

Correlation analysis was done on home range areas of individual caracal for three different areas (P.N.R., south-western Cape, Mountain Zebra National Park - data obtained from literature) and Standard Metabolic Needs (worked out for each caracal as body weight$^{0.75}$ - data obtained from literature) to look for correlations between the two factors within each study area.

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CHAPTER 3

DENSITY AND DISTRIBUTION OF SMALL MAMMALS IN THE WEST COAST NATIONAL PARK AND ON SURROUNDING FARMS

ABSTRACT

Small mammals were sampled in eight different plant communities in the West Coast National Park and on two farms adjacent to the Park, and along various slopes in the Postberg section of the W.C.N.P. *Rhabdomys pumilio* was by far the most abundant species at all sites, although its density varied between plant communities and seasons. Species diversity, absolute and relative density, cover preference and breeding activity of some small mammals are also discussed.

INTRODUCTION

The South West Cape biotic zone is characterized by a depauperate mammal fauna (Rautenbach & Nel 1980), following an east-west (Nel 1975) and a north-south (Rautenbach 1982) decline in species richness. Apart from Avery, Rautenbach & Randall (1990) who listed the small mammals trapped and represented in owl pellets in the West Coast National Park (W.C.N.P.), little has been published on the small mammal fauna of the West Coast Strandveld. Present studies on the diet of small carnivores in this area (see Chapter 5) has shown rodents, especially *Rhabdomys pumilio* and *Otomys unisulcatus*, to be important prey while Cavallini & Nel (1990) and Avenant & Nel (1992) have reported high densities of especially *R. pumilio* in this ecosystem.

Resource (= food) distribution and density have been shown to affect carnivore ecology and behaviour (Macdonald 1983); thus data on the distribution, habitat preference, density and seasonal fluctuation in density of prey are essential for understanding the predator niche of particular carnivores, and in the present case for the conservation management of the West Coast Strandveld. The aims of this study were to determine the density of small mammal species in representative plant communities in the W.C.N.P., their densities and habitat selection along altitudinal gradients, and to compare these data with those from farms outside the W.C.N.P., but also within the West Coast Strandveld. An understanding of small mammal distribution and dynamics would be of value in conservation management in the relatively recently established W.C.N.P.

C) STUDY AREA

This study was conducted in the West Coast National Park (W.C.N.P.), including the privately owned Postberg Nature Reserve (P.N.R.) and two of the surrounding farms (Yzerfontein and Blombos), with the centre of the study area at *ca* 33° 12'S ; 18° 08'E. The whole area is within the West Coast Strandveld region (34b - Acocks 1988). The total area of the W.C.N.P. is *ca* 24 000 ha, and of the P.N.R. *ca* 2000 ha; the two farms (Yzerfontein and Blombos) combined cover *ca* 5 000 ha.

The P.N.R., situated on the Langebaan peninsula, topographically consists of low granite hills interspersed with sandy flats, the latter with a few fallow lands. The altitude varies from sea level to 193 m (Vlaeberg). The rest of the W.C.N.P. consists mainly of consolidated and unconsolidated dunes. Boucher & Jarman (1977) gave a detailed description of the different plant communities and soil characteristics in the study area. They named these communities using differentiating species which were conspicuous and related to outstanding habitat features. Prominent plant communities in the P.N.R. according to Boucher & Jarman (1977) are the *Atriplex-Zygophyllum* Coastal-shelf Dwarf Shrubland (community A), *Ehrharta-Maurocenia* Hillside Dense Shrubland on granite soils (D), *Nenax-Maytenus-Zygophyllum* Evergreen Shrubland (E), *Pteronia uncinata* Evergreen Dwarf Shrubland on limestone soils (F), and the *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland (G), and, in the rest of the W.C.N.P., *Willdenowia striata* Consolidated-dune Dense Evergreen Restioid Shrubland (H) and marsh communities, together with community G (*Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland). Freshwater marshes at the south-eastern part of the lagoon were, however, also sampled. The surrounding farms consisted mainly of sanddunes comparable to those in the W.C.N.P. Although they carry small stock (sheep and goats), these farms still have a 60 - 90% cover of natural Strandveld vegetation.

Warm, dry summers and cold, wet winters characterize this area. Mean annual rainfall at Geelbek at the southern tip of Langebaan lagoon is 270 mm with most rain falling in May and July (Boucher & Jarman 1977). Rainfall at Postberg is probably only slightly higher (Schaaf pers.comm.; pers.obs.). Relative percentage humidity of the air is highest during the late autumn and winter, coinciding with the period of most fog and rain (Weerburo 1988). Rainfall for 1990 (when most field work was undertaken) was above the mean, and earlier than usual. Mean monthly temperatures (Min/Max) range from 8.7°C/14.6°C in July to 13.2°C/21°C in February (Weather Bureau 1965). Winds are predominantly from the south throughout the year with northerly winds most frequent between May and August (Weather Bureau 1988). Wind speed often exceeds 10 m/s from both directions at the higher altitudes of Postberg.

D) MATERIALS AND METHODS

Absolute densities of rodents and insectivores were determined in four different plant communities (habitats) within the P.N.R., in two communities in the rest of the W.C.N.P., and in two on adjacent farms (Table 3.1). These communities were representative of the study area (Boucher & Jarman 1977), and were: Community A - *Atriplex-Zygophyllum* Coastal-shelf Dwarf Shrubland with vegetation in two layers (5 - 10 cm & 50 - 100 cm high) and canopy cover highly variable (30 - 85%);

D - *Ehrharta-Maurocenia* Hillside Dense Shrubland on granite soils, mainly around the base of granite rock domes; three strata occur (25 - 50 cm high; 1.0 - 2.0 m; 1.2 - 4.0 m), with canopy cover being 70 - 95%;

F - *Pteronia uncinata* Evergreen Dwarf Shrubland on limestone soils; dominated by the 30 - 50 cm tall ericoid shrub *Pteronia uncinata*, one of the few shrubs flowering in autumn; canopy cover = 50 - 80%;

G - *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland; has a dense, single stratum of 1.25 m tall spiny evergreen and drought-deciduous shrubs whose crowns generally interlock;

H - *Willdenowia striata* Consolidated-dune Dense Evergreen Restioid Shrubland; scatterd clumps of *Willdenowia striata* (ca 1 m tall and 1 m in diameter) gives the community its distinctive restioid character; canopy cover is stable, with a mean canopy cover of *ca* 80%;

Mc - *Typha capensis*-dominated form of the *Juncus kraussii* Dense Sedgelands; extensive dense (80 - 100% of area) stands of *Juncus kraussii* occur and include some *Typha capensis* individuals reaching 2.0 - 3.0 m in height.

Table 3.1 Sites at which rodents were trapped in the study area, within the W.C.N.P. (including the P.N.R.) and on farms outside. Plant communities according to Boucher & Jarman (1977); see text for a description of each.

Site no.	Plant community	Height a.s.l.(m)	Gradient
1	F (P.N.R.)	127	0-15 S
2	D (P.N.R.)	128	0-15 SSW
3	A (P.N.R.)	20	0-30 S
4	G (P.N.R.)	5	0
5	Mc (Marsh)	1	0
6	H (Sanddunes)	20	0
7	G (Farm "Yzerfontein")	20	0
8	H (Farm "Blombos")	30	0

In the six plant communities (habitats) inside the W.C.N.P. traps were set during all four seasons of 1990, while plant communities on the farms were sampled once only, during spring 1991. One trapping site per community was employed. Trapping was done using the catch, mark (toe-clip method of Twigg 1975), recatch method (Dice, 1941). In each community 50 Sherman live traps (230 x 90 x 75 mm) were set in a grid of 5 lines of 10 traps each. Traps were spaced 10m apart on each line, with lines 10 m apart. This spacing enabled comparison with the data obtained by Bond *et al.* (1980) in the southern Cape mountains, and lessened the possibility of a high proportion of the traps being occupied because of the very high numbers of rodents in this area (Cavallini & Nel 1990). Immigration, emigration, natality and mortality could not be determined, but were thought to have little effect on the population density during a trapping session, except during spring when rodent numbers increased and more young rodents were caught; longer trapping sessions were then needed to obtain a higher than 90% recapture rate during three consecutive catches (12 h periods).

A mixture of peanut butter, oats, golden syrup and sunflower oil was used as bait. No prebaiting was done. Traps were left open continuously and checked and rebaited 2 or 3 times a day, depending on trapping success and weather conditions. Trapping sessions at a site lasted until recapture rate exceeded 90% for three consecutive catches (Cavallini & Nel, 1990b) and lasted from 4 to 10 days. All trapping sessions (at all sites combined) within a season was kept as short as possible, the longest trapping period lasting 34 days.

The longest rectilinear distance between two traps in which each *R. pumilio* individual was caught was taken as the diameter of that animal's home range. A distance of half the maximum diameter (of the individual with largest diameter caught at a trapping site) was added as a boundary strip around the 40 x 90 m plot containing the traps, and this total area was taken as the "trapping area"; the size of the trapping areas in various plant communities thus differed (Table 3.5). *Rhabdomys pumilio* (the most abundant rodent species caught) minimum density for a site was calculated as follows: 100 divided by the mean recapture percentage of the last three catches x the total number of *R. pumilio* caught until then, divided by the "trapping area" (Cavallini pers. comm.). Although the sizes of home ranges could vary between seasons, calculating the size of a "trapping area" was only done once for each plant community (March 1990) and therefore only numbers (but not density as well) of rodents caught at trap sites could be compared between seasons. Small mammal species diversity for each trap site (plant community or habitat type) was calculated using the Shannon-Wiener information index (Bond *et al.* 1980)

$$H = -\sum(p_i)(\log_2 p_i)$$

where :

H = diversity index

p_i = proportion of total sample belonging to the i'th species.

This index is a measure of both the number of species and equality of representation of the individuals of all species.

Otomys unisulcatus was not easily trapped (see also Vermeulen & Nel 1988), and its relative density was calculated and compared by counting their lodges in a 0.5 ha area at the trapping sites (a boundary strip of 5 m included). According to Vermeulen & Nel (1988), each lodge harbours one *O. unisulcatus* individual on average. *O. unisulcatus* nests were counted during March (early autumn) and September (early spring) at the six trapping sites in the W.C.N.P. and the following September at the two sites on the farms.

Between 25 May 1991 and 11 June 1991, 15 trap lines (each 190 m long, 20 traps/line) were put out at the bottom of slopes, at midslopes, upper slopes and plateaux in communities A, C, D, and F. Traps were spaced 10 m apart on each line and trap lines were at least 200 m apart and parallel to each other where possible. Trapping continued until the recatch percentage was >90% for three consecutive catches (12 h periods).

A preliminary test was run during March 1990 on the southern aspect of Konstabel Kop in P.N.R. (plant community A) to see in what ratio rodent densities occur at different contours. Ten traps were put out in each transect and from the number of animals caught a ratio of *ca* 100:50:10 was found for transects on the bottom slope, midslope and upper slope respectively. According to the Chi-Square Goodness-of-Fit Test, eleven *R. pumilio* caught at the bottom slope, therefore, will be enough to give a 10:50:10 ratio to test significant differences in densities between trap lines. For this 20 traps/line would be sufficient. Trapping on the slopes was done within the space of 18 days, well before rodent numbers started to increase in spring 1991. Populations at the different sites were therefore taken to be all in the same phase of increase.

RESULTS

Four species of rodent and two of insectivore were caught at the eight trapping sites (Table 3.2). In all habitat types (plant communities) sampled *R. pumilio* had the highest densities (Relative percentage occurrence = >94%) (see also Avery *et al.* 1990). Mean male : female ratio for *R. pumilio* in all plant communities and during all seasons, was 1.116 : 1 (n = 24; s = 0.3) with no significant differences between seasons or plant communities ($p > 0.01$). Figure 3.1 shows the fluctuations in the *R. pumilio* numbers caught in six habitats in the W.C.N.P. As expected, trapping success (Fig. 3.2), of *R. pumilio* followed changes in numbers. Of *R. pumilio* young, 98% were caught during the September - October trap sessions, while natality ceased almost completely before the December trapping session. More rodents were, however, caught in summer than in spring. Most *Rhabdomys pumilio* (and *Otomys unisulcatus* nests) were found at the bottom of slopes, with highest numbers in community A (Table 3.3). New *O. unisulcatus* nests were only built after winter in the study area (pers.obs.) and a few more nests were in use during the September counts than in March (Table 3.4). The only young *O. unisulcatus* trapped (14.3% of individuals caught) were trapped in September. Although captured in much smaller numbers than *R. pumilio*, *Myosorex varius*, *Mus minutoides* and *Gerbillurus paeba* showed the same trend in numbers as did *R. pumilio* and *O. unisulcatus*. Absolute density of *R. pumilio* was only calculated for autumn and varied between 84 individuals/ha and 197 individuals/ha in the different plant communities (Table 3.5). The density distribution between plant communities differed significantly ($p<0.05$) with the highest density occurring within communities A (197/ha) and F (143/ha). Mean *R. pumilio* density during autumn in the six plant communities inside the W.C.N.P. was 125 ± 40.2 per hectare. Throughout the year, *R. pumilio* was not uniformly distributed between the six plant communities inside the W.C.N.P. ($p<0.01$). Most *R. pumilio* was trapped in community A, and fewest in community Mc (Table 3.2). The number of rodents trapped on farms was significantly less ($p<0.05$) than in the same communities inside the W.C.N.P. The same result pertains to *O. unisulcatus* lodges present (Tables 3.2 & 3.4). Stick nest numbers exceeded the number of individuals trapped, except in community H where no stick nests were found. The frequency distribution of lodges between plant communities during both spring and autumn was not uniform. According to lodge counts (nests in use), highest densities of *O. unisulcatus* occurred in communities G, A & F.

Mus minutoides was caught in all habitat types, except on the sand dunes of communities G and H, both inside the W.C.N.P. and on the farms. *Gerbillurus paeba* was caught in small numbers, and only in community H of the W.C.N.P. and on the farms. *Myosorex varius* was the most abundant insectivore in the study area, and was caught in every habitat type in the W.C.N.P. *Elephantulus edwardii* was only caught once at one of the trap sites, in community G, but three individuals were also later caught in trap lines in communities A & C.

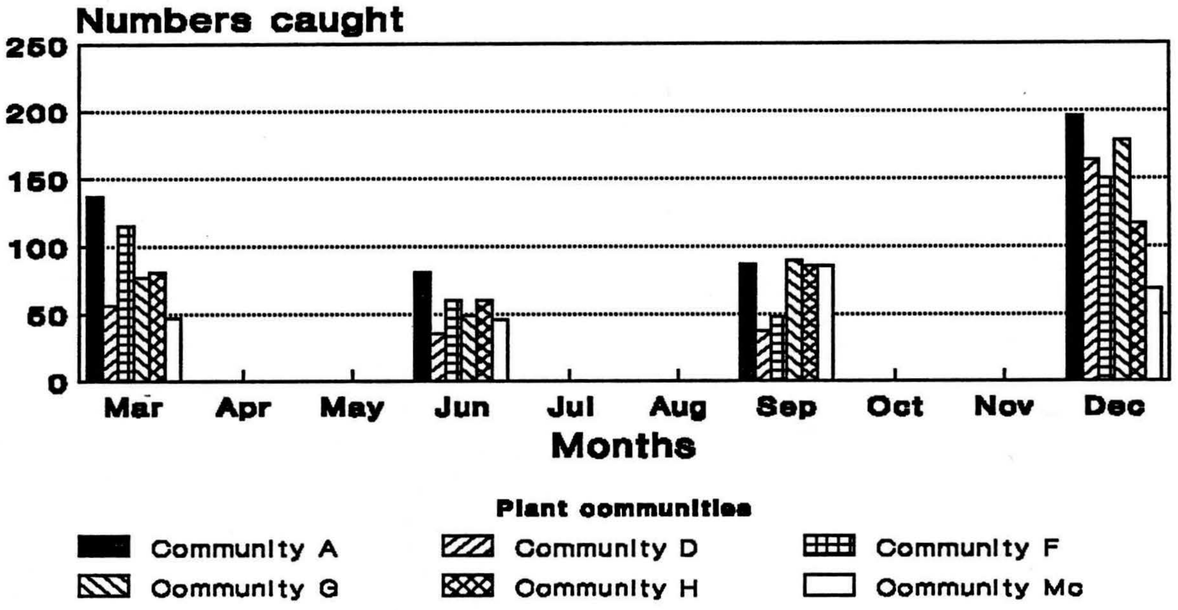

Figure 3.1: Fluctuation in *Rhabdomys pumilio* numbers in the West Coast National Park, trapped during March, June, September and December 1990. Plant communities according to Boucher & Jarman (1977); for a description of each community see text.

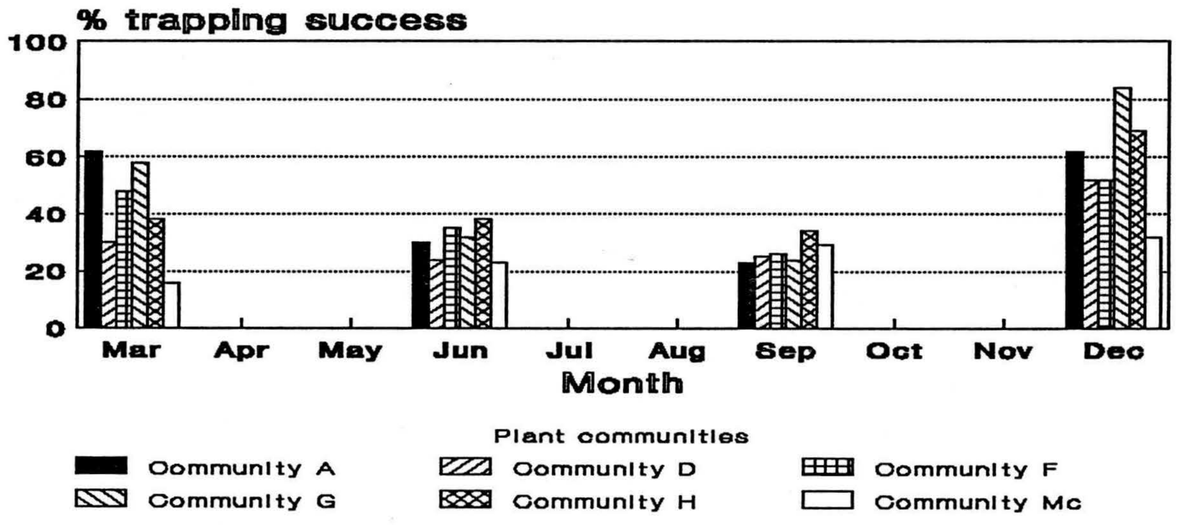

Figure 3.2 Mean seasonal trapping success for *Rhabdomys pumilio* in different plant communities of the West Coast National Park, trapped during March, June, September and December 1990. Plant communities according to Boucher & Jarman (1977); for a description of each community see text.

Table 3.2: Numbers of small mammals trapped at various trapsites in the West Coast National Park and on adjacent farms.

	Autumn	Winter	Spring	Summer
Community A (P.N.R.)				
Rhabdomys pumilio	137	81	87	196
Otomys unisulcatus	0	1	2	4
Mus minutoides	2	4	16	5
Myosorex varius	0	0	6	4
Community D (P.N.R.)				
Rhabdomys pumilio	56	35	37	164
Mus minutoides	1	2	2	3
Myosorex varius	0	0	1	3
Community F (P.N.R.)				
Rhabdomys pumilio	115	60	48	150
Otomys unisulcatus	2	0	1	1
Mus minutoides	1	0	0	0
Myosorex varius	0	0	1	
Community G (P.N.R.)				
Rhabdomys pumilio	77	49	90	178
Otomys unisulcatus	0	1	2	
Elephantulus edwardii	0	0	0	1
Myosorex varius	0	0	0	1
Community H (Sand dunes)				
Rhabdomys pumilio	81	60	86	117
Otomys unisulcatus	0	0	1	0
Gerbillurus paeba	0	1	2	3
Myosorex varius	0	1	11	4
Community Mc (Marshes)				
Rhabdomys pumilio	47	46	86	69
Otomys unisulcatus	0	0	6	7
Mus minutoides	1	0	0	2
Myosorex varius	0	4	11	3
Community G (Farms)				
Rhabdomys pumilio	-	-	15	-
Community H (Farms)				
Rhabdomys pumilio	-	-	58	-
Gerbillurus paeba	-	-	2	-

Table 3.3 Numbers of *Rhabdomys pumilio* trapped and *Otomys unisulcatus* nests in use, in transects at different contours in plant communities at the Postberg Nature Reserve.

(B = bottom of slope; M = midslope; U = upper slope; P = plateau; S = south; N = north; E = east; SE = south east). Plant communities according to Boucher & Jarman (1977); see text for description.

Transect	Plant community	Height a.s.l. (m)	Slope	Number	
				Trapped	Nests
1	A	20	B S	53	7
2	A	70	M S	20	1
3	A	120	P	31	1
4	A	70	M N	33	1
5	C	20	B N	14	2
6	A	20	B N	33	3
7	A	70	M N	34	1
8	A	140	U N	17	2
9	C	10	B E	24	1
10	C	70	M E	8	0
11	E	20	B E	18	1
12	E	100	P	23	0
13	E	70	B W	45	5
14	D	15	B SE	21	1
15	D	70	M SE	16	0

Table 3.4 Number of *Otomys unisulcatus* lodges per 0.5 ha in different plant communities in the West Coast National Park and on adjacent farms.

	Autumn	Spring
Community A (P.N.R.)		
Old nests	12	14
Nests in use	12	11
Community D (P.N.R.)		
Old nests	15	4
Nests in use	4	5
Community F (P.N.R.)		
Old nests	6	10
Nests in use	9	13
Community G (P.N.R.)		
Old nests	6	13
Nests in use	13	14
Community H (Sanddunes)		
Old nests	0	0
Nests in use	0	0
Community Mc (Marshes)		
Old nests	2	3
Nests in use	6	9
Community G (Farms)		
Old nests	-	2
Nests in use	-	5
Community H (Farms)		
Old nests	-	0
Nests in use	-	0
Total (farms excluded)		
Old nests	41	44
Nests in use	44	52

Table 3.5 Absolute densities of *Rhabdomys pumilio* at various trap sites in Autumn 1990 in the West Coast National Park.
(* - Postberg Nature Reserve; + - Sanddunes; # - Marshes)

Plant Community	Number caught	Boundary strip(m)	Trapping area(ha)	Density (no/ha)
A*	137	11	0.694	197
D*	56	7	0.562	100
F*	115	14	0.802	143
G*	77	11	0.694	111
H+	81	11	0.694	117
Mc#	47	7	0.562	84
Mean density = 125 ± 40.183/ha				

The frequency distribution of lodges between plant communities during both spring and autumn was not uniform. According to lodge counts (nests in use), highest densities of *O. unisulcatus* occurred in communities G, A & F.

Mus minutoides was caught in all habitat types, except on the sand dunes of communities G and H, both inside the W.C.N.P. and on the farms. *Gerbillurus paeba* was caught in small numbers, and only in community H of the W.C.N.P. and on the farms. *Myosorex varius* was the most abundant insectivore in the study area, and was caught in every habitat type in the W.C.N.P. *Elephantulus edwardii* was only caught once at one of the trap sites, in community G, but three individuals were also later caught in trap lines in communities A & C.

Non-significant differences ($p>0.05$) of small mammal species diversities occurred within all plant communities between seasons and non-significant differences ($p>0.05$) between plant communities for all seasons. Communities A and Mc showed the highest species diversity throughout the year (except in autumn when species diversity in community F was highest), with lowest diversity in communities F (except in autumn) and G (Table 3.6). Species diversity in spring on the farms was also much lower than in the same plant communities within the W.C.N.P. Species diversity fluctuated in unison with fluctuations in densities, with diversity being lowest in autumn (except for community F) and highest in spring, just before the main increase in *R. pumilio* numbers. On the transects, more *R. pumilio* were caught on the bottom slopes than on the mid or upper slopes of communities A (south facing), C (east facing), D (east facing) and E (west facing) (Table 3.3). Although the number of *O. unisulcatus* nests counted was low, most nests in use were also located on the bottom slopes in plant communities A (south & north), C (east), E (west) and D (south east)(Table 3.3). Highest numbers of nests and *R. pumilio* caught were in community A (bottom of south facing slope). No significant differences in small mammal species diversities or absence/presence of species at different contours (bottom, mid-slope, top) within plant communities could be found.

F) DISCUSSION

Species diversity of birds (MacArthur & MacArther 1961; Terborgh 1977) and small mammals (Rozenzweig & Winakur 1969; Nel 1975; Rautenbach & Nel 1980; Bond *et al.* 1980; Gerber 1990) has been correlated to habitat structure and plant species diversity. Bond *et al.* (1980) argue that habitat

Table 3.6 Small mammal species diversity* indices (H) in different plant communities in the West Coast National Park and on adjacent farms.

	Autumn	Winter	Spring	Summer	Mean
Postberg					
Community A	0.074	0.251	0.700	0.300	**0.331**
Community D	0.090	0.210	0.314	0.176	**0.198**
Community F	0.133	0.000	0.196	0.042	**0.093**
Community G	0.000	0.098	0.106	0.068	**0.068**
Sand dunes					
Community H	0.000	0.164	0.497	0.254	**0.229**
Freshwater marshes					
Community Mc	0.102	0.279	0.555	0.562	**0.375**
Farms					
Community G			0.000		
Community H			0.145		

* H = - đ(p_i)($\log_2 p_i$)

features are probably of greater significance in niche partitioning of most mammal and bird species in the fynbos than floristic composition, and that the latter will be of less value in predicting small mammal diversity or population size than plant life-form composition or variables describing habitat structure.

When results of Gerber (1990), obtained in autumn and spring at the same sites as the present, were correlated with present trapping results, the following emerges: In general, *R. pumilio* density decreases with vertical foliage diversity. However, seasonal changes in rodent densities in communities showed food source to be the most important factor in determining rodent densities in the West Coast Strandveld. Vertical foliage diversity may play a role in protection from predators, which together with the influence on micro-climate and level of intra-specific confrontation (thus behavioural stress), is one of the more important features determining small mammal densities and species diversity (Birney *et al.* 1976). *Rhabdomys pumilio* and *Otomys unisulcatus* are both diurnally active (Bond *et al.* 1980; Vermeulen & Nel 1988) and thus vulnerable to diurnal predators, which partly explains the correllation between vertical diversity and density. Choate (1972 in: Bond *et al.* 1980) found *R. pumilio* males occupying well-separated areas in the field, and that in captivity they would not tolerate other males in their cages. *Otomys unisulcatus*, like *O. irroratus*, may be asocial as Vermeulen & Nel (1988) found usually only one *O. unisulcatus* individual per lodge at a given time. The much higher cover values due to annual growth in spring and summer in all communities, may thus favour higher population densities of at least these two species.

No correlation was found between horizontal foliage diversity or horizontal foliage variation and rodent density (Gerber 1990). *R. pumilio* had the highest density in community A throughout the year, except in spring when *Eriocephalus racemosus* seeds in community G were available early and the onset of *R. pumilio* births preceeded *R. pumilio* births in community A. Comparatively high autumn densities in community F may also be the result of a good food source: *Pteronia uncinata* is covered in yellow flowers and makes this community the only community in the study area in flower during this time of year. *Otomys unisulcatus* lodge densities were also high in community A, and only slightly higher in communities G and F. Vermeulen & Nel (1988) found a correllation between lodge density of *O. unisulcatus* and the density of the shrub *Exomis microphylla* var. *axyrioides* (one of the shrubs used in lodge construction by *O. unisulcatus*) at the study area. Although no nests could be found in community H (inside and outside the W.C.N.P.) during both autumn and spring, *O. unisulcatus* was trapped there. All trap sites were more than 150 m from ecotones with other plant communities. Like all mammals caught, *O. unisulcatus* had a peak in density, probably due to natality, at the end of summer. The slight increase in the number of nests during September can be explained as young individuals will share lodges until dispersal and a further increase of nests in use is expected later in spring and summer. Young *O. unisulcatus* were only caught during the September trapping period.

David & Jarvis (1985) found population fluctuations of *R. pumilio* to be much the same on the Cape Flats (ca. 100 km south of the present study area; also Mediterranean climate, but mainly alien vegetation) as near Langebaan. They found the breeding season on the Cape Flats to last from September/October (first young caught in October) till the end of May. The mean peak density (over a five-year period) occurred during February, with an increase of from less than three to more than six times during a six-month increase phase. Present results show that an increase of between ca 1.9 to 4.7 in the six different plant communities in the West Coast Strandveld occurred during the 1990/91 breeding season. In the W.C.N.P. young of *R. pumilio* were already caught in September and none in March, indicating an earlier, and perhaps shorter, breeding season in the drier West Coast Strandveld near Langebaan than at the Cape Flats. Unfortunately no data on *R. pumilio* density on the Cape Flats are available for comparison. Like on the Cape

Flats, and unlike in the summer rainfall region of the Transvaal highveld (Brooks 1974; Coetzee 1965), breeding intensity of *R. pumilio* is inversely correlated with rainfall, and *R. pumilio* has retained a spring-summer breeding pattern in the Cape because of an increased spring and summer food supply.

The significantly lower numbers of rodents trapped, *O. unisulcatus* stick nests and lower species diversity found on the farms compared to that found in the same plant communities inside W.C.N.P. may be the result of grazing and predator control methods used by farmers (Avenant, *in prep.*).

Highest small mammal species diversity was found in spring in community A. Mean yearly species diversity in community A was second to that found on the marshes, which had a smaller diversity standard deviation. No correlation in species diversity with any habitat qualities could be found. As the Shannon-Wiener index is also a measure of the equality of representation of the individuals of all species, results could have been strongly influenced by the high *R. pumilio* numbers. Highest densities of *R. pumilio* in summer kept summer species diversity low, but could also have prevented other mammals from getting trapped, through competition for empty traps.

Productivity (P) of *R. pumilio* (g/ha/year) for each plant community can be estimated by the equation:

$$\mathbf{P = D\,F\,W}$$

(Cavallini & Nel 1990), where D = female density (overall density in winter/2, for equal sex ratio); F = fertility (= litter size x number of litters per year); W = mean mass (mean of male & female). In the case of *R. pumilio* in community A, if D =

58.2 ($^{81}/_{137}$ x $^{197}/_{2}$, this study), F = 15 (Perrin 1980: in Cavallini & Nel 1990 p.128), W = 45 g (Smithers 1983), then P = 39.285 kg/ha/year. This is *ca* 3 kg/ha/year more than calculated by Cavallini & Nel (1990) for this same area. Our method differed from theirs in that they used summer densities in community A, and their trap site was at a higher altitude on an "upper" southern slope. Our study found densities to be higher at the bottom of slopes in each community and highest in community A, especially on the wetter, denser southern slopes. Predators "specializing" in small mammals as prey are thus expected to occur in higher densities and spend more time at different altitudes and in different plant communities if food is the main factor influencing their ranging behaviour. Biomass of *R. pumilio* during winter in plant community A is therefore 116.4 x 45 g = 5.238 kg/ha.

If densities can be related to trapping success, densities of rodents at nearly all our trap sites (Fig. 2) may be at least as high as that found in the Swartberg (capture rate 9.0%) and Baviaanskloof (capture rate 16.3%)(Bond *et al.* 1980). These trap sites differed from ours in that at every trap station three Sherman traps were set in comparison to our one. It is also not known if rodent numbers fluctuate there as much as in the W.C.N.P., and if it does, in what stage of fluctuation it was during Bond *et al.*'s (1980) study period. In Bond *et al.*'s (1980) turn, they state that densities in the Swartberg and Baviaanskloof may be at least two or three times greater than that in the fynbos of the western Cape (Bigalke 1980, in: Bond *et al.* 1980).

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CHAPTER 4

FEEDING BEHAVIOUR OF CARACAL FELIS CARACAL SCHREBER, 1776, IN A WEST COAST STRANDVELD ECOSYSTEM

A) ABSTRACT

Small mammals, mostly *Otomys unisulcatus* and *Rhabdomys pumilio*, were by far the most frequent prey item represented in caracal scats (> 84% occurrence) throughout the year in the West Coast National Park. A low incidence of larger prey e.g. antelope, hyrax and hares probably reflect their low densities in the study area. Caracal feeding patterns tracked fluctuations in density and group size of various prey species. Predation by caracal on introduced springbok was highly seasonal, mostly from late January to early June, i.e. more or less from when caracal young were born until they started dispersing.

B) INTRODUCTION

The caracal *Felis caracal* is one of the most widespread predators in Africa and a major threat to the small-stock farming industry in southern Africa (Stuart 1982; Brand 1990). However, published data on its ecology are scanty, probably due to its shyness and nocturnal habits (Moolman 1986). Grobler (1981), Stuart (1982), Moolman (1984) and Palmer & Fairall (1988) give data on the diet of caracal, and they have been shown as feeding on prey varying in size and taxon from insects and arthropods to 31 kg antelope (Grobler 1981). However, no attempt has previously been made to compare availability with utilization of particular prey sources. Here, the effects of prey availability on caracal diet are assessed by comparing prey consumed, based on scat analysis, to prey abundance, size and group size, and comparing caracal diet in different habitat types within the West Coast Strandveld ecosystem.

C) STUDY AREA

The study was conducted in the West Coast National Park (W.C.N.P.) (33° 10' S;18° 05' E), Cape Province, and on eight adjacent farms. The vegetation is West Coast Strandveld - 34b (Acocks 1988); Boucher & Jarman (1977) provide more details and a division into plant communities. These communities form a mosaic. The Postberg Nature Reserve (P.N.R.) contractual area (*ca* 2 000 ha) at the northern extreme of the Langebaan Peninsula is unique in the W.C.N.P. in having granite outcrops, a comparative high floristic diversity (Boucher & Jarman 1977; pers.obs.) and therefore also a seemingly high diversity in prey species (pers.obs.). Fallow lands (last ploughed in 1964 - P. Hauman pers.comm.), clear floristic differences between northern and southern slopes (Boucher & Jarman 1977; pers.obs.) and floristic changes between seasons (Gerber 1990; pers.obs.) occur. The whole Langebaan lagoon is fringed by marshes, except where a rocky coast occurs (Boucher & Jarman 1977). The rest of the W.C.N.P. (*ca* 24 000ha) consists mainly of sand dunes mostly covered with the endemic climax West Coast Strandveld vegetation (Boucher & Jarman 1977). The eight adjacent farms (Seeberg, Mooimaak, Blombos, Mooimeisiesfontein, El be, Yzerfontein, Grootwater,De la Rey), are floristically comparable to the sand dunes. They are small stock farming areas (sheep & goat) and are minimally cultivated.

The climate is mediterranean. Mean monthly temperatures (max/min) range from 14.6°C/8.7°C in July to 21°C/13.2°C in February (Weerburo 1986). Annual precipitation at Langebaan village (*ca* 20 km north of the centre of the study area) averages 253mm, almost all falling during winter (Weather Bureau, 1965). Precipitation during summer is in the form of morning dew and advective fog off the cold Benguela current.

D) MATERIALS AND METHODS

Diet

Because caracal has such large home ranges (see chapter 6), their diet in four large, but different, areas within the study area was compared. A total of 523 caracal scats was collected at the four different sites (P.N.R. area of the W.C.N.P., fresh water marshes at the south-eastern border of the Langebaan lagoon, consolidated sand dunes of the W.C.N.P., and on adjacent farms) for each month over a 13-month period (February 1990 - February 1991). As monthly samples of scats from the farms and the sand dunes were very small, results were pooled for seasons: Autumn (March - May), Winter (June - August), Spring (September - November) and Summer (December - February); these same periods were used when assessing the mean seasonal prey availability. Only fresh scats (less than ten days old; tested for colour against known age scats in different micro-habitats in the field) were collected, individually placed in brown paper bags and the locality, date, number of scats in the immediate vicinity, presence of spoor and micro-habitat where collected, written on the bag. In the laboratory scats were air-dried and later teased apart. Large, easily diagnosed fragments of prey were macroscopically identified while hair, teeth, feathers and reptilian scales were identified under a stereo microscope at 25x or 50x magnification. Prey items were identified to species level where possible by comparing undigested remains with a reference collection from the South African Museum (Cape Town), the John Ellerman Museum (Dept.Zoology, Univ. of Stellenbosch), from carcasses found in the study area, and also with published results, eg. scales on hair imprints (Keogh 1983 a & b) and tooth form (De Graaff 1981).

Only results from scats containing caracal hair (75 % of all scats collected) were used to describe the diet of caracal, using the Percentage of Occurrence (Corbett 1989) and Percentage of Volume (or average percentage proportion - Cooper & Skinner 1979) methods. Neither of these methods can by themselves describe the diet of carnivores accurately (Putman 1984; Bowland & Bowland 1991), and both were used, also to enable comparison with other studies. An Importance value for main prey items was calculated: I = estimated mass eaten of each prey item x relative percentage of occurrence (Grobler 1981, Kruuk & Parish 1981). Main items were taken as prey species contributing > 40% per volume in scats; minor items (Arthropoda, Insecta, grass) contributed < 5%, and were ignored in calculating the relative percentage occurrence as used in calculations of Importance Values.

Scats collected near springbok (*Antidorcas marsupialis*) carcasses could not be used in scat analysis as they were more easily collected than scats deposited elsewhere; such scats mostly contained only springbok hair. Assessing the impact of caracal on springbok thus solely depended on carcasses found.

Food availability:

From February 1990 to March 1991 an attempt was made to quantify the abundance and group size of the prey found to be most important in caracal diet in this (from regular scat analysis) or previous studies, on a monthly (or seasonal) basis. It involved the trapping of rodents, counting of bush Karoo rat stick nests, numbers of hyrax, hares, small antelope, guinea-fowl and francolin, casual observations on bush preferring bird and reptile breeding seasons, regular counts of live springbok and counts of springbok and sea-bird carcasses.

Fifty aluminium live traps (230 X 90 X 75 mm) (Sherman Traps Inc., Florida, U.S.A.) were set out 10 m apart in a grid 0.5 ha big (5 lines of 10 traps each) every three months (March, June, September, December 1990) in six different habitat types. These different habitat types correspond to different plant communities (Boucher & Jarman 1977), viz. Communities A (*Atriplex-Zygophyllum* Dwarf Shrubland) on the coastal shelf, D (*Ehrharta-Maurocenia* Hillside Dense Shrubland) on granite derived soil, F (*Pteronia uncinata* Evergreen Dwarf Shrubland) on limestone soils, G (*Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland), H (*Willdenowia striata* Consolidated-dune Dense Evergreen Restioid Shrubland) on consolidated dune sands and M (*Juncus kraussii* Dense Sedgelands) on the freshwater marshes. Traps were checked two or three times a day, depending on the trapping success and climatic conditions. Each individual was identified up to species level, sexed, toe-clipped (Twigg 1975) for identification when recaught and released at the capture site. Trapping was stopped when the proportion of recaptures (of total number of captures) exceeded 90% during three successive checking of traps (Cavallini & Nel 1990). The total number of different individuals captured was taken as a minimum estimate of the number of that species present, assuming negligible immigration, emigration, natality and mortality during the 8 to 12 days that trapping continued.

Although bush Karoo rats (*Otomys unisulcatus*) were abundant in the study area, they were not easily trapped (Vermeulen & Nel, 1988) and their stick nests (taken to be in use when fresh *O. unisulcatus* scats were present) were counted in the same six 0.5 ha areas during autumn and spring 1990. According to Vermeulen & Nel (1988) one bush Karoo rat inhabits every stick nest in use.

Other possible prey (steenbok, duiker, grysbok, hares, guinea-fowl, francolin) were counted along fixed transects in predetermined areas representative of the whole W.C.N.P.. These strip counts (Bothma 1986) were done each month over the same routes, in the same direction and at the same constant speed when it did not rain and windspeed was < 4m/s. Boucher & Jarman (1977) mapped separate plant communities and the numbers and sizes of possible prey groups seen or startled along the transects and within particular plant communities were plotted on a photostat of their map. Areas covered by each transect were calculated as follows in order to compare monthly densities of prey animals: Area = (length of transect in a specific plant community) x (Width of transect in the same plant community). "Widths" (mean diameter) differed in the different plant communities and was estimated by R. Lotze & A. Spies (National Parks Board) and myself as the mean maximum distance from the road that the target animals could be clearly identified. Areas of each transect stayed constant throughout the year despite changes in the vegetation. Animals clearly outside the borders were not counted. This method differs from that of Bothma (1986) and Dice (1941) where widths were worked out as the mean distance from the longitudinal axis that animals were seen. In the heterogeneous study area transects were relatively short in each plant community (Max=4.7 km; Min=1.0 km) and only a few animals were seen. This resulted in strip counts being done using three different methods:

(a) Night counts with a spotlight from a Toyota (4x4) LDV at a constant speed of 25 km/h, over marked distances along narrow gravel roads, within the 10 days around full moon, starting at sunset and lasting *ca* 90 minutes. Total length of transects were 23,4 km and the area covered 76,7 ha.

(b) First light counts at sunrise the morning after night counts, along the same routes (constant speed of 30-35 km/h) and in the same direction as the previous night. If it rained or if the wind speed was > 4m/s, counts were done on the first suitable morning thereafter.

(c) Mid-morning counts on foot along three predetermined routes (a total length of 19.62km and covering an area of 128.75ha), mapping group sizes of all possible prey seen (or startled) within a fixed distance from the longitudinal axis of the transect in each plant community. Each of the three routes were walked within the middle two weeks of each month, on seperate days. Counting started 1 h after sunrise and each route took more or less 2 h to complete.

Hyrax were counted during summer (Nov-Dec.1990) and winter (June-July 1991) using the Colony Plotting Method (Davies, in litt.) to compare densities, group sizes and time of highest natality.

At least once a week (every second day during the season when most carcasses were found), springbok at P.N.R. were counted and the area thoroughly scanned from a vehicle and on foot for lambs and carcasses.

Counts on sea bird carcasses were conducted monthly by the African Seabird Group (Avery & Underhill 1986) along the 26 km stretch of beach, the W.C.N.P.'s western border; these data were made available to me.

E) RESULTS

Food availability:

Rodent density and species diversity differed between the six vegetation types but striped mice, *Rhabdomys pumilio*, were most often trapped (94.3%). Other mammals trapped were *O. unisulcatus* (1.3%), *Gerbillurus paeba* (0.3%), *Mus munitoides* (1.7%), *Elephantulus edwardii* (0.1%) and *Myosorex varius* (2.4%). Rodent densities in all six vegetation types showed similar fluctuations with an increase in spring (due to high natality) and a seemingly slow decrease from summer towards the next spring. However, *Rhabdomys pumilio* and *Otomys unisulcatus* densities in nearly all communities were higher during summer trapping sessions (Fig. 4.1) than in spring, probably the result of trapping early in spring when some young were captured but others had not yet entered the trapable population. If trapping had been undertaken three weeks later, densities could have been higher than in summer when young were absent in traps. Results indicate that rodents in this West Coast Strandveld region may only have a single breeding season, during spring and ending before January. Community A (*Atriplex-Zygophyllum* Dwarf Shrubland) had the highest small mammal density throughout the year. This is reflected in caracal ranging behaviour and habitat preference. Figure 4.1 also gives the number of *O. unisulcatus* stick nests per ha in the six plant communities. Like *R. pumilio*, *O. unisulcatus* densities (stick nests) were highest in communities A (26% of total) & G (28%) and lowest in communities H (0%) & Mc (12.5%) and they probably have the same seasonal fluctuation in densities as do *R. pumilio*; the number of stick nests in use (i.e. with fresh *O. unisulcatus* scats) were more or less the same throughout the year in all six plant communities. The increase in the numbers of old (disused) nests indicate that new nests were built after winter. The only young *O. unisulcatus* (14.3% of

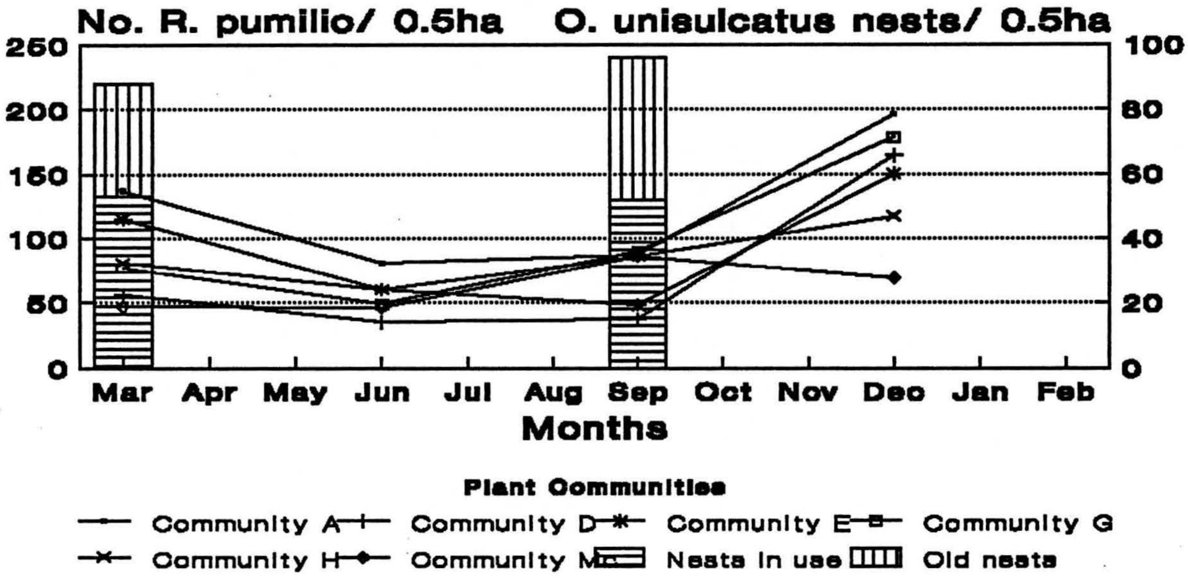

Figure 4.1 Seasonal fluctuations in *Rhabdomys pumilio* and *Otomys unisulcatus* densities in different plant communities in the West Coast National Park. One *O. unisulcatus* nest in use is taken to represent one individual.

all individuals) recorded were trapped during spring.

Unmodified results of strip counts usually underestimate densities of game (Dasmann & Mossman 1962), but in the present study it sufficed to indicate fluctuations in densities. Mid-morning counts proved to be the most reliable as more animals were seen at this time and with this method. Clear seasonal patterns in densities of duiker, steenbok, hares and francolin were observed (Fig. 4.2). Results of Night counts and First light counts proved much more inaccurate and were ignored; these results, however, did not contradict the seasonal patterns observed with mid-morning counts.

Steenbok, duiker and hare densities were highest in autumn, concurring with the peak in their lambing season (Smithers 1983) and slowly decreased until the next spring. Density of grysbok was much lower than that of the other antelope (maximum/month = < 0.011 individuals/ha). However, no grysbok were counted between June & October; they probably show similar fluctuations in numbers as steenbok and duiker.

Most birds' eggs hatched around the middle of October. Because the September counts were also used to calculate the mean density for spring, mean densities of guinea-fowl and francolin were highest during summer (Fig. 4.2). Mean group sizes of these birds (Fig. 4.3) were also highest during October (guinea-fowl) and October & November (francolin) and lowest during August and September, the time of mating, nesting and breeding. Table 4.1 shows that some prey species are more common in certain plant communities. Steenbok were more prevalent in the more open vegetation of communities I & J and on the old fallow lands. In the other vegetation types steenbok densities were highest in communities A & G. Highest mean density of duiker was in the thicker vegetation of community G, with density in community A the second highest. Density of grysbok was much lower than that of other antelope in all plant communities. Hares, like steenbok, prefered the more open vegetation of the old fallow lands and communities I & J and C. Of the bigger birds counted,

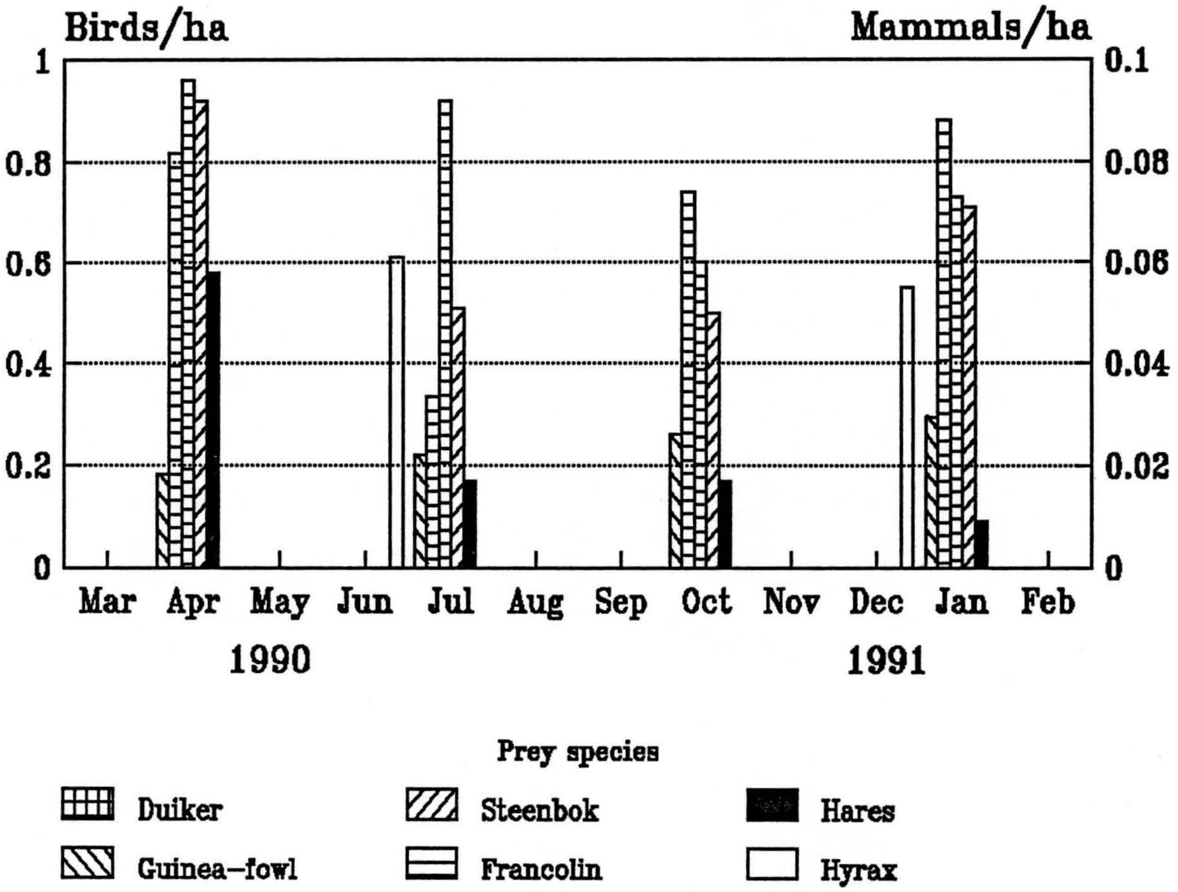

Figure 4.2 Seasonal fluctuations in mean density (means of plant communities) of prey species at Postberg Nature Reserve, West Coast National Park.

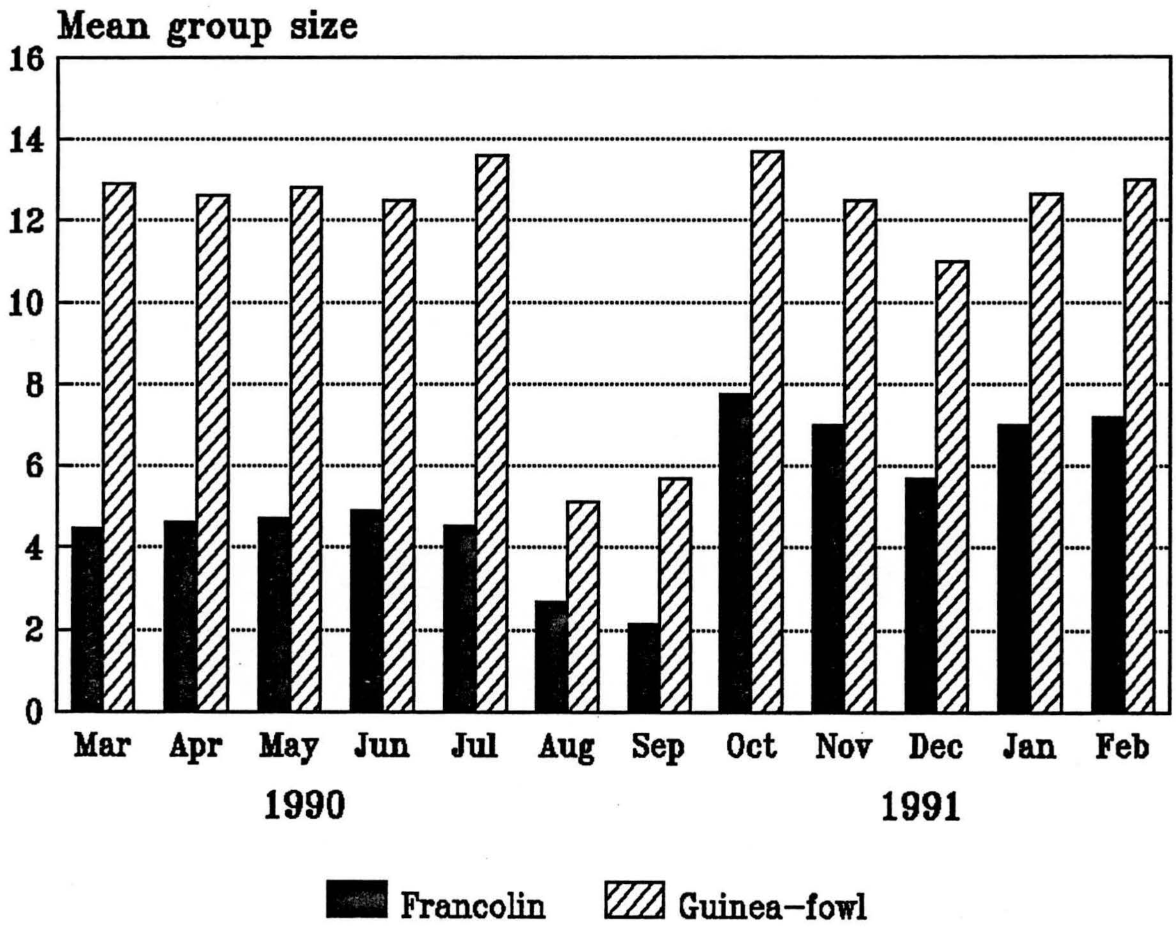

Figure 4.3 Mean group size of francolin and guinea-fowl at Postberg Nature Reserve, West Coast National Park, based on strip counts.

Table 4.1: Mean of monthly densities (± SD)(individuals/ha) of some caracal prey in different plant communities at Postberg Nature Reserve, West Coast National Park during March 1990 - February 1991; results are of mid-morning counts. Plant communities following Boucher & Jarman 1977.

Prey	**Plant community**						
	A	**C**	**D**	**E**	**G**	**I&J**	**Lands**
Steenbok							
Mean	0.023	0.009	0.019	0.014	0.022	0.094	0.038
SD	±0.017	±0.015	±0.026	±0.012	±0.034	±0.025	±0.018
Duiker							
Mean	0.016	0.006	0.013	0.014	0.097	0.005	0.003
SD	±0.014	±0.011	±0.022	±0.012	±0.035	±0.008	±0.005
Grysbok							
Mean	0.002	0.005	0.013	0.003	0.003	0.001	0.000
SD	±0.008	±0.009	±0.042	±0.006	±0.008	±0.003	±0.001
Hares							
Mean	0.003	0.012	0.009	0.006	0.007	0.013	0.019
SD	±0.008	±0.018	±0.026	±0.010	±0.026	±0.017	±0.026
Francolin							
Mean	0.416	0.125	0.500	0.290	0.221	0.112	0.197
SD	±0.188	±0.102	±0.565	±0.168	±0.280	±0.134	±0.138
Guinea-fowl							
Mean	0.045	0.209	0.126	0.045	0.073	0.006	0.505
SD	±0.072	±0.156	±0.267	±0.090	±0.162	±0.020	±0.2

francolin were present in higher numbers in the denser vegetation (communities D & A), while guinea-fowl on the other hand preferred the open vegetation of the old fallow lands. These lands mostly occur in community A, and is today surrounded by the vegetation of community A - the most likely vegetation type then where guinea-fowl will spend the nights while being inactive. Large standard deviations (Table 4.1) is the result of seasonal fluctuations (especially birds with higher densities) and very low sample sizes (example grysbok & hares).

Factors having a negative influence on Night & First light counts were the relative short distance over which counts could be done (mean area/community at Postberg = 7.33 ha), the heterogeneity of the study area, and the different behaviour of the various prey species (eg. guinea-fowl and francolin could not be counted during night counts and in the early mornings tend to assemble on the roads where they are more easily seen; while duikers, unlike steenbok, keep to the more dense areas and away from the more open patches along the road). Additional factors were the dense vegetation permitting very narrow "widths" in places, the very low densities of prey animals (one additional animal seen or missed alter the results completely) and the fact that only active animals could be counted.

Dassie counts (Fig. 4.2) showed densities to be slightly higher ($p>0.01$) during winter (0.061/ha) than during summer (0.055/ha). Half ($n=8$) of the 16 colonies found gave a mean group size of 6.88 during summer (min\max = 6\8) and 7.63 in winter (min\max.= 7\9). This difference is thought to result from all young being born between December and June. Extrapolation of the results give a total of 110 and 122 individuals at P.N.R. during summer and winter respectively, and a maximum density of 0.061 individuals/ha over the entire P.N.R. which includes a large portion of "unsuitable" dassie habitat (i.e. lack of rocks for shelter).

During the 23-month study period the number of springbok at P.N.R. gradually decreased (Fig. 4.4) by 54.1%, from 98 to 45. During this period only 34 lambs were seen with an estimated lambing success of *ca* 40% during the first 12 months. At least 22 (59.4%) of the 37 springbok carcasses found during the first 12 months were killed by caracal (based on killing and feeding patterns of the predator - Gosling 1984; Moolman 1986), while caracal fed on 25 of the carcasses found. The other 12 carcasses (Fig. 4.4) were not fed upon and they appeared to have resulted from illness, all during August and early September.

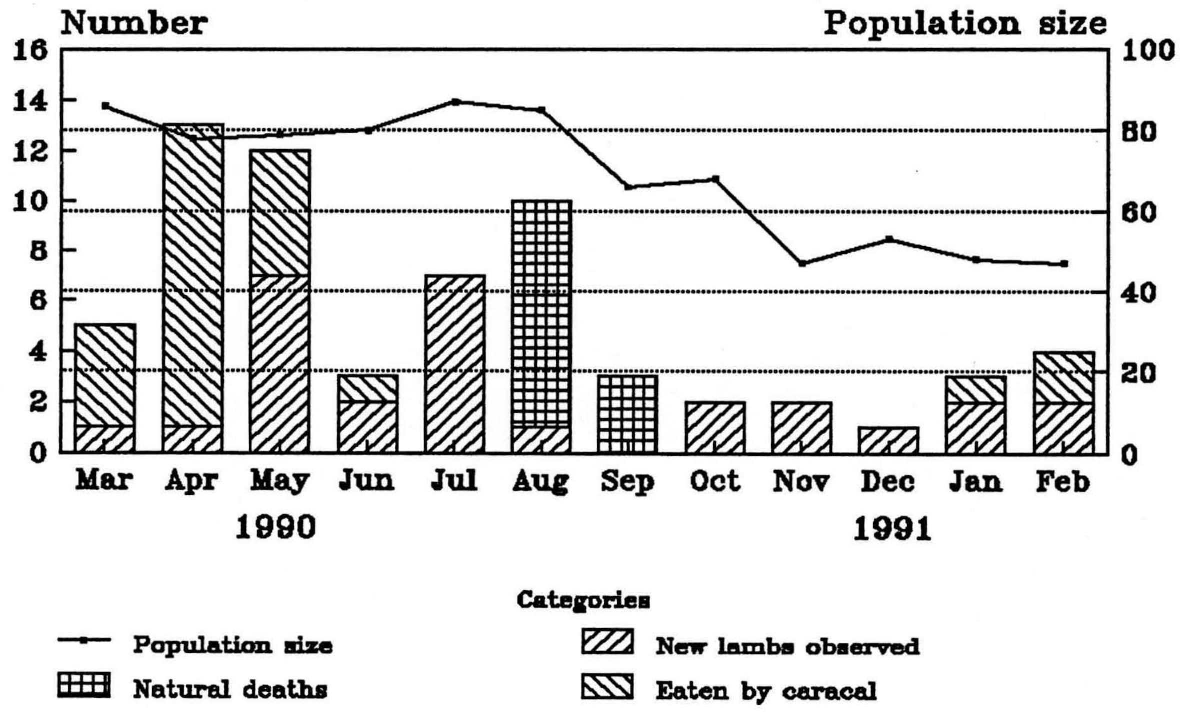

Figure 4.4 Total population size of springbok and number of new lambs, natural deaths and number eaten by caracal at Postberg Nature Reserve, West Coast National Park.

The annual number of sea bird carcasses counted on Sixteen Mile Beach stays remarkably constant (Avery 1984) with a mean monthly density of 1.723/km (1979 - 1982). Carcasses of Cape gannet, Cape cormorant and Kelp gull were the most common, and density was strongly influenced by juvenile mortality (Avery 1988).

Diet

As in previous studies (Stuart 1982, Smithers 1983, Moolman 1984, Palmer & Fairall 1988), mammals as a group was most utilized by caracal (a 100% occurrence in scats) in this West Coast Strandveld area, with Cricetidae & Muridae the taxa most often present in scats from each individual habitat type (Table 4.2). Then followed birds, reptiles and arthropods respectively. Analysis using the Percentage Of Volume method showed that antelope was second in importance to rodents at P.N.R., but they occurred only sporadically. Figure 4.5 presents the relative percentage of occurrence of cricetid and murid species in scats from P.N.R. *O. unisulcatus* (66.53%) and *R. pumilio* (28.53%) were the most important prey items. Results from analyses using both percentage occurrence and volume methods are given to enable comparison of results with those from other studies. The low percentage volume (despite high % occurrence) of plant material shows that some plant material was probably ingested accidentally. Some scats (4.98% of those containing plant material) however, had grass contributing > 25% of the scat, indicating that grass was sometimes ingested actively. The remains of ticks (present mainly in August, September & October) probably also indicate accidental ingestion. Due to their small body size, insects (mostly orthopterans and coleopterans) and arthropods (solifuges & scorpionids) contributed less to the diet of caracal, but their presence in scats

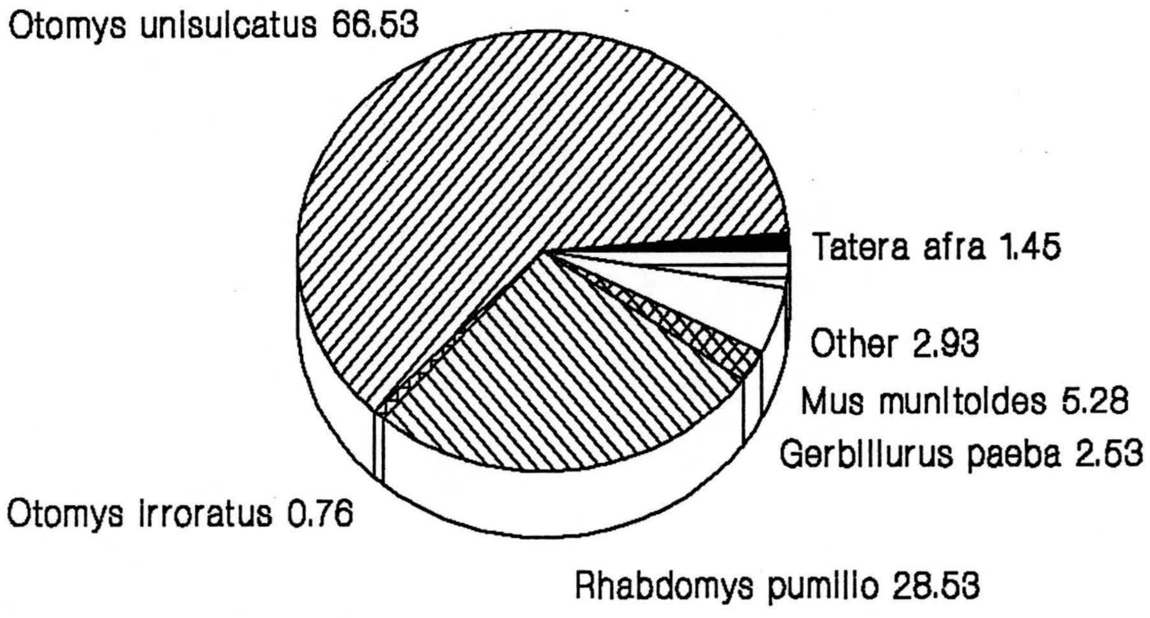

Figure 4.5 Proportion of different rodent species in caracal scats from Postberg Nature Reserve, West Coast National Park, 1990-1991

Table 4.2 Mean monthly percentage occurrence and percentage volume of prey items in scats of caracal (n=391) in four different habitats in the study area (1990-1991). Data from habitats 3 and 4 are combined for seasons.

(1 = P.N.R.; 2 = Freshwater marshes; 3 = Sand dunes in Rest of W.C.N.P.; 4 = Adjacent farms

	1		2	3	4
	% Occ.	% Vol.	% Occ.	% Occ.	% Occ.
Number of scats	201		104	38	48
MAMMALS	100	87.34	100	100	100
Cricetidae & Muridae	84.20	71.66	98.12	89.83	90.70
* Antelope	6.56	5.12	-	2.50	1.68
Carnivores	1.94	1.84	0.64	-	-
Hares	2.00	1.70	2.38	2.28	3.95
Hyrax	1.93	1.78	-	-	-
Insectivores	7.02	2.96	15.55	-	6.58
Rodent moles	4.88	2.28	2.61	-	3.58
Stock	-	-	-	-	3.58
BIRDS	17.71	5.06	20.74	15.95	23.18
REPTILES	12.36	2.48	6.51	10.28	17.38
INSECTS	6.20	0.38	2.38	3.13	16.80
ARTHROPODS	12.36	0.93	5.76	2.28	6.93
Solifugas & Scorpionids	10.64	0.84	-	-	1.68
Ticks	4.56	0.09	5.76	2.28	5.25
PLANT	46.55	3.91	46.47	44.65	50.65

* - excluding springbok

illustrates the caracal's generalist and opportunistic feeding behaviour. The low density of hyrax, hares and antelopes in the study area (Fig. 4.2) probably resulted from earlier conservation strategies at P.N.R. and predator control and hunting methods on the surrounding farms. This low density was reflected by their low presence in caracal scats.

Main prey items of caracal were the rodents *R. pumilio* and *O. unisulcatis*, antelope (steenbok, duiker, springbok), hyrax, hares (*Lepus saxatilis* & *Lepus capensis*), rodent moles (e.g. *Cryptomys hottentotus*), other carnivores (*Atilax paludinosus*, *Galerella pulverulenta*, *Ictonyx striatus*) and birds (Table 4.3). Often remains of two or more rodents occurred in one scat, contributing > 40% to the volume of 98.22% of the scats. Rodent importance value was therefore calculated as: Relative percentage occurrence x Estimated mass (of one individual consumable by caracal) x 2. Birds only in 28% of occasions contributed > 40% to the volume of a scat, because a number of the smaller bush-prefering birds (e.g. Olive thrush - Roberts No.577, Cape robin - 601, Karoo robin - 614, Bokmakierie - 746) were eaten together with francolin and guinea-fowl. Bird importance value was therefore calculated as (Relative percentage occurrence x Estimated mass) ÷ 3 (Table 4.3). The approximate mass of one individual of a prey catagory ingested by caracal was determined as follows: (a) *Lepus saxatilis* and *Procavia capensis* from the literature (Grobler 1981); (b) Cricetidae & Muridae - (Relative %Occ. of *O. unisulcatus* and *R. pumilio*) x (mean adult male & female mass of each given in Smithers 1983) ÷ 100; (c) antelope - (maximum taken as two nights eating 1kg/night, Grobler 1981); (d) rodent moles (80% of mean mass of *Cryptomys hottentotus* as given in Smithers 1983), (e) carnivores (80% of mean mass of *G. pulverulenta*, *A. paludinosus* and *I. striatus* as given in Smithers 1983); (f) birds (90% of mean mass of Francolin and

Guinea-fowl as given in Roberts 1985). From these mass values a mean importance value for each main prey type at P.N.R. was calculated (Table 4.3).

Table 4.3 Importance value of main prey items in the diet of *Felis caracal* at P.N.R. during 1990-1991.

Importance value = Relative percentage occurrence x Mass (kg)

Prey items	% Occ.	Rel. % Occ.	Mass kg	Importance value
Cricetidae & Muridae	84.20	70.63	0.095	13.42
* Antelope	6.56	5.50	2.00	11.00
Rodent moles	4.88	4.09	0.101	0.41
Carnivores	1.94	1.63	1.327	1.73
Hyrax	1.93	1.62	1.10	1.78
Hares	2.00	1.68	1.05	1.76
Birds	17.71	14.85	0.839	4.153
Total	119.22	100		

* - excluding springbok

According to these figures rodents, especially Cricetidae & Muridae, had highest importance values of all prey at P.N.R. and the rest of the study area. If the sprinbok eaten at P.N.R. were taken into account, importance value of the antelope increases to be the most important prey of caracal at P.N.R. Table 4.2 shows that antelope, in contrast to rodents, was less important as prey on the farms and on the sand dunes of the rest of the W.C.N.P. than at P.N.R.

Differences were found in caracal diet in different habitat types: hyrax was only present at P.N.R., while no remains of stock were found in scats collected in the W.C.N.P. as a whole. Less Cricetidae & Muridae and more natural antelope (springbok therefor excluded) and carnivores (*Galerella pulverulenta*, *Atilax paludinosus*, *Ictonyx striatus*) were eaten at P.N.R. The frequency distribution of antelope differed significantly ($X^2 = 9.0163 > 3.841$) within the four areas, with the antelope being non-uniformly distributed. The same result was obtained for insects ($X^2 = 12.5179 > 3.841$) and rodents ($X^2 = 23.9415 > 3.841$), but not for carnivores ($X^2 = 2.3014 < 3.841$). Binomial tests showed that there was no significant difference ($p>0.05$) in percentages of rodents and carnivores eaten on P.N.R. and farms, or between P.N.R. and the sand dunes of the rest of the W.C.N.P. Significant differences ($p<0.05$) in percentages of antelope and insects eaten on P.N.R. and the farms was found.

Scat analysis showed definite monthly fluctuations in the diet of caracal at P.N.R. (Fig. 4.6). Although the sample size from the other habitats was much smaller, the same pattern was apparent. Rodent presence in scats was high throughout the year, but lowest in the winter months; it increased with increasing rodent density (Fig. 4.1) in spring. Bird presence in scats drastically increased in October when density of birds also increased (Fig. 4.2), as a result of more young and a concomitant increase in bird group size (Fig. 4.3). From then on the percentage occurrence of birds slowly decreased towards the next spring. Reptiles (eg. lizards *Mabuya capensis* and *Cordylus niger*, snakes *Bitis arietans* and *Psammophylax* sp. and tortoise *Chersina angulata* and *Homopus* sp.) were mostly present in scats during the warmer summer months when they were more active and their young had hatched

(Patterson & Bannister 1987). Although hyrax, rodent moles, hares and antelope were only present in scats in low mean percentages, they did occur during specific seasons, eg. hyrax and rodent moles during winter and natural antelope (excluding springbok) mainly during summer and autumn. Results thus indicate that the diet of caracal reflected fluctuations in prey availability.

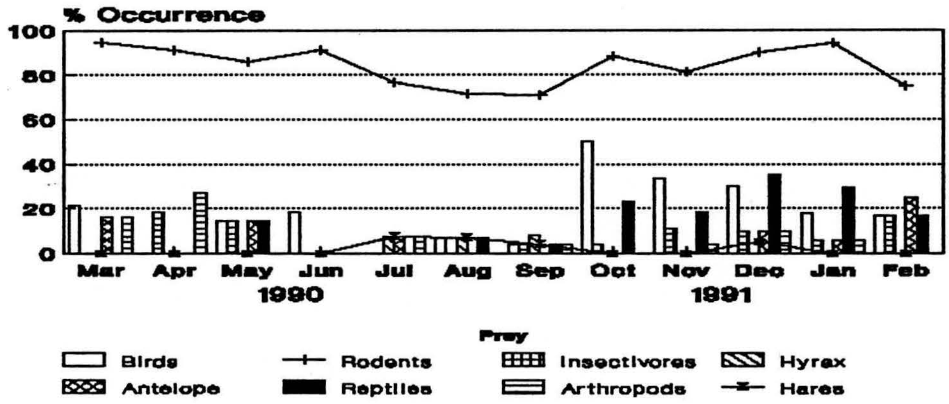

Figure 4.6 Monthly fluctuations in the composition of the diet of caracal at Postberg Nature Reserve, West Coast National Park, as deduced from scat analysis. (Mean No.scats/month = 16.8 ± 6.5)

Caracal preyed most heavily upon springbok from April to June 1990 (Fig. 4.4). This coincided with the time when the young of three territorial female caracal seen at P.N.R. could have started eating flesh and also at the time when rodent densities decreased. Caracal fed on 25 of the carcasses (67.6%) found during the first 12 months; 18 of which they definitely killed. All the carcasses, especially lambs, could not be found, however, as some were dragged off into the denser vegetation or if they were killed away from the old fallow lands. One carcass was scavenged by caracal a week after it had died probably from sickness (but definitely not killed by caracal).

F) DISCUSSION

The opportunistic and generalist feeding behaviour of caracal, e.g. utilizing prey of widely different size and identity whenever they become more available, is important in helping this felid to adapt to a large number of habitat types all over Africa. In the present study area for example, rodents were the most important prey in each of the four habitat types where prey utilization by caracal was studied. This differs from the situation in the Mountain Zebra National Park (Grobler 1981, Moolman 1984), Karoo National Park (Palmer & Fairall 1988) and on farmland in the south western Cape (Stuart 1982) where larger prey e.g. hyrax and mountain reedbuck had highest importance values. Availability of prey items larger than rodents was low in the present study area, while Cavallini & Nel (1990) and Avenant & Nel (1992) have reported on the relatively high densities of rodents in this West Coast Strandveld area. In the present study, insects and arthropods were found to be utilized throughout the year, but in small quantities, while the presence of birds, reptiles, antelope, hyrax and hare remains in scats fluctuated according to the season. Seasonal changes in abiotic factors (especially rainfall, temperature and mist) triggers changes in the West Coast Strandveld vegetation; this in turn has a major effect on caracal prey species (e.g. onset or cessation of natality) and therefore caused fluctuations in the caracal's diet. The role of the caracal as a generalist predator and not a specialist on one or a few prey helps bring about high prey species diversity in the study area, because domination by a single prey species insofar as numbers are concerned, is prevented.

Caracal were at times trapped using only a dead francolin hanging head down in traps. This, and the fact that caracal undoubtedly fed on at least one of the springbok carcasses that died of causes other than predation, indicate that caracal do scavenge at times. On the other hand, although caracal tracks were observed around old seabird carcasses on Sixteen Mile beach from time to time, no increase in bird remains in scats were found during December to February, the period when seabird mortalities were the highest. In the present study area the brown hyaena (*Hyenea brunnea*) and black-backed jackal (*Canis mesomelas*) have been eradicated (the absence of the latter being given as one of the reasons why caracal numbers have increased over the last decade - Stuart 1982, Brand 1990). Cape fox (*Vulpes chama*) is present at very low densities (pers.obs.). Scat analysis, keeping watch at carcasses at night (n=6 nights) and regular checks at carcasses showed no other carnivores (except kelp-gulls (visual observation) and yellow mongoose; remains found in one scat) to scavenge on springbok carcasses.

No accurate figures on how many springbok lambs were born and how many adults or lambs were killed by caracal or by other predators or how many died of illness could be obtained. Probably no springbok carcasses lying on the old fallow lands were missed during counts in the first 12 months of the study. The highly seasonal predation on springbok at the time when female caracal still cared for their young suggests selection for larger prey during this time. It was also the time when most small stock remains were found in scats and coincided with the lambing period of small stock in this area. Predation on stock on some farms was probably higher than found, due to differences in habitat on farms not adjacent to the W.C.N.P.

The ratio in which prey taxa were present in caracal scats from the different habitat types may be a true reflection of the densities of the specific prey items in those habitats. Except for P.N.R., the rest of the W.C.N.P. only recently was afforded conservation status. The park was proclaimed in 1985 and is still expanding. It is interesting to note the differences in caracal diet between P.N.R. and other areas inside the W.C.N.P., and especially the surrounding farming areas. The higher percentage of carnivores present in scats collected at P.N.R. may be the result of predator control on the farms, which would also explain the higher presence of rodents and insects in scats collected on these farms. According to the results following the method of Grobler (1981), viz. (Rel.%Occ. - 100) x (365 / mass) x 2, approximately 5427 Cricetidae & Muridae were killed by one adult caracal per year at P.N.R. According to Grobler (1981), an adult caracal consumes *ca* 1 kg of meat per day. Present results were multiplied by two as two or more rodents were often represented in one scat. A similar estimate shows approximately 10.4 natural antelope, 148 rodent moles and 5.4 dassies per year killed by each adult caracal at P.N.R., but fewer on farms. The lower occurrence of antelope in scats collected on farms may reflect lower antelope densities there. Overall lower prey densities is expected on the farms because of differences in habitat, but also as a result of killing all caracal and not just those responsible for stock losses.

This indiscriminate killing could result in the loss of territorial caracal and a concommittant increase in nomadic cats. All remaining caracal would also tend to increase exponentially and therefore ever decreasing natural prey densities can be expected. Not all caracal prey on small stock (Stuart 1982; Hanekom pers.comm.). Small stock farmers can take note of the role of caracal in the West Coast Strandveld ecosystem in keeping down densities of among others, hyrax, moles and rodents and appreciate that a blanket control of caracal may have a negative effect on prey species diversity and species density in general.

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CHAPTER 5

A COMPARISON OF THE DIETS OF FIVE SYMPATRIC CARNIVORES IN THE WEST COAST NATIONAL PARK

A) ABSTRACT

The diet of five sympatric carnivore species was examined by analysis of scats collected over a 14-month period in the West Coast National Park, representing a West Coast Strandveld ecosystem. Dietary patterns of all species correllated with fluctuations in densities of main prey items. Food niche widths accordingly changed seasonally, being widest during spring then contracting gradually towards winter. A considerable amount of food niche overlap existed between species pairs. The main prey item of all the carnivores examined was rodents (mainly *Rhabdomys pumilio* and *Otomys unisulcatus*), which were utilized heavily throughout the year, despite marked declines in numbers towards winter.

B) INTRODUCTION

The idea of competition is central to the theory of evolution. Volterra (1926) demonstrated mathematically that coexistence between ecologically similar species is possible only when the interspecific competition coefficients are low. In practice, however, all species occurring in a habitat coexist and overall competition between them should therefore be small. This idea of non-coexistence of ecologically similar species has led to the exclusion principle of Gause, which states that two coexisting species cannot occupy identical niches. Elton (1927) considered the niche as the fundamental role of the organism in the community. Hutchinson (1958) suggested that "an organism's environment consists of many physical and biological variables, each of which can be considered as a point in a multidimentional space (hypervolume)". The idealized "fundamental" niche of a species assumes the absence of other competing species, which is rarely the case. The conditions under which an organism actually exists in any given situation, constitute its realized niche (Smith 1986). Competition between species could operate in a number of ways for a number of different resources, all falling under competition for space (eg. reproduction, resting and feeding sites) and physiological requirements (eg. food, water, micronutrients).

This study compares the seasonal fluctuation in diet of the five most numerous sympatric species of small to medium-sized carnivores (caracal *Felis caracal*, wild cat *Felis lybica*, water mongoose *Atilax paludinosus*, Cape grey mongoose *Galerella pulverulenta*, and yellow mongoose *Cynictis penicillata*) in the West Coast National Park (W.C.N.P.), and relates this to fluctuations in prey densities.

To date, only isolated projects have been done on the diet of individual carnivores in the West Coast Strandveld ecosystem: Cape grey mongoose *Galerella pulverulenta* (Cavallini & Nel 1990; Wolff 1989), water mongoose *Atilax paludinosus* (Barnard 1990), and yellow mongoose *Cynictis penicillata* (Cavallini in prep.), and one comparative study of the diet of bat-eared foxes *Otocyon megalotis*, *C. penicillata*, *G. pulverulenta* and *A. paludinosus* (MacDonald & Nel 1986). None of these studies have reported on the impact that changes in prey abundance have on the diet of these sympatric predators.

C) STUDY AREA, MATERIALS AND METHODS

The WCNP (near Langebaan; *ca* 100 km north of Cape Town) lies within the West Coast Strandveld (veld type 34b) of Acocks (1988). Warm, dry summers and cold, wet winters are characteristic of the climate of this area. Mean yearly rainfall is 270 mm (Weather Bureau 1965), with most rain and fog in winter. Mean monthly temperature (Max/Min) is $23^{o}C/11^{o}C$ (Weather Bureau 1965). Wind is predominantly from the south, or north-west in winter, and often reaches speeds of up to 5 m/s on the higher koppies. Vegetation is typical West Coast Strandveld, mostly on deep sandy soil, and shows marked floristic changes between autumn (dry, barren) and spring (deciduous plants in bloom; dense stands of annuals (Gerber 1990; pers.obs.). Boucher & Jarman (1977) divided almost the whole present WCNP into 18 different plant communities. Because these communities form a mosaic, they were arranged for the purpose of this study into three larger areas differing markedly in geology, flora and fauna: The Postberg Nature Reserve (PNR) (a contractual part of the Park); the freshwater marshes at the south-eastern part of the Langebaan lagoon; and the mostly consolidated and vegetated sand dunes of the rest of the W.C.N.P.

All fresh carnivore scats encountered were collected once a month over a 12-month period (Chapter 2), separately placed in brown paper bags, air dried in the laboratory and later teased apart. All scats (except those of *C. penicillata*) were found lying separate from each other, and probably contained the remains of separate feedings (Floyd *et al.* 1978). Large diagnostic prey fragments in scats were macroscopically identified while hair, teeth, feathers and reptilian scales were identified under a stereo microscope (Wild M5D) at 25x or 50x magnification. Prey items were identified up to species level where possible by comparing undigested remains with a reference collection, comprising material obtained from the South African Museum (Cape Town), the John Ellerman Museum (Department of Zoology, University of Stellenbosch) and from carcasses in the study area. Prey fragments were also compared with diagnostic features as published, eg. scales on hair imprints (Keogh 1983 a & b) (Method of Faliu *et al.* 1979) and tooth form (De Graaff 1981).

Only scats containing a particular species' hair were used to describe that species' diet, using the Percentage of Occurrence method (see, for example, Corbett 1989). Although this method by itself cannot accurately describe the diet of carnivores (Putman 1984; Bowland & Bowland 1991), it was used to quantify and compare the fluctuations in number of prey taxa utilized as food with the fluctuations in numbers of prey available, to compare the utilization of each taxon by the five predators, and to enable a comparison with the results from studies done elsewhere.

Only the diets of *G. pulverulenta*, *A. paludinosus*, and *F. lybica* are described here in detail; that of *C. penicillata* has been published elsewhere (Avenant & Nel 1992) while that of *F. caracal* is discussed in Chapters 5. Food niche overlap and niche width is calculated (following Pielou 1972), where:

Niche width = đ $u_i h_i(b)$, and

Niche overlap = đ $v_j h_j(a)$

$u_i = x_i{*}/N$, $x_i{*}$ is the frequency of occurrence of the *i*th animal species in all c habitats; $h_i(b)$ is the habitat diversity of the *i*th species; N is the total number of occurrences observed. $v_j = x{*}_j/N$, $x{*}_j$ is the frequency of occurrence of all r animal species in the *j*th habitat; $h_j(a)$ is the species diversity within the *j*th habitat. Insect-, reptile-, bird and mammal orders (except Rodentia), classes Arachnida, Crustacea and Osteichthyes, phylum Mollusca and eggs, were regarded as resource classes.

An Importance Value for rodents, a common prey item in the diet of all the carnivores studied, was calculated as: I = relative percentage of occurrence x estimated mass eaten of rodents (the mean mass of the sexes of each species x the species' relative percentage occurrence in scats) (Grobler 1981, Kruuk & Parish 1981). Mass values are from areas closest to our study area listed in Smithers (1983). Main items were taken as resource classes contributing >40% of the volume in scats when present; minor items contributed <4%.

D) RESULTS

Diet

Galerella pulverulenta

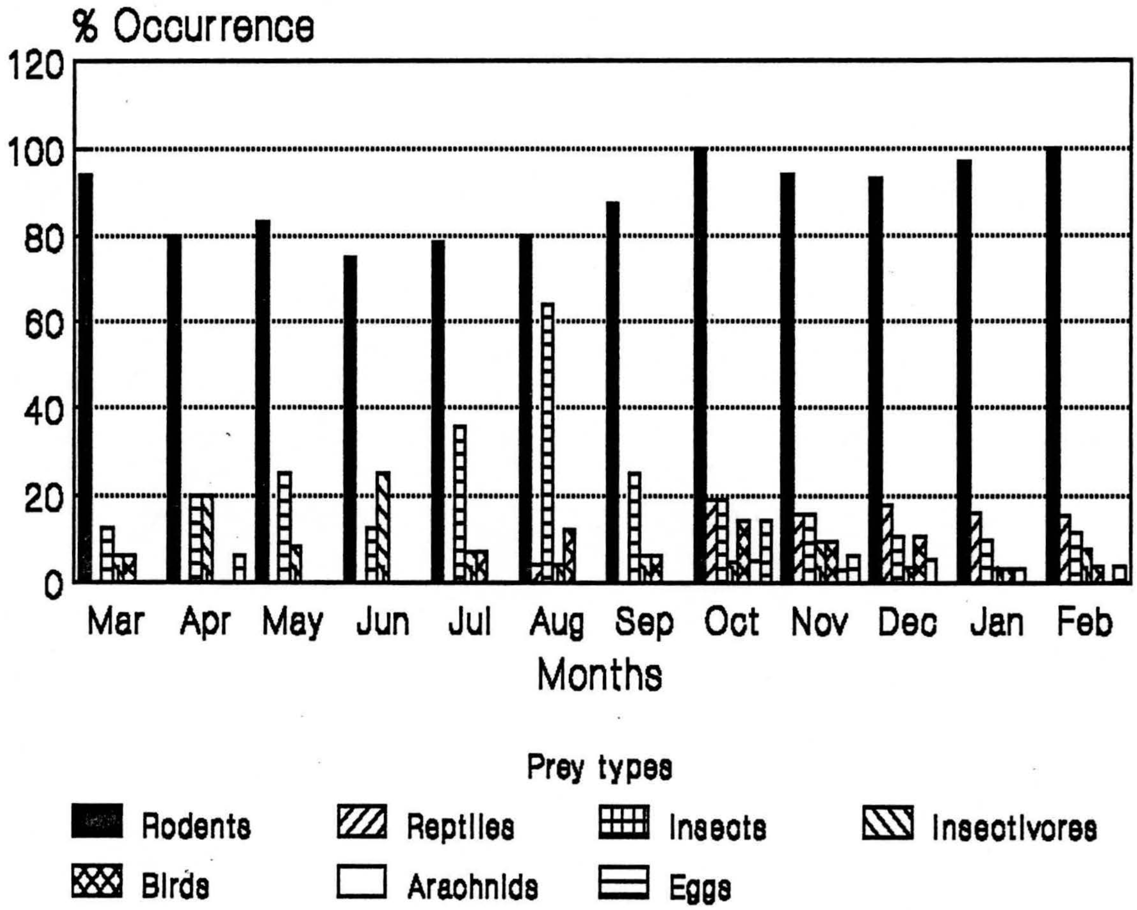
Although the diet of *G. pulverulenta* in P.N.R. and the freshwater marshes differed (mean monthly percentage occurrence of prey items - Table 5.1), the occurrence of individual items fluctuated in unison. (Figs. 5.1 & 5.2). Rodents were the single most important prey item throughout the year at both sites. Although the actual density of rodents was much lower on the marshes (the mean density in four plant communities at P.N.R. was 138 *R. pumilio* / ha. vs 84 *R. pumilio* / ha in autumn on the marshes (Chapter 3)), the occurrence of rodents in scats collected from the marshes was very similar to that in scats from the P.N.R. The percentage occurrence of prey items in general increased as their numbers, and therefore availability, increased (see Chapter 3). The simultaneous and corresponding fluctuations in availability and usage of prey such as relatively small food items e.g. coleopterans, scorpions and spiders, indicate an absence of dietary specialization and a generalist feeding behaviour. The presence of birds and eggs in scats also increased in the beginning of spring which coincided with the laying and hatching of eggs. The eggs occurring in scats at the end of summer may be reptile eggs (Cavallini & Nel 1990). Adult birds were taken throughout the year. Shrews (mostly *Myosorex varius*) occurred more frequently in scats when rodents were available in lowest percentages, i.e. late autumn to winter. Reptiles were mainly eaten in the warmer summer months, when they were more active and bred (G. Tomsett pers. comm.; Patterson & Bannister 1987). In Table 2 the diet of *G. pulverulenta* is compared with the other three carnivores studied at P.N.R. Plant material (grass and sticks) was present only as a minor item, contributing less than 4 % to the volume of scats when present, and was probably ingested accidentally.

Atilax paludinosus

The percentage occurrence of different prey items in the diet of *A. paludinosus* at both P.N.R. and on the freshwater marshes during different months also fluctuate (Fig. 5.3 & 5.4). Rodents were also the main prey item throughout the year at both sites. In addition, water mongooses also utilized fish and crabs, the latter being more important as prey during the drier summer months, and also more important throughout the year on the marshes than at P.N.R. Crab occurrence in scats increased markedly after winter as the marshes dried up. As rodent densities were still comparatively high during this time of year (Chapter 3), crabs must have become more available to water mongooses, either because of increasing density, increased activety, or simply being easier to capture in more shallow water. The overall lower density of rodents on the marshes (see above) was probably responsible for a higher percentage occurrence of crustaceans, fish and birds in scats, and a lower percentage rodent occurrence in scats. Reptiles (mostly lizards *Mabuya capensis* and *Cordylus niger*, but also one puff adder *Bitis arietans*), insects and arachnids were, together with rodents, more heavily utilized at P.N.R. Scorpion fragments were present in 85% of scats containing

Table 5.1. The diet of *Galerella pulverulenta* and *Atilax paludinosus* at Postberg Nature Reserve and on the freshwater marshes. (Mean monthly percentage occurrence in scats; March 1990 - February 1991)

	G. pulverulenta		*A. paludinosus*	
	P.N.R.	Marshes	P.N.R.	Marshes
Mammals	98.9	99.0	100.6	88.6
Insectivora	3.6	15.8	16.3	9.2
Rodentia	94.9	93.2	87.9	79.4
Birds	6.1	7.8	17.6	19.7
Small birds	5.4	7.8	17.2	19.7
Big birds	0.7	-	0.4	-
Reptiles	7.3	3.5	7.8	3.6
Serpentes	1.0	0.5	0.4	-
Lacertes	6.3	3.0	7.4	3.6
Insecta	21.8	10.4	28.7	17.7
Coleoptera	15.9	6.7	12.6	9.3
Hemiptera	0.3	-	-	-
Hymenoptera	0.6	0.4	0.5	0.5
Isoptera	0.3	-	-	-
Odonata	1.2	0.3	1.1	0.8
Orthoptera	3.5	3.0	14.5	7.2
Arachnida	1.4	1.2	25.6	5.5
Pisces	-	-	0.4	2.2
Crustacea	-	-	4.2	32.1
Eggs	2.6	2.7	-	-
Mean No.scats/month	19.9±8	18.5±3	17.5±5	14.3±2



(Percentage occurrence in scats)

Figure 5.1: Fluctuations in the diet of *Galerella pulverulenta* at Postberg Nature Reserve, West Coast National Park, from March 1990 - February 1991.

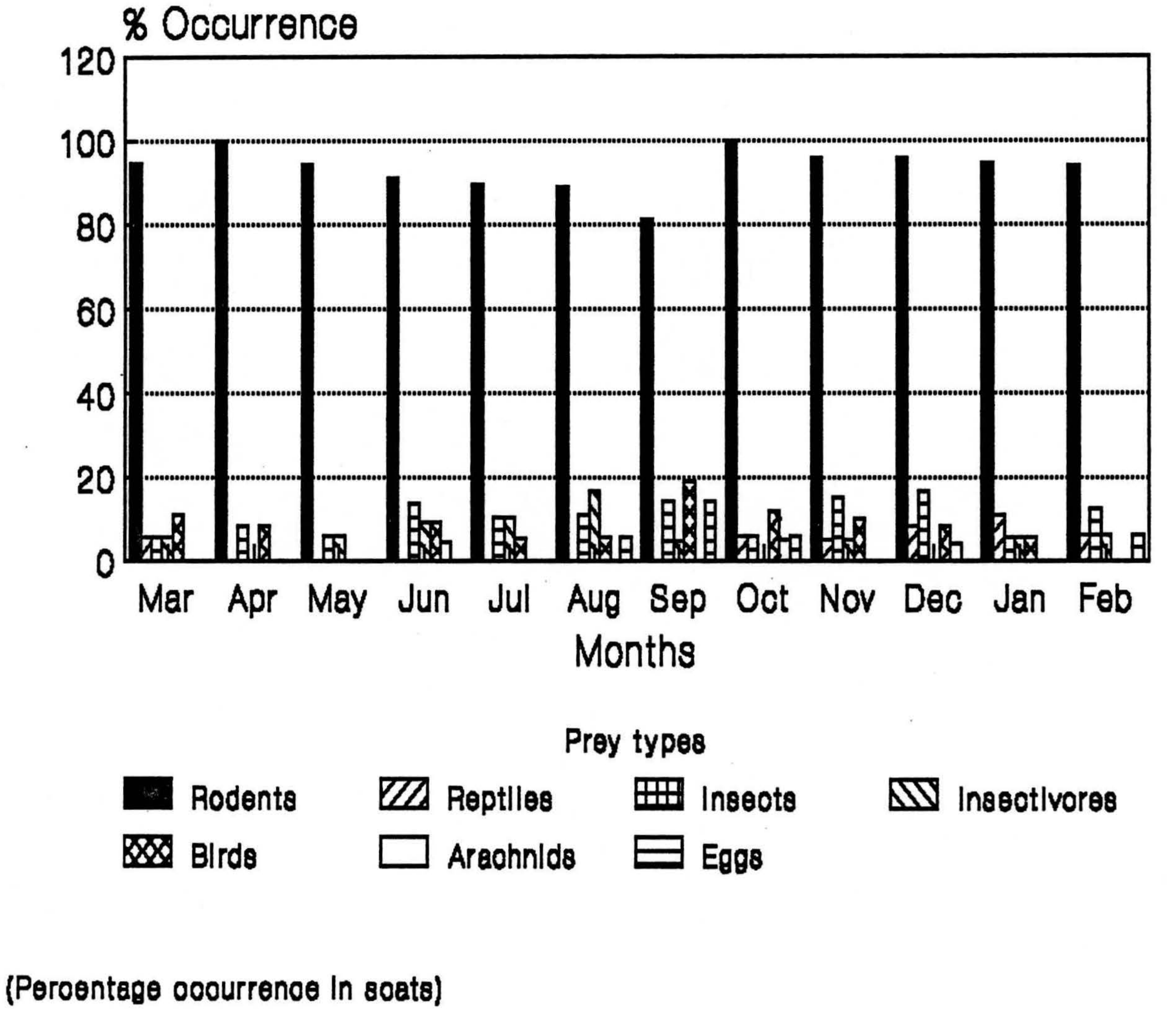


Fig.5.2: Fluctuations in the diet of *Galerella pulverulenta* on the freshwater marshes, West Coast National Park, from March 1990 - February 1991.

Table 5.2. Mean monthly percentage occurrence of prey items in the scats of five sympatric carnivores in the Postberg Nature Reserve, March 1990 - February 1991. (A) *Cynictis penicillata,* (B) *Galerella pulverulenta,* (C) *Atilax paludinosus,* (D) *Felis lybica* and (E) *Felis caracal.*

	A (n=332)	B (n=239)	C (n=210)	D (n=8)	E (n=201)
Mammals	40.8	98.9	100.0	100.0	100.0
Artiodactyla	-	-	-	-	6.6
Carnivora	-	-	-	-	1.9
Hyracoidea	-	-	-	-	1.9
Insectivora	-	3.6	16.3	12.5	7.0
Lagomorpha	-	-	-	-	2.0
Rodentia	40.8	94.9	78.9	87.5	89.1
Birds	12.8	6.1	17.6	37.5	17.7
Passeriformes	12.8	5.4	17.2	25.0	10.7
Galliformes	-	0.7	0.4	12.5	7.0
Reptiles	13.3	7.3	7.8	12.5	12.4
Serpentes	-	1.0	0.4	-	0.5
Licertes	13.3	6.3	7.4	12.5	11.9
Insecta	90.0	21.8	28.7	25.0	6.2
Coleoptera	23.4	15.9	12.6	12.5	1.2
Hemiptera	0.6	0.3	-	-	-
Hymenoptera	0.8	0.6	0.5	-	-
Isoptera	51.3	0.3	-	-	-
Odonata	1.3	1.2	1.1	-	0.5
Orthoptera	12.6	3.5	14.5	25.0	4.5
Arachnida	1.2	1.4	25.6	-	10.6
Crustacea	-	-	4.2	-	-
Osteichthyes	-	-	0.4	-	-
Mollusca	1.5	0.3	-	-	-
Bird & Reptile eggs	2.0	2.6	-	-	-

arachnids; in 71% of these scats, grass constituted more than 4% of scat volume (max.% volume = 60 %; mean = 14.3 ± 14.6 % of volume).

Felis lybica

Only eight scats could be found at P.N.R. during the >12 month study period. Results from the scats were pooled and are given in Table 5.2. This small number of scats probably do not reflect the true diet of *F. lybica* at P.N.R., and also do not take possible seasonal fluctuations into account. Niche width and overlap for *F. lybica* were therefore not calculated. Rodents were the main prey item (87.5 percentage occurrence), with insectivores (*Myosorex varius*), birds (Passeriformes), lizards and insects also present.

Cynictis penicillata & *Felis caracal*

The diets of these two species are discussed in detail elsewhere (Avenant & Nel 1992 & below), but for comparative purposes a summary is given in Tables 5.2, 5.3 & 5.4. Like *G. pulverulenta* and *A. paludinosus* (and most probably also *F. lybica*), they seem to be generalist and opportunistic predators with prey taxa more abundant in scats as their particular population densities increase.

Dietary separation

Table 5.2 shows the mean monthly percentage occurrence of prey types in the faecal remains of the five carnivore species studied. Except for *Cynictis penicillata*, all utilized rodents most often as prey throughout the year, and the occurrence of rodents, especially *Rhabdomys pumilio*, in their scats fluctuated in unison with availability (increase

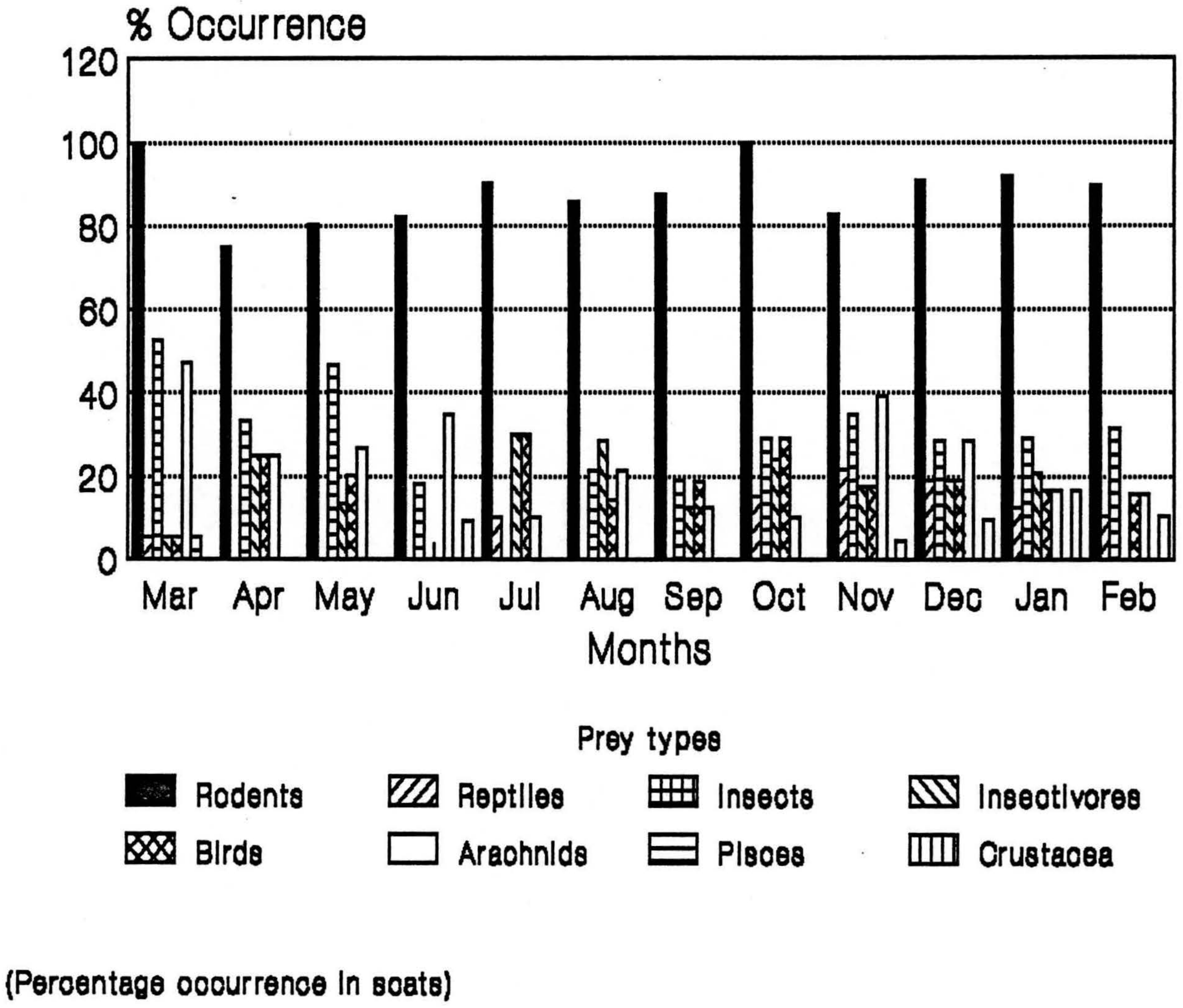
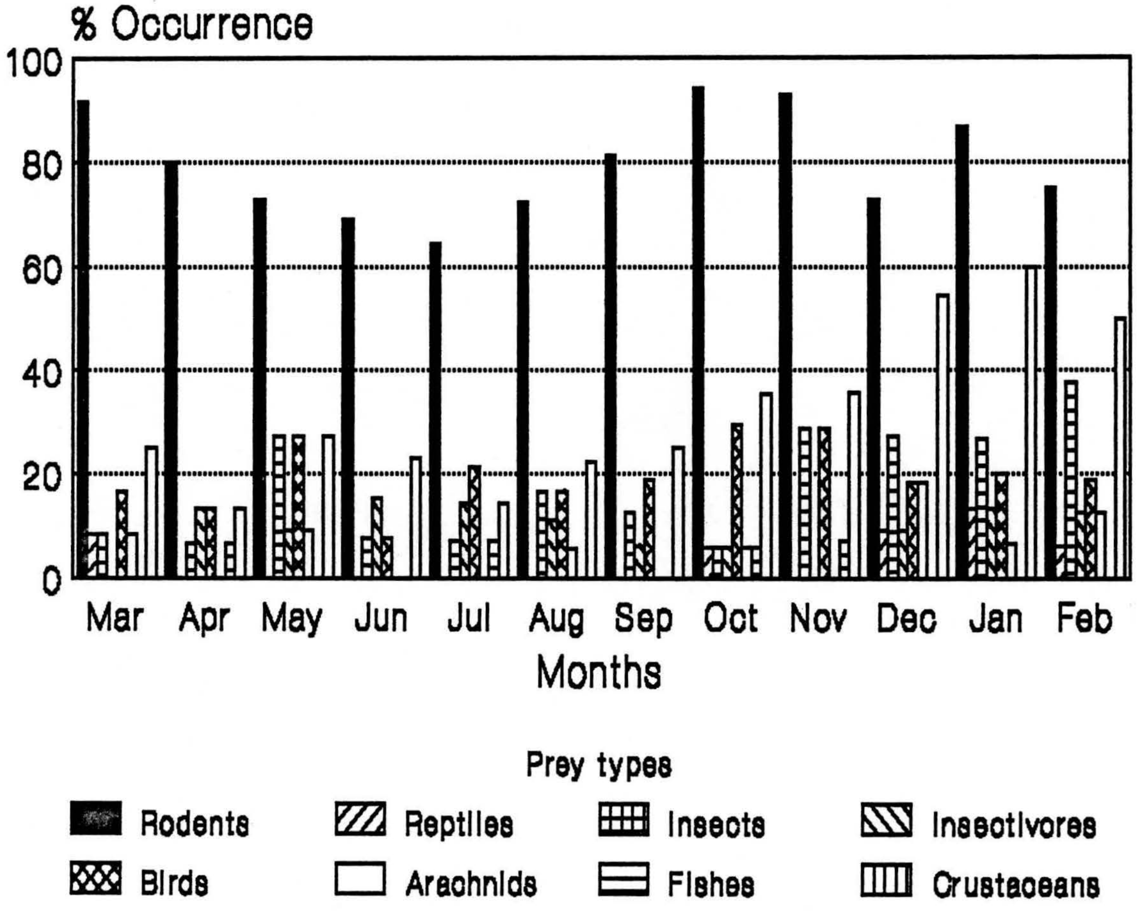


Figure 5.3: Fluctuations in the diet of *Atilax paludinosus* at Postberg Nature Reserve, West Coast National Park, during 1990-1991.



(Percentage occurrence in scats)

Fig.5.4: Fluctuations in the diet of *Atilax paludinosus* on the freshwater marshes, West Coast National Park, during 1990-1991.

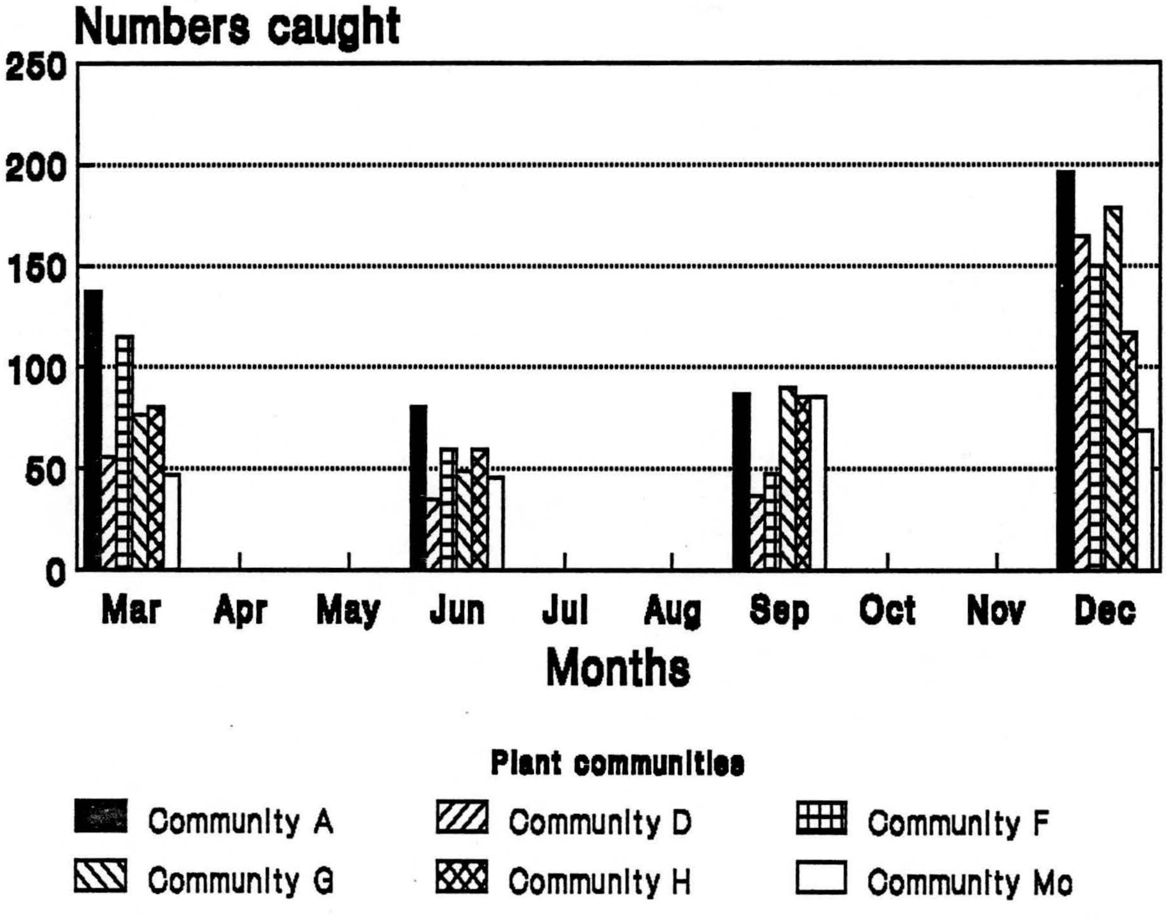


Figure 5.5: Fluctuation of *Rhabdomys pumilio* density in the West Coast National Park, as trapped during March, June, September and December 1990.

in density - Fig. 5.5). Rodent presence in the diet of *C. penicillata* fluctuated the most (see Avenant & Nel 1992), indicating that this carnivore does not depend on rodents as food as much as do the others (although there are not enough data available for *F. lybica*). Mean percentage occurrence of rodents was highest in *G. pulverulenta* scats (94.9%). Competition for available rodents among the carnivores was lessened as the different rodent species (Table 5.3), and rodents relative to other prey (Table 5.2) was taken in somewhat different proportions by the different carnivore species. The carnivore species also differed in times of activity and preferred habitat. *R. pumilio* was by far the most numerous rodent in this study area; at least seven times more than that of *O. unisulcatus* in all plant communities in the W.C.N.P. (Chapter 3). The higher relative percentage occurrence of *O. unisulcatus* compared to *R. pumilio* in the larger scats of *F.caracal* and *A. paludinosus*, may be somewhat biased figures as pieces of skulls and teeth could be recognized as belonging to more than one *R. pumilio* individual (shown as a problem in scat analysis by Weaver & Hoffman 1979). However, even if the percentage occurrence of *R. pumilio* is multiplied by two to get a maximum number eaten, the percentage occurrence of *O. unisulcatus* was still higher in scats of the two larger carnivores. If the densities of these two rodent species are taken into account (Chapter 3), all the carnivores probably select (or prefer) *O. unisulcatus* above *R. pumilio*. *Otomys unisulcatus* had by far the highest importance value of all rodents in all carnivores' scats (Table 5.4).

The varying seasonal occurrence of birds and reptiles in the diet of four carnivores (not enough data are available for *Felis lybica*) suggests that these prey types were probably taken in the same proportions each by all four carnivores. The largest carnivore in this ecosystem, *F. caracal* (6 - 20kg), had the widest range in size of prey items (from Odonata to Artiodactyla)(Table 5.2). Water mongoose (*ca* 3-4

Table 5.3: Mean monthly percentage occurrence of rodent species relative to each other in scats of five carnivore species at Postberg Nature Reserve, West Coast National Park, during 1990-1991. Mean monthly number of scats (+ SD) analyzed given in parenthesis: A = *Cynictis penicillata* (n = 27.7 ± 16.8), B = *Galerella pulverulenta* (n = 19.9 ± 8.3), C = *Atilax paludinosus* (n = 17.5 ± 5.5), D = *Felis lybica* (Total number of scats = 8), E = *Felis caracal* (n = 16.8 ± 6.5)

Rodents	A	B	C	D	E
Otomys unisulcatus	55.6	44.7	61.9	42.9	61.7
Rhabdomys pumilio	43.0	41.0	31.9	42.9	22.6
Mus minutoides	1.4	5.6	0.9	14.5	4.5
Gerbillurus paeba	-	1.0	-	-	2.3
Tatera afra	-	2.9	0.9	-	2.3
Unidentified	-	4.8	3.5	-	3.6
Rodent mole	-	-	0.9	-	3.0

kg), the second largest carnivore, had the second largest size range of prey (Orthoptera to rodent moles), while the smallest carnivore, yellow mongoose (*ca* 0.5 - 0.9 kg), fed on the smallest range (Hymenoptera to *Otomys unisulcatus*). Small grey mongoose (*ca* 0.5 - 1.25 kg; MacDonald & Nel 1986) ate prey in size ranging from insects to francolin. Caracal

Table 5.4: Importance value (I) of rodent species in the diet of four carnivore species at Postberg Nature Reserve, West Coast National Park, during 1990-1991 where I = Relative percentage ocuurence x Mean estimated mass (g) of all rodents. n = total number of scats. A - *Cynictis penicillata* (n = 332), B - *Galerella pulverulenta* (n = 239), C - *Atilax paludinosus* (n = 210), D - *Felis caracal* (n = 201)

	A	B	C	D
Otomys unisulcatus (124.5g)	2826.2	5278.8	6075.6	6723.0
Rhabdomys pumilio (22,9g)	400.8	890.8	577.1	453.4
Mus munitoides (3.1g)	1.9	16.4	2.2	12.1
Gerbillurus paeba (25.4g)	-	22.9	-	50.8
Tatera afra (97.1g)	-	271.9	68.0	194.2
Rodent moles (375. 8g)	-	-	263.1	977.1
Total	3228.9	6480.8	6986.0	8410.6

fed on four prey items (antelopes, other carnivores, dassies and hares) not utilized by any of the other carnivores, water mongoose on two (crustaceans and fish), and yellow & grey mongoose together on four (2 insect orders, molluscs and eggs). On the other hand, caracal fed on six items fewer than all the other carnivores together, water mongoose on eight, small grey mongoose on eight, and yellow mongoose on nine. Seasonal niche breadth (Fig.5.6) of all carnivores were widest in spring (except for *C. penicillata*) and smallest in winter (except for *A. paludinosus*), and was found to vary for each carnivore species depending on the relative availability of the different prey. Caracal had widest niche breadth (overall = 0.98) and yellow mongoose the narrowest (0.77). Small grey mongoose (0.96) and water mongoose (0.95) had overall niche breadths more or less similar to that of caracal, and can therefore be taken as more generalist feeders than yellow mongoose.

Food niche overlap (Fig.5.7) was largest between small grey mongoose and water mongoose, and smallest between caracal and yellow mongoose.

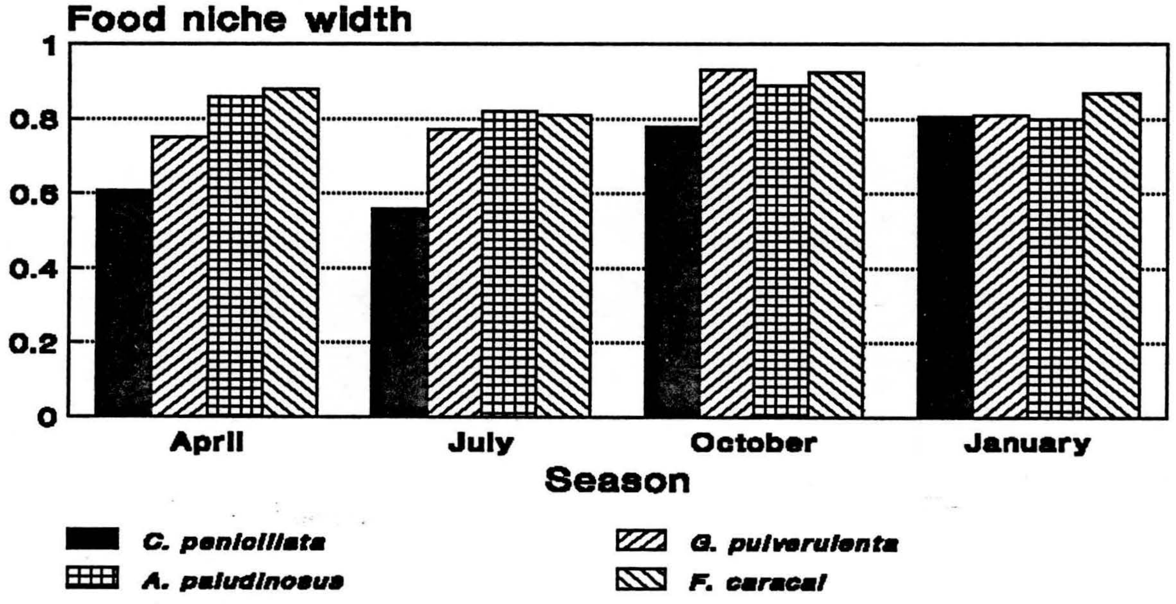


Figure 5.6: Seasonal variation in food niche width of four sympatric carnivores at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

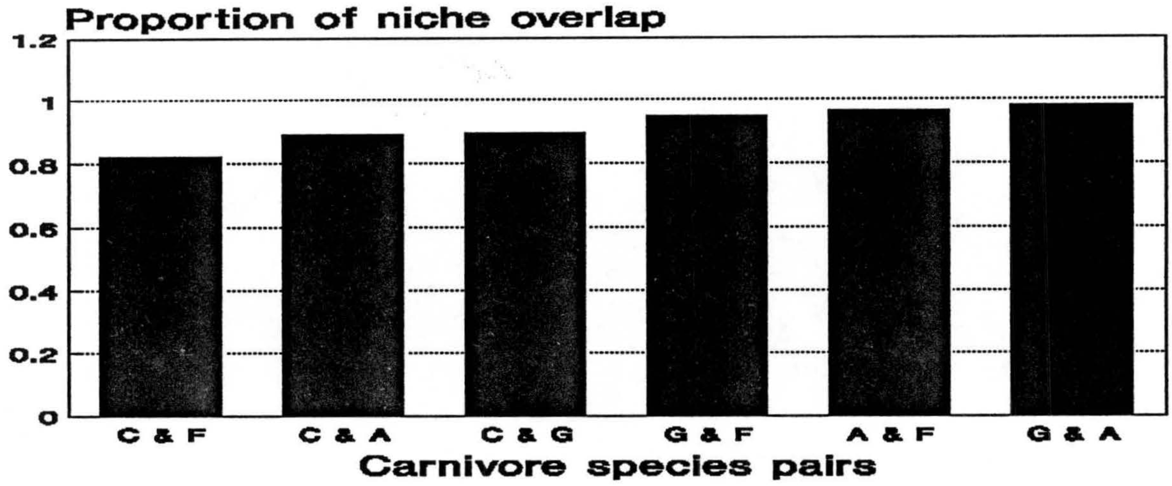


Figure 5.7: The proportion of food niche overlap between four sympatric carnivore species at Postberg Nature Reserve, West Coast National Park, during 1990-1991. C - *Cynictis penicillata*; G - *Galerella pulverulenta*; A - *Atilax paludinosus*; F - *Felis caracal*

E) DISCUSSION

Carnivore populations are generally thought to be limited by the availability of prey (Van Hensbergen 1984). Ecological separation of some carnivore species in the West Coast Strandveld could be elucidated by the study of the exploitation of food resources. Like most carnivores (MacDonald & Nel 1986), the carnivores studied here were generalist feeders, as the percentage occurrence of specific prey items in their scats in different habitats generally closely followed relative numbers and availability of prey. Although the main study area, P.N.R., is relatively poor in small mammal species (Avery *et al.* 1990; Chapter 3), it has very high rodent numbers/ha

(Cavallini & Nel 1990; Chapter 3). Probably because of this high rodent density (as well as separation in space and time), little exploitative or interference competition as far as rodent prey is concerned, occurred between the carnivore species studied. Although rodent utilization decreased slightly as rodent numbers decreased seasonally, rodents were throughout the year present in 77% - 98% of scats from three of the carnivore species studied. Intra- & interspecific predator/prey interactions and intraspecific social interactions therefore probably played a major role in limiting carnivore numbers in study area, rather than limitations imposed by food supplies. The high density of snakes and birds of prey in the area (pers. obs.) support the data on rodent abundance.

The higher percentage occurrence of insectivores, birds and a lower percentage occurrence of reptiles, insects and arachnids in small grey mongoose scats at the marshes may well reflect the differences in comparative availability of these items in the different habitat types.

The fact that small prey items like Hymenoptera were taken in small quantities, and the seasonal occurrence of specific prey items observed in the diet of all carnivores studied, shows all of these carnivores to be opportunistic in their feeding habits. Grass were at times almost certainly ingested on purpose, especially by water mongoose and caracal.

The largest carnivore, caracal, is the most generalized feeder of the four (even when wildcat is included), while the smallest, the yellow mongoose, the most specialized. Palmer & Fairall (1988) found more or less the same percentage occurrences of the same prey species in 11 *Felis lybica* scats from the Karoo National Park, as was found in the small sample from P.N.R. Smithers (1983) reported that wild cat also take reptiles, solifuges, amphibians, Aranea, Myriapoda, scorpions and wild fruit. These items could have shown up in larger sample of scats.

From food availability studies (Chapter 3), winter is the lean season and should be the time when interspecific competition for food should be highest. Interspecific competition tends to oppose an increase in niche breadth because individuals taking less preferred food may come into competition with other species (Pianka 1983, In: Van Hensbergen 1984). Interspecific competition can be avoided if two species change their resource usage; the use of different resources by similar species is known as "ecological separation". Interspecific competition need not be evident at all times, but should occur only at times when an essential resource is short for each of the species (Van Hensbergen 1984). If carnivore populations are limited by food, the limitation is thus likely to apply only at some critical time of year when a food source is reduced. Variation in the availability of the major prey items in the study area is due to fluctuations in the prey populations induced by factors other than predation. For many species (eg. stoats - Erlinge 1983) the critical time is the reproductive season when the energy requirements of individuals is high and the time available for feeding is short.

On the other hand, intraspecific competition tends to increase niche breadth because individuals using less favoured sources of food, but without competing for them, will increase their fitness more than individuals competing strongly for a preferred food. However, trophic niche breadth may still vary depending on the relative availability of foods for each species of carnivore.

To conclude: The difference in body size of the four carnivores indicate that some difference in prey size selection does occur even when foraging in similar habitats.

This, plus the differences in the degree of opportunism, habitat selection and activity cycles, could effectively reduce the amount of interspecific competition, allow increase in niche widths and coexistence.

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CHAPTER 6

HABITAT USE AND HOME RANGE SIZE OF CARACAL, IN RELATION TO PREY DENSITY

A) ABSTRACT

Habitat use and home range size of caracal (*Felis caracal*) were studied in relation to rodent (Cricetidae and Muridae) density in strandveld on the Cape West coast. Rodent remains occurred in 72-96% of caracal scats collected on a monthly basis. Habitat use by five transmitter-equipped caracal indicated that they used the bottom slopes of granite kopjes more extensively than open flats, upper slopes or plateaux, especially in the denser *Atriplex-Zygophyllum* Dwarf Shrubland and the *Ehrharta-Maurocenia* Hillside Dense Shrubland. Caracal spent most of their time active in specific areas where highest rodent densities and species diversities were found. Males were 45-180 min. active in a given area (patch) before moving without stopping to another patch; females covered their ranges more uniformly.
The mean home range size (26.97 ± 0.750 km^2) of two males inhabiting the same area but at different times was 3.6 times larger than the mean home range of three females (7.39 ± 1.68 km^2). The female with lowest mass had the smallest home range. Home ranges overlapped both within and between sexes. Caracal were mostly nocturnal, but were also active during daytime in the colder winter. No correlation was found between degree of activity and cloud cover, full or dark moon, wind speed, or rain, but a strong correllation existed between amount of activity and temperatures above or below 20^oC - 22^oC. Caracal were solitary and probably territorial as overlap of ranges was small and males and females almost never came

together, based on radio-tracking. Mean litter size was 2.25 ± 0.96, with kittens staying ca 120 days with their mother in her territory, a time which coincided with the time when most springbok were killed and when highest stock loss was reported on farms in the Swartland Regional Council.

B) INTRODUCTION

The majority of carnivore species (five of seven families) are primarily solitary , with little contact between conspecifics (Gittleman 1989). *Felis caracal* is one of the solitary cat species (Stuart 1982; Smithers 1983; Moolman 1986), occurring in nearly every habitat type over most of southern Africa. Despite being heavily hunted as a "problem" animal, causing losses to small stock, over the past 75 years (Brand 1990), there is little published information on caracal foraging methods and home range use. Radio-telemetry on this medium-sized (<24kg) predator have been undertaken in the Mountain Zebra National Park (Moolman 1986), the farmlands of the southwestern Cape (Stuart 1982) and on one individual in the fynbos of the Hottentots Holland mountain range in the western Cape (Norton & Lawson 1985). Home range use in none of these studies, however, was correlated with diet or prey abundance, nor had individuals been followed continuously for more than 30 min. at a time. Large variations in home range size have been found, which could have resulted from differences in prey density and prey size, amount of cover available and degree of persecution by man in the different study areas (Moolman 1986). Home range size of carnivores is dependent on their energy and reproductive requirements as well as intra- and interspecific relations (McNab 1963). Home range size of different carnivores has more than once been reported to be inversely correlated with prey density, e.g. the resource dispersion hypothesis of Macdonald

(1981)(Smith 1968; Holmes 1970; Mares, Watson & Lochner 1976). Sandell (1989) assumed that amount and distribution of food determines the distribution of females of solitary carnivores, whereas Erlinge & Sandell (1986) found that spacing in males, at least during the mating season, is determined by the distribution of females.

Rodents were the single most abundant (based on percentage occurrence in scats) prey item of caracal in the West Coast Strandveld study area (see Chapters 3, 4 & 5), and home range size and use (Macdonald 1981) could therefore be influenced by the distribution and density of rodents. The present study attempted to relate caracal activity patterns and home range size and configuration to the density and distribution of rodents at the Postberg Nature Reserve (P.N.R.) in the West Coast National Park (W.C.N.P), and to estimate numbers of caracal in the whole park. Caracal spatial relationships and social structure in this area, where no trapping or hunting have been undertaken for more than five years, were also investigated.

C) STUDY AREA

This study was conducted in the Postberg Nature Reserve (P.N.R.), an integral part of the West Coast National Park (W.C.N.P.), and in the adjacent Donkergat Military Area (33^{o} 05' S;18^{o} 02' E). The total area involved was ca 3 000 ha. The topography is dominated by two granite outcrops (189 m and 193 m a.s.l.), interspersed with flats in places cultivated until 1968. The area is situated in the West Coast Strandveld (34b) of Acocks (1988). Climate is mediterranean, with nearly all precipitation in winter and with a mean of 253 mm per year (Weather Bureau 1965). Mean monthly temperatures (max:min) range from 14,6^{o}C:8.7^{o}C in July to 21^{o}C:13.2^{o}C in February; maximum temperatures often exceed 25^{o}C in summer. The vegetation is characterized by a complex mosaic of scrubby associations on deep sand or granite-derived soils. Boucher & Jarman (1977) divided the whole study area into the following plant communities using differentiating species which are, wherever possible, also conspicuous and related to outstanding habitat features: Community A (*Atriplex-Zygophyllum* Dwarf Shrubland); B (*Pelargonium-Muraltia* Dwarf Shrubland); C (*Galenia-Senecio* Hillside Closed Dwarf Shrubland); D (*Ehrharta-Maurocenia* Hillside Dense Shrubland); E (*Nenax-Maytenus-Zygophyllum* Evergreen Shrubland); F (*Pteronia uncinata* Evergreen Dwarf Shrubland); G (*Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland), and I & J (*Thamnochortus spicigerus* Dune Dense Tall Restioid Herbland & *Hermannia pinnata* Littoral-dune Dwarf Succulent Shrubland).

The P.N.R. is bordered in the west and east by the cold Benguela current of the Atlantic ocean, and the Langebaan lagoon respectively. The Donkergat military area (ca 1000 ha) at the northern tip of the Langebaan peninsula is managed as a natural area, while the consolidated and usually well vegetated sand dunes of the rest of the W.C.N.P. stretches for ca 25 km southwards along the coast, and inland around the southern tip of the Langebaan lagoon.

A wide array of other predators, and therefore possible competitors, are still present in the study area, but all are smaller than caracal (Avery, Rautenbach & Randall 1990). The area is locally well known for its very high densities of snakes and smaller birds of prey, an indication of high rodent density.

D) MATERIALS & METHODS

Studies on rodent density and species diversity in four different plant communities and at 15 different contours at P.N.R. were undertaken as described in Chapter 3. Some results are repeated in this chapter to aid in the interpretation of caracal home range size and foraging behaviour.

Single-door walk-in box traps consisting of a metal frame covered with heavy meshed wire, and measuring 1,8 x 0,6 x 0,6 m (as described by Schellingerhout 1978) was used to trap caracal. Baits used were dead francolin, dead bush-preferring birds (e.g. the Cape wagtail, Cape robin, Olive thrush), live chickens, scent bait (a mixture of rotten ox blood, meninges and fish), fresh caracal scats, female caracal urine, a black and white feather hanging on a string at the back of the cage, and various combinations of the different baits. Non-target animals caught were released immediately after discovery. Caracal caught were manoevered and held tight against the side of the traps with the aid of round wooden droppers, and injected intramuscularly with Ketalar (Ketamine HCl, Parker-Davies; 50mg/ml) at an estimated dose of 0.2ml/kg. Anaesthetized animals were weighed, sexed and measured to determine age (Stuart 1982, Brand 1990).

Adult caracal were fitted with radio collars, while young caracal were ear marked and fitted with dull-coloured (brown, light brown, green, green and red, light brown and red) flexible conveyer-belt neck bands to facilitate visual recognition when free ranging, or when recaptured. All captured caracal were released at the capture site at least five hours after anaesthetizing, the same evening or early the next morning. Radio collars weighed between 240 g and 300 g (less than 4% of body mass) with the transmitter powered by a lithium battery with a theoretical life of 12 months.

Radio-tracking was done on foot with a single hand-held 4-element yagi antenna and a Yaesu FT-290 Mark 1 receiver (Yaesu Musen Co., Ltd., Tokyo). Radio-transmitters were constructed by G. van Urk of Potchefstroom University, and operated on 144-148 mHz. A grid was drawn on a 1:50 000 topographical map of the study area so that the grid lines represented imaginary lines actually 250 m apart. The position of each caracal followed was plotted to the nearest 125 m every 15 min. on this grid. Bearings for every plot were taken from two or more directions from points between 300 and 800 m away from the caracal, and with intersection of angles between 45^{o} and 90^{o} so as to reduce the error in the polygon size; and always downwind from the caracal. Tracking was undertaken continuously over periods lasting from 1 to 120 h. Each caracal was tracked for such varying periods over a total time span of at least 130 days. Since none of the current measures of home range size is free of problems (Anderson 1982), and also to make possible comparisons with other studies, three methods were used to calculate home range size: the convex polygon (Southwood 1966), concave polygon, and the minimum area method of Mohr (1947). Resting places of caracal were excluded from these analyses and only a single fix was taken when a caracal was inactive so as to measure habitat preference of active caracal only. No allowance in calculating home range size was made for the increased area of granite slopes. Home range analyses by the convex polygon and concave polygon methods were done using the computer program Mcpaal (Smithsonian Institution, Washington, D.C.), and home range size and area of home range overlap were calculated by joining the outer points of respective home ranges, and counting the number of squares (1.653 ha each in size) that fell inside this area.

The linear distances moved between successive fixes (15 min interval) for each caracal were added to compare distances moved and foraging speed of males and females when active. Like Brand, Keith & Fischer (1976) and Ward & Krebs (1985) we assumed that caracal were foraging whenever they were travelling. "Core areas" or "centres of activity" (Witmer & DeCalesta 1986) were calculated for individuals of both sexes, to help describe use of different parts of their home ranges. The time

E) RESULTS

Rodent densities

Throughout the year, rodent (mainly *Rhabdomys pumilio* and *Otomys unisulcatus*) densities were highest in the Atriplex-Zygophyllum Dwarf Shrubland (Community A)(Tables 6.1 & 6.2 and Chapter 3). Autumn densities of *R. pumilio* for different plant communities at P.N.R. were as follows: Community A = 197/ha, Community D = 100/ha, Community F = 143/ha, and Community G (111/ha)(Chapter 3). These densities nearly tripled with the marked changes in the appearance of the vegetation from the hot and dry late autumn months to the cool, wet and lush late winter and spring months (Table 6.1).

spent active in this areas was also correlated with total time active while being radio-tracked, as well as with the time spent active in different plant communities, as compared to the relative areas of those specific plant communities within each individual's home range. Fluctuations in signal strength (Ferguson 1988) and positive identification of movement have been taken as signs of activity.

Table 6.1: Numbers of small mammals trapped at various trapsites in the Postberg Nature Reserve, West Coast National Park, during 1990 - 1991.

	Autumn	Winter	Spring	Summer
Community A				
Rhabdomys pumilio	137	81	87	196
Otomys unisulcatus	-	1	2	4
Mus minutoides	2	4	16	5
Myosorex varius	-	-	6	4
Community D				
Rhabdomys pumilio	56	35	37	164
Mus minutoides	1	2	2	3
Myosorex varius	-	-	1	3
Community F				
Rhabdomys pumilio	115	60	48	150
Otomys unisulcatus	2	-	1	1
Mus minutoides	1	-	-	-
Myosorex varius	-	-	1	-
Community G				
Rhabdomys pumilio	77	49	90	178
Otomys unisulcatus	-	1	2	-
Elephantulus edwardii	-	-	-	1
Myosorex varius	-	-	-	1

Table 6.2: Number of *Otomys unisulcatus* lodges per 0.5 ha in different plant communities in the Postberg Nature Reserve, West Coast National Park, during 1990/91.

	Autumn	Spring
Community A		
Old, disused nests	12	14
Nests in use	12	11
Community D		
Old, disused nests	15	4
Nests in use	4	5
Community F		
Old, disused nests	6	10
Nests in use	9	13
Community G		
Old, disused nests	6	13
Nests in use	13	14
Total		
Old, disused nests	39	41
Nests in use	38	43

Table 6.3: Numbers of *Rhabdomys pumilio* trapped and *Otomys unisulcatus* lodges in use, on transects at different contours in plant communities at the Postberg Nature Reserve, West Coast National Park, during 1990 - 1991. (B = bottom of slope; M = midslope; U = upper slope; P = plateau; S = south; N = north; E = east; SE = south east). Plant communities according to Boucher & Jarman (1977); see text for descriptions.

Transect number	Plant community	Height a.s.l. (m)	Slope	Number trapped	Number lodges
1	A	20	B S	53	7
2	A	70	M S	20	1
3	A	120	P	31	1
4	A	70	M N	33	1
5	C	20	B N	14	2
6	A	20	B N	33	3
7	A	70	M N	34	1
8	A	140	U N	17	2
9	C	10	B E	24	1
10	C	70	M E	8	0
11	E	20	B E	18	1
12	E	100	P	23	0
13	E	70	B W	45	5
14	D	15	B SE	21	1
15	D	70	M SE	16	0

Highest small mammal species diversity were also found in the Atriplex-Zygophyllum Dwarf Shrubland (Community A)(Table 6.4 and Chapter 3). Rodent species diversity fluctuated in unison with densities, with diversity being lowest in autumn and highest in spring, just before the main increase in *R. pumilio* numbers (Table 6.4).

Table 6.4: Small mammal species diversity* in different plant communities in the Postberg Nature Reserve, West Coast National Park, during 1990 - 1991.

	Autumn	Winter	Spring	Summer	Mean
Community A	0.074	0.251	0.700	0.300	**0.331**
Community D	0.090	0.210	0.314	0.176	**0.198**
Community F	0.133	0.000	0.196	0.042	**0.093**
Community G	0.000	0.098	0.106	0.068	**0.068**

* $H = - đ(p_i)(\log_2 p_i)$ (Bond *et al* 1980 & Krebs 1985)

No differences in small mammal species diversities or absence/ presence of species at different contours (bottom, mid-slope, top) were found.

Caracal captured

Between April 1990 and June 1991, 14 caracal (two adult males, three adult females, nine subadults [<6kg; Bernard & Stuart 1987]) and 19 non-target animals (two *Galerella pulverulenta*; two *Felis lybica*; three *Otocyon megalotis*; one *Vulpes chama*;

eight *Hystrix africaeaustralis*; one *Sylvicapra grimmia*; two guinea-fowl *Numida meleagris*) were caught. Two sub-adult caracal (one male and one female), adult female 2 (F2), and adult male 2 (M2) were recaptured once each. M2 was recaptured and killed by a farmer near Paternoster ca 10 months after it had left its home range at P.N.R. A mean of 46.4 trapnights were required to catch one caracal (a 2.15% trapping success, all trapnights included), with 12 out of the 16 caracal (two recaptures included) being caught within the first three nights of setting the traps. Twelve (75%) of the caracal were trapped using a scent & visual bait (trapping effort of 39 nights per caracal) (Table 6.5). Visual bait (all kinds) alone was more effective (three caracal caught; 29 trapnights spent per caracal), while scent bait as a type used alone was by far the least effective, at 188 trapnights needed to trap a single caracal. The single, most effective bait was "No.9" & strips of silver fish skin, followed by caracal scats & urine, silver strips of fish skin alone, live chickens, and fish & dead francolin. Nine (64%) of the caracal caught were subadults and assumed to be non-territorial. The sex ratio for the caracal caught was skewed in favour of females (2.5 females:1 male; $p > 0.01$). The mass of the two adult males was 19.5 and 17 kg, and for the three adult females 8.5, 8.5, and 6.5 kg respectively, indicating a mass-related sexual dimorphism in this species.

Home range characteristics

Altogether 2 724 locations (radio-fixes) of the five caracal fitted with radio-collars were obtained, during a total of 891 hours spent radio-tracking them. Home ranges of the two males (mean = 26.97 ± 0.750 km^2) were significantly ($p<0.05$) larger than those of the three females (mean = 7.39 ± 1.68 km^2 - minimum area method of Mohr 1947)(Table 6.6),

Table 6.5: Bait used in caracal traps in the West Coast National Park during this study, from 4 April 1990 to 12 June 1991. (Number of trap nights and results of trapping efforts).

Bait	Trapnights Number (% of total)	Caracal caught	% Trapping success
SCENT BAIT			
Blood x Fish x Vide ("No.9")	43 (5.79)	0	0
Fish entrails	20 (2.69)	0	0
Fly bait	65 (8.75)	0	0
Fly bait x Meat	50 (6.73)	0	0
Caracal scats & urine	10 (1.34)	1	10
	188	1	0.53
VISUAL BAIT			
Grysbok (dead)	7 (0.94)	0	0
Francolin (dead)	24 (3.23)	1	4.2
Bush-prefering bird (dead)	2 (0.27)	0	0
Fish skin (silver strips)	11 (1.49)	1	9.1
Fish heads	17 (2.29)	0	0
Crayfish (shells)	10 (1.34)	0	0
Chickens (live)	17 (2.29)	1	5.9
	88	3	3.41
SCENT & VISUAL BAIT			
"No.9" & Francolin	70 (9.42)	3	4.3
"No.9" & Rat	13 (1.75)	0	0
"No.9" & Feathers	247 (33.24)	3	1.2
"No.9" & Fish skin	6 (0.81)	2	33.3
Fish & Francolin	17 (2.29)	1	5.9
Fly bait & Skunk	9 (1.21)	0	0
Fly bait & Francolin	105 (14.13)	3	2.9
	467	12	2.57
TOTAL	743 (100)	16	2.15%

with no significant difference within sexes ($p > 0.05$). The minimum convex polygon method probably overestimated the range size of all the caracal as areas where they have never being located or cannot occur, as in the lagoon, were included in these calculations. The much smaller home range areas obtained using the concave polygon method was the result of the caracal visiting some areas in their home range areas much more often than other areas, and were ignored by this method. Home range size of the individual caracal remained stable during the time span over which each individual was radio-tracked, except for female F2 who for a period of ca 5 months (December 1991 - May 1992), i.e. until her two young were ca 3.5 - 4 months old, remained within a 2.97 ha area before visiting the southern part of her range again. During the last four months of the five-month period she also moved shorter distances at night than otherwise (Table 6.7); these nightly distances covered steadily increased thereafter. From February 1991 the younger male (M1) gradually increased his home range size until it overlapped almost completely with that of the older male (M2). In March 1991, M2 left his territory. He was seen 16 days after the last location at P.N.R., ca 45 km distant on a farm near Darling (F. Duckitt, pers.comm.) and 6 days later on the same farm by a local problem animal hunter (Japie Tango, pers.comm.). He left this area 2 weeks later, and was killed at Paternoster, ca 90 km distant, in a trap during January 1992.

The home ranges of caracal overlapped both within and between sexes (Table 6.8). In the males, the younger of the two gradually took over the home range of the older one and utilized its whole area after the older one had left. Home ranges of three females overlapped between 9% and 19%, although no overlap occurred between F1 & F3 (Fig. 6.1), and it is possible that another, untrapped, territorial

Table 6.6: Home range size (km^2) of five radio-collared caracal at Postberg Nature Reserve, West Coast National Park, during 1990-1991. See text for methods.

		Home range size in km^2		
Id. no.	Number of fixes	Minimum method of Mohr	Minimum convex polygon	Concave polygon
M1	298	27.50	32.87	8.52
M2	352	26.44	29.16	6.15
F1	52	5.59	9.95	0.84
F2	558	8.91	20.11	3.33
F2*	228	2.97	5.10	0.45
F3	375	7.66	13.53	1.94

F2* - Female 2 with young aged < 4 months

Table 6.7: Mean foraging speed (m/h) and distance (m) that caracal travelled per active cycle (here 8.6 ± 1.2 hour period of activity) at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

	Active cycles	Foraging speed m/h	Distance travelled m
M1	10	712 ± 172	7547 ± 1823
M2	6	642 ± 138	6848 ± 1472
F1	3	256 ± 178	2475 ± 1721
F2*	6	201 ± 28	1970 ± 274
F2	9	332 ± 74	3353 ± 747
F3	9	347 ± 220	3509 ± 2224
Males		677 ± 155	7198 ± 1648
Females (excluding F2*)		312 ± 157	3112 ± 1406

F2* - Female no.2 with young < 4 months

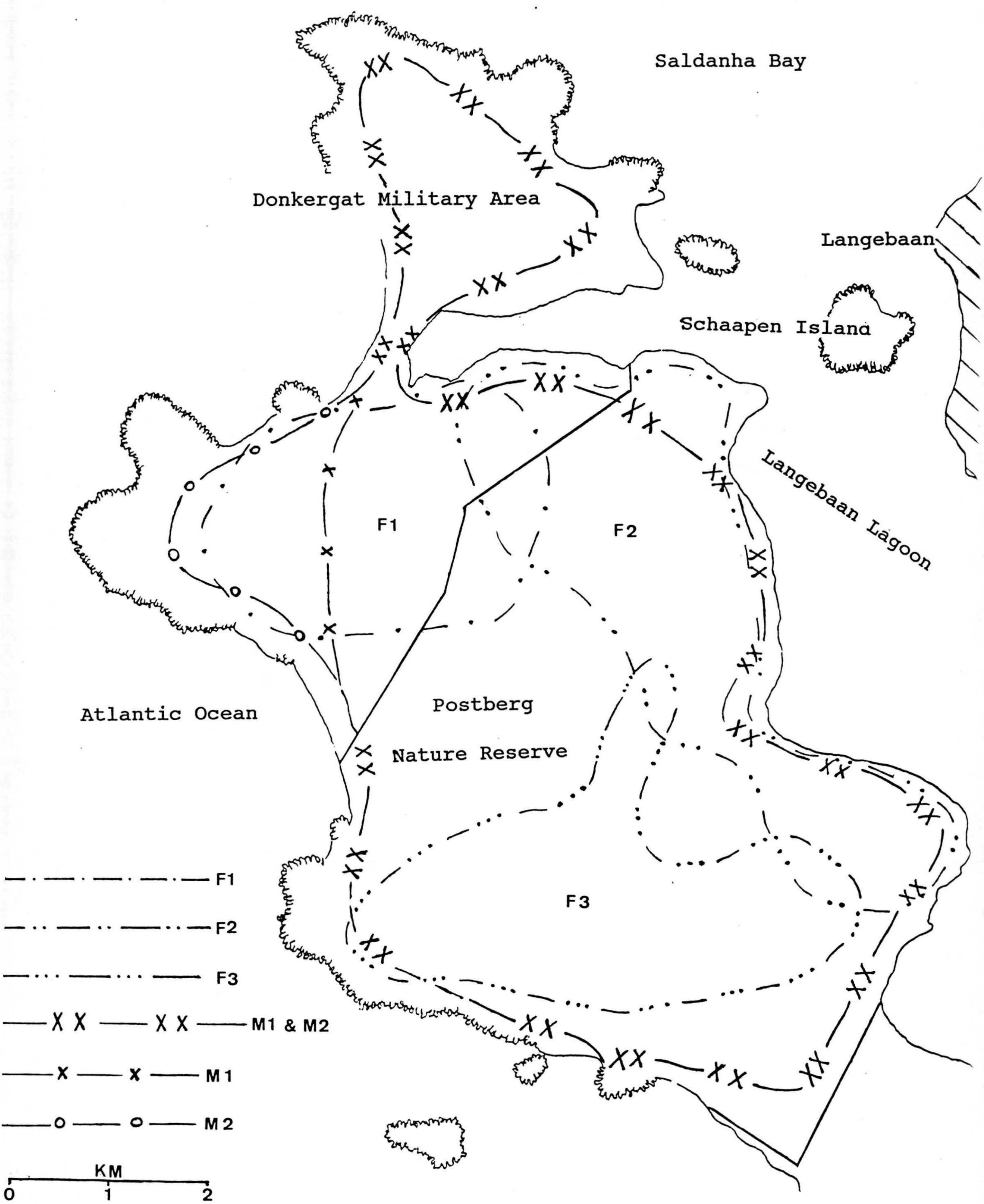

Figure 6.1: Home range areas of two male and three female caracal at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

female may have occupied the area separating the ranges of F1 and F3. The home ranges of both males included that of all three females at P.N.R. (81% - 99% of the respective females' home ranges) and extended into the Donkergat military area. It also overlapped with the territory of the possible fourth female. During the period when radio-tracked none of the caracal moved beyond the southern border of the P.N.R. in the W.C.N.P.; during radio-tracking, both males were found on more than one occassion to turn back when close to the 2 m high fence.

Table 6.8: Home range overlap (percentage of the range of animal in group A shared with animal in group B) of caracal at Postberg Nature Reserve, West Coast National Park, during 1990-1991. Minimum method of Mohr 1947; in brackets the actual overlap area (in ha) is given

			B				
			M1	**M2**	**F1**	**F2**	**F3**
	°	**M1**	-	96 (2644)	20 (540)	31 (853)	28 (758)
	°	**M2**	100 (2644)	-	17 (453)	33 (870)	28 (766)
A	°	**F1**	97 (540)	81 (453)	-	19 (106)	0 (0)
	°	**F2**	97 (853)	99 (870)	12 (106)	-	9 (80)
	°	**F3**	98 (758)	99 (766)	0 (0)	10 (80)	-

Activity & Movements

Caracal were active during both night and day, depending on weather conditions (Table 6.9). Onset of activity varied according to ambient temperature, and not so much whether it was daylight or darkness. All caracal were active for at least a part of each night (minimum = 210 min.) when radio-tracked, but were active for longer periods during colder nights (<20^{o}C). All caracal tracked became inactive ca 1 h before sunrise on clear days and would start activity again ca 1 h after sunrise if they were active during the day at all. Depending on ambient temperature and light intensity, caracal were also active during daytime. At ambient temperatures below 20^{o}C, and during all seasons, radio-collared caracal were active for a mean of 53.6 % of the time (n= 127h) when tracked by day (n=34 days), with no apparent difference between males and females. No females were active at ambient temperatures above 20^{o}C (n=27 days). In contrast, males were active for 22.8% of the time tracked on days with temperatures 20^{o}C - 22^{o}C (n=19 days), but none were active at temperatures above 22^{o}C (n=24 days). For both males and females no relationship were found to exist between degree of activity and full moon, wind speed, rain or minimum temperature, as caracal were almost equally active under all variations of these conditions. Light intensity, together with temperature, may be important during daytime at temperatures exceeding 20^{o}C; in the temperature range 20 - 22^{o}C, males were active more often when it was overcast during daytime than when not. Females were less active during nights when temperature were higher than 22^{o}C (58.4% of the time when radio-tracked on such nights; n=7 nights) while no male was tracked on such a night.

Mean foraging speed ($p=0.0012 < p=0.05$) and distance covered ($p=0.0004 < p=0.05$) per active cycle (Table 6.7) were significantly higher for males than for females. Mean foraging speed for males was 667 m/h ± the standard deviation of 155 m/h (n=159h radio-tracked), with no significant difference ($p>0.05$) between the two males occupying the same area, but at different times. Mean foraging speed for females was 312 ± the standard deviation of 157 m/h (n=175h radio-tracked) with no significant difference between the

Table 6.9: Percentage of time that five caracal were found active under various weather conditions (n=2726 locations during radio-tracking) at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

		Sunrise - Sunset		Sunset - Sunrise
		clouds or rain	sunshine	
9-19^{o}C:	Females	31.2	23.7	92.5
	Males	25.3	22.2	98.6
20-22^{o}C:	Females	0.0	0.0	78.9
	Males	18.4	4.4	100.0
>22^{o}C:	Females	0.0	0.0	58.4
	Males	0.0	0.0	-

No. locations: Females = 1702; Males = 1024 individual females ($p > 0.05$). Males and females were active for similar periods per night (ca 10 h; n=43 nights) with males covering more than twice the distance than females during an active period. There was no significant difference between individuals of males ($p > 0.05$) or between individual of females ($p > 0.05$) in the distance covered per active cycle. Distance travelled per active cycle ($p = 0.0003 < p = 0.05$) and foraging speed ($p = 0.0004 < p = 0.05$) of F2 differed significantly ($p < 0.05$) between when she had young, and when not. Male and female foraging behaviour differed in that core areas of males were further apart (0.750 km-2.708 km)(Fig. 6.2), in contrast to females who utilized their smaller territories almost as a single core area. Core areas (n=10) for the two territorial males were always (n = 10) located in thick vegetation at the bottom and lower third of slopes. Half of the core areas (21.2% more than expected) of both males was located in plant community A, 30% (27% more than expected) in community G and 20% (10% less than expected) in community E. No core areas were found in communities C, D and I & J. After M1 took over the territory from M2, he followed the same direct routes from a particular core area to the next, and rested within 250 m of M2's usual resting places. Core areas of the two males overlapped 100% spatially, but not temporally. The frequency distribution of all caracal was not as expected (Table 6.10) with a significantly higher frequency of individual caracal occurring on the bottom third of slopes (eg. male 1 was located on the bottom third of slopes 53.4% compared with the expected 17.3%) in comparison to the upper two-thirds, plateaux and flats between koppies.

All caracal were more active in plant community A (Atriplex-Zygophyllum Dwarf Shrubland), then in communities E (Nenax-Maytenus-Zygophyllum Evergreen Shrubland) and D (Ehrharta-Maurocenia Hillside Dense Shrubland) respectively

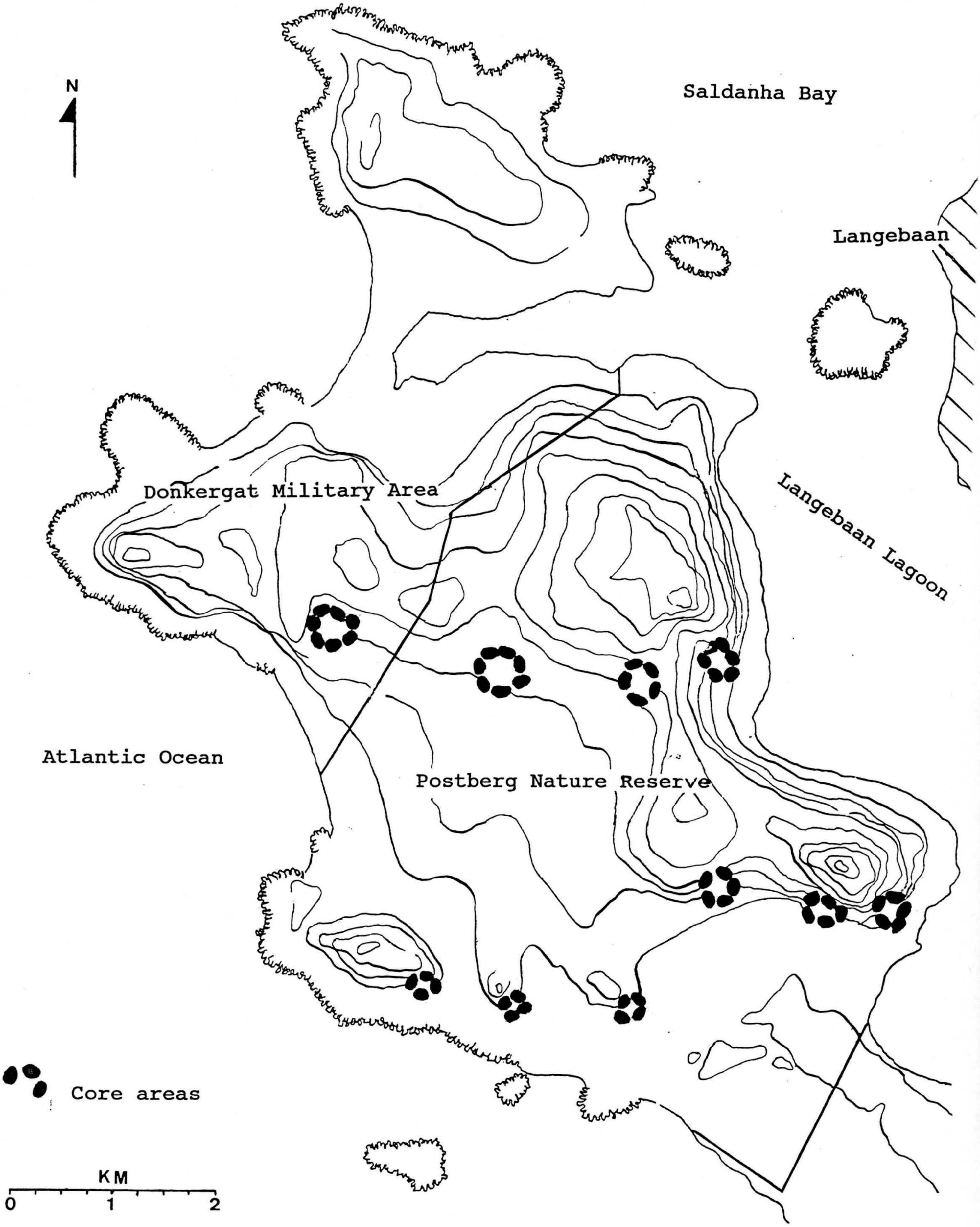

Figure 6.2: Core areas of two male caracal at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

(Table 6.11) with the frequency distribution within plant communities not as expected. Caracal were present more often in communities C (mean = 2.5 times of expected), A (mean = 1.38 times of expected), D (mean = 1.25 times of expected) and G (mean = 1.1 times of expected) than expected, and less then expected in communities E (mean = 0.80 times of expected) and I & J (mean = 0.13 times of expected). This preference changed very little (males, females, or sexes combined) as the vegetation in their respective home ranges changed, indicating clear preferences for certain habitats. Tables 6.12 & 6.13 indicates on what contours and in what plant communities caracal has been most active, as well as whether there were significant differences (Á=0.05) in caracal activity between contours and plant communities and it is clear that caracal were significantly more active on the bottom slopes and in plant community A than in other contours and plant communities.

Social interactions and population densities

During the whole radio-tracking period, the two males were only once located within 250 m of each other (n = 112.5 h radio-tracking), females 2 and 3 twice (167.8 h), and females 2 and 1 never (71.5 h). Apart from this one "encounter", the two males were never located closer than 500 m to each other. After the one close

Table 6.10: Observed and *expected percentage frequencies of occurrence of two adult male and three adult female caracal in sub-habitats when active, in their respective home ranges at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

n = number of locations from radio-tracking.

	Caracal				
	M1	M2	F1	F2	F3
	n=298	n=352	n=52	n=558	n=375
Bottom slope:					
Observed	53.4	49.4	75.0	57.0	74.1
(Expected)	17.3	17.3	25.6	23.8	14.7
Upper slope:					
Observed	15.4	19.3	7.7	19.4	6.7
(Expected)	21.5	21.5	6.0	29.3	8.3
Plateau:					
Observed	9.7	6.5	7.7	17.2	9.1
(Expected)	13.3	13.3	38.9	31.5	--
Flats:					
Observed	21.5	24.7	9.6	6.5	10.1
(Expected)	48.0	48.0	29.5	15.4	--

* - Expected % frequencies = Relative % area

X^2 for M1 = 275 > 7.815 = significant

X^2 for M2 = 261 > 7.815 = significant

X^2 for F1 = 1286 > 7.815 = significant

X^2 for F2 = 261 > 7.815 = significant

X^2 for F3 = 342 > 7.815 = significant

Table 6.11: Observed and *expected percentage frequencies of two adult male and three adult female caracal in plant communities when active in their respective home ranges at Postberg Nature Reserve, West Coast National Park, during 1990-1991. Plant communities according to Boucher & Jarman 1977.

		M1	M2	F1	F2	F3
		n=298	n=352	n=52	n=558	n=375
Plant communities:						
A:	Observed	40.3	33.3	50.0	59.0	79.1
	(Expected)	28.8	28.6	47.7	54.0	35.3
C:	Observed	7.7	7.7	0	8.1	0
	(Expected)	2.6	2.5	0	6.0	0
D:	Observed	14.8	16.5	0	31.4	6.1
	(Expected)	11.5	11.4	0	17.7	13.2
E:	Observed	29.2	33.6	50.0	1.6	11.0
	(Expected)	30.3	30.9	52.3	21.5	43.3
G:	Observed	5.0	4.3	0	0	3.7
	(Expected)	3.0	2.9	0	0.8	3.0
I & J:						
	Observed	3.0	4.6	0	0	0.3
	(Expected)	23.8	23.7	0	0	5.2

* - Expected % frequency = Relative % area

Community A: *Atriplex-Zygophyllum* Dwarf Shrubland
Community C: *Galenia-Senecio* Hillside Closed Dwarf Shrubland
Community D: *Ehrharta-Maurocenia* Hillside Dense Shrubland
Community E: *Nenax-Maytenus-Zygophyllum* Evergreen Shrubland
Community G: *Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland
Community I & J: *Thamnochortus spicigerus* Dune Dense Tall Restioid Herbland & *Hermannia pinnata* Littoral-dune Dwarf Succulent Shrubland

X^2 for M1 = 104 > 7.815 = significant
X^2 for M2 = 106 > 7.815 = significant
X^2 for F1 = 70 > 7.815 = significant
X^2 for F2 = 172 > 7.815 = significant
X^2 for F3 = 325 > 7.815 = significant

Table 6.12: Multiple comparisons of observed frequencies of occurrence of caracal in sub-habitats when active , in their respective home ranges at Postberg Nature Reserve, West Coast National Park, during 1990-1991.

n = 1635 locations of radio-tracking.

S = significant differences in occurrence of caracal between contour levels.

Á = 0.05

Code (level)	Mean	P	U	F	B
P	10.04	.	.	.	S
U	13.7	.	.	.	S
F	14.48	.	.	.	S
B	61.78	S	S	S	.

P = Plateau; U = Upper slope; F = Flats; B = Bottom slope

encounter the younger male (M1) moved off at a sharp angle while M2 remained at the site; this encounter happened 27 days (19 February 1991) before M2 was found outside the P.N.R., and lasted less than 45 minutes - no noise or signs of fighting emanated. In the case of F2 & F3, no aggressive behaviour was thought to have taken place by either one on the two occasions they approached each other to less then 500 m: once, they remained for 30 min within 125 m of each other before the younger female, F3, left the area first. On the other occasion they passed each other at ca 250 m distance,

Table 6.13: Multiple comparisons of the observed frequencies of caracal occurrence in plant communities when active in their respective home ranges at Postberg Nature Reserve, West Coast National Park, during 1990 - 1991. Plant communities according to Boucher & Jarman 1977.

n = 1635 locations of radio-tracking.

S = significant differences in occurrence of caracal between plant communities.

Á = 0.05

Code (Level)	Mean	A	B	C	D	E	F
A	1.58	.	.	.	.	S	S
B	2.60	.	.	.	.	S	S
C	4.70	.	.	.	.	S	S
D	13.76	.	.	.	.	.	S
E	25.08	S	S	S	.	.	S
F	52.34	S	S	S	S	S	.

A = Community I&J; B = Community G; C = Community C; D = Community D; E = Community E; F = Community A

and 15 minutes later was ca 500 m from each other. In the first instance, both females were within the overlapping zone, while in the latter case F2 was in the overlapping zone and F3 ca 250 m outside the observed "border" of the same zone. On both occasions no noise could be heard or signs of fighting subsequently found. These incidents took place 22 days apart. Two of the three females (F2 and F3) were only once located together in home range overlapping zones during 69.25 h of radio-tracking.

Four caracal litters were seen on nine occasions, and each litter over a period of less than 3 weeks (F2 = 2 litters; F1 = 1 litter; F3 = 1 litter). During that time litter sizes remained unchanged for the two litters (those of F1 & F3) observed more than once. Mean observed litter size was 2.25 ± 0.96 (F2 = 3 & 1; F1 = 2; F3 = 3). Females 1 and 3 and their young were altogether observed on 7 nights 100-150 m distant, using a spotlight, when feeding on springbok carcasses. Females and their young returned to a carcass for between 3 and 4 nights in a row (Chapter 4).

For 132 days after first observation the tracks of F2 and cubs from her second litter remained together; thereafter she roamed alone again. Two other sub-adult caracal (a female, 4.5 kg; a male, 5.5 kg), which were collared and ear clipped on initial capture, were retrapped. The female (eight months old) was retrapped 34 days after her initial capture, and ca 11 km from the initial trapping site on the farm Grootberg near Darling. The male was retrapped two months after initial capture on the farm Blombos ca 22 km from the initial trapping site (then ca 10 months old following Stuart 1982).

Based on the observed home ranges and their seeming territoriality caracal density in the P.N.R. - Donkergat area was estimated to be at least one territorial male, four territorial females and two subadults in the ca 3 000 ha area, at any given time. Territorial females may together have 8 - 10 kittens, born from ca December to March, while two - eight subadults could also be present. Some 7 - 13 caracal, therefore, may be expected to occur in the 3000ha area from ca March to December of each year.

F) DISCUSSION

In this study a high (for caracal) trapping success of 2.15% (recaptures included) was obtained. This is higher than that obtained by Stuart (1982; 0.21%) and Norton & Lawson (1985; 0.2%) in the Western Cape, and Moolman (1986; 1.1%) and Grobler (1981; 0.19%) in the eastern Cape. Brand (1990) obtained his highest trapping success (0.83%) in the Western Cape. Present success can partly be explained in that trapping was conducted within a nature reserve (as by Moolman 1986), situated in an area identified by Brand (1990) as one of the three areas in the Cape Province with the highest caracal density and stock loss due to caracal. Perhaps most important was the selection of good trapping sites (Chapter 2) and the use of potent bait, especially a visual lure. The small number of traps available also made it necessary to move traps frequently, at least every 3 weeks, so that probably at least part of every territory or home range was covered. However, the large number of captures (five adults, nine sub-adults) does not necessarily point to a high density of subadult caracal in the area. Since they are not yet bound to fixed home ranges many sub-adults could pass through the trapping area and may more readily enter the traps than resident individuals, as areas of maximum prey density are unknown and also because such dispersing caracal could be less wary than territorial adults.

Home ranges of the two males radio-tracked were 3,6 times larger than those of the females, compared to the 2,8 times found by Moolman (1986) on farms near Cradock. Home ranges of males were also larger than those of males radio-tracked by Moolman (1986) on farms near Cradock (26.97km^2 vs 23,7 km^2), which in their turn were significantly larger than the home ranges of the males he radio-tracked in the Mountain Zebra National Park (Moolman 1986). However, male home ranges in the present study were smaller than the 65 km^2 found by Norton & Lawson (1985) in the mountains near Stellenbosch. Home ranges of females in the P.N.R. were, however, smaller than those of females in the Mountain Zebra National Park (M.Z.N.P.)(8,5 ± 2,15 km^2, Minimum method of Mohr 1947, vs 7,39 ± 1,68 km^2)(Moolman 1986). In their turn females in the M.Z.N.P. had significantly smaller home ranges than those in the southwestern Cape (18,2 ± 7,54 km^2 vs 8,5 ± 2,15 km^2; Moolman 1986). This differences in home range size may be the result of diffences in the size and density of prey available, habitat characteristics, degree of persecution by man and density of caracal. Erlinge & Sandell (1986) expect home range size to be determined by food availablity during the most critical period, but food dispersion may also have some influence. Gittleman & Harvey (1982) found that home range size increases with metabolic needs, irrespective of taxonomic affinity, and among the ecological variables including activity patterns, habitat, diet and zonation, only diet showed a significant influence on home range sizes of a wide range of carnivores, including the felids. Standardized metabolic needs (body weight$^{0.75}$; Gittleman & Harvey 1982, Litvaitis, Sherburne & Bissonette 1986, Sandell 1989, and McDonald, Edwards & Greenhalgh 1991) were calculated for each caracal radio-tracked at Postberg, a farming area of the south western Cape (Stuart 1982), the western Cape mountains (Norton & Lawson 1985), and the Mountain Zebra National Park (Moolman 1986), and the relation between home range size and standard metabolic needs (SMN) compared (Fig.6.3). A strong positive correlation of 0.98 (n=5) was found between SMN and home range size in our study area indicating that the two factors are linearly dependent. The correlation between SMN and home range size as determined in the two previous studies was r = 0.06 (n=6) as determined by Stuart (1982) and Norton & Lawson (1985) in the south western Cape and r = 0.89 (n=7) as determined by Moolman (1986) in the M.Z.N.P. Results of this study are in agreement with that of Moolman

(1986), but differs from the studies done in the south western Cape. The latter poor correlation can be explained by the very divergent habitat over which caracal were radio-tracked in the southwestern Cape, ranging from the Jonkershoek mountains to coastal sandveld, both on farmland and in conservation areas.
Data on prey availability (- density) are, however not available from the study areas of Moolman (1986) or Stuart (1982) in the same format as in the present study.

In our study area rodent densities in plant communities G and H were lower on the sanddunes of the rest of the W.C.N.P. than inside the P.N.R. and rodent densities on farms lower than in the same plant communities inside the W.C.N.P. (Chapter 3). This implies larger home ranges for caracal outside the P.N.R., and even larger outside the W.C.N.P. If depending on prey available (rodents) alone, home range areas of ca $66km^2$ and $18km^2$ for males and females respectively can be expected on the sanddunes of the rest of the W.C.N.P., and ca $93km^2$ and $26km^2$ respectively for males and females on farms with the same vegetation type as the farm Yzerfontein. Lower densities of this solitary cat are thus expected here in these areas.
As caracal are killed at frequent intervals on farms, their density will change on farms from time to time in that none to more than one adult male or female may be present in vacuum areas big enough for only one territorial cat (male or female) for some time before they settled dominancy. This, out of a nature conservation point of view may decrease prey density and species diversity and increase stock losses. Like the correlation between caracal home range size and SMN (Fig.6.3), there should probably also be a correlation between caracal home range size and prey density, and an ever-decreasing prey population may lead to ever increasing home range areas of dominant territorial cats until the size where territoriality may "cease to

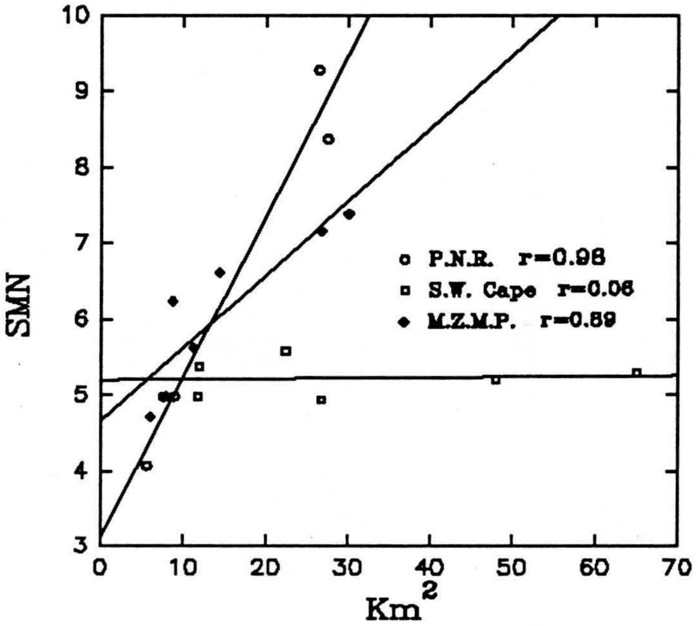

Figure 6.3. Correllations between Standard Metabolic needs (SMN) and home range area (km^2) of caracal radio-tracked in three different habitats in the Cape Province, South Africa.

P.N.R. - Postberg Nature Reserve (this study); S.W. Cape - south-western Cape (Stuart 1982 & Norton & Lawson 1985); M.Z.N.P. - Mountain Zebra National Park (Moolman 1986).

exist" and most caracal become nomadic. Ward & Krebs (1985) found that lynx increased their home range size concurrent with a decline in snowshoe hare abundance, and that they abandoned their home ranges and became nomadic below a certain density for this prey type. Bigger home range sizes also implies bigger territories for dominant cats to patrol and protect, which may lead to more non resident cats staying longer periods in such territories, resulting in a further decrease in prey densities and increase in stock losses - another reason for farmers to protect a territorial cat (as long as it does not catch stock) and its prey.

F2 was the only female who yielded enough data on foraging speed and home range size when alone, or accompanied by cubs, for a comparison to be possible. Before her young were born, she began to use a smaller area at the bottom part of a north-facing slope. About one month after this conspicuous change in behaviour was noticed, spoor of her and her young were found. Another 27 days later she and a kitten were caught in the same single-door trap. Based on its mass and head, tail and hind leg measurements (Stuart 1982), this kitten was between 4 and 6 weeks old. Tracking data indicated that F2 was restricted to a small area from ca one month before giving birth until ca 4 months postpartum, when she gradually began enlarging her home range as well as increasing her foraging speed. The area she chose to rear her young was at the bottom of a warmer north-facing slope in the Atriplex-Zygophyllum Dwarf Shrubland (community A). On the other hand the males' core areas were mostly on the wetter southern slopes (Fig.6.2) where rodent densities were higher (Chapter 3). The area F2 occupied was therefore not often or intensively visited by males, which might have been important for the safety of her young, especially during and after March when the younger new male (M1) occupied the area. (Cannibalism by new males on young sired by previous males, has, for example, been observed in lions - Gittleman 1989. Cannibalism by an adult male caracal on a younger (also adult) female has been reported in the West Coast Strandveld - Hanekom pers.comm.). The fact that F2 increased her home range size again to the original after her young had left her territory shows that she probably for some or other reason occupied a smaller area when her young were with her. F2's young left her home range in June 1991; this may be the time when most young caracal disperse at Postberg.

All four litters seen at Postberg probably were born between December and March, which agrees with findings by Stuart (1982) and Bernard & Stuart (1987). This means that the females had to suckle their young during autumn, the time of year when rodent densities in the West Coast Strandveld are decreasing, and the young leaves the mother's territory when rodent density is at the lowest. All the springbok caught by caracal at P.N.R. were caught from January-June, ca from the time when females fell pregnant or started to suckle their young until the time when young leave the female's territory (Chapter 4). This was also the time when most small stock remains were found in caracal scats on the farms surrounding the W.C.N.P., when stock loss in the Swartland Divisional Council is highest (Hanekom pers.comm.), and coincides with the lambing period of small stock in this area. Although rodent numbers are very low during this time of year, the hypothesis is that caracal also have a preference for bigger prey items at this time of year to fulfil in their higher energy requirements, and bigger natural prey is only present in very low densities (Chapter 4). Mean litter size in P.N.R. (n=2,25) corresponds with that found by Stuart (1982; n=2,2) in the southwestern Cape. However, the presence of introduced springbok at P.N.R. may make it possible for female caracal to raise more young than would have been possible without this relative easily caught, large and introduced prey. In the second year of observations, F2 stayed in the northern part of her home range where there were no springbok and fewer rodents than on the part she stayed on during the first year of this study and raised only one kitten (in comparison to the three of the first year). In the West Coast Strandveld ecosystem in general, outside the P.N.R. area, the density of rodents and bigger prey items like antelope is lower than at P.N.R. (Chapters 3 & 4), and it may be that fewer caracal young survive there; for the same reason, home ranges of adults may be larger and therefore densities lower than at P.N.R.

The home range overlap between females F2 and F3 of 80 ha (4.8% of combined home ranges) and 106 ha (7.3% overlap) between F1 and F2 was more than the 4% mean observed by Moolman (1986) in the Mountain Zebra National Park. Stuart (1982), Moolman (1986) and the Problem Animal Officer of C.P.A. in this area, Mr. S. Hanekom also found that one male's territory included those of several females. Although males were not once found near females during our study, males are apparently not territorial against females.

Caracal have been described as being mainly nocturnal (Stuart 1982; Smithers 1983; Moolman 1986). In the WCNP ambient temperatures are often below 22°C during daytime, a possible reason why caracal here are also active during daylight hours. Activity decreased as temperatures rose above 20°C in the study area. Like Moolman (1986) and Brand (1989), no correlation between activity and minimum temperature, rain, windspeed or moonphase could be found. The fact that males were more active than females during days when temperatures ranged between 20°C - 22°C may be explained by the larger home ranges they had to patrol. This, together with their foraging behaviour (foraging in patches and crossing directly from one patch to another), also explain the males' higher foraging speed and longer distances covered per night. Core areas (patches foraged in constantly) fell in areas with highest rodent density (Chapter 3), mainly on the bottoms of southern slopes in the Atriplex-Zygophyllum Dwarf Shrubland and Ehrharta-Maurocenia Hillside Dense Shrubland communities which probably provided good cover and abundant food for the rodents. Female caracal, too, spent more time in areas and plant communities with the highest rodent densities. It corresponds with the results of Ward & Krebs (1985) who found that lynx sought out and concentrated their foraging efforts in areas of relatively high hare abundance. Krebs (1978) states that it will always be to the advantage of a predator to concentrate its foraging efforts in the patches of highest prey abundance if prey are not uniformly distributed.

Caracal social behaviour may also play an important role in the size of home ranges and caracal density. Both males and females are highly territorial as shown by their behaviour towards individuals of the same sex, and even males and females only come together for short periods when mating (Pringle & Pringle 1979; Bernard & Stuart 1987). Radio-tracking data obtained from females show that they do not generally visit overlapping areas of their home ranges simultaneously and therefore remain spatially seperated. When the younger male (M1) eventually displaced the older male (M2), the latter became a nomad, and could not hold another territory. It is probably such individuals, together with young dispersing caracal, who are responsible for most stock losses as they do not possess a territory in which they know the areas of highest prey density, and therefore become predators on other, introduced and easily caught prey.

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CONCLUSIONS:

Caracal (*Felis caracal* Schreber 1776) is a major threat to small stock farmers in the West Coast Strandveld. According to Brand (1990) the Swartland is one of the five Divisional Councils in the Cape Province with the highest stock losses due to caracal (>2.0 stock losses/1000ha) and accounts for the most caracal caught by the problem animal hunting clubs (>1.0 caracal/1000ha) each year. However, from this study, the role of the caracal as predator in the West Coast Strandveld became evident and was proved that it is an important link in this ecosystem. As an opportunistic and generalist predator caracal will help to control animal densities distributed over a wide range in size and is the sole predator left in this ecosystem to prey upon some of the bigger animals present here, eg. antelope, hyrax, hares, and other predators such as the small grey mongoose, water mongoose, striped mongoose and bat-eared fox. It may help to eliminate the weak, preventing disease, and ensuring strong, healthy prey populations together with a bigger species diversity. This in an area where some of the farms surrounding our area of study still consists of up to 90% natural vegetation. The elimination of caracal from this area may bring about some disorder which, in the long run, would create other problems, some of which may bring about greater financial loss, eg. rodent and mole plagues. According to our results, at the Postberg Nature Reserve, each adult caracal eats approximately 5427 Cricetidae and Muridae and 148 rodent moles per year, and we expect higher numbers on the farms surrounding the West Coast National Park. Results obtained from studies on caracal home range size, activity patterns, habitat preferences, social behaviour, litter size and time of dispersal, energy requirements during certain times of the year, predation on the exotic springbok population at P.N.R., caracal trapping-results and prey availability, should all be taken into account in future management plans for caracal as a problem animal in the West Coast Strandveld. We also believe that this study will be of value to the National Parks Board in the management of the relatively recently proclaimed W.C.N.P. and can contribute to an increase in awareness and general knowledge concerning nature conservation in the local farming community.

APPENDIX 1

IMPACT OF CARACAL ON THE INTRODUCED SPRINGBOK POPULATION IN THE POSTBERG NATURE RESERVE

Springbok has been listed as an exotic animal in the West Coast Strandveld (Avery, Rautenbach & Randall 1990). However, between 1968 and 1970, 38 springbok had been introduced by the Postberg Syndicate to the Postberg-Donkergat area and had multiplied to 579 in 1985. In 1983 caracal was for the first time reported as catching springbok. On 1 July 1987 the National Parks Board took over the management of the Postberg Nature Reserve (P.N.R.) when this area was incorporated into the West Coast National Park (W.C.N.P.) as a contractual Park. From then onwards the management of springbok and predators in this area changed and springbok numbers decreased to 45 in 1991 (a mean decrease of 37% of the population each year). Old springbok were no longer culled every year, putting out salt licks for game use were discontinued, and caracal (the only surviving predator on adult springbok in this area) were no longer controlled. The present study indicated that caracal indeed had an influence on springbok numbers as they were responsible for the deaths of at least 22 of the 37 carcasses found (59.4%) during 1990/91. Twelve of the remaining 15 carcasses (14.1% of the total population at that time) died of natural causes, all in August and September. Incidence of vrotpootjie had been reported earlier. Seven of eight springbok carcasses found in a single count in September 1988 had died of vrotpootjie; the other one was caught by caracal (Spies, Thomsett & Hauman pers. comm.). During the study period (1990/91) springbok had a very poor lambing success of less than 40% during the first 12 months (this study), with newborn lambs seen throughout the year, but mostly from May to July. No account could be given of the number of lambs that died because of predators (eg. caracal and Cape fox), or of natural causes. It is thus clear that springbok is not adapted to survive under natural conditions in the West Coast Strandveld, especially not when confined to three relatively small camps (mean size = 667 ha) during all seasons. Springbok kept mostly to the old lands (total area of ca 443 ha in the ca 2000 ha P.N.R.), where they also slept at night, and ignored the denser vegetation of communities A (*Atriplex-Zygophyllum* Dwarf Shrubland), D (*Ehrharta-Maurocenia* Hillside Dense Shrubland) and G (*Maytenus-Kedrostis* Consolidated-dune Dense Evergreen Shrubland)(Boucher & Jarman 1977) completely.

The relative "ease" with which caracal caught springbok is also an indication that springbok is not adapted to this area where caracal has been only one of a few larger predators (lion, leopard, brown hyaena, spotted hyaena, black-backed jackal, etc. - Avery, Rautenbach & Randall 1990), all extinct now. Caracal caught springbok on the open man-made fallow lands, anything from 2 - 200 metres from the nearest bush (>20 cm high) and with a regularity of one adult sprinbok every 3.9 (± 2) nights during March, April and May. The thick mist and the noise of the nearby sea might have aided in the caracal's success. However, no success rate of number of attempts for caracal catching springbok could be calculated.

Increased male mortality, relative to that of females, has been observed in many studies of ungulate populations, including mule deer (Robinette, Gashwiler, Jones & Cranz 1957; Klein & Olson 1960: in Fitzgibbon 1990), tsessebe (Child *et al.* 1972: in Fitzgibbon 1990), hartebeest (Rudnai 1974: in Fitzgibbon 1990) and Thomson's gazelles (Fitzgibbon 1990). Reasons for this may be because males of populations with a resource defence polygyny social system are often on their own and in poorer condition (Hornocker 1970: in Fitzgibbon 1990); they are less wary and tend to be around the periphery of herds (Robinette *et al.* 1957: in Fitzgibbon 1990; Fitzgibbon 1990); that territorial males are more at risk in territory-holding species (Bradley 1977: in Fitzgibbon 1990; Estes & Goddard 1967); and that non-territorial bachelor males may in fact be more vulnerable since they tend to be in high vegetation, normally in unfamiliar habitat, and are often injured during fights (Walther 1969 and Gosling 1986: in Fitzgibbon 1990; Fitzgibbon 1990). According to Clutton-Brock *et al.* (1982: in Fitzgibbon 1990) the fact that males have increased body size, early growth rates and increased levels of competitive interactions, will leave them in poorer physical condition and leave them less wary as increased time for feeding is required. In this way predators contribute to female bias in gazelle populations (Kruuk pers.comm. and Fitzgibbon 1990).

According to the selection index of Fitzgibbon (1990) caracal did not have a preference for springbok of any sex or age class during any certain month or over the whole study period at P.N.R., but female:male ratio dropped from 3:1 to less than 1.1:1.. The highest selection index (0.323) for springbok at P.N.R. was found for females in May. Eighteen out of the 22 carcasses identified as being killed by caracal were females between the age of 9-24 months, three were adult males, and one a subadult female. Only two of the eighteen females were heavy pregnant while none of the carcasses found were suspected to have been ill. Most springbok ewes were, however, killed in April and May (seven and four respectively), the time when most ewes were pregnant at P.N.R. It may be that pregnant and lactating females is less vigilant as they have to spend more time foraging to fulfil in their energetic needs (FitzGibbon 1990). Ewes were also present in larger groups (max group size = 33, with 32 being females) than males (max bachelor group size = 9). During the period August and September when 12 springbok died of natural causes no springbok were killed by caracal. According to Kruuk (pers.comm.) stalking predators (like caracal) may not have too much opportunity to select animals in poor condition, at least not as much as coursing predators (FitzGibbon & Fanshawe 1988). Nevertheless, two adult rams with broken horns were seen over a period of at least 5 weeks each during May to July, but their carcasses were never found. A springbok ewe with a broken leg were seen over a period of 8 days before she was shot.

The highly seasonal exploitation of springbok by caracal, the non-selectivety for certain springbok as prey, constant decrease in female to male ratio, and the fact that caracal did not specifically hunt out the sick or old may be an indication that springbok is not a natural prey of caracal in this ecosystem, but that springbok is an easy prey to capture here, and also that there is enough natural prey for caracal throughout the year with autumn being the lean season in the West Coast Strandveld. During 1990/91 caracal preyed most heavily on springbok from February to May, and not at all in the period July to December. This coincided with the time when the young of three territorial female caracal seen at P.N.R. could have started eating meat and lasted untill the time when that young have dispersed. It also coincided with the time when rodent density was at the lowest, when most springbok lambs were seen, and with the lambing season of sheep on the surrounding farms. This highly seasonal predation on springbok suggests selection for larger prey when female energy requirements is highest. A female with her kittens will return to a carcass for up to four nights in a row (mean = 2.7 +- 0.7 nights/carcass; n = 18 carcasses) and may enable her to give birth to and raise bigger litters. It may also lead to the delayed dispersal of kittens (Beckoff & Wells 1980; Bowen 1981).

Even though the springbok population (number of lambs) still increased in June, July and August, no springbok were killed by caracal between 9 June 1990 and 16 January 1991. This can be ascribed to the dominant, territorial caracal being established in the area and keeping out non-territorial cats to such an extent that they did not get any chance to hunt springbok (the stalking of springbok is expected to take some time). However, in August a young caracal scavenged on a springbok carcass seven days after its initial discovery. This was the only time caracal was definitely found to eat something that itself did not kill and fits into the hypotheses that non-territorial cats do not know the areas of highest prey densities, will be more hungry, and will take unnatural and easy prey.

To conclude:

This study has indicated the importance of caracal in this West Coast Strandveld ecosystem. It has also indicated the inability of springbok to adapt to this ecosystem although it can be farmed with under man-made conditions in human-disturbed areas. The presence of springbok in this ecosystem have an influence on caracal behaviour, natality and fitness. This may indirectly have an effect on other prey in the immediate vicinity as well as further away (eg. farming areas). Springbok may also directly affect the ecosystem in the manner of competition with other natural animals for food and space, and certain plant species may benefit at the expense of others through springbok grazing and trampling. There may be even more reasons for excluding springbok from the West Coast National Park. Springbok as an economical preference through tourism should not be of consequence as other antelope and carnivores (like red hartebeest, duiker, steenbok, grysbok, grey rhebok, eland, gemsbok, bat-eared fox, aardwolf, etc.)(Avery, Rautenbach & Randall 1990) should also benefit directly or indirectly from a more natural ecosystem. Results of this minor study of the influence of caracal on springbok should be of help and taken into account in future caracal management programs in the West Coast Strandveld as small stock is also, like springbok, an introduced, easy, and to some extent unnatural, prey to caracal.

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"Harmony with land is like
harmony with a friend; you
cannot cherish his right hand
and chop off his left
you cannot love game
and hate predators ..."

- Aldo Leopold -