DIET, HOME RANGE AND MOVEMENT PATTERNS OF SERVAL ON FARMLAND IN NATAL

By

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PREFACE

This research was carried out while I was a student in the Department of Zoology and Entomology, University of Natal, Pietermaritzburg, from January 1988 to April 1990. The project was supervised by Professor M.R. Perrin and co-supervised by Dr. D. Lawson.

This research is my original work and has not been submitted in any form to another University. Where use was made of the work of others it has been duly acknowledged in the text.

J.M.BOWLAND

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This research would not have been possible without the financial and material help of the Endangered Wildlife Trust, the University of Natal/Natal Parks Board Research Fund, CSIR, University of Natal Graduate Assistantship and the Gay Langmuir Bursary.

My supervisors, Prof M.R. Perrin and Dr. D. Lawson, both ensured the smooth running of the project.

Natal Parks Board staff were always willing to help, especially Dr. D.T. Rowe-Rowe with his knowledge of small carnivores and the Drakensberg and Dr. M. Keep who advised on anaesthesia and captive care of servals. Eric and Jenny Dixon, John and Val Crowson, Frans Roux and Moses Ndlovu helped enthusiastically with trapping servals.

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I sincerely thank the Zoology undergraduate students and friends who gave up their vacations to radio-track for long hours in uncomfortable conditions. Alida Faurie and Margaretha Wielsma helped with scat analysis. Olaf Wirminghaus allowed use of his reference material. Ant Maddock gave advice and lent me his reference collection. Rowen Thiel helped care for captive animals and did the electric fencing trials in his honours project. The science workshop staff, especially Chris Morewood, were always helpful in making and fixing equipment.

Thanks to my parents, who stimulated my interest in conservation and financed my undergraduate years. A special thanks to Tony Bowland who gave advice, support and encouragement, helped with captive studies and with field work.

ABSTRACT

Servals (Felis serval) are rare cats occurring in the Natal midlands farmland, Drakensberg mountains and in game reserves in Zululand. They are thought to be extremely uncommon on farmland, yet are sometimes caught and killed in predator control programmes. The objectives of this study were to determine home range, habitat requirements, population density and diet of servals and thereby propose management recommendations for their conservation on farmland in the Natal midlands.

Radio-telemetry was used to determine home range and habitat requirements, while diet was determined using scat analysis. Prey availability and vegetation changes in the habitat were monitored seasonally.

Servals range over areas of 15-30km^2, but concentrate their activity in wetland areas where their preferred prey, Otomys irroratus, are most abundant. Over 90% of serval prey comprises small mammals, which occur at high density in the wetlands, but low density elsewhere in the study area. The results of this project have highlighted the importance of wetlands to farmland ecosystems.

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CHAPTER 1

INTRODUCTION

Conservation

Conservation of animals on farmland is becoming increasingly important as demand for land to produce food for the burgeoning human population increases. The sanctity of reserve boundaries are subject to political whims and economic pressure which are unlikely to subside in the foreseeable future. Conservation goes beyond preserving big and spectacular animals for aesthetic reasons, but is a matter of ensuring sustained ecosystem functions on which human and other life depends.

The objectives of the World Conservation Strategy (Allen 1982) are:

1. To maintain essential ecological processes and life support systems.
2. To preserve genetic diversity.
3. To ensure the sustainable utilization of species and ecosystems.

The importance of single species conservation is widely documented (Myers 1979; Ehrlich and Ehrlich 1981; Norton 1986), but sometimes questioned. Conserving one species usually means conserving its habitat which invariably includes a range of species and ecosystem functions (Kellert 1986). Carnivores, being at the top of the energy pyramid, can be used as indicator species to determine the health of the ecosystem in which they occur (Wrogemann 1975). Many carnivores are appealing, spectacular animals which can be used to raise funds for species and ecosystem conservation.

Project background and motivation

Predators generally range further than similar sized herbivores (McNab 1963) and often may not be confined within reserve boundaries. Stock loss to predators on farmland is a problem which has raged for centuries. Increasing predation on sheep in Natal resulted in survey (Lawson 1987) that quantified the financial loss to the wool industry resulting from sheep predation. Some farmers reported servals (Felis serval) as being responsible for sheep or lamb predation (Table 1.1), which is supported by some circumstantial evidence.

Servals are sometimes killed in predator control programmes either deliberately, or accidentally when non-selective control methods are used. During predator control trapping by Natal Wildlife Services in 1987 eight serval were caught in a period of three months on four farms in the Kamberg area.

Table 1.1. Predators reported by farmers as the main culprits in sheep killing in Natal (data from Lawson 1987).

predator	% cause of sheep loss to predation
Black backed jackal (Canis mesomelas)	43.7
Dog (Canis domesticus)	31.0
Caracal (Felis caracal)	9.4
Theft by man	11.3
Serval (Felis serval)	0.8
Other	3.9

Servals are classified as rare in the South African red data book (Smithers 1986) and are thought to be uncommon in the Natal Drakensberg. Little is known of the ecology of serval and studies have not been undertaken on farmland.

Objectives

The objectives of this project are:

1. To determine and quantify the diet of servals on sheep farms in the Natal midlands.

2. To establish home range and density estimates of serval on farmland.

3. To determine the habitat requirements of serval in terms of vegetation structure and prey availability.

4. To evaluate the extent of serval predation on domestic stock and to establish control methods.

5. To formulate conservation and management guidelines for serval.

Serval description and taxonomic status

Servals, Felis serval Shreber, 1776, (family Felidae, order Carnivora) are medium sized tall, slender cats with large ears and a short tail. The background colour is yellowish, with black spots on the flanks, stripes on the nape and rings on the tail. A detailed description is given by Smithers (1983).

Mensural data collected during this project are presented in Appendix 1. Other body measurements of servals from South Africa have been taken from a male in Giants Castle Nature Reserve (W.Birkenstock, NPB unpubl. record, cited in Rowe-Rowe 1978), an immature male from Alcockspruit (R.R.Duke, NPB unpubl. record, cited in Rowe-Rowe 1978) and a female from the Eastern Transvaal (Zambatis 1985).

Seventeen subspecies of serval have been described (Allen 1939). Descriptions are based on ground colour and size of spots, although considerable variation occurs even within litters. Felis brachyura, the small spotted serval or servaline, was found to be the same species as Felis serval when both forms were discovered in the same litter (Dorst and

Dandelot 1972). Melanistic servals are fairly common in Kenya (York 1973; Kingdon 1977). Rosevear (1974) gives a detailed description of the pelage and skulls of specimens from West Africa. Smithers (1978) describes the coat and gives body measurements of servals from the Salisbury district in Zimbabwe. Both Rosevear (1974) and Smithers (1978) came to the conclusion that it was unjustified to recognise subspecies in West Africa and Zimbabwe respectively.

Distribution

Servals are widely distributed in African savanna and grassland (Fig.1.1), but are declining in numbers at the north, west and extreme south of their range (Rosevear 1974; Burton and Pearson 1987). In East Africa they are threatened by the skin trade (Kingdon 1977) and are persecuted as poultry thieves throughout Africa (Visser 1977). In the southern African subregion they are found throughout Zimbabwe and Mozambique, near the Okovango Delta in Botswana and in north-east Namibia. They are common in the Kruger National Park but rare elsewhere in the Transvaal (Visser 1977; Rautenbach 1982). They are absent from the Orange Free State. In the Cape Province they formerly occurred along the coastal belt from Cape Town to the Transkei, where they are now thought to be extinct or rare (Von Richter 1972) owing to hunting, trapping and habitat loss (Stuart 1985). They occur in western and northern Natal mainly in the Drakensberg region (Visser 1977,

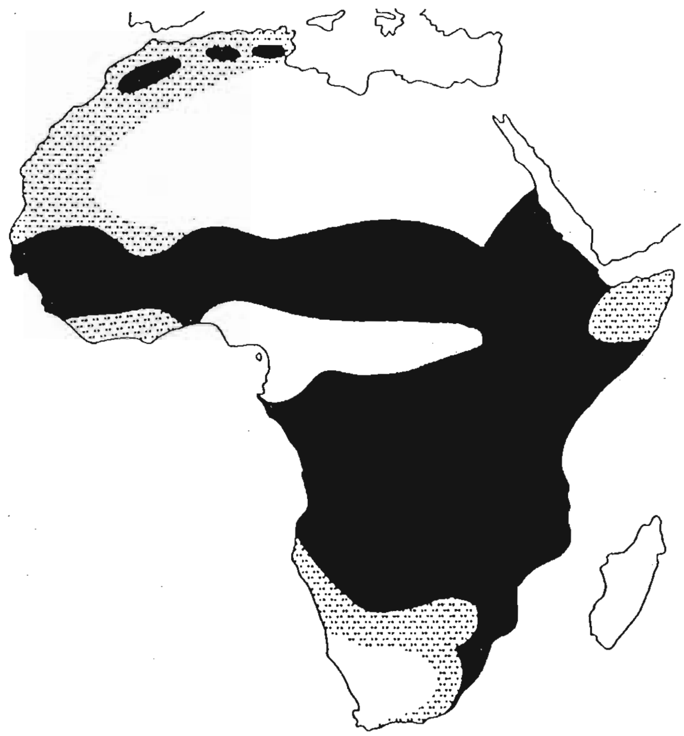


Figure 1.1. Serval (Felis serval) distribution in Africa (after Burton and Pearson 1987).

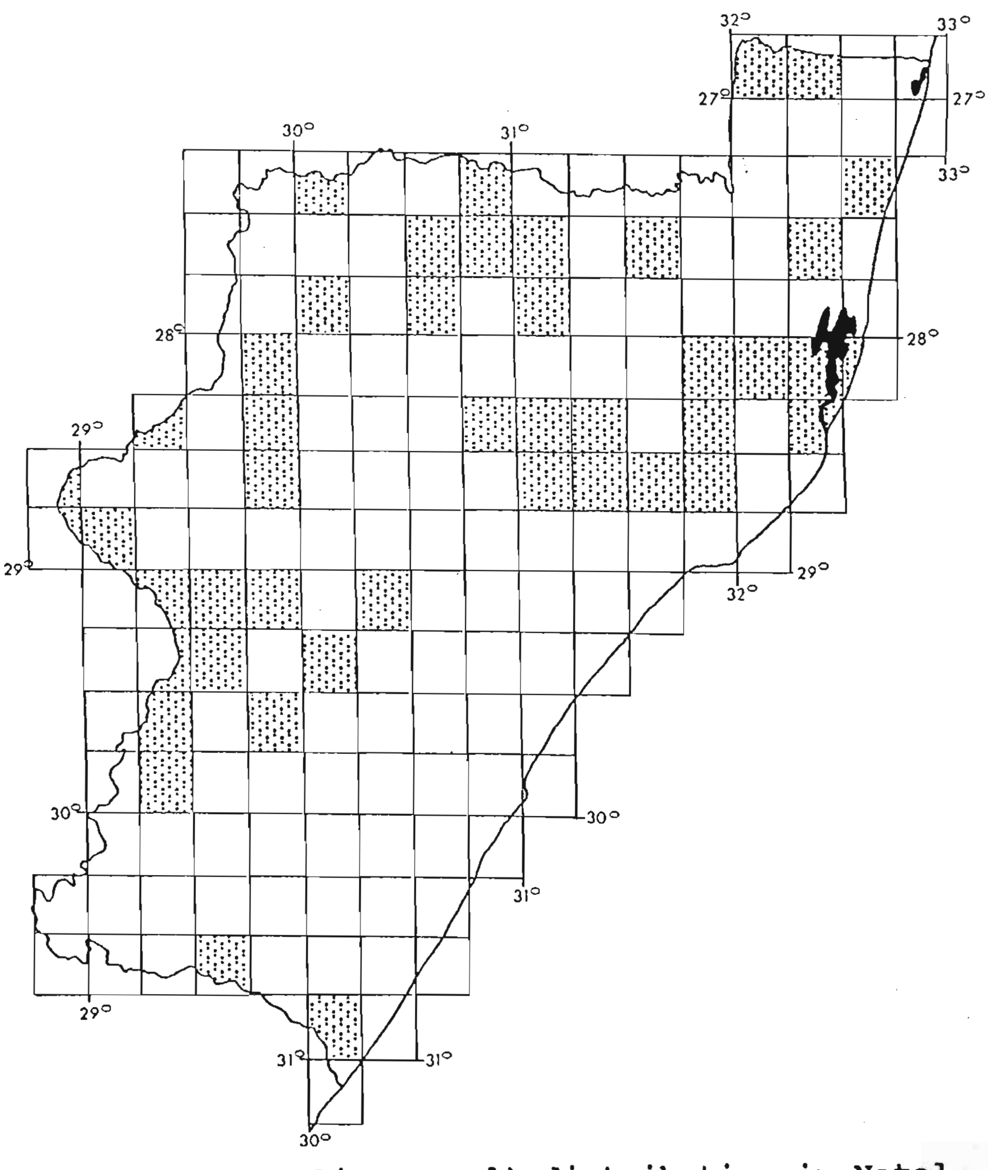


Figure 1.2. Serval (Felis serval) distribution in Natal (modified from Rowe-Rowe 1978).

Rowe-Rowe 1978) and in reserves in Zululand (Fig.1.2). In southern Natal their occurrence is unlikely (Von Richter 1972).

Generally servals have declined in numbers, but remain common in some areas (Burton and Pearson 1987). They are found in all major national parks and reserves within their range but are thought to be uncommon outside reserves.

Study area

The study area is located in the Kamberg Biosphere Reserve which incorporates the Kamberg Nature Reserve (KNR) and surrounding farmland ($29^{0}21'S$ $29^{0}38'E$ - $29^{0}27'S$ $29^{0}48'E$). Altitude ranges from 1585m to 2244m a.s.l. and the topography is steep to undulating. The Mooi river and its tributary, the Reekie Lynn, flow through the area (Fig 1.3).

Mean monthly rainfall ranges from 8.3mm in July to 170.0mm in January. Mean monthly minimum and maximum temperatures are 0.7°C and 17.4°C respectively in July and 13.1°C and 24.2°C respectively in January (S.I.R.I Natal Region, Cedara). Heavy frost is common for at least six months of the year and snow occurs occasionally. Lightning and hailstorms are common in summer.

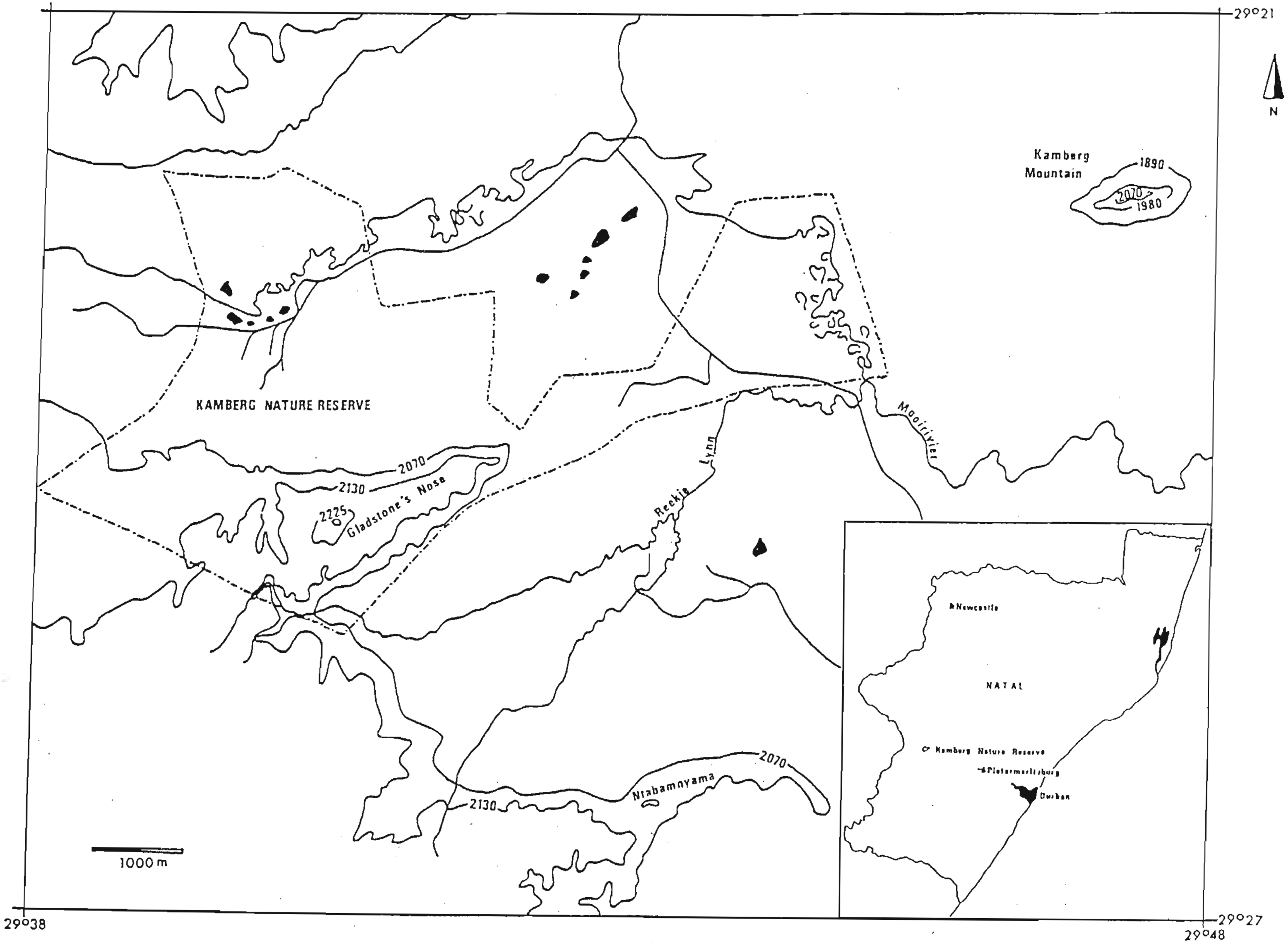


Figure 1.3. Map of the study area showing major rivers and mountains and its position in Natal.

Vegetation in the study area is predominantly highland sourveld grassland (Acocks 1975) with Themeda triandra being the dominant species. Bush clumps, comprising Leucosidia sericea, Buddleia salviifolia and Podocarpus latifolius, grow in the drainage lines on the slopes. Maize, seed potatoes and pasture grasses are grown. Patches of black wattle (Acacia mearnsii) grow randomly throughout the lower regions. Domestic stock include sheep, beef and dairy cattle.

Predators, other than serval, occurring in the study area are caracal (Felis caracal), black-backed jackal (Canis mesomelas), large grey mongoose (Herpestes ichneumon), white-tailed mongoose (Ichneumia albicauda), water mongoose (Atilax paludinosus), large-spotted genet (Genetta tigrina), Cape clawless otter (Aonyx capensis), Cape fox (Vulpes chama), African wild cat (Felis lybica) and feral cat (Felis catus).

CHAPTER 2

HOME RANGE AND HABITAT REQUIREMENTS

Introduction

Animal species have requirements for particular habitat types which provide various resources particularly shelter and food. These requirements are important when considering the conservation of a species in situ, in captive breeding situations and for relocation.

Home range is defined as that area traversed by an animal in its normal activities of food gathering, mating and caring for young (Burt 1943). Alternatively, home range is an area with a certain productivity that meets the energy requirements of the individual that occupies it (Jewell 1966). Core areas, which are used more frequently than other areas in the home range, were first recognized by Kaufmann (1962). These areas provide bedsites, refuges and the most dependable food sources (Burt 1943; Kaufmann 1962). Thus, core areas are particularly important when considering the habitat requirements or survival of a species.

To draw fixed boundaries to home ranges which fluctuate temporally with food availability and reproductive activity and which are subject to great irregularity in intensity of use gives a false impression of animals movements (Burt 1943; Jewell 1966). Techniques that estimate space utilization rather than defining set home range boundaries are more realistic in representing animal space use patterns (Samuel et al. 1985). The more recent models for determining home range such as the 95% ellipse (Jennrich and Turner 1969), Ford and Krumme's utilization distribution (1976), the harmonic mean (Dixon and Chapman 1980) and the Fourier transformation (Anderson 1982), are based on probabilistic definitions of home range which give the probability of finding an animal at a particular location, and are centered about a calculated activity locus.

Home ranges of servals in the Ngorogoro crater, Tanzania, were monitored by Geertsema (1985) and three captive bred servals were released and radio-tracked in the Rustenberg Nature Reserve (Van Aarde and Skinner 1986). Little is known about serval movements on farmland or their precise habitat requirements, although they are generally associated with moist grasslands (Smithers 1983).

The objectives of this chapter are to determine home range, habitat requirements and density estimates of servals on farms in the Natal midlands for conservation and management.

Methods

Cage traps (50x50x100cm and 70x60x120cm) were set throughout the study area, each was camouflaged with vegetation and baited with dead chicken and a commercially available sound lure (H.Terblanch, Greytown). Twice a caged live chicken was tied to the back of the trap as bait.

Captured servals were immobilized with a 100mg intramuscular injection of ketamine hydrochloride (Ketalar, Parke Davis) (Rowe-Rowe and Lowry 1982a) which induces a state of dissociative anaesthesia (Harthoorn 1976). Mensural data were recorded (Appendix 1) and a collar housing a transmitter (AVM P2B, 148-149MHz, AVM Instrument Co., California) and battery (Lithium, 3.6V) was fitted.

Collars weighed ca. 200g, approximately 2.5% of an adult servals body mass. This falls below the recommended maximum mass of 3-5% of body mass which can be put on an animal without injury or interference with normal activity (Macdonald and Amlaner 1980).

Initially radio-tracking was attempted using the "predictive tracking" technique where animals are located using hand-held equipment and their positions are plotted according to signal strength and topography (Macdonald 1978, Hersteinsson and Macdonald 1982). This proved impractical because of the distance servals move and because of the difficulty of negotiating the hilly terrain at night. Therefore null-peak radio-tracking stations were established at two high points 8.0 km apart in the study area (Fig.2.1) and the animals were located by triangulation (Heezen and Tester 1967). This method provides a reliable fast means of radio location (Banks et al. 1975) showing precision of the order of 0.5^0 (Smith and Trevor-Deutsch 1980). Aerials, described by Lawson (1986), and Yaesu receivers (all-mode transceivers FT290R, Yaesu Musen Co. Ltd. Japan) were used for radio-location.

Animals were located and bearings were taken simultaneously every 15 minutes from both stations. Locations were plotted by hand on a topographical map with a 500m X 500m grid overlay. Grid locations were analysed to estimate home range areas with the MCPAAL program version 1.2 (Smithsonian Institute) which analyses animal location data employing five commonly used models. The minimum convex and minimum concave polygons are non-statistical, while the Fourier transformation, 95% ellipse and harmonic mean are statistically based.

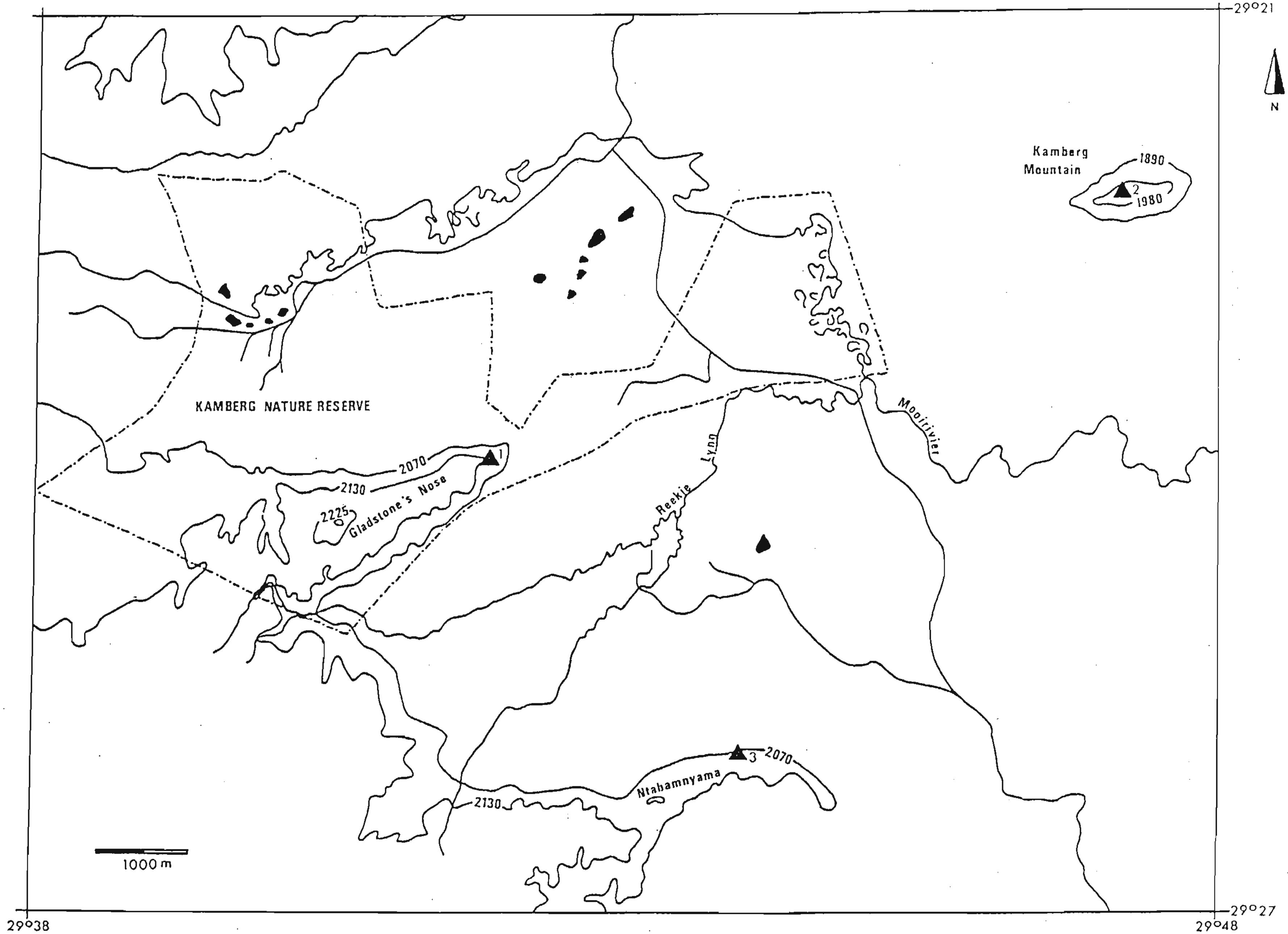


Figure 2.1. Map of the study area showing radio-tracking stations (▲) and Kamberg Nature Reserve boundary.

Results

Six servals were captured and collared over the period May to October 1988 (Table 2.1). More than 20 locations were obtained for four animals and the last locations for three of these were recorded in January 1989. The last serval was trapped in October 1989 and radio-tracked from November 1989 to January 1990.

Continuous movement data were not obtained because of the uneven nature of the terrain. Serval coded "S" (Table 2.1) was located simultaneously from both stations 54.4%, "G" 8.1% and "E" 69.4% of the total tracking time. Problems were experienced with the weather, in that high winds reduced precision and heavy summer rain inhibited tracking. Cliff faces and rocks at the tops of the valleys caused signals to bounce and lowered the accuracy of bearings or prevented location.

Serval "E"s home range fell between the two null-peak tracking stations causing an artificial concentration of location points close to the tracking stations as the triangulation angles tended towards 180^{o}. The data were therefore truncated and all readings within 3^{o} of the bearing of the other station were removed. The serval was therefore effectively located 15.3% of the total tracking time. An additional 30 locations were obtained by triangulation from Gladstones Nose station and a third station on Ntabamnyama (Fig 2.1). Radio-location was done with hand held aerials and bearings were taken with Suuntu compasses. Bearings were also taken from a transmitter at a known location to determine error. Error was consistent and corrections were made on the animal's bearings before plotting.

Home range estimates given by each of the MCPAAL models are listed in Table 2.2. No one method is ideal for analysing location data of all species in all situations (Sanderson 1966). Each has its advantages and disadvantages, thus most information can be derived by subjecting the data to a number of methods.

The minimum convex polygon (Fig.2.2a-d) is the simplest graphically and is historically widely used (Dalke and Sime 1938; Mohr 1947; Southwood 1966). Since it is used in most studies (Sandell 1989) it is useful to include for comparative purposes. It may include large unused areas in the estimate by assuming that home range shape is convex, and is influenced by sample size such that the home range estimate increases with increasing sample size (Jennrich and Turner 1969; Anderson 1982).

Table 2.1. Results of serval trapping and tracking.

Animal code	Sex	Date trapped	Last located	Number of locations	Type of tracking	Probable cause of failure to locate animal
Q	F	31.5.88	7.7.88	20	Predictive	Transmitter failure in snow
B	M	8.7.88	9.9.88	24	Predictive/ triangulation	changed range
G	M	8.8.88	15.12.88	39	triangulation	transmitter failure in wet weather
T	F	10.8.88	6.9.88	13*	predictive	death/loss of collar
S	F	9.10.88	20.1.89	151	triangulation	transmitter failure in wet weather
E	F	19.10.89	28.1.90	83	triangulation	study ended, collar functional in January

* all locations were in the same place

Table 2.2. Home range areas calculated by MCPAAL.

Method	Home range size (km^2)			
	serval S (n=151)	serval G (n=39)	serval B (n=24)	serval E (n=83)
minimum convex polygon	19.8	31.5	2.25	15.8
minimum concave polygon	12.1	16.4	1.0	11.8
95% ellipse	19.5	69.3	8.6	17.5
Fourier transformation (95%)	45.8	*	*	44.4
(50%)	11.3			16.4
harmonic mean (95%)	16.8	32.6	3.0	10.7

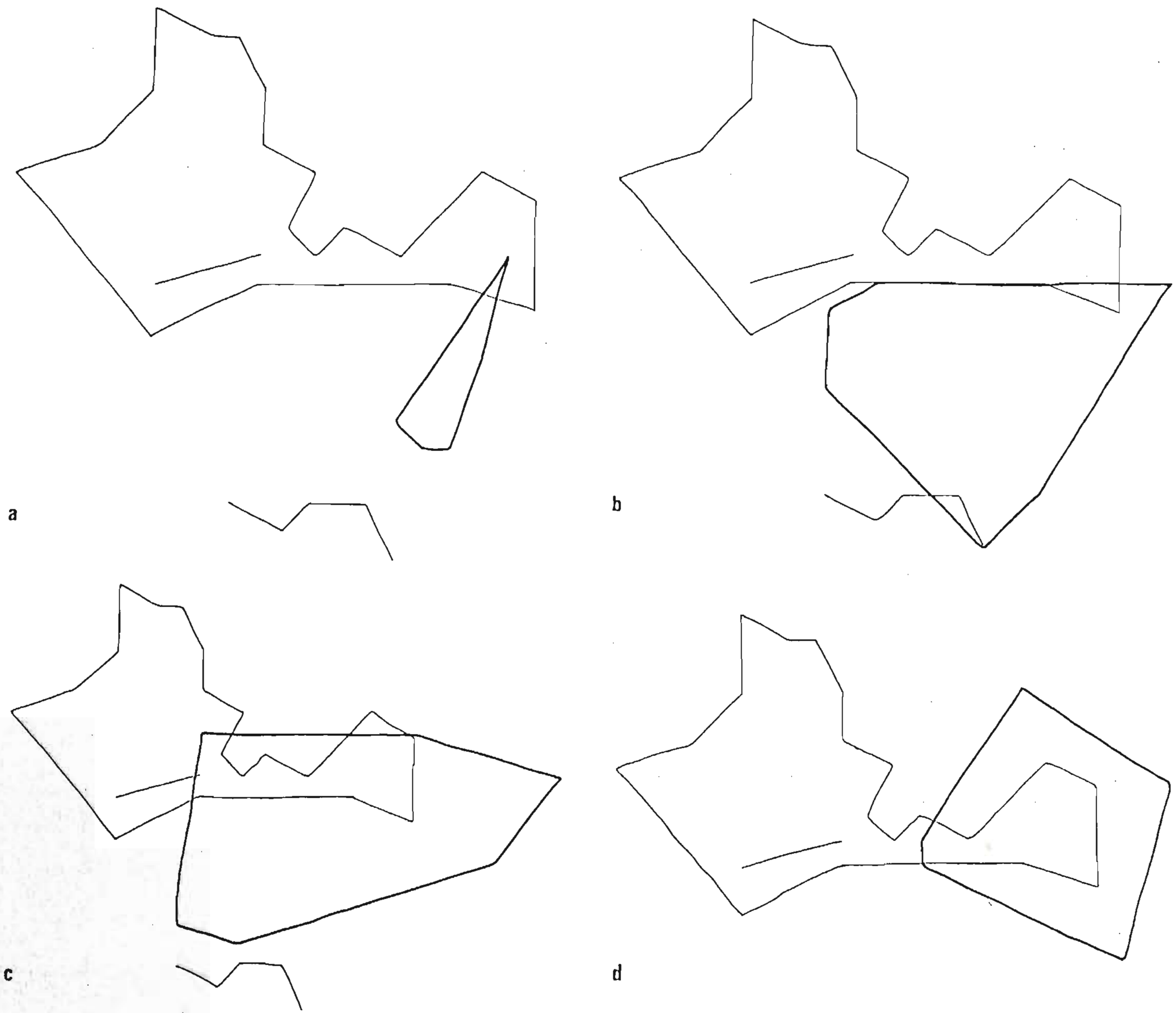


Figure 2.2. Minimum convex polygon home range areas for
(a) B (juvenile/young adult male) (b) S (young adult female)
[illegible] (d) F (young adult female).

The minimum concave polygon method is a modification of the above method which attempts to exclude the unused areas included in the convex polygon. The exact methods used to join location points to draw the home range boundaries are seldom clearly defined (Stickle 1954; Southwood 1966; Jennrich and Turner 1969). Harvey and Barbour (1965) arbitrarily used one quarter of the range length as the maximum distance between two outer points in the range in determining area. In MCPAAL the area calculated depends on the size of the grid cells used. If they have too many sides concave polygon home ranges become meaningless (Fig.2.3a and b).

The 95% ellipse method (Jennrich and Turner 1969) has little biological meaning in that the home range is always drawn as a perfect ellipse (Fig.2.4a-d) and the position of the ellipse is markedly influenced by movements within the range. Its other major shortfall is that it assumes the data are bivariate normal which is seldom the case and difficult to establish (Anderson 1982). However, the area estimated by this method is not as easily influenced by sample size as other methods (Table 2.3). It has been included in the analysis to provide an estimate of range size for serval "B", for which few locations were available.

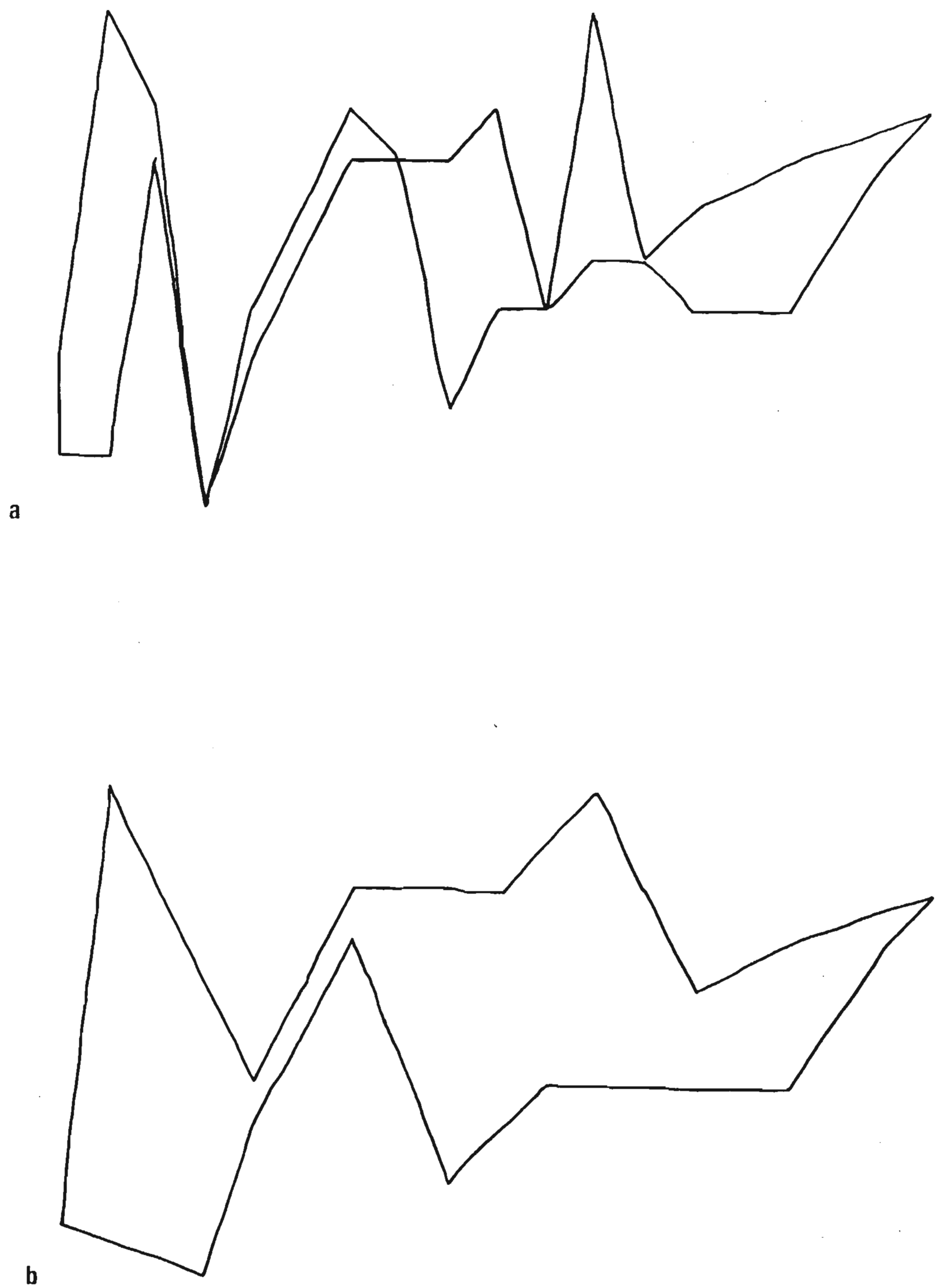


Figure 2.3. Minimum concave polygon home range areas for G (adult male) showing grid cell width of (a) 500m and (b) 1000m.

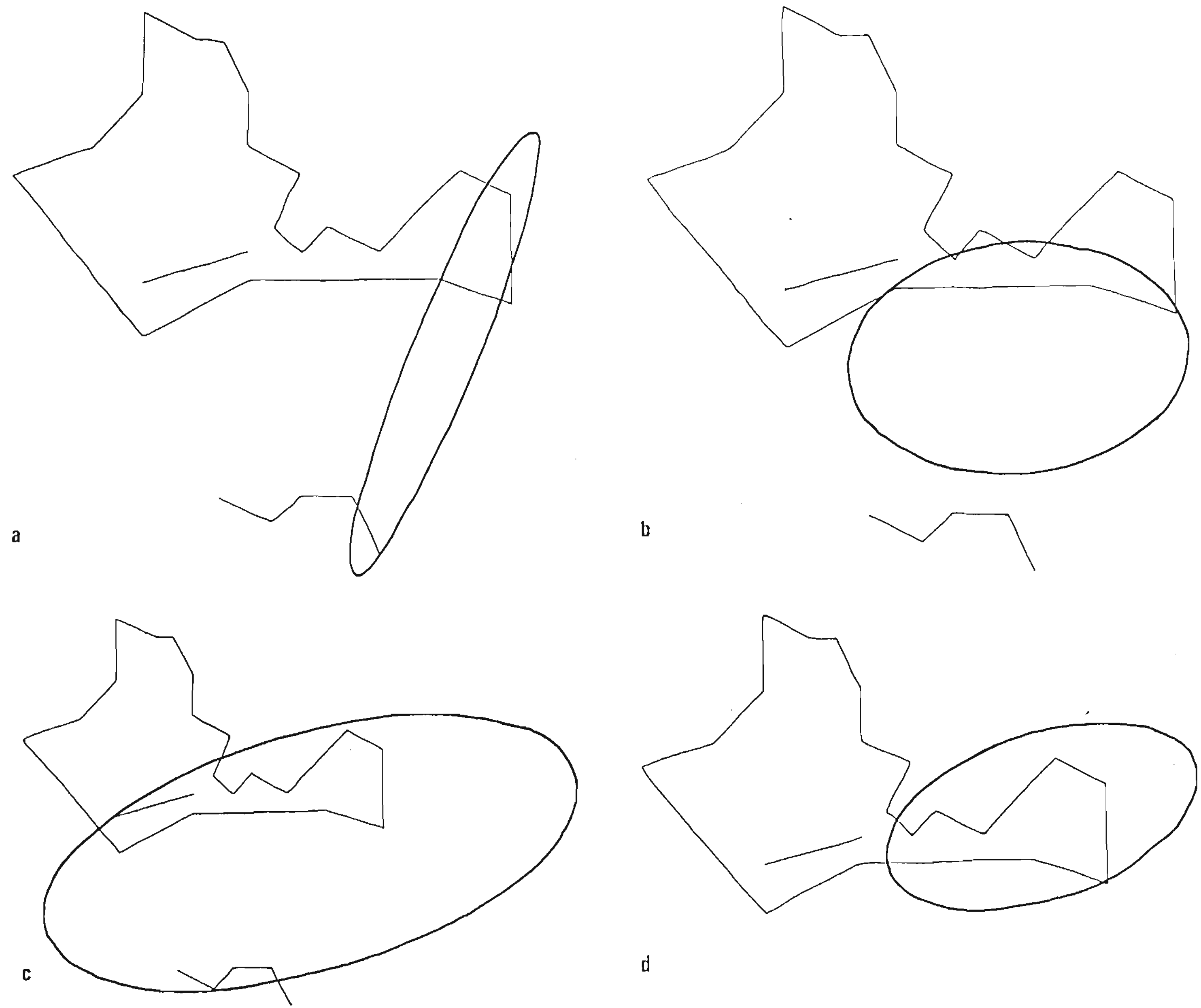


Figure 2.4. 95% ellipse home range areas for (a) B (juvenile/young adult male) (b) S (young adult female) (c) G (adult male) (d) E (young adult female).

Table 2.3. Home range size calculations with different sample sizes from the same individual.

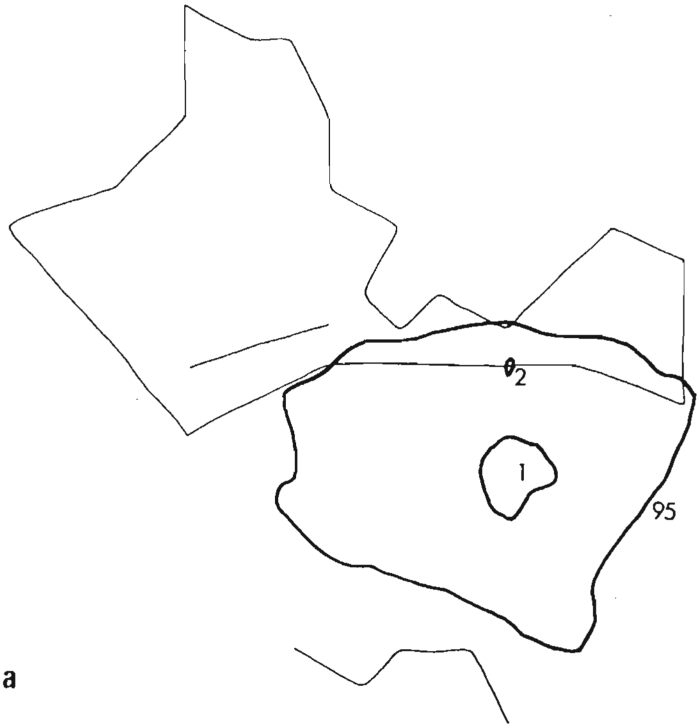
Sample size	Home range size (km^2) convex polygon	95% ellipse	harmonic mean
151	19.8	19.5	16.8
50	13.4	17.8	16.3
20	9.8	19.2	12.9

The Fourier transformation (Anderson 1982) is based on nonparametric statistics. Sufficient data for this method were only collected for two animals. Home range is calculated as the smallest area which accounts for some percent of the total distribution of locations. The choice of what percentage to include involves a trade off as a high percentage (90-95%) suits the generally accepted definition of home range (Burt 1943), however large errors in estimation arise because of the small number of data points in the tails of the distribution curves. If 50% of the total distribution is used then a more accurate estimate can be made. This method emphasizes the importance of space utilization within an area rather than defining its boundaries and can be used to identify core areas. The areas of the range estimated with the 95% and the 50% contour are included for comparative purposes.

The harmonic mean model (Dixon and Chapman 1980) is based on calculation of the harmonic mean centre which is a close approximation to the animals true centre of activity. More than one centre of activity can be defined. Other statistical methods of home range calculation are based on the arithmetic mean (probability circles, Calhoun and Casby 1958; probability ellipses, Jennrich and Turner 1969) which has a number of disadvantages:

1. It is not necessarily located inside the area of animal activity.
2. It does not necessarily indicate any characteristics of the home range where it is located.
3. It is greatly affected by outliers in the location set.
4. Its location is extremely sensitive to movement within the home range.

The harmonic mean centre must be located within the area of the animals movement and is relatively insensitive to movements within the home range. Isopleths, lines joining points of equal activity about the activity centre or harmonic centre (Fig.2.5a-d), can define home ranges of any shape thereby excluding areas of non activity. Isopleths are directly related to the intensity of activity. Within the home range isopleths can be used to define core areas of activity, which is particularly valuable in heterogenous habitats. It has the disadvantage of encircling large areas of unused habitat when home range distributions are strongly linear or disjunct or highly skewed and leptokurtic (Spencer and Barrett 1984).



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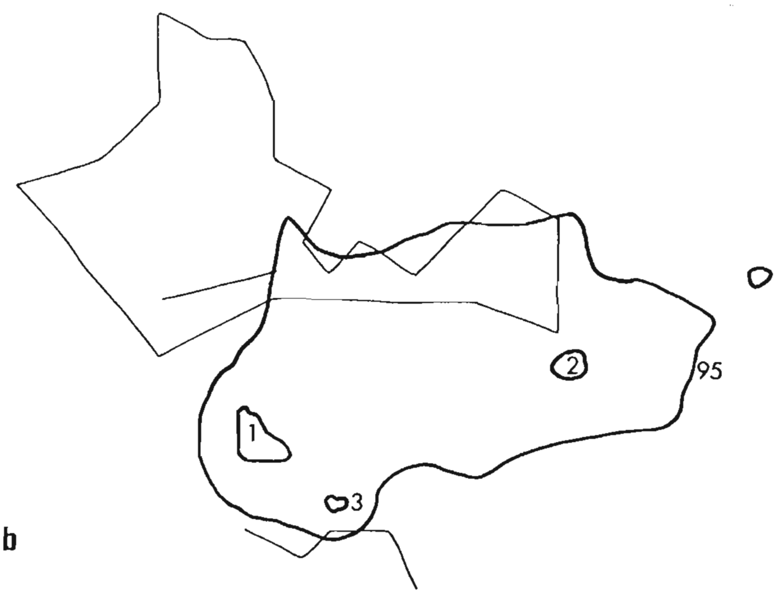

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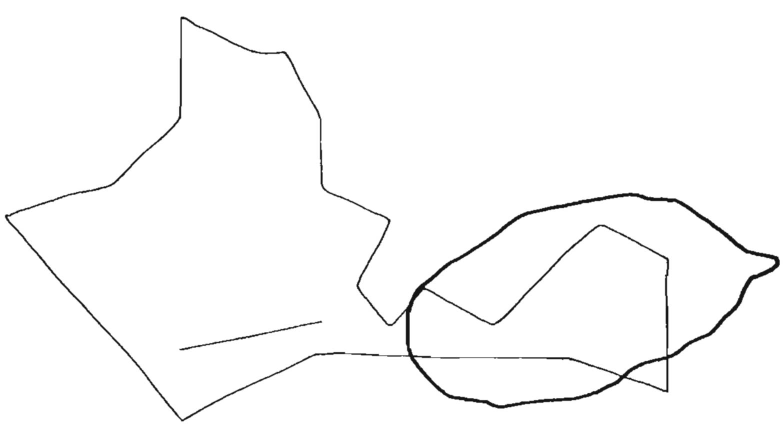

c

Figure 2.5. Harmonic mean transformation home range areas for (a) S (young adult female) showing 95% isopleth and core areas 1 ($0.77km^2$) and 2 ($0.01km^2$) identified with 10% isopleths (b) G (adult male) showing 95% isopleth and core areas 1 ($0.56km^2$), 2 ($0.22km^2$) and 3 ($0.04km^2$) identified with 20% isopleths (c) E (young adult female) showing 95% isopleth.

Core areas were clearly identified in the home ranges of servals "S" and "G" using the harmonic mean method (Fig.2.5a & b). "G" used his areas less intensively than "S". Core areas were either in wetlands (area 1 and 2 for "G" and area 1 for "S") or in patches of woody vegetation (area 3 for "G" and area 2 for "S"). Wetlands are foraging areas (see Chapter 4) while patches of woody vegetation are daytime refuges. This information corresponds with that obtained for servals "Q" and "B" with predictive tracking.

The home ranges of servals "G" and "S" overlapped by 67% at the same time. Five animals, "Q", "B", "G", "S" and "E", utilized common areas, although there was no recorded temporal overlap between "Q" or "E" and the other animals.

Discussion

There is little agreement between the methods used to estimate home range area, however from the available data it is likely that average home range areas approximate 15-30km^2. The home ranges estimated for servals in the Ngorogoro crater (Geertsema 1985) using the minimum convex polygon method were considerably smaller than those estimated in this study. In the Ngorogoro crater home range areas of an adult female and adult male were 9.5km^2 and 11.5km^2 respectively while in the Kamberg values of 19.8km^2 and 15.8km^2 for two females and 31.5km^2 for a male were recorded. Prey abundance and availability is of primary importance in determining the home range size of carnivores (Geertsema 1985). Optimal habitat with high rodent population densities is probably more widely dispersed on farmland than in a pristine wilderness area, resulting in larger serval home ranges in the Kamberg than in Ngorogoro.

Servals frequently lay up in patches of woody vegetation during the day. Previous studies record servals as lying up in long grass during resting periods (Smithers 1983; Geertsema 1985). This difference in behaviour is probably due to the greater disturbance from people and livestock on farmland and to more intensive hunting and trapping pressure than in wilderness areas.

In this study temporal and spatial overlap in home ranges was recorded between "G" and "S". Other servals utilized the same areas, but temporal overlap was not recorded. Geertsema (1985) recorded extensive temporal and spatial overlap in serval home ranges between sexes. Exclusive home ranges are not common among female solitary carnivores (Sandell 1989) as a local seasonal abundance in prey may cause several individuals to exploit the same food source. Common use, however, does not necessarily mean simultaneous use as cats may use a system of mutual avoidance rather than territorial defence (Leyhausen 1979).

There is a trend evident in the results in Table 2.2, also noted by Geertsema (1985) that female servals have smaller home ranges than males. The home ranges of male solitary carnivores are often exclusive as they are determined by the location of and competition for females (Sandell 1989). There is evidence suggesting that male felids may defend an area containing several females (Thapar 1986; Belden et al. 1988; Sandell 1989). Circumstantial support for this hypothesis was shown by the disappearance of serval "B", a subadult male, soon after "G", an adult male, was located in the area.

Sandell (1989) found that there is a significant negative correlation between density and female home range area in solitary carnivores (Fig.2.6). Using this regression and estimating a female home range area of 18km^2 gives a density of 0.08 animals/km^2 or 12.5km^2 per serval in the study area. The minimum convex polygon home range estimates were used from "S" and "E" to give a mean female home range size, since data used to derive the regression were based on minimum convex polygon home range estimations for various other solitary carnivore species. This may be an over-estimate of serval density since the calculated home ranges were for summer when prey was not limiting (Chapter 4). Home range areas may expand at the end of winter when food is scarce. However, the results suggest that servals are probably more common in the area than previously supposed.

Servals are clearly able to adapt to farming activity by increasing their home ranges and lying up in sites where they are unlikely to be disturbed. The study confirms previous observations that servals are associated with wetlands.

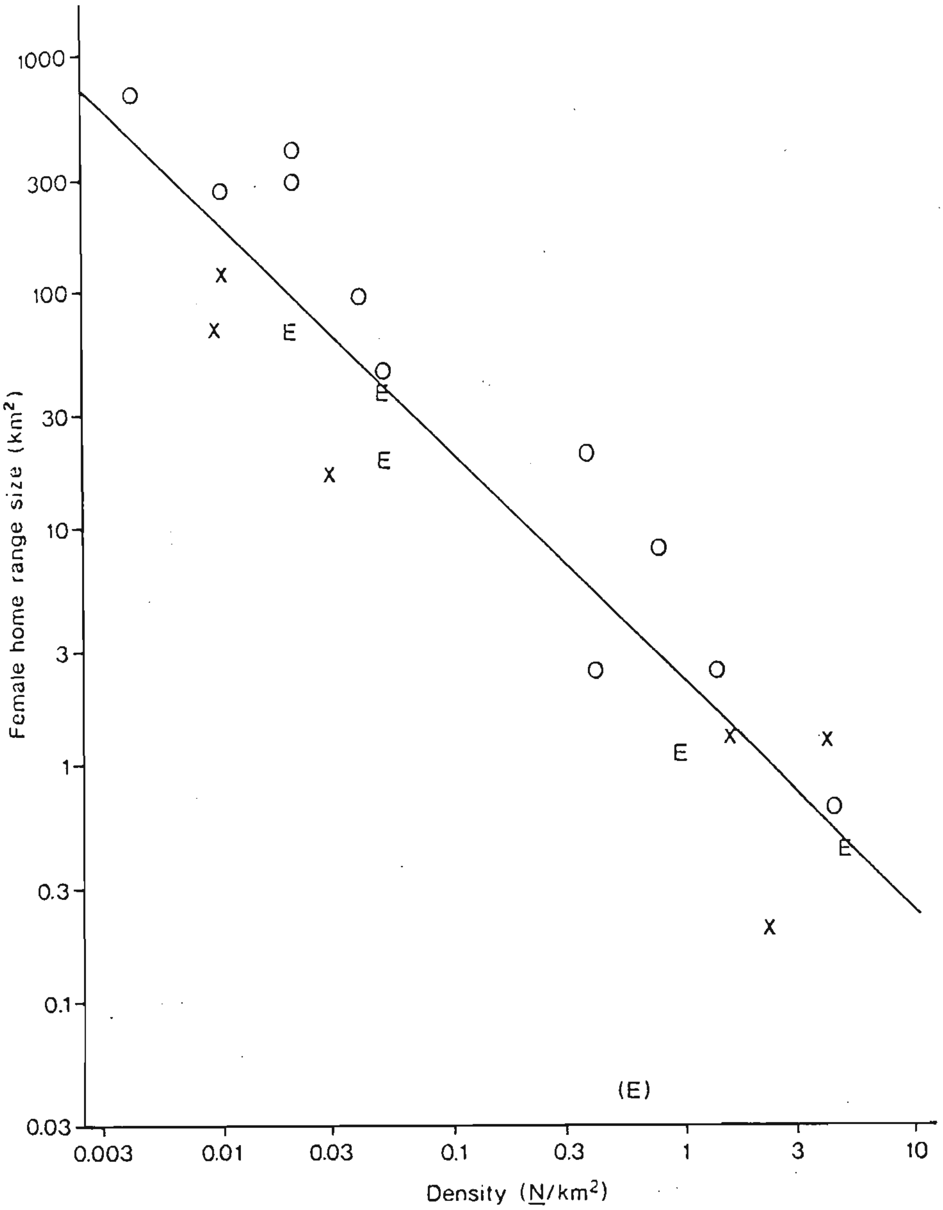

Figure 2.6. The relationship between density and female home range area in solitary carnivores. The line is the regression for all points except E. O=studies where females have overlapping home ranges, E=studies where females have exclusive home ranges and X=studies without data on overlap. (from Sandell 1989).

CHAPTER 3

DIET

Introduction

Previous information about the diet of serval consists mostly of anecdotal accounts and incidental observations (Fitzsimons 1919; Pienaar 1969; Dorst and Dandelot 1972; Kingdon 1977; Rowe-Rowe 1978). Smithers (1978) provides some systematic data on serval food habits from stomach content analysis in Zimbabwe. Geertsema (1985) describes serval diet in the Ngorogoro Crater from direct observation and faecal analysis.

Faecal analysis, used to determine serval diet on farmland during this study, relies on identifying and quantifying undigested prey remains found in scats (Gamberg and Atkinson 1988). It is a widely used technique of determining the diet of animals which are difficult to observe and which cannot be sacrificed for stomach content analysis.

Problems with faecal analysis when attempting to quantify remains and determine the relative importance of different food types are:

1. Differential digestibility of different prey types causes the proportion of remains in the scat to differ considerably

from the proportion in which the foods were eaten (Putman 1984).

2. The number of prey items represented by a particular set of fragments cannot always be easily determined (Putman 1984).

3. Differential passage rates of different components of the prey may induce errors in the estimation of prey consumed (Meriwether and Johnson 1980; Hiscocks and Bowland 1990).

4. Partial consumption of large prey and feeding behaviour of the predator, e.g. skinning the prey, not consuming the extremities and gut, can lead to error when assuming that the entire prey is always eaten (Lockie 1959).

5. Carrion and prey killed by the predator cannot always be distinguished (Scott 1941) since the age of the carcass and prevailing weather conditions determine its state of decomposition.

Frequency of occurrence is the most widely used method of quantifying prey remains (Scott 1941; Erlinge 1968; Grobler and Wilson 1972; Shepherd and Leman 1983; Norton et al. 1986). The first occurrence of each prey type in a scat is recorded and the total for each prey species is expressed as a percentage of the total number of scats analysed. This method is imprecise as it tends to over-estimate prey types with a large proportion of indigestible remains and under-estimate prey types which are easily digested (Lockie 1959; Wise et al. 1981; Maddock 1988). Also no attempt is made to estimate prey numbers when using frequency of occurrence.

Alternatives to frequency of occurrence are volumetric or bulk estimation methods which are widely recommended (Lockie 1959; Kruuk and Parish 1981; Wise et al. 1981). However these methods are still subject to the problem of differential digestibility of prey types as they are based on the proportion of prey remains in the faeces.

Attempts have therefore been made to estimate the biomass of prey consumed by either multiplying the number of prey individuals identified in the scat by the anticipated mean live mass of that prey species (Putman 1984; Maddock 1988) or by using correction factors (Putman 1984). Correction factors are derived by a direct calibration between ingested biomass of prey given and measured mass of undigested remains (Lockie 1959; Floyd et al. 1978; Frank 1979; Liberg 1982).

The former method of estimating biomass of prey consumed is simpler and does not require time consuming feeding trials with prey species which may be difficult to obtain in sufficient quantities. However, the number of prey items consumed cannot be precisely determined from undigested material. Smaller prey are less detectable in scats than larger prey of the same class when quantifiable remains (bones and teeth) are used for identification (Weaver and Hoffman 1979; Johnson and Aldred 1982). Therefore some authors have calculated percent digestibility for various prey types thereby enabling calculation of correction factors to determine the number of prey items consumed (Lowe 1980; Johnson and Aldred 1982).

The aims of this chapter are to determine the diet of servals on farmland so that food availability can be measured and the extent of stock predation be predicted.

Methods

Scats were collected along paths, roads and in long grass. They were stored in paper bags with the date and location of collection recorded, dried at 60^{o}C to constant mass and numbered. Dry scats were softened in boiling water and 4% formalin, then macerated in a 1mm mesh sieve under running water until clean. Teeth, jaw fragments, vegetation, feathers and any other identifiable remains were separated from the rest of the scat which was predominantly hair. Serval hairs resulting from grooming behaviour were removed from the scat for its positive specific identification (Saunders 1963). All scats without serval hair were rejected.

Grass was redried and weighed. Feathers and skeletal remains were used to identify birds as far as possible (Maclean, pers. comm.). Teeth and jaws were used to identify small mammal remains to species using tooth alveoli patterns (Bowland and Bowland 1990) and reference material collected during the study. Otomys irroratus teeth were aged using six age classes based on the wear of the lower first molar (Wirminghaus, unpubl. data).

Hair was floated in a shallow dish and five clumps, each ca. 0.1g, were randomly picked as subsamples. The hairs in each subsample were identified using scale patterns, shape and colour (Perrin and Campbell 1980; Keogh 1985). In five scats ten hair subsamples were taken to confirm that all species present were recorded in the first five subsamples.

Feeding trials were carried out on captive servals to:

1. determine correction factors by calibration between ingested biomass of prey and mass of undigested remains (Putman 1984).
2. determine the percent detectability of various prey types thereby enabling calculation of the exact number of each prey type eaten (Lowe 1980; Putman 1984).

1. Large prey within a class have a smaller proportion of indigestible parts relative to digestible material than small prey in the same class (Floyd et al. 1978). Thus, the correction factor or ratio of food mass to scat mass should be smaller for small rats than for large rats. Sufficient individuals of wild caught rodent species were not available for experimentation therefore adult and juvenile Rattus rattus were used to test the above hypothesis. Three servals were fed

a constant diet of 400g R.rattus, mass 40-60g each, for 13 days. Scats were collected daily and stored and dried separately. Correction factors were calculated for each serval by dividing total intake by total scat mass for the last 10 days of the feeding trial. This ensured that all remains of food prior to the experiment had been passed (Bowland and Bowland, in prep.). The experiment was repeated with one serval using R.rattus weighing ca. 200g each and with Rhabdomys pumilio weighing ca. 30g each.

2. Servals were fed the following food items alone or in various combinations: R.rattus, O.irroratus, R.pumilio, Mastomys natalensis, Myosorex varius and Mus musculus. The exact number of heads of each species eaten were recorded and scats for three days following ingestion were examined for teeth. Detectability was expressed as the percentage of teeth eaten which were not recovered in the scats. Teeth were used in these trials since they are easily recognisable and quantifiable and they were used in the analysis of field collected scats.

Cafetaria tests (Pinowski and Drodz 1975) were conducted with four servals to determine if there was any preference in prey type eaten or whether species were randomly chosen. Servals were given a choice of 3 O.irroratus, 3 R.pumilio, 5-6 M.varius and half a chicken for 5 nights each. The amount of each food type eaten was recorded on a scale of 0-3 where 0=0%

eaten, 1=1-30% eaten, 2=31-60% eaten and 3=61-100% eaten .The score for each food type was summed and divided by the number of nights the test ran.

Results of scat analysis were recorded using frequency of occurrence where the first occurrence of a prey type in a scat was recorded and expressed as a percentage of the number of scats analysed. Second, the percentage of the total number of occurrences of all prey items was recorded for each prey type as percentage occurrence. Third, mass ingested was calculated by multiplying the number of times individuals of a species occurred by the mean live mass of that species and expressing each prey type as a percentage of the total biomass ingested. Frequency of occurrence and percentage biomass ingested were plotted on paired of axes to show relative importance of the various prey types (Kruuk and Parish 1981; Maddock 1988).

Results

Most scats were collected during winter and autumn when invertebrate activity and rainfall were low and scats remained intact longer. Ninety of 211 scats were positively identified as serval scats. The rest were unidentified or came from other carnivores.

Grass, thought to mechanically aid digestion (Smithers 1978), was present in small quantities in nearly all scats, comprising on average 0.67% of the total scat mass.

The detectability trials for the various food species showed a high degree of individual variation between servals (Table 3.1) making any calculation of correction factors for determining prey numbers consumed suspect. Similarly a correction factor calibration between food mass and scat mass could not be determined because of individual variation between the servals (Table 3.2). The calculated correction factor for adult rats fed to serval "1" was lower than that for juvenile rats (x=16; SE=1.4) rather than higher as expected. Since serval diet was relatively uniform and correction factors were unreliable it was decided not to apply them.

Four prey categories were identified in serval scats (Fig.3.1). Small mammals (rodents and insectivora) accounted for 93.5% of prey item occurrences. Birds constituted 5% and reptiles (order Squamata) and insects (order Orthoptera) 1.6% combined. No attempt was made to identify reptiles or insects beyond order level because of their low occurrences. Birds were identified as far as possible (Table 3.3), however a large proportion could not be identified since feathers were too finely macerated or came from juveniles. An average mass was estimated for birds that could be identified to family or

Table 3.1. Detectability of prey species in scats.

serval individual	% loss of teeth					
	Rattus rattus	Otomys irroratus	Rhabdomys pumilio	Myosorex varius	Mus musculus	Mastomys natalensis
1	75.0	26.2	-	88.5	-	-
1	75.0	22.4	-	-	-	-
2	43.7	74.3	100	77.5	-	-
2	-	9.5	-	-	-	-
3	83.6	52.9	100	-	100	91.7
4	87.5	-	-	-	-	-

- no trial

Table 3.2. Correction factors for prey of various mass.

serval individual	food	mean mass food (g)	total mass food (g)	total scat mass (g)	correction factor*
1	R.rattus	200.6	4011.8	280.0	14.3
1	R.rattus	44.3	3629.9	244.2	14.8
1	R.pumilio	28.0	1820.2	143.0	12.7
2	R.rattus	54.4	4351.6	250.1	17.4
3	R.rattus	58.1	4068.7	258.2	15.8

* total mass food/total scat mass

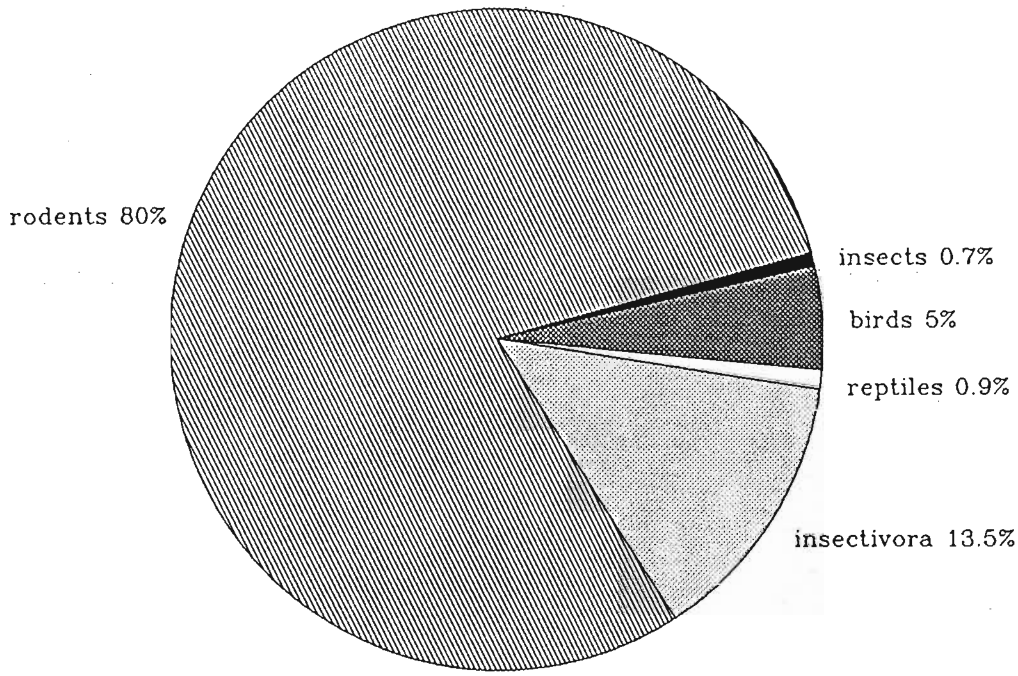

Figure 3.1. Percentage occurrence of prey types in serval diet from scat analysis.

genus (Maclean 1985) and a mean mass was used for the unidentified birds. This estimate may be inaccurate because of the relatively large proportion of unidentified occurrences and the range of body mass.

Table 3.3. Birds identified in serval scats (mean mass from Maclean 1985).

	Number of occurrences	mean mass (g)
Sarothrura sp.	6	39.1
Alandidae/Montacillidae	3	44.0
Ortygospiza sp.	1	12.0
Estrilda astrild	1	8.4
Euplectes sp.	1	23.1
Cisticola sp.	2	13.4
large bird*	1	700.0
unidentified	7	75.8

* One scat contained feather quills from an unidentified large bird. It was assumed that this constituted one meal which, from captive studies, is a maximum of 700g.

A mean biomass of all identified small mammal species was used to calculate biomass of the unidentified group (Table 3.4). The mean mass of *R.pumilio* and *M.varius* was obtained by multiplying the number of scats collected in a season by the mean mass of *R.pumilio* and *M.varius* trapped in that season (see Chapter 4) and dividing by the total number of scats. For *O.irroratus*, *Tatera brantsii*, *Mus minutoides*, and *Dendromus melanotis* an overall mean mass of individuals caught was taken. Percentage biomass ingested of each small mammal

Table 3.4. Scat analysis results.

prey type	frequency of occurrence	total occurrences	mean mass (g)	total biomass ingested (g)	% biomass ingested	source mean mass data
Otomys irroratus	94.4	155	126.5	19607.5	62.6	own data
Rhabdomys pumilio	75.6	134	35.7	4783.8	15.2	own data
bird	23.3	22	75.8	1667.5	5.5	calculated Table 3.4
Myosorex varius	41.1	55	11.9	654.5	2.1	own data
Dasymys incomtus	10.0	10	106.8	1068.0	3.4	De Graaff 1981
Amblysomas hottentotus	4.4	4	67.9	271.6	0.9	Kuyper 1979
Mastomys natalensis	13.3	20	58.0	1160.0	3.7	De Graaff 1981
Cryptomyus hottentotus	10.0	9	126.5	1138.5	3.6	De Graaff 1981
Tatera brantsii	2.2	2	93.7	187.4	0.6	own data
Mus minutoides	5.6	6	8.4	50.4	0.2	own data
Dendromus melanotis	3.3	3	10.5	31.5	0.1	own data
unidentified small mammal	10.0	9	72.7	654.7	2.1	calculated

species was calculated to give the relative contribution of each species to the small mammal component of the diet (Fig 3.2).

O.irroratus is the most important serval prey species (Fig.3.3), occurring in 94.4% of the scats analysed and constituting over 60% of the total biomass consumed (Table 3.4). The second most important prey species is R.pumilio, then birds, contributing 5.6% of the biomass consumed. Flufftails (Sarothrura sp.) were the most frequently eaten birds (Table 3.3).

Cafetaria tests showed that servals choose O.irroratus before other food types. Their second choice was chicken, then R.pumilio and lastly M.varius (Table 3.5). M.varius were usually rejected and two servals never ate them.

No new prey types (small mammal species or other classes) were found after the 50th scat was analysed when ordered according to date collected (Fig 3.4). A sample size of 90 scats was therefore assumed to be an adequate representation of serval diet on farmland.

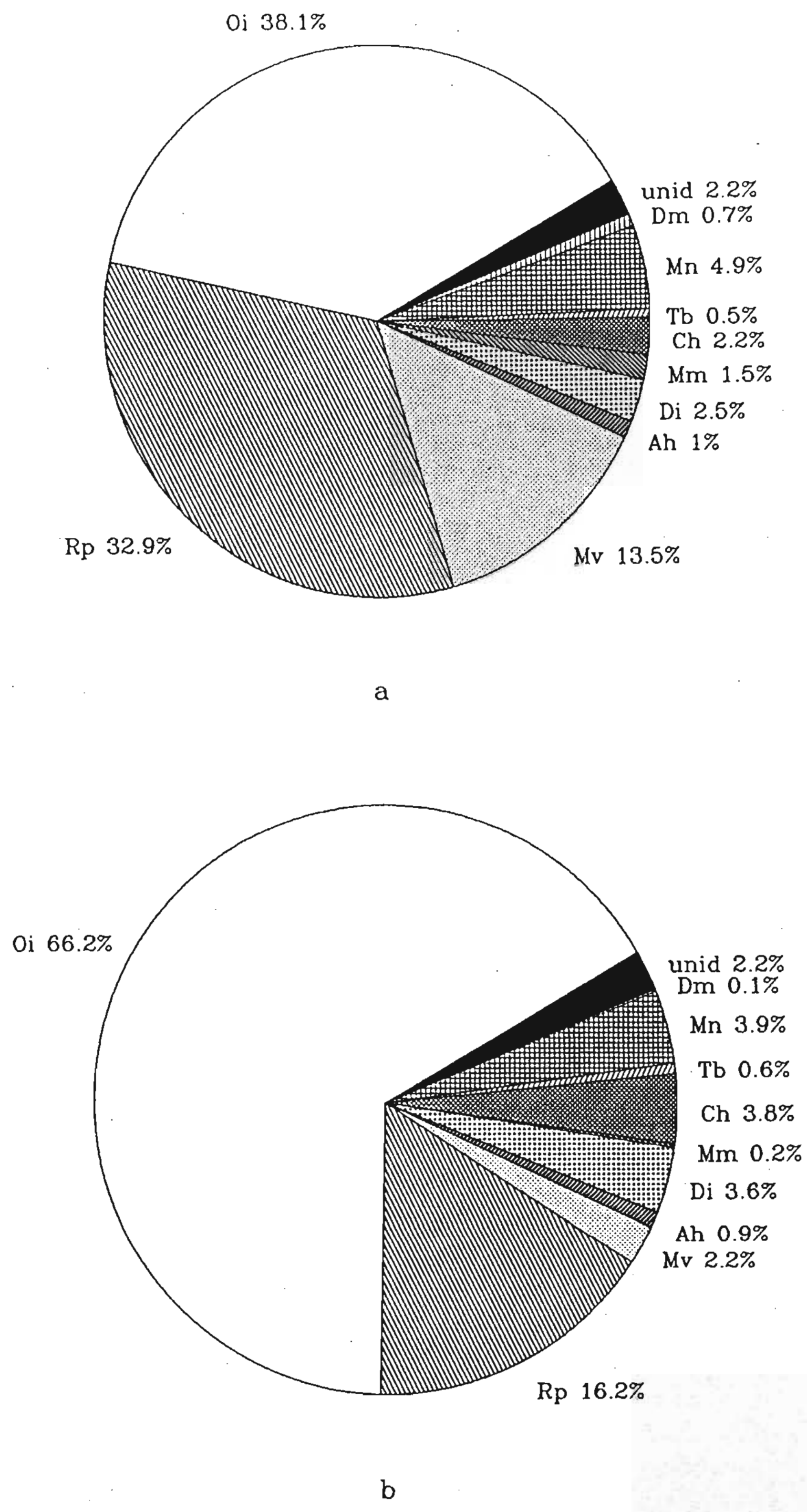

Figure 3.2. Small mammal component of serval diet (a) percentage occurrence (b) percentage biomass ingested, Ah=Amblysomas hottentotus; Ch=Cryptomus hottentotus; Di=Dasymys incomtus; Dm=Mastomys natalensis; Mm=Mus minutoides; Mv=Myosorex varius; Oi=Otomys irroratus; Rp=Rhabdomys pumilio; Tb=Tatera brantsii; unid=unidentified small mammal.

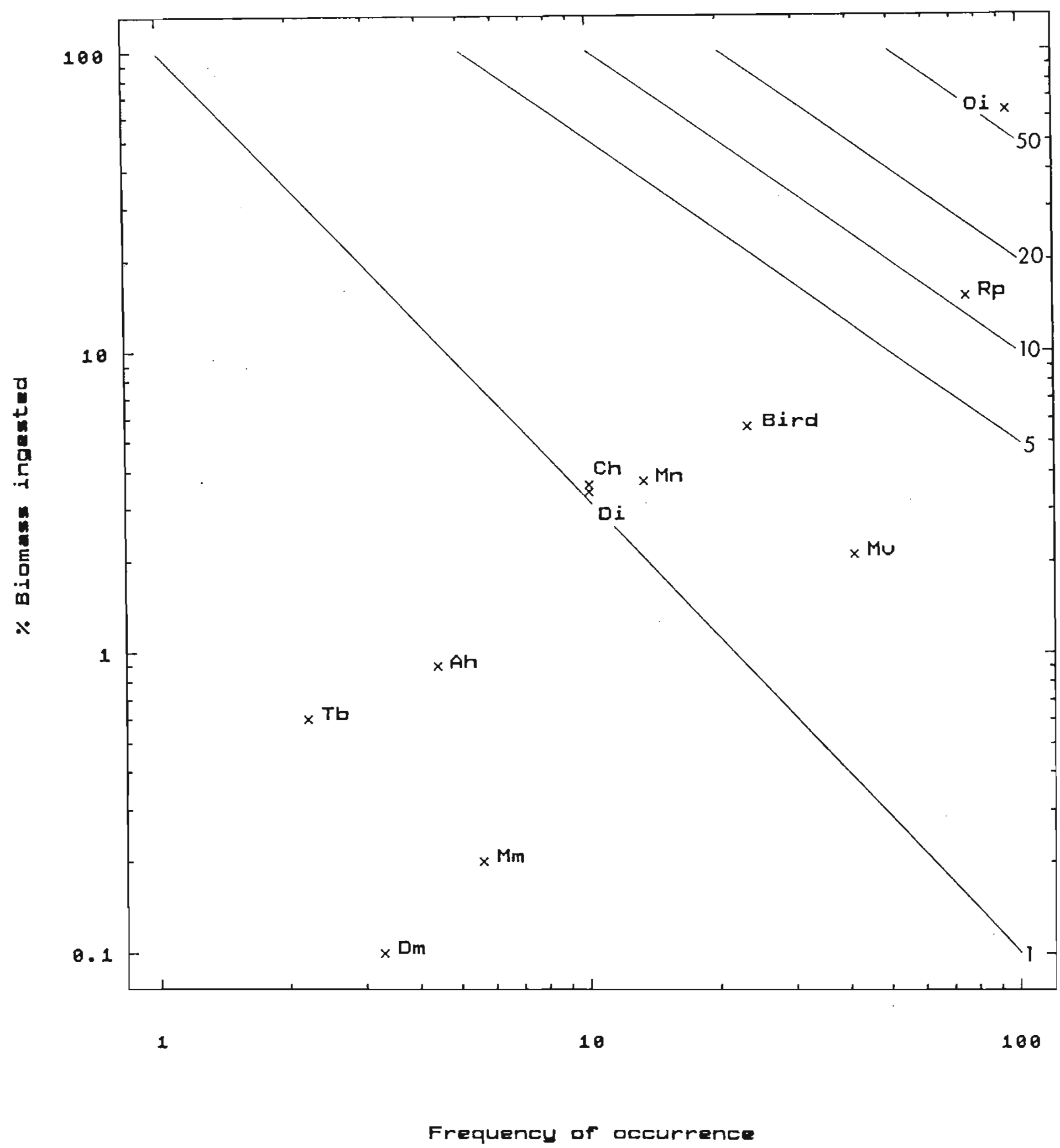

Figure 3.3. Relative importance of various prey types in serval diet. Isolines connect points of equal importance.

Table 3.5. Results of cafetaria tests giving the mean score for each prey type eaten (0=0% 1=1-30% 2=31-60% 3=61-100%).

food types	serval individual				
	1	2	3	4	total
<u>Otomys irroratus</u>	3.0	2.0	2.8	3.0	10.8
<u>Rhabdomys pumilio</u>	1.3	0	0.4	1.0	2.7
<u>Myosorex varius</u>	0.4	0	0	0.4	0.8
chicken	1.3	0	1.0	2.2	4.5

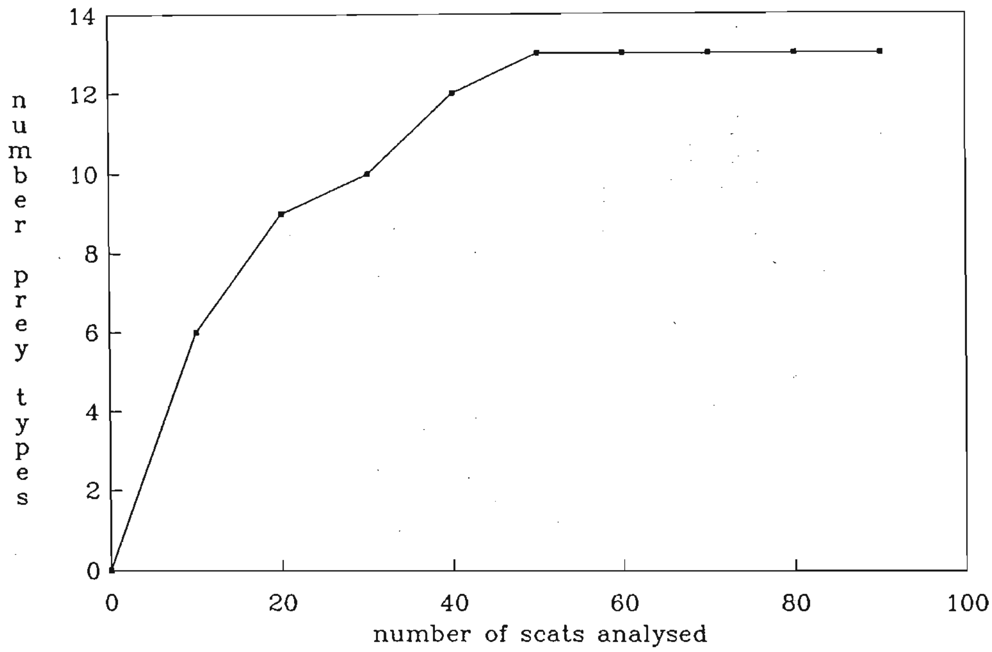

Figure 3.4. Cumulative curve of number of prey types identified against number of scats analysed.

Discussion

Correction factor results were probably confounded by using juvenile and adult rodents in the trials since digestibility is partly determined by age of the prey (Lowe 1980). Correction factors have usually been calculated for different prey classes or orders, rather than for different species within the same order. Where the majority of prey falls into one order, as in the case of the serval, it is probably less important to determine correction factors than where diet is very diverse as there is less variability in digestibility within than between orders. Individual variation in detectability of prey may be influenced by the physiological state of the predator, which is a factor often not considered by authors recommending correction factors.

Otomys irroratus are usually associated with lush grasses and sedges near streams, marshes and vleis (Davis 1973). This habitat type corresponds with the core areas of servals home ranges. Otomys sp. form the primary component of servals diet throughout Africa. Otomys angoniensis and M.natalensis occurred in 48% of serval stomach contents analysed in Zimbabwe (Smithers 1978) while O.angoniensis and M.minutoides were the dominant species found in the scats from Ngorogoro Crater (Geertsema 1985). They are comparatively large rodents, nest above the ground (Davis 1973) and are relatively slow moving, making them easy prey and giving a high energy return per unit catch effort.

Shrews (M.varius) occurred more frequently in the scats than was expected since most predators reject them (Ewer 1973) and they were usually rejected in cafetaria tests. However, M.varius are most active nocturnally (Goulden and Meester 1978; Baxter, Goulden and Meester 1979) and they are abundant in the core areas of the servals home ranges, making them likely prey. Myosorex sp. may be less distasteful than Crocidura sp. which also occurred in the study area, but were not found in the scats.

Flufftails were the most frequently occurring birds in serval scats, most likely because they are associated with a similar habitat and are nocturnal (Maclean 1985). They are ground-dwelling, poor flyers, and thus may be easy to catch.

The results of this study support the proposition that servals prey almost entirely on small mammals. In Zimbabwe (Smithers 1978), there was a greater diversity of small mammal prey species than in Kamberg. Geertsema (1985) found in Ngorogoro that small mammals accounted for 89% of serval prey from direct observation and 98.2% from scat analysis. Kingdon (1977) lists Mastomys sp., Arvicanthis sp., Lemniscomys sp., Dasymus sp., Tachyoryctes sp. and Cryptomys sp. as serval prey. Other prey includes amphibians, birds, reptiles and insects.

Larger prey reported include hares, Lepus saxatilis, cane rats, Thryonomys swinderianus (Smithers 1983, York 1973), duikers (species not recorded) and young of oribi, Ourebia ourebi, and bushbuck, Tragelaphus angasii, (Verheyen 1951, cited in Kingdon 1977), steenbuck, Raphicerus campestris, and impala lambs, Aepyceros melampus, (Pienaar 1969) and a gazelle lamb, Gazella sp. (York 1973). Most of the observations regarding large prey are incidental and anecdotal.

Servals can be regarded as small mammal selectors, with birds contributing about 10% to their diet. The wide range of prey species reported indicate that servals are able to use other types of prey when Otomys sp. are at low density.

CHAPTER 4

PREY AVAILABILITY

Introduction

The suitability of an area for an animal species and the population density of that species depends inter alia on the availability of food (King 1980; Sandell 1989). Small mammals contribute over 90% of serval food by mass (Chapter 3). Small mammal communities were sampled to obtain indices of abundance, diversity and distribution throughout the study area, and to detect at what time of the year food is most likely to limit serval population density.

Small mammal populations are largely dependant on vegetation structure in terms of cover as protection from predation (Rowe-Rowe and Meester 1982; Bowland and Perrin 1987). Servals were observed by radio-tracking and direct observation to prefer areas with long grass to those with short grass. Vegetation structure was therefore monitored to determine to what extent changes influence small mammal population demography and serval movements.

Study area

The study area was divided into six habitat types. These were:

1. High plateau, above 2088m, flat, dominatad by Themeda triandra, Festuca costata and Harpechloa falx.
2. Steep valley sides (altitude 1800m-2080m) with a large proportion of boulders, rocks and cliff faces. Bush clumps of Leucosidia sericea and Buddleia salvifolia occurred in the drainage lines.
3. Gentler slopes, below 1800m, generally dry and not rocky, dominated by Themeda triandra and Tristachya leucothrix.
4. Wetlands, mostly at the valley bottoms, (altitude 1660m) varying from fairly extensive marshes with the soil submerged or waterlogged all or part of the year to areas of lush vegetation growth along the banks of rivers.
5. Cultivated pastures in the valley bottoms, characterized by monocultures of Eragrostis curvula (weeping lovegrass) and Lolium perenne (ryegrass).
6. Forest, incorporated the smallest total area and included patches of black wattle (Acacia mearnsii) and indigenous bush higher up the slopes.

The slopes and high plateau are burnt biennially in spring in the Kamberg Nature Reserve and on farmland surrounding the reserve. Wetlands on the farm are burnt triennially. Planted pastures are cut in late summer and autumn for hay and silage.

Methods

Small mammals

The distribution of small mammals was determined by placing trap lines in different parts of the study area as follows (Fig. 4.1):

Transect 1. Farm wetland

Transect 2. Kamberg Nature Reserve (KNR) wetland

Transect 3. High plateau

Transect 4. Steep rocky slope

Transect 5. Cultivated ryegrass pasture

Transect 6. Lower slope burnt in 1988, not burnt in 1989

Transect 7. Lower slope not burnt in 1988 or 1989

Trapping was conducted once each season (spring = September-November; summer = December-February; autumn = March-May; winter = June-August).

At each site 25 trap stations were placed 15m apart with two traps, baited with a mixture of peanut butter and oats, per station. Traps were set for four days and checked once in the morning to give 200 trap nights per trapping session. One day prebait at the beginning of each trapping session allowed the animals to familiarize themselves with the traps in their home ranges. PVC live traps (Willan 1979) and folding aluminium Elliot live traps (32x9x10cm) were used. Rodents were marked with a toe clip code, weighed, sexed and checked for reproductive condition (i.e. females' vaginal opening

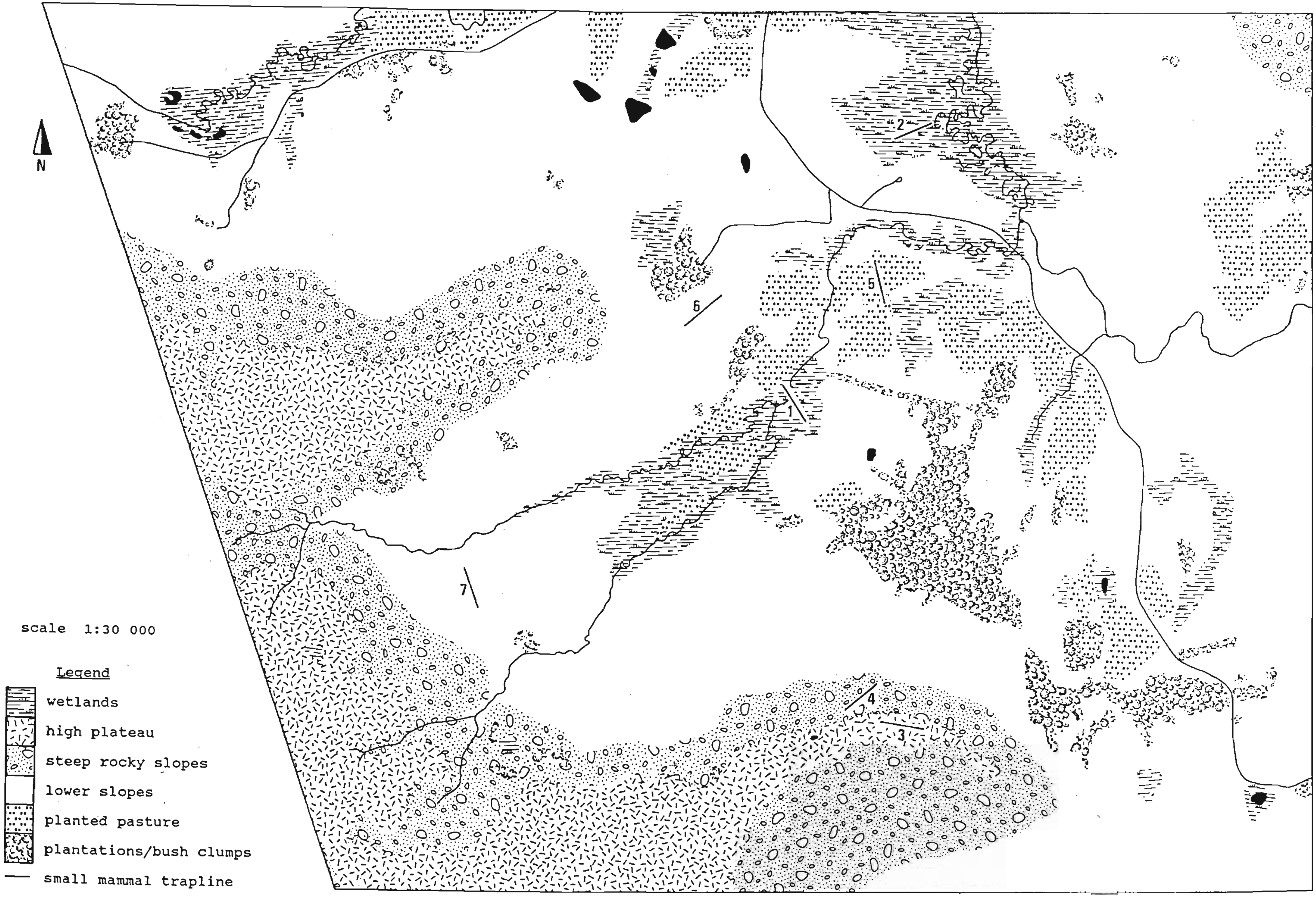

Figure 4.1. Map of study area showing major habitat types and

perforate or imperforate and males' testes abdominal or scrotal).

Snap traps were set in a line along a river in summer 1988/1989 and autumn 1989 primarily to catch rodents for feeding trials, but provided some useful information. There were a total of 226 snap trap nights in summer and 702 snap trap nights in autumn.

Results from the trap lines were analysed using the modified Petersen method (Begon 1979), the weighted mean (Begon 1979) and by calculating percentage catch per trap night. The following assumptions are associated with capture mark recapture (CMR) techniques (Begon 1979, Collinson 1985):

-All individuals have the same probability of being caught in the first sample.

-Marking does not affect the probability of recapturing an individual.

-Marked and unmarked individuals have equal chance of being caught.

-All individuals have equal chance of dying or emigrating.

-Marks are not lost during the capture period.

-Sampling periods are short in relation to total lifespan.

Vegetation

Two vegetation transects were sampled near each of the small mammal transects. A meter square quadrat was placed 1m from a tape on both sides at 5m intervals for 250m. Average grass height was measured against a meter stick and the percentage vegetative cover (Greig-Smith 1983) was estimated visually in each quadrat. Vegetation transects could not be randomly placed because of the nature of the terrain and the shape of the different habitats, however this was offset by the position of the quadrats being objectively determined. Cover estimates were divided into five classes: 0-30%; 31-50%; 51-70%; 71-90% and 91-100%.

Otomys irroratus constitute a large proportion of the diet of servals (Chapter 3), but are not easily caught in live traps (Maddock 1988; pers. obs.). The number of piles of cut grass left by Otomys sp. after feeding (Davis 1973) were counted in vegetation quadrats to give an index of their numbers. Only those piles with green material still present were counted.

Results

Six rodent species, Rhabdomys pumilio, Otomys irroratus, Mastomys natalensis, Mus minutoides, Tatera brantsii, Dendromys melanotis, and two insectivora, Myosorex varius, and Crocidura flavescens, were trapped.

Percentage catch per trap night (i.e. trapping success) indicated the relative abundance of small mammals in different parts of the study area most reliably. The results obtained with capture mark recapure methods (Appendix 2) varied widely because of small sample sizes and because of violation of some assumptions. First, all individuals do not have the same probability of being caught. Shrews and R.pumilio are trap prone (Maddock 1988) while O.irroratus is trap shy (Davis 1973; Rowe-Rowe and Meester 1982; Maddock 1988). Second, marking affects the probability of recapturing some species. Shrews seemed most vulnerable to being trapped and handled. There was a high trap mortality (33%) and sometimes released individuals were found dead near the trap the following day. Third, no marked individuals of O.irroratus or shrews were recaptured possibly because of trap avoidance after handling stress. The assumptions that marks are not lost and sampling periods are short are valid.

Seventy-one percent of small mammals were caught in the wetlands (Table 4.1). Low numbers were recorded for other areas. Wetlands comprise 7% of the total study area (Table 4.2), but account for 22,4% of the total small mammal population.

Live trapping results indicate that R.pumilio is the most common small mammal species in the area and M.varius the second most common. The results of the snap trap line (Table 4.3), however, indicate that O.irroratus is the second most common species at least in the wetlands.

Table 4.1. Accumulated results of small mammal live trapping.

Transect	1	2	3	4	5	6	7
Habitat	farm wetland	Kamberg Nature Reserve wetland	plateau	rocky slope	pasture	lower slope burnt 1988	lower slope unburnt 1988
No. trap nights	800	800	700	800	850	850	800
No. captures	319	331	54	86	52	45	30
% trap success	39.9	41.4	7.7	10.8	6.1	5.3	3.8
No. individuals							
Total	212	197	70	64	43	34	27
R.pumilio	150	140	12	17	26	20	1
M.varius	42	50	51	38	8	9	25
O.irroratus	14	3	0	1	1	2	1
M.minutoides	2	0	4	1	1	1	0
C.flavescens	4	4	0	2	1	1	0
D.melanotis	0	0	3	2	0	0	0
M.natalensis	0	0	0	3	2	0	0
T.brantsii	0	0	0	0	4	0	0
No. species	5	4	4	7	7	5	3
Diversity (H')	0.8691	0.7462	0.8285	1.1815	1.2759	1.0407	0.3250

Table 4.2. Habitat type areas and contribution to small mammal populations.

	area (km^2)	%total area	number of small mammals caught	% small mammal population
wetland	5.5	6.9	325*	22.4
plateau	8.6	10.8	54	5.8
rocky slope	10.8	13.5	86	11.6
pasture	4.2	5.3	52	2.8
lower slopes	47.8	59.6	37.5+	22.4
forest	3.1	3.9	0 (no traps)	-

* mean of transect 1 and 2
\+ mean of transect 6 and 7

Table 4.3. Results of small mammal snap trapping in farm wetland.

	summer	autumn
No. trap nights	226	702
% trap success	11.5	14.8
No. individuals		
Total	26	104
R.pumilio	11	69
M.varius	3	1
O.irroratus	11	41
C.flavescens	1	2
M.natalensis	0	1

A number of factors affect small mammal abundance and diversity (Table 4.4). These include the vegetation (Rowe-Rowe and Meester 1982; Bowland and Perrin 1987), altitude (Rowe-Rowe and Meester 1982), burning patterns (Rowe-Rowe and Lowry 1982b; Bowland and Perrin 1988), and rainfall (Taylor and Green 1976).

The mean grass height was significantly different between seasons in each of the sites except the plateau. Cover was not significantly different in the KNR wetland, rocky slope and veld unburnt in 1988 (Table 4.5). There is a perfect correlation (K=1) (Wardlaw 1985) between grass height and rodent population density in the pasture. The highest rodent density was recorded in summer when grass height was at its peak (Fig 4.2a). In the other areas although the seasonal

Table 4.4. Small mammal trapping results in relation to various habitat parameters.

habitat	season	% catch/ trap night	small mammal diversity	% cover class 0-30	31-50	51-70	71-90	91-100	mean grass height (cm)	burning policy	months since last burn	altitude (m)
farm wet-land	winter	40.0	0.4843	3	7	10	24	156	23.3	triennial	22	1677
	spring	43.0	0.5993								24	
	summer	37.5	0.8094								28	
	autumn	49.0	1.0005	1	1	6	20	172	32.9		30	
	winter	33.0	0.7187	4	3	4	19	170	23.9		32	
	spring	-	-	5	6	20	51	118	19.0		35	
	summer	4.0	0.9561	9	11	39	67	74	22.6		2	
KNR wet-land	spring	40.0	0.8368	4	1	6	21	168	41.7	irregular	>25	1646
	summer	27.6	0.9538	3	5	3	26	163	49.6		>28	
	autumn	50.5	0.6171	4	3	13	14	166	55.4		>32	
	winter	53.0	0.4599	3	7	8	20	162	44.3		>34	
plateau	spring	19.3	0.9365	3	6	6	37	148	19.8	biennial	13	2088
	summer	8.4	0.1985	3	2	9	7	179	19.3		17	
	autumn	19.0	0.7531	3	3	5	7	182	21.4		21	
	winter	7.0	0.9256	3	4	11	21	161	17.3		22	
rocky slope	spring	12.6	0.8974	26	10	35	37	92	16.2	biennial	12	1982
	summer	8.8	0.8086	21	19	28	44	88	17.0		16	
	autumn	11.0	1.0184	28	15	20	45	92	15.8		20	
	winter	11.5	1.2328	23	12	41	41	83	13.3		21	

Table 4.4. continued

habitat	season	% catch/ trap night	small mammal diversity	% cover class 0-30	31-50	51-70	71-90	91-100	mean grass height (cm)	burning policy	months since last burn	altitude (m)
lower slope burnt 1988	summer	2.4	0.8679	12	24	71	93	0	9.8	biennial	4	1738
	autumn	5.0	0.9168	2	8	12	21	157	13.4		8	
	winter	11.5	0.6363	4	7	17	44	128	14.2		10	
	spring	2.5	0.6730	5	6	20	51	118	12.3		13	
lower slope unburnt 1988	autumn	7.5	0.2860	7	5	8	13	167	17.7	biennial	19	1784
	winter	4.0	0.3768	6	2	8	18	166	15.7		21	
	spring	2.0	0.0	5	4	5	26	160	14.0		24	
	summer	1.5	0.0	4	1	7	23	165	17.1		27	
pasture	spring	4.8	1.1191	12	4	25	87	72	8.5	never		1662
	summer	13.0	0.4652	0	2	18	77	103	30.7			
	autumn	5.0	0.8979	0	0	0	6	194	14.1			
	winter	2.0	1.0397	1	0	3	36	160	3.7			

differences in grass height were statistically significant they were not biologically significant. The greatest small mammal diversity (Shannon Weaver measure; Poole 1974) was where there was most disturbance to the vegetation (pasture and farmvlei) and where there was greatest heterogeneity (rocky slope).

Table 4.5. Statistical significance of seasonal differences in vegetation cover and height.

Transect	cover		mean grass height	
	X^2 df=12	significance level	F ratio df=199	significance level
1	160.568	*	14.513	*
2	16.083	-	8.908	*
3	43.836	*	2.347	-
4	13.950	-	5.745	*
5	226.787	*	380.832	*
6	299.397	*	17.465	*
7	10.176	-	7.833	*

- not significant
* significant at 5% probability level

Myosorex varius and R.pumilio were recorded at all trapping sites. Rhabdomys pumilio were dominant in the wetlands and pasture and their numbers relative to M.varius decreased with altitude. Rowe-Rowe and Meester (1982) found no R.pumilio above 2700m. Seventy-seven percent of the O.irroratus trapped were in the wetlands. Davis (1973) and Rowe-Rowe and Meester (1982) found O.irroratus were not confined to vleis. In this study O.irroratus were only caught away from wetlands in moist patches of long grass. Signs of O.irroratus were seen in damp valleys on south-facing mountain slopes.

Lowered cover after burning causes a decline in the rodent population. Two months after burning the farm wetland trap success had dropped from 33% to 4% and the amount of cover in the 91-100% class was lowered. Four months after burning on the lower slopes cover and grass height were low and trap success was low. Maximum trap success on the lower slopes was 10 months after the burn (Fig 4.2b and c). Greatest small mammal diversity occurred 4-8 months after burning and after two years only small numbers of M.varius were caught (Table 4.6). Rowe-Rowe and Lowry (1982b) found small mammals decline in the second year after burning and decrease in diversity with time since burning.

There was greater diversity in the farm wetland than in the KNR wetland which is burnt less often. Otomys irroratus was mainly caught in the farm wetland, however feeding signs suggested that there is not much difference in their numbers between the wetlands (Table 4.7). Mastomys natalensis was caught in the farm wetland only after burning.

Seasonal factors influencing the small mammal populations were difficult to identify as trapping only covered one year and other influences overrided obvious seasonal influences. The plateau (Fig 4.2d) and farm wetland (Fig 4.2e) showed peaks in

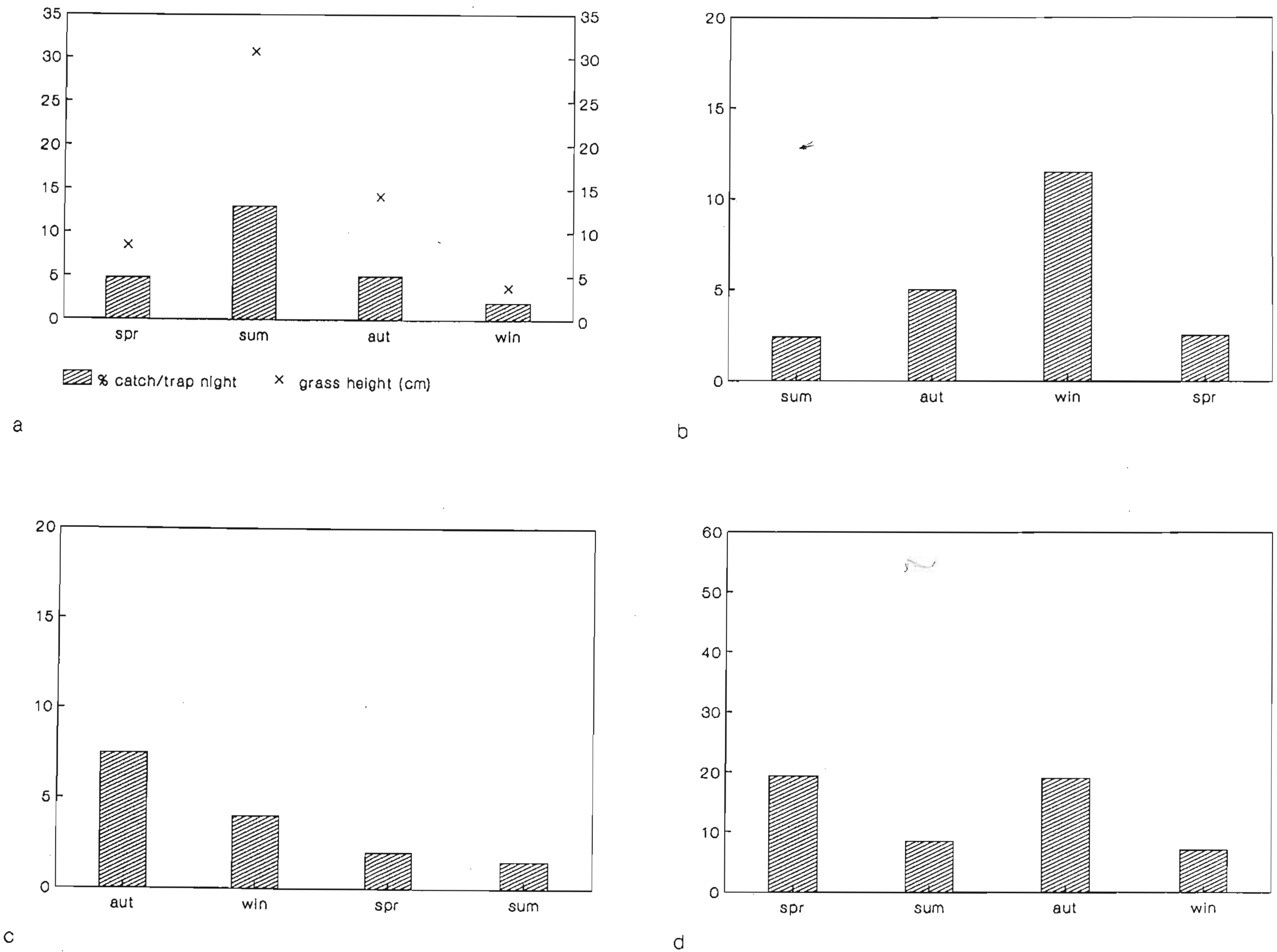

Figure 4.2. Trap success (% catch/trap night) in; (a) pasture (b) lower slope burnt 1988 (c) lower slope unburnt 1988 (d) plateau

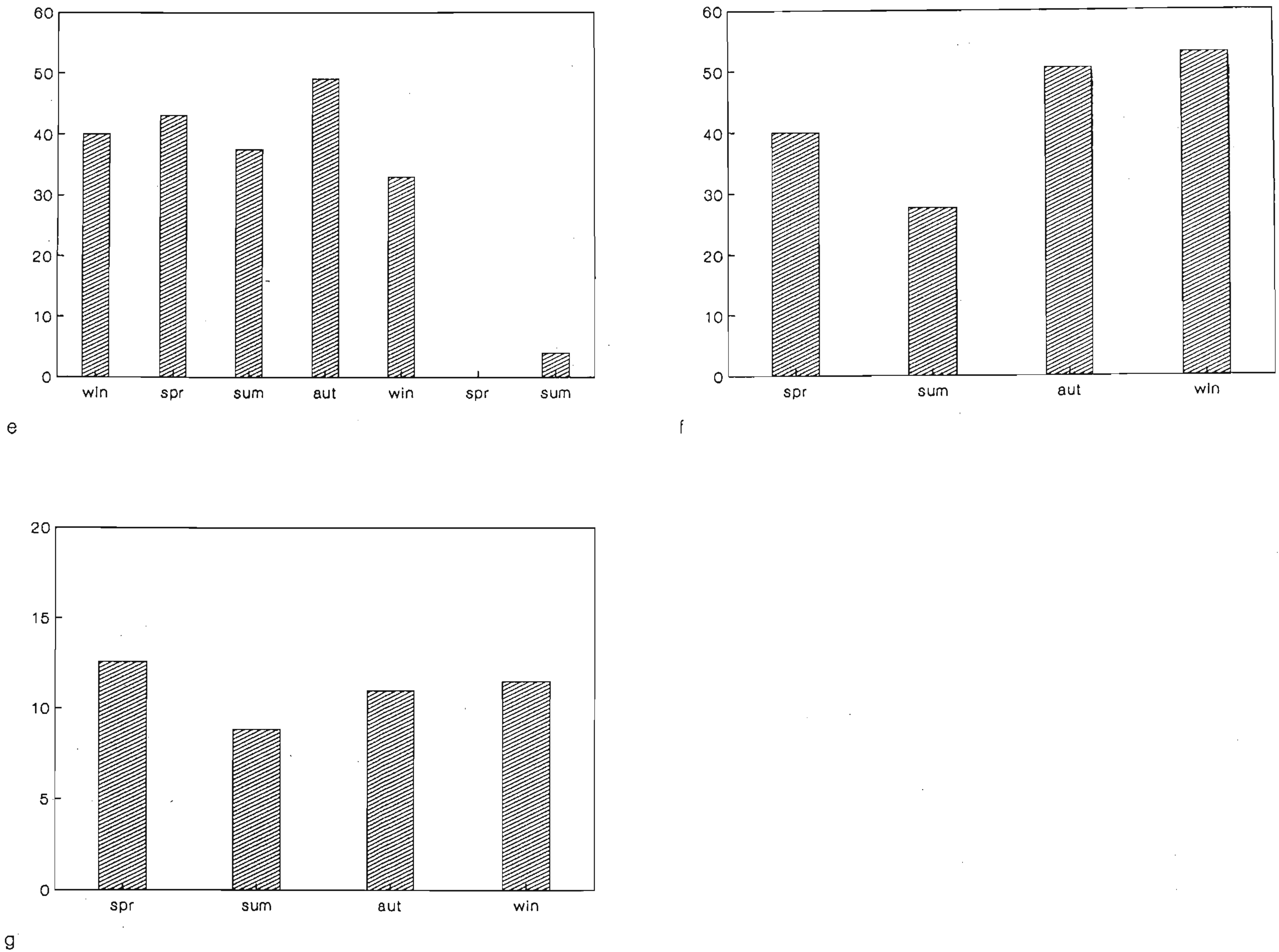

Figure 4.2. continued; (e) farm wetland (f) Kamberg nature

Table 4.6. Influence of burns on the small mammal populations on the lower slopes.

	transect 6					transect 7		
months since last burn	4	8	10	13	19	21	24	27
No. individuals								
<u>M.minutoides</u>	1	0	0	0	0	0	0	0
<u>C.flavescens</u>	0	1	0	0	0	0	0	0
<u>O.irroratus</u>	0	0	0	2	1	0	0	0
<u>M.varius</u>	1	4	4	0	11	7	4	3
<u>R.pumilio</u>	4	6	8	2	0	1	0	0
% catch/trap night	2.4	5.0	11.5	2.5	7.5	4.0	2.0	1.5
diversity	0.8679	0.9168	0.6363	0.673	0.286	0.3768	0	0

Table 4.7. <u>Otomys irroratus</u> feeding signs (number grass piles/m^2).

	summer	autumn	winter	spring	summer
Farm wetland	-	1.13	0.69	0.16	* 0
Kamberg Nature Reserve wetland	0.58	1.07	0.76	* 0	-

* burn

trap success in autumn and spring. The KNR wetland (Fig 4.2f) peaked in early winter and the rocky slope (Fig 4.2g) peaked in spring. All the sites had low numbers in summer. However, all four sites had the greatest number of individuals caught in autumn and the lowest number in spring (Fig 4.3) suggesting that the rodents were less trap prone in summer when food availability was high. Trappability, a measure of trap response which may obscure differences in density (Wingate and Meester 1977), was high in winter and spring (Fig 4.4) and low in summer and autumn.

Rhabdomys pumilio was the only species caught in sufficient numbers to identify a breeding cycle (Fig 4.5). The highest number of reproductive adults were caught in late spring and early summer and the highest number of juveniles (mass<20g; Brooks 1974) in midsummer. There appears to be only one peak in breeding activity, not two peaks as sometimes recorded (Mendelsohn 1982).

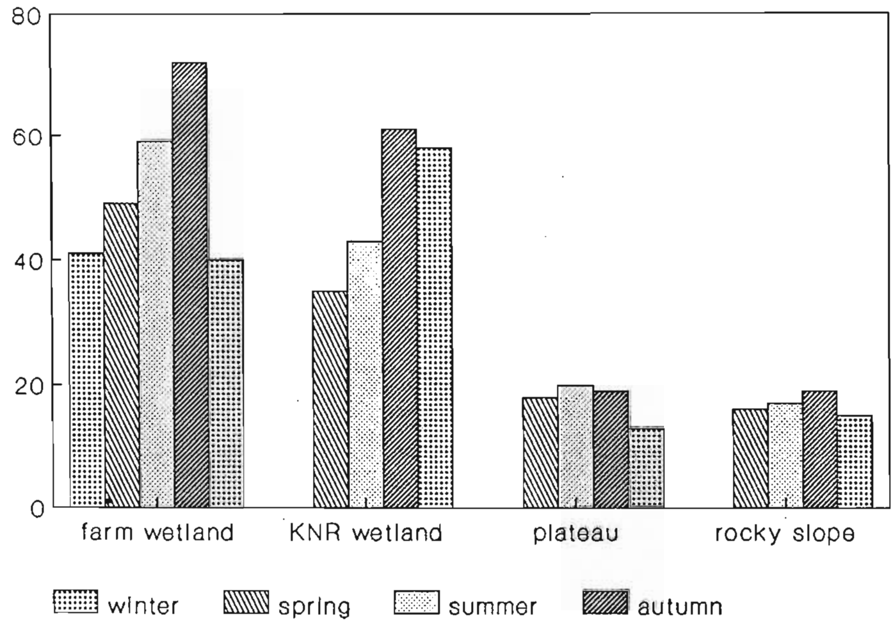

Figure 4.3. Number of individuals caught in small mammal traps each season.

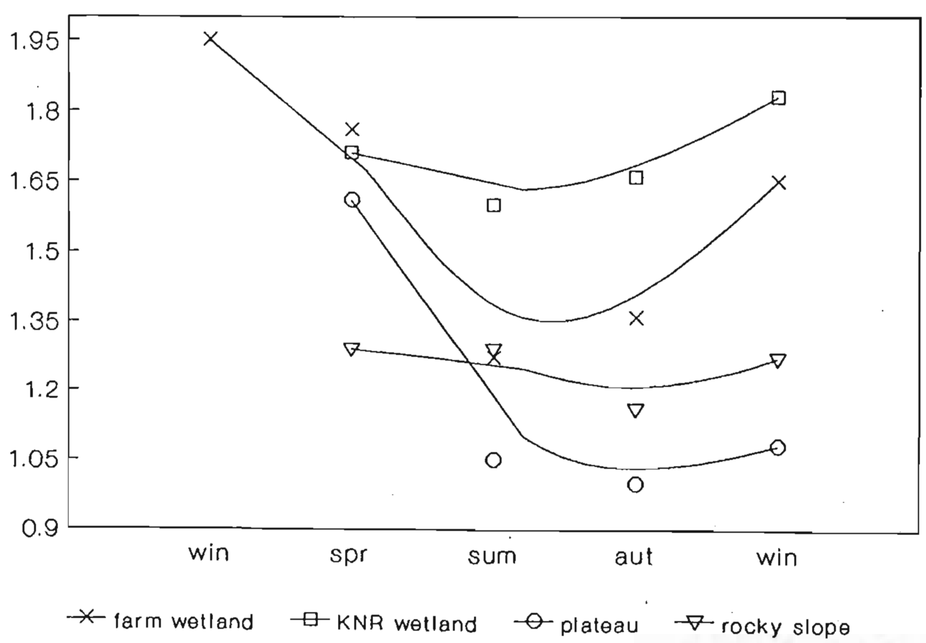

Figure 4.4. Trappability (total number of captures/number individuals).

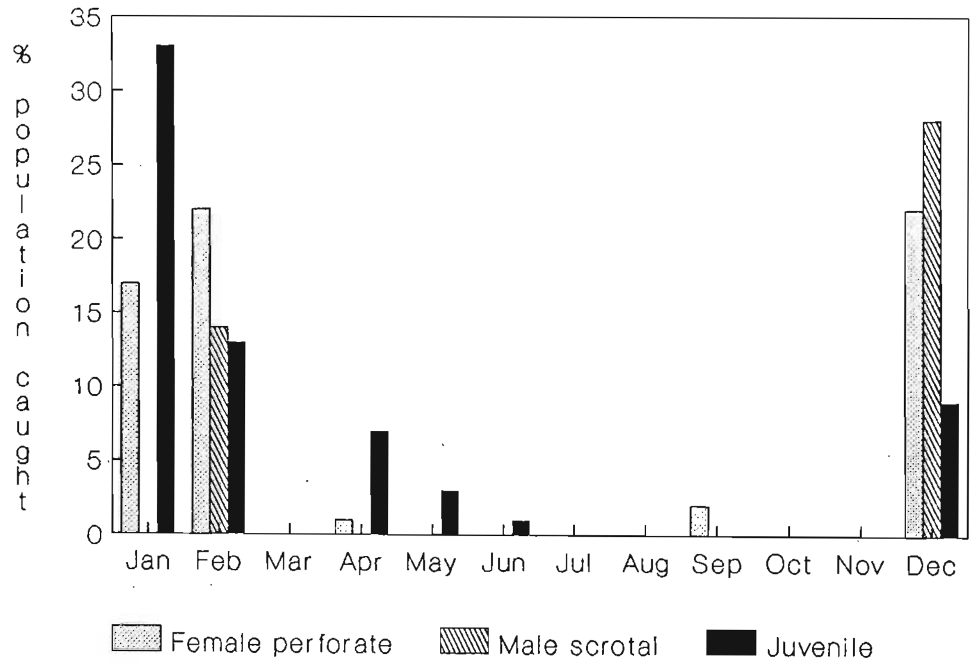

Figure 4.5. Breeding activity of Rhabdomys pumilio.

Discussion

The following species were not trapped, but were identified in serval scats: Dasymys incomtus, Cryptomus hottentotus and Amblysomus hottentotus. Dasymus incomtus is trap shy (Maddock 1988) and C.hottentotus and A.hottentotus are both subterranean, and mole traps were not set to catch them.

Trapping results in areas other than the wetlands showed fairly low small mammal population numbers. These results compare favourably with those of Rowe-Rowe and Meester (1982) from Giants Castle Game Reserve. Wetlands, however, support a fairly dense small mammal population and are the preferred habitat of O.irroratus, clearly indicating why they are at the centre of activity for servals.

Seasonal factors and species behaviour influenced small mammal trapping results. The most marked enviromental effect on the density of small mammals was burning, which reduced the population from high to low density in a short period. Although not recorded this must have a marked effect on the movement patterns of servals. The entire core area of serval "S"s home range was burnt in spring 1989. This would have forced her to shift the boundaries of her home range to obtain sufficient food. The density of small mammals was lowest in late winter and early spring.

The proportions of the three most common prey species identified by scat analysis differed markedly from the proportions in which they were caught. Otomys irroratus, the most frequently occurring dietary item, appeared to be relatively uncommon from the live trapping results, however snap trapping and feeding signs indicated an under-estimation of O.irroratus numbers.

Rhabdomys pumilio was the most common species trapped and the second most common dietary item. It was expected that they would not be eaten in direct proportion to their abundance since R.pumilio are diurnal (Brooks 1974) to crepuscular (Christian 1977; Perrin 1981) and they utilize burrows (Brooks 1974). Otomys irroratus however are active both day and night tending towards crepuscularity (Davis 1973).

Myosorex varius was the second most common species caught, but numerically the third most common in the diet although its activity pattern coincides with that of serval.

There is strong evidence that servals exhibit some dietary selection. O.irroratus is the preferred food, while shrews are often rejected in captivity. Such selection is predicted by optimal foraging models (Krebs and Davis 1987) which can be summarized as follows (Barnard 1983):

1. predators should prefer more energetically profitable prey.

2. they should feed selectively when profitable prey are abundant.

3. they should ignore unprofitable prey, regardless of how common, when profitable prey are abundant.

In the field selection probably manifests itself in the time spent chasing a prey item. The giving up time (Charnov 1976) would be shorter for _M.varius_ and _R.pumilio_ than for _O.irroratus_. In addition, servals hunt in the wetlands where they are most likely to encounter _O.irroratus_.

CHAPTER 5

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Introduction

Con

Conservation of a species necessitates conserving its habitat for utilization by that species and on preventing over-exploitation of the species. Threats to serval populations include direct killing to prevent stock predation or for use in traditional dress. The most severe threat, however, is habitat loss. Serval conservation in the Natal midlands is reliant on conservation of wetlands since they provide food and shelter. Wetlands in Natal have declined drastically in the last 50 years (Begg 1986) and are one of the most endangered habitat types in the world (Maltby 1986).

The importance of wetlands is a conservation issue which has recieved considerable attention for a number of reasons. They: function as natural water storage, discharge and purification plants; hinder soil erosion and control flood waters; have a high productivity, contributing to food supplies and support a high biotic diversity (Walmsley 1988).

There is a substantial literature regarding the importance of wetlands and emphasising the need for research and management guidelines (Begg 1986; Maltby 1988), but practically, there is relatively little known about wetland dynamics (Weller 1978; Thompson and Hamilton 1983) and sustainable utilization of wetland systems. "Wetlands appear from several points of view to be potentially highly beneficial components of South African drainage systems and yet at the same time a source of considerable practical problems. Surprisingly, however, totally insufficient information is available on them to take even simple decisions on their conservation, utilization and management or removal" (Noble and Hemens 1978). In the list of wetlands research projects in the Wetlands Research Programme report (Walmsley 1988) none concern agricultural management in the higher altitude marshes and sponges.

Some questions arising in the Wetlands Research Programme (Walmsley 1988) are:

-What are the key species which inhabit wetlands and how dependant are they on the habitat?

-What is the relationship between habitat diversity and species diversity?

-What are the enviromental requirements of wetland dependant animals?

Wetland habitat referred to in this study falls into the marsh and sponge categories of Noble's classification (1974). Over 50% of such areas in the Natal midlands have been lost in the last 37 years (Welgemoed 1990). These areas support a comparatively high small mammal population density, while other habitat types harbour low small mammal numbers. Wetland plant growth is rapid and new growth begins early in spring because of moisture availability, making them highly productive, and thus able to support the high small mammal density recorded. Small mammals are undoubtedly key components of farmland ecosystems. There are a range of small- to medium-sized predators, including raptors, in the region which are to varying extents dependant on small mammals for food.

Conservation of wetlands will not only ensure the survival of those species dependant on wetland habitats, e.g. wattled crane, but also contribute to the welfare of many other species, including serval, limited by wetland enviroments (Fritzell 1988; this study). Wetlands are an important and integral part of the food web and probably a sustaining factor of "natural" ecosystems on montane farmland.

Conserving wetlands does not preclude their agricultural utilization. Indeed, such utilization may benefit the ecosystem by sustaining maximium primary productivity, providing the water table and vegetation cover are maintained. Burning and grazing at optimum levels stimulate new grass growth, increase vegetational diversity and thereby encourage small mammal colonization.

Management recommendations

The present Natal Parks Board control of much of the optimal serval habitat in Natal ensures the immediate relative security of the serval population.

Management goals should work towards: (a) preserving montane grassland and wetlands in conservation areas; (b) maintaining serval populations on farmland and re-establishing the species where they are extinct or in danger of becoming extinct; (c) minimizing conflict between small stock farmers and servals.

conc

Serval interference with sheep stock is minimal (Appendix 3), but there are exceptions. Individuals that prey on lambs can be effectively excluded with electric fencing, and those raiding chicken hocks can easily be caught in cage traps and relocated.

It is recommended that "problem" individuals be relocated in reserves where servals have become uncommon or extinct. Reserves should encompass 100km^2 with good grass cover and contain rodent and ground dwelling bird populations sufficient to sustain viable serval populations. Possible reserves in Natal are the Hluhluwe/Umfolozi complex, Itala and Ndumu game reserves. Reserves in the southern and eastern Cape Province may also be satisfactory. At present there is no infrastructure for relocation of problem animals caught alive by farmers, consequently rare species caught unintentionally are often shot. It is suggested that NPB zone officers be provided with boxes suitable for transport of small animals (a modified "tea box", 40x50x60cm, is adequate and quickly assembled). A network should be established so that trapped animals can quickly be moved to suitable reserves when farmers are unwilling to release them.

Although, it would be beneficial to obtain a precise estimate of serval distribution and status in Natal, research regarding serval habitat preservation is more urgent. Practical wetland management policies concerning burning, grazing and cutting regimes are urgently required for long term serval conservation to be effective on farmland and in wilderness areas in the Natal midlands and Drakensberg.

APPENDIX 1

Serval mensural data

Mensural data were collected from all servals handled during the study (Table A1.1). All animals were caught on farmland in the Natal midlands between June 1988 and October 1989, except "AK" who was born in captivity in Pretoria Zoo. Serval "CP" was trapped while a kitten and kept in captivity where measurements were taken periodically.

Age classes were determined from canine length and wear, and body mass. Total length was measured from nose tip along the spine to tail tip. Height was measured at the shoulder. Mean measurements of adults and young adults are given in Table A1.2.

Table A1.2. Mean adult and young adult serval measurements (cm).

	n	mass (kg)	total length	height	tail	hind foot	ear
male	5	11.2	113.6	49.4	28.3	18.7	8.6
female	6	8.4	104.2	47.3	26.4	17.8	8.6

Table A1.1. Serval mensural data (K=kitten, 0-6months; J=juvenile, 6-12 months; YA=young adult, 1-2years; A=adult, >2years).

serval code	sex	age	mass (kg)	total length (cm)	height (cm)	tail (cm)	hind foot (cm)	ear (cm)	canine length (mm)	bite width (mm)
Q	F	YA	8.0	109	50	27	17.5	9.0	11.5	19.5
B	M	J	7.9	105	44.5	27.5	18	9	7	-
G	M	A	12.4	113	51	27	18	8.9	12	24
T	F	A	9.6	108	47	26	18	8.8	10	-
CP	F	K	5.2	95.5	37	24	16.5	8	4	11
		J	8.0	105	45	25.5	17.5	8.6	12	22
		YA	8.2	-	-	-	-	-	11.5	23.5
CM	F	A	9.2	104	51	26	18	8.8	-	23
S	F	YA	7.0	100	40	27.5	16.5	7.9	10.5	19.5
CR	M	A	9.8	101	45	26	18	8.5	14	24
CH	F	YA	7.6	100	47	25.5	17.5	8.3	9	20
CB	F	J	6.0	93	40	23	16	8.0	11	18
CK	M	A	10.7	121	51	30.5	19.5	9.0	7.5	24
CG	M	A	12.1	125	50	33	19.5	8.2	12.5	22.5
CE	M	A	10.3	108	50	25	18.5	8.2	14	23
CO	F	A	9.8	-	49	26.5	19	8.5	11	23
AK	M	A	12.0	-	-	-	-	-	17.5	24
CT	F	K	4.3	-	-	-	-	-	4.5	18
E	F	J	7.5	102	40	29	17	8.6	9.5	21

APPENDIX 2

Small mammal capture mark recapture results

Table A2.1. Estimation of small mammal population size using capture mark recapture (CMR) methods from Begon (1979).

CMR method	1988	/	1989			/
	spring	summer	autumn	winter	spring	summer
Farm wetland						
Weighted mean	41.9	*	56.9	25.4		4.6
Modified Petersen Estimate	29.4	47.5	46.0	21.7		2.0
Baileys triple catch	33.7	*	51.8	24.2		-
KNR wetland						
Weighted mean	19.4	24.2	46.9	36.5		
Modified Petersen Estimate	18.7	15.4	46.2	36.9		
Baileys triple catch	16.3	14.9	48.7	31.8		
Mountain Plateau						
Weighted mean	7.0	-	*	4.0		
Modified Petersen Estimate	6.7	1.0	2.5	1.0		
Rocky slope						
Weighted mean	6.6	3.0	3.6	7.6		
Modified Petersen Estimate	5.0	2.0	4.0	6.0		
Lower slope burnt 1988						
Weighted mean		-	-	9.1	8.0	
Modified Petersen Estimate		2.0	2.0	9.3	1.0	
Lower slope unburnt 1988						
Weighted mean			-	-	-	-
Modified Petersen Estimate			1.0	1.0	-	-
Planted pasture						
Weighted mean	10.0	15.1	-	-		
Modified Petersen Estimate	15.0	12.3	2.0	0		

* trapping not continued long enough for calculation
\- sample size too small for calculation

APPENDIX 3

Extent of serval interference with domestic stock

Introduction

Farmers taking part in a problem predator survey (Lawson 1987) suggested servals were responsible for 0.8% of stock loss. There is circumstantial evidence of servals being involved in sheep predation from the Mooiriver and the Impendle Districts. The objectives of this section were to determine if servals can kill lambs and if so how to control them.

Methods

Trials were run on three captive female servals. In the first trial servals were fed nothing on night 0 and offered a lamb weighing 6.5kg on night 1. In the second trial, on night 2, they were offered an 8.0kg lamb. In the third trial they were fed half rations on night 0 and offered two lambs weighing 7.3kg and 13.4kg on night 1. The same two lambs were offered on night 2 in the fourth trial. A lamb carcass of 5.1kg was offered after they had not eaten for 3 nights. In the last trial they were offered 3 lambs weighing 13.4kg, 7.3kg and 12.5kg after not eating for 5 nights.

Results

During the trials two lambs were killed by the servals (Table A3.1). The first kill was bitten at the anterior of the trachea and showed little haemorraging or bruising. It was opened at the sternum and the heart was eaten. The thoracic contents, ribs, lower neck, one upper forelimb and shoulder were eaten of the second kill. The lamb carcass offered was not fed upon.

Table A3.1. Results of serval lamb killing trials.

trial number	lamb mass (kg)	nights without food	carcass mass (kg)	bite width (mm)
1	6.5	1	5.2	17-20
2	8.0	0	not killed	
3	13.4	0	not killed	
3	7.3	0	not killed	
4	13.4	1	not killed	
4	7.3	1	not killed	
5	13.4	5	not killed	
5	12.5	5	not killed	
5	7.3	5	6.0	17-20

Discussion

Servals are capable of killing lambs although indications are that they would be unable to kill an adult sheep. Servals are known to be chicken thieves. The stomach contents of a serval shot in June 1989 contained chicken feathers. An individual may return to a chicken hock regularly and is therefore easy to trap using a cage trap (at least 80cm high and 60cm wide) baited with a live ckicken in a cage behind the trap.

Captive servals were prevented from entering their feeding enclosure by 3 strands of electric fencing offset from a standard stock fence with the highest strand 40cm above the ground and the lowest 10cm above the ground (Thiel unpubl. data). Only 2 electric fencing strands are required to prevent caracal from crossing a stock fence. It is highly probable that lamb stock protection measures taken against caracal would be adequate for serval since large mammals are not a favoured food. In addition captive servals had time to learn to negotiate the electric fencing and had no alternative food source.

Servals feed primarily on small mammals. There is no evidence of them taking larger prey such as young antelope or hares from scat analysis in the study area.

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