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The feeding ecology of the Cape grey mongoose, *Galerella pulverulenta* (Wagner 1839) in a coastal area

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Summary

The diet and food availability of the Cape grey mongoose, *Galerella pulverulenta* were investigated in an area of the South African West Coast. 234 scats were analysed. Small mammals (mainly *Otomys unisulcatus* and *Rhabdomys pumilio*) constituted the bulk of the diet (90·4%), while insects were a secondary food resource (4·9%). These results contrast with previous studies, which attributed greater importance to insects. Such a discrepancy might be related to differences in methodology and/or food availability. This mongoose appears to conform to the general hypothesis of a relationship between a carnivorous diet and solitary behaviour, as opposed to insectivory and group living. The productivity of the two major prey species appears to be much higher than the food requirements of this mongoose population, thus suggesting weak intraspecific competition. This may explain the apparent lack of territoriality reported for this and other species.

Key words: food, mongoose, South Africa, ecology.

Résumé

Le régime et la disponibilité en nourriture de la mangouste grise du Cap (*Galerella pulverulenta*) ont eté étudiés dans une région de la côte ouest sud-africaine. On a analysé 234 excréments. Le gros du régime (90·4%) était constitué de petits mammifères (surtout *Otomys unisulcatus* et *Rhabdomys pumilio*) tandis que les insectes étaient une source de nourriture secondaire (4·9%). Ces résultats constrastent avec des études antérieures qui accordaient une plus grande part aux insectes. Un tel écart peut devoir être mis en relation avec des différences de méthodologie et/ou de disponibilité en nourriture. Cette mangouste semble se conformer à l'hypothèse générale d'une relation régime carnivore – comportement solitaire, par opposition à régime insectivore – vie en groupe. La productivité des deux principales espèces-proies semble être bien plus élevée que les besoins alimentaires de cette population de mangoustes, ce qui laisse supposer qu'il y a peu de compétition intraspécifique. Ceci peut expliquer le manque apparent de territorialité rapporté pour cette espèce et pour d'autres.

Introduction

Food habits have been suggested (e.g. Ewer, 1973; Gorman, 1979) to be one of the most important variables, together with predation (e.g. Rasa, 1987), determining

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he spatial and social organization of mongooses (Carnivora: Herpestidae; following Wozencraft, 1982). According to this theory, higher sociality is expected in the insectivorous species, while predation on vertebrates should lead to a solitary life style. However, 'there are no thorough studies of food habits for most species of mongooses' (Rood, 1986), this being a major factor limiting the development of theories on the social evolution in this family. In addition, published studies rarely give any information about food availability. Thus it is difficult to understand the degree of opportunism of the species and consequently, to generalize from the results of particular studies.

Papers on the diet of the Cape grey mongoose *Galerella pulverulenta* (Wagner) are few (Du Toit, 1980; Stuart, 1981; Lynch, 1983; MacDonald & Nel, 1986) and based on small sample sizes (range: 16–44). No other information on the feeding ecology of this species (e.g. food availability) is available. The aims of this paper are to report on the diet and food availability of the Cape grey mongoose in a coastal area and to discuss the possible importance of these factors in explaining the spatial and social behaviour of this species.

Study area

The study was conducted in the Postberg Nature Reserve (33°05'S, 18°E; 2700 ha), a section of the West Coast National Park, Cape Province, South Africa. The climate is mediterranean; average monthly temperatures (Max; min) range from 14·6°C; 8·7°C in July to 21°C; 13·2°C in February. Annual precipitation at Langebaan village (*c.* 2 km east) averages 253 mm, almost all in winter (Weather Bureau, 1965). Aridity is mitigated by morning dew and advective fog off the cold Benguella current is common. The topography is dominated by two granite outcrops (193 m and 189 m a.s.l.). The study area is delimited by a lagoon in the east and the Atlantic Ocean in the west. The vegetation is characterized by a complex mosaic of scrubby associations, although some areas, cultivated until 1969, are covered by short grass. Boucher & Jarman (1977) give a phytosociological outline of the area. Many carnivores occur in the reserve (see Cavallini & Nel, in press), among which the Cape grey mongoose is probably the most abundant (pers. obs., and G. Tomsett, National Parks Board, pers. comm.). The area also supports many raptors (especially common are *Elanus coeruleus* Desfontaines and *Milvus migrans* Boddaert).

Materials and methods

Food abundance

During January 1989, an attempt was made to quantify the abundance of the major prey species of the Cape grey mongoose as determined in this or previous studies (see Table 1). The densities of small mammals in the area were estimated using a grid (Dice, 1941) of 60 aluminium live traps (Sherman Traps Inc., Florida, USA) spaced 15 m apart. The grid covered 1·35 ha (including a strip of 7·5 m all around) and was established within the area where scats were collected. Traps were checked three times daily and the animals captured were identified to the species level, toe-clipped for subsequent reidentification and released at the capture point. Trapping was stopped when the proportion of recaptures (of total number of captures) exceeded 90% in four successive checkings. The total number of different individuals captured was taken as a minimum estimate of the number present, assuming

Table 1. A comparison of Cape grey mongoose, *Galerella pulverulenta* diets from different studies. Figures shown are recalculated from original data as relative frequency of occurrence

	DuToit 1980	Stuart 1981	Lynch 1983	MacDonald & Nel 1986	This study
VERTEBRATA					
Mammalia	25	29·5	25·0	15·3	62·8
Carrion	—	7·7	—	—	—
Aves	—	5·1	6·3	—	3·6
Eggs (bird or reptile)	—	—	—	—	3·0
Reptilia	18	5·1	—	—	—
Amphibia	—	1·3	—	—	—
Vertebrates (unidentified)	—	—	—	4·5	—
INSECTA	46				
Isoptera		7·7	25·0	21·9	6·6
Coleoptera:			21·9	10·8	
adults		9·0			9·0
larvae		6·4			—
Orthoptera		14·1	18·8	10·8	1·1
Formicidae		—	—	4·5	—
Others & Unidentified		—	—	10·8	2·2
ARACHNIDA	—	7·7	3·1	2·1	—
MYRIAPODA & DIPLOPODA	1	1·3	—	2·1	—
MOLLUSCA	—	—	—	10·8	0·5
DECAPODA	—	—	—	—	0·8
PLANTS	10	3·8	—	2·1	2·4
Refuse	—	—	—	—	7·9
Undetermined	—	—	—	4·5	—
Sample size & type	? Scat	44 Stomach	19 Stomach	16 Scat	234 Scat
Collection season	Winter?	?	?	Feb–July	See text

negligible immigration, emigration, natality and mortality during the trapping period. Bush Karoo rats (*Otomys unisulcatus* Cuvier), while abundant in the area, are not easily trapped (Vermeulen & Nel, 1988). Thus, during January 1989, their nests were counted in 26 transects ($100 \times 4\ m^2 = 1{\cdot}04$ ha) regularly spaced over the area of scat collection. Orthoptera and Coleoptera were counted every hour (from sunrise to sunset) along two transects (200 m) during two consecutive days. This allowed the determination of the relative temporal changes in abundance of these insects. Subsequently the same insects were counted at their time of peak abundance in six strips ($150 \times 1\ m^2$). Counts were repeated for three consecutive days. All transects were surveyed on foot.

Diet analysis

Scats were collected in a small area (80 ha), sporadically from April to October 1988 and more intensively from November 1988 to February 1989. They were teased apart with tweezers under a stereo-microscope (Wild M5D) usually at 6 or 12 × magnification power. Scats not containing *Galerella* hair (easily recognizable by the banded black and white pattern) were discarded. The most frequent items in the diet were identified to the species level, where possible, whereas rare food items were identified to a higher taxonomical level. The specimens of the Ellerman Museum (Department of Zoology, University of Stellenbosch) were used as reference material. We evaluated the diet composition with the estimated bulk method described by Kruuk & Parish (1981). However, two main factors prevented us from using the same method within the category 'Mammals': (i) no data are available on the digestibility of *O. unisulcatus* and *R. pumilio* by *Galerella* (it is not possible to extrapolate digestibility values of hair and bones, neither among predators nor among prey species, see Gamberg & Aktinson, 1988; Weaver & Hoffman, 1979) (ii) Selectivity of consumption markedly alters the apparent digestibility of vertebrate prey in a largely impredictable way (e.g. Lockie, 1959; and pers. obs.: caged mongooses tend to eat last, and sometimes leave uneaten, the skin of rodents, especially the bigger ones). As a result, the same prey item may be present in more than one scat, while some individuals of the same species may leave very little remains in the scat. These factors made it impossible for us to relate the quantity of hair and bones recovered in the scats to actual prey consumption. We therefore decided to use only the relative frequency of occurrence to roughly estimate the proportion of various species within the category 'Mammals'.

Results

Food abundance

Most of the mammals trapped were striped mice, *Rhabdomys pumilio* Sparrmann (96·2%), of which 126 different individuals were captured (i.e. a minimum of 93·3 mice/ha). The trapping session lasted 7 days, with 92·9% of different individuals captured within the first 5 days. In this short period, our assumptions of negligible immigration, emigration, natality and mortality appear reasonable. In the *O. unisulcatus* transects 64 nests were counted—a density of 61·5 nests/ha. The relative abundance of orthopterans and coleopterans peaked at midday. During the strip counts an average of 196·3 orthopterans/ha were seen (range: 1–6 individuals/150 m^2) but only two coleopterans were counted in the 2700 m^2 searched. Most of the orthopterans seen were <4 cm.

Diet analysis

Altogether 234 Cape grey mongoose scats were analysed. Due to uneven sampling effort, most (84·6%) were collected during summer (November to February); fewer were collected during late autumn (April to June; 9·0%) and late spring (October; 6·4%). Overall, small mammals constituted the bulk of the diet (90·4%; Table 2). Of these, the most important appeared to be *O. unisulcatus*, both because of its high relative frequency of occurrence in the scats (57·1% of all mammals; Table 3) and because of its larger mass (124 g; Smithers 1983). *R. pumilio* appeared less frequently (29·5%) and is also lighter (45 g; Smithers 1983). Other species appeared only sporadically (Table 3). Insects, especially coleopterans, were the only other food items of some importance, although not a main resource (Table 2). Over 80% of 'refuses' eaten came from the bait of traps from an adjacent study. The rest came

Table 2. Diet composition of the Cape grey mongoose *Galerella pulverulenta* in the West Coast National Park, South Africa. Figures represent the estimated percentage of volume (following Kruuk & Parish, 1981)

	Autumn	Spring	Summer	Total
VERTEBRATA				
Mammalia	87·1	89·7	90·7	90·4
Aves	0	0·2	1·3	1·1
Eggs	5·4	0·2	0·2	0·7
INSECTA (total)	(2·1)	(9·6)	(4·7)	(4·9)
Isoptera	2·0	0·2	1·0	1·0
Coleoptera	0	9·4	3·4	3·5
Orthoptera	0	0	0·2	0·2
Others	0·1	0	0·1	0·1
MOLLUSCA	0	0	0·1	0·1
DECAPODA	0	0	0·2	0·1
PLANTAE	0·9	0·2	0·4	0·4
Refuse	4·6	0·2	2·4	2·4
n	21	15	198	234

Table 3. Mammals in Cape grey mongoose *Galerella pulverulenta* scats. Both the number of occurrences (*n*) and the relative frequency of occurrence over the total mammal occurrences (%) are given

	%	*n*
Otomys unisulcatus	57·1	157
Rhabdomys pumilio	29·5	81
Gerbillinae	4·0	11
Insectivora	1·8	5
Hystrix africaeaustralis	2·2	6*
Unidentified	5·5	15

*All from a group of scats found near the remains of a young porcupine.

from house garbage. Thus, the importance of the 'refuses' as shown in Table 2 is overestimated with respect to an undisturbed situation. Birds (mostly passerines) were eaten both rarely, occurring in 5·6% of the scats, and in small quantities (average volume when present: 19·2% of the total volume of the scat). The consumption of eggs, mostly of reptiles, were probably underestimated, due to their high digestibility. To partially compensate for this we assumed that a whole egg was consumed even when only a small fragment was found in the scat. Plant material was composed of seeds and grass and always occurred in small quantities (average volume when present: 9·7%), possibly resulting either from the stomach content of rodents or from accidental ingestion. Some seasonal fluctuation in the composition of the diet occurred, especially as regard the use of eggs, isopterans, coleopterans and refuse (Table 2). On the basis of our uneven sample, however, major seasonal trends could not be revealed.

Discussion

The genus *Herpestes*, in which *Galerella* is often included (e.g. Ewer, 1973), is adapted, both morphologically (dental pattern) and behaviourally (hunting method) to the capture of small mammals, often their main prey (see Rood, 1986 for a review). The present study, in which rodents constituted by far the most important food item, supported this view. The Cape grey mongoose is basically, although not completely, solitary (e.g. Ewer, 1973; Cavallini & Nel, in press). This social strategy appears more adaptive than group-living for a predator of relatively shy and fast-moving species (Gorman, 1979). Our results are therefore consistent with the hypothesis that relates carnivorous diet with solitary behaviour and insectivory with group-living. In contrast, most previously published data on the diet of this species stress the importance of insects (Table 1). From these data, mammals appear to be a secondary food resource, averaging 23·7% of the relative frequency of occurrences over four studies (Table 1).

Possible reasons for this discrepancy are:

(a) Seasonal diet variation. While our sample reflects mainly a summer diet, at least some of the other studies were conducted in winter. Our limited winter sample, however, tends to exclude this possibility.

(b) Local differences in food availability; in fact, orthoptera density was estimated at 1860 and 3760 individuals/ha in two areas *c.* 80 km from our study site (Schlettwein & Giliomee, 1987), while we counted 193 individuals/ha. Our method obviously underestimated insect abundance by overlooking some individuals. However, that factor alone is unlikely to have produced such a great difference. On the other hand, rodent density appears to be high in comparison with other areas of the Cape Province (I.L. Rautenbach, Transvaal Mus., pers. comm.), but unfortunately no data are available. It might then be possible that our collection area had a higher rodent density and a lower insect density than others, leading to the observed differences in mongoose diet.

(c) Neither Du Toit (1980) nor MacDonald & Nel (1986) indicated the criterion used to identify scats. It cannot therefore be excluded with absolute certainty that yellow mongoose (*Cynictis penicillata* Cuvier; a more insectivorous species, cf. Earle, 1981) scats were included in the analysis. This error in such small samples (Table 1) could have contributed to bias their results.

Food availability is also an important factor underlying the spatial system of animals (Davies, 1978). In particular, Carpenter and MacMillen (1976) showed that territorial defence confers feeding advantages only when food is neither extremely scarce nor much more abundant than the requirements. The productivity (P) of rodents (in g/ha/year) can be estimated as follows:

$$P = D\,F\,W,$$

where: D = female density (= density/2, assuming equal sex ratio); F = fertility (= litter size × number of litters per year); W = mean weight (average male + female).

In the case of *Rhabdomys pumilio*, if $D = 46{\cdot}7$ (this study), $F = 15$ (Perrin, 1980), $W = 45$ g (Smithers, 1983), then $P = 31{,}489$ g/ha/yr. In the case of *Otomys unisulcatus*, no information on the reproduction is available; if we assume that: (*i*) fertility is the same as the similar *O. irroratus* Brants, and (*ii*) each nest we counted was occupied by one *Otomys* (a minimum estimate: see Vermeulen & Nel, 1988), then $D = 30{\cdot}75$ (this study), $F = 10$ (Perrin, 1980), $W = 124$ g (Smithers, 1983), and consequently $P = 38{,}130$ g/ha/yr.

On the other hand, mongoose food requirements (g/individual/year) can be estimated as follows:

$$F = C\,M\,365,$$

where: C = daily food consumption rate (g food/g body mass); M = body mass (average male + female); 365 = number of days in a year. If we assume that the consumption rate of *Galerella pulverulenta* is the same as that of the closely related slender mongoose, *G. sanguinea* Ruppel, then $C = 0{\cdot}16275$ (average male + female, winter + summer; from Baker (1980)), $M = 779{\cdot}5$ g (average of the weights published by Stuart (1980) and Lynch (1983); $n = 121$), and consequently $F = 46{,}305$ g/individual/year. *Galerella* density in the area is probably less than 0·1 individuals/ha (Cavallini & Nel, in press). Thus, the food productivity for the two most important prey species alone would be about 15 times that required to maintain the actual Cape grey mongoose population.

Because of the many explicit and implicit assumptions, these are only very approximate estimates; however, they tend to suggest that some other factor than direct intraspecific competition for food, such as interspecific competition, parasites, predation, may be limiting this mongoose population. In this ecological contest, there seems to be little need for territoriality, as the cost of resource sharing is likely to be low. A spatial system characterized by overlapping ranges, such as that found by Cavallini & Nel (in press), is to be expected. We suggest that the same reason could underlie analogous spacing patterns, such as those found by Rood & Waser (1978) for the slender mongoose and by Gorman (1979) for the small Indian mongoose *Herpestes auropunctatus* Hodgson.

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References

BAKER, C.M. (1980) *Biology and Behaviour of the Slender Mongoose*, Herpestes sanguineus (Ruppel, 1934). M.Sc. thesis, University of Natal, Pietermaritzburg.

BOUCHER, C. & JARMAN, M.L. (1977) The vegetation of the Langebaan area, South Africa. *Trans. R. Soc. S. Afr.* **42,** 241–272.

CARPENTER, F.L. & MACMILLEN, R.E. (1976) Threshold model of feeding territoriality and test with a Hawaiian Honeycreeper. *Science* **194,** 639–642.

CAVALLINI, P. & NEL, J.A.J. (1990) Ranging behaviour of the Cape grey mongoose *Galerella pulverulenta* (Wagner, 1839) in a coastal area. *J. Zool., Lond.* in press.

DAVIES, N.B. (1978) Ecological questions about territorial behaviour. In: *Behavioural Ecology—An Evolutionary Approach* (Eds J.R. Krebs and N.B. Davies). Blackwell Scientific Publications, Oxford.

DICE, L.R. (1941) Methods for estimating population of animals. *J. Wildl. Mgmt* **5,** 398–407.

Du Toit, C.F. (1980) The yellow mongoose *Cynictis penicillata* and other small carnivores in the Mountain Zebra National Park. *Koedoe* **23,** 179–184.

Earle, R.A. (1981) Aspects of the social and feeding behaviour of the yellow mongoose *Cynictis penicillata* (G. Cuvier). *Mammalia* **45,** 143–152.

Ewer, R.F. (1973) *The Carnivores*. Cornell University Press, Ithaca.

Gamberg, M. & Aktinson, J.L. (1988) Prey hair and bone recovery in ermine scats. *J. Wildl. Mgmt* **52,** 657–660.

Gorman, M.L. (1979) Dispersion and foraging of the small Indian mongoose, *Herpestes auropunctatus* (Carnivora: Viverridae) relative to the evolution of social viverrids. *J. Zool., Lond.* **187,** 65–73.

Kruuk, H. & Parish, T. (1981) Feeding specialization of the European badger *Meles meles* in Scotland. *J. Anim. Ecol.* **50,** 773–788.

Lockie, J.D. (1959) The estimation of food of foxes. *J. Wildl. Mgmt* **23,** 224–227.

Lynch, C.D. (1983) The mammals of the Orange Free State. *Mem. Nas. Mus. Bloemfontein* **18,** 1–218.

MacDonald, J.T. & Nel, J.A.J. (1986) Comparative diets of sympatric small carnivores. *S. Afr. J. Wildl. Res.* **16,** 115–121.

Perrin, M.R. (1980) The breeding strategies of two co-existing rodents, *Rhabdomys pumilio* (Sparrman, 1784) and *Otomys irroratus* (Brants, 1827). *Acta Oecol.* **1,** 387–414.

Rasa, O.A.E. (1987) The dwarf mongoose: a study of behavior and social structure in relation to ecology in a small, social carnivore. *Adv. Study Behav.* **17,** 121–163.

Rood, J.P. (1986) Ecology and social evolution in the mongooses. In: *Ecological Aspects of Social Evolution: Birds and Mammals*. (Eds D.I. Rubenstein and D.G. Wrangham). Princeton University Press, Princeton.

Rood, J.P. & Waser, P.M. (1978) The slender mongoose, *Herpestes sanguineus*, in the Serengeti. *Carnivore* **1,** 54–58.

Schlettwein, C.H.G. & Giliomee, J.H. (1987) Comparison of insect biomass and community structure between fynbos sites of different ages after fire with particular reference to ants, leafhoppers and grasshoppers. *Ann. Univ. Stellenbosch* **2(2),** 1–76.

Smithers, R.H.N. (1983) *The Mammals of the Southern African Subregion*. University of Pretoria, Pretoria.

Stuart, C.T. (1981) Notes on the mammalian carnivores of the Cape Province, South Africa. *Bontebok* **1,** 1–58.

Vermeulen, H.C. & Nel, J.A.J. (1988) The bush Karoo rat *Otomys unisulcatus* on the Cape West Coast. *S. Afr. J. Zool.* **23,** 103–111.

Weather Bureau (1965) *Climate of South Africa*. Government Printer, Pretoria.

Weaver, J.L. & Hoffman, S.W. (1979) Differential detectability of rodents in coyote scats. *J. Wildl. Mgmt* **43,** 783–786.

Wozencraft, W.C. (1982) Family Herpestidae. In: *Mammal Species of the World* (Eds J.H. Honacki, K.E. Kinman and J.W. Koeppl). Allen Press, Lawrence.

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