

## Diet of the South African large-spotted genet *Genetta tigrina* (Carnivora, Viverridae) in a coastal dune forest

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We studied seasonal variations in the diet of the large-spotted genet *Genetta tigrina* Schreber, 1776 in the coastal dune forest of the Dwesa Nature Reserve, Eastern Cape Province, South Africa. The food items with the highest relative percentage occurrence were Coleoptera, Orthoptera and Mammalia. However, by volume they ate mostly grass then followed by Coleoptera and Orthoptera. Main prey items originated from the litter layer or low lying bushes, such as arachnids, insects, myriapods, and most mammals. The latter included ten rodent (main staple: *Dendromus* sp.), two golden mole and two shrew species, from 10–100 g mass. They were represented dependent on species density, but switching between seasons and habitats occupied. Birds appeared under-represented in the diet for a semi-arboreal carnivore, although this correlates with data from other studies. Remains of birds in the diet, however, peaked during winter and spring probably as a result of the main nesting period in spring. There were some variation in diet between habitats (riparian, forest and beach) and seasons. Our results show the South African large-spotted genet to have an opportunistic, generalist diet.

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### Introduction

Despite a high diversity of small carnivores in Africa, little is known about their ecology and their role as primary and secondary consumers. It is important to understand the ecological role of carnivores, and not only that of the better-studied larger species, in ecosystems to enable

effective conservation and management strategies (Gittleman *et al.* 2001). Especially for species requiring forested habitat this necessity becomes even more important, given the major and ongoing reduction of forest cover in Africa and elsewhere (Buskirk and Zielinski 2003). Such small carnivores include the genets, woodland and forest dwelling members of the family Viverridae (Wozencraft 2005).

The genets are adapted to a semi-arboreal lifestyle, with bifocal vision and an ability to climb (Taylor 1976, Kingdon 1977). Extant members are widespread in Africa, with one species – the small-spotted genet *Genetta genetta* – extending into southern Europe and the Arabian Peninsula (Schlawe 1980, 1981). Species diversification within the genus *Genetta* has led to a number of species exploiting the whole spectrum of habitats containing at least some trees in Africa (Kingdon 1977, Gaubert *et al.* 2004). Some are true forest species, one – *G. genetta* – is adapted to more arid habitats, while others inhabit wide swathes of savanna. As a group, genets have a catholic diet, but diets of specific species in different habitats are poorly documented. Like some other carnivores (Kok and Nel 2004), at least some genets like *G. genetta*, can “utilize” buffering by different food sources at different times of the year when principal prey becomes scarce (Virgós *et al.* 1999). The restricted distribution of this species in Eurasia has been ascribed to poor adaptation to harsh winters, as both fruit and rodents (their main prey) are common in this region (Virgós *et al.* 2001). Genets are mostly solitary, and usually nocturnal or crepuscular (Skinner and Chimimba 2005) but can be active on rainy days (Kingdon 1977).

Recent morphometric and genetic analyses indicate that *Genetta tigrina sensu stricto* Schreber, 1776 occurs only in or close to coastal forests stretching from the southern Western Cape Province to southern KwaZulu-Natal Province in the Republic of South Africa (Bronner *et al.* 2003, Gaubert *et al.* 2005a, b). Previous distributions (Lack 1977, Wemmer 1977, Skinner and Chimimba 2005) therefore refer to other *Genetta* species, with *G. maculata* replacing *G. tigrina* to the north of *G. tigrina s.s.* distribution (Bronner *et al.* 2003). Most previous studies on the diet of genets concern *G. genetta* in western Europe (diet review in Virgós *et al.* 2001, and references therein) or in southern Africa (Skinner and Chimimba 2005). The diet reported in Skinner and Chimimba (2005) for *G. tigrina* therefore refers to that of *G. maculata*, as previous studies concerned genets outside the distribution range of *G. tigrina s.s.*

Any dietary analysis isolates a particular time frame in a dynamic process and diet is usually found to vary both temporally and spatially. To understand the feeding habits of a single species it is therefore necessary to know what it eats in a variety of habitats covering its entire range, as well as during different seasons of the year to cover its annual cycle (Ewer 1973).

This study provides the first comprehensive report on the diet of *G. tigrina* as determined from scat analysis. The only previous studies on undoubted *G. tigrina* diet (Stuart 1981, Purves 1995) relied on a small samples of stomachs or scats, perhaps too few from a single locality to allow a reliable assessment (Trites and Joy 2005). We studied dietary composition in different seasons and in different habitats at one locality to test if there was variation in dietary composition between seasons and amongst habitats.

## Study area

Scats were collected in the Dwesa Nature Reserve (DNR) (32°12'S, 28°58'E), situated on the Eastern Cape Province Coast, Republic of South Africa. DNR comprises ca. 3900 ha of coastal and dune forest habitat, and adjoins the smaller but similar Cwebe Nature Reserve to the north. DNR experiences dry winters (May–August) of 21.5°C average, and slightly warmer (24°C) and wetter summers (December–February), the latter period contributing the majority of the 1069 mm falling in DNR annually (Timmermans and Naicker 2002).

DNR comprises two lengths of narrow sandy beach separated by a grass and scrub topped scarp face headland rising to 97 m a.s.l., and the adjoining inland forest belt. The strip along the foredunes and high tide line consists mainly of stands of red milkwood *Mimusops caffra* woodland, with shrubs *Scaevola thunbergii* predominant on the unstable dunes and the woodland seaboard edges (Farrell and Van Riet 1975). The majority of the mature forest occurs from 100 to 800 m from the beach up to the perimeter fence where forest largely makes way for communal agricultural lands and scrub. Cooper and Swart (1992) described dune forest and South Coast forest within this region and distinguished this forest type from that of the Pondoland Forests to the north, although more recently reclassification of South African forests collated these types into coastal forest (Bailey *et al.* 1999). Assemblages of indigenous yellowwood *Podocarpus latifolius*, Natal mahogany *Trichilia dregeana* and *Acacia* spp. situated on the old stabilised dunes (up to 124 m a.s.l.) constitute the main components to the forest, with pockets of *Aloe* spp., *Rhoicissus tomentosa*, *Phoenix reclinata*, *Euphorbia* spp. and stands of *Heywoodia lucans*.

The majority of DNR's grasslands occur between the continuous forest and the beach *Mimusops* woodland and are characterised by tall grasses such as *Stenotaphrum secundatum*, *Apochaete hispida*, *Aristida junciformis*, *Themeda triandra* and *Cymbopogon* spp. (Farrell and Van Riet 1975).

## Material and methods

Latrine sites of *G. tigrina*, the only genet species present in DNR, were identified by an accumulation of faeces in prominent locations with identity of depositor species confirmed by odour, morphology, and dimensions of the faecal material, with further support by the nearby presence of spoor, if available. Identification of genet scats followed Taylor (1989), Stuart and Stuart (1998), Stuart and Stuart (2000) and Chame (2003).

Scats were collected from October 2003 to May 2004 and individually bagged and tagged. Sampling frequency was dependent on distance to and accessibility of latrine sites. Seven latrine sites were visited daily, 28 weekly and 24 monthly. Eighteen latrines were sampled only once while another 16 sites had no fresh deposits when checked. Fresh scats (372 scats from 51 latrines) collected were subdivided for the overall analysis into seasonal (winter/spring: June–November,  $n = 55$ , summer: December–February,  $n = 154$  and autumn: March–May,  $n = 163$ ) and habitat (beach:  $n = 178$ , forest:  $n = 142$ , riparian:  $n = 52$ ) samples. Ten latrines were located along the beach, within or adjacent to the approximately 100 m wide band of *Mimusops*-dominated dune forest. Eight latrines were located in the riparian habitat within the forest but within ca. 10 m of streams or rivers. We found 47 latrines within the rest of the forest, mostly on or adjacent to the roads and paths and further than 10 m from a waterway.

Each scat was washed in running water through a 0.5 mm brass sieve to separate remains, which were drained and air-dried. These were then placed on a ceramic tile (150 × 150 mm) divided into 25 squares, and relative volume of each prey type assessed using a dissecting microscope (8 – 64× magnification). Scale patterns were examined under a compound microscope (400× magnification) and hair identified using Keogh (1983, 1985) and specimens from the Zoology Department Museum, Walter Sisulu University, South Africa. Fragments of mammalian dentition sometimes further confirmed identification (Skinner and Chimimba 2005). The remains of arthropods were identified using descriptions in Barnes (1980), Lawrence (1983) and Scholtz and Holm (1985).

The presence of each prey category in each scat was recorded, and the frequency of occurrence (FO) of each prey category calculated. Totals of each category were also expressed as a percentage of the total number of scores of all categories, yielding relative frequency of occurrence (RFO). Although this method has been shown to closely approximate the proportions of different items actually consumed by some species (eg European otters *Lutra lutra* (Erlinge 1968) and African clawless otters *Aonyx capensis* (Rowe-Rowe 1977)), Carss and Parkinson (1996) argued that for *L. lutra* it should only be used to rank importance

of prey. As a measure of their energetic contribution to the diet the mean volume of prey items were also presented (Reynolds and Aebischer 1991).

A general linear model (GLM) main effects ANOVA was done to test whether there were significant differences between the RFO of prey categories of birds, insects, mammals, fruits/seeds, other vegetation, other invertebrates and 'other' (including reptiles, fish, scavenged and non-food items like dung and sand) between seasons and between habitats.

## Results

Overall, the diet included a wide spectrum of invertebrate taxa, Coleoptera contributing the largest component, followed by Orthoptera. However, by volume they ate mostly grass followed by Coleoptera and Orthoptera (Table 1). Oligochaetes consisted of only two virtually intact specimens present in two scats from riparian latrines in August 2003. The majority of vertebrate remains were from a diverse spectrum of mammals of which *Dendromus* sp., *Otomys* sp., *Mastomys* sp. and *Graphiurus* sp. were the most prominent. There was little sign of birds, with those found coming from African wagtail *Motacilla aguimp* and the forest weaver *Ploceus bicolor*. Vegetable matter probably utilized as food included seeds and fruits from a variety of plant species, as well as flower stamens. Leaf matter (9.89% RFO), may have been incidentally ingested during prey capture, as was dung and inorganic matter.

Overall there was some seasonal and habitat variation in diet (Figs 1 and 2). However, the RFO of the various categories did not differ significantly between seasons ( $F = 2.654$ ,  $df = 8$ ,  $p = 0.302$ ) or habitats ( $F = 6.201$ ,  $df = 8$ ,  $p = 0.146$ ). The between-subjects test found "other invertebrates" to differ significantly between seasons ( $F = 21.808$ ,  $df = 2$ ,  $p = 0.007$ ) with the Fisher LSD test showing that winter/spring differed significantly from both summer ( $p = 0.003$ ) and autumn ( $p = 0.008$ ) by containing more of this category. The category "other" also showed significant seasonal variation ( $F = 15.488$ ,  $df = 2$ ,  $p = 0.032$ ) with winter/spring differing significantly from both summer ( $p = 0.028$ ) and autumn ( $p = 0.017$ ) by again showing more of this category.

Table 1. Results from the analysis of 372 scats of *Genetta tigrina* from Dwesa Nature Reserve, Eastern Cape Province, South Africa. FO – frequency of occurrence, RFO – relative frequency of occurrence.

Items		Observed	FO	RFO	Mean volume	
Invertebrates						
Nematodes	Ascarida	2	0.54	0.08	0.00	
Molluscs	Prosobranchia	3	0.81	0.12	0.01	
	Pulmonata	4	1.08	0.16	0.01	
Annelids	Oligochaeta	1	0.27	0.04	0.01	
Arachnids	Acarina	10	2.69	0.39	0.03	
	Aranae	51	13.71	1.99	0.30	
	Scorpiones	51	13.71	1.99	0.66	
Crustaceans	Cirripedia	2	0.54	0.08	0.00	
	Decopoda	92	24.73	3.60	1.13	
	Isopoda	1	0.27	0.04	0.00	
Myriapods	Juliformia	33	8.87	1.29	0.40	
	Oniscomorpha	54	14.52	2.11	0.80	
	Chilopoda	79	21.24	3.09	1.42	
Odonata	Undetermined	3	0.81	0.12	0.01	
Orthoptera	Undetermined	329	88.44	12.87	10.88	
Dictyoptera	Undetermined	2	0.54	0.08	0.00	
Hemiptera	Scutelleridae	1	0.27	0.04	0.00	
Coleoptera	Caraboidea	244	65.59	9.54	7.38	
	Hydrophilidae	5	1.34	0.20	0.03	
	Staphyliniidea	6	1.61	0.23	0.04	
	Scarabaeidea	95	25.54	3.72	2.06	
	Lucanidae	1	0.27	0.04	0.00	
	Cryptophagidae	30	8.06	1.17	0.52	
	Chrysomeliodea	35	9.41	1.37	1.03	
	Apoidea	3	0.81	0.12	0.01	
	Larvae	5	1.34	0.20	0.02	
	Lepidoptera	Undetermined	2	0.54	0.08	0.00
	Diptera	Undetermined	18	4.84	0.70	0.05
	Hymenoptera	Formicidae	73	19.62	2.85	0.26
		Undetermined	5	1.34	0.20	0.05
Vertebrates						
Fish	Salmonoid	7	1.88	0.27	0.06	
Reptiles	Chelonia	1	0.27	0.04	0.01	
Reptiles	Undetermined	22	5.91	0.86	0.78	
Birds		29	7.80	1.13	2.38	
Mammals						
Insectivora	<i>Chrysophalax</i> sp.	9	2.42	0.35	1.20	
	<i>Amblysomus</i> spp.	7	1.88	0.27	0.77	
	<i>Mysorex</i> sp.	32	8.60	1.25	1.51	
	<i>Crocidura</i> sp.	14	3.76	0.55	0.81	
	<i>Graphiurus</i> sp.	23	6.18	0.90	1.43	
Rodentia	<i>Dendromus</i> sp.	38	10.22	1.49	1.66	
	<i>Aethomys</i> sp.	22	5.91	0.86	1.06	
	<i>Dasymys incomptus</i>	16	4.30	0.63	0.60	
	<i>Rhabdomys pumilio</i>	11	2.96	0.43	0.33	
	<i>Mastomys coucha</i>	33	8.87	1.29	1.97	
	<i>Mus minutoides</i>	5	1.34	0.20	0.28	
	<i>Mus musculus</i>	7	1.88	0.27	0.18	
	<i>Rattus</i> sp.	5	1.34	0.20	0.22	
	<i>Otomys</i> sp.	36	9.68	1.41	1.64	
	Carnivora	<i>Genetta tigrina</i> (Groomed hair)	90	24.19	3.52	1.56
	Mammal	Unidentified	45	12.10	1.76	2.76

Table 1 – concluded.

Items	Observed	FO	RFO	Mean volume
Plants				
Seeds/Fruit				
<i>Phoenix reclinata</i>	12	3.23	0.47	0.41
<i>Acacia karroo</i>	1	0.27	0.04	0.01
<i>Ziziphus mucronata</i>	50	13.44	1.96	1.88
<i>Rhoicissus tomentosa</i>	7	1.88	0.27	0.13
<i>Sideroxylon inerme</i>	19	5.11	0.74	0.91
<i>Mimusops caffra</i>	27	7.26	1.06	1.42
<i>Diospyros dichrophylla</i>	1	0.27	0.04	0.01
Unidentified Seeds/Fruit	55	14.78	2.15	2.15
Other Plant Matter				
Flower Stamen	2	0.54	0.08	0.00
Grass	256	68.82	10.01	12.31
Leaf Litter	253	68.01	9.89	7.25
Wood	56	15.05	2.19	0.54
Algae	1	0.27	0.04	0.05
Dung	28	7.53	1.10	1.88

Habitat significantly affected the categories “other invertebrates” ( $F = 8.065$ ,  $df = 2$ ,  $p = 0.039$ ), “fruits/seeds” ( $F = 12.021$ ,  $df = 2$ ,  $p = 0.020$ ) and “other” ( $F = 15.996$ ,  $df = 2$ ,  $p = 0.012$ ). Scats found on the beach had significantly less “other invertebrates” than forest scats ( $p = 0.016$ ) while containing more “fruits/seeds” than

both forest ( $p = 0.015$ ) and riparian ( $p = 0.012$ ) scats. In the category “other” beach differed significantly from both forest ( $p = 0.009$ ) and riparian ( $p = 0.007$ ) by contain more of this category.

Some species of small mammal were more common during summer and autumn periods (eg Soricidae species in autumn, and *Mastomys* sp.

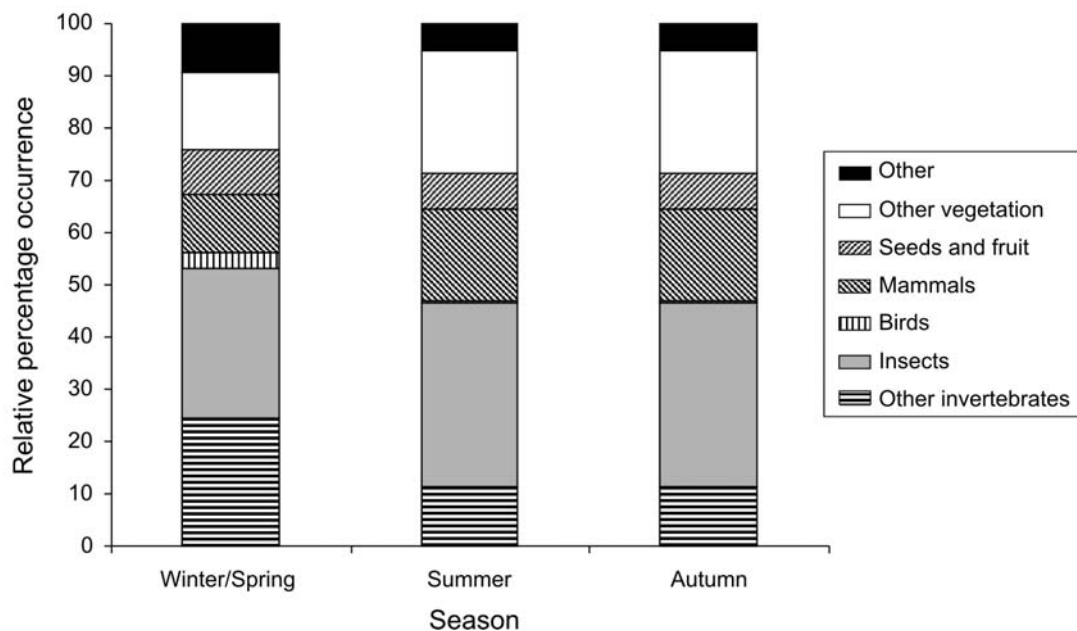


Fig 1. Seasonal diet of *Genetta tigrina*, presented as relative percentage occurrence, from Dwesa Nature Reserve, Eastern Cape Province, South Africa

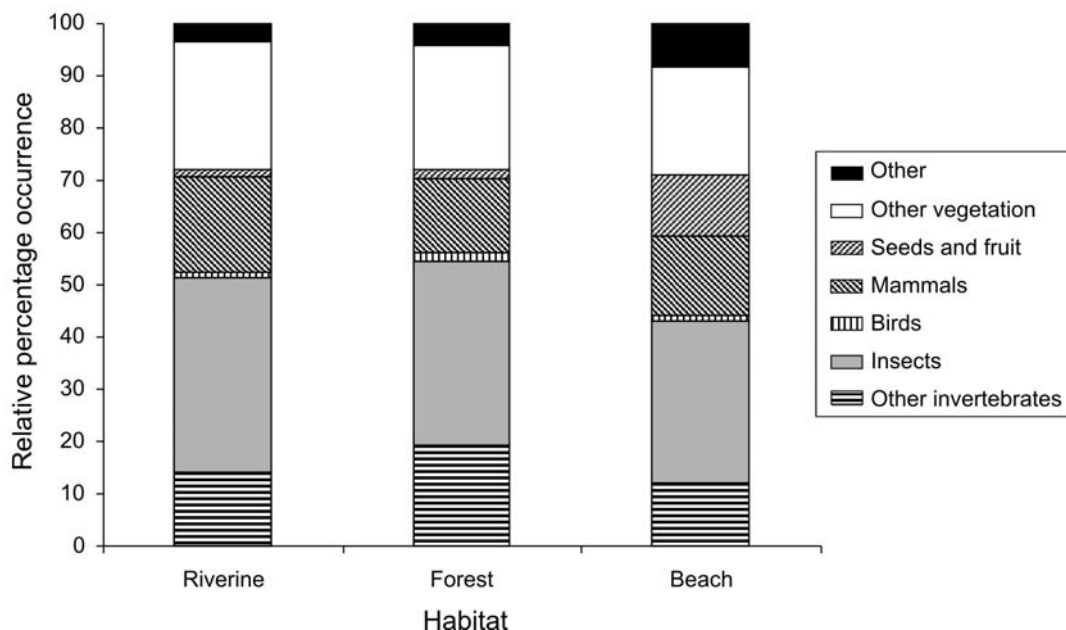


Fig 2. Diet of *Genetta tigrina*, presented as relative percentage occurrence, from various habitats in Dwesa Nature Reserve, Eastern Cape Province, South Africa

in summer). Decapods occurred within scats collected from all habitats but the highest RFO was seen in forest samples. Freshwater species were more numerous than marine species in beach scats and were the only type in the forest and riparian habitats. Estuarine crabs were completely absent in all scats sampled. Fruit remains in scats were noticeably seasonal but not significantly so, with *Ziziphus mucronata* consumed most in winter/spring, to be replaced largely by *Mimusops caffra* in summer and by a combination of these two in autumn, while other species were eaten less frequently but again were represented according to their individual accessibility.

Orthoptera (including grasshoppers) were well represented across all habitats. Myriapoda were most often seen in forest scats, and there were differences in the incidence of particular classes of Coleoptera. *Otomys sp.* was found less in forest whereas the contrary was true for *Rhabdomys pumilio*.

High values for fruit remains were found in beach scats, due at least partly to the presence of species such as *Mimusops caffra*, *Sideroxylon inerme* and *Diospyros dichrophylla* in the dune

forest and by the campsite respectively. Only three *Mimusops caffra* seeds of over 100 from all species found appeared chewed. The remainder showed little or no damage from passage through the alimentary tract.

## Discussion

Scat analysis, based solely on frequency or relative frequency of occurrence expressed as percentages, does not reveal the importance of various prey with regard to biomass or energy consumed. Diet analysis (eg used for *L. lutra*) using this method has come under severe criticism, with Carss and Parkinson (1996) showing that such data should only be used to rank the importance of various prey categories rather than be used as an indication of relative quantities in the diet. The present data indicate a diverse diet for *G. tigrina*, with some seasonal and habitat differences evident.

As with many other carnivores grass appeared in scats, perhaps to aid digestion, to dislodge hair in the intestines, to induce vomiting

for the purging of toxins ingested, for relief of throat inflammation and stomach irritation or to source folic acid from sap (Morris 1996). Only Stuart and Stuart (2003) for *G. maculata* and Engel (1998) for *G. rubiginosa* have reported grass to be part of the diet of genets with 39.8% and 13.7% respectively. The remaining studies may not have reported grass as the authors may not have considered it to be part of the diet.

As in a previous study in riparian and fynbos-type habitat in the Western Cape Province (Purves 1995), the most common prey taxa of *G. tigrina* were insects and mammals. In DNR small ground-dwelling animals are more common in the scats than larger or arboreal animals. Four rodent species only were recorded by Purves (1995) which probably reflect lower small mammal diversity in the fynbos. The rank of other key categories also differed widely: while arachnids were common in genet scats from DNR, these were scarce in fynbos, and myriapods were absent. The difference in diet between these two studies probably reflects the differences in the habitats they were conducted in, one being the Fynbos biome and the other a combination of habitats in the forest biome.

A comparison with avian predation by other genet species in Africa suggests that DNR representation roughly corresponds more to that of *G. maculata* and *G. genetta* in southern Africa (Skinner and Chimimba 2005). European genets probably differ in diet due to differences in prey densities and biodiversity (between 45.5% and 88.4% of birds for *G. genetta* in Spain, Virgós *et al.* 1996). The apparent rise in consumption of birds in the winter/spring in DNR probably relates to greater vulnerability of birds during the mating and nesting period, as also indicated by the diet of *G. genetta* in Spain within the equivalent period (Virgós *et al.* 1996). Overall, broad similarity in the diets of the various genet species reflect common morphological adaptations stemming from a common ancestry.

Myriapods rarely occurred in scats from DNR. We also recorded myrmecophagy that was reported as absent in genets' diet by Wemmer (1977). But, as with Diptera and Scarabeidae remains, this could result from contamination of scats at the latrine sites. Remains of scorpions

suggest that *G. tigrina* may have disarmed them by attacking and consuming the pedipalps and stinger un-masticated before consuming the remainder. Occurrence was always low, but given their high density and diversity in DNR they seem to be under-represented in the diet, and therefore may not be particularly palatable.

Plant matter was much rarer in Purves' (1995) samples than in DNR. However, fruit-bearing trees occur at higher densities and with a greater diversity in dune forest (Farrell and Van Riet 1975) but few of their fruits were represented in the diet. Algae found could have been eaten for their salt content. Some scavenged items from a campsite were also identified.

The diet composition of *G. tigrina* in DNR indicates a primarily terrestrial foraging zone. However, unless marshy, the genets appear to favour the riparian zone of the forest (Fuller *et al.* 1990). We therefore suspect that the fish found in the diet were probably scavenged from the beach or elsewhere. Although fish were found in scats collected in all habitats, it was more common in those from the beach. *G. tigrina* were observed scavenging from the camping site in DNR (P. D. Roberts, pers. obs.) as observed elsewhere in South Africa (R. M. White, M. J. Somers, pers. obs.). On the other hand, additional scavengeable food was often noted on the beach but was never represented in scats.

Birds could have been caught in trees or on the ground. However, the peak in birds in the diet in winter/spring may indicate the genets are eating easily obtainable chicks in spring. If no fruit was consumed arboreally but only the birds, then the RFO of arboreal prey was only 1.13%. If, however, fruit was gleaned in trees the arboreal component rises to 7.82% RFO, still a rather low figure. This does not point to *G. tigrina* having a predilection for arboreal food sources, even though it can be classified as an opportunistic omnivore.

Amphibians, although present in large numbers during all seasons in DNR were absent in scats. This could reflect reluctance on the part of *G. tigrina* to enter water, contrary to *G. genetta* in Europe (Delibes *et al.* 1989, Ruiz-Olmo and López-Martin 1993, Rosalino and Santos-Reis 2002). Most published results refer to *G. genetta*

and not *G. tigrina*. It is therefore difficult to speculate on between-habitat differences in *G. tigrina* on a large geographic scale. Within our study area, however, some variation in prey taken by the different sympatric carnivores must be expected. As argued by Kok and Nel (2004) constituent species of a long-stable guild show anatomical and behavioural adaptations to allow prey apportioning. In addition a particular carnivore species can switch between prey species (or food items) thus buffering the effect of competition from a more specialized (or successful) species for a particular food source. Sympatric species at DNR which could fall in this category are *Canis mesomelas*, *Herpestes ichneumon* (both generalists) and also *Ictonyx striatus*, *Poecilogale albinucha* and *Felis silvestris lybica*, the latter three being rather more specialized in diet but still showing some overlap with *G. tigrina*. In addition, divergent physiological constraints between the guild members enhance the apparently similarly sized predators' capacity to coexist whilst exploiting divergent sources or locality of food sources (McNab 1989, Alexander 1993).

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