

Diet of the marsh mongoose around a non-permanent reservoir: response of a generalist opportunist forager to the absence of crabs

Emmanuel Do Linh San^{1,*}, Aviwe Nqinana¹, Zimkitha JK Madikiza² and Michael J Somers³

¹ Department of Zoology and Entomology, University of Fort Hare, Alice, South Africa

² School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa

³ Eugène Marais Chair of Wildlife Management, Mammal Research Institute, Centre for Invasion Biology, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa

*Correspondence: emmanuel.dolinhсан@gmail.com

Abstract

The diet of the marsh or water mongoose *Atilax paludinosus* has been well studied in coastal and inland riverine habitats, where crabs often constitute the main prey in terms of frequency of occurrence. We investigated the feeding ecology of a small number of marsh mongooses living next to a small, non-permanent reservoir (Andries Vosloo Kudu Nature Reserve, Eastern Cape), where freshwater crabs were not available. Using a combined metric of the percentage of occurrence and the percentage volume of food remains in 133 scats collected from 2006–2009, no primary prey could be detected. Amphibians, mammals, arthropods and fish all acted as secondary prey. Plants supplemented the diet, whereas birds only occurred as trace foods. There were seasonal variations in the diet, with peaks in amphibian (spring), arthropod (summer) and fish (autumn) consumption contributing to the change. Dietary diversity and niche breadth were relatively high throughout the year. This study strongly suggests that the marsh mongoose is in fact a generalist opportunist feeder. Although it consumes crabs and other aquatic prey in areas where they are particularly abundant, it can adapt to local food availability and include a significant proportion of terrestrial prey in its diet.

Keywords: *Atilax paludinosus*, diet, scat analysis, water mongoose

The marsh or water mongoose *Atilax paludinosus* is widely distributed in sub-Saharan Africa, although it is absent from most of Namibia, Botswana and the more arid parts of South Africa (Do Linh San et al. 2015; Baker et al. 2016). This herpestid (Order Carnivora, Family Herpestidae) is one of the larger members of the family, with a body mass of between 2 and 5.45 kg and an average head–body length of about 50 cm (Baker 1992). It is mostly nocturnal and primarily associated with aquatic habitats, such as coastal areas, rivers and streams, and salt marshes (Baker and Ray 2013). As specific morphological adaptations to this lifestyle, it possesses dense underfur that is water resistant, and unwebbed feet that allow this mongoose to seek out aquatic prey hidden in underwater cavities (Skinner and Chimimba 2005).

This link with water habitats results in its diet being mostly dominated by aquatic prey, and particularly crustaceans (see review in Baker and Ray 2013). For example, along the Atlantic Ocean coastline at Betty's Bay (Western Cape, South Africa), crabs were the dominant prey with a relative percentage occurrence of 39%, with fish, amphibians and mammals

accounting only for a combined 8.4% of food remains in scats (Louw and Nel 1986). The situation reported for inland-dwelling marsh mongooses living along riverine habitats does not depart from this pattern. In two montane grassland study sites in KwaZulu-Natal, Rowe-Rowe (1977) found that freshwater crab *Potamonautes* spp. remains were dominant in the scat samples he studied, with a relative percentage occurrence of 43%, whereas amphibians, mammals and birds each contributed only 14% to the diet. The above results, therefore, raise the question as to whether the marsh mongoose is mostly or at least partly dependent on crabs.

In South Africa, reservoirs are widespread and are an essential component of sustainable water resource management. The larger, permanent reservoirs are mainly used for irrigation purposes and to supply urban areas with water (DBSA, undated). The smaller reservoirs often serve as a source of water for livestock and wildlife (Bothma and du Toit 2016), but also as a soil conservation measure, notably to flood and rehabilitate severely eroded areas (Coetzee 2005). Whereas at least some species of freshwater crabs of the genus *Potamonautes* are known to disperse overland between water bodies (Daniels 2015), they are not necessarily present in or around small reservoirs. This is particularly the case of reservoirs that dry up regularly or for long periods, which are located far away from rivers, and/or are surrounded by arid land with a deep water table (S Daniels, pers. comm. 2020).

Here, we aimed to determine how the absence (or at best the low availability) of freshwater crabs would affect the diet of the marsh mongooses living around a small, non-permanent reservoir located in a semi-arid inland conservation area. We predicted that this small carnivore would rely more on other aquatic prey, such as amphibians and fish, but also on terrestrial prey, such as small mammals and arthropods.

The Andries Vosloo Kudu Nature Reserve is a 64 km² provincial conservation area that lies between Grahamstown and Fort Beaufort, in the Eastern Cape province, South Africa. It is one of three entities forming the Great Fish River Nature Reserve. The reserve falls within the Albany Thicket Biome and is dominated by the Great Fish Thicket (Hoare et al. 2006). The area is semi-arid, with summer temperatures often exceeding 35 °C. Rainfall varies from 250 to 650 mm per year, with peaks in spring and autumn (Birch et al. 1999).

Data collection took place next to the Kentucky dam (33°6'59.73" S, 26°39'30.81" E), a small non-permanent reservoir. During the study period, the water level of the reservoir changed significantly, as affected by rainfall patterns and drought events. Although the sampling site is peripherally included in the range of the Natal river crab *Potamonautes sidneyi* (Cumberlidge 2008), no crabs or their carcasses were observed in the dam area or along the riverine thickets despite intensive field presence of the first and third authors, both at night and during the day.

Scat samples were collected from May 2006 to June 2009 at three latrines that were located on the grass banks of the reservoir. Latrines were first discovered when tracking a radio-collared water mongoose female that regularly rested among nearby tall grass vegetation during the day, with clear paths leading to the latrines. Species identification was further ascertained by matching defecation sites, as well as scat diameter and appearance, with corresponding information provided in Stuart and Stuart (2000). Collected scats were placed into plastic freezer bags that were referenced with scat code, coordinates and date of

collection. Samples were then stored in a freezer until the time of analysis.

Frozen scats were thawed in an oven for three days (72 hours) at 50 °C. However, because most of the scats were then hard and difficult to analyse, they were subsequently soaked in water for two days until they were soft. After soaking, they were washed under running water using fine-meshed sieves (1 mm and 0.5 mm). They were dried again for 72 hours and later teased apart over a 10 × 10 cm grid to estimate the volumetric proportion of each food remains category.

In order to prevent the possibility that our sample included scats from other carnivores (e.g. otters) that defaecated in the same latrines as marsh mongooses, following Maddock (1988) only scats containing the characteristic banded hair of *A. paludinosus* were used for assessing the diet. A dissecting microscope was used to identify prey remains that were difficult to determine by the naked eye. Food items were categorised into (1) mammals – as revealed by the presence of hair, bones and teeth, (2) arthropods – exoskeletons, (3) birds – feathers, (4) plants – leaves, grass and seeds, (5) fish – scales and bones, (6) amphibians – bones, and (7) unidentified material. As dominant food categories in terms of frequency of occurrence (>75%, see Results), arthropods and, where possible, mammals were further identified to order and species level, respectively. The hairs embedded in the scat samples were prepared into slides by use of gelatine and were later identified based on cuticular scale patterns with the help of a compound microscope. Identification guides (Perrin and Campell 1980; Yalden 2003; Scholtz and Holm 2008) and insects collected in the field (Mmodana 2014; Sikade 2017) were used to identify prey remains in the scats.

The diet of the water mongoose was analysed as (1) percentage of occurrence (PO; the number of scats in which a food category occurred/total number of scats × 100), (2) percentage volume (PV; volumetric proportion of each food remain category), and (3) percentage overall importance (POI) of various food categories by plotting PV against PO on paired axes (Kruuk and Parish 1981). Following Maddock et al. (2016), primary prey were considered to lie above the 25% isopleth and secondary prey between the 6% and 25% isopleths. Supplementary food categories were considered to be between the 1% and 5% isopleths, and categories that lay below the 1% isopleth were regarded as 'trace' foods.

Four seasons were considered in our analyses: spring (September–November), summer (December–February), autumn (March–May) and winter (June–August). Chi-square tests of independence were used to examine whether there were variations in the absolute occurrence of the broad food

categories in the diet of the marsh mongoose throughout the year. Because the data were not distributed normally (Shapiro-Wilk test, $p < 0.05$), Kruskal–Wallis tests were performed to examine possible seasonal differences in the number of food categories, in the number of prey items, in the percentage volume of dominant items and in the percentage volume of each food category consumed. These statistical analyses were carried out with SPSS 17.0 (SPSS Inc.).

Using formulae provided in Krebs (1999), additional comparative tests were performed using the relative frequency of occurrence (RFO = $RPO/100$) and the relative volume (RV = $PV/100$) as proportions for each food category in calculating (1) the Shannon–Wiener diversity index (H' ; range 0–2.807 for seven categories), (2) the evenness measure of

representation (J' ; range 0–1), (3) Levin's standardised dietary niche breadth (BA; range 0–1) and (4) Pianka's dietary niche overlap (α ; range 0–1) between pairs of seasons. In order to facilitate ecological interpretation and comparison between (pairs of) seasons, we considered J' , BA and α values as high/broad when >0.65 , low/narrow when <0.35 , and intermediate when ranging between 0.35 and 0.65.

The diet of the marsh mongoose was analysed based on 133 scats. An overall mean (\pm SD) number of 4.1 ± 0.9 food categories (range 1–6) and 4.5 ± 1.2 food items (range 1–8) were present in each scat. Dominant items constituted a mean percentage volume of $63.7 \pm 16.7\%$ of the scat remains at the yearly scale. The number of food categories consumed ($H = 2.17$, $df = 3$, $p = 0.54$), the number of food items ($H = 4.89$, $df = 3$, $p = 0.18$) and the percentage volume of dominant items in scats ($H = 2.53$, $df = 3$, $p = 0.47$) remained stable throughout the seasons (Table 1).

Arthropods (78%) and mammals (76%) were the dominant food items in terms of percentage occurrence, followed by amphibians and plant material (59% each) and fish (32%). The presence of arthropods peaked in spring and summer, that of fish in autumn, whereas birds were mostly consumed during winter. Amphibians occurred more frequently in spring and summer. The overall diet, expressed as absolute occurrence, changed significantly over the seasons ($\chi^2 = 42.4$, $df = 18$, $p < 0.001$). However, when considering each food category separately, only the occurrence of fish ($\chi^2 = 24.38$, $df = 3$, $p < 0.0001$) and amphibians ($\chi^2 = 25.66$, $df = 3$, $p < 0.0001$) varied significantly throughout the year.

Mammal remains were found in 103 scats, but the species consumed could only be conclusively identified in 21 scats. These were the western rock sengi *Elephantulus rупestris* (33%), thicket rats *Grammomys* spp. (24%), bush Karoo rat *Otomys unisulcatus* (19%), vlei rat *O. irroratus* (19%) and pigmy mouse *Mus minutoides* (5%). The insect orders identified were Coleoptera (beetles; in 57% of cases, $n = 142$ items from 104 scats), Isoptera (termites; 19%), Hymenoptera (ants; 6%), Orthoptera (grasshoppers; 6%) and Odonata (dragonflies; 2%). Another arthropod taxon found was Diplopoda (millipedes; 10%). No remains (exoskeleton, chelipeds) of crabs were found.

The most important prey items in terms of percentage volume of food remains in scats were amphibians (26%), fish (21%), mammals (19%) and arthropods (15%) (Figure 1). Significant seasonal changes in the percentage volume of remains in scats were found for amphibians ($H = 20.530$, $df = 3$, $p < 0.001$), fish ($H = 35.862$, $df = 3$, $p < 0.001$) and arthropods ($H = 39.911$, $df = 3$, $p < 0.001$), but not for the other food categories ($p > 0.086$).

An assessment of the percentage overall importance revealed the absence of a primary prey type in the diet of the marsh mongoose at the study site (Figure 2). Instead, amphibians, mammals, arthropods and fish all acted as secondary prey. Plant material was a supplementary food, whereas birds could be regarded as trace prey.

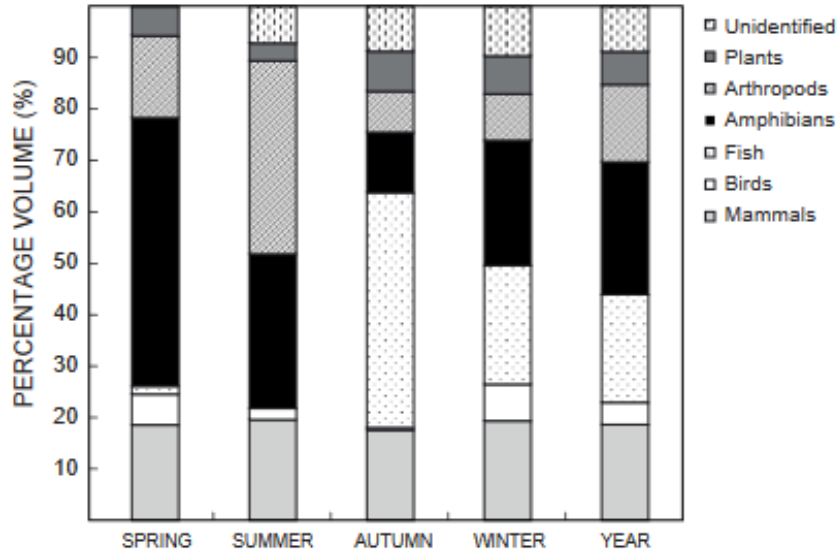


Figure 1: The seasonal and yearly percentage volume of prey items found in the scats ($n = 133$) of the marsh mongoose *Atilax paludinosus* in the Andries Vosloo Kudu Nature Reserve, Eastern Cape province, South Africa

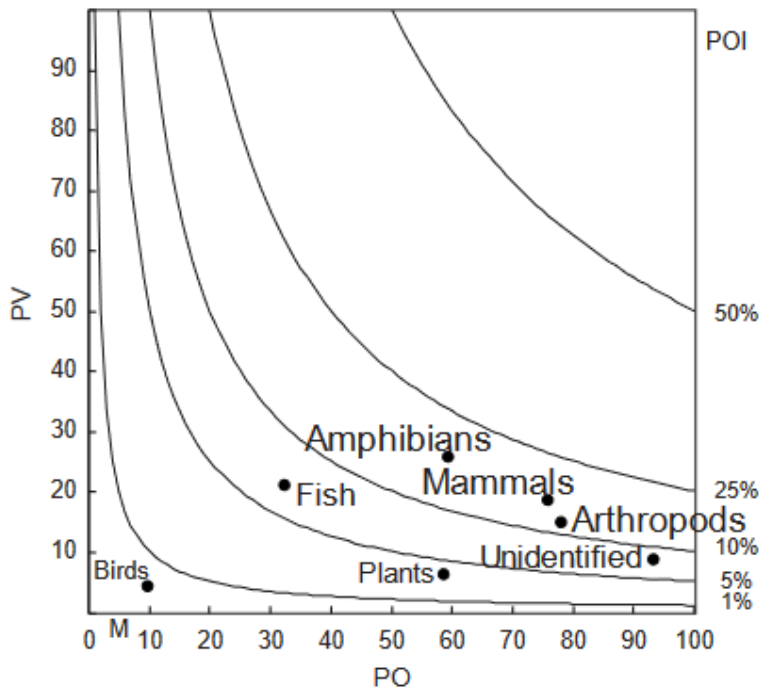


Figure 2: Graphical representation of the percentage overall importance (POI) of broad food categories in the diet of the marsh mongoose *Atilax paludinosus* based on the analysis of 133 scats collected between May 2006 and June 2009 in the Andries Vosloo Kudu Nature Reserve. Percentage volume (PV) is plotted against the percentage of occurrence (PO) of the corresponding food category. Isopleths connect points of equal overall importance. Font size used to represent food categories is proportional to their overall importance in the diet

When comparing diet diversity over the year using Shannon–Wiener’s formula, the diversity indices (2.10–2.70; $H'_{max} = 2.8074$), and therefore the evenness measures of representation

(0.74–0.95), were high, with only slight variations between seasons (Table 1). The seasonal and yearly values calculated with RFO and RV did not differ substantially. The standardised niche breadth was broad (0.63–0.84) when calculated with RFO, but spring to autumn values obtained with RV were intermediate (0.40–0.44). The diet overlap indices between the six possible seasonal dyads were generally high (0.70–0.98), although intermediate overlaps were recorded between spring and autumn (0.41), and between summer and autumn (0.40), using RV as proportions.

Table 1: The number of marsh mongoose *Atilax paludinosus* scats collected in the Andries Vosloo Kudu Nature Reserve (Eastern Cape province, South Africa) from 2006 to 2009 and corresponding seasonal dietary parameters

Parameters	Spring	Summer	Autumn	Winter	Year
Number of scats	21	25	33	54	133
Mean number of food categories per scat (n)	3.95 ± 1.12	3.88 ± 0.78	4.15 ± 1.00	4.20 ± 0.81	4.09 ± 0.91
Mean number of food items per scat (n)	4.52 ± 1.50	4.84 ± 1.28	4.42 ± 1.20	4.26 ± 0.98	4.45 ± 1.19
Mean percentage volume of dominant items in scats (%)	64 ± 16	60 ± 17	66 ± 18	64 ± 16	64 ± 17
Shannon–Wiener diversity index (H')					
With RFO	2.43	2.33	2.59	2.68	2.62
With RV	2.20	2.07	2.24	2.63	2.60
Evenness of representation (J')					
With RFO	0.866	0.829	0.922	0.953	0.934
With RV	0.782	0.738	0.798	0.939	0.925
Standardised dietary niche breadth (B_n)					
With RFO	0.682	0.630	0.793	0.836	0.798
With RV	0.408	0.436	0.441	0.759	0.752

Previous publications suggest that aquatic prey, and particularly crustaceans, can or often dominate the diet of the marsh mongoose in both coastal and inland riverine systems (e.g. Rowe-Rowe 1977; Louw and Nel 1986; Purves et al. 1994). Several of those studies were, however, based on small sample sizes (30–50 scats) and/or short study durations (Whitfield and Blaber 1980; MacDonald and Nel 1986; Baker 1989; Somers and Purves 1996; Ray and Sunquist 2001). Consequently, their results may not have been fully representative of the true local diets. Our study is based on a moderate, but yet adequate number of scats (>94 sensu Trites and Joy 2005) collected opportunistically over a four-year period. Although our results are probably only representative of the diet of a small number of marsh mongooses (possibly 3–4 individuals), they allow us to draw three main conclusions on the feeding ecology of this species.

First, marsh mongooses can subsist in areas where, or at least during periods when, crabs are absent. As expected, our data indicated that this usual primary prey is replaced by a wide range of secondary prey, both aquatic (amphibians, fish) and terrestrial (mammals, arthropods). The idea that marsh mongooses could locally rely on other food sources had already been hinted by studies based on small sample sizes, with molluscs dominating in a stomach content survey carried out in Nigeria (Angelici 2000), and mammals and arthropods being the main prey in some other inland areas in South Africa and Zambia (Stuart and Stuart 1998, 2003a, 2003b).

Second, marsh mongooses are generalist rather than specialist foragers. This is suggested by several of our findings. The number of food categories and food items per scat was high (between 4 and 5 on average) and constant throughout the year, indicating that individuals consume several types of food per feeding bout (i.e. 'meal'). In addition, diet diversity and dietary niche breadths were also quite broad throughout the year, with high overlaps between seasonal dyads. The generalist feeding nature of this species may have been partly overlooked, because previous studies only assessed the diet based on the (relative) frequency of occurrence of food items. These diet descriptors may, however, be misleading,

because some foods are eaten frequently, but in small quantities. In our study, the percentage volume of food remains, and the percentage overall importance were also determined to obtain a better estimate of the quantitative and ecological significance of each food category (Kruuk and Parish 1981; Klare et al. 2011). Using this approach, no primary prey emerged, and up to four secondary food categories were shown to have an overall similar importance in the diet. Plants only acted as supplementary food, whereas the fruits/seeds were likely eaten intentionally. It remains unclear whether the more fibrous materials, such as leaves or grass, were ingested purposely (e.g. to remove and purge intestinal parasites) or accidentally (e.g. when grabbing arthropods).

Third, marsh mongooses are opportunist foragers. This aspect appears clearly in our study (Figure 1). At the daily scale, although several food items were eaten each night, one of the prey would dominate consistently, representing on average 60–65% of the volume of remains. This suggests that when a marsh mongoose finds an attractive food resource, whatever the type, it will capitalise on it. The same behaviour is apparent at the seasonal scale, with peaks of prey consumption noted in spring and partly summer for amphibians (rainy season and amphibians' mating period; du Preez and Carruthers 2017); arthropods in summer (warmest season and peak in arthropod activity; Mdoana 2014; Sikade 2017); and fish in autumn and to a lesser extent winter (when the water is colder and fish are more lethargic and easier to catch; Rowe-Rowe 1977). Paradoxically, the finding that the diet was the most diversified and 'balanced' during the lean winter season is also in line with what would be expected from an opportunist forager. Using the same logic, it is anticipated that marsh mongooses would predominantly feed on crabs – or any other food type for that matter – in areas where, or during seasons, when crabs or any other food type are particularly abundant.

As a concluding remark, small mammals occurred in 76% of scats – with a higher value of 100% only previously recorded by Avenant and Nel (1997) – and the percentage volume of their remains was constant throughout the year. Mammals certainly represent a higher amount of ingested biomass and leave lower volumes of remains in scats than freshwater crabs, for example. For this reason, future studies that include an estimation of ingested biomass might reveal that small mammals could, in fact, play a more significant role in the diet of the marsh mongoose than previously thought.

Acknowledgements

We are indebted to Brad Fike and Dean Peinke for their support and for authorising the research in the Great Fish River Reserve. Tembisa Matolengwe kindly helped with the identification of amphibian bones in selected samples and Savel Daniels provided information on the ecology of freshwater crabs. This manuscript was substantially improved through the comments of Carolyn Baker and one anonymous reviewer. This research was generously funded by the Govan Mbeki Research and Development Centre at the University of Fort Hare via a research seed grant to EDLS and a supervisor-linked bursary to AN.

ORCID

Emmanuel Do Linh San ID <http://orcid.org/0000-0002-6513-5665>

Zimkitha JK Madikiza ID <http://orcid.org/0000-0001-7993-8795>

Michael J Somers ID <https://orcid.org/0000-0002-5836-8823>

References

- Angelici FM. 2000. Food habits and resource partitioning of carnivores (Herpestidae, Viverridae) in the rainforests of southeastern Nigeria: preliminary results. *Revue d'Ecologie (La Terre et la Vie)* 55: 67–76.
- Avenant NL, Nel JAJ. 1997. Prey use by four syntopic carnivores in a strandveld ecosystem. *South African Journal of Wildlife Research* 27: 86–93.
- Baker CM. 1989. Feeding habits of the water mongoose (*Atilax paludinosus*). *Zeitschrift für Säugetierkunde* 54: 31–39.
- Baker CM. 1992. *Atilax paludinosus*. *Mammalian Species* 408: 1–6.
- Baker CM, Ray JC. 2013. *Atilax paludinosus* Marsh mongoose. In: Kingdon J, Hoffmann (Eds), *Mammals of Africa. Volume V: Carnivores, Pangolins, Equids and Rhinoceroses*. London, UK: Bloomsbury Publishing. pp. 298–302.
- Baker C, Stuart C, Stuart M, Nqinana A, Peinke D, Maddock AH, Perrin MR, Somers MJ, Do Linh San E. 2016. A conservation assessment of *Atilax paludinosus*. In: Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT (Eds). *The Red List of Mammals of South Africa, Swaziland and Lesotho*. Pretoria and Johannesburg, South Africa: South African National Biodiversity Institute and Endangered Wildlife Trust.
- Birch NV, Avis AM, Palmer AR. 1999. The effect of land use on the vegetation communities along a topo-moisture gradient in the mid-Fish River valley, *South Africa*. *African Journal of Range & Forage Science* 16: 1–8. <https://doi.org/10.2989/10220119909485712>.
- Bothma J du P, du Toit JG (Eds). 2016. *Game ranch management*, (6th edn). Pretoria, South Africa: Van Schaik Publishers.
- Coetzee K. 2005. *Caring for natural rangelands*. Scottsville, South Africa: University of KwaZulu-Natal Press.
- Cumberlidge N. 2008. *Potamonautes sidneyi*. The IUCN Red List of Threatened Species 2008: e.T64390A12768129. [Accessed 15 March 2020].
- Daniels S. 2015. Crabs, prawns and crayfish - Order Decapoda. In: Griffiths C, Day J, Picker M (Eds), *Freshwater life: A field guide to the plants and animals of Southern Africa*. Cape Town, South Africa: Struik Nature. pp. 244–248.
- DBSA. Undated. *Guide to best practice in the operation, maintenance and safety of dams*. Halfway House, South Africa: Development Bank of Southern Africa.

Do Linh San E, Angelici FM, Maddock AH, Baker CM, Ray J. 2015. *Atilax paludinosus*. The IUCN Red List of Threatened Species 2015: e.T41590A45204865. [Accessed 15 March 2020].

du Preez L, Carruthers V. 2017. *Frogs of Southern Africa: A complete guide*, (2nd edn). Cape Town, South Africa: Struik Nature.

Hoare DB, Mucina L, Rutherford MC, Vlok JHJ, Euston-Brown IW, Palmer AR, Powrie LW, Lecmere-Oertel RG, Procheş ŞM, Dold AP, et al. 2006. Albany Thicket Biome. In: Mucina L, Rutherford MC (Eds), *The vegetation of South Africa, Lesotho and Swaziland*. Pretoria, South Africa: South African National Biodiversity Institute. pp 540–567.

Klare U, Kamler JF, Macdonald DW. 2011. A comparison and critiques of different scat-analysis methods for determining carnivore diet. *Mammal Review* 41: 294–312. <https://doi.org/10.1111/j.1365-2907.2011.00183.x>.

Krebs CJ. 1999. *Ecological methodology*, (2nd edn). Menlo Park, South Africa: Benjamin/Cummings.

Kruuk H, Parish T. 1981. Feeding specialisation of the European badger *Meles meles* in Scotland. *Journal of Animal Ecology* 50: 773–788. <https://doi.org/10.2307/4136>.

Louw CJ, Nel JAJ. 1986. Diets of coastal and inland dwelling water mongoose. *South African Journal of Wildlife Research* 16: 153–156.

MacDonald JT, Nel JAJ. 1986. Comparative diets of sympatric carnivores. *South African Journal of Wildlife Research* 16: 115–121.

Maddock AH. 1988. Resource partitioning in a viverrid assemblage. PhD thesis, University of Natal, South Africa.

Maddock AH, Do Linh San E, Perrin MR. 2016. Some data on the feeding habits of the banded mongoose in a coastal area (South Africa). *African Journal of Ecology* 54: 245–247. <https://doi.org/10.1111/aje.12273>.

Mdodana LA. 2014. Seasonal abundance, diversity and richness of terrestrial arthropods in the Great Fish River Reserve: a comparison of two habitats. BSc Honours thesis, University of Fort Hare, South Africa.

Perrin MR, Campell BS. 1980. Key to the mammals of the Andries Vosloo Kudu Reserve (Eastern Cape), based on their hair morphology, for use in predator scat analysis. *South African Journal of Wildlife Research* 10: 1–14.

Purves MG, Kruuk H, Nel JAJ. 1994. Crabs *Potamonautes perlatus* in the diet of the otter *Aonyx capensis* and the water mongoose *Atilax paludinosus* in a fresh water habitat in South Africa. *Zeitschrift für Saugetierkunde* 59: 332–341.

Ray JC, Sunquist ME. 2001. Trophic relations in a community of African rainforest carnivores. *Oecologia* 127: 395–408. <https://doi.org/10.1007/s004420000604>.

Rowe-Rowe DT. 1977. Food ecology of otters in Natal, South Africa. *Oikos* 28: 210–219. <https://doi.org/10.2307/3543973>.

Scholtz CH, Holm E (Eds). 2008. *Insects of Southern Africa*. Pretoria, South Africa: Protea Book House.

Sikade L. 2017. Arthropod abundance, diversity and richness in the Andries Vosloo Kudu Nature Reserve (Eastern Cape, South Africa): seasonal and habitat variations. BSc Honours thesis, University of Fort Hare, South Africa.

Skinner JD, Chimimba C. 2005. *The mammals of the Southern African Subregion*, (3rd edn). Cape Town, South Africa: Cambridge University Press.

Somers MJ, Purves MG. 1996. Trophic overlap between three syntopic semi-aquatic carnivores: Cape clawless otter, spotted-necked otter and water mongoose. *African Journal of Ecology* 34: 158–166. <https://doi.org/10.1111/j.1365-2028.1996.tb00609.x>.

Stuart C, Stuart T. 1998. Notes on the diet of four species of viverrid in a limited area of southern Namaqualand, Northern Cape, South Africa. *Small Carnivore Conservation* 19: 9–10.

Stuart C, Stuart T. 2000. *A field guide to the tracks and signs of Southern and East African wildlife*, (3rd edn). Cape Town, South Africa: Struik Publishers.

Stuart C, Stuart T. 2003a. A note on the diet of the water mongoose *Atilax paludinosus* in the central Great Karoo, South Africa. *Small Carnivore Conservation* 29: 13–14.

Stuart C, Stuart T. 2003b. A short note on the analysis of the scats of water mongoose *Atilax paludinosus* and rusty-spotted genet *Genetta maculata* from Kasanka National Park. *Small Carnivore Conservation* 29: 15.

Trites AW, Joy R. 2005. Dietary analysis from fecal samples: how many scats are enough? *Journal of Mammalogy* 86: 704–712. [https://doi.org/10.1644/1545-1542\(2005\)086\[0704:DAFFSH\]2.0.CO;2](https://doi.org/10.1644/1545-1542(2005)086[0704:DAFFSH]2.0.CO;2).

Whitfield A, Blaber SJM. 1980. The diet of *Atilax paludinosus* (water mongoose) at St. Lucia, South Africa. *Mammalia* 44: 315–318. <https://doi.org/10.1515/mamm.1980.44.3.315>

Yalden DW. 2003. *The analysis of owl pellets*, (3rd edn). London, UK: Mammal Society.