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ORIGINAL ARTICLE

The diet of African Civet *Civettictis civetta* in two vegetation types of the Savannah biome in South Africa

Pamela J. AMIARD[1], Caroline V. KRUGER[1] & Ralf H.E. MULLERS[1]

[1] Mogalakwena Research Centre, P.O Box 60, Alldays 0909, Limpopo Province, South Africa.

Correspondence:
Pamela J. Amiard
pamela.amiard@gmail.com

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Abstract.

The diet of the African Civet *Civettictis civetta* was compared between two vegetation types in South Africa: Limpopo Sweet Bushveld (LSB) and Musina Mopane Bushveld (MMB), both located in the Savannah biome. Food items found in scat samples were similar in both vegetation types, but their frequency of occurrence differed. Wild fruits such as raisin bush *Grewia* spp. and invertebrate species like millipedes *Archispirostreptus gigas* formed the two major components of the Civet diet in both bushveld types. Fruit species were more abundant in the LSB scat samples with a 62.2% frequency of occurrence whereas invertebrate remains were more frequent (64.5%) in samples from the MMB. Remains of venomous scorpion species, mainly from the Buthidae family, were found in considerable quantities as well, the first time scorpions are reported to be part of the Civet diet. Our results confirm the omnivorous and opportunistic behaviour of the African Civets as their diet reflects the temporal availability of prey, fruits and seeds in their immediate habitat. Moreover, the large amount of seeds ingested by Civets suggests that they could act as an important seed disperser.

Keywords: African civet, scat analysis, diet, vegetation type, savannah biome.

Introduction

The African civet *Civettictis civetta* (Schreber 1776) is a medium-sized, fairly common carnivore that occurs in Sub-Saharan Africa (Ray *et al.* 2008). In South Africa, the density of two sub-populations is estimated at 10.1 ± 0.56 and 14.1 ± 4.15 civets/100 km² (Amiard 2014, Swanepoel *et al.* In prep.), suggesting a healthy population. However, despite the relative abundance across their range, little is known about the ecology of the species due to their elusive and secretive behaviour (Ray 1995).

To assess the role of carnivores such as civet in the ecosystem, it is essential to understand their diet and the relative contributions of different prey items (Ripple *et al.* 2014). Despite their elusiveness, investigate civets diet is relatively easy because they use communal latrines, called civetries, to defecate. These latrines are established in natural hollows in the ground near roads, normally less than 0.5 m^2 (Randall 1977, Bekele *et al.* 2008b). Civetries are characterized by large amounts of prey remains, such as seeds, insect remains and millipede rings (Bekele *et al.* 2008a). The few studies that quantified the remains in these civetries established that civets are omnivorous and their diet is dominated by fruits of various plants, insects and rodents (Ray 1995, Ray *et al.* 2005, Bekele *et al.* 2008a). Civets are also able to consume toxic prey such as millipedes and highly decayed carrion (Randall 1977, Ray *et al.* 2005).

Due to their function as a latrine, civetries also act as a source of information for other civets (Randall 1977). Civetries are used for 1) the exchange of information as civets can visit latrines without defecating themselves, 2) the familiarization with the home range as their position is remembered, and 3) the territorial demarcation as they are located at territorial borders (Randall 1977, Hutchings & White 2000). Besides their function as an information source for civets, civetries are also a source of information for researchers interested in the diet of this species.

The aim of this study was to quantify and compare the diet of the African civet in Limpopo Sweet Bushveld and Musina Mopane Bushveld (Acocks 1988), two vegetation types located in the Limpopo province of South Africa. In most habitats, plant communities determine the physical structure of the environment and therefore have a considerable influence on the distribution and interaction of species (Tews *et al.* 2004). The heterogeneous conditions and the environmental diversity in the two vegetation types, offer the possibility to study the response of civets to different environments through their diet.

Materials and methods

Study areas

Our study was conducted in the North of the Limpopo Province, in South Africa, where we selected four private reserves. The reserves fall within two different bioregions characterized by different vegetation types of the Savannah biome (Mucina *et al.* 2006) (Figure 1, Table 1).

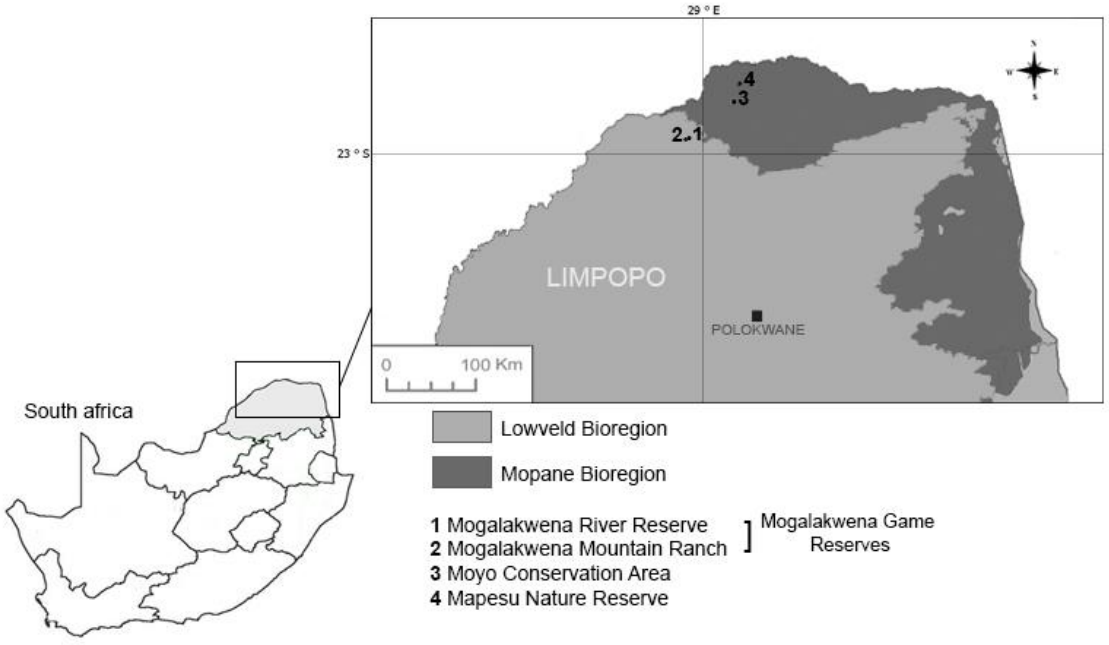

Figure 1. Localization of the study sites in the Limpopo province, South Africa.

Table 1. Complementary information about the reserves selected for the study.

Reserve		Area (hectares)	Coordinates*	Vegetation type
Mogalakwena Game Reserves	Mogalakwena River Reserve	1,400	22°43′32″ S 28°46′3″ E	Limpopo Sweet Bushveld
	Mogalakwena Mountain Ranch	2,000	22°43′30″ S 28°47′07″ E	
Moyo Conservation Area		1,000	22°28′14″ S 29°10′07″ E	Musina Mopane Bushveld
Mapesu Nature Reserve		6,000	22°14′14″ S 29°28′46″ E	

* Centre point of the reserve

On the one hand, Mogalakwena Reserves, with Mogalakwena River Reserve and Mogalakwena Mountain Ranch, are situated in the Limpopo Sweet Bushveld (LSB). The habitat of Mogalakwena River Reserve is described as a moderately closed to open shrubland where raisin bush *Grewia* spp., Umbrella Thorn *Acacia tortilis*, Purple-pod Cluster-leaf *Terminalia prunoides* and corkwoods *Commiphora* spp. are the dominant species. Whereas Mogalakwena Mountain Ranch is a predominantly closed habitat dominated by Mountain Syringa *Kirkia wilmsii*, corkwood species and Mountain Fig *Ficus glumosa*.

On the other hand, Moyo Conservation Area and Mapesu Nature Reserve are both located in the Musina Mopane Bushveld (MMB) vegetation type. The landscape is relatively flat with open woodland to moderately closed shrubveld dominated by Mopane *Colophospermum mopane*, raisin bush and Purple-pod Cluster-leaf.

Methods

Civetries were located during track surveys in the reserves from February to June 2014. Roads were walked five times per week covering different sections of the reserves between 07h00 and 10h00 and 15h00 and 17h00. When a new civetry was discovered, we recorded the GPS-coordinates. We visited each civetry every three weeks during the study period and collected randomly two to three scats (*i.e.*, one sample) per visit, which were kept in paper bags until analyses.

Scats were washed in running water through a brass sieve (*i.e.*, 0.5 mm diameter) until the water was clear. All undigested parts like seeds, hairs, bones, insect cuticles and millipede rings were separated and air-dried for 24 hours. These food items were then compared to reference collections and identified at the order level. Because scats could not be identified separately, the statistical unit is each unique civetry. The contribution of each food item to the diet was calculated as the frequency of occurrence in each civetry: FOi (%) = 100 x (number of occurrences of the food item i/total number of occurrences of all food items).

The standardized niche breadth index of Levins (Krebs 1999) was used to compare the degree of diet specialization per habitat type, by taking five food categories into account (*i.e.*, fruits, invertebrates, birds, mammals, and others). The index of Levins was calculated as: BA = (B-1)/(n-1) with $B = 1/\Sigma p_j^2$ where pj is the fraction of food items that are of food category j and n the number of food categories present. The index ranges from 0 for very specialized diets to 1 for very generalist diets.

A Fisher's exact test was used to compare the homogeneity of the distribution of food items found in the scat samples from both vegetation types in R v.2.15.1 (R Core Team 2014).

Results

In total we found 22 civetries with 15,509 food items. All food items could be identified to the order level.

Limpopo Sweet Bushveld

During this study fourteen samples were collected, nine at the River Reserve and five at the Mountain Ranch. A total of 51 different prey species were found and were categorized in 13 groups of common food items (Table 2). Seeds of wild fruit species such raisin bush dominated the scat samples (*i.e.*, 66.1% at the River Reserve and 57.4% at the Mountain Ranch). A greater variety of fruit species was identified in the scat samples from the Mountain Ranch. Mountain Fig accounted for 15.3% of the diet and other fruits like Star Chestnut *Sterculia rogersii* and Marula *Sclerocarya birrea* contributed 5.3% to the civet diet. Invertebrates such as the African Giant Black Millipede *Archispirostreptus gigas* and Coleoptera species were the second most consumed food category. Invertebrate remains were found in similar proportions at both sites, although millipede remains were higher at the Mountain Ranch. Table 1 gives an overview of all food items found in scat and their frequency of occurrence.

Musina Mopane Bushveld

A total of eight samples were collected, three at Moyo Conservation Area and five at Mapesu Nature Reserve, and a total of 33 prey species were divided into 10 categories (Table 3). Invertebrate remains and seeds of wild fruits were the most common food items in the scat samples. Diet composition differed between the two sites. Seeds of Raisin bush were most frequent in scat samples from Moyo (55.7%), whereas invertebrate remains were the dominant prey item at Mapesu (82.6%). An overview of food items and their frequency of occurrence are given in Table 2.

Table 2. Food items found in the samples analysis from the Limpopo Sweet Bushveld vegetation type.

Food items	Parts eaten	Occurrences	FO (%)	FO (%) observed at the two sites	
				MRR	MMR
Grewia sp.	Fruits	5,582	52.76	66.0	36.7
Ficus glumosa	Fruits	731	6.91	-	15.3
Other fruits	Fruits	270	2.54	0.2	5.3
Archispirostreptus gigas	Whole	1,073	10.14	3.1	18.7
Coleoptera sp.	Whole	1,984	18.75	18.8	18.7
Orthoptera sp.	Whole	182	1.72	2.2	1.1
Diptera sp.	Whole	6	0.06	0.1	0.0
Scorpiones sp.	Whole	64	0.60	0.9	0.3
Francolinus sp.	-	136	1.29	0.7	2.0
Rodentia sp.	Whole	274	2.59	4.4	0.4
Other mammals	-	5	0.05	<0.05	0.1
Grass	-	269	2.54	3.6	1.3
Plastic / Foil *	-	3	0.03	0.1	-
Total	**-**	**10,575**	**100**	**100**	**100**

With: MRR = Mogalakwena River Reserve and MMR = Mogalakwena Mountain Ranch.
*Probably eaten with human food waste found around lodges.

Table 3. Food items found in the samples analysis from the Musina Mopane Bushveld vegetation type

Food items	Parts eaten	Occurrences	FO (%)	FO (%) observed at the two sites	
				MCA	MNR
Grewia sp.	Fruits	1,288	26.1	55.7	1.4
Other fruits	Fruits	19	0.4	0.6	0.2
Archispirostreptus gigas	Whole	2,052	41.6	21.0	58.8
Coleoptera sp.	Whole	558	11.3	21.3	3.0
Orthoptera sp.	Whole	549	11.1	0.4	20.0
Scorpiones sp.	Whole	22	0.4	-	0.8
Francolinus sp.	-	328	6.6	<0.05	12.2
Rodentia sp.	Whole	45	0.9	0.8	1.0
Grass	-	71	1.4	0.1	2.5
Plastic / Foil *	-	2	<0.05	-	0.1
Total	**-**	**4,934**	**100**	**100**	**100**

With: MCA= Moyo Conservation area and MNR= Mapesu Nature Reserve.
*Probably eaten with human food waste found around lodges.

Comparison between the two vegetation types

Seeds of wild fruits appear to be more frequent in the LSB scat samples (62.2%), whereas invertebrate remains and in particular that of millipedes dominated the samples from the MMB vegetation type (64.5%). A higher proportion of bones, hairs and/or feathers were found in the scat samples from MMB (*i.e.*, 7.5% compared to 4.0% for LSB). In more detail, we identified a higher proportion of rodent remains in the scat from the LSB (*i.e.*, 2.6% compared to 0.9% in the MMB), but remains of bird species were more frequently encountered in scats from the MMB (*i.e.*, 6.6% compared to 1.3% in the LSB). The proportion of food items observed in scat samples were significantly different between the two vegetation types (Fisher's exact test: $P < 0.001$).

According to the Levin's index, civets from the LSB seem to have a similar standardized trophic niche (BA-LSB = 0.264) as civets from the MMB vegetation types (BA-MMB = 0.260).

Discussion

In this study we compared the diet of the African Civet between two vegetation types. In both bushveld types, civets had an omnivorous diet as described before (Randall 1977, Smithers 1986, Bekele *et al.* 2008a), with wild fruits and invertebrates dominating the diet. More than 70% of the civet diet consisted of non-vertebrate food items, which would make the civets in our study hypo-carnivores rather than meso-carnivores (van Valkenburgh 2007), at least during our study period. Recent findings in Ethiopia confirm this suggestion (Bekele *et al.* 2008a, Mull & Balakrishnan 2014). Thirteen categories of common food items in the Limpopo Sweet Bushveld and 10 categories in the Musina Mopane Bushveld were defined. However, in the LSB wild fruits such as raisin bush dominated the diet, whereas in the MMB invertebrates (*i.e.*, mainly African Giant Black Millipede) were the most abundant prey species. Civets from the LSB consumed a wider variety of food species than civets from the MMB.

On the Mogalakwena Reserves, fruit-bearing trees are more abundant than at the Moyo and Mapesu reserves (Mucina *et al.* 2006, Fauré 2010, Benichou 2013), which most likely explains why wild fruits are the dominant species in the civet diet in the LSB. Also, when seeds were found in scats, one fruit species generally dominated the composition of the scat. This observation would suggest that particular fruit species were ingested in great quantity at the same time, likely representing the seasonal abundance of particular fruits. Civets thus have the capacity to adapt their feeding behavior and take advantage of temporarily available resources in their environment.

Due to their frugivorous nature, civets could act as an important seed disperser through endo-zoochory (Randall 1977, Pendje 1994). Some important criteria are met by civets to act as seed dispersers, like covering large surface areas and having long digestion times characteristic of carnivores (Zhou *et al.* 2008), and selecting microhabitats for defecation through civetries. Indeed, it was not uncommon to observe seeds germinating in civetries during scat collection. Seed dispersal by Civets in shrublands could be an interesting topic to investigate in future studies because of its ecological impact. For example, raisin bush species are known to be involved in the shrub encroachment process in the savanna biome (Trollope 1982, Roques *et al.* 2001, Tews *et al.* 2004) and civets could play a significant role in this.

Civets are known to be able to eat millipedes and highly decayed carrion (Randall 1977, Ray 1995, Ray *et al.* 2005). African giant black millipedes secrete an irritating fluid that makes them unpalatable to predators (Eisner *et al.* 1978) but nevertheless they were an

important food resource for civets in many studies (Randall 1977, Bekele *et al.* 2008a, Mullu & Balakrishnan 2014), including our study. Many Viverrid species are able to eat noxious prey and resist their toxins (Randall 1977). But surprisingly scorpion species, and especially from the Buthidae family, were also found in significant quantities in civet scats. Several of the consumed scorpion species, such as *Parabuthus transvaalicus* and *P. mossambicensis*, are highly toxic (Leeming 2003), but nevertheless present in the scats from the Mogalakwena Game Reserves. The consumption of poisonous species has been reported in cooperative animals like Banded Mongooses *Mungos mungo* and Meerkats *Suricata suricatta* (Barett *et al.* 2012), but not for a solitary species like the African Civet. Malay Civets *Viverra tangalunga*, in the rain forest of Borneo, are known to eat scorpions as well (Colon & Sugau 2012) but these species are relatively harmless (Garbutt & Prudente 2006). To our best knowledge this is the first time it was shown that civets can feed on toxic scorpions. The ability to eat such prey allows the African civet to take advantage of a dietary resource not consumed by other same sized carnivores.

In the MMB, civet scats contained more vertebrate remains like hairs, feathers and bones than in the LSB. Overall, civets showed a higher consumption of protein-rich food items in the MMB compared to LSB, including invertebrates, birds such as francolins *Francolinus* spp., and rodents like Pouched Mice *Saccostomus campestris*. No hair or bone remains were found in scats from the LSB, but camera traps set at the same time as our study, showed that civets did feed on large herbivore carrion, in this case Giraffe *Giraffa camelopardalis*. Probably due to the large availability of wild fruits during our study, civets had easy access to food and did not have to supplement their diet with extra protein. It would be interesting to investigate the proportion of vertebrates in the diet outside the fruiting season, as we expect this proportion to increase (Bekele *et al.* 2008a).

Undigested grasses were often encountered in the scat samples. Grass ingestion is considered to be a form of self-medication facilitating digestion (Bekele *et al.* 2008a) or helping with the elimination of parasites. Plant ingestion is reported for various carnivore species like the GrayWolf *Canis lupus*, the Black-backed Jackal *Canis mesomelas* and the Small Indian Civet *Viverricula indica* for example (Huffman *et al.* 2012, Su *et al.* 2013).

Anthropogenic food items were identified in the samples as well. Mainly pieces of plastic and foil were found, indicating that Civets fed on human food waste, which has been reported before (Bekele *et al.* 2008a, Barett *et al.* 2012). Civets are suspected to be involved in crop raiding in many areas of Africa and are willing to travel long distances for these (Bekele *et al.* 2008a). Even though there are croplands within 5 km from Mogalakwena Game Reserve, no seeds from fruit crops were found during the scat analysis, possibly again indicating that wild fruits were readily available during our study. More investigations on crop raiding patterns are required to confirm these suspicions.

The wide variety of different food items found in the diet of African Civet suggests that this species is highly opportunistic, which might explain its relative abundance throughout its range. By taking advantage of food that is most abundant at different times of the year, African Civets are able to survive in different habitats under variable conditions.

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