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Diets of the African Civet *Civettictis civetta* (Schreber, 1778) in selected coffee forest habitat, south-western Ethiopia

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Abstract

Feeding ecology of the African civet, *Civettictis civetta* (Schreber, 1778), was studied in selected coffee forest habitat for two seasons between December 2012 and October 2013. The study was conducted in Limu Seka district, south-west Ethiopia. Faecal analysis was employed to assess the diet spectrum, seasonal abundance and relative importance of food items. Over 55 different food items were identified from the analysis of 387 scat samples collected during the dry and wet seasons. In the coffee forest habitat, African civets showed omnivorous feeding habit with plant-to-animal diet biomass ratio of 1 : 1.36. A slight diet specialization was observed during the wet season (BA = 0.46) favouring animal prey. However, during the dry season, they showed generalist feeding habit (BA = 0.87) with more plant biomass in their diet. With over 64% occurrence and 14.4% biomass, coffee berries significantly contributed to the civets dry season plant diets. The excreted coffee beans, after civets ingested ripe coffee berries, are the tastiest product used by farmers for consumption and market. Seasonal collection of civet coffee from coffee forest floor economically supports the farmers while increasing the importance of civets in the habitat and hence contributing for its conservation.

Key words: African civet, civetry, coffee forest, diet biomass, faecal analysis, feeding ecology

Résumé

L'écologie alimentaire de la civette africaine, *Civettictis civetta* (Schreber, 1778), a été étudiée dans un habitat sélectionné de forêts de caféiers, pendant deux saisons, entre décembre 2012 et octobre 2013. Cette étude fut réalisée dans le district de Limmu Seka, dans le sud-ouest éthiopien. Nous avons utilisé des analyses fécales pour évaluer le spectre alimentaire, l'abondance saisonnière et l'importance relative des divers aliments. Nous avons identifié plus de 55 aliments différents à partir de l'analyse de 387 échantillons fécaux collectés en saison des pluies et en saison sèche. Dans l'habitat de forêt de caféiers, les civettes africaines présentaient des habitudes alimentaires omnivores, avec un ratio entre nourriture végétale et animale de 1/1.36. Nous avons observé une légère spécialisation en saison des pluies (BA = 0.46) en faveur des proies animales. Mais en saison sèche, elles montraient des habitudes alimentaires généralistes (BA = 0.87) avec plus de biomasse végétale dans l'alimentation. Avec une présence de plus de 64% et 14% de la biomasse, les baies de café contribuaient significativement au régime alimentaire végétal des civettes en saison sèche. Les baies de café excrétées après que les civettes ont ingéré des baies mûres sont le produit le plus apprécié par les producteurs pour la consommation et le marché. La collecte saisonnière du café de civette sur le sol des forêts de caféiers est une aide économique pour les agriculteurs tout en augmentant l'importance des civettes dans cet habitat, ce qui contribue à leur conservation.

Introduction

Among the four subfamilies of viverridae, viverrinae comprised six Afro-Asiatic species (called civets) in three genera. Possession of the perineal glands and musk secretion are the derived characters for the subfamily (Goswami & Friscia, 2010). Civets used musk for

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intraspecific communication and territorial marking (Kingdon, 1997; Nowak, 1999). Traditional societies in civet range countries, on the other hand, extensively used musk from civets for medicinal, cultural, religious and economic purposes (Dannenfeldt, 1985; Ray, 1995; Balakrishnan & Sreedevi, 2007a,b).

The African civet *Civettictis civetta* is the largest member of viverrinae endemic to Africa (Ray, 1995). The species is recognized by its dark facial mask, large hind quarter and low-head stance (Ester, 1991; Ray, 1995). It is fairly distributed in the tropical and subtropical Africa with range extending from Senegal to the east coast (Skinner & Smithers, 1990; Kingdon, 1997). In Ethiopia, the species is quite abundant in the south and south-western montane forest of the country (Yalden, Largen & Kock, 1980).

Maintaining civets in captivity and extracting musk for the stated purposes was a long tradition in Ethiopia (Dannenfeldt, 1985; Skinner & Smithers, 1990; Ray, 1995). At present, with over 90% export share, Ethiopia is the world's leading musk supplier to the perfume industries (Kumera, 2005). The distribution of civet farms in Ethiopia is localized and highly concentrated in the south and south-western part of the country (Abebe, 2003).

Information on the feeding ecology of wild animals contributes to the understanding of their behavioural ecology (Mills, 1991), diet item diversity, preference and seasonal availability, foraging strategies and their activity patterns (Fuller & Kat, 1990; Henschel & Skinner, 1990). In addition, understanding the nutritional requirements of animals in the wild provides the required information for formulating feeds for captive wildlife (such as civets) and to plan supplemental feeding (Cheeke, 1999).

While feeding ecology of most Asian civets has been well recorded (e.g. Ho, 2009), limited information is available for the African civet from southern (Rautenbach & Nel, 1978) and the central and western Africa (Skinner & Smithers, 1990), but no report is available for the eastern part of the continent. Recently, Bekele, Afework & Balakrishnan (2008) reported diet of the species from natural forest in the central highland of Ethiopia. No report is available on the feeding ecology of the African civet from coffee dominated forest habitat of the south and south-western Ethiopia where the species was reported to be fairly abundant (Yalden, Largen & Kock, 1980) and highly utilized (Abebe, 2003; Kumera, 2005). Therefore, the purpose of this study was to record the diversity and seasonal abundance of diet items of the African civet from selected coffee forest habitats of the south-western Ethiopia.

Materials and methods

Study area

The study area was Limu Seka district, Oromia regional state, south-west Ethiopia. The district is located between 89°00′ and 98°00′N latitude and between 24°00′ and 30°00′E longitude and covers an area of 1777 km^2 (Fig. 1). The altitude ranges between 1338 and 2200 m asl. The area experiences moderately highland climatic conditions with over 1550 mm average annual rain fall and moderately warm temperature having a mean minimum and maximum annual temperatures of 13.6°C and 26.9°C, respectively (ENMA, 2012). Limu Seka is one of the districts in the south-western part of the country considered as the centre of origin and known to produce Arabica coffee (*Coffea arabica*) (Gole, 2003; Aerts *et al.*, 2011). The district, with over 55% surface forest cover, is among the best forest reserve areas of the country, and the entire forest is managed for coffee production.

The district was selected for this study because most of the previous montane forest has been cleared and replaced by coffee plantation and converted into coffee forest habitat. In such intensively managed coffee forest habitat, few dominant tree species are maintained and provide shade for coffee shrubs.

Methods

Feeding ecology of the African civet in coffee forest habitat was studied using faecal analysis (Sutherland, 2006; Gilmour & Skinner, 2012). Of the 28 farmer associations (FAs) in the district, six (Dame-Gabisa, Koma, Kurana-Lebu, Mirikuz, Lule-Worke and Abe-Gibe) were randomly selected to study civets feeding ecology (Fig. 1). African civets establish permanent latrine sites (civetries) and regularly visit for defecation and scent marking (Ray, 1995; Kingdon, 1997). All civetries within the boundary of each FAs were recovered and recorded. Regardless of the size of the FAs, five representative civetries, from each, were randomly selected and permanently used to collect scat data. The selected civetry was visited every 5-day interval throughout the study period (between December 2012 and March 2013 for the dry, and between July and October 2013, for the wet season). Recently dropped scats (1–2 days old) of adult civets were selectively collected, individually kept in zip-locked plastic bags, air-dried and placed in moisture-free setting until the analysis.

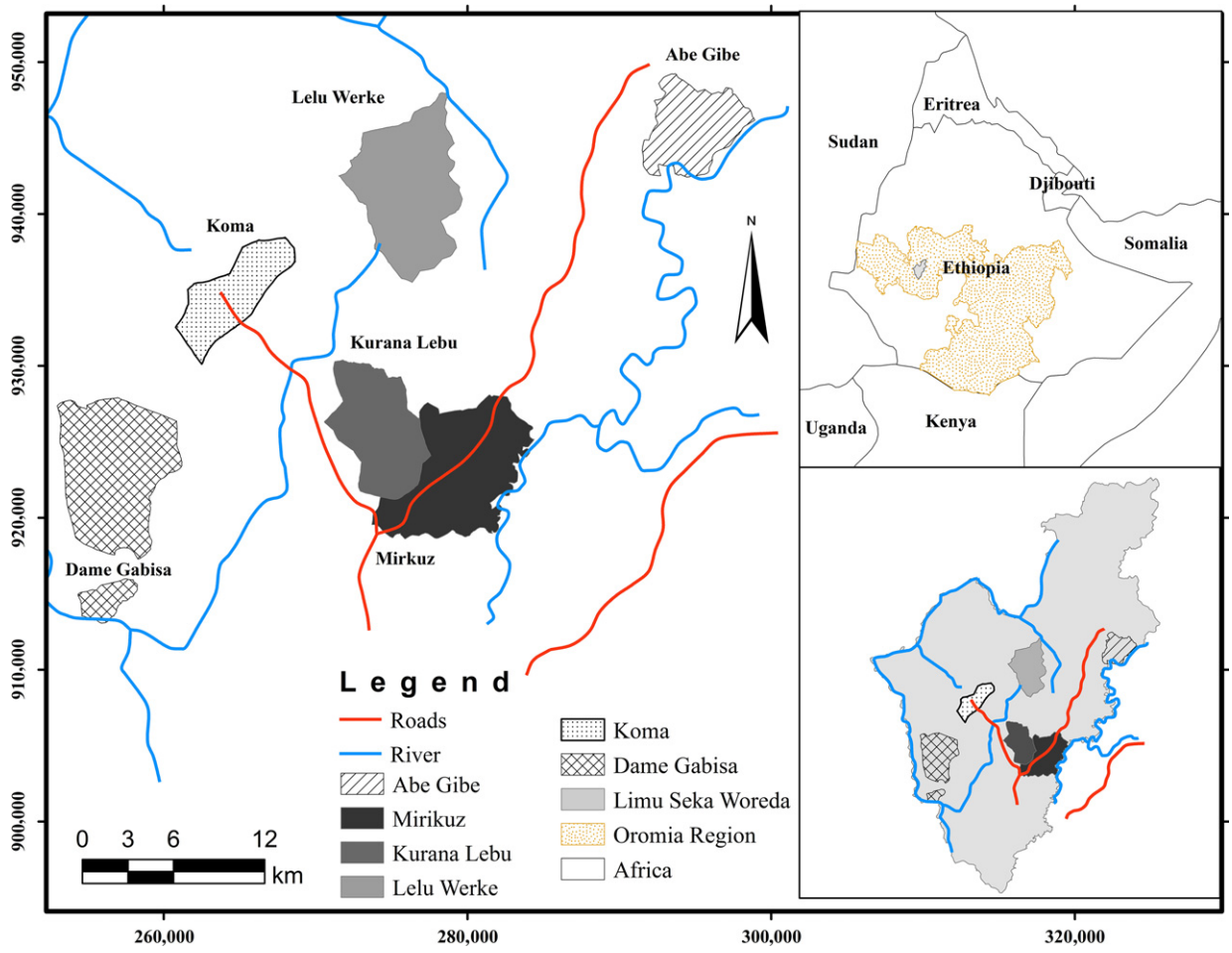

Fig 1 Map of the study area

During the analysis, each scat was crushed by hand, autoclaved and washed on metal sieves with 2, 1 and 0.5 mm mesh size to extract the undigested food remains (Trites & Joy, 2005; Gilmour & Skinner, 2012). The remaining solid food items were oven dried for 48 h at 60°C (Koike, 2009). The dried materials were weighed to the nearest gram. The prey remains were separated (as hairs, feathers, bones, teeth, exoskeleton and appendages of arthropods, egg and snail shells, seeds and other plant parts) and weighed individually to compute for the biomass contributed by the diet item, and hence its relative importance (Vieira & Port, 2007).

Mammalian and avian prey remains were identified to the lowest possible taxon using reference specimens at the Natural History Museum, Addis Ababa University. Field guide for East African mammals (Kingdon, 1997) and birds (Perlo, 1995) were also used. Arthropod remains were identified to order level (Goldenberg *et al.*, 2010). Mammalian remains that were beyond the African civets hunting abilities were all considered carcasses (Kingdon, 1997; Vieira & Port, 2007). In scats, determination of remains of rats and mice to the species level was difficult (Breuer, 2003); hence, they all were merged and quantified as murids. Voucher specimens were prepared to differentiate seeds from the four *Ficus* spp. Plant remains (seed and grasses) were identified to species level in the Herbarium of Jimma and Addis Ababa Universities. Hand lens and compound microscope were used when necessary.

Diets of the African civet were first expressed as percentage frequency of occurrence (%FO). Percent frequency of occurrence (%FO) = number of scats with prey *i*/

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total number of scats (Rex *et al.*, 2010). The importance of the different food items in civet's diet was inferred from the relative biomass contribution of each prey item in a scat (Bacon *et al.*, 2011). Seasonal variations and importance of major diet categories were also evaluated (Goldenberg *et al.*, 2010).

The niche breadth (BA) of the African civet in coffee forest habitats for both seasons was calculated using Levin's equation: $BA = [(1/\sum p_i^2) - 1]/(n - 1)$, where p_i = proportion of occurrence of each food category, and n = number of food categories (Vieira & Port, 2007). Simpson's similarity index (SI) was used to compare food items similarity between seasons (Narendran & Balakrishnan, 2008).

Result

A total of 203 civetries were recorded from the six selected study sites. The 382 sampled scats in two seasons yielded 1874 remains of food items sorted into 55 animal and plant diet species. The recovered food remains were classified into six categories, namely mammals, birds, arthropods, nonarthropod invertebrates, eggs and plants. With the plant-to-animal diet ratio of 1 : 1.36, African civet in the present coffee forest habitat showed omnivorous feeding habits.

The number of food items per scat ranged between one and six (mean ± SD: 3.8 ± 0.23; n = 179) during the wet season and between two and nine (5.79 ± 0.55; n = 203) during the dry season. The relative importance of plant and animal items varied seasonally. During the wet season, 69.1% of the diet biomass was from animal source, while during the dry season, plants (54.3%) contributed slightly more to diet biomass than animals (45.7%). Mammalian prey items contributed the highest (45.4%) to the overall animal diet biomass, of which rodents have the highest share (64.1%).

A good proportion of animal diet biomass comes from birds. Ten bird species were identified from both seasons; however, relatively more diet biomass was recorded from the dry season scats (16.2%) than the wet season scats (13%). Garden chicken contributed over 2% of the dry season animal diet biomass. Insects and nonarthropod invertebrates occurred in 82.6% (wet season) and 64.5% (dry season) civet scats. However, African civets utilized more insect diet during the wet season (27.7%) than the dry season (7.2%), and the difference was statistically significant (F = 29.5, df = 1, $P < 0.001$). Dung beetles (Coleoptera) contributed the highest proportion (84.8% during the wet and 62% dry seasons) of invertebrate diet biomass.

Nineteen plant species contributed about 28.9% and 54.3% of civet diet biomass during the wet and dry seasons, respectively. The relative importance of specific plant items varied between seasons. During the wet season, plant materials occurred in 73.8% of the scats, with single species (garden-raided corn seeds) accounting for 87.5% of the season's plant diet biomass. Similarly, 98% of dry season scats contained plant materials; however, seeds/fruits of six plant species (the four *Ficus* spp., *Cordia africana* and *C. arabica*) contributed over 85% of plant diet biomass. Of these, seeds of *C. africana* contributed 36.4%, fruits of the four *Ficus* spp. 35.5% and coffee berries contributed 28.1% (Table 1).

Six grass species contributed about 3.3% overall diet biomass; however, two (*Panicum maximum* and *Berchemia discolor*) contributed the largest (75.5%). About 1.8% (wet) and 1.3% (dry) seasons scat biomass were from nonfood items. The items include mud (clay), plastic and rubber materials, fabrics, cartons and papers, ceramic and metallic materials. Niche breadth analysis showed that in coffee forest habitat, African civet exhibited generalist feeding habits during the dry season (BA = 0.87) and moderately specialist feeding habits during the wet season (BA = 0.46), favouring animal diets. Seventy-three per cent of prey species were similar between seasons.

Discussion

The omnivorous feeding habits of the African civet from the western and southern Africa have been reported

Table 1 Summary of the % frequency of occurrence and % biomass contribution of different items in the food of the African civet

	Wet		Dry	
Food items	%FO	% Biomass	%FO	% Biomass
Animals	98.8	69.1	97	44.4
Mammals	56.9	25.3	66	20.1
Birds	22.9	13.2	37.9	16.2
Insects + other inv.	82.6	27.7	64.5	7.2
Eggs	20.6	2.8	13	0.8
Reptiles	–	–	3.4	0.2
Plants	73.8	28.9	98.2	54.3
Nonfood items	15.0	2.0	33.5	1.3

(Skinner & Smithers, 1990; Ray, 1995; Kingdon, 1997). Wild fruits, insects, rodents and carrion were food items used by the species in the above stated regions (Kingdon, 1977; Ray, 1995). Bekele, Afework & Balakrishnan (2008) reported feeding ecology of the African civet in natural forest, central Ethiopia. This is the first report on the detailed assessment of feeding habits of the species in the coffee forest habitats of south-western Ethiopia.

In the coffee forest habitats, the dense coffee shrubs form the second layer. The canopy is formed by few characteristic shade tree species (Gole, 2003). The floor is covered by different species of herbs that are annually cleared to ease coffee harvesting. In the coffee forest habitat, African civets have wider alternative food items shifting from one to the other based on the seasonal availability. In some instances, specific identification of items in scats become difficult in which case some prey items were merged. For instance, all rats and mice were collectively named Murids and all snail species called Molluscs. However, for the recorded list of prey species, the present coffee forest habitat was very high relative to earlier reports from different habitats (Skinner & Smithers, 1990; Reynolds & Aebiscer, 1991; Bekele, Afework & Balakrishnan, 2008).

Civet diet contained both plant and animal prey during both seasons. However, animal diet was more important during the wet season (69.1% diet biomass) and plants (54.3%) during the dry season. Shifting diets seasonally, as a result of availability and abundance of food items, is a common behaviour of animals (Giannatos *et al.*, 2009). Reports show that some mammals, such as primates, are difficult to hunt particularly for ground-dwelling prey (Breuer, 2003). The other principle states that predators prefer to hunt prey smaller than their own size. During this study, however, preys of both categories were recovered from scats of the African civets. Remains of three species of primates and large prey such as adult antelopes and species from Suidae were commonly recovered from scats of both seasons. These were probably scavenged not hunted. This evidence confirms former reports that state the African civets as reputed carrion and carcass scavengers (Randall, 1977; Skinner & Smithers, 1990).

With over 22% and 37% occurrence, birds significantly contributed to the wet and dry season civet diet, respectively. Chickens and two ground nesting birds, Guinea fowls (*Numida meleagris)* and Francolins (*Francolinus* sp.), were most hunted by civets during both seasons. Civets were reported to raid chicken coops (Kingdon, 1977; Ray, 1995).

The majority of the invertebrate diet biomass was contributed from beetles (coleopterans). Beetles and other insects are protein rich and easily available prey for any age and sized predators to subsist on (Louw & Seely, 1982; Goldenberg *et al.*, 2010). Remains of beetles were the major component of scats from juvenile civets (T. Habtamu & A. Bekele, personal observation).

In coffee forest habitat, wet season is not a fruiting season. As a result, scats of the season contained more animal remains. The highest plant diet biomass for the season was from garden-raided corn seeds. Reports also showed that they are notorious garden raiders (Kingdon, 1977; Ray, 1995). In the present study area, however, they were not considered vermin and are not targeted for retaliation because of their medicinally valued musk. Local farmers collected the scent marked musk from the field and used as a medicine to cure several ailments (Abebe, 2003; Kumera, 2005).

In coffee forest habitat, dry season is a fruiting season for most fruit/seed plant which created more diversified diet alternatives for the African civets. During this season, civets showed more generalist feeding habit with a higher niche breadth (BA = 0.87) relative to the moderately specialist behaviour during the wet season (BA = 0.46). Such tendencies of seasonal diet specialty are common among different carnivores (Giannatos *et al.*, 2009; Rex *et al.*, 2010).

The bulk (44.9%) of the African civet's dry season plant diet, during this study, came from six plant species. These are fruit/seed plants selectively maintained in the habitat to provide shade for coffee shrubs. In the present study area, *C. africana* rips early and serve as a major diet component of the season (31.1% plant diet biomass). The four *Ficus* species (*Ficus vasta, Ficus sur, Ficus sycomorus* and *Ficus vallis*) sequentially ripe and form the second most used diet component of the season (30.2% plant diet biomass). With 23.9% plant diet biomass contribution, coffee berries (*C. arabica*) were the third most important fruit for the dry season. After digesting the fleshy part, civets excreted coffee beans in their scats. Coffee farmers in the study area believe that coffee beans excreted in scats are the tastiest product collected for human consumption. Marcone (2004) confirmed that civet coffee from the African civets has similar components, taste and flavour with that of the Indonesian civet coffee (Kopi-Luwak). Kopi-Luwak (civet coffee), coffee processed in the gastrointestinal tracts of the Asian palm civet, *Paradoxurus hermaphrodites*, is the tastiest and most expensive coffee ever known to man and recently

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categorized under the biological niche commodity (BNC) (Waroux & Lambin, 2012). In addition to the medicinally valued musk, this special behaviour of African civet increases its importance in coffee forest areas, hence contributing for its conservation.

Maintaining civets in captivity and extracting musk for traditional and commercial purpose was an old tradition by Ethiopian farmers. On the other hand, there was no tradition of breeding civets in captivity; hence, all civets on farm are trapped from the wild (Abebe, 2003). Currently, this tradition persists and maintained only in some southwestern coffee-producing districts of Ethiopia (Mesfin, 1995; Kumera, 2005). Coffee forest ecosystem may favour the abundance of civets, hence accessible for trapping and stocking farms.

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