

First report of the thick-tailed bushbaby (*Otolemur crassicaudatus*) being preyed upon by an endemic carnivore (*Caracal caracal*) in South Africa

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Abstract

To date, there have been few published reports of *Caracal* spp. (or other non-domestic carnivores) preying upon nocturnal strepsirrhine primates anywhere in continental Africa. However, in South Africa, most studies of caracal diet have been conducted outside of the known geographic range of South Africa's nocturnal primates. Here we report *Otolemur crassicaudatus* (the greater or thick-tailed bushbaby/galago) remains recovered from the stomach of a caracal, collected in Limpopo province, South Africa, in 2018, which included portions of the limbs, tail, skull and dentition, allowing confident taxonomic assignment. Sixty-seven carnivores (equal in size or larger than *O. crassicaudatus*), including one other caracal, also had stomach contents examined between 2012 and 2019 in northern South Africa. None included *O. crassicaudatus* remains, making this the first documented example of this non-human primate species being preyed upon by an endemic carnivore; kills of *O. crassicaudatus* by domestic dogs, though not being consumed, have previously been documented. These data expand the knowledge of the diet of caracal in southern Africa and may signal an expanding caracal dietary regime and possible behavioural changes in *O. crassicaudatus*, such as increased terrestrial movement, with increasing human actions and reduction of endemic forests and habitats.

Keywords: caracal, conservation, predation

The thick-tailed bushbaby (or often galago), *Otolemur crassicaudatus*, is a nocturnal strepsirrhine primate with a wide geographic range throughout forested areas in Sub-Saharan Africa, ranging east to Kenya, west to Angola and south to northern areas of South Africa (e.g. Nekaris and Bearder 2011; Masters and Génin 2016). Due in part to its presence in popular tourist areas, such as rest camps in the Kruger National Park in South Africa and even in more urban areas, this species is often viewed as ubiquitous and currently has an IUCN Red List rating of Least Concern (Masters and Génin 2016; Cuozzo et al. 2020). However, given the many and increasing human-induced threats to this (and other) lesser-studied non-human primate (NHPs) species (Van der Ree et al. 2015), this rating has recently been questioned (Cuozzo et al. 2020). This species has a varied diet, with adults being sexually dimorphic in body mass, ranging in size from slightly less than one kilogram, to near one and a half kilograms for the largest males (Nekaris and Bearder 2011). *Otolemur* spp. is often described as an arboreal 'walker and runner' (Crompton 1984; Fleagle 2013), but based on recent field observations (Cuozzo et al. 2020) this species does come to the ground to feed and more importantly, to move between forest patches, including crossing roads in northern South Africa (Cuozzo et al. 2020). *O. crassicaudatus* has received limited attention, since initial studies in the 1970s and 1980s (e.g. Bearder 1974; Harcourt 1980; Masters et al. 1988; see comments in Masters and Génin 2016), especially when compared

with other strepsirrhine primates, such as Madagascar's lemurs.

The caracal (*Caracal caracal*) has a wide geographic range in continental Africa and southwestern Asia (Marker and Dickman 2005; Thorn et al. 2011; Avgan et al. 2016; Avenant et al. 2016; Jones 2016). Although on the verge of extirpation in many areas of Southwest Asia (Avgan et al. 2016), within South Africa, this felid is often viewed as a pest or as vermin, often killing, or perceived to be killing, domestic animals, including pets and is commonly killed by ranchers and farmers (Stuart 1982; Davies 1999; Bothma 2012; Du Plessis et al. 2015; Avenant et al. 2016; Jansen 2016; Kerley et al. 2017; Pirie et al. 2017; Jansen et al. 2019; Natrass and O'Riain 2020). As the largest of Africa's 'small' carnivores, caracals are important members of varied ecological communities and are one of the last remaining (non-extirpated) wild felids in many areas of southern Africa (e.g. Jansen et al. 2019). Caracals have a body mass range of 13–19 kg (Nowak 1991). They prey on a variety of other organisms, often focusing on birds and small mammals, such as rodents, but are also known to prey upon ungulates up to 50 kg (e.g. Viljoen and Davis 1973; Stoddard 1979; Grobler 1981; Palmer and Fairall 1988; Avenant and Nel 2002; Melville et al. 2004; Jansen et al. 2019). Largely because of its relatively common occurrence in Sub-Saharan Africa, this species has a current IUCN rating of Least Concern (Avgan et al. 2016; Avenant et al. 2016). Although the diet of the caracal has been studied in detail for several decades in South Africa (e.g. Viljoen and Davis 1973; Stoddard 1979; Grobler 1981; Palmer and Fairall 1988; Avenant and Nel 2002; Melville and Bothma 2006; Braczkowski et al. 2012) there are no reports of caracals preying upon any strepsirrhine primates. This may reflect a spatial bias in caracal dietary studies, with most detailed research occurring outside the distributional range of the thick-tailed bushbaby (e.g. Du Plessis et al. 2015).

However, there are reports of caracals preying on vervet monkeys in terrestrial habitats in the Eastern Cape province of South Africa (Ducheminsky et al. 2014), a rarely documented example of caracals preying upon South African non-human primates.

Here we present the first empirical evidence (to our knowledge) of the likely predation and consumption of *Otolemur crassicaudatus* by the common caracal.

In April 2018, a caracal was culled from a farm, assumed to be a predator of livestock, in the Louis-Trichardt/Vivo, R522 corridor in northern Limpopo province, South Africa. Collection of data from deceased animals is permitted under permit number ZA/LP/87586 through the Department of Limpopo Development, Environment & Tourism (LEDET). All new data reported here on living *O. crassicaudatus* were collected with permission of the Lajuma Research Centre, with permit NZG/RES/P/001/F/08 submitted with assistance of the National Zoological Gardens of South Africa (SANBI) and with IACUC approval by the University of Colorado-Boulder (USA) (Protocol Number 2510).

Remains from this adult caracal were transported to the University of Limpopo Parasitology Laboratory (near Polokwane) under cold conditions and examined. The examination of the stomach contents of the necropsied caracal was performed according to Grafton (1965) and Bothma (1966, 1971). However, the stomach contents were received frozen and not in formalin. Visual appraisal of the defrosted contents was followed by a thorough wash through a sieve and items (e.g. bones, hair and insect parts) were separated for further identification under a Leica ® stereomicroscope.



Figure 1: Remains of *Otolemur crassicaudatus* collected from the stomach contents of a common caracal: (a) partial skull and mandible retaining portions of the dentition, including the toothcomb; (b) portion of the tail; (c) right forelimb; (d) left forelimb; (e) right hind limb. Scale in cm. Diagnostic features of *Otolemur crassicaudatus* visible in this image include the jaw and tooth comb (a), grasping first digits on the hands and feet (c, d and e) and the grooming claw on the second digit of the left foot (e)

The remains of a partially digested *O. crassicaudatus* were recovered (Figure 1), among other prey items (e.g. unidentified avian components). These remains include a partial skull and articulated mandible, the left and right forelimbs, the right hindlimb, the distal portion of the tail and several other fragments. Limb size, digit structure (specifically the grasping first digit) and dental maturity (e.g. Cuozzo 2016) indicate an adult *O. crassicaudatus*. The presence of an intact toothcomb also indicates an adult strepsirrhine primate (e.g. Cuozzo 2016). The only other endemic strepsirrhine primate in this region of southern Africa is *Galago moholi*, the southern lesser galago, adults of which are approximately one tenth the size of *O. crassicaudatus* (e.g. Nekaris and Bearder 2011; Fleagle 2013). These remains, particularly the size of the limbs, structure of the digits, as well as portions of the dentition,

such as the toothcomb, were therefore intact enough to make a confident age and taxonomic identification. For broader comparison, Table 1 lists 67 instances of new unpublished data on the stomach contents of endemic carnivores similar in size to, or larger than *O. crassicaudatus* (including one additional caracal) from the Limpopo and Mpumalanga provinces of South Africa. These stomach contents were examined following the methods described herein between 2012 and 2019 and contained no evidence of the predation of *O. crassicaudatus* by this varied predator guild. Analysis of stomach contents alone does not preclude that the remains of this *O. crassicaudatus* were scavenged. However, literature on caracal diet suggests that this felid rarely scavenges (e.g. Minnie et al. 2018), therefore increasing the probability that it was attacked and killed. In addition, there was an absence of fly larvae and other maggots in the stomach contents, which supports the inference of predation, rather than scavenging.

Table 1: New unpublished data collected by two of the co-authors on the stomach contents of endemic carnivores (n = 67) similar in size to, or larger than *O. crassicaudatus* collected between 2012 and 2019 from the Limpopo and Mpumalanga provinces of South Africa. No evidence of the predation of *O. crassicaudatus* by this varied predator guild was noted. Table does not include the caracal described herein

Order/Family	Species	Common Name	Location	Sample Number
Carnivora/Canidae	<i>Canis mesomelas</i>	Black-backed Jackal	Limpopo province	6
Carnivora/Canidae	<i>Otocyon megalotis</i>	Bat-eared Fox	Limpopo province	1
Carnivora/Canidae	<i>Vulpes chama</i>	Cape Fox	Mpumalanga province	1
Carnivora/Felidae	<i>Caracal caracal</i>	Caracal	Limpopo province	1
Carnivora/Felidae	<i>Felis silvestris lybica</i>	African Wildcat	Limpopo province	1
Carnivora/Felidae	<i>Leptailurus serval</i>	Serval	Mpumalanga province	8
Carnivora/Felidae	<i>Panthera leo</i>	Lion	Mpumalanga province	4
Carnivora/Felidae	<i>Panthera pardus</i>	Leopard	Mpumalanga province	3
Carnivora/Herpestidae	<i>Ichneumia albicauda</i>	White-tailed Mongoose	Limpopo province	12
Carnivora/Hyaenidae	<i>Crocuta crocuta</i>	Spotted Hyena	Mpumalanga province	4
Carnivora/Hyaenidae	<i>Proteles cristata</i>	Aardwolf	Limpopo province; Mpumalanga province	2
Carnivora/Mustelidae	<i>Mellivora capensis</i>	Honey Badger	Limpopo province	2
Carnivora/Viverridae	<i>Civettictis civetta</i>	African Civet	Limpopo province	8
Carnivora/Viverridae	<i>Genetta genetta</i>	Small-spotted Genet	Limpopo province	4
Carnivora/Viverridae	<i>Genetta maculata</i>	Rusty-spotted Genet	Limpopo province	10

Non-human primates (NHPs) are important components of many ecological communities, including being both predator and prey (e.g. Miller 2002). Predation of strepsirrhine primates by endemic carnivores (and some omnivores) is often assumed to be common throughout these primate's ranges. However, Bearder (2007) noted it is rare to document predation on larger bodied nocturnal NHPs. Although a likely target of predation by various organisms, known incidents of predation on *Otolemur* spp. (including the sister taxon of *O. crassicaudatus*, *O. garnetti*) are limited in the literature. Burnham et al. (2012) and Svensson et al. (2018) noted that for nocturnal primates in general, nocturnality and sleeping site selection may preclude, or at least function to deter, predation. Nash (1983), Crompton (1984) and Bearder (2007) noted that *Otolemur* spp. may fall prey to birds of prey, such as owls, as well as snakes and carnivores, such as leopards, jackals and genets. On continental Africa, strepsirrhine primates including *O. crassicaudatus* and *Galago senegalensis*, are also known to be killed and consumed by common chimpanzees (*Pan troglodytes* [e.g. Nishida et al. 1979, Uehara 1997; Pruetz and Bertolani 2007]). One report (Ososky 1998) notes the predation of the dwarf galago (*Galagoides*) by the African golden cat (*Caracal aurata*) in the Congo Basin. It is therefore not a surprise that terrestrial carnivores, like the caracal, would prey on a greater galago, especially because *O.*

crassicaudatus falls within the size range of known caracal prey (e.g. Drouilly et al. 2018; Jansen et al. 2019; Minnie et al. 2018; Veals et al. 2020). The caracal's random foraging strategy, i.e. consuming prey within its range when prey abundance is low (e.g. Minnie et al. 2018), may have facilitated the consumption of an animal novel to its dietary regime. The human-altered habitat in which this caracal was ranging (i.e. farmland) may further explain the consumption of *O. crassicaudatus* given that the disruption of forests has also likely altered the movements of the thick-tailed bushbaby (Cuozzo et al. 2020).

The presence of a partial skull and mandible, forelimbs and hands and feet suggest that the caracal had taken this *O. crassicaudatus* in total, consuming the entire animal. As noted above, scavenging was unlikely, because caracals rarely scavenge (e.g. Minnie et al. 2018). That the entire individual was likely consumed, based on the remains recovered also strongly suggest predation, because an *O. crassicaudatus* that had been previously killed (or had otherwise died) would likely have been only partially intact, having probably been scavenged upon its death by a varied group of known scavengers, such as birds, rodents, reptiles and even smaller carnivores (Moleón and Sánchez-Zapata 2015).

In addition to expanding our knowledge of caracal diet in southern Africa and broadening the known diversity of *O. crassicaudatus* predators, the information we report herein suggests that the caracal is preying upon species not previously recorded. There may be a number of reasons behind this. First, increased habitat loss and urbanisation may be forcing the caracal to prey upon a wider variety of taxa than has been previously recorded, for example domestic cats (Nattrass and O'Riain 2020). This seems especially likely, given the caracal's ability to switch prey in response to both spatial and temporal resource fluctuations (e.g. Minnie et al. 2018). Second, whereas *Otolemur* spp. are usually described as arboreal 'walkers and runners' (e.g. Fleagle 2013) they are known to move terrestrially, at least at times. During our recent eleven-month study at the Lajuma Research Centre, Limpopo province, South Africa, in the same general region where the caracal described herein was collected, *O. crassicaudatus* was observed moving on the ground three times across 78 nights of behavioural observation (unpublished data). The Lajuma Research Centre is an intact forested habitat, suggesting only occasional ground movement in intact habitats. In contrast, in more disturbed areas, such as farmland where the caracal described herein was recovered and in more developed areas, *O. crassicaudatus* may be more terrestrial. Indeed, they have been frequently observed to fall victim to moving vehicles, along both primary and secondary roads, in areas where the habitat is much more disturbed (e.g. Cuozzo et al. 2020). It is therefore likely that *O. crassicaudatus* is more frequently coming to the ground in areas of disturbed habitat, which creates the potential for caracals to prey upon this species, because caracals are known to be effective terrestrial hunters (e.g. Viljoen and Davis 1973; Stoddard 1979; Grobler 1981; Brackowski et al. 2012; Du Plessis et al. 2015; Avenant et al. 2016; Minnie et al. 2018; Jansen et al. 2019; Veals et al. 2020).

Similar to Du Plessis et al. (2015), our data suggest the necessity to more fully assess caracal diet in areas aside from western South Africa's dry regions, including more forested and degraded habitats in the north and northeast. Such research may signal that the predation of bushbabies reported here is not a rare event. The data presented herein broaden our knowledge of the diet of the caracal, as well as the potential predators of a vastly understudied non-human primate.

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