African golden cat and serval in forest-savannah transitions in Cameroon

Short running title: African golden cat and serval in Cameroon

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Introduction

African golden cats (*Caracal aurata* Temminck, 1827; hereafter, 'golden cat') occur in the forests and forest-savannah mosaics (hereafter, 'FSM') of West and Central Africa (Bahaa-el-din *et al*., 2015). Another medium-sized wild felid, the serval (*Leptailurus* [*Caracal*] *serval* Schreber, 1776) occurs in well-watered savannah and long-grass environments that are widespread across sub-Saharan Africa (Fig. 1a; Thiel, 2019). Golden cats and servals are closely-related felids (Johnson *et al*., 2006), deriving from a common ancestor approximately 5.4 million years ago (O'Brien & Johnson, 2007). They are known to be sympatric only within a small portion of their collective geographic range, including in the Central African Republic (Hickisch & Aebischer, 2013), in the FSM of the western Congo Basin (Henschel *et al*., 2014), and in Uganda (Mills *et al*., 2019).

Within the forest zone of Cameroon, camera-trap surveys have provided evidence of the golden cat in Mpem et Djim National Park (hereafter, 'MDNP') (Simo *et al*., 2019), Mbam et Djerem National Park (Mouafo *et al*. in prep), and the Dja Faunal Reserve (Bruce *et al*., 2018ab). Serval are restricted to the northern part of Cameroon on the current IUCN

range map (Thiel, 2019). In Northwest Cameroon, however, hunters of the Kilum-Ijim area state that the serval is still present in the region (Maisels *et al*., 2001). Here, we use camera-traps to provide the first record of the serval in Deng-Deng National Park (DDNP) and the co-occurrence of the serval and the golden cat in MDNP, Cameroon. This is a new locality for co-occurrence and a range extension for the serval. Co-occurring species of caracal lineage are rare and considered a notable record (Henschel *et al*., 2014; Hickisch & Aebischer, 2013).

Method

Study area

Deng-Deng National Park [5°-5° 25' N, 13°- 23° 34' E; 682 km^2; average altitude: 703 m)] and Mpem et Djim National Park [5°-5°20' N, 11°30'-12° E; 975 km^2; average altitude: 640 m)] are located in the East and Centre Regions of Cameroon, respectively (Fig. 1b). Both protected areas (PAs) are located in the Northern Congolian forest-savanna mosaic (FSM) that lies between the equatorial Congolian forests to the south and the drier East Sudanian savannah to the north (Dinerstein *et al*., 2017). They are roughly situated at the same latitude and support a mosaic of closed-canopy forest, savannah grasslands, and gallery forests that are home to both forest and savannah-dwelling species. MDNP may host at least 76 mammal species representing 58% of the mammal species estimated from Cameroon (MINFOF, 2011). These include larger terrestrial vertebrates such as aardvark (*Orycteropus afer*), chimpanzee (*Pan troglodytes*), African forest elephant (*Loxodonta cyclotis*), African forest buffalo (*Syncerus caffer nanus*), giant pangolin (*Smutsia gigantea*), and golden cat (*C. aurata*) (Simo *et al*., 2019). A recent survey confirmed the presence of lion (*Panthera leo*) in the vicinity of this protected area (Kirsten *et al*., 2020). Two leopard (*Panthera pardus*) pelts were seized in 2016 at a checkpoint around the MDNP (Bissek Jean Pierre, pers. comm.). However, there was no direct evidence that the leopards were hunted inside the PA. In DDNP, 40 mammal species have been recorded (Diangha, 2015), including chimpanzee (*Pan troglodytes*), African forest elephant (*Loxodonta cyclotis*), buffalo (*Syncerus caffer nanus*), bay duiker (*Cephalophus dorsalis*), bongo (*Tragelaphus eurycerus*), and the most northern population of the western lowland gorilla (*Gorilla gorilla*) (Fotso *et al*., 2002; Maisel *et al*., 2010). Past surveys all relied on transect sampling. Camera-trap surveys often document species that are difficult to survey through transects (Bruce *et al*., 2018a).

Camera-trapping

We surveyed the forest and the FSM of DDNP and MDNP (Figs. 1c and 1f) between 2018 and 2020 using camera traps (see Table 1 for details on survey periods and efforts). Our survey was designed to monitor pangolin presence and behaviour (see Simo *et al*., 2020). For this purpose, camera-traps were set at sites where pangolin were thought to be active based on feeding signs, scat, and burrows. The cameras were spaced from 200 to 1,200 m apart. All the camera-traps were set at a distance of c. 4 m from the activity sign and

programmed to take three images per trigger event day and night with the lowest delay available between triggers according to each camera-trap model (zero seconds for Cuddeback and one or two seconds for Bushnell and Moultrie, respectively). All other settings were set at default. Cameras were strapped to trees or stakes at a height of 30-45 cm above the ground level suitable for smaller- to medium-sized terrestrial mammals (Amin *et al*. 2015; Bruce *et al*., 2018ab). The camera-trap models used for the surveys in both PAs include Cuddeback X Change Colour Model 1279, Cuddeback Long Range IR E2, Moultrie 30i, Bushnell Trophy Camera 119836, and Bushnell Trophy Cam HD 119875C.

Results

Of the two sites we surveyed in DDNP, only one yielded records of servals (2 records out of a total of 2,196 trapping days), and we found no evidence of golden cats at either site (of a total of 4,167 trapping days). One serval was recorded in grassland-savannah habitat while the other was recorded in woodland-savannah (Fig. 1d). None were recorded in the dense forest (Fig. 1e). These represent the first camera trap records of servals in the area and extend the recognised IUCN distribution by approximately 186 km southward (Thiel, 2019; Fig. 1b).

Both golden cats and servals were recorded in MDNP. Golden cats were recorded twice in the FSM (out of a total of 1,363 trapping days; Fig. 1g) and nine times in the dense forest area (out of a total of 5,148 trapping days; Fig. 1h). Servals were recorded twice in the FSM and not at all in the dense forest. Golden cats and servals were never recorded at the same station, and records of the serval were situated between 1.74 km to 5.38 km from where the first and second golden cat events were recorded. Both habitat types yielded similar capture rates for golden cats and servals (Table 1).

Of the two PAs that we surveyed, records of servals occurred during daytime (09:31 AM) and during night-time (01:25 AM) in DDNP, while in MDNP, all serval detections were recorded at night. Camera-trap captures for golden cats suggest a diurnal activity pattern in MDNP.

Differences in coat pattern suggest that the two servals recorded in MDNP were different individuals. The golden cat pelage recorded over the forest and savannah appears greyish brown with some black spotting on the belly and on the undersides of the front and back legs (Fig. 2ac). Servals photographed in DDNP and MDNP were of the “serval” morph (Kingdon *et al*., 2013) where the coat appears as yellowish tan with heavy black spots, bands, and stripes (see Fig. 2bd).

Discussion

Our study recorded the serval outside of their current known range and we obtained new locality records for the golden cat. Most notable was the records of these two felids in MDNP. This is a rare case of recorded serval/golden cat co-occurrence with only few sites

of co-occurrence known, such as at Odzala-Kokoua National Park (hereafter, OKNP) in the northern Republic of Congo (Henschel *et al*., 2014), the Chinko/Mbari drainage basin of eastern Central African Republic (Hickisch & Aebischer, 2013), the Batéké Plateau National Park in Gabon (Bout, 2006 as cited in Pearson *et al*., 2007), and the Kibale National Park in south-western Uganda (Mills *et al*., 2019). Each of these localities supports forest-savannah mosaics, a likely habitat type for co-occurrence of these two habitat specialist species.

Our detection rate of both felids was relatively low, perhaps as a result of our study design being focused on documenting the occurrence of pangolins at sites with pangolin signs. Captures of serval all occurred at camera-trap sites established to monitor suspected giant pangolin/aardvark burrows. Serval often rest in abandoned burrows during hot hours of the day and some young are born in these burrows (Thiel, 2011). Serval may also avoid game trails when there are other competitive carnivores in the area (Bohm & Hofer, 2018). Our current effort did not record golden cat in DDNP. Previous reports of golden cat and serval presence in DDNP and MDNP have been raised by local people during environmental impact studies prior to creation of these protected areas (MINFOF, 2011; EDC, 2011). The serval was missed in DDNP during the first survey and only recorded during the second. Future surveys may determine if the observed servals are resident individuals or long-distance dispersers.

Habitat partitioning

Golden cats prefer forest (Bahaa-el-din *et al*., 2015) while servals prefer savannah (Thiel, 2019). Both species were recorded in the FSM of MDNP, but no camera stations recorded both species. We recorded the golden cat and the serval at camera-trap stations separated by 1.74 km and27 days apart. Both species have been recorded at the same camera-trap site in the FSM of OKNP in Republic of Congo (Henschel *et al*., 2014), but no information is given on the number of days that separate these records. No servals were recorded in forested areas of either PA during our study despite serval being documented in dense forests along waterways elsewhere (Thiel, 2019). Both felid species largely prey on rodents (Bahaa-el-din *et al*., 2015; Thiel, 2019), although the golden cat has been found to consume small- to medium-sized duikers and arboreal primates (Bahaa-el-din *et al*., 2015). The golden cat, like the serval and the caracal (*Caracal caracal*), may be able to catch flying birds (Bahaa-el-din *et al*., 2012), suggesting partial overlap in diet. However, servals may specialise their diet on small prey species, thereby reducing interspecific competition with golden cats and other carnivores (Geertsema, 1984, cited by Bout, 2011).

Activity pattern

The low number of our records makes it difficult to discern activity patterns of each species with confidence. Servals were recorded during both day and night at DDNP while only at night in MDNP. Bohm and Hofer (2018) observed a difference between male and female serval in their activity period in OKNP, with males being predominantly active during the night and females during the day. We recorded 13 events of golden cat in this study and they all occurred during the day. The golden cat has been described as

primarily crepuscular or nocturnal (Kingdon *et al*., 2013), but shows no strong affinity for either daytime or night time hours in some studies (e.g. Bahaa-el-din *et al*., 2015). Alves and colleagues (2017) suggest that the golden cat is cathemeral with a highly flexible activity pattern whereby individuals can adapt to ecological conditions. They also feed on both diurnal and nocturnal species. Golden cat activity is particularly affected by presence of leopard (*Panthera pardus*) (Bahaa-el-din *et al*., 2016) that are known to prey on golden cat (Bahaa-el-din *et al*., 2015; Henschel *et al*., 2005; Henschel & Ray, 2003). Where leopards are uncommon, golden cats may time activity to coincide with larger, diurnal prey species like duikers and monkeys. Though records of golden cats and servals were temporally separated in MDNP, additional records are needed to better understand activity patterns and interspecific interactions. Both golden cats and servals are reported to co-occur in Uganda with a moderate overlap of 50% of their core activity period (Mills *et al*., 2019).

Colour Morphs

We recorded only the grey morph of the golden cat in MDNP. The coats of golden cats are polymorphic with large intergradation and variation between morphs within local populations (Bahaa-el-din *et al*., 2015). Populations with only a single colour morph are unusual. The greyish and the golden/reddish brown are the predominant colour form of the species (Bahaa-el-din *et al*., 2015). The "gold/red" and melanistic morphs are frequent in Bwindi Impenetrable National Park, Uganda (Mugerwa *et al*., 2013). While early observations mentioned the "grey" morph to be the most common form in Uganda (Pitman, 1949, cited by van Mensch & van Bree 1969), more recent observations suggest the "grey" morph to be the rarest morph (B. Mugerwa pers. comm.). The gold/red and grey morphs are thought to be equally represented throughout the species range based on skins and camera-trap photos, with few variations across localities (Bahaa-el-din *et al*., 2015). This observation has been corroborated using individual identification in Kibale National Park in Uganda, where a gold/red mother golden cat was photographed with a grey kitten. The melanistic morph was not recorded in Kibale, but they do occur in Maramagambo forest (D. Mills, unpublished data). There are even indications that the golden cat may change morphological colour over time. However this has only been observed in one individual and may be associated with a pathological condition (Boy, 2003; Aronsen, 2009; Bahaa-el-din *et al*., 2015). The relative dominance of one morph over another and the reasons behind the variation remains unclear.

Only servals of the "serval" morph with large spots, have been detected in MDNP and DDNP. The "servaline" morph which has small "freckled" spots (Kingdon *et al*., 2013) is present in OKNP, northern Republic of Congo (Henschel *et al*. 2014) and in Kibale grasslands (D. Mills, unpublished data), but is reportedly more common in West Africa (Nowell & Jackson, 1996). A serval cub of "servaline" form has been photographed with a mother of serval form in the Batéké Plateau National Park, Gabon (P. Henschel, unpublished data).

Conservation

Golden cats are considered an indicator for relatively intact forest ecosystems (Bahaa-el-din *et al*., 2016) and the serval the same for the humid savannah biotope (Thiel, 2019). Major threats to golden cats throughout their range include by-catch in snares (Ray *et al.,* 2005; Bahaa-el-din *et al*., 2015; Simo *et al*., 2019), hunting for pelts and bushmeat (Csuti, 2010; Bahaa-el-din *et al*., 2015), habitat loss and degradation (Bahaa-el-din *et al*., 2015), persecution, and depletion of its prey (Nowell & Jackson, 1996).

Despite their habitat dependence, servals have been reported to survive in fairly high human population density areas around farmlands in OKNP (Bohm & Hofer, 2018) and in South Africa (Ramesh & Downs, 2013) and to occur at relatively high densities around industrial sites (Loock *et al*., 2018)—all attributed to a high abundance of rodent prey and an absence of competitor species. Servals' predilection for rodents could even be beneficial to crop farmers. Historically, the serval has been persecuted to local extirpation from much of its range (Stuart, 1985). In recent years, the serval may be moving into previously unoccupied areas as forests are cleared and savannah habitats expand (Ray *et al*., 2005; Stratford *et al.,* 2016; Finerty *et al.,* 2019; Thiel, 2019). Major threats to the serval include loss and degradation of wetland habitat (Thiel, 2011), frequent burning of savannahs, over-grazing by livestock, mortality from snaring, and depletion of prey, such as small mammals and birds (Nowell & Jackson, 1996; Ray *et al*., 2005). The use of rodenticides in farmlands also causes mortality of servals (Ramesh & Downs, 2013).

Around DDNP and MDNP, clearing for cocoa plantations and frequent bushfires by nomadic pastoralists from the Cameroonian northern regions are creating more savannah habitats. These activities may be contributing to human-mediated range expansion of serval. Co-occurrence strategies for these two wild felids remain poorly known. To better understand how these ecologically-similar species co-occur, we recommend additional surveys in DDNP, MDNP, and surrounding areas (e.g., Council forest of Yoko) employing survey methods targeting golden cat and serval. Bahaa-el-din and colleagues (2015) recommend a protocol to maximise photo captures of golden cat by placing camera-traps at c. 25 cm above the ground and 1.5–2.0 m from the edge of abandoned logging roads, skidder tracks, and large game trails, facing at an angle to the track, and spacing cameras 600 to 800 m apart.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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