

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

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3 **Short running title:** African golden cat and serval in Cameroon

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5 Franklin T. Simo¹, Ghislain F. Difouo¹, Sévilor Kekeunou¹, Daniel J. Ingram², Iris Kirsten³,
6 David Olson⁴

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8 1 Laboratory of Zoology, Department of Biology and Animal Physiology,
9 University of Yaoundé I, Yaoundé, Cameroon

10 2 African Forest Ecology Group, Biological and Environmental Sciences,
11 University of Stirling, Stirling, FK9 4LA, United Kingdom

12 3 Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), ProPE
13 Cameroon

14 4 WWF-Hong Kong, 15/F, Manhattan Centre, 8 Kwai Cheong Road, Kwai Chung,
15 NT, Hong Kong SAR

16

17 **Correspondence:** Franklin T. Simo, Laboratory of Zoology, Department of Biology and
18 Animal Physiology, University of Yaoundé I, Yaoundé, Cameroon

19 Email: franklinsimo77@gmail.com

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26

27 Introduction

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

38

39 Within the forest zone of Cameroon, camera-trap surveys have provided evidence of the
40 golden cat in Mpem et Djim National Park (hereafter, 'MDNP') (Simo *et al.*, 2019), Mbam
41 et Djerem National Park (Mouafo *et al.* in prep), and the Dja Faunal Reserve (Bruce *et al.*,
42 2018ab). Serval are restricted to the northern part of Cameroon on the current IUCN

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

50

51 **Method**

52

53 **Study area**

54 Deng-Deng National Park [5°-5° 25' N, 13°- 23° 34' E; 682 km²; average altitude: 703 m]]
55 and Mpem et Djim National Park [5°-5°20' N, 11°30'-12° E; 975 km²; average altitude:
56 640 m]] are located in the East and Centre Regions of Cameroon, respectively (Fig. 1b).
57 Both protected areas (PAs) are located in the Northern Congolian forest-savanna mosaic
58 (FSM) that lies between the equatorial Congolian forests to the south and the drier East
59 Sudanian savannah to the north (Dinerstein *et al.*, 2017). They are roughly situated at the
60 same latitude and support a mosaic of closed-canopy forest, savannah grasslands, and
61 gallery forests that are home to both forest and savannah-dwelling species. MDNP may
62 host at least 76 mammal species representing 58% of the mammal species estimated
63 from Cameroon (MINFOF, 2011). These include larger terrestrial vertebrates such as
64 aardvark (*Orycteropus afer*), chimpanzee (*Pan troglodytes*), African forest elephant
65 (*Loxodonta cyclotis*), African forest buffalo (*Syncerus caffer nanus*), giant pangolin
66 (*Smutsia gigantea*), and golden cat (*C. aurata*) (Simo *et al.*, 2019). A recent survey
67 confirmed the presence of lion (*Panthera leo*) in the vicinity of this protected area
68 (Kirsten *et al.*, 2020). Two leopard (*Panthera pardus*) pelts were seized in 2016 at a
69 checkpoint around the MDNP (Bissek Jean Pierre, pers. comm.). However, there was no
70 direct evidence that the leopards were hunted inside the PA. In DDNP, 40 mammal
71 species have been recorded (Diangha, 2015), including chimpanzee (*Pan troglodytes*),
72 African forest elephant (*Loxodonta cyclotis*), buffalo (*Syncerus caffer nanus*), bay duiker
73 (*Cephalophus dorsalis*), bongo (*Tragelaphus eurycerus*), and the most northern
74 population of the western lowland gorilla (*Gorilla gorilla*) (Fotso *et al.*, 2002; Maisel *et al.*,
75 2010). Past surveys all relied on transect sampling. Camera-trap surveys often document
76 species that are difficult to survey through transects (Bruce *et al.*, 2018a).

77

78

79 **Camera-trapping**

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

86 programmed to take three images per trigger event day and night with the lowest delay
87 available between triggers according to each camera-trap model (zero seconds for
88 Cuddeback and one or two seconds for Bushnell and Moultrie, respectively). All other
89 settings were set at default. Cameras were strapped to trees or stakes at a height of 30-
90 45 cm above the ground level suitable for smaller- to medium-sized terrestrial mammals
91 (Amin *et al.* 2015; Bruce *et al.*, 2018ab). The camera-trap models used for the surveys in
92 both PAs include Cuddeback X Change Colour Model 1279, Cuddeback Long Range IR E2,
93 Moultrie 30i, Bushnell Trophy Camera 119836, and Bushnell Trophy Cam HD 119875C.

94
95

96 **Results**

97 Of the two sites we surveyed in DDNP, only one yielded records of servals (2 records out
98 of a total of 2,196 trapping days), and we found no evidence of golden cats at either site
99 (of a total of 4,167 trapping days). One serval was recorded in grassland-savannah habitat
100 while the other was recorded in woodland-savannah (Fig. 1d). None were recorded in the
101 dense forest (Fig. 1e). These represent the first camera trap records of servals in the area
102 and extend the recognised IUCN distribution by approximately 186 km southward (Thiel,
103 2019; Fig. 1b).

104

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

112

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

117

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

124

125 **Discussion**

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

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

136 Our detection rate of both felids was relatively low, perhaps as a result of our study design
137 being focused on documenting the occurrence of pangolins at sites with pangolin signs.
138 Captures of serval all occurred at camera-trap sites established to monitor suspected
139 giant pangolin/aardvark burrows. Serval often rest in abandoned burrows during hot
140 hours of the day and some young are born in these burrows (Thiel, 2011). Serval may
141 also avoid game trails when there are other competitive carnivores in the area (Bohm &
142 Hofer, 2018). Our current effort did not record golden cat in DDNP. Previous reports of
143 golden cat and serval presence in DDNP and MDNP have been raised by local people
144 during environmental impact studies prior to creation of these protected areas (MINFOF,
145 2011; EDC, 2011). The serval was missed in DDNP during the first survey and only
146 recorded during the second. Future surveys may determine if the observed servals are
147 resident individuals or long-distance dispersers.

148 **Habitat partitioning**

149 Golden cats prefer forest (Bahaa-el-din *et al.*, 2015) while servals prefer savannah (Thiel,
150 2019). Both species were recorded in the FSM of MDNP, but no camera stations recorded
151 both species. We recorded the golden cat and the serval at camera-trap stations separated
152 by 1.74 km and 27 days apart. Both species have been recorded at the same camera-trap
153 site in the FSM of OKNP in Republic of Congo (Henschel *et al.*, 2014), but no information
154 is given on the number of days that separate these records. No servals were recorded in
155 forested areas of either PA during our study despite serval being documented in dense
156 forests along waterways elsewhere (Thiel, 2019). Both felid species largely prey on
157 rodents (Bahaa-el-din *et al.*, 2015; Thiel, 2019), although the golden cat has been found
158 to consume small- to medium-sized duikers and arboreal primates (Bahaa-el-din *et al.*,
159 2015). The golden cat, like the serval and the caracal (*Caracal caracal*), may be able to
160 catch flying birds (Bahaa-el-din *et al.*, 2012), suggesting partial overlap in diet. However,
161 servals may specialise their diet on small prey species, thereby reducing interspecific
162 competition with golden cats and other carnivores (Geertsema, 1984, cited by Bout,
163 2011).

164

165 **Activity pattern**

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

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

185

186 **Colour Morphs**

187 We recorded only the grey morph of the golden cat in MDNP. The coats of golden cats are
188 polymorphic with large intergradation and variation between morphs within local
189 populations (Bahaa-el-din *et al.*, 2015). Populations with only a single colour morph are
190 unusual. The greyish and the golden/reddish brown are the predominant colour form of
191 the species (Bahaa-el-din *et al.*, 2015). The “gold/red” and melanistic morphs are
192 frequent in Bwindi Impenetrable National Park, Uganda (Mugerwa *et al.*, 2013). While
193 early observations mentioned the “grey” morph to be the most common form in Uganda
194 (Pitman, 1949, cited by van Mensch & van Bree 1969), more recent observations suggest
195 the “grey” morph to be the rarest morph (B. Mugerwa pers. comm.). The gold/red and
196 grey morphs are thought to be equally represented throughout the species range based
197 on skins and camera-trap photos, with few variations across localities (Bahaa-el-din *et*
198 *al.*, 2015). This observation has been corroborated using individual identification in
199 Kibale National Park in Uganda, where a gold/red mother golden cat was photographed
200 with a grey kitten. The melanistic morph was not recorded in Kibale, but they do occur in
201 Maramagambo forest (D. Mills, unpublished data). There are even indications that the
202 golden cat may change morphological colour over time. However this has only been
203 observed in one individual and may be associated with a pathological condition (Boy,
204 2003; Aronsen, 2009; Bahaa-el-din *et al.*, 2015). The relative dominance of one morph
205 over another and the reasons behind the variation remains unclear.

206

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

214

215 **Conservation**

216 Golden cats are considered an indicator for relatively intact forest ecosystems (Bahaa-el-
217 din *et al.*, 2016) and the serval the same for the humid savannah biotope (Thiel, 2019).
218 Major threats to golden cats throughout their range include by-catch in snares (Ray *et al.*,
219 2005; Bahaa-el-din *et al.*, 2015; Simo *et al.*, 2019), hunting for pelts and bushmeat (Csuti,
220 2010; Bahaa-el-din *et al.*, 2015), habitat loss and degradation (Bahaa-el-din *et al.*, 2015),
221 persecution, and depletion of its prey (Nowell & Jackson, 1996).

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

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

246

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261

262 **Declaration of Conflicting Interests**

263 The author(s) declared no potential conflicts of interest with respect to the research,
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265 **Data availability statement**

266 The data that support the findings of this study are available from the corresponding
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268

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