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COMMUNICATION

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POPULATION DYNAMICS OF MEDIUM AND LARGE MAMMALS IN A WEST AFRICAN GALLERY FOREST AREA AND THE POTENTIAL EFFECTS OF POACHING

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Abstract: Few studies are available on the population dynamics of medium and large mammals in gallery forests of the Sudan and Sahel regions of West Africa. Line-transect studies of the abundance (estimated by KIA) of nine species of ungulates and three species of primates were carried out between 2004 and 2013 in the Comoé-Leraba protected area of Burkina Faso, West Africa. No peer-reviewed study of population sizes of mammals in this protected area has been published, making the data presented of special relevance. Population size trends varied significantly across years in both primates and ungulates, with some species (*Papio anubis*, *Phacochoerus africanus*, *Alcelaphus busephalus* and *Tragelaphus scriptus*) decreasing consistently. Significant relationships were observed between poaching intensity and population oscillations in *Erythrocebus patas*, *Kobus ellipsiprymnus*, *Kobus kob*, *Ourebia ourebi* and *Cephalophus rufilatus*.

Keywords: Burkina Faso, Comoé-Leraba, illegal hunting, Mammalia, population dynamics.

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Author Contribution: EMH and LL designed the study; YO, MM, EMH performed the field study, WG coordinated the field staff; LL, FP, MDV performed the statistical analyses; EMH, LL, FP drafted the paper; all authors read and approved the written draft.

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INTRODUCTION

Guineo-Congolian lowland rain forest and secondary grasslands give way in northern latitudes to isolated pockets of riparian or gallery forests following the course of large rivers such as the Niger, Comoé and Leraba, which are surrounded by undifferentiated Sudanian woodlands and savannahs (White 1983). These gallery forests are crucial landscape elements in Sudan and Sahel regions because they carry typical rainforest faunal elements inhabiting the Gulf of Guinea region up to the otherwise dry regions of Burkina Faso, Niger and Mali (e.g., Böhme et al. 1996; Joger & Lambert 2002). Despite their importance for the ecology of the region, the gallery forests have been poorly studied in terms of their faunal composition and inter-species interactions (Craigie et al. 2010). In particular, very little information is available on mammal populations and their ecological dynamics in any gallery forest area of West Africa (Craigie et al. 2010).

The Comoé-Leraba area in southwestern Burkina Faso (western Africa) represents an unique opportunity for studying the composition and population dynamics of the mammal populations of gallery forest areas, because it is a protected area that has been regularly monitored by the NGO Association Inter Villageois de GEstion des REssources Naturelles et de la Faune Comoé-Leraba (AGEREF/CL) and governmental agencies across the years. This provides opportunities to monitor species composition, population trends and the threats that mammals face in this type of habitat. Here we analyze several years of population data (2004–2013) for medium-sized and large mammals (ungulates and primates) in the Comoé-Leraba area, with emphasis on decreasing trends. In addition, we compare year-by-year population size patterns with indices of poaching in order to establish whether illegal hunting in this habitat type as well as in other savannah habitats (e.g., Caughley et al. 1990; Krebs 2009) may be a main factor conditioning the population dynamics of ungulates and primates.

MATERIALS AND METHODS

Study area

The present study was carried out between 2004 and 2013 in the Forest Classée et Reserve Partiel de Faune / Comoé-Leraba (FCRPF / CL), a protected area located south-west of Burkina Faso in the region of Cascades in the province of Comoé within the departments

of Mangodara and Niangoloko (Fig. 1). The area is located at about 100km south of Banfora, capital city of the Cascades region. The protected area is about 1245.1km². The southern limit is about 150km along the international boundary of Burkina with Côte d'Ivoire. The climate is similar to that of southern Sudan with a rainy season of six months (May to October) and a dry season for the rest of the time (Guinko 1984). It is a transition zone between the dry tropical climates of the Sahelian north and the humid ones of southern Guinea. During the dry season, the prevailing winds are harmattan and during the rainy season a humid warm monsoon wind blows from the southwest. An average rainfall ranging between 950mm and 200mm characterizes the pluviometric regime of the study area. The Comoé and the Léraba rivers are the two most important rivers in the area. They are perennial and cross the zone from north to south by the Comoé and from the west to the east by the Leraba. The plains are traversed by important rivers, which cause flooding during the rainy season in some places.

The vegetation is characterized by semi-deciduous forest galleries and clear forests. The dominant natural vegetation consists of numerous Guinean species including *Daniellia oliveri*, *Isoberlinia doka*, *Pterocarpus erinaceus*, *Khaya senegalensis*, *Detarium microcarpum*, *Burkea africana* and *Vitellaria paradoxa*. The FCRPF/CL is an important wildlife reservoir for Burkina Faso; the fauna here presents an enormous diversity integrating Sahelian with Guinean species.

Field protocol

All data were collected by the line transect data collection method. The transects (61 portions) were systematically arranged at an average equidistance of 1.7km and with a north-south and east-west orientation depending on the major drainage line of the major rivers in the census zone (Fig. 1). All transects were carried out in the dry season (February–May). Transects were walked by 13 teams of three people in each team. Every team consisted of an experienced warden (team leader) and two observers (one from the riverine villages and one field tracker). The teams walked along strictly straight lines using a compass that indicated the centres of the transects. The teams were equipped with GPS, compasses, binoculars, rangefinders, maps and field-books to record data on the observed species, their numbers, sex, age, apparent activity, and eventual notes on the presence of signs of illegal activities along the transect, etc.

For all teams, walking started very early in the

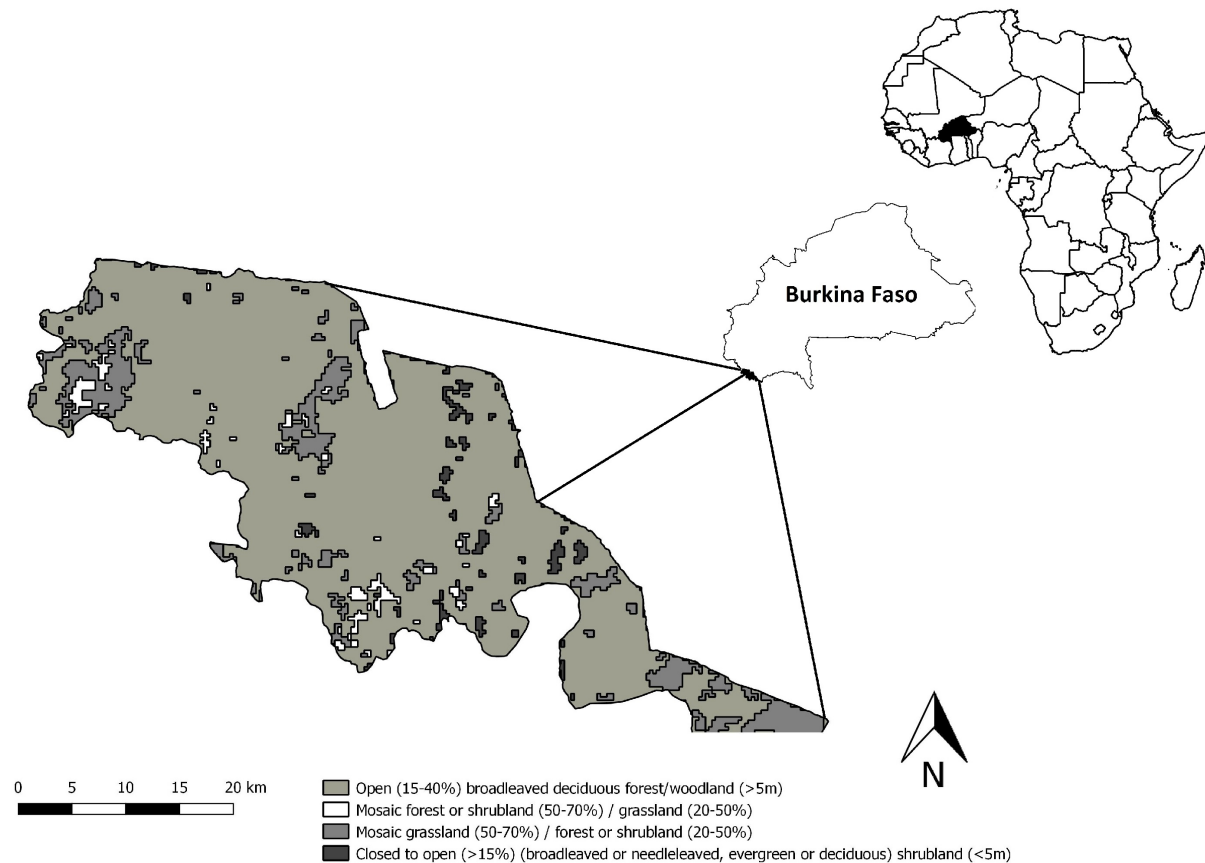


Figure 1. Map of Comoé-Léraba area, showing the Corine land-cover.

morning as soon as daylight made it possible to distinguish objects precisely (6:00 am). All the data on the signs of poacher activities were collected from within the transects. The types of illegal activities recorded by the team include: (i) poacher hunting lodges; (ii) poacher camping sites; (iii) animal carcasses; (iv) gun shots heard; (v) empty cartridges; (vi) traps for animals; (vii) poacher trails inside gallery forest vegetation; (viii) signs of bicycles and food prints of poachers; (ix) tree cuts; (x) unauthorized trespassing; and (xi) seized goods (vehicles, guns, etc).

Statistical analyses

The data were entered in an Excel spreadsheet and a kilometric abundance index (KA) for each species in each year of the study was calculated (Vincent et al. 1991; Maillard et al. 2001; Barrio et al. 2010). The inter-annual trends in KA abundances of the various species were determined by linear models with Past 3.0 statistical software. A heterogeneity of slopes test (one-way ANCOVA) for the general regressions of year of study versus yearly KA of each species was used to determine whether the inter-annual trends differed significantly

among the various species of ungulates and primates. Ungulates and primates were analyzed separately because of their obvious ecological differences.

In the text, the means are followed by ± 1 standard deviation. All tests were two-tailed and alpha was set at 5%. Non-normally distributed variables (Shapiro-Wilk W normality test, $P < 0.05$) were log transformed to achieve normality.

RESULTS

Primates

Three primate species were regularly encountered during the line transect surveys: Olive baboon (*Papio anubis*), Tantalus Monkey (*Chlorocebus tantalus*) and Pata's Monkeys (*Erythrocebus patas*) (Fig. 2). Overall, the mean KA density was nearly identical between *Papio anubis* and *Chlorocebus tantalus* (0.76 ± 0.046 individuals per km and 0.75 ± 0.025 individuals per km respectively), whereas the density of *Erythrocebus patas* was much higher (1.134 ± 0.050 individuals per km). A heterogeneity of slopes test revealed that the trends

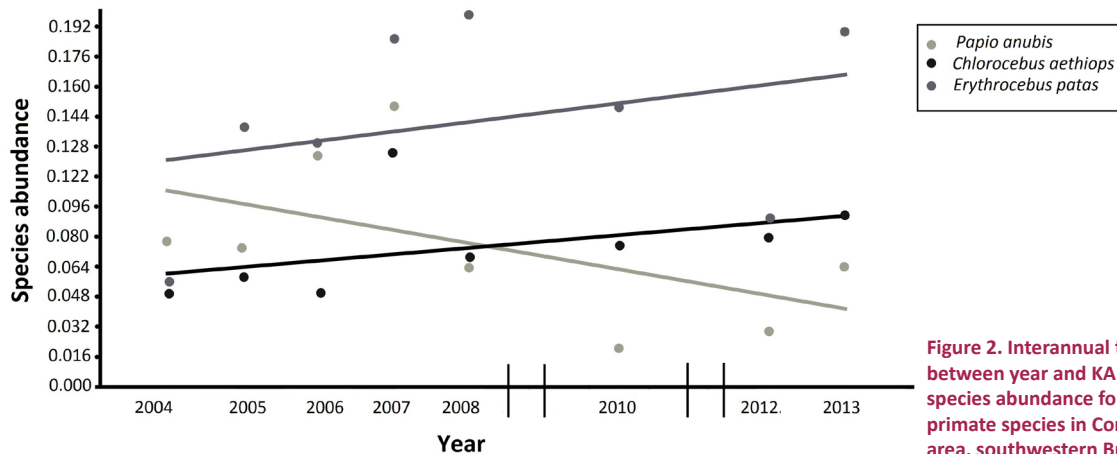


Figure 2. Interannual trends between year and KA index of species abundance for the three primate species in Comoé-Léraba area, southwestern Burkina Faso.

Table 1. Descriptive statistics for the KA estimates of the various species of ungulates along eight years of study, in Komoé-Leraba area, southwestern Burkina Faso.

Species	Min	Max	Mean	Std. error	Variance	Stand. dev	Median	25 prcntil	75 prcntil	Coeff. var
<i>Alcelaphus busephalus</i>	0.056	0.447	0.216	0.044	0.016	0.125	0.176	0.140	0.309	57.575
<i>Sylvicapra grimmia</i>	0.002	0.044	0.017	0.005	0.000	0.013	0.015	0.007	0.023	76.409
<i>Kobus ellipsiprymnus</i>	0.012	0.039	0.022	0.004	0.000	0.011	0.017	0.013	0.035	50.503
<i>Kobus kob</i>	0.011	0.062	0.027	0.006	0.000	0.016	0.026	0.015	0.031	58.561
<i>Tragelaphus scriptus</i>	0.009	0.053	0.034	0.005	0.000	0.014	0.033	0.026	0.047	41.935
<i>Hippotragus equinus</i>	0.118	0.392	0.250	0.037	0.011	0.106	0.275	0.132	0.346	42.321
<i>Ourebia ourebi</i>	0.004	0.017	0.013	0.002	0.000	0.005	0.015	0.010	0.017	35.642
<i>Cephalophus rufilatus</i>	0.000	0.015	0.006	0.002	0.000	0.006	0.006	0.001	0.012	90.799
<i>Phacochoerus africanus</i>	0.079	0.271	0.175	0.025	0.005	0.071	0.166	0.115	0.251	40.338

of the three primate species varied significantly across years (one-way ANCOVA, $F_{2,20}=6.786$, $P<0.01$), with the KA of *Papio anubis* decreasing remarkably, and the KA density of the other two species slightly increasing (Fig. 2).

Ungulates

Nine species of ungulates were regularly observed along the surveyed transects, while two additional species: the Bohor Reedbuck *Redunca redunca* and Cape Buffalo *Syncerus caffer*, were observed outside transects. The mean KA densities varied remarkably among the species (Table 1) and across the years (Fig. 3). Overall, the two large-sized gregarious species Hartbeest *Alcelaphus busephalus* and Roan Antelope *Hippotragus equinus* were the two most common species, whereas the small-sized solitary species the Red-flanked Duiker *Cephalophus rufilatus* and Oribi *Ourebia ourebi* were the least common (Table 1). A heterogeneity of slopes test revealed that the trends of

the various ungulate species varied significantly across years (one-way ANCOVA, $F_{8,62}=22.8$, $P<0.0001$), with the KAs of the Common Warthog *Phacochoerus africanus*, *Alcelaphus busephalus* and the Kewel Bushbuck *Tragelaphus scriptus* decreasing remarkably, and the KA density of the other two species showing no remarkable fluctuations over the years (Fig. 3).

Hunting pressure

The synopsis of the data collected on hunting pressure throughout the study period is presented in Table 2. (Log) Annual KA estimates statistically decreased with increases of (log) number of signs of hunting activities in *Erythrocebus patas* ($r=-0.177$, $P<0.05$), Waterbuck *Kobus ellipsiprymnus* ($r=-0.674$, $P<0.001$), Kob *Kobus kob* ($r=-0.779$, $P<0.001$), *Ourebia ourebi* ($r=-0.452$, $P<0.01$), and *Cephalophus rufilatus* ($r=-0.299$, $P<0.05$). On the other hand, there was no significant relationship between (log) number of signs of hunting activities and (log) year-by-year KAs for any of the other species (at least, $P=0,1299$).

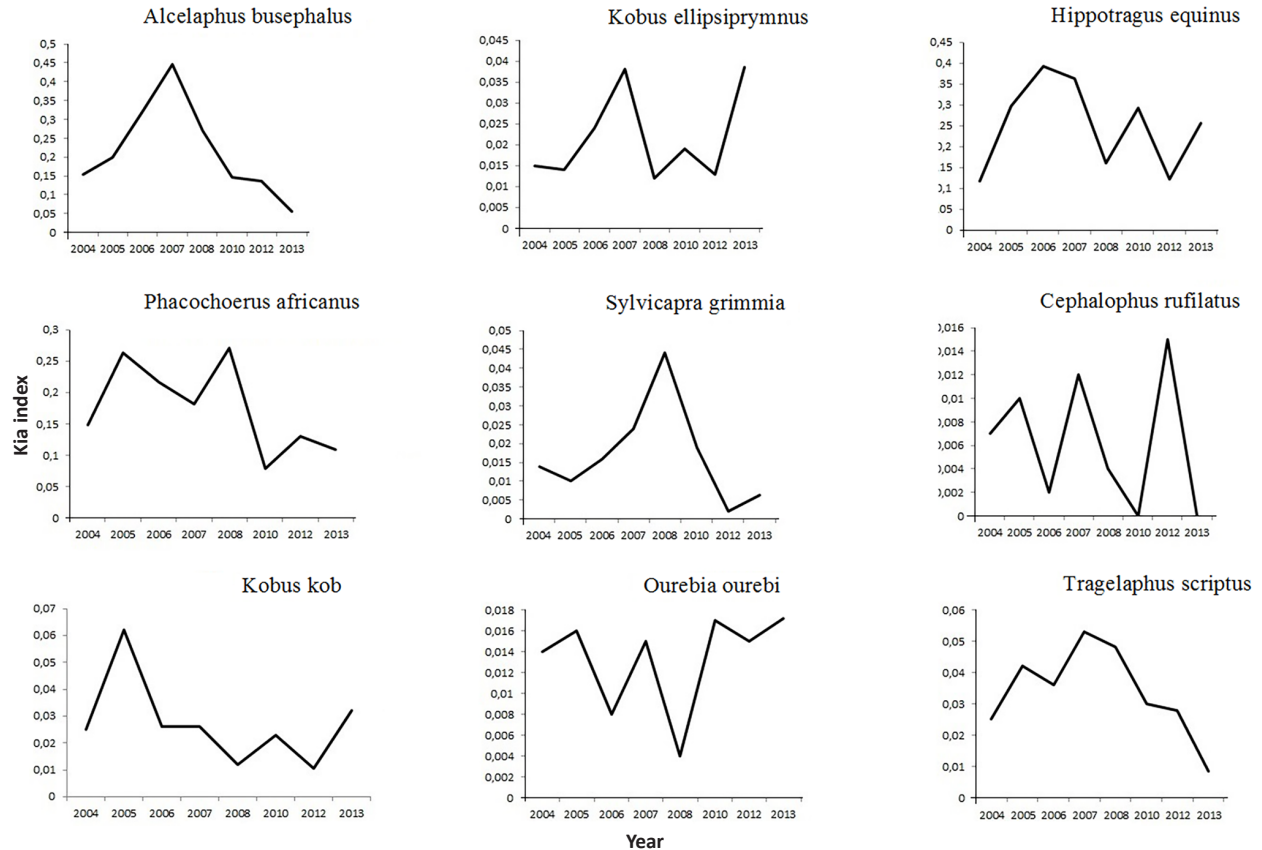


Figure 3. Year-by-year fluctuations of the KIA indices of the various ungulate species at the Comoé-Léraba area, southwestern Burkina Faso. For the statistical results on these yearly fluctuations, see the text.

DISCUSSION

The data on the year-by-year fluctuations in population sizes should be interpreted with caution when considering the smaller and more elusive species, such as *Cephalophus rufilatus*, *Sylvicapra grimmia* and *Ourebia ourebi*, as may or may not be encountered while walking the transect by the surveyors. Indeed, for instance, *Cephalophus rufilatus* was never observed in 2010 but was later observed again, and both *Cephalophus rufilatus* and *Ourebia ourebi* showed high fluctuations across years, but without any long-term trend. Instead, the inter-annual trends for *Sylvicapra grimmia* were more consistent with a declining pattern over time, and since this species inhabits more open habitats than *Cephalophus rufilatus* (Hema 1998; Oualiou et al. 2007), it was likely least exposed to observation biases than the latter. The decline of population size of *Phacochoerus africanus* across years was also consistent with a similar trend observed in another Burkina Faso protected area (Nazinga Game Ranch) where poaching and relative mismanagement by the responsible authorities may be considered the main cause (Hema et al. 2017). Also,

the absence of buffalos (*Syncerus caffer*) from the transects was certainly due to suboptimal searching methodology for this species, which was encountered on some occasions by wardens and local people. Buffalo live in thick forests where detectability is low (Eniang et al. 2016) and they tend to move away before teams walking along a transect arrive owing to their keen sense of smell. Since the thicker forest patches are situated at the confluence between the rivers Comoé and Leraba and along the main tracts of these two rivers, the line transects were not laid in this type of thick riverine forest. Thus, there was a low probability of detecting buffalos using the field methodology employed in the present study.

Interestingly, the collected data on hunting pressure along transects were consistent with the KA estimates for some species, showing a negative correlation between intensity of hunting and KAs population size estimates. This was evident in three species of small body size (*Erythrocebus patas*, *Ourebia ourebi* and *Cephalophus rufilatus*) and in two medium-sized species (*Kobus* spp.). On the other hand, no large species were apparently affected significantly by the intensity of hunting pressure.

Table 2. Synopsis of the data collected on the illegal hunting activities along the surveyed transects in the Comoé-Leraba area of Burkina Faso.

Illegal activities	May 2004	May 2005	Feb 2006	Feb 2007	May 2010	May 2011	Apr 2012
No. hunting lodges	6	1	2	4	2	1	0
No. camping sites of poachers	3	3	3	3	3	5	5
No. of carcasses	13	3	5	8	6	0	0
No. of gun shots	14	0	1	2	5	4	0
No. of cartridges	2	1	1	3	1	2	0
No. of traps for animals	0	0	1	4	1	0	0
No. of poachers' trails inside vegetation	0	0	34	11	29	0	28
No. of signs of bicycles	27	9	20	20	2	26	0
No. of livestock	0	0	0	0	3	3	7
No. of trees cut	0	0	0	2	1	3	7
Unauthorized human presence	3	0	0	1	0	7	0
No. of seized goods (vehicles, guns, etc)	3	0	0	1	0	0	0
Total	71	17	67	59	53	51	47

We speculate that small and medium sized species are preferred targets by poachers because (i) they are easier to hide and smuggle outside the boundaries of the protected area, and (ii) they are easy to approach and shoot for the poachers. Indeed, both *Erythrocebus patas* and the four above-mentioned ungulate species live in small groups (Hall 1966; Wirtz & Loerscher 1983; East 1991; Corson 2004; Fischer & Linsenmair 2007), and thus may be least prone to be able to detect, and escape from, approaching poachers (Fischer & Linsenmair 2007; Yaokokore-Beibro et al. 2010). Poachers possibly prefer smaller species as they are more likely to be sold in comparison to large species. Hence making it a better investment in terms of time for the poachers (Ntiamoa-Baidu 1997; Kümpel 2006; Wright & Priston 2010). In this regard, it should be mentioned that *Kobus kob* was also the target of heavy overhunting in the Comoé National Park in Côte d'Ivoire (Fischer & Linsenmair 2007), i.e., in an environment that is very similar, and geographically adjacent, to that of Comoé-Leraba in Burkina Faso.

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Article

Dna barcoding, population genetics, and phylogenetics of the illegally hunted Philippine Duck *Anas luzonica* (Aves: Anseriformes: Anatidae)

-- Ardea Mingoa Licuanan, Mariano Roy Martin Duya, Perry Sim Ong & Ian Kendrick Carandang Fontanilla, Pp. 10141–10150

Communications

Population dynamics of medium and large mammals in a West African gallery forest area and the potential effects of poaching

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