Raptors in changing West African savannas : the impact of anthropogenic land transformation on populations of Palearctic and Afrotropical raptors in northern Cameroon

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Chapter 10

Biogeographical and anthropogenic determinants of landscape-scale patterns in a raptor assemblage in Cameroon

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Abstract

We examine the role of biogeographical zonation and land use in northern Cameroon on patterns of abundance, richness, and diversity of raptors in a West African savanna, and ascertain the conservation value of West African savannas for raptors on a continental and global scale. We documented raptors along road transects from 2007-2010 on 7700 km during the dry season and 7340 km during the wet season. Transects covered three biogeographical zones differing in protected area coverage and degree of habitat modification: the relatively well-preserved Inundation and Guinea savanna zones in the north respectively the south, and the heavily exploited Sudan savanna in between. Patterns of raptor relative abundance, richness, and diversity were examined separately for Palearctic migrants and Afrotropical species. Results showed that Palearctic and Afrotropical raptor abundance was highest in the Inundation zone. Raptor diversity peaked in the Guinea zone during both seasons, while richness was higher in the Guinea zone than the Inundation zone during the wet season. Afrotropical raptor diversity was highest in the Guinea zone, and their richness higher there than in the Inundation zone, where Palearctic species density was higher compared to the other biogeographical zones. Richness and diversity of Palearctic and Afrotropical raptors did not differ between protected and unprotected areas in the same biogeographical zone. West African savannas support a comparably rich raptor assemblage on a continental and global scale. We conclude that land use, determined by protected area coverage and human exploitation, may override the dominant role of biogeographical zonation in shaping community patterns of West African raptors at the landscape scale, leading to greater abundance within potentially suboptimal habitat at the periphery of distribution ranges. Given the high raptor richness and immense pressure from human populations, West Africa’s savannas should be regarded a priority region for raptor conservation.

Left: Lappet-faced Vulture (right) and Egyptian Vulture in Waza National Park.

10.1 Introduction

The current biodiversity crisis makes it imperative to understand the role of land use on landscape-scale patterns of biodiversity (Sinclair *et al.* 2002, Hoffman *et al.* 2010), and to minimize biodiversity loss by defining priority areas for conservation and efficient protected area networks (Margules *et al.* 1994, Brooks *et al.* 2006, Fjeldså 2007). Raptors, like other top predators, are among the most vulnerable taxa to environmental disturbance, and their presence often used as a proxy for high biodiversity values (Sergio *et al.* 2006, 2008). Strong raptor population declines have recently been reported throughout the African continent (Thiollay 2006a,b,c, 2007a,b, Ogada & Keesing 2010, Virani *et al.* 2011), notably in West Africa, where the pressure on wildlife and their supporting habitats is huge due to some of the highest human densities and growth rates on the continent (UN World Population Prospects 2010). Although West Africa's protected area network has a crucial role in maintaining raptor assemblages in the face of growing human pressure (Thiollay 2006a,b, 2007a), it is highly fragmented and covers a small area compared to East and southern Africa (Chape *et al.* 2005), potentially constraining the effectiveness in conserving raptor populations (Herremans & Herremans Tonnoeyr 2000), and other wildlife (Wilkie *et al.* 1998, Brashares *et al*. 2001, 2004). This is alarming given the region's importance to raptor conservation, with 69 regularly occurring species (excluding vagrants; Borrow & Demey 2001) representing 22% of the world's raptors, the majority (*c.* 91%) of which at least seasonally dependent on West African savannas. Currently, thirteen of these raptors are considered threatened ("Near Threatened", "Vulnerable", or "Endangered"; IUCN Red List 2012), including three out of twenty-three regular Palearctic migratory raptors.

An understanding of biogeographical patterns of species distribution is a prerequisite for identifying priority areas and efficient protected area systems for conservation (Ray 1984, Emanuel *et al.* 1992, Turpie 1995). The raptor assemblage inhabiting West Africa's savannas is composed of populations of Afrotropical sedentary, Palearctic and Afrotropical migratory raptors. The latter group migrates in response to changes in herbaceous layer cover and height (Thiollay 1977a, 1978a, 1989), which is the main driver of prey availability for raptors (Thiollay & Clobert 1990). As a result, raptor richness and diversity is centred on the Sudan zone, decreasing in the Sahel zone to the north because of decreasing productivity and food supply during the dry season, and in the more productive Guinea savannas to the south, where higher rainfall and a dense grass cover constrain terrestrial prey accessibility during the wet season (Thiollay 1977a, 1978a). Within the Sudan and Sahel zones, productive inundation zones offer a superabundant prey supply for Palearctic and Afrotropical migratory raptors during the dry season and at the start of the rains (Thiollay 1989, Zwarts *et al.* 2009), but floods and high grass cover limit prey accessibility during part of the year (Thiollay 1978a).

Our aim was to unravel the role of biogeographical zonation and land use in determining Palearctic and Afrotropical raptor community composition at the landscape scale in Cameroon. Significant raptor population declines in Cameroon's savannas were limited to nine out of 42 raptor species (i.e. 21% of species declined, Thiollay 2001), whereas the majority of raptors declined significantly in central West Africa (87%; n = 38 species, Thiollay 2006c), suggesting that raptor populations in northern Cameroon had been comparably well preserved due to an extensive protected area network (*c*. 25% of the land surface; Figure 1). However, protected areas cover part of northern Cameroon's floodplains, and Guinea savannas of the Bénoué Valley, whereas the densely populated Sudan savannas are little protected, raising the question whether their intensive exploitation had influenced biogeographical patterns of raptor community richness and diversity. To investigate whether this was the case, we document year-round patterns of raptor species richness, diversity, and relative abundance in the Inundation zone, Sudan savanna and Guinea savanna of Cameroon, covering four years and dry and wet seasons. We expect that (1) raptor abundance peaks in the Inundation zone, whose rich grasslands attract high numbers of Palearctic and Afrotropical migrants; (2) protected areas in the Inundation and Guinea savanna zones have a higher raptor diversity and richness compared to non-protected areas in the same zone; (3) as a consequence of their better preservation, the Guinea savannas and Inundation zones of Cameroon have a higher raptor species richness, species density, and diversity than the heavily exploited Sudan savannas; and (4) the high protected area coverage of Cameroon's savannas ensures a comparably rich raptor assemblage on a continent-wide and global scale.

10.2 Materials and methods

Study area

The study area was located in the Far North, North and Adamawa Provinces of Cameroon (7º6'N-12º2'N and 13º'E-15º3'E; Figure 1). The climate is semi-arid, with rains occurring between April into October, peaking between June-September in the north and between May-October in the south. Mean annual temperature is 24 ºC-28 ºC and peaks in March-May when temperatures of 47 ºC are reached in the Inundation zone.

Road surveys covered three main biogeographical zones with distinct vegetation composition and productivity, along a gradient of increasing rainfall from north to south (Figure 1). Zone 1. The Inundation zone. Located in the transition zone of the Sudan and Sahelian savanna belts (rainfall: 450-700 mm/annum), it supports edaphic grassland mosaics with communities of *Acacia* and broad-leaved trees (White 1983). The Waza-Logone floodplains situated along the Logone River have a surface area of 8000 km^2 in Cameroon and are part of the more extensive Lake Chad Basin. The inundation extends from August to November in average years, and duration, depth and extent of flooding varies between years (Scholte 2005). The partly flooded grasslands are fringed by open *Sclerocarya birrea* woodland with *Anogeissus leiocarpus*, *Balanites aegyptiaca*, and *Acacia seyal*. Agriculture covers < 20% of the land surface and includes mainly dry-season sorghum, millet, and rice. Human population density is low (10-25 people/km^2) but has increased following partial floodplain rehabilitation (Scholte 2003). The 1700-km^2 Waza N.P. protects part of the floodplains and small populations of herbivores, but large wildlife has been virtually exterminated in the 45-km^2 Kalamaloué N.P. (Scholte 2003). The floodplain was designated a Ramsar Wetland of International Importance in 2006.

Zone 2. Sudan zone. Located within the Sudan savanna belt (rainfall: 700-1100 mm/annum) with undifferentiated Sudanian woodlands (White 1983). The zone borders the inundation plains of the Lake Chad Basin and is characterized by hilly terrain which rises to the Mandara Mountains in the west at 500-1000 m a.s.l. with isolated peaks up to 1442 m. The entire area is densely populated (averagely *c*. 50 people/km^2, but > 100-150 people/km^2 in many areas, locally up to 350 people/km^2) and deforestation has been significant during the past 20 years (Fotsing 2009), with cultivation covering > 40% of the land and < 10% original woodland cover. Sorghum, millet, maize, beans, and groundnut are the most important food crops and cotton is cultivated throughout the zone as the main cash crop. Few patches of natural habitat remain in scattered, small (< 40 km^2) and heavily exploited forest reserves with *Isoberlinia doka*, *Balanites aegyptiaca*, *Piliostigma reticulatum* and *Combretum erythrophyllum*.

Zone 3. Guinea zone. Located largely within the Guinea savanna belt (rainfall: 1100-1600 mm/annum) but incorporating Sudanian woodland with abundant *Isoberlinia* in the north (White 1983), on undulating terrain with some scattered rocky outcrops. The Bénoué Valley encompasses a large river system and three National Parks (Bénoué, Boubandjidda, Faro) covering an area of approximately 7600 km^2. Twenty-eight sport-hunting zones cover an additional 16,000 km^2 and are managed as protected areas but with hunting quota for larger mammals and gamefowl (Mayaka 2002). The region has a low human population density (on average 13 people/km^2), which is rapidly increasing (growth rate is *c*. 5%; Mayaka 2002). Cultivation covers *c*. 20% of the zone, particularly traditional crops such as millet but increasingly cotton.

Sampling design

In each biogeographical zone, a subset of navigable roads was identified for road surveys, which were widely spaced to reduce dependency of counts, and broadly encompassed the zone within the country boundaries (Figure 1). Habitat along the roads reflected gradients of human population density, topography, and land use. Eight transects were surveyed in each zone, varying in length from 35 to 115 km. The total length of the road transects was 425 km in the Inundation zone, 897 km in Sudan savanna, and 603 km in Guinea savanna. A total of 90 km of the transect network was located inside a protected area in the Inundation zone (21% of the total transect length), and 310 km in Guinea savanna (51%). Road transects were surveyed over a 4-year period between March 2007 and December 2010 in the dry (15 October-15 April) and wet seasons (15 April-15 October). Each transect was surveyed four times in each season and a total of eight surveys for each transect. Repetitions for each transect were spread evenly throughout the study period, i.e. one survey for every 6-month period. Repeat transect surveys were initiated from opposite directions to reduce a time bias in raptor detectability resulting from species-specific activity peaks. In the Guinea zone, 90 km of the transect scheme was inaccessible during the wet season and only surveyed four times during the dry season. Overall, the distance covered by road surveys was 7700 km during the dry season and 7340 km during the wet season.

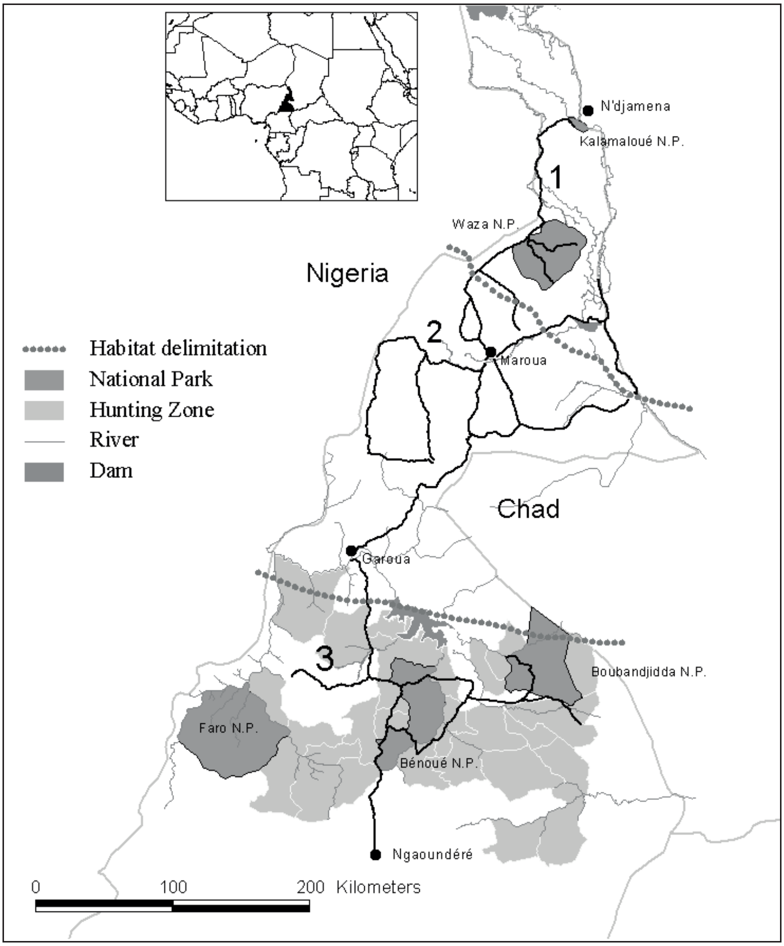


Figure 1. Study area in northern Cameroon with location of road transects. Numbers refer to the biogeographical zones: (1) Inundation zone, (2) Sudan zone, and (3) Guinea zone.

Raptors were counted by two experienced observers (one driving) from a slow-driving vehicle (average driving speed 20-25 km/hour) as widely used for raptors (Fuller & Mosher 1981, Bibby *et al*. 1992). This method provides an index of relative abundance, i.e. the number of raptors seen along a fixed transect length, that is sensitive to the behaviour of the species involved, the speed of the vehicle, the habitat, weather, hour, season, and number and experience of the observers. Since road transects often follow contours and edges, abundance estimates may be inflated as some raptors tend not to be distributed randomly across the landscape (Meunier *et al*. 2000), but comparisons of relative abundance, community composition, and large-scale habitat associations can successfully be made when potential differences in raptor detectability are accounted for (Millsap & LeFranc 1988).

All raptors perched or flying on either side of the road within eyesight range were recorded and identified with 10x42 binoculars. Stops were made at 1-km intervals to aid detectability of small and uncommon species. Additional stops were necessary to identify species and individuals spotted during stops were included in the counts. The transect length and position of each raptor along transects was recorded for each km with a geographical positioning system to the nearest 5 m. The distance from the road to the raptors was measured with a calibrated rangefinder to establish perpendicular distances for estimation of the effective strip width (Buckland *et al.* 1993). The effective strip width was estimated to assess potential differences in raptor detectability between biogeographical zones, which may bias comparisons of relative abundance. Surveys were conducted only with fine weather, i.e. clear or slightly clouded skies with low to moderate winds, starting at 06:30-07:30. Counts were finalized before 12:30-13:30 when detectability decreased due to the rise in air temperature (when raptors are either very high up or in the shade).

We examined patterns of community composition between zones and seasons for Palearctic migrants and Afrotropical species. Palearctic migrants are species which breed in Eurasia or Northern Africa and winter in sub-Saharan Africa, whereas Afrotropical species breed in sub-Saharan Africa. Black Kite *Milvus migrans*, Common Kestrel *Falco tinnunculus*, and Egyptian Vulture *Neophron percnopterus* included both Afrotropical and Palearctic populations, with distinct races for Black Kite and Common Kestrel (Ferguson-Lees and Christie 2001). For analyses at the species' level, we used the origin (Afrotropical or Palearctic) of the majority of individuals making up the population for these three species. Common Kestrel and Egyptian Vultures were separated into Afrotropical and Palearctic individuals for analyses of patterns of Afrotropical and Palearctic populations but not for Black Kite as individuals of Afrotropical or Palearctic origin could not be safely distinguished at all times.

Statistical analyses

Distance 6.0 software (Thomas *et al*. 2006) was used to estimate the strip widths of raptors detected along transects in each zone, because differences in vegetation structure and density, underlying potential differences in detectability (Buckland *et al*. 1993), might confound comparisons of relative abundance. Effective strip widths (ESW) were estimated based on the combined set of perpendicular distances to the road for flying and perching raptors, for species with > 40 observations per zone. The perpendicular distances of raptors with < 40 observations were pooled in groups of comparable size (small, medium-sized, large) to determine their zone-specific ESW. To determine ESW separately for each zone, six combinations of key functions with expansion series were used to model the detection functions: the half-normal key function with cosine and Hermite polynomial adjustment terms, the hazard-rate key function with cosine and simple polynomial, and the uniform key function with cosine and simple polynomial. Following Buckland *et al*. (1993), models with the lowest Akaike Information Criterion (AIC) value was selected for estimation of ESW and significant differences were based on overlap of 95% confidence intervals.

To calculate relative abundance, raptor counts on transects were expressed as the number of individuals per 100 km of transect, which allowed for comparisons between zones with transects of different length. To avoid losing data, the entire transect network was used for these analyses during each season, including transect sections surveyed only during the dry season. The latter was possible since the relative abundance estimates were expressed as numbers of individuals per 100 km of transect. In case of significantly different ESW between zones, we corrected relative abundance estimates to account for such differences by multiplying these with 1/ESW, and used the corrected estimates for comparisons within GEEs. Generalized Estimated Equations (GEEs; Hardin & Hilbe 2003) with robust variance estimation were used to examine the association between relative abundance estimates and biogeographical zones in SPSS 19.0 (SPSS Inc, Chicago, IL, USA), separately for raptors with > 10 observations on all transects combined, and for counts of Palearctic, Afrotropical and all raptors combined. The GEEs enabled the fitting of a log-linear model and permitted the assumption that the error distribution would follow a Poisson or Negative Binomial distribution. Biogeographical zone identity (n = 3) and transect number (n = 8) were taken as subject variables, with the period in which transects were surveyed (n = 8) as the within-subject variable. We included biogeographical zone identity and year as fixed categorical factors, the latter to control for annual variations in counts. Differences in relative abundance among zones were tested using pair-wise comparisons in GEE and considered significant at $P < 0.05$ but adjustments were made for Type I error using Bonferroni correction.

For comparing richness of the raptor assemblages between zones for the dry and wet seasons, we followed recommendations by Gotelli & Colwell (2001) and used sample-based rarefaction, which allowed for the statistically robust comparisons based on equivalent numbers of individuals and samples (Colwell *et al.* 2004). Sample-based rarefaction computes the expected number of species when samples are drawn at random (without replacement) from a set of samples that are collectively representative of an assemblage (Gotelli & Colwell 2001). We used 10-km transect segments that were surveyed eight times as our units of replication, totalling 39 sample units in Inundation zone, 87 in Sudan savanna, and 51 in Guinea savanna. Since every raptor observation was GPS-referenced, observations could be assigned to each 10-km segment using ArcView GIS 3.2 software (Esri 1999) and the cumulative counts in each season for each segment were used for comparisons of richness. The Mau Tau estimator of rarefied species richness (Mao *et al.* 2005) was used to compute rarefaction curves in EstimateS Version 8.0 software (Colwell 2006). Samples were randomized 50 times for each dataset without replacement. We standardized comparisons by plotting expected species numbers against (1) the total number of road segments surveyed (a measure of species density; Gotelli & Colwell 2001) and (2) the total number of individuals observed (a measure of richness). Shannon diversity estimates were compared between zones and seasons in Cameroon in EstimateS 8.0 (Magurran 1988). We used sampling with replacement which allowed estimation of confidence intervals and comparisons of diversity between zones sampled at equal effort. The criterion used to determine whether the estimations of species richness and diversity were significantly different ($P < 0.05$) was the absence of overlap among the 95% confidence intervals (Colwell *et al.* 2004).

For comparisons of raptor richness between protected (i.e. those with frequent anti-poaching efforts: National Parks and adjoining hunting zones) and unprotected areas (all other areas), sampling was stratified according to protective status, on roads inside protected areas and/or buffer (i.e. hunting) zones and on roads outside these areas. Since counts limited comparisons for dry and wet seasons separately, we examined species richness in protected areas by combining dry- and wet-season counts on 9 sample units (10-km segments) in the Inundation zone and on 31 units in the Guinea zone. Thirty sample units in the Inundation zone and 20 units in the Guinea zone were used to examine species richness in unprotected areas. Since the Sudan zone did not have a National Park, no such assessment could be made for this zone.

For comparison of raptor richness in northern Cameroon with regional richness assessments elsewhere in the (sub-)tropics, we searched publications and unpublished reports of raptor road counts using comparable methods and data on survey effort (i.e. individuals counted; Colwell *et al*. 2004) and covering similar habitats (e.g. woodland savanna, open grasslands). Comparisons of richness estimates were standardized based on counts of individuals rather than sampling effort or area, which may compromise such comparisons (Gotelli & Colwell 2001). Only road surveys which presented detailed information on methodology, number of species and individuals counted were considered. The combined count data of 177 sample units (i.e. 1770 km) for the three biogeographical zones were used to derive a cumulative species richness curve for the study area in Cameroon. Since most published raptor surveys were conducted in a restricted period of the year (e.g., the dry season or “breeding season”), we also limited our richness estimate to the dry season to allow for meaningful comparisons between study sites.

10.3 Results

Patterns of raptor abundance

A total of 58 raptor species was identified during road surveys and 16,968 individuals were detected (Table 1). The three most commonly recorded species, Black Kite, Hooded Vulture *Necrosyrtes monachus*, and Grasshopper Buzzard *Butastur rufipennis* comprised over half of the individuals detected (53%). Booted Eagle *Hieraaetus pennatus* and Eurasian Marsh Harrier *Circus aeruginosus* represented 54% of the total number of Palearctic raptors detected, which together accounted for respectively 21%, 9% and 4% of Inundation, Sudan and Guinea zones during the dry season, and 8% of total counts. GEE model results showed a significant effect of biogeographical zone on the relative abundance of Palearctic raptors during the dry season (χ^2_2 = 84.3, P < 0.001) and Afrotropical raptors during the dry (χ^2_2 = 38.6, P < 0.001) and wet seasons (χ^2_2 = 45.8, P < 0.001; Figure 2). The entire raptor assemblage was most abundant year-round in the Inundation zone, significantly less abundant in the Sudan zone and least abundant in the Guinea zone (χ^2_2 = 109.4, P < 0.001). Five Afrotropical raptors were most abundant in the Guinea zone during the dry season, and four during the wet season (Table 2). The abundance of four Afrotropical raptors peaked on the Inundation zone during the dry and wet seasons, including two species whose relative abundance across zones remained significantly different after corrections were made for significantly different ESWs between zones. No raptor was most abundant in the Sudan zone, and only Gabar Goshawk *Micronisus gabar*, Fox Kestrel *Falco alopex*, and Hooded Vulture were more abundant there than in another zone during the dry or wet season. Conversely, five large-bodied raptors with a distribution range centered on the Sudan zone, African Hawk Eagle *Hieraaetus spilogaster*, Brown Snake Eagle *Circaetus cinereus*, African White-backed Vulture *Gyps africanus*, White-headed Vulture *Trigonoceps occipitalis*, and Bateleur *Terathopius ecaudatus*, were more abundant in the Inundation or Guinea savanna zones during the dry or wet season.

Table 1. Species number and percentage population composition in three biogeographical zones (I = Inundation Zone, S = Sudan Zone, G = Guinea zone) in northern Cameroon, during road transect surveys between 2007 and 2010. The percentage composition relative to total numbers is presented separately for the three biogeographical zones and for dry and wet seasons.

		Dry season			**Wet season**		
	Total	I	S	G	I	S	G
Afrotropical raptors							
Black Kite *Milvus migrans* [1, 4]	**3771**	36	11	2	43	7	2
Hooded Vulture *Necrosyrtes monachus*	**3345**	7	40	3	7	43	< 1
Grasshopper Buzzard *Butastur rufipennis*[4]	**1912**	9	4	25	24	4	11
Fox Kestrel *Falco alopex*	**815**	< 0.1	9	7	< 1	11	5
Dark Chanting Goshawk *Melierax metabates*	**724**	4	4	3	4	4	6
African Swallow-tailed Kite *Chelictinia riocourii*[4]	**674**	10	3	< 1	3	1	-
Wahlberg's Eagle *Aquila wahlbergi*[4]	**574**	1	2	6	2	6	14
Black-winged Kite *Elanus caeruleus*	**567**	3	3	5	2	3	10
Rüppell's Vulture *Gyps rueppellii*	**520**	1	6	2	< 1	6	2
Lanner Falcon *Falco biarmicus*	**390**	1	3	5	2	2	3
Red-necked Buzzard *Buteo auguralis*[4]	**295**	< 0.1	1	4	1	4	5
Gabar Goshawk *Micronisus gabar*	**270**	1	2	1	2	2	< 1
African White-backed Vulture *Gyps africanus*	**195**	2	< 1	2	2	< 0.1	3
Tawny Eagle *Aquila rapax*	**187**	2	1	1	2	1	< 1
Grey Kestrel *Falco ardosiaceus*	**182**	< 0.1	1	3	< 1	2	6
Bateleur *Terathopius ecaudatus*	**174**	1	< 0.1	4	1	< 0.1	4
Shikra *Accipiter badius*[4]	**169**	< 0.1	< 1	5	< 1	1	4
Long-crested Eagle *Lophaetus occipitalis*	**156**	< 1	< 0.1	5	< 1	< 1	6
Brown Snake Eagle *Circaetus cinereus*	**107**	-	1	3	< 0.1	< 1	4
Red-necked Falcon *Falco chicquera*	**98**	1	< 1	1	1	< 1	2
African Harrier Hawk *Polyboroides typus*	**72**	< 1	< 1	2	< 1	< 1	2
Beaudouin's Snake Eagle *Circaetus beaudouini*[4]	**54**	< 1	-	< 1	1	< 1	< 1
African Hawk Eagle *Hieraaetus spilogaster*	**42**	< 0.1	< 0.1	1	< 0.1	< 1	1
Lapped-faced Vulture *Torgos tracheliotus*	**40**	< 1	-	-	1	-	< 1
Ayres's Hawk Eagle *Hieraaetus ayresii*	**38**	-	< 0.1	< 1	< 0.1	1	1
African Fish Eagle *Haliaeetus vocifer*	**37**	< 1	-	1	< 1	< 0.1	< 1
Martial Eagle *Polemaetus bellicosus*	**37**	-	< 1	1	-	< 1	1
Lizard Buzzard *Kaupifalco monogrammicus*	**36**	-	< 0.1	1	-	< 0.1	2
Western Banded Snake Eagle *Circaetus cinerascens*	**31**	-	-	1	-	< 0.1	1
White-headed Vulture *Trigonoceps occipitalis*	**23**	< 0.1	< 0.1	1	< 0.1	< 0.1	< 1
African Cuckoo Hawk *Aviceda cuculoides*	**20**	-	-	< 1	-	< 1	1
African Hobby *Falco cuvierii*	**7**	-	-	< 0.1	-	< 0.1	< 1
Ovambo Sparrowhawk *Accipiter ovampensis*	**4**	-	-	< 1	-	-	< 1
Bat Hawk *Macheiramphus alcinus*	**3**	-	-	< 1	-	< 0.1	-

Table 1. (Continued).							
Secretary Bird *Sagittarius serpentarius*	**2**	< 0.1	-	-	-	-	< 1
Red-thighed Sparrowhawk *Accipiter erythropus*	**1**	-	-	< 0.1	-	-	-
Palearctic raptors							
Eurasian Marsh Harrier *Circus aeruginosus*	**491**	9	< 1	1	1	< 0.1	-
Booted Eagle *Hieraaetus pennatus*	**262**	3	3	1	-	-	-
Common Kestrel *Falco tinnunculus*[2]	**174**	1	2	1	-	1	-
Short-toed Eagle *Circaetus gallicus*	**119**	2	1	< 1	< 0.1	< 0.1	-
Montagu's Harrier *Circus pygargus*	**112**	2	1	< 1	-	-	-
Steppe Eagle *Aquila nipalensis*	**57**	1	< 0.1	< 1	< 0.1	-	-
Pallid Harrier *Circus macrourus*	**56**	1	< 1	< 1	-	-	-
Egyptian Vulture *Neophron percnopterus*[5]	**28**	< 1	< 0.1	-	< 0.1	< 1	-
Long-legged Buzzard *Buteo rufinus*	**22**	< 1	< 0.1	-	-	-	-
Honey Buzzard *Pernis apivorus*	**19**	-	< 1	< 1	-	< 0.1	< 1
Lesser Kestrel *Falco naumanni*	**18**	< 1	< 0.1	-	-	-	-
Osprey *Pandion haliaetus*	**13**	< 1	-	-	< 0.1	-	< 1
Barbary Falcon *Falco pelegrinoides*	**7**	< 1	-	-	< 0.1	-	-
Eurasian Hobby *Falco subbuteo*	**4**	-	-	-	< 0.1	-	< 1
Eastern Imperial Eagle *Aquila heliaca*	**3**	< 0.1	-	-	-	-	-
Red-footed Falcon *Falco vespertinus*	**3**	-	< 0.1	-	< 0.1	-	-
Levant Sparrowhawk *Accipiter brevipes*	**2**	-	-	-	-	-	< 1
Peregrine Falcon *Falco peregrinus*[3]	**2**	< 0.1	< 0.1	-	-	-	-
Common Buzzard *Buteo buteo*	**1**	< 0.1	-	-	-	-	-
Eleonora's Falcon *Falco eleonorae*	**1**	-	-	-	-	-	< 1
Lesser Spotted Eagle *Aquila pomarina*	**1**	< 0.1	-	-	-	-	-
Sooty Falcon *Falco concolor*	**1**	-	-	-	-	< 0.1	-
Unidentified raptors	**122**						

[1] The majority of Black Kites referred to the local race *parasitus* (Yellow-billed Kite); < 1% of dry season counts referred to the Palearctic race *migrans*.
[2] The resident race *F. t. rufescens* comprised 22% of total counts.
[3] Only the Palearctic race *calidus* was recognized on these surveys.
[4] Intra-African migrants, known for seasonal displacements (Thiollay 1978a, 2001).
[5] The local population comprised 25% of counts.

Patterns of richness and diversity

Raptor species richness and species density did not differ significantly between zones during the dry and wet seasons (Figure 3), apart from the higher species richness in the Guinea zone than the Inundation zone during the wet season. Afrotropical raptors richness was higher during both seasons in the Guinea zone than the Inundation zone (Figure 4), and Afrotropical species density was higher in the Guinea than the Inundation zone during the wet season. Although Palearctic species density in the Inundation zone surpassed species density in the other zones during the dry season, we did not find evidence of differences in Palearctic raptor richness between zones (Figure 5). Raptor diversity peaked in the Guinea zone during both seasons for Afrotropical and the complete raptor community, but no differences in Palearctic raptor diversity were detected between zones (Figure 6).

Table 2. Relative abundance (birds/100 km) of Palearctic and Afrotropical raptors recorded during road transect surveys performed in three biogeographical zones in northern Cameroon between February 2007 and December 2010. Mean values for transects in each zone (n = 8) are presented ±S.E. The association between biogeographical zones and relative abundance was investigated with Generalized Estimating Equations. Letters (a,b,c) indicate differences in relative abundance between zones ($P < 0.05$) using pair-wise comparisons and after Bonferroni correction.

	Afrotropical raptors											
	Dry season						Wet season					
Species	Inundation zone		Sudan zone		Guinea zone		Inundation zone		Sudan zone		Guinea zone	
African Cuckoo Hawk	-	-	-	-	0.12	±0.09	-	-	0.13	±0.08	0.55	±0.17
African Fish Eagle	1.77	±1.69	-	-	0.3	±0.23	0.25	±0.16	0.03	±0.04	0.35	±0.27
African Hawk Eagle	0.07^{a}	±0.07	0.08^{a}	±0.07	0.69^{b}	±0.22	0.08^{a}	±0.08	0.14^{a}	±0.12	0.82^{b}	±0.35
Ayres's Hawk Eagle	-	-	0.06	±0.05	0.34	±0.19	0.07^{a}	±0.07	0.45^{ab}	±0.16	0.55^{b}	±0.18
Bateleur	1.88^{ab}	±1.07	0.04^{a}	±0.03	2.39^{b}	±0.83	4.42^{ab}	±3.27	0.07^{a}	±0.07	3.22^{b}	±1.12
Beaudouin's Snake Eagle	0.54	±0.28	-	-	0.13	±0.09	1.87	±1.00	0.23	±0.09	0.36	±0.16
Black Kite[1]	107.7^{a}	±29.9	6.70^{b}	±2.18	3.05^{b}	±2.12	43.10^{a}	±15.0	9.15^{b}	±3.14	2.14^{c}	±0.86
Black-winged Kite	9.85^{a}	±2.63	3.22^{b}	±0.92	2.87^{b}	±1.12	5.94^{a}	±1.01	2.39^{b}	±0.42	4.57^{ab}	±1.30
Brown Snake Eagle	-	-	0.55	±0.17	1.77	±0.62	0.08^{a}	±0.08	0.29^{a}	±0.11	2.43^{b}	±0.66
Dark Chanting Goshawk**	15.15^{a}	±3.75	4.58^{b}	±1.41	1.80^{b}	±0.60	10.6^{a}	±2.36	3.90^{b}	±1.11	2.73^{b}	±0.80
Fox Kestrel	0.07^{a}	±0.06	7.24^{b}	±2.87	3.06^{ab}	±1.58	0.74^{a}	±0.50	9.48^{b}	±3.89	2.45^{ab}	±0.92
Gabar Goshawk	4.17^{a}	±1.10	2.05^{b}	±0.74	0.67^{b}	±0.39	3.39^{a}	±0.63	1.79^{b}	±0.45	0.67^{c}	±0.54
Grasshopper Buzzard**	29.56^{a}	±8.13	3.57^{b}	±0.93	15.3^{ab}	±6.22	56.4^{a}	±15.5	3.91^{b}	±1.00	6.23^{b}	±2.15
Grey Kestrel	0.16^{a}	±0.16	0.58^{a}	±0.24	1.77^{b}	±0.46	0.36^{a}	±0. 31	1.48^{b}	±0.32	3.35^{c}	±1.00
African Harrier Hawk	0.36^{a}	±0.18	0.18^{a}	±0.14	1.20^{b}	±0.21	0.41	±0.19	0.39	±0.14	0.94	±0.25
Hooded Vulture	26.2^{ab}	±12.9	34.9^{a}	±6.75	1.38^{b}	±1.28	23.6^{ab}	±16.8	38.8^{a}	±7.42	0.20^{b}	±0.12
Lanner Falcon	4.26	±0.94	2.48	±0.72	2.92	±0.59	4.55	±1.22	1.79	±0.55	1.44	±0.30
Lapped-faced Vulture	1.56	±0.85	-	-	-	-	1.62	±0.72	-	-	0.13	±0.10
Lizard Buzzard	-	-	0.02	±0.02	0.46	±0.28	-	-	0.04	±0.03	1.09	±0.32
Long-crested Eagle	1.17^{a}	±0.52	0.09^{b}	±0.07	2.59^{c}	±0.53	0.98^{a}	±0.63	0.09^{a}	±0.06	2.77^{b}	±0.56
Martial Eagle	-	-	0.09	±0.05	0.68	±0.15	-	-	0.33	±0.15	0.72	±0.31
Common Kestrel[2]	-	-	0.41	±0.31	0.04	±0.05	-	-	0.41	±0.37	-	-
Red-necked Falcon	3.21	±2.42	0.3	±0.17	0.48	±0.13	1.93^{a}	±0.86	0.17^{b}	±0.08	0.62^{a}	±0.19
Red-necked Buzzard**	0.38^{a}	±0.31	1.10^{ab}	±0.45	2.45^{b}	±0.81	1.44^{a}	±0.59	4.27^{b}	±1.15	2.14^{ab}	±1.16
Rüppell's Vulture	4.19	±2.26	6.6	±4.42	0.26	±0.21	1.68	±0.84	6.45	±3.71	1.41	±1.13
Shikra	0.31^{a}	±0.17	0.28^{a}	±0.13	2.43^{b}	±0.88	0.62^{a}	±0.22	1.02^{ab}	±0.30	2.06^{b}	±0.65
African Swallow-tailed Kite	42.54^{a}	±26.9	2.55^{a}	±1.30	0.08^{b}	±0.08	5.59	±2.28	1.06	±0.81	-	-
Tawny Eagle	5.87^{a}	±2.35	0.60^{b}	±0.18	0.86^{ab}	±0.38	4.38	±2.86	0.5	±0.14	0.24	±0.12
Wahlberg's Eagle	3.78	±0.84	1.51	±0.55	3.26	±1.04	4.52	±0.89	5.07	±1.11	5.23	±1.27
Western Banded Snake Eagle	-	-	-	-	0.57	±0.21	-	-	0.03	±0.03	0.62	±0.14

Table 2. (Continued).

African White-backed Vulture	5.11^{a}	±3.19	0.14^{b}	±0.11	0.81^{ab}	±0.58	5.39^{ab}	±3.75	0.07^{a}	±0.05	1.65^{b}	±0.78
White-headed Vulture	0.14	±0.14	0.04	±0.05	0.29	±0.21	0.19^{ab}	±0.13	0.03^{a}	±0.03	0.53^{b}	±0.25

[1] The majority of Black Kites referred to the local race *parasitus*; *c.* < 1% of dry season counts referred to the Palearctic race *migrans*.

[2] Only includes the resident race *F.t. rufescens*.

** ESW significantly greater ($P < 0.05$) in Inundation zone and Sudan savanna compared to Guinea savanna; significant differences in relative abundance between zones as presented here not affected after correction.

	Palearctic raptors											
	Dry season						**Wet season**					
	Inundation zone		**Sudan zone**		**Guinea zone**		**Inundation zone**		**Sudan zone**		**Guinea zone**	
Booted Eagle	9.26^{a}	±3.16	3.91^{a}	±1.34	0.37^{b}	±0.13	-	-	-	-	-	-
Common Kestrel[3]	6.11^{a}	±1.66	1.69^{b}	±0.47	0.67^{b}	±0.28	-	-	-	-	-	-
Egyptian Vulture[4]	2.02	±1.88	-	-	-	-	0.23	±0.16	-	-	-	-
Short-toed Eagle	4.87^{a}	±1.23	0.73^{b}	±0.38	0.23^{b}	±0.23	0.06	±0.05	0.03	±0.02	-	-
Honey Buzzard	-	-	0.19	±0.11	0.23	±0.10	-	-	0.07	±0.05	0.36	±0.20
Lesser Kestrel	0.84	±0.32	0.04	±0.04	-	-	-	-	-	-	-	-
Long-legged Buzzard	1.64	±1.34	0.03	±0.04	-	-	-	-	-	-	-	-
Eurasian Marsh Harrier	22.9^{a}	±5.37	0.44^{b}	±0.17	0.62^{b}	±0.21	0.32	±0.20	0.03	±0.04	-	-
Montagu's Harrier	5.19^{a}	±1.80	1.18^{a}	±0.42	0.35^{b}	±0.23	-	-	-	-	-	-
Osprey	0.66	±0.45	-	-	-	-	0.2	±0.16	-	-	0.04	±0.05
Pallid Harrier	3.22^{a}	±1.21	0.33^{b}	±0.28	0.13^{b}	±0.06	-	-	-	-	-	-
Steppe Eagle	3.74^{a}	±2.03	0.02^{b}	±0.02	0.10^{b}	±0.10	0.08	±0.08	-	-	-	-

[3] Only includes the Palearctic race *F.t. tinnunculus*.

[4] Excluding local breeders.

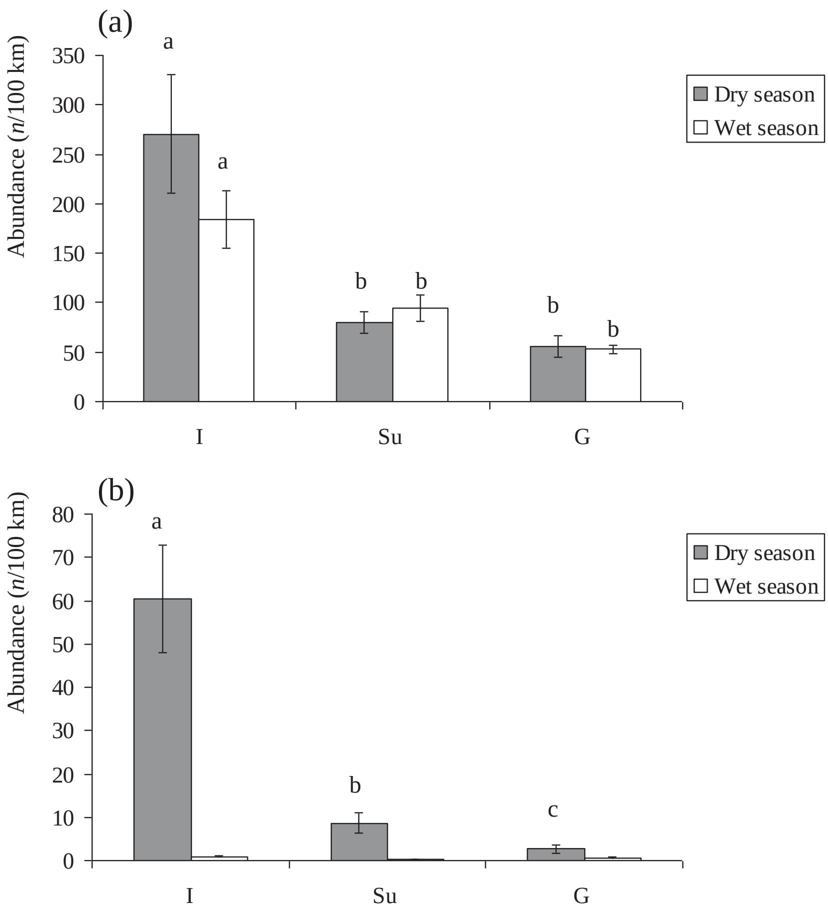


Figure 2. Relative abundance (birds/100 km) of (a) Afrotropical and (b) Palearctic raptors recorded during road transect surveys performed the Inundation zone (I), Sudan (Su), and Guinea savanna (G) of Cameroon between February 2007 and December 2010. Mean values for transects in each zone (n = 8) are presented ±S.E. The association between biogeographical zones and relative abundance was investigated with Generalized Estimating Equations. Letters (a,b,c) indicate differences in relative abundance between zones ($P < 0.05$) using pair-wise comparisons and after Bonferroni correction.

Richness and diversity in protected and unprotected areas

We did not find a significant difference in species richness and diversity (Figure 7) between protected and unprotected areas in the Inundation zone and the Guinea savannas for wet and dry season data combined, or for wet and dry seasons separately (not shown), but a trend for lower richness and diversity outside protected areas was evident for both zones and for Afrotropical and Palearctic species.

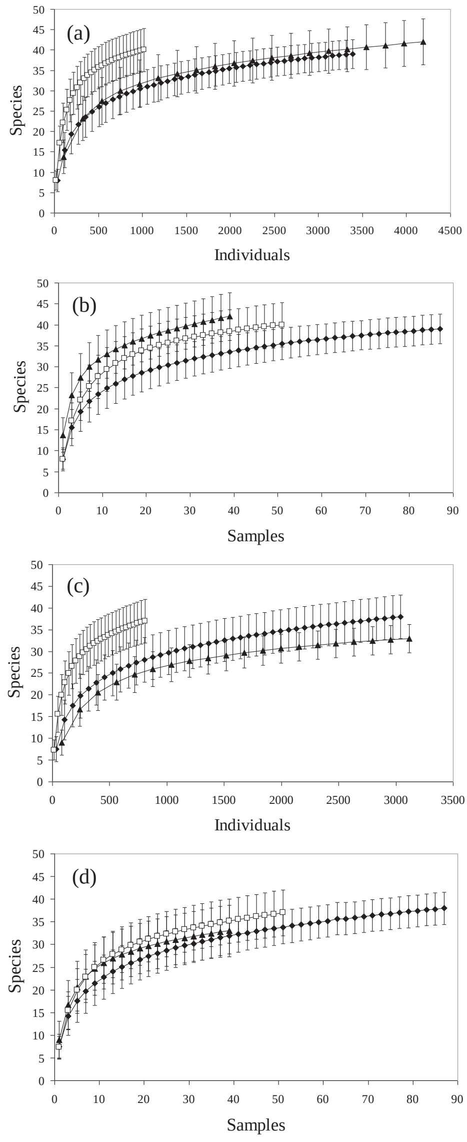


Figure 3. Sample-based rarefaction curves (with 95% CI) of raptor richness for the Inundation zone (▲), Sudan (◆), and Guinea savanna (□) in north Cameroon against (a,c) the total number of individuals detected (i.e. species richness) and (b,d) 10-km sample units (i.e. species density) during the dry (a,b) and wet seasons (c,d). Every second point is shown.

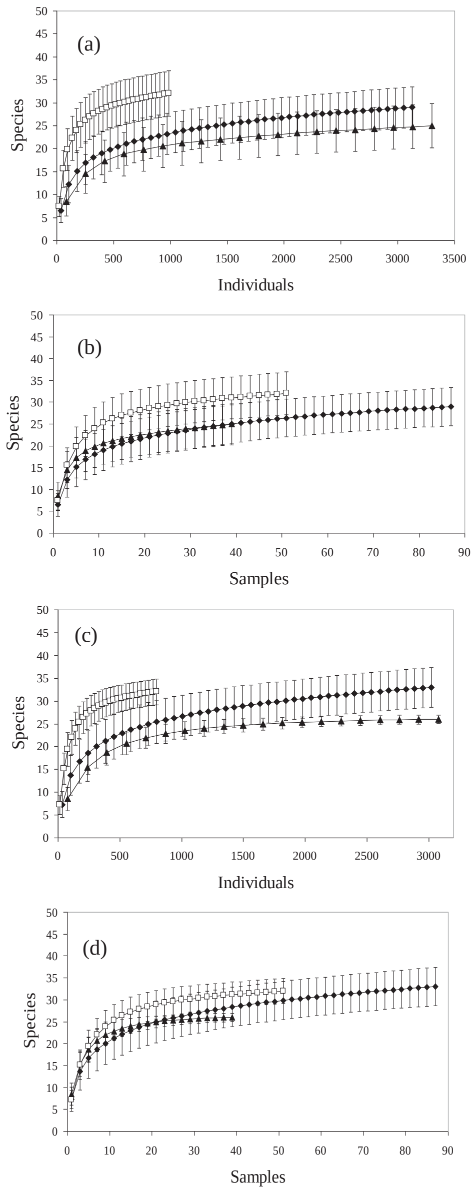


Figure 4. Sample-based rarefaction curves (with 95% CI) of Afrotropical raptor richness for the Inundation zone (▲), Sudan (◆), and Guinea savanna (□) in north Cameroon against (a,c) the total number of individuals detected (i.e. species richness) and (b,d) 10-km sample units (i.e. species density) during the dry (a,b) and wet seasons (c,d). Every second point is shown.

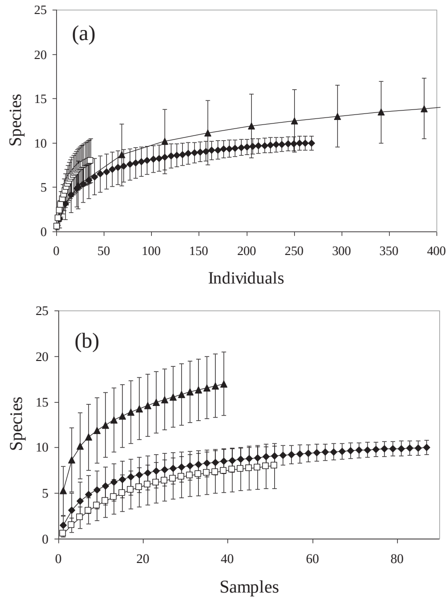


Figure 5. Sample-based rarefaction curves (with 95% CI) of Palearctic raptor richness for the Inundation zone (▲), Sudan (◆), and Guinea savanna (□) in north Cameroon against (a) the total number of individuals detected (i.e. species richness) and (b) 10-km sample units (i.e. species density), during the dry season. Every second point is shown.

Comparisons with regional, continental and global raptor richness

Most studies (one exception) conducted elsewhere in West Africa generated species richness estimates within the 95% confidence limits of our cumulative species richness curve (Figure 8), indicating comparable richness to northern Cameroon. Conversely, raptor richness estimates from comparable habitats in South America, Asia, and southern Africa were below and outside the 95% confidence limits of the richness curve of Cameroon. Raptor richness in the savannas of Cameroon thus appears to be representative for the region, but comparatively high on a continental and global scale, surpassed only by raptor richness in East African savannas.

10.4 Discussion

We detected clear patterns of raptor abundance, richness and diversity between Cameroon’s biogeographical zones. Raptor diversity and richness did not peak in the heavily exploited Sudan savanna zone, previously cited as the core biogeographical zone for the West African raptor assemblage, with the highest species diversity and richness (Thiollay 1977a). Rather, diversity was highest in the dense, relatively well preserved Guinea savannas, during the wet and dry seasons, while richness was largely comparable between zones.

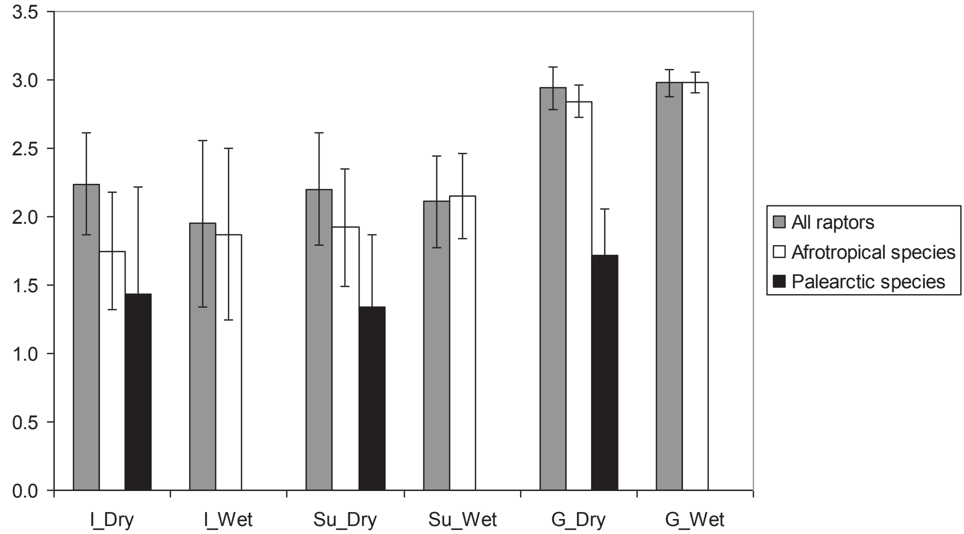
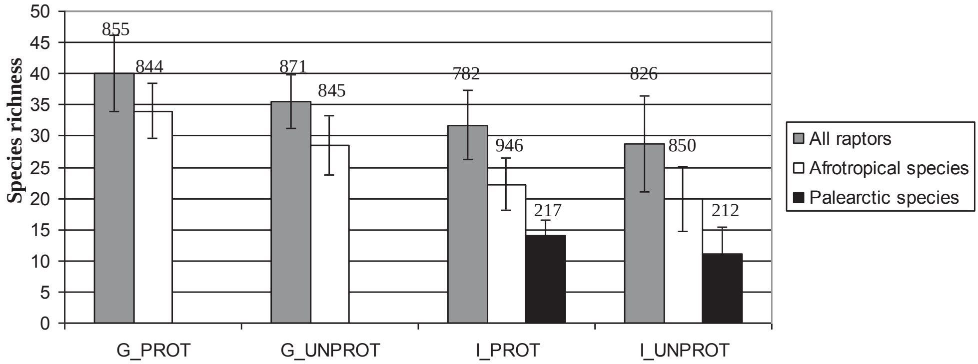


Figure 6. Shannon diversity indices (with 95% CI) for all raptors, Afrotropical raptors, and Palearctic raptors detected in the the Inundation zone (I), Sudan savanna (Su), and Guinea savanna (G), in north Cameroon, during the dry and wet seasons. Palearctic raptor diversity is presented only for the dry season since limited numbers prevented stabilization of Shannon diversity during the wet season. Diversity indices were estimated at approximately equal sampling effort (*n* = 798-850 individuals for "all raptors", *n* = 796-843 for "Afrotropical species", *n* = 37-44 for "Palearctic raptors").

Interestingly, only three Afrotropical raptors with a distribution range centered on the Sudan savannas were more common there than in biogeographical zones at more northerly or southerly latitudes. This contrast general patterns of species abundance, which tends to decline in peripheral areas of distribution ranges (Brown *et al*. 1995) where conditions are less favorable (Pulliam 2000, García & Arroyo 2001) and sensitivity to habitat alteration higher (Swihart *et al.* 2003).

Our results showed that five Afrotropical large-bodied raptors, whose distribution was centered on the Sudan zone, were more common in the Inundation zone and Guinea savannas than the Sudan zone. The higher abundance of only three raptors in the Sudan zone, compared to the other zones during either season, further underlined the impoverished state of the raptor assemblage in the Sudan savannas. These results suggest that human-induced habitat modification influenced raptor communities at the landscape scale, leading to greater abundance within potentially suboptimal habitat at the periphery of distribution ranges. It further suggests that extensive habitat modification resulting from anthropogenic land use may override the dominant role of biogeographical zonation in shaping community patterns of West African raptors.

(a)



(b)

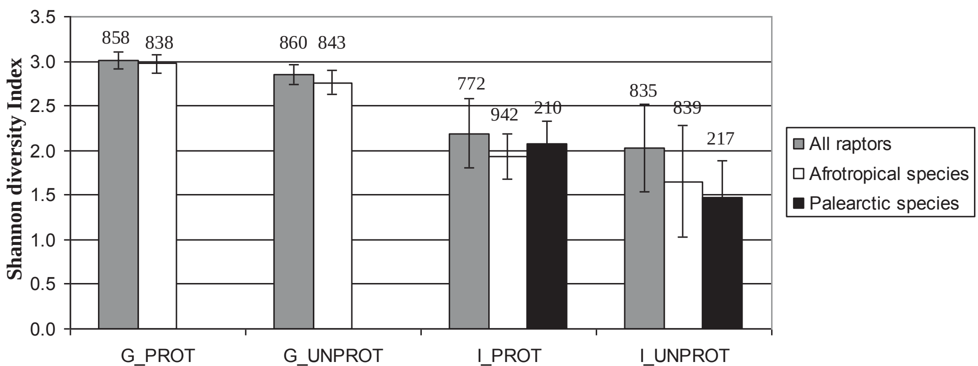


Figure 7. Species richness (A) and Shannon diversity indices (B) for all raptors, Afrotropical raptors, and Palearctic raptors in protected (PROT) and unprotected (UNPROT) areas of the Inundation zone (I), and Guinea savanna (G) in north Cameroon. Numbers of Palearctic migrants in the Guinea zone were too low for accurate comparisons and were left out. Indices were estimated at approximately equal sampling effort (*n* indicated). Values are presented with 95% CI.

Raptor richness and diversity in protected and unprotected areas

Despite a trend for lower raptor richness and diversity in unprotected compared to protected areas, these differences were not significant, which might have had several causes. First, we used lack of overlap of the 95% confidence intervals as a criterion of statistical difference, which is generally considered overly conservative (Payton *et al.* 2004), although it is the most appropriate criterion currently available for rarefaction curves (Colwell *et al.* 2012). Second, the hunting zones included in the analysis as protected areas in the Guinea zone, might have had lower raptor richness than the core conservation areas (Thiollay 2007a), but our transect coverage inside hunting zones was insufficiently extensive to test this assumption. Also, this did not play a role in the Inundation zone, where the entire protected area network had the status of national park. Third, protected and unprotected areas were located in relative proximity, while the wide-ranging habits of raptors dependent on protected areas might make differences only apparent at greater distances (Herremans & Herremans Tonnoeyr 2000). This effect may have been enhanced by the inclusion of wet-season counts in our assessment, since rains and changes in vegetation structure may render cultivated habitats around parks interesting for migratory or nomadic raptors. Further, moderately affected woodlands around protected areas in the Inundation and Guinea zone provided breeding habitat for small to medium-sized raptors, and foraging opportunities for large raptors breeding in the park. These results suggest that protected areas might act as source areas for raptor populations, which ensured preservation of the integrity of the raptor assemblage at the landscape-scale.

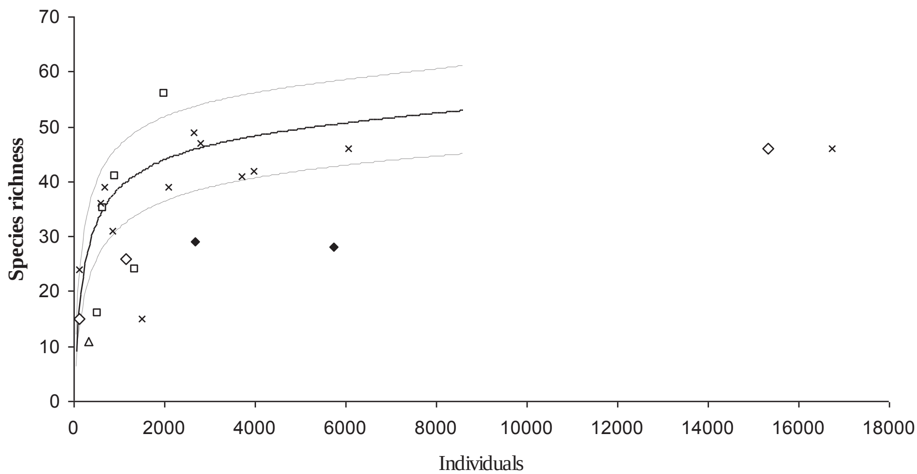


Figure 8. Raptor richness accumulation curve (solid line) with 95% confidence intervals (dashed lines) based on 7080 km dry-season road transect surveys in northern Cameroon between 2007 and 2010, compared to raptor richness recorded on road surveys in similar habitats in West Africa (X), East Africa (□), southern Africa (◊), South America (◆), and Asia (Δ). Numbers refer to published records (see Appendix 10.1).

Comparisons with regional, continental and global raptor richness

Our data illustrated the comparatively high richness of Cameroon's savanna raptor community, on a continental and global scale, which may be considered representative for raptor community richness in West African savannas. Since raptor richness is influenced by many factors, such as ecosystem productivity, topographical and vegetational diversity (Sergio *et al.* 2006, 2008), caution is needed when comparing richness estimates between widely spaced localities differing in such parameters. However, other studies used similar methods and frequently incorporated similarly diverse, productive and often partly protected areas (see Appendix 10.1), justifying our comparative assessment. As previously reported (Thiollay 1978a), the Lake Chad Basin and associated floodplains are of particular importance to Palearctic raptors, which is located on the western edge of the African winter range for some, while others reach higher densities here compared to areas further west (Thiollay 1977a). Adding to these wintering populations are Palearctic migrants which routinely traverse Cameroon's Sudan and Guinea savannas en route to and from their winter range at more southerly latitudes (Hake *et al.* 2003, Gschweng *et al.* 2008, Strandberg *et al.* 2009). Together, the rich assemblage of Palearctic winter and passage migrants and Afrotropical raptors highlight the region's importance as a focal point for raptor conservation in Africa.

Conservation concerns

Few protected area networks in West Africa cover the range of habitats necessary to maintain the diverse assemblage of species adapted to different vegetation types and structure (Thiollay & Clobert 1990), or support migratory populations with almost constantly shifting populations along latitudinal gradients (Thiollay 1978a). Cameroon may be a positive exception in this regard, and savanna habitat preservation at different latitudes may have been instrumental in maintaining its rich raptor community. The presence of large-bodied raptors in the heavily exploited Sudan savannas contrasts the situation in central West Africa, where few or no large sedentary eagles were detected outside protected areas or their peripheral zones in the Sudan savanna zone (Thiollay 2006a,b,c). This also implies that connectivity between core populations still exists in Cameroon, which is an important prerequisite for population viability. On the other hand, poaching and increased disturbance following human population increase may have contributed to the current scarcity of Secretary Bird *Sagittarius serpentarius* and Martial Eagle *Polemaetus bellicosus*, formerly regularly encountered in the Inundation zone (Louette 1981, Scholte *et al.* 1999). Similarly, White-headed and *Gyps* Vultures, which were still recorded breeding in the 1980s and 1990s (Mundy *et al.* 1982, Scholte 1998), have declined considerably and stopped breeding in the 1990s (Scholte 1998), or more recently in Waza N.P. (R. Buij pers. obs.). This suggests that the protected area network failed to safeguard breeding populations of some of the largest, most sensitive, and threatened raptors. Similarly strong declines of eagles and vultures has been reported from various other, small (< 2500 km^2) protected areas in Burkina Faso (Thiollay 2000, 2006b), Nigeria (Tende & Ottosson 2008), and Guinea Conakry (Rondeau *et al.* 2008), whereas larger protected areas (> 4000 km^2) such as the Mole N.P. in Ghana (Dowsett-Lemaire & Dowsett 2008), the Comoé N.P. in Ivory Coast (Salewski 2000), the Bénoué Valley in Cameroon (this study), and Arli-W-Pendjari Complex in central West Africa (Thiollay 2006a) appear to retain their large raptor populations, albeit at lower densities than previously for some. Protected area size thus seems to play a crucial role in maintaining threatened raptor populations, as observed in southern Africa (Herremans & Herremans Tonnoeyr 2000), and for other vertebrate populations in West Africa (Brashares *et al.* 2001), but further studies are urgently needed to identify causes for the decline of breeding raptors inside the region's protected areas.

Appendix to Chapter 10

Appendix 10.1. List of published and unpublished reports of raptor richness estimated using road transects in western Africa, South America, and Asia.

	Reference	Country	Habitat	Coverage[1]	Year	S[2]
1	Jensen *et al*. 2005	Venezuela	Wetlands, agriculture, forests	R	2000-02	D,W
2	Rondeau *et al*. 2008	Guinea	Guinea and Sudan savannas, protected area	R	2006	D
3	Thiollay *et al*. 2006a	Burkina Faso, Mali and Niger	Floodplain, Sahel and Sudan savannas, protected area	R	2003–4	D
4	Thiollay *et al*. 2006a	Burkina Faso, Mali and Niger	Floodplain, Sahel and Sudan savannas, protected area	R	1969–73	D
5	Thiollay 1975a	Chad	Sudan savanna, protected area	L	1973	D
6	Cade 1969	South Africa	Woodland savanna, protected area	L	1959-65	W
7	Herremans & Herremans-Tonnoeyr 2000	Botswana	Woodland savanna, Kalahari, protected area	R	1991-95	D,W
8	Anadón *et al*. 2010	Mauritania, Mali	Sahel savannas	R	2004	D
9	Thiollay 2001	Cameroon	Sudan savanna, protected area	R	2000	D
10	Thiollay 2001	Cameroon	Sudan savanna, protected area	R	1973	D
11	Carrete *et al*. 2009	Argentina	forest, floodplain, grasslands, woodland, mountain forest, desert	R	2002-05	B
12	Sanchez-Zapata *et al*. 2003	Kazakhstan	Grassland, floodplain	R	1999	B
13	Thiollay 2007a	Burkina Faso	Sudan savanna, grassland, floodplain, woodland, protected area	R	2004-05	D
14	Weesie & Belemsogbo 1997	Burkina Faso	Sudan savanna, protected area	L	1991-92	D
15	Thiollay 1975b	Ivory Coast	Guinea savanna, protected area	L	1968-73	D
16	Thiollay 1975b	Ghana	Guinea savanna, protected area	L	1972	D
17	Ogada & Keesing 2010	Kenya	savanna woodland, protected area	L	2001-03	D,W
18	Ogada *et al*. 2010	Kenya	savanna woodland, protected area	R	2010	D
19	Njilima *et al*. 2010	Tanzania	savanna woodland, protected area	R	2010	D
20	Thiollay *et al*. 2008	Tanzania	savanna woodland, protected area	R	2008	D
21	Sorley & Andersen 1994	Kenya	savanna woodland, protected area	L	1990	D
22	Thiollay 1970	Senegal	Sudan savanna, protected area	L	1969	D
23	Barkhuysen 2004	South Africa	Grassland, agriculture, forest, protected area	R	2003	D,W

[1]Regional (R): transects covered region within a country or multiple countries; local (L): transects covered single protected areas, with or without buffer zones. [2]Season: dry (D), wet (W), breeding season (B)

Box B

Sightings of Sooty Falcon in the far north of Cameroon

Ralph Buij

Published in: *Bull ABC* (2010), 18(2): 211-215

Sooty Falcon *Falco concolor* is considered a rare Palearctic vagrant to western Africa (Borrow & Demey 2001). Confirmed records exist for eastern Chad in May and June. In addition, four to five Sooty Falcons were observed at several locations in and around the northern Aïr Mountains in Niger, between July and September; at least one was in its second calendar year (NiBDaB 2010). These constitute the only summer records for the region. The following describes observations made by the author of Sooty Falcons in northernmost Cameroon in May and July 2010.

On 1 May 2010, I photographed a Sooty Falcon south of the village of Rhumsiki in the Kapsiki Mountains (10°40'N 13°56'E; 1100 m; Figure 1a). Temperature was 35°C with clear skies; the first seasonal rains had fallen several days earlier. The falcon was hawking insects at 13:27 at 150–200 m above ground and moved off north-west. Its plumage was uniform bluish grey, including the flight feathers; the cere and feet were yellow. The ochre cheeks and chin and the dark moustachial indicate the bird was probably in its third calendar-year, or perhaps older (Forsman 1999). The habitat consisted of undulating hills and rocky outcrops with cultivation, *Combretum* and *Terminalia* shrubland and scattered villages. Several Eurasian Hobbies *F. subbuteo* were observed hawking insects in the same area that day.

Between 7 and 28 July 2010, I observed at least five Sooty Falcons near the village of Waza, south of Lake Chad and close to Waza National Park in northern Cameroon (11°40'N 14°57'E; 300 m). Photographs of at least four different individuals indicated they had barred, i.e. juvenile-type, flight feathers and relatively short wings (especially the 'hand'), suggesting they were in their second calendar-year (Forsman 1999). All observations were made near or from three granite outcrops, which constitute the only higher ground in this relatively flat area and which rise to 400–500 m. Surrounding habitat consists of seasonally flooded grassy plains, interspersed by cultivation (millet, sorghum), small villages, and higher lying *Sclerocarya birrea* and *Anogeissus leiocarpus* tree savanna, *Combretum* and *Terminalia* shrubs, and stands of *Hyphaena thebaica*. *Acacia seyal* tree savanna on black clay soils is saturated with water in the rainy season. Rainfall (peak from May–September) is irregular with an annual mean of 450-700 mm. From June, the area received above average rainfall, with rains at least every 2–3 days continuing into July. As a result, much of the surrounding grassy plains were permanently inundated.

On 7 July, two Sooty Falcons were hawking insects and 'playfully' chasing each other above the rocky outcrops. They were seen around 17:00 in overcast conditions after a day of heavy rain. Other raptors simultaneously hawking insects above the outcrops included several juvenile Lanner Falcons *F. biarmicus*, two African Hobbies *F. cuvierii* and 12 Fox Kestrels *F. alopex*. On 16–18 July, at least two Sooty Falcons were seen infrequently at the same location, mostly in the afternoon, at 16:30–18:30, when they were hawking insects together around the outcrops (Figure 1b). Once, a Sooty Falcon was seen at 07:34. On 19 July, a group of five Sooty Falcons were hawking insects together at 16:35, after a day of heavy rain.

On 24–25 July, up to three Sooty Falcons were seen together from the highest rocky outcrop in the area (500 m), which was visited for the entire day on both dates (Figures 2–4). A Sooty Falcon appeared around 14:30 on 24 July, in fine weather coinciding with the development of a distant rainstorm. It was hawking insects at very close range, pursuing prey in rapid flight among the boulders at the top of the hill, and dismembering and consuming insects in flight. Prey included dragonflies and alate termites, possibly also locusts. It often stooped at great speed from 50–70 m up, twice at dragonflies. Other raptors attracted to the insect food included two African Hobbies, a single Grey Kestrel *F. ardosiaceus* and several Lanner Falcons and Fox Kestrels. After 20 minutes, the Sooty Falcon flew off in the direction of the rainstorm. Two more Sooty Falcons appeared 30 minutes later and after some time spent hawking insects near the top of the hill, also moved off in the direction of the storm. Three Sooty Falcons - probably the same individuals - were seen higher up at 16:00, hawking insects in the rain, by which time other falcons had ceased their hunting activities. Three Sooty Falcons were again seen together at the same location on 25 July, around 13:00, in light rain. After several minutes they moved off to forage above the distant flooded grasslands.

The last observation of a Sooty Falcon was made on 28 July at 15:20; this bird was seen only briefly after it had started raining. No further visits were made to the area after 28 July. Despite five years of intensive raptor studies by myself and various year-round bird surveys by others during the past 20 years, these are the first observations of Sooty Falcons in Cameroon. Thiollay (1977a) did not observe the species during his seven years of raptor studies between Mauritania and Cameroon. The Sooty Falcons in Niger were only recorded in one out of 12 years of bird studies, following heavy rains which resulted in a superabundance of locusts (J. Newby pers. comm.). Sooty Falcons may only visit western Africa infrequently and perhaps only when heavy rains trigger a rich supply of food. Their frequency of occurrence may be under-estimated, however, due to the scarcity of observers.

It is important to note, in this respect, the paucity of observations of the ecologically similar Eleonora's Falcon *F. eleonorae* in western Africa. Intensive raptor surveys resulted in a single observation of Eleonora's Falcon in northern Cameroon (Chapter 10) and another in the south (Hivekovics & Palatitz 1998), while there are only three records elsewhere in the region: single black-morph individuals at the Banc d'Arguin, north-west Mauritania, in November and January (Lamarche 1988, Meininger *et al.* 1990), and a bird video-taped in Mount Peko National Park, Côte d'Ivoire, in March (G. Rondeau *in Bull. ABC* 8: 147). Recent satellite transmitter studies have revealed, however, that West and Central Africa - especially Niger, Nigeria, Cameroon, Chad, Central African Republic and Congo-Kinshasa - are routinely crossed by Eleonora's Falcons en route to and from their breeding grounds in the western Mediterranean (Gschweng *et al.* 2008, Lopez-Lopez *et al.* 2010). The third calendar-year Sooty Falcon seen in May in northern Cameroon was perhaps following a similar migratory route, although it was slightly west of the expected flight path, given the location of the westernmost known breeding grounds of Sooty Falcons in eastern Libya.

The Eleonora's Falcon satellite studies revealed the over-summering of juvenile Eleonora's Falcons on the African continent, away from the breeding grounds (Gschweng *et al.* 2008).

The very low proportion of subadult Sooty Falcons at some breeding colonies, such as in Oman (M. McGrady in litt.), suggests young Sooty Falcons also summer away from their breeding colonies. Similar to Eleonora's, summering Sooty Falcons may range widely on the African continent, tracking strong rains and the superabundance of prey that they bring. Observations of Sooty Falcons in eastern and southern Africa, including Madagascar, during July–October are extremely rare; only a handful were reported from Tanzania during this period, some of which may have been misidentified Grey Kestrels (N. Baker in litt.). The Sooty Falcons observed in northern Cameroon in July, and in Niger in July–August suggest that summering Sooty Falcons may be particularly attracted to good rains in this part of Africa.

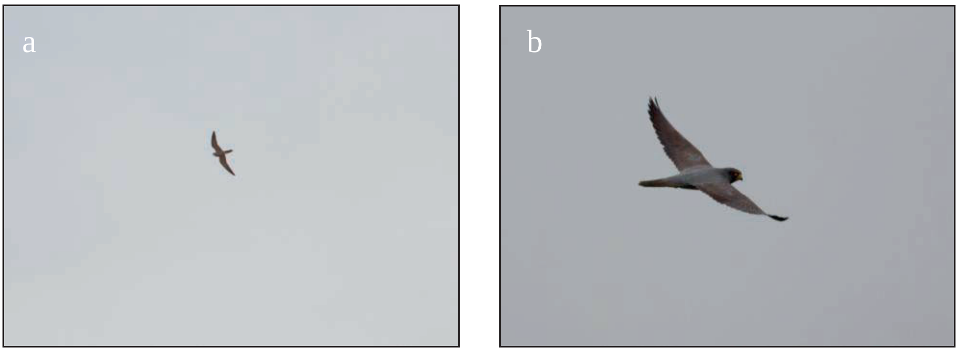


Figure 1. (a) Third calendar-year or older Sooty Falcon, 13 km south of Rhumsiki, Cameroon, 1 May 2010. Note the long wings; (b) second calendar-year Sooty Falcon; the mantle, rump and head feathers have been moulted, but note the retained juvenile upperwing-coverts, remiges and retrices, Waza, Cameroon, 17 July 2010.

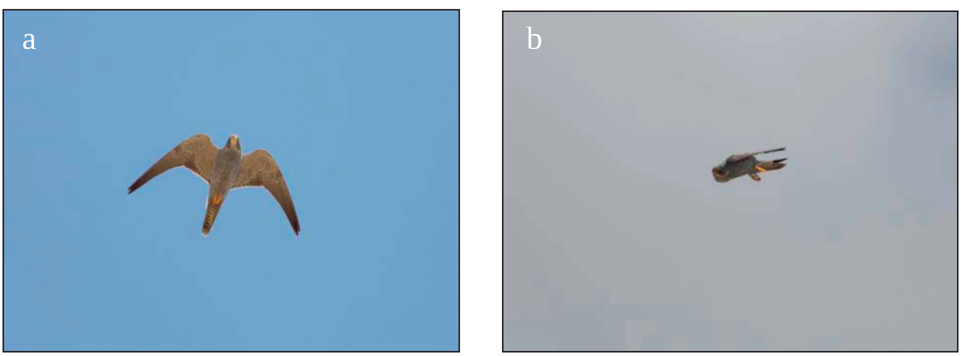


Figure 2. (a) Second calendar-year Sooty Falcon hawking insects, Waza, Cameroon, 24 July 2010; and (b) the same individual stooping at a dragonfly.

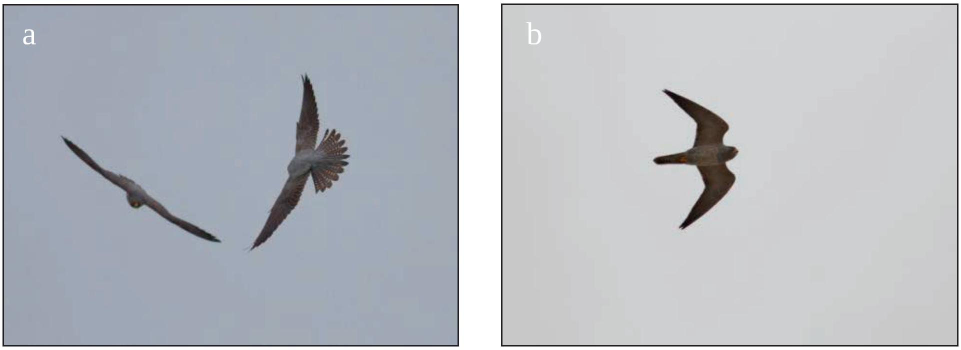


Figure 3. (a) Second calendar-year Sooty Falcon "playfully" chasing each other, Waza, Cameroon, 24 July 2010; and (b) second calendar-year Sooty Falcon; the moult of body feathers is less advanced than in the bird depicted in Figures 2a-b, Waza, Cameroon, 24 July 2010.

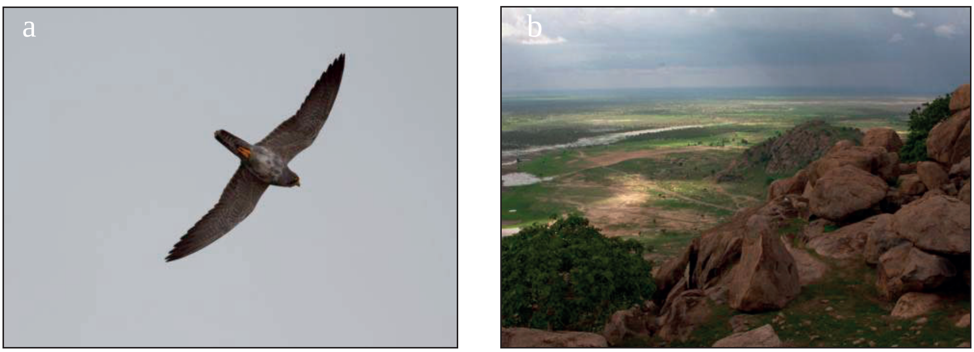


Figure 4. (a) Second calendar-year Sooty Falcon, Waza, Cameroon, 24 July 2010; and (b) Sooty Falcon habitat, a rocky outcrop of 500 m elevation in otherwise flat terrain; the falcons chased insects among the boulders and also visited the distant inundated grasslands, Waza, Cameroon, 24 July 2010.