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Short Note

Seasonal movements of Black Coucals *Centropus grillii* in Nigeria

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The scale of movement associated with the migration of many intra-African bird species is still poorly known even with the increasing availability of tracking devices. In this study, we tracked the movements of Black Coucals *Centropus grillii* breeding in Nigeria from late July using satellite telemetry. Individuals remained on the breeding site for several months; two individuals transmitted after October and these two moved shorter distances (< 100 km) away from the breeding site in early December. One of these was tracked for a full year, moving to a site 175 km south of the breeding site in early January and returning to the breeding site in late May. The bird migrated faster during the return journey (58 km day^{-1}) as compared to the post-breeding journey (5.9 km day^{-1}). The overall home range (90% kernel density) during breeding was 20.4 ± 3.3 km^2 (mean ± s.d.) and the core (50%) 5.0 ± 1.6 km^2 with no apparent clear change outside of the breeding season. Vegetation conditions at the distant site were apparently poorer although in an average year the move would have led to improved conditions. Short-distance seasonal migration of Black Coucals might be widespread in drier seasonal habitats.

Mouvements saisonniers des Coucals noirs *Centropus grillii* au Nigeria

L'ampleur des mouvements associés à la migration de nombreuses espèces d'oiseaux intra-africains est encore mal connue, même avec la disponibilité croissante des dispositifs de suivi. Dans cette étude, nous avons utilisé de la télémétrie par satellite pour faire le suivi des mouvements de Coucals noirs *Centropus grillii* se reproduisant au Nigeria à partir de la fin juillet. Les individus sont restés sur le site de reproduction pendant plusieurs mois. Seulement deux individus ont continué à transmettre le signal après octobre ; ils se sont éloignés du site de reproduction sur de courtes distances (< 100 km) au début du mois de décembre. L'un d'entre eux a été suivi pendant une année complète, se déplaçant vers un site situé à 175 km au sud du site de reproduction début janvier et revenant sur le site de reproduction à la fin du mois de mai. L'oiseau a migré plus rapidement pendant le voyage de retour (58 km jour^{-1}) que pendant le voyage post-nuptial (5,9 km jour^{-1}). Le domaine vital global (densité de 90% des noyaux) pendant la reproduction était de 20,4 ± 3,3 km^2 (moyenne ± écart-type) et le noyau (50%) de 5,0 ± 1,6 km^2 sans changement clair apparent en dehors de la saison de reproduction. Les conditions de végétation sur le site éloigné étaient apparemment moins bonnes, bien que dans une année typique, le déplacement aurait conduit à une amélioration des conditions. Dans des habitats saisonniers arides, la migration saisonnière à courte distance des Coucals noirs pourrait être une stratégie répandue.

Keywords: intra-African bird migration, short-distance migration, vegetation greenness

The extent of occurrence of most bird species in Africa is relatively well described. However, less is known about the seasonality of occurrence shown by intra-African migrants (Moreau 1972). In many cases, it is only known that the occurrence is seasonal and few details of the migration patterns involved are known – so-called migratory connectivity, involving for example, directions and distances and variability among individuals (Webster et al. 2002; Wakelin et al. 2011). Curry-Lindahl (1981) categorised 532 species (including seabirds such as shearwaters, Procellariidae) as intra-African migrants, of which 444 species were Afrotropical migrants showing marked changes in seasonal occurrence within sub-Saharan Africa. In general, these migrants move toward wetter areas in the dry season, most within the northern or southern tropics, or southern temperate zone with fewer crossing the Equator (Newton

2008) and with the average temperature of the coldest month being a strong predictor of the proportion of migrants (Hockey 2000). Some species move longer distances. Both obligate and facultative migration is found (Newton 2008). The shortest facultative migrations are presumed similar to those performed by intra-European short-distance migrants responding to weather (Newton 2008).

Documented individual tracks reveal high variability in the migration distance of intra-African migrants. For example, the migration distance of trans-equatorial migrant species like the Abdim's Stork *Ciconia abdimii* averaged 3 750 km (Jensen et al. 2006), an individual Wahlberg's Eagle *Hieraaetus wahlbergi* travelled 3 520 km (Meyburg et al. 1995) and Woodland Kingfishers *Halcyon senegalensis* also travelled far (roughly 3 000 km, Nussbaumer et al. 2022). Migration distance in other species, not crossing the Equator, like the African Cuckoo *Cuculus gularis* and Black Harrier *Circus maurus*, averaged 730 km and 814 km, respectively (Iwajomo et al. 2018; Garcia-Heras et al. 2019). Based on pressure sensors, Nussbaumer et al. (2022, 2023) provide some of the first direct evidence of short-distance seasonal movements in individual Mangrove Kingfishers *Halcyon senegaloides* and Red-capped Robin-Chats *Cossypha natalensis* but otherwise few data describe short-distance migration within the intra-African system.

Black Coucals *Centropus grillii* occur widely in Africa in wet habitats, such as moist and flooded grassland and marshes. Males tend to the nest and females are on average slightly larger, polyandrous and maintain territories. It is considered a poor flier and individuals are rarely observed flying longer distances – instead they tend to creep away low in the vegetation (Erritzøe et al. 2012). Vernon (1971) suggested that Black Coucals are sedentary in year-round wet areas but may move to breed in seasonal wet habitats during the rains and Hockey (2000) categorised its migratory status as 'intra-African, N and S of the tropics but with extensive tropical residency'. During the breeding season females maintain a relatively larger home range due to their territorial habit as compared to males (Goymann et al. 2004).

Here, we present the first data on movements of Black Coucals breeding in central southern Nigeria. Our study was motivated by the apparent disappearance of Black Coucals from this site outside of the rainy season. We deployed satellite tracking on five individuals, of which two remained operational after the breeding season, one of which for the whole year. With this limited data set, we focus mainly on describing large-scale movements and relate the spatiotemporal patterns to the local vegetation dynamics.

Black Coucals were caught at Weppa Farms (07°07'N, 06°41'E) during the breeding season. The 13 000 ha private farm is near Agenebode, Edo State and about 5 km from the western bank of the Niger River. The farm experiences six to seven months of rainfall, with the peak being in September. Hence the area remains green for most of the year. Birds were caught with mist nets and tape lures on 20 and 21 July 2014 (Table 1). Individuals were aged and sexed based on plumage characteristics and size differences (see Goymann et al. 2004). Five Black Coucals (Table 1) were fitted with Solar PTT-100s 5-g satellite transmitters (Figure 1; Microwave Telemetry Inc.) as a backpack using a 2 mm braided nylon string. Transmitter weight constituted < 5% of individuals' body weight. Transmitters were on a 10-hour-on, 48-hour-off cycle. Geographical positions of the transmitters were obtained from ARGOS/CLS Service Argos (Argos 2011). We included only high-quality positions (classes 1–3 with an error radius of less than 1.5 km) during the period of transmission.

Tags transmitted from 49 to 362 days. Locations after deployment indicated that all birds were initially alive and moving but only two birds left the breeding area

Figure 1: Black Coucal *Centropus grillii* with transmitter

Table 1: Details of individual Black Coucals *Centropus grilli* tagged. The sexing based on size is only indicative.

Bird	Age	Sex	Wing	Mass	Start date	End date	#Days	Sites
136830	4	F	167	139	20/07/2014	24/10/2014	96	1
136831	4	M	149	100	20/07/2014	26/03/2015	249	2
136832	4	M	144	98	20/07/2014	20/09/2014	62	1
136833	4	F	165	151	21/07/2014	08/09/2014	49	1
136834	4	F	168	152	21/07/2014	18/07/2015	362	3

while transmitting. In no case was it possible to ascertain whether transmitters had failed or the bird had died when transmission ceased. Black Coucals often stay low in dense vegetation which might prevent sufficient charging of the solar cells because of shading, and radio signal propagation might also be impeded. Difficulties in moving around in dense vegetation with a transmitter attached could potentially occur. However, the harness design and fabric have been successfully applied to African Cuckoos (Iwajomo et al. 2018) without adverse effects observed and the design has been applied to a range of species including the secretive Corn crake (Peške et al. 2017).

We defined stationary non-breeding sites as locations < 10 km at which the birds stayed for at least five days and from where they moved onwards. Visual inspection of the bird locations revealed that distances between locations within the breeding ground and stopover sites ranged between 0.1 and 9 km. Only in one individual (136834) did we find movements up to 14 km from the breeding area. In this case, the bird returned to the breeding site in less than 24 hours. Thus, we consider such movements to likely result from foraging trips or in response to some intraspecific interactions.

We investigated differences in home range size among individuals and sites based on the satellite-derived locations. Given that these are relatively imprecise with error radius of up to 1.5 km, these are biased high for smaller home range sizes. Home ranges were estimated as kernel densities (Worton 1989, 1995) using the package *adehabitatHR* (Calenge 2011) in R 4.1.2 (R Core Team 2021). The home ranges were derived based on the 50% and 90% isopleths using the href method. For all individuals, we estimated the size of the breeding ground home ranges, while for the two individuals that migrated we also estimated the home range of the stopover sites. The 90% kernel density home range estimates (KDEs) were an order of magnitude larger than the error ellipse and were unrelated to sample size (p = 0.89) indicating that at least the 90% KDEs reflect true differences among home range sizes. However, given the error associated with the locations we regard the 50% isopleths (core home range) as unreliable.

To investigate potential resource availability across the annual cycle, we estimated the vegetation greenness at stationary locations throughout the year based on Normalised Difference Vegetation Index (NDVI). NDVI was downloaded from NOAA STAR (https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_ftp.php) as weekly GEO-TIFFs with 4x4 km resolution (Blended-VHP data). Expected NDVI was calculated as the 10-year average for the ten preceding years. Tracking data used in this study are available from the Movebank Digital Repository at www.movebank.org.

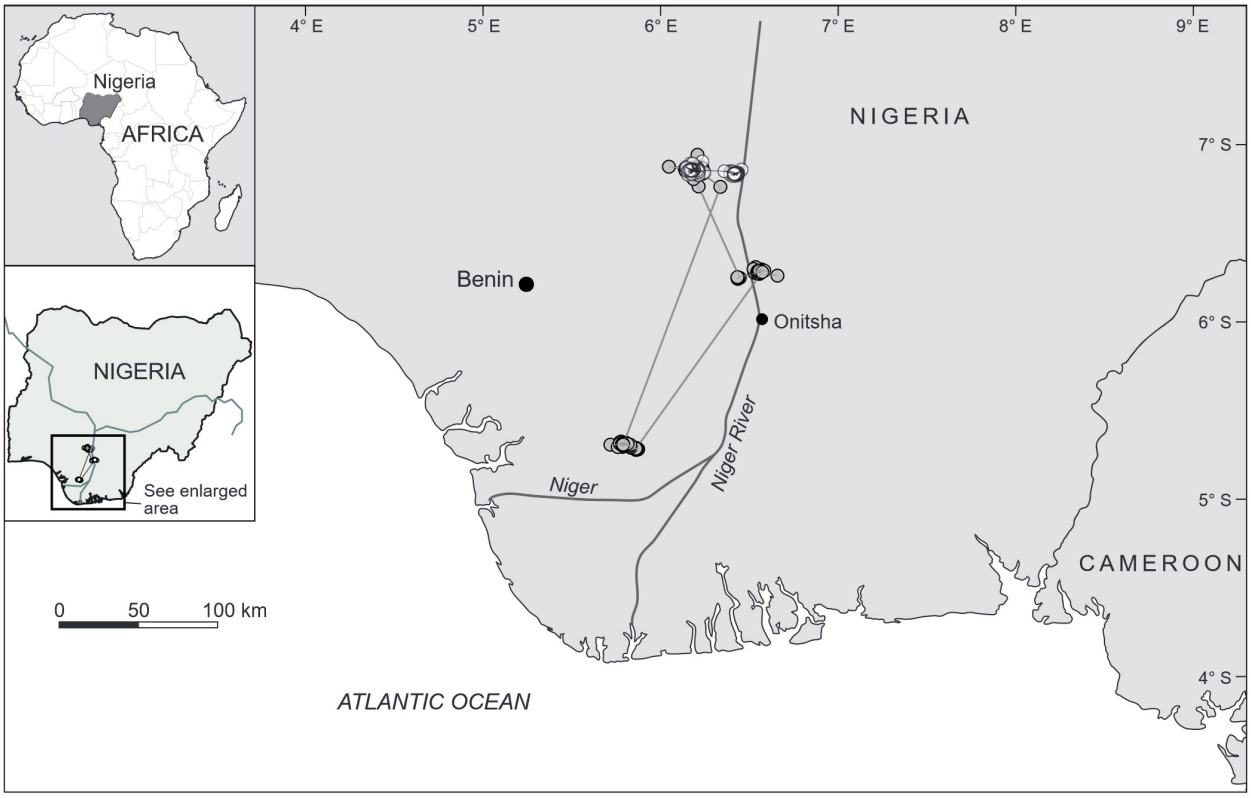

Figure 2: Migration routes of two Black Coucals *Centropus grillii* (#136834: sexed female and represented by black line and black open circle; #136831: sexed male and represented by red line and red open circle) from the breeding ground in central southern Nigeria to southern South Nigeria. Map was produced in QGIS version 3.4.13 using data from Natural Earth (https://www.naturalearthdata.com)

For three individuals, transmission stopped while still at the breeding site (last transmission between 8 September and 24 October 2014). The remaining two individuals last transmitted from the breeding site on 13 (#136834) and 15 December 2014 (#136831) having moved to new respective locations, 25 km (#136831) and 75 km away (#136834) (Figure 2). One individual (#136831) remained at this site until transmission stopped. The other individual (#136834) moved on 10 January 2015 to a site 175 km to the south of the breeding site, returning to the breeding site on 21 May 2015 (Figures 2 and 3). Travel speed was higher for this individual during the return journey (58 km day^{-1}) as compared to the departure journey (5.9 km day^{-1}).

Stopover habitats used by individual #136831 were the grassy floodplains on the eastern bank of the Niger River, whereas bird #136834 stayed for 16 days on the grassy agricultural landscapes with numerous rice fields and farmlands located between Anaku and Umuelum towns in Anambra state, southeast Nigeria (Asadu et al. 2019).

Table 2: Kernel density home range estimates (KDE) of tagged Black Coucals *Centropus grilli* during breeding and stationary non-breeding sites

Bird	Sex	Location	50% KDE (km^2)	90% KDE (km^2)	Sample size
136830	F	Breeding ground	2.5	18.3	162
136831	M	Breeding ground	3.2	19.0	222
		Non-breeding	2.8	15.6	72
136832	M	Breeding ground	2.3	13.9	111
136833	F	Breeding ground	6.4	29.1	77
136834	F	Breeding ground	2.1	20.7	274
		Non-breeding	5.4	27.5	44
		Non-breeding	5.5	31.0	203
		Breeding ground	3.3	21.2	99

Thereafter, it moved to the final non-breeding ground located north of Niger Delta region of Nigeria.

The mean overall home range on the breeding ground covered 20.4 ± 5.0 km^2 (mean ± s.d.; 90% kernel density; range [13.9–29.1]) with no obvious differences between males and females (Table 2). Mean overall (90%) non-breeding home ranges covered 24.7 ± 8.1 km^2 (Table 2).

When individual #136834 moved south by 175 km, the vegetation greenness was declining (Figure 4a) but the vegetation greenness at the new site was poorer (Figure 4a). However, in an average year the change in location would have resulted in higher vegetation greenness of the area used (Figure 4b).

Our study documents the complete migration of a Black Coucal within southern Nigeria. The spatiotemporal pattern of the migration suggests a directed movement over a relatively short distance in response to past environmental conditions. The two tracked Black Coucals left the breeding area at a time of declining vegetation conditions, likely because the ground dried out. Although our sample size was very small, not warranting general conclusions at this stage, our data did show that some individuals leave the breeding area, which is consistent with the suggestion by Vernon (1971) that Black Coucals are likely short-distance seasonal migrants in more dry parts of their distribution with movements coinciding with the rains. This study suggests that, like some other intra-African migrants (e.g. Abdim's Stork, Jensen et al. 2006; African Cuckoo, Iwajomo et al. 2018) and many Palaearctic-African migratory species, Black Coucals migrate slowly during the post-breeding journey but faster during the return journey. Nilsson et al. (2014) posited that this is an adaptive strategy for arriving at the breeding grounds early and so benefiting from early occupation of territories and mate selection. For now, we can only speculate that this is also true for intra-African migrants like the Black Coucal.

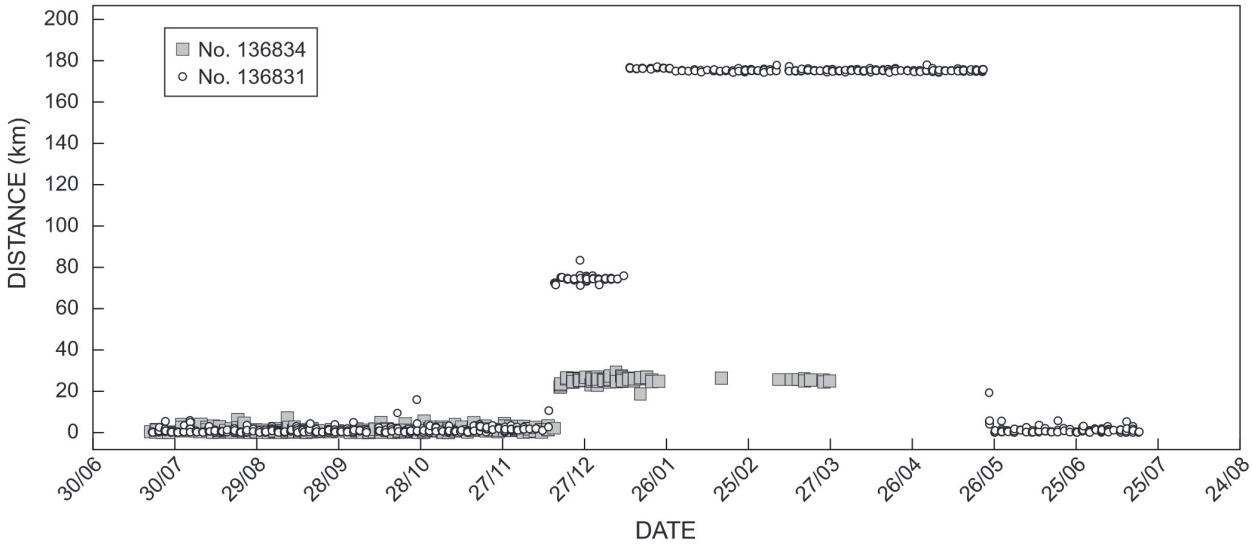

Figure 3: Distance to the breeding site in relation to time for two Black Coucals *Centropus grillii* (#136834: black circles; #136831: red squares) tracked throughout the annual cycle

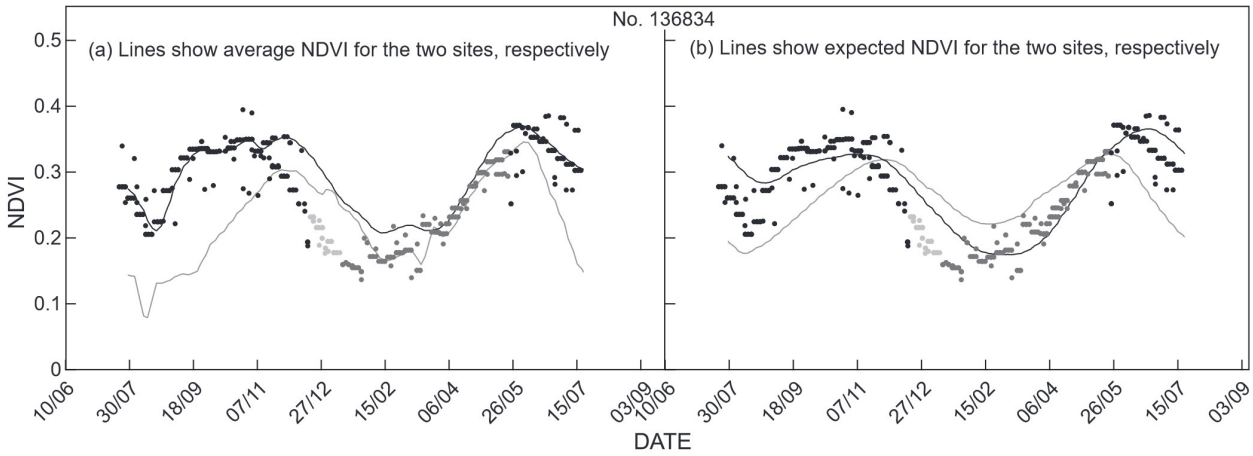

Figure 4: Greenness of the vegetation (Normalised Difference Vegetation Index) at the location of the Black Coucal *Centropus grillii* tracked for the full annual cycle (different sites indicated by differently shaded dots) compared to actual (a) and expected (b) NDVI (lines, shading corresponding to site), respectively, at the two major sites visited for this individual

The individual that was tracked to a longer-term non-breeding site ranged over a relatively larger area compared to the area used on the breeding ground and did not experience better vegetation conditions. However, in an average year the move would have resulted in better conditions and the moves coincided with general local seasonality as also found in African Cuckoos (Iwajomo et al. 2018). It seems likely that the Black Coucal simply followed its schedule from previous years and moved to the non-breeding site when current conditions at the breeding grounds deteriorated, in this case reaching poorer vegetation. Despite the less green vegetation the non-breeding site might still have provided wetter ground, which the Black Coucals seem to prefer.

Our small sample revealed previously undescribed local movement in response to vegetation dynamics in the Black Coucals. Such movements might be widespread among African species in areas with seasonal rains. Our study highlights the need for more tracking studies that will help provide a better understanding of the intra-African bird migration system. This knowledge will also assist in conservation decisions that will benefit Afrotropical bird species wintering across Africa.

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Ethics and permits — This study was carried out in accordance with Guidelines to the use of wild birds in research of the Ornithological Council (Fair et al. 2010). No special permits are required for capturing and tagging wild birds in Nigeria.

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