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PLATINUM
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First assessment of bird diversity in the UNESCO Sheka Forest Biosphere Reserve, southwestern Ethiopia: species richness, distribution and potential for avian conservation

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Abstract: The Sheka Zone in southwestern Ethiopia is covered by some of the largest remaining forests in the Eastern Afromontane biodiversity hotspot. Owing to the rich biodiversity and a high degree of endemism, it was declared as a biosphere reserve by UNESCO in 2012 and is considered a Key Biodiversity Area. Detailed knowledge on species diversity and distribution in the reserve is, however, severely limited. From February to April 2016, an assessment of the bird diversity and distribution in the reserve was made for the first time through point count transects, camera-trap recordings and opportunistic observations. In total, 244 bird species were identified, of which 19% was only found within the reserve's designated protected zones. Our study indicates a remarkable bird species richness across the different habitats in Sheka Forest Biosphere Reserve and can be used as a baseline for future monitoring studies and conservation planning.

Keywords: Avifauna, Eastern Afromontane Biodiversity Hotspot, habitat occupation, Horn of Africa, inventory, IUCN.

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Author Contribution: MDB and MB designed the study, MVO, BO, JE and MDB collected the data, BO and MDB analysed the data. MVO, JE and MDB wrote the manuscript.

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INTRODUCTION

Ethiopia is recognized among the 35 most biodiverse regions in the world and its biodiversity is renowned for its high percentage of endemism. The highlands in the southwest, where most of the larger forest tracts remain, are part of the Eastern Afromontane Biodiversity Hotspot (Mittermeier et al. 2011). Natural habitats are highly diverse in this region, where the forest structure changes along a large elevation gradient (Friis 1992), with moist evergreen Afromontane rainforests presenting the dominant vegetation type, but also including bamboo forests and transitional rainforests leading down to semi-deciduous forests at lower altitudes. In most areas, the forests are interspersed with wetlands or, at higher altitude, moorlands. Ethiopian natural forests are however rapidly disappearing (Dessie & Kleman 2007; Reusing 2000), with approximately 11.4% or 12,499,000ha of total forest cover left (FAO 2015).

The Sheka Zone in southwestern Ethiopia still harbors some of the largest remaining Afromontane forests in the country (>100,000ha). Nevertheless, the combination of a rising population, ongoing land-allocation to agricultural investors and a lack of land-use planning are increasing pressure on the remaining natural habitats. As such, the deforestation rate within Sheka is one of the highest in Ethiopia, with severe impacts on local economy, culture and environment (Woldemariam & Fetene 2007). Sheka forest is considered a Key Biodiversity Area (Birdlife International 2017) and, in 2012, it was recognized by UNESCO as the Sheka Forest Biosphere Reserve. This recognition has led to the zonation of the area into core-, buffer- and transition zones (Fig. 1). These are, respectively, devoted to long-term protection of intact forests (core zones), participatory forest management and low-intensity production (buffer zones), and sustainable human settlement and agriculture (transition zones) (Gole & Getaneh 2011). The forest furthermore provides an important refuge for the native genetic diversity of wild crop relatives with significant agricultural value. The most prominent example is the indigenous wild coffee *Coffea arabica*, which can still be found in reasonable densities in the broadleaf forest of Sheka, but also other wild crop relatives that are imperative for local food provisioning such as Enset or 'False Banana' *Ensete ventricosum* and Ethiopian Cardamom *Aframomum corrorima*. All combined, there are strong incentives to safeguard this forest also from an economic and agricultural perspective (De Beenhouwer et al. 2013; Aerts et al. 2015).

Biodiversity and conservation research has seen a recent increase in southwestern Ethiopia, mainly in relation to agroforestry (e.g., Hundera et al. 2013; Tadesse et al. 2014); however, biodiversity studies in remote forest regions such as Sheka have been very limited thus far, despite the recognition as a UNESCO biosphere reserve and strong ongoing habitat degradation. Detailed insights in the diversity, distribution and abundance of species in the area are hardly available. Likewise, information on the bird diversity in Sheka forest is very scarce, but limited research done in the broader region (e.g., Woldegeorgis & Wube 2012) provides clear indications for a large bird species diversity in remaining forest tracts of southwestern Ethiopia. Here, we present a first comprehensive inventory of the bird diversity in Sheka Forest Biosphere Reserve, discuss our observations in relation to the delineated management zones, and highlight the biosphere reserve as an understudied yet highly valuable area for bird conservation and continued biodiversity studies.

MATERIALS AND METHODS

From Masha (around 7.749^0N & 35.471^0E; ca. 2,250m), the largest village in the area and capital of the Sheka Zone, we surveyed a variety of core-, buffer- and transition zones across the three districts, or 'woredas', situated in the biosphere reserve (Masha, Anderacha and Yeki). Our field expeditions took place from 2 February 2016 until 30 April 2016, and nine different 'kebeles' (the smallest administrative division) were visited across the three woredas (Table 1). The humid highlands of southwestern Ethiopia are characterized by a short rainy season from March to April and a long rainy season from June to October, with an average temperature of 18.4°C and yearly precipitation of 1,783mm. Hence, our expeditions were carried out immediately prior to and during the short rainy season. Permission for the field work was granted by the Ethiopian Wildlife Conservation Authority (EWCA) at the national level, the head office of the Sheka Zone and by kebele leaders on the local administrative level. The study was part of a larger expedition to assess the biodiversity in the reserve.

Birds were identified using visual, vocal and camera trap observations. Photo and audio recordings were made to support identification. When recordings of certain species were lacking, only those with double observations were listed. Visual and vocal assessments were done during early morning point transect surveys and on an ad hoc basis in all locations visited throughout

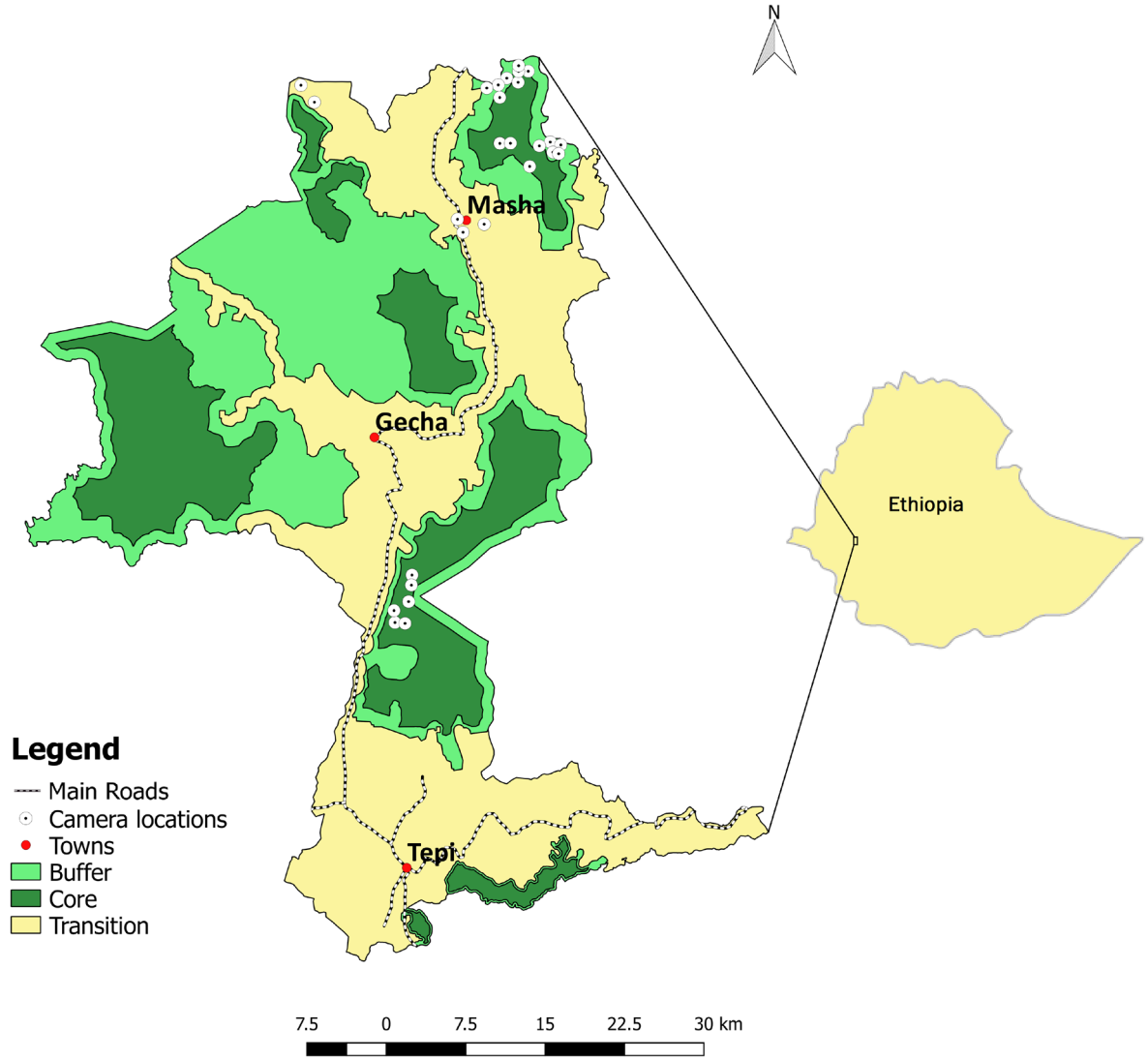

Figure 1. An overview of the Sheka Forest Biosphere Reserve and its location in Ethiopia, showing the proposed zoning into different management zones (see legend; Gole & Getaneh 2011) and camera trapping locations within the reserve. Masha, Gecha and Tepi are the central towns, respectively, in the woredas of Masha, Anderacha and Yeki.

the expedition. Because the delineation between core and buffer zones was not always clear in the field, observations herein were collectively assigned to the 'protected zones' within the reserve. Assessments were carried out covering a wide variety of habitats. These were divided into seven categories for a provisional overview of species' habitat occupation throughout the reserve (Table 2). Early morning point transect surveys consisted of six counts of 10 minutes, interspersed by five minutes of walking in a predetermined direction. All birds seen and/or heard within a perimeter of 25 meters around the observer were noted. In this way, a total of 74 point transect surveys were carried out, with one survey always restricted to the same habitat. Species identification was done using the Helm field guide 'Birds

Table 1. An overview of the locations visited in Sheka Forest Biosphere Reserve during the inventory, highlighting the central areas and field camps around which search efforts were concentrated and their altitude as approximated by GPS readings.

Woreda	Location/kebele	GPS	Altitude (m)
Masha	Masha	7.749^{0}N & 35.471^{0}E	2293
	Ateso	7.711^{0}N & 35.450^{0}E	2332
	Shato forest (north)	7.856^{0}N & 35.506^{0}E	1681
	Shato forest (south)	7.803^{0}N & 35.551^{0}E	1712
	Karina	7.859^{0}N & 35.339^{0}E	2176
	Atele	7.707^{0}N & 35.407^{0}E	2385
Anderacha	Gecha	7.562^{0}N & 35.404^{0}E	2231
	Gandochi	7.417^{0}N & 35.425^{0}E	2576
Yeki	Tepi (and Gilo River)	7.198^{0}N & 35.425^{0}E	1097

Table 2. The studied habitat categories, including the number of point transect surveys conducted per habitat and the average number of bird species recorded per survey. Surveys were not focussed on settlements (Se) and grazing lands (Gr), which instead were assessed through opportunistic search efforts and camera trapping.

Habitat	Description	Surveys	No. of species, survey
Riverine forest (Rf)	Broadleaf forest and woodland along waterways.	9	24, 3
Wetland (We)	Open habitat, either permanently or seasonally saturated with water.	23	22, 3
Moorland (Mo)	Open habitat, characterised by low-growing vegetation on acidic soils.	8	16, 1
Broadleaf forest (Br)	Broadleaf forest and woodland.	22	22, 6
Bamboo forest (Bf)	Evergreen forest with bamboo as main vegetation type.	12	13, 4
Settlement (Se)	Villages and surroundings.	-	-
Grazing Land (Gr)	Grazing land and all other open areas except for wetland and moorland.	-	-

of the Horn of Africa' (Redman et al. 2011) as a main reference. Occasional unknown sounds were recorded and identified afterwards using the xeno-canto database (http://www.xeno-canto.org).

Camera trap monitoring was done with 16 camera traps in 28 different locations (see Fig. 1) for a total of approximately 510 camera trap days. Camera trap locations were selected based on their potential to monitor mammal diversity, but additional bird observations were made of crepuscular species and analysed as part of the present study.

RESULTS

We recorded a total of 244 bird species from 55 different families in the Sheka Forest Biosphere Reserve (Table 3; Images 1–4). Of the species recorded in the reserve during our fieldwork, 47 species or 19% were only found in the designated protected zones. All other species were found across a variety of management zones. Of the 155 species identified during the point transect surveys, 16 species were observed across all studied habitats, of which *Bradypterus cinnamomeus* (89.2% of surveys), *Turdus (olivaceus) abyssinicus* (83.8%), and *Zosterops poliogastrus kaffensis* (78.4%) were the most common bird species identified during the surveys. Riverine forest was the most species-rich habitat sampled with on average 24.3 species sampled per survey, while bamboo forest was the least species rich habitat with an average of 13.4 species recorded per survey (Table 2). Based on our observations, the main habitat types used by each species are noted, except for the species encountered on migration, for which no habitats could be determined (Table 3).

Eleven bird species that were recorded during the surveys are considered threatened based on the IUCN Red List. With the notable exception of the recorded vultures, these observations largely stem from within the designated protected zones of the reserve. Details on these species and their identification are discussed below:

Necrosyrtes monachus (Critically Endangered) (Image 1C)

A smaller brown vulture, identified based on its naked pink head and whitish-grey 'hooded' hindneck and nape. It is common and still very abundant around settlements in the region, but rather rare in a variety of other habitats. Like the other African vultures listed below, it is severely threatened by a combination of factors, including land conversion, active persecution as well as secondary poisoning.

Trigonoceps occipitalis (Critically Endangered)

A rather large blackish vulture with contrasting white belly and large red-colored bill. Singles and pairs are uncommon but found to be widespread in a variety of habitats including settlements.

Gyps africanus (Critically Endangered) (Image 1D)

A typical vulture with a bright brown back, dark brown plumage, dark bill and down feathers on the neck. Seen in groups of up to 20 birds but also often in the presence of other vulture species. Common and widespread in a variety of habitats, most numerous around settlements.

Gyps rueppellii (Critically Endangered)

This vulture is similar to *Gyps africanus* but easily distinguished based on its yellow bill and scaled appearance in adult birds caused by bright edges on dark feathers. Rather uncommon, but widespread and present in a variety of habitats including settlements.

Image 1 . Photographic records of bird species observed in Sheka Forest Biosphere Reserve: A. *Anhinga rufa* | B. *Bostrychia hagedash* | C. *Necrosyrtes monachus* | D. *Gyps africanus* | E. *Buteo augur* | F. *Stephanoaetus coronatus* | G. *Pternistis squamatus* (camera trap recording) | H. *Rougetius rougetii*.

Torgos tracheliotus (Endangered)

A very large, dark brown vulture with a pink head that shows distinctive skin folds. Pairs and solitary birds were encountered only a limited number of times around smaller settlements and agricultural areas.

Aquila nipalensis (Endangered)

A large eagle with brown upper parts and blackish flight feathers, larger and darker than *Aquila rapax*. Observed and photographed on only one occasion while on migration northwards on 18 April 2016 above a highland moorland at Gandochi.

Polemaetus bellicosus (Vulnerable)

A very large brown eagle with white body underparts. Only one sighting in a wetland in the protected zone of Shato where a territorial pair was seen and heard in flight on 24 April 2016.

Balearica pavonina (Vulnerable)

An unmistakable crane with predominantly black body plumage and a crown of golden feathers. Limited number of sightings on a single day during a wetland inventory around the town of Masha.

Terathopius ecaudatus (Near Threatened)

Easily recognised in flight from below, based on the black body plumage, black and white wings and chestnut tail. Observed only one time at Shato forest (south) and two times in highland moorland at Gandochi, where a male was photographed on 30 March 2016.

Stephanoaetus coronatus (Near Threatened) (Image 1F)

Large eagle with crest, giving the head a rather triangular appearance. Barred black and white from below, with chestnut underwing coverts. Widespread and common in the core forested areas, very rare elsewhere. Both juveniles and adults were seen and photographed on several occasions throughout the study.

Rougetius rougetii (Near Threatened) (Image 1H)

A brown rail with white undertail coverts. Very common in highland wetlands, also common in Moorlands and along the Gebba river.

Several species that were found in the reserve during the monitoring occur only in a very restricted range in Ethiopia. Although these species are not considered threatened on the IUCN red list nor are endemic, their isolated distribution within Ethiopia and/or occurrence at the extremes of their distribution ranges deserves special conservation attention. Except for *Cinnyris chloropygius*, these species were exclusively found within the protected zones of the reserve.

Sarothrura elegans

Most common in forest interior, but also more open woodland types. Never seen, but regularly heard at night or early morning during the short rainy season. Sometimes, several males could be heard and were recorded giving a long and low hooting “whooooooooo” lasting approximately three seconds and repeated at intervals of approximately five seconds.

Sarothrura rufa

Adult males have a chestnut red head and chest with otherwise black plumage with narrow but striking white streaks. Adult males were observed two times during an inventory in a wetland around Shato when flushed from about 5m from the observers in a wet grassland.

Bradypterus alfredi

Sound recorded at two different locations in highland bamboo forest were uncommon and localized. A rapid series of short notes all at the same pitch “chit-it chit-it chit-it”.

Halcyon malimbica (Image 2E)

A striking blue kingfisher, distinguished from *Halcyon senegalensis* based on its blue breast-band and more extensive amount of black on its wings. Rare and secretive, but present around the largest rivers in the area. Often heard in wetland and riverine forest habitat in Shato forest, and one individual was photographed in lowland riverine forest near Tepi.

Anomalospiza imberbis

A small finch-like species. Males were recognised based on their black bill and yellow head and underparts. Only observed once in the largest wetland at the side of the Gebba River. A male was seen on 28 February 2018 for approximately 30 seconds sitting on top of a shrub at 15m from the observers during a wetland survey.

Cinnyris chloropygius

Males showed a metallic green head, breast and upper parts, a red breast-band and olive belly. Uncommon in open riverine woodland in the lowlands of Tepi, where one territorial male was seen actively foraging during a riverine forest survey by several observers.

Image 2. Photographic records of bird species observed in Sheka Forest Biosphere Reserve: A. *Actophilornis africanus* | B. *Turtur tympanistria* | C. *Poicephalus flavifrons* | D. *Agapornis taranta* | E. *Halcyon malimbica* | F. *Ispidina picta* | G. *Merops albicollis* | H. *Merops pusillus.*

Table 3. Bird species identified within Sheka Forest Biosphere Reserve, with IUCN conservation status (LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered), predominant habitat occupation (see Table 2, Mi: Migration), the identification method leading to species detection (OO: opportunistic observation; PT: point count transect observation; CT: camera trap observation), and main verification method (PH: photographic recording; AU: audio recording; DO: double observation). Species endemic to the Horn of Africa (Redman et al. 2011) are indicated with †. Species that were only observed in the protected zones are indicated with ‡. IUCN status according to https://www.iucnredlist.org, accessed on 29 September 2018.

	Species/family	Common name	IUCN	Habitat	Identification	Verification
	Podicipedidae (1)					
1	*Tachybaptus ruficollis*	Little Grebe	LC	Rf, We	CT, OO, PT	PH
	Phalacrocoracidae (1)					
2	*Phalacrocorax africanus*	Long-tailed Cormorant	LC	Rf	OO, PT	DO
	Anhingidae (1)					
3	*Anhinga rufa‡*	African Darter	LC	Rf	OO, PT	PH
	Heliornithidae (1)					
4	*Podica senegalensis‡*	African Finfoot	LC	Rf	OO, PT	DO
	Ardeidae (6)					
5	*Nycticorax nycticorax‡*	Black-crowned Night Heron	LC	Rf	OO	DO
6	*Bubulcus ibis*	Cattle Egret	LC	Gr	OO, PT	DO
7	*Ardeola ralloides‡*	Squacco Heron	LC	Mi	OO	PH
8	*Butorides striata‡*	Striated Heron	LC	Rf	OO	DO
9	*Ardea purpurea*	Purple Heron	LC	Rf	OO, PT	DO
10	*Ardea melanocephala*	Black-headed Heron	LC	Rf, We	OO, PT	DO
	Ciconiidae (5)					
11	*Ciconia ciconia*	White Stork	LC	Mi	OO	DO
12	*Ciconia microscelis*	African Woollyneck	LC	Rf, We, Gr	OO, PT	PH
13	*Ciconia abdimii*	Abdim's Stork	LC	Gr, Se	OO	PH
14	*Anastomus lamelligerus*	African Openbill	LC	Mi	OO	PH
15	*Leptoptilos crumeniferus*	Marabou Stork	LC	We, Se	OO	PH
	Threskiornithidae (2)					
16	*Bostrychia hagedash*	Hadada Ibis	LC	We, Gr, Se	CT, OO, PT	PH
17	*Bostrychia carunculata†*	Wattled Ibis	LC	We, Gr	CT, OO, PT	PH
	Anatidae (5)					
18	*Plectropterus gambensis‡*	Spur-winged Goose	LC	We	OO	DO
19	*Alopochen aegyptiaca*	Egyptian Goose	LC	We, Rf	OO, PT	DO
20	*Anas undulata*	Yellow-billed Duck	LC	Rf	PT	PH
21	*Anas sparsa*	African Black Duck	LC	Rf	OO	PH
22	*Anas crecca‡*	Eurasian Teal	LC	Mi	OO	DO
	Accipitridae (28)					
23	*Milvus migrans*	Black Kite	LC	Gr, Se	OO, PT	PH
24	*Milvus (migrans) aegyptius*	Yellow-billed Kite	LC	Gr, Se	CT, OO, PT	PH
25	*Haliaeetus vocifer*	African Fish-Eagle	LC	Rf	OO, PT	PH
26	*Necrosyrtes monachus*	Hooded Vulture	CR	Gr, Se	CT, PT	PH
27	*Trigonoceps occipitalis*	White-headed Vulture	CR	Gr, Se	PT	PH
28	*Torgos tracheliotus*	Lappet-faced Vulture	EN	Gr, Se	OO	PH
29	*Gyps africanus*	White-backed Vulture	CR	Gr, Se	OO	PH
30	*Gyps rueppellii*	Rüppell's Vulture	CR	Gr, Se	OO	PH
31	*Circaetus cinereus‡*	Brown Snake-Eagle	LC	Br	OO	PH
32	*Circaetus pectoralis‡*	Black-chested Snake-eagle	LC	Br	OO	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
33	*Accipiter tachiro*	African Goshawk	LC	Br	OO, PT	PH
34	*Accipiter rufiventris*	Rufous-breasted Sparrowhawk	LC	Br	OO	PH
35	*Accipiter minullus‡*	Little Sparrowhawk	LC	Rf	OO	DO
36	*Accipiter melanoleucus*	Great Sparrowhawk	LC	Br	OO	PH
37	*Aviceda cuculoides‡*	African Cuckoo-Hawk	LC	Br	OO	PH
38	*Polyboroides typus*	African Harrier-Hawk	LC	Br, Gr, Se	OO, PT	PH
39	*Pernis apivorus*	European Honey-Buzzard	LC	Mi	OO	PH
40	*Buteo augur*	Augur Buzzard	LC	Gr, Br	OO, PT	PH
41	*Buteo buteo*	Common Buzzard	LC	Mi	OO, PT	PH
42	*Buteo rufinus‡*	Long-legged Buzzard	LC	Mi	OO	DO
43	*Clanga pomarina‡*	Lesser Spotted Eagle	LC	Mi	OO	PH
44	*Aquila rapax*	Tawny Eagle	LC	Gr	OO, PT	PH
45	*Aquila nipalensis‡*	Steppe Eagle	EN	Mi	OO	PH
46	*Hieraaetus pennatus‡*	Booted Eagle	LC	Mi	OO	DO
47	*Hieraaetus ayresii*	Ayres's Hawk-Eagle	LC	Br	OO	PH
48	*Terathopius ecaudatus‡*	Bateleur	NT	Gr	OO	PH
49	*Lophaetus occipitalis*	Long-crested Eagle	LC	Br, Gr	OO, PT	PH
50	*Polemaetus bellicosus‡*	Martial Eagle	VU	We	OO	PH
51	*Stephanoaetus coronatus*	African Crowned Eagle	NT	Br	OO	PH
	Falconidae (3)					
52	*Falco ardosiaceus‡*	Grey Kestrel	LC	Gr	OO	PH
53	*Falco cuvierii‡*	African Hobby	LC	Rf	OO	PH
54	*Falco subbuteo‡*	Eurasian Hobby	LC	Mi	OO	DO
	Phasianidae (2)					
55	*Pternistis squamatus‡*	Scaly Francolin	LC	Br	CT	PH
56	*Pternistis castaneicollis†*	Chestnut-naped Francolin	LC	Br, Gr	OO	AU
	Sarothruridae (2)					
57	*Sarothrura elegans‡*	Buff-spotted Flufftail	LC	Br	OO	AU
58	*Sarothrura rufa‡*	Red-chested Flufftail	LC	We	OO, PT	DO
	Rallidae (4)					
59	*Amaurornis flavirostra*	Black Crake	LC	Rf, We	OO, PT	PH
60	*Rougetius rougetii†*	Rouget's Rail	NT	Rf, We, Mo	CT, OO, PT	PH
61	*Rallus caerulescens*	African Rail	LC	Rf, We	OO, PT	PH
62	*Gallinula chloropus*	Common Moorhen	LC	Rf	OO	DO
	Gruidae (1)					
63	*Balearica pavonina*	Black Crowned Crane	VU	We	OO	DO
	Jacanidae (1)					
64	*Actophilornis africanus‡*	African Jacana	LC	Rf	CT, OO	PH
	Scolopacidae (4)					
65	*Actitis hypoleucos*	Common Sandpiper	LC	Rf, We	OO	DO
66	*Tringa glareola‡*	Wood Sandpiper	LC	We	OO	DO
67	*Tringa ochropus*	Green Sandpiper	LC	We	OO	DO
68	*Gallinago nigripennis‡*	African Snipe	LC	We	PT	DO
	Columbidae (10)					
69	*Treron calvus*	African Green Pigeon	LC	Br	OO, PT	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
70	*Treron waalia*	Bruce's Pigeon	LC	Br	OO, PT	DO
71	*Columba guinea*	Speckled Pigeon	LC	Se	OO	DO
72	*Columba arquatrix*	African Olive Pigeon	LC	Br, Mo, Bf	OO, PT	PH
73	*Turtur afer‡*	Blue-spotted Wood Dove	LC	Br	OO, PT	DO
74	*Turtur tympanistria*	Tambourine Dove	LC	Br, Gr, Se	CT, PT	PH
75	*Streptopelia vinacea*	Vinaceous Dove	LC	Br, Gr	PT	DO
76	*Streptopelia semitorquata*	Red-eyed Dove	LC	Br, Gr, Se	OO, PT	PH
77	*Streptopelia lugens ‡*	Dusky Turtle Dove	LC	Br	PT	DO
78	*Aplopelia larvata‡*	Lemon Dove	LC	Br	CT, OO	PH
	Psittacidae (2)					
79	*Poicephalus flavifrons†*	Yellow-fronted Parrot	LC	Br	PT	PH
80	*Agapornis taranta†*	Black-winged Lovebird	LC	Br	PT	PH
	Musophagidae (1)					
81	*Tauraco leucotis*	White-cheeked Turaco	LC	Br, Bf	OO, PT	AU
	Cuculidae (7)					
82	*Cuculus canorus*	Common Cuckoo	LC	Mi	OO	DO
83	*Cuculus solitarius*	Red-chested Cuckoo	LC	Br, Se	OO, PT	PH
84	*Cuculus clamosus*	Black Cuckoo	LC	Br	PT	AU
85	*Chrysococcyx klaas*	Klaas's Cuckoo	LC	Br, Se	OO, PT	AU
86	*Chrysococcyx cupreus*	African Emerald Cuckoo	LC	Br, Se	PT	PH
87	*Centropus senegalensis*	Senegal Coucal	LC	Br	CT, OO, PT	PH
88	*Centropus monachus*	Blue-headed Coucal	LC	Rf, We, Mo	OO, PT	PH
	Strigidae (2)					
89	*Strix woodfordii*	African Wood Owl	LC	Br	OO	AU
90	*Bubo cinerascens*	Greyish Eagle-Owl	LC	Br, Se	OO	DO
	Apodidae (3)					
91	*Tachymarptis melba*	Alpine Swift	LC	Mi	OO, PT	DO
92	*Apus apus*	Common Swift	LC	Gr, Se	OO, PT	DO
93	*Apus niansae*	Nyanza Swift	LC	Gr, Se	OO, PT	DO
	Coliidae (1)					
94	*Colius striatus*	Speckled Mousebird	LC	Se	CT, OO, PT	PH
	Trogonidae (1)					
95	*Apaloderma narina*	Narina Trogon	LC	Br	PT	AU
	Alcedinidae (8)					
96	*Ceryle rudis*	Pied Kingfisher	LC	Rf	OO, PT	PH
97	*Megaceryle maxima*	Giant Kingfisher	LC	Rf	PT	PH
98	*Halcyon senegalensis*	Woodland Kingfisher	LC	Rf, Br	PT	PH
99	*Halcyon malimbica‡*	Blue-breasted Kingfisher	LC	Rf	PT	PH
100	*Halcyon chelicuti*	Striped Kingfisher	LC	Br	OO	PH
101	*Alcedo semitorquata‡*	Half-collared Kingfisher	LC	Rf	OO, PT	PH
102	*Corythornis cristatus*	Malachite Kingfisher	LC	Rf	OO, PT	PH
103	*Ispidina picta*	Pygmy Kingfisher	LC	Rf, We	OO	PH
	Meropidae (4)					
104	*Merops pusillus*	Little Bee-eater	LC	Gr	OO	DO
105	*Merops (variegatus) lafresnayii*	Blue-breasted Bee-eater	LC	Br, Gr	OO	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
106	*Merops apiaster*	European Bee-eater	LC	Gr	PT	DO
107	*Merops albicollis*	White-throated Bee-eater	LC	Rf, Br	PT	PH
	Coraciidae (1)					
108	*Eurystomus glaucurus*	Broad-billed Roller	LC	Rf	OO, PT	DO
	Bucerotidae (1)					
109	*Tockus alboterminatus*	Crowned Hornbill	LC	Br	OO, PT	AU
	Bucorvidae (2)					
110	*Bycanistes brevis*	Silvery-cheeked Hornbill	LC	Br	OO, PT	PH
111	*Bucorvus abyssinicus*	Abyssinian Ground-hornbill	LC	We, Gr	OO, PT	DO
	Lybiidae (4)					
112	*Pogoniulus chrysoconus*	Yellow-fronted Tinkerbird	LC	Br	OO, PT	PH
113	*Pogoniulus pusillus*	Red-fronted Tinkerbird	LC	Br	PT	AU
114	*Lybius bidentatus*	Double-toothed Barbet	LC	Br	OO	PH
115	*Lybius undatus*†	Banded Barbet	LC	Br	OO	DO
	Indicatoridae (4)					
116	*Indicator indicator*‡	Greater Honeyguide	LC	Rf	PT	PH
117	*Indicator variegatus*‡	Scaly-throated Honeyguide	LC	Rf	PT	AU
118	*Indicator minor*	Lesser Honeyguide	LC	Rf, Br	OO	AU
119	*Prodotiscus zambesiae*‡	Green-backed Honeybird	LC	Rf	OO	DO
	Picidae (5)					
120	*Jynx torquilla*	Eurasian Wryneck	LC	Mi	OO	DO
121	*Campethera nubica*	Nubian Woodpecker	LC	Br	PT	DO
122	*Dendropicos fuscescens*	Cardinal Woodpecker	LC	Br	OO, PT	PH
123	*Dendropicos abyssinicus*†	Abyssinian Woodpecker	LC	Br	PT	PH
124	*Dendropicos spodocephalus*	Grey-headed Woodpecker	LC	Gr	OO	DO
	Hirundinidae (12)					
125	*Ptyonoprogne fuligula*	Rock Martin	LC	Se	OO, PT	DO
126	*Riparia paludicola schoensis*	Plain Martin	LC	Gr	OO	DO
127	*Delichon urbicum*	Common House Martin	LC	Gr, Se	OO, PT	DO
128	*Cecropis daurica*	Red-rumped Swallow	LC	Gr, Se	OO, PT	DO
129	*Cecropis senegalensis*	Mosque Swallow	LC	Gr, Se	OO, PT	PH
130	*Cecropis abyssinica*	Lesser Striped Swallow	LC	Gr	OO	DO
131	*Pseudhirundo griseopyga*	Grey-rumped Swallow	LC	Mi	OO	DO
132	*Hirundo rustica*	Barn Swallow	LC	Gr, Se	OO, PT	DO
133	*Hirundo lucida*	Red-chested Swallow	LC	Gr	OO, PT	DO
134	*Hirundo smithii*	Wire-tailed Swallow	LC	Gr, Se	PT	PH
135	*Hirundo aethiopica*	Ethiopian Swallow	LC	Se	OO	DO
136	*Psalidoprocne pristoptera*	Black Saw-wing	LC	We, Gr, Se	OO, PT	PH
	Motacillidae (9)					
137	*Motacilla flava (flava)*	Yellow Wagtail	LC	Gr, Se	OO, PT	DO
138	*Motacilla aguimp*	African Pied Wagtail	LC	Rf	CT, OO, PT	PH
139	*Motacilla clara*	Mountain Wagtail	LC	Rf	OO, PT	PH
140	*Motacilla alba*	White Wagtail	LC	Mi	OO	DO
141	*Anthus cinnamomeus*	Grassland Pipit	LC	We, Gr	CT, OO	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
142	*Anthus leucophrys omoensis*	Plain-backed Pipit	LC	Gr	OO	PH
143	*Anthus similis*	Long-billed Pipit	LC	Gr	OO	PH
144	*Anthus cervinus*	Red-throated Pipit	LC	Mi	PT	PH
145	*Anthus trivialis*	Tree Pipit	LC	Mi	OO	DO
	Campephagidae (2)					
146	*Campephaga phoenicea*	Red-shouldered Cuckooshrike	LC	Br	PT	PH
147	*Coracina caesia*	Grey Cuckooshrike	LC	Rf, Br	OO	DO
	Pycnonotidae (2)					
148	*Pycnonotus barbatus schoanus*	Common Bulbul	LC	Br, Mo, Gr, Se	CT, OO, PT	PH
149	*Atimastillas flavicollis*	Yellow-throated Leaflove	LC	Br	PT	DO
	Muscicapidae (20)					
150	*Cossypha semirufa*	Rüppell's Robin-Chat	LC	Br, Bf, Gr, Se	CT, OO, PT	PH
151	*Cossypha heuglini*	White-browed Robin-Chat	LC	Rf	OO	DO
152	*Phoenicurus phoenicurus*	Common Redstart	LC	Mi	OO, PT	DO
153	*Saxicola (torquatus) albofasciatus*	African Stonechat	LC	We, Gr	OO, PT	PH
154	*Saxicola rubetra*	Whinchat	LC	We, Gr	OO, PT	DO
155	*Oenanthe oenanthe*	Northern Wheatear	LC	Mi	OO	PH
156	*Cercomela sordida*	Moorland Chat	LC	We, Mo, Se	OO, PT	PH
157	*Psophocichla litsitsirupa*	Groundscraper Thrush	LC	Se	OO, PT	PH
158	*Monticola saxatilis*	Common Rock Thrush	LC	Mi	OO, PT	DO
159	*Turdus (olivaceus) abyssinicus*	African Mountain Thrush	LC	Br, Bf, Gr, Se	CT, PT	PH
160	*Turdus pelios*	African Thrush	LC	Gr, Se	OO	DO
161	*Zoothera piaggiae*	Abyssinian Ground Thrush	LC	Br	CT, PT	PH
162	*Melaenornis chocolatinus†*	Abyssinian Slaty Flycatcher	LC	Br, Gr, Se	OO, PT	PH
163	*Melaenornis edolioides*	Northern Black Flycatcher	LC	Gr, Se	OO	PH
164	*Bradornis microrhynchus*	African Grey Flycatcher	LC	Br	OO	DO
165	*Bradornis pallidus*	Pale Flycatcher	LC	Se	OO	DO
166	*Muscicapa adusta*	African Dusky Flycatcher	LC	Br, Mo, Bf, Se	PT	PH
167	*Muscicapa striata*	Spotted Flycatcher	LC	Mi	OO	DO
168	*Terpsiphone viridis*	African Paradise Flycatcher	LC	Br, Gr, Se	CT, OO, PT	PH
169	*Myioparus plumbeus*	Lead-coloured Flycatcher	LC	Br	PT	PH
	Locustellidae (6)					
170	*Bradypterus baboecala*	Little Rush Warbler	LC	Rf, We	OO, PT	AU
171	*Bradypterus cinnamomeus*	Cinnamon Bracken Warbler	LC	Br, Mo, Bf	PT	PH
172	*Bradypterus alfredi‡*	Bamboo Warbler	LC	Bf	OO, PT	AU
173	*Acrocephalus baeticatus‡*	African Reed Warbler	LC	Rf	OO, PT	AU
174	*Acrocephalus schoenobaenus‡*	Sedge Warbler	LC	Mi	OO	DO
175	*Chloropeta natalensis*	African Yellow Warbler	LC	We, Gr	PT	PH
	Cisticolidae (8)					
176	*Camaroptera brevicaudata*	Grey-backed Camaroptera	LC	Br, Mo	OO, PT	AU
177	*Eremomela canescens‡*	Green-backed Eremomela	LC	Br	OO	DO
178	*Cisticola (galactotes) lugubris†*	Ethiopian Cisticola	LC	Rf, We, Mo	OO, PT	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
179	*Cisticola erythrops*	Red-faced Cisticola	LC	Rf	OO	DO
180	*Cisticola cantans*	Singing Cisticola	LC	Gr, Se	PT	DO
181	*Prinia subflava*	Tawny-flanked Prinia	LC	Gr, Se	PT	PH
182	*Apalis flavida*	Yellow-breasted Apalis	LC	Br, Gr, Se	PT	DO
	Phylloscopidae (3)					
183	*Phylloscopus trochilus*	Willow Warbler	LC	Br, Gr, Se	OO, PT	DO
184	*Phylloscopus collybita*	Common Chiffchaff	LC	Br, Gr, Se	OO, PT	AU
185	*Phylloscopus umbrovirens*	Brown Woodland Warbler	LC	Br, Mo, Bf	OO, PT	PH
	Sylviidae (5)					
186	*Sylvia atricapilla*	Blackcap	LC	Br, Gr, Se	OO, PT	PH
187	*Sylvia borin‡*	Garden Warbler	LC	Mi	OO, PT	AU
188	*Sylvia abyssinica*	African Hill Babbler	LC	Br, Mo	OO, PT	PH
189	*Turdoides leucopygia*	White-rumped Babbler	LC	Br	OO, PT	PH
190	*Parophasma galinieri†‡*	Abyssinian Catbird	LC	Mo, Bf	OO, PT	AU
	Platysteiridae (2)					
191	*Batis erlangeri*	Western Black-headed Batis	LC	Br	PT	AU
192	*Platysteira cyanea*	Brown-throated Wattle-eye	LC	Br	OO, PT	AU
	Zosteropidae (2)					
193	*Zosterops poliogastrus kaffensis*	Montane White-eye	LC	Br, Bf	OO, PT	DO
194	*Zosterops abyssinicus*	Abyssinian White-eye	LC	Br	OO, PT	DO
	Nectariniidae (6)					
195	*Nectarinia tacazze*	Tacazze Sunbird	LC	Br, Mo, Gr, Se	OO, PT	PH
196	*Cinnyris cupreus*	Copper Sunbird	LC	Br, Gr, Se	OO, PT	DO
197	*Cinnyris venustus fazoglensis*	Variable Sunbird	LC	Br, Gr, Se	PT	PH
198	*Cinnyris chloropygius*	Olive-bellied sunbird	LC	Rf	OO	DO
199	*Chalcomitra senegalensis*	Scarlet-chested Sunbird	LC	Br	PT	AU
200	*Cyanomitra olivacea ragazzii*	Olive Sunbird	LC	We, Br, Gr	PT	PH
	Laniidae (3)					
201	*Lanius humeralis*	Northern Fiscal	LC	We, Gr, Se	PT	PH
202	*Lanius excubitor leucopygos*	Great Grey Shrike	LC	Mi	OO	DO
203	*Lanius collurio/isabellinus‡*	Red-backed/Isabelline Shrike	LC	Mi	PT	DO
	Malaconotidae (3)					
204	*Laniarius aethiopicus*	Ethiopian Boubou	LC	Br, Gr, Se	CT, OO, PT	PH
205	*Dryoscopus cubla*	Northern Puffback	LC	Br, Gr, Se	OO, PT	AU
206	*Tchagra senegalus*	Black-crowned Tchagra	LC	Br	OO	DO
	Oriolidae (3)					
207	*Oriolus oriolus‡*	Eurasian Oriole	LC	Mi	OO, PT	PH
208	*Oriolus larvatus rolleti*	Black-headed Oriole	LC	Br	OO, PT	DO
209	*Oriolus monacha†*	Abyssinian Oriole	LC	Br, Bf	OO, PT	PH
	Corvidae (3)					
210	*Corvus capensis*	Cape Crow	LC	Se	OO, PT	PH
211	*Corvus rhipidurus*	Fan-tailed Raven	LC	Se	OO	PH
212	*Corvus crassirostris†*	Thick-billed Raven	LC	Gr, Se	CT, OO, PT	PH

	Species/family	Common name	IUCN	Habitat	Identification	Verification
	Buphagidae (1)					
213	*Buphagus erythrorynchus*	Red-billed Oxpecker	LC	Gr	OO	PH
	Sturnidae (8)					
214	*Poeoptera stuhlmanni*	Stuhlmann's Starling	LC	Br	OO, PT	PH
215	*Onychognathus morio*	Red-winged Starling	LC	Br	OO	DO
216	*Onychognathus tenuirostris*	Slender-billed Starling	LC	Br, Gr	PT	DO
217	*Lamprotornis chalybaeus*	Greater Blue-eared Starling	LC	Br, Gr, Se	OO, PT	PH
218	*Lamprotornis splendidus‡*	Splendid Starling	LC	Rf, Br	OO, PT	DO
219	*Lamprotornis purpuroptera*	Rüppell's Starling	LC	Rf	OO, PT	AU
220	*Pholia sharpii*	Sharpe's Starling	LC	Br, Bf	OO, PT	PH
	Passeridae (1)					
221	*Passer swainsonii*	Swainson's Sparrow	LC	Gr, Se	OO, PT	PH
	Ploceidae (7)					
222	*Ploceus cucullatus abyssinicus*	Village Weaver	LC	Se	OO, PT	DO
223	*Ploceus ocularis*	Spectacled Weaver	LC	Br, Gr, Se	OO, PT	DO
224	*Ploceus nigricollis*	Black-necked Weaver	LC	Br	OO	PH
225	*Ploceus baglafecht*	Baglafecht Weaver	LC	Br, Gr, Se	OO, PT	DO
226	*Amblyospiza albifrons‡*	Grosbeak Weaver	LC	Rf, We	PT	PH
227	*Anaplectes rubriceps*	Red-headed Weaver	LC	Br	OO	DO
	Viduidae (5)					
228	*Anomalospiza imberbis‡*	Cuckoo Finch	LC	Rf, We	OO	DO
229	*Euplectes axillaris‡*	Fan-tailed Widowbird	LC	Rf, We	PT	DO
230	*Euplectes albonotatus‡*	White-winged Widowbird	LC	Rf, We	PT	DO
231	*Vidua macroura*	Pin-tailed Whydah	LC	Gr, Se	OO	DO
232	*Vidua chalybeata*	Village Indigobird	LC	Gr, Se	OO	PH
	Estrildidae (8)					
233	*Mandingoa nitidula*	Green Twinspot	LC	Br	OO	DO
234	*Cryptospiza salvadorii*	Abyssinian Crimsonwing	LC	Br, Bf	PT	AU
235	*Lagonosticta senegala*	Red-billed Firefinch	LC	Gr, Se	OO, PT	PH
236	*Coccopygia quartinia*	Yellow-bellied Waxbill	LC	Br, Gr, Se	OO, PT	PH
237	*Estrilda astrild peasei*	Common Waxbill	LC	Gr, Se	CT, OO, PT	PH
238	*Estrilda (Paludicola) ochrogaster*	Abyssinian Waxbill	LC	Gr, Se	OO, PT	DO
239	*Lonchura cucullata*	Bronze Mannikin	LC	Gr, Se	OO	DO
240	*Spermestes bicolor poensis*	Black-and-white Mannikin	LC	Br, Gr	PT	PH
	Fringillidae (4)					
241	*Serinus mozambicus*	Yellow-fronted Canary	LC	Gr	OO	DO
242	*Serinus citrinelloides*	African Citril	LC	Gr, Se	OO, PT	PH
243	*Serinus tristriatus*	Brown-rumped Seedeater	LC	Gr, Se	OO, PT	PH
244	*Serinus striolatus*	Streaky Seedeater	LC	Gr, Se	PT	PH

Image 3. Photographic records of bird species observed in Sheka Forest Biosphere Reserve: A. *Lybius bidentatus* | B. *Hirundo smithii* | C. *Anthus cervinus* | D. *Saxicola (torquatus) albofasciatus* | E. *Turdus (olivaceus) abyssinicus* | F. *Zoothera piaggiae* (camera trap recording) | G. *Myioparus plumbeus* | H. *Bradypterus cinnamomeus*

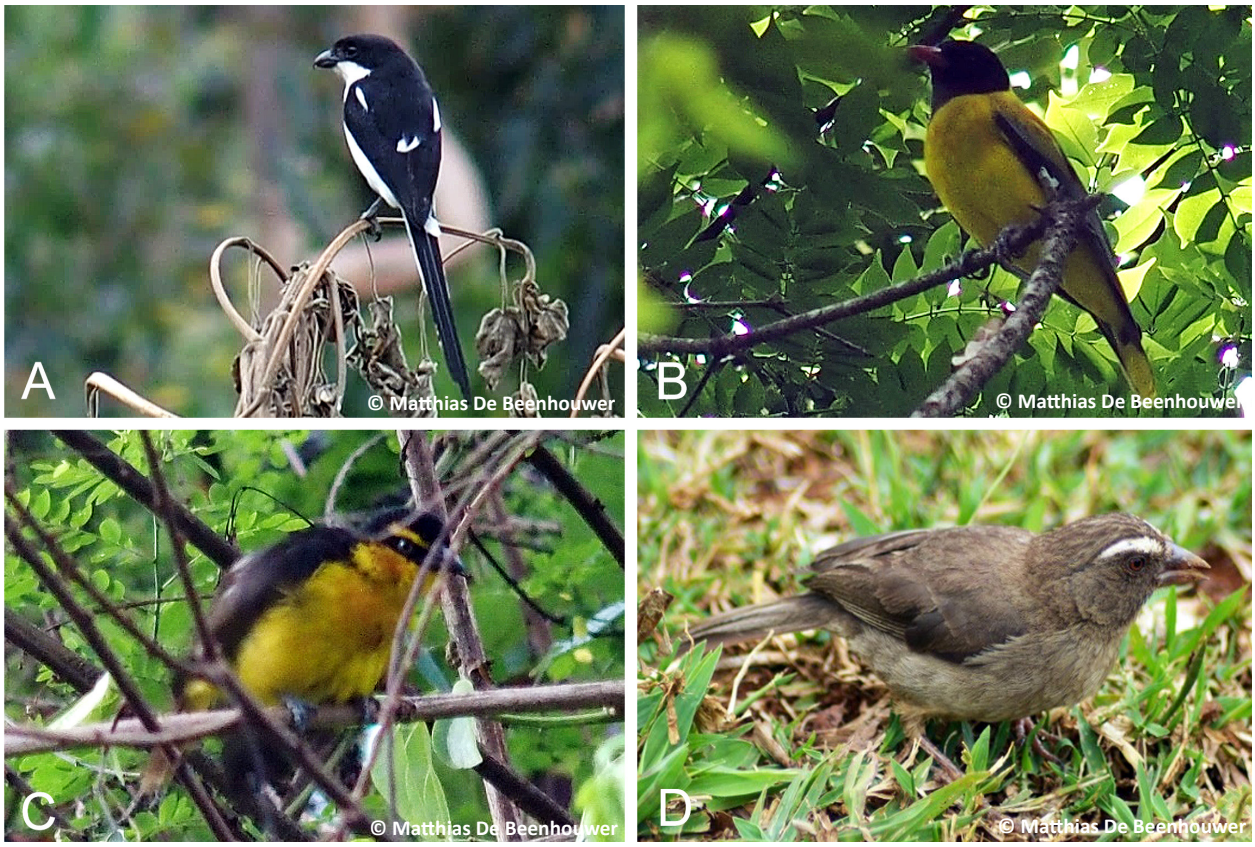

Image 4. Photographic records of bird species observed in Sheka Forest Biosphere Reserve: A. *Lanius humeralis* | B. *Oriolus monacha* | C. *Ploceus nigricollis* | D. *Serinus tristriatus*.

Twelve of the bird species observed inside the reserve are considered endemic to the Horn of Africa. All of these endemic species were encountered regularly within suitable habitat. Details on species identification are listed below (except for *Rougetius rougetii*, already discussed above):

Bostrychia carunculata

A dark ibis with white shoulder patches and a small wattle hanging from its throat. Common and abundant around highland wetlands and grasslands.

Pternistis castaneicollis

A large francolin with black forehead and creamy white belly. Uncommon but widespread in a variety of open woodland and forest edges, where often identified by its early morning call. On one occasion a large group (six birds) was seen in a tea plantation near the Gebba River.

Poicephalus flavifrons (Image 2C)

A medium-sized green parrot, identified by the presence of yellow colouring on the head. Common in a wide variety of forest and woodland, rare around farmland.

Agapornis taranta (Image 2D)

A bright green lovebird with green rump and red forehead. Common in highland woodland, rather rare in a variety of other habitats.

Lybius undatus

A barbet with red forecrown and barred plumage. Rare in open highland forest but common in lowland forest areas near Tepi.

Dendropicos abyssinicus

Small woodpecker with green back, heavily barred wings and bright red rump. Common in a variety of highland forest where identified and photographed on several occasions during the study.

Melaenornis chocolatinus

A large, dark grey-brown highland flycatcher with conspicuous yellow eye. Very common around settlements and a wide variety of other highland

habitats.

Cisticola (galactotes) lugubris

A cisticola with black and grey streaked mantle and rufous crown. Extremely common and abundant around wetland, highland moorland and big rivers.

Parophasma galinieri

A distinctive grey bird with whitish forehead and orange-red undertail coverts. Common in highland bamboo forest, where recorded in high densities in forest edges around moorlands, very rare elsewhere.

Oriolus monacha (Image 4B)

A large black-headed oriole with grey wing panel. Very common in a wide variety of highland habitats, not restricted to forests.

Corvus crassirostris

A large raven with white patch on nape and very large bill. Common and abundant around settlements and farmland, rare around wetlands and open forest and not recorded from the core zones.

DISCUSSION

This study highlights the importance of the Sheka Forest Biosphere Reserve for globally threatened and Ethiopian endemic bird species, and in particular raptors and vultures. The results not only emphasize a high species richness in the reserve, but also indicate the importance of the proposed zonation, with increased control and protection, for bird conservation. Our findings are comparable to other recent ornithological studies in Ethiopia (e.g., Engelen et al. 2017; Rodrigues et al. 2018), showing a structurally diverse landscape, mostly in traditional low-intensity use, supporting a diverse range of bird species, and with undisturbed forest habitats and wetlands presenting a central refuge for vulnerable range-restricted and specialist bird species.

Our inventories were nevertheless confined to the short Ethiopian rainy season, as well as a subset of kebeles and transition-, buffer-, and core zones. Additional bird species, including seasonally present migrants, can undoubtedly be recorded during future studies in different periods and subregions. For instance, two endemic red-listed species, expected to occur in the reserve based on distribution maps, were not found (*Macronyx flavicollis* and *Cyanochen cyanoptera*). More extensive surveys, specifically during the long rainy season and in the vast moorlands in the eastern highlands of Anderacha woreda might still indicate their continued presence. In addition, point transect surveys were mainly conducted to map species diversity and distributions across habitats, but were inadequate to accurately characterize the relative abundance of species in the reserve. Thus, our study provides a first indication of bird species richness in Sheka forest, and is a baseline that needs complementary monitoring studies to provide more detailed insights in its species composition, population sizes and dynamics. Our study also showed the added value of camera trapping to record crepuscular species, with *Pternistis squamatus* and *Zoothera piaggiae* only being visually observed through camera trap observations.

The large elevation and climatic differences that are present in the reserve add up to a large habitat variation and exceptionally rich bird diversity, underlining the protected status assigned to Sheka forest and the urge to safeguard its habitats from ongoing degradation. Our observations furthermore emphasize the understudied nature of this remote biosphere reserve and the importance of continued biodiversity studies to inform conservation planning. The forests of Sheka provide innumerable services to local communities and many people are directly relying on forest resources for their subsistence. As a result, the forests have been sustained through a long tradition of natural resource management (Woldemariam & Fetene 2007), making Sheka Forest Biosphere Reserve an ideal subject for directed long-term and community-based initiatives to conserve some of the largest remaining Afromontane rainforests.

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