Primate community composition at the Kafa Biosphere Reserve

Andrea Schell and Karina Schell

Highlights

→ This is the first broad assessment to determine the primate species composition of the Kafa BR. It was conducted in a diverse set of habitats such as bamboo and montane forests or wetlands covering an altitudinal gradient from 1400 to 2700 m a.s.l.

→ The Kafa BR is possibly home to six primate species of five different genera. We recorded all of them:

- Olive baboon (*Papio anubis*),
- Guereza (*Colobus guereza* ssp. *guereza*),
- Grivet (*Chlorocebus aethiops* ssp. *aethiops*),
- Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*),
- De Brazza's monkey (*Cercopithecus neglectus*),
- Boutourlini's blue monkey (*Cercopithecus mitis* ssp. *boutourlinii*).

→ We can confirm the presence of one vulnerable primate species endemic to the western side of the Ethiopian Rift Valley: Boutourlini's blue monkey (*Cercopithecus mitis boutourlinii*).

→ Boutourlini's blue monkey, just like De Brazza's monkey, is a forest-dwelling monkey that avoids colonising disturbed forest patches. These two primate species will profit hugely from the BR and the permanent establishment of extended core areas and buffer zones.

→ We present the first proof of the presence of the Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*) at the Kafa BR. We also provide the first loud-call recording of this species, crucial for subspecies determination.

→ We support the current choice of the guereza as the flagship species for the Kafa BR, as it is very common, easy to recognize and widely appreciated.

→ All primate species mentioned in this report are known to be strongly affected by habitat integrity and even moderate agriculture and/or forestry. We therefore strongly recommend using the following primate species as indicators for the intactness and diversity of a habitat, and to ensure environmentally sound agricultural and/or forest management:

- Intact and diverse forest ecosystem: Boutourlini's blue monkey, De Brazza's monkey, Ethiopian lesser galago,
- Environmentally sound (forest) farming: guereza, Ethiopian lesser galago.

→ Olive baboons and grivets are usually seen as crop raiders, often causing conflicts with small-scale farmers. This bad reputation is confirmed by a variety of locals of the Kafa BR, thus showing the potential for participatory learning and action (PLA)-based workshops on human-wildlife conflict management. Activities should be directed towards farmers who rely on plant cultivation.

→ We found olive baboons, guerezas and grivets across a broader altitudinal range than Boutourlini's blue monkeys, Ethiopia lesser galagos and De Brazza's monkeys.

1. Introduction

According to the relevant literature (Butynski et al. 2013; Berhan 2008), six primate species can be found in the Kafa BR: olive baboon (*Papio anubis*), guereza (*Colobus guereza* ssp. *guereza*), grivet (*Chlorocebus aethiops* ssp. *aethiops*), Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*), De Brazza's monkey (*Cercopithecus neglectus*) and Boutourlini's blue monkey (*Cercopithecus mitis* ssp. *boutourlinii*).

1.1 Olive baboon (*Papio anubis*)

The genus Papio includes five species, all of which feature on the IUCN Red List of endangered species (IUCN 2014): *Papio anubis* (olive baboon), *Papio cynocephalus* (yellow baboon), *Papio hamadryas* (Hamadryas baboon), *Papio papio* (Guinea baboon) and *Papio ursinus* (Chacma baboon) (Groves 2001).

Olive baboons are common (IUCN 2014) and extremely adaptable. They are the most extensively distributed baboon species, inhabiting Sahelian woodlands and forest-mosaic habitats (e.g., Butynski et al. 2013). P. anubis occupies an enormous variety of vegetation and climate conditions from lowlands to high mountains from 500 to 3300 m a.s.l. in Ethiopia (Yalden et al. 1977) and elsewhere. It is viewed as a crop raider throughout its range, and continuing habitat loss intensifies conflicts with humans (Kingdon et al. 2008a; Butynski et al. 2013).

1.2 Guereza (*Colobus guereza*)

Guerezas (*Colobus guereza*) belong to the black-and-white colobus monkeys of the genus Colobus (Groves 2005, 2007). They are distributed across forested areas in the centre of Africa, ranging from Nigeria and Cameroon through the northern Democratic Republic of Congo and southern Sudan to Ethiopia, Kenya and Uganda and southwards into northern Tanzania (Oates 1977; Groves 2001). Their preferred forest habitats include lowland and medium-altitude moist forest, montane forest, swamp forest, dry forest and gallery forest. They are found in disturbed forests (Oates 1994; Fashing et al. 2012), but the highest population densities are found in fragmented and secondary forests (Oates 1977). Oates' investigation reveals that they appear to be highly adaptable to altitude, with reports of occurrences from around 200 m a.s.l. in Cameroon to at least 3300 m a.s.l. in Ethiopia.

According to the latest IUCN (2014) assessment, guerezas' conservation status is of "Least Concern". Although some populations have seen local decline due to habitat loss, this generally widespread species is not thought to be declining fast enough to place it in a higher threat category (Kingdon et al. 2008b).

As the guereza taxonomy is subject to ongoing debate, we apply the provisional classification by Groves (2001, 2005) and Grubb et al. (2003), which lists eight subspecies: *Colobus guereza* ssp. *occidentalis*, *C. g.* ssp. *dodingae*, *C. g.* ssp. *matschiei*, *C. g.* ssp. *percivali*, *C. g.* ssp. *kikuyuensis*, *C. g.* ssp. *caudatus*, *C. g.* ssp. *gallarum* and *C. g.* ssp. *guereza*.

The latter two subspecies are known to occur in Ethiopia (Butysnki et al. 2013). *C. g.* ssp. *gallarum* is restricted to the Ethiopian Highlands east of the Rift Valley, while *C. g.* ssp. *guereza* is present in the forested areas west of the Rift Valley (Grubb et al. 2003). Döschner (2010) further confirms the presence of *C. g.* ssp. *guereza* in the Kafa BR. The study also suggests that guerezas are more susceptible to habitat disturbance and degradation than previously thought (Chapman et al. 2000; Fashing 2002; Lwanga 2006; Harris & Chapman 2007). Döschner further found that the population density of guerezas negatively correlates with the intensity of coffee management in their potential forest habitats.

1.3 Grivet (*Chlorocebus aethiops*)

The genus *Chlorocebus* (or African green monkey) is widely distributed throughout Sub-Saharan Africa (Butynski et al. 2013). This report follows the most recent taxonomic findings by Groves (2001, 2005), who recognises six species: *C. aethiops* (grivet), *C. djamdjamensis* (bale monkey), *C. sabeus* (green monkey), *C. cynosuros* (Malbrouck monkey), *C. tantalus* (tantalus monkey; with subspecies *C. t.* ssp. *budgetti*, *C. t.* ssp. *marrensis*, *C. t.* ssp. *tantalus*) and *C. pygerythrus* (vervet; with subspecies *C. p.* ssp. *hilgerti*, *C. p.* ssp. *excubitor*, *C. p.* ssp. *nesiotes*, *C. p.* ssp. *rufoviridis*, *C. p.* ssp. *pygerythrus*).

Except for *C. djamdjamensis*, an endemic and "Vulnerable" species from the Ethiopian Bale Mountains (Butysnki et al. 2008; Mekonnen 2012), all other *Chlorocebus* species are abundant in a variety of habitat types and are listed as "Least Concern" (IUCN 2014). Grivets are extremely adaptable and can live in both rural and urban environments. They are persecuted as crop pests (Kingdon & Butynski 2008; Butynski et al. 2013), and the expansion of agricultural activities has intensified the conflict between grivets and humans (Zinner et al. 2002).

We expected to find *C. aethiops* (Butynski et al. 2013; Haus & Zinner, pers. comm.) at the Kafa BR, a common species also native to Djibouti, Eritrea, South Sudan and

Sudan (Dandelot & Prevost 1972). This species is present in savannah, open woodland and forest-grassland mosaic, especially close to rivers (Dorst & Dandelot 1972; Zinner et al. 2002). Dandelot (1974) describes a geographic variation, *C. a.* ssp. *matschiei*, endemic to southwest Ethiopia within and west of the Rift Valley (Kafa and Jimma districts). Haus (pers. comm.) also found that the specimens of *C. aethiops* found in the Kafa region differ from the typical "Savannah aethiops", being darker with woolly fur and a less pronounced browband. It resembles *C. djamdjamensis*, but genetically should be assigned to *C. aethiops* (Haus et al. 2013).

1.4 Lesser galago (*Galago senegalensis* ssp.)

Galagos (family *Galagidae*) are nocturnal and often difficult to observe, and most species are phenotypically cryptic (Masters & Bragg 2000). They can best be identified by their species-specific advertisement calls (e.g., Butynski et al. 2013). Two galago species have been described for Ethiopia: *G. gallarum* in the northwestern Rift Valley (Butynski & de Jong 2004) and the *G. senegalensis* group. The latter are possibly the most widespread small galagos in the whole of Africa (Butynski et al. 2013). This species, listed as "Least Concern", is found in all strata of savannah woodland, in dense to open bushland areas, in montane forest (e.g., Mau Forest, Kenya, and Harenna Forest, Ethiopia), and even in highly fragmented forests or cultivated areas (Bearder et al. 2008).

In addition to *G. s.* ssp. *senegalensis*, Grubb et al. (2003) recognizes three more subspecies: *G. s.* ssp. *braccatus*, *G. s.* ssp. *sotikae* and *G. s.* ssp. *dunni*. The latter subspecies has been described for the Ethiopian Plateau and Somalia, but its actual range boundaries are uncertain (Butynski et al. 2013). However, *G. s.* ssp. *dunni* is the only subspecies currently recognized for Ethiopia (Butynski pers. comm.).

1.5 Genus *Cercopithecus*

Both De Brazza's monkey (*Cercopithecus neglectus*) and the blue monkey (*Cercopithecus mitis* spp.) belong to the genus *Cercopithecus* (guenons). De Brazza's monkey is one of the most widespread African forest monkeys, although it is never very abundant (Brennan 1985; Decker 1995; Maisels et al. 2007; Mwenja 2007). The species ranges from northeastern Angola, Cameroon, Equatorial Guinea and Gabon in the west of its range to Uganda, Kenya and southwestern Ethiopia in the east (Maisels et al. 2007). Ethiopia is the northern limit of the species' range (Brown & Urban 1969). It is also known as the swamp monkey, as it is found close to rivers in lowland and submontane tropical moist forests, semi-deciduous forests and acacia-dominated forests (Kingdon 1971). De Brazza's monkey is considerably less conspicuous than most other guenons (Gautier-Hion & Gautier 1978).

According to the IUCN (2014), De Brazza's Monkey is probably not threatened in the main forest block of central Africa. But it probably is in East Africa, where its habitat is under severe threat of human encroachment through deforestation for agricultural land and timber (Brennan 1985; Butynski 2002b; Mwenja 2007). Although Brown & Urban (1969) find De Brazza's monkey to be common in southwest Ethiopia (near Godare), its actual status in Ethiopia is unknown (Butynski et al. 2013).

The blue monkey belongs to the *Cercopithecus* (*nictitans*) group, in which three species are frequently recognized: *C. nictitans*, *C. mitis* (blue monkey) and *C. albogularis* (Sykes's monkey). The wide morphological variability and taxonomy of monkeys in the C. (*nictitans*) group remain poorly understood (Grubb et al. 2003).

The blue monkey is a versatile and widespread African species (Colyn & Verheyen 1987; Lawes 1990; Colyn 1991; Gautier-Hion et al. 1999; Butynski 2002a/b). It is present in many different forest types, including lowland and montane tropical moist forests, riverine and gallery forests and bamboo forests (Lawes et al. 1990). Southwestern Ethiopia is the range of *C. m. boutourlinii* (Napier 1981), one of the 17 recognized subspecies of *Cercopithecus* mitis ssp. (Groves 2001, 2005; Grubb et al. 2003). Boutourlini's blue monkey is endemic to the area from Lake Tana southwards along the western side of the Ethiopian Rift Valley (Yalden et al. 1977; Butynski & Gippoliti 2008; Butynski et al. 2013). *C. m.* ssp. *boutourlinii* is categorized as "Vulnerable". According to the IUCN 2014, its greatest threats are destruction and fragmentation of forest habitat for agricultural land. Although this species tolerates low quality and disturbed habitat better than most guenons (Lawes et al. 1990; Tesfaye et al. 2013), it nevertheless occurs in lower densities in these habitats (Chapman et al. 2000). It shows poor local colonising ability in response to forest fragmentation and seldom occupies small forest patches (Lawes et al. 2000, Chapman et al. 2003).

Initial field studies into the habitat requirements of *C. m.* ssp. *boutourlinii* in southwest Ethiopia (Jibat Forest) were conducted in 2009 (Tesfaye et al. 2013). Interestingly, in the final report of the Kafa faunal survey, Prof Afework Bekele of Addis Ababa University suggests a possible hybrid of *C. neglectus* and *C. mitis* ssp. in the Kafa region.

This biodiversity assessment in the Kafa BR covers a wide range of different habitats, from bamboo and montane forests to wetlands, covering an altitudinal gradient from 1400 m a.s.l. to nearly 3000 m a.s.l. Due to their ecological flexibility and extreme adaptability, we expected to find the generalist primate species such as *Papio anubis*, *C. g.* ssp. *guereza* and *C. aethiops* in all investigated habitats, including anthropogenically altered landscapes. We expected a similar pattern for *Galago s.* ssp. *dunni*, although it might also be present at lower altitudes. We expected the forest monkeys *C. m.* ssp. *boutourlinii* and *Cercopithecus neglectus* to be abundant in both lowland and montane forest, from riverine and gallery to bamboo forests. As the latter species prefers swampy habitats and is often found close to rivers we especially expected to find it in the wetlands of the Kafa BR.

2. Materials und Methods

2.1 Study sites

Due to time constraints, this biodiversity assessment focused on sites in two of the three National Forest Priority Areas: Bonga and Boginda Forests.

2.1.1 Bonga Forests

We explored the Boka Wild Bamboo Forest, a unique habitat covered by the monodominant species *Arundinaria alpina*, a mountain bamboo which forms thickets on mountain slopes at 2400-3000 m a.s.l., mostly in isolated patches. It is found in the very eastern stretch of the Bonga Forest area, which is notable for its unique faunal composition of very dense bamboo undergrowth, homogeneous or mixed, as well as for a rather high altitude between 2400 and 3050 m a.s.l. and almost sub-Afroalpine conditions. It had the highest elevation of any site in our assessment.

As a reference area for lower altitudes and moderate forest management conditions, we assessed montane and riverine habitats inside the Sheka Wild Coffee Forest. These areas are located in the Awurada Valley, which is located in the southernmost stretch of the Bonga Forest area and the whole Kafa BR in general. This forest occurs between 1500 and 2600 m a.s.l. and is of global conservation significance, as wild arabica coffee (*Coffea arabica*) still grows naturally in this area. Parts of the area are under Participatory Forest Management (PFM). Land conversion and timber extraction are causes for concern.

We also surveyed the Komba Forest, an evergreen montane forest and grassland complex distributed between 1900 and 3300 m a.s.l., located in the northern part of the Bonga Forest area. It is a highly populated, fragmented and rather overgrown forest, and is already classified as a high priority core zone. We also explored the forest habitats close to Bonga town and the Kafa Development Association Guesthouse (KDA GH). These sites are in the northern, more central part of the Bonga Forest area. The "Guesthouse Forest" is part of a heavily disturbed stretch of open woodland. Finally, Kayakela Forest is located even further outside of Bonga city and is a comparatively less disturbed area with a maximum elevation of 1700 m a.s.l. (Döschner 2010).

2.1.2 Boginda Forests

Inside the Boginda Forest areas we surveyed different sites that are all located in the southern, central part of this forest priority area. The furthermost point was again a moist evergreen montane forest, the Saja Forest, merging into the riverine, rather marshy habitats of the Gojeb Wetland, with altitudes ranging from 900 to 2600 m a.s.l. This whole ecosystem is highly at risk, due to intense harvesting activities and exploitation.

Tulla Forest (hot spring hiking trail) is situated towards the southern part of Boginda, towards Bonga. It is characterized by a montane forest extending into an evergreen montane forest and grassland complex.

2.2 Sample methods

2.2.1 General data acquisition

Instead of standardised distance or transect walks, we conducted a general survey throughout predetermined areas to generate an initial, general assessment of the primate community composition of the Kafa BR. This decision was made based on the behavioural ecology of our target group. Primates, especially shyer species and species with large territories or home ranges, are extremely difficult to track in unknown and unexplored areas, especially within a very limited timeframe. Therefore, we concentrated on obtaining very general indices of the primate species pool by conducting continuous field surveys during the fieldwork period (covering several sites in Bonga forest areas and areas in Boginda Forest (see Tab. 1)). This data can be used as the basis for further, more rigorous research and monitoring activities.

2.2.2 Surveys and interviews

To select our study areas, we began by conducting interviews with five local field assistants, rangers and small farmers. We showed interviewees photographs of various primate species that could occur in the Kafa BR and asked for information about them. For nocturnal and hence less visible primate species, e.g., bushbabies (Galagidae), we played audio recordings. This procedure was repeated at each sample site with locals from the study area.

We included images of primate species that we knew could not occur in the BR, such as Barbary macaques (*Macaca sylvanus*) or chimpanzees (*Pan troglodytes*). We also formulated open questions ("Tell us something about the primate species you recognise in the pictures.") to allow respondents to tell us anything they thought would be useful. This allowed us to minimise false statements and learn about the respondents' interests and attitudes towards certain primate species (e.g., baboons, which are widely regarded as crop raiders).

We conducted both day and crepuscular or night surveys, sampling each site just once. Our sample methods employed a rather opportunistic approach, relying on direct observations, camera traps, vocal recordings and live traps (collapsible squirrel/muskrat sized Tomahawk live traps, code 202, from Tomahawk Live Trap, Hazelhurst, Wisconsin, U.S.A.). The latter two mapping methods were mainly applied during crepuscular or night surveys to determine the occurrence of nocturnal primates such as bushbabies (Galagidae). Live traps were equipped with bait such as mashed ripe bananas and fermented honey wine (Pozzi pers. comm.).

Records of diurnal primate species were collected through direct observations and/or through their vocalising behaviour. General survey walks differed in terms of length and time spent in the field. On average, we started early morning at sunrise, collecting live traps that we had set the previous night during a night survey, which started at around sunset. Core surveys during the day began in the morning and ended before dusk.

We determined the geographic coordinates of each record using a Garmin GPSMAP® 62s device Garmin (Garmin Ltd., Schaffhausen, Switzerland), set to the WGS 84 datum format. Audio files were recorded using a Marantz PMD 660 sound recorder (Marantz Corporation, Kawasaki, Japan) equipped with a Sennheiser ME66 shotgun condenser microphone covered with a windshield (Sennheiser GmbH and Co. KG, Wedemark-Wennebostel, Germany). Video footage and pictures were taken with a Nikon D90 SLR camera together with a Nikon 18-200 mm Nikkor Lens (Nikon Corporation, Chiyoda/Tokyo, Japan).

Table 1: Survey timetable and sampling site selection. During a full nine-day biodiversity assessment, we sampled different sites in the Bonga and Boginda Forest areas. General survey walks differed by length and time. Night surveys began at dusk and were followed up the next day. Legend: ✪ night survey only, ○ day survey only, ● night and day surveys

	Sampled site and habitat type (number and code of study sites)		03.12.14	04.12.14	05.12.14	06.12.14	07.12.14	08.12.14	09.12.14	10.12.14	11.12.14
Bonga Forests	Sheka Coffee Forest (4, AW)	Moist evergreen montane forest, PFM site					●	●			
	Boka Bamboo Forest (1, BA)	High elevation, bamboo forest		●	●						
	"Guesthouse Forest" (11, KDA GH)	Montane forest remnants				○					
	Kayakela Forest (11, KDA GH)	Montane forest remnants	✪								
	Komba Forest (3, KO)	Evergreen montane forest and grassland complex									○
Boginda Forests	Boginda Forests (10, BO)	Moist evergreen montane forest							○		○
	Tulla Forest (10, BO)	Moist evergreen montane forest									○
	Saja Forest (8, GO-wet)	Evergreen montane forest and grassland complex							●	●	

2.3 Biological data collection

Faecal samples were collected opportunistically and measured, photographed and predetermined in accordance with relevant literature such as *"A Field Guide to the Tracks and Signs of Southern, Central and East African Wildlife"* by Chris and Mathilde Stuart.

We used small branches and disposable gloves to collect faecal samples, employing a careful handling routine to avoid (cross) contamination. Each sample was stored in a 20 ml collection tube filled with at least 90% undiluted ethanol and was labelled with a clearly traceable number for further DNA analysis. All faecal samples were kept for at least 24 hours in ethanol before being transferred onto silica and dried until DNA extraction. We used orange silica gel as a drying agent (Carl Roth GmbH and Co. KG, Karlsruhe, Germany). We then prepared 20 ml storage tubes with matching labels and filled them halfway with silica and a piece of cotton to separate specimens from the drying agent. Dry tissue and hair samples, occasionally collected from roadkill or animals killed by, e.g., snare traps were stored directly on silica.

2.4 Data analysis of image and sound files

Records of primates from image files and/or direct observations were determined using relevant classification literature, such as *"The Kingdon Field Guide to African Mammals"* by Jonathan Kingdon. For more detailed classification at the subspecies level, image and/or sound material was discussed with renowned primatologists familiar with species in this or surrounding areas, including Thomas M Butynski PhD (Wild Solutions) and Andrew Perkin PhD (Nocturnal Primate Research Group) for blue monkeys (*Cercopithecus mitis* ssp.) and lesser galagos (*Galago senegalensis* ssp.), Dr Dietmar Zinner (German Primate Centre) for baboons (*Papio anubis*) and guerezas (*Colobus guereza* ssp.) and Dr Tanja Haus (German Primate Centre) for green monkeys (*Chlorocebus aethiops* ssp.).

Predetermined faecal samples were analysed in accordance with the national regulations of the Ethiopian Biodiversity Institute (EBI). All organic samples were prepared and exported properly and with no other objective than to complete a full species list for the Kafa BR. Sample analyses were undertaken at the Primate Genetics Laboratory at the German Primate Centre in Goettingen, Germany, and in collaboration with other experts: Christiane Schwarz (Technical Assistant), Dr Rasmus Liedigk (Guest Scientist) and PD Dr Christian Roos (Senior Scientist). The following chapter contains further information on DNA analyses.

2.5 Data analysis of biological samples

2.5.1 DNA extraction

We used the First-DNA all tissue kit from GEN-IAL (GEN-IAL GmbH, Troisdorf, Germany) when extracting DNA from all faecal, tissue and urine samples, because it is suitable for various substrates, even degraded ones, and because it is known for high yields of pure molecular DNA. We followed the standard protocol with minor changes (see Appendix). For hair samples, we removed hair follicles from three hairs in each sample and amplified DNA via direct polymerase chain reaction (PCR) rather than prior DNA extraction.

2.5.2 DNA amplification

We used wax pellets as a vapour barrier in our reaction tubes, separating the contents into two distinct layers: a lower layer comprising all dNTPs and primers and an upper layer consisting of Taq polymerase, BT and template DNA. This delayed reagent mixing and reduced the occurrence of non-specific products until the first heating step of the PCR amplification. We also used BioTherm™ Taq DNA polymerase (Ares Biosciences GmbH, Cologne, Germany) for all samples in a 20 µl PCR mix (premix 1: 1 µl reaction buffer, 0.2µl dNTPs, 1 µl forward primers, 1 µl reverse primers and 6.8 µl HPLC-purified water; premix 2: 2 µl reaction buffer, 4 µl BT, 0.2 µl Taq polymerase, 10.8 µl HPLC-purified water) with 10 µl of premix 1, 17 µl of premix 2 and 3 µl of template DNA for all faecal, tissue and urine samples, but 20 µl of premix 2 together with several hair follicles for hair samples. PCR reactions were conducted with a single negative control (HPLC-purified water).

We generated two overlapping 700bp long fragments of the cytochrome b region. PCR amplification involved a pre-denaturation step at 94°C for 2 min, followed by 40 cycles at 94°C for 1 min, annealing at 60°C for 1 min, extension at 72°C for 1 min and a final phase at 72°C for 5 min. Primers available upon request.

2.5.3 DNA sequencing

PCR products were visualised on a 1% agarose gel. Sequences were run on an ABI 3130xL sequencer using the BigDye® Terminator Cycle Sequencing Kit (both: Applied Biosystems by Thermo Fisher Scientific, Waltham, Massachusetts, U.S.A.) and matching forward and reverse primers.

We assembled and aligned sequences using the BioEdit 7.2.5 software program (Tom Hall, Ibis Biosciences, Carlsbad, California, U.S.A.).

3. Results and Discussion

3.1 Assessment of primate species composition

We obtained 57 records of six primate species (*Papio anubis*, *Colobus guereza* ssp. *guereza*, *Chlorocebus aethiops* ssp. *aethiops*, *Galago senegalensis* ssp. *dunni*, *Cercopithecus neglectus*, *Cercopithecus mitis* ssp. *boutourlinii*) comprising 19 biological samples (18 faecal and one urine sample) as well as 31 direct sightings, one footprint and four vocal recordings from eight different sampling sites (see Table 2).

Due to a lack of sufficient data, we cannot clearly specify the area or habitat type with the highest or lowest primate species diversity. Detection frequency closely correlates with the behavioural ecology of a target species, along with its social system or tolerance towards humans or landscapes altered by humans. These factors all affect a species' abundance, distribution and detectability. Shy or rare species are almost impossible to track in unknown areas and within a very limited timeframe, whereas curious and common species are easy to find. Considering this bias, we are only able to vaguely highlight "primate-rich areas".

Table 2: Species composition and sample collection. We obtained records of six primate species evident through a number of different detection methods (sightings, DNA samples, audible behaviours and vocal recordings, tracks and signs). Some primate species are detected more often as others due to their behaviour patterns, distribution and abundance. Legend: ●●● = direct proof, sighting; ●● = indirect proof, DNA sample (e.g. scat); ● = indirect proof, audible behaviour; t = indirect proof, track; * = personnel communication; (x, xx) = number, code of study site

	Sampled site and habitat type (number and code of study sites)		*Cercopithecus mitis* ssp. *boutourlinii*	*Chlorocebus a.* ssp. *aethiops*	*Colobus g.* ssp. *guereza*	*Cercopithecus neglectus*	*Galago senegalensis* ssp. *dunni*	*Papio anubis*
			vu	lc	lc	lc	lc	lc
Bonga Forests	Sheka Coffee Forest (4, AW)	UTM zone 37 N 7.093674 N 36.22671 E 1400 – 1800 m a.s.l.			●●● ●		●	●●● ●● ●
Bonga Forests	Boka Bamboo Forest (1, BA)	UTM zone 37 N 7.268285 N 36.455492 E 2000 – 2700 m a.s.l.		●●●	●●●		●●● ●	●●● ●● ●t
Bonga Forests	"Guesthouse Forest" (11, KDA GH)	UTM zone 37 N 7.241035 N 36.45217 E 1800 – 1900 m a.s.l.	●●● ●●		●●●			*
Bonga Forests	Kayakela Forest (11, KDA GH)	UTM zone 37 N 7.314515 N 36.242543 E 1700 – 1800 m a.s.l.						*
Bonga Forests	Komba Forest (3, KO)	UTM zone 37 N 7.299871 N 36.090997 E 1800 – 2200 m a.s.l.	*	●●●	●●●			
Boginda Forests	Boginda Forests (10, BO)	UTM zone 37 N 7.508285 N 36.061888 E 2100 – 2200 m a.s.l.						●●
Boginda Forests	Tulla Forest (10, BO)	UTM zone 37 N 7.44789 N 7.44789 E 1600 – 1800 m a.s.l.		●●●	●●●	●●●		●●● ●●
Boginda Forests	Saja Forest (8, GO-wet)	UTM zone 37 N 7.55529 N 36.060923 E 1500 – 2200m a.s.l.		●●●				●●● ●●

Some primate species were detected more often than others. We found olive baboons (*Papio anubis*) in seven out of eight sampling sites. Guerezas (*Colobus guereza* ssp. *guereza*) were detected at five sites. Records of grivets (*Chlorocebus a.* ssp. *aethiops*) were obtained were found at half of all sites (four out of eight). Ethiopia lesser galagos (*Galago senegalensis* ssp. *dunni*), Boutourlini's monkey (*Cercopithecus mitis* ssp. *boutourlinii*) and De Brazza's monkey (*Cercopithecus neglectus*) were only recorded at two sites (one and one site, respectively).

The same pattern was found for the detectability of primate species along an altitudinal gradient. We found olive baboons, guerezas and grivets in a broader altitudinal range than Boutourlini's blue monkeys, Ethiopia lesser galagos and De Brazza's monkeys, the latter having the narrowest range. Our total surveying activity covered a very wide altitudinal range (1400 to 2700 m a.s.l.), with olive baboons and guerezas both present at every elevation we sampled at. Similar results were found for grivets (1700 to 2600 m a.s.l.). The ranges of the Ethiopia lesser galago and Boutourlini's blue monkey were less remarkable or elevated, but still fairly wide (1500 to 2200 m a.s.l.). The very shy De Brazza's monkey was only recorded between 1600 and 1700 m a.s.l.

We can confirm the presence of four out of six species in both the dense and high-altitude Boka Bamboo Forest and the moist evergreen montane forests in Boginda Forest areas such as Saja and Tulla Forests. Three out of six primate species were found in the Sheka Coffee Forest, a PFM area in the Awurada Valley, along with Komba Forest. Surveys in the forest stretches around the KDA Guesthouse also produced the same result. The two latter forests also provided evidence of Boutourlini's blue monkey, the only 'Vulnerable' primate species recorded. Although they are two very different habitats, surveys in the Boka Bamboo Forest and Sheka Coffee Forest provided data on the occurrence of the Ethiopia lesser galago.

We can therefore confirm that the olive baboon, guereza and grivet are very generalistic primate species which can cope with a variety of different habitats, including anthropogenically altered landscapes (Butynski et al. 2013; Döschner 2010; Zinner et al. 2002). They even seem to benefit from anthropogenic objects and changes in land use such as the conversion of forests into agricultural land. The olive baboon in particular appears to flourish in agricultural centres. Its adaptability and ecological flexibility are responsible for its bad reputation as a crop raider among small-scale farmers (Kingdon et al. 2008c).

These three species can be found throughout the study area. In contrast, the remaining three primate species were recorded considerably less, for various reasons. De Brazza's monkey is stenoecious, and its very specific habitat requirements make it vulnerable to habitat destruction and loss (Brennan 1985; Butynski 2002b; Gautier-Hion and Gautier 1978; IUCN 2014; Mwenja 2007). Boutourlini's blue monkey is already listed as Vulnerable. Finally, the Ethiopia lesser galago is nocturnal, and thus harder to record. The latter is common but dependent on mostly undisturbed or moderately managed mature, primary forests.

3.2 More specific findings

3.2.1 *Papio anubis*

Molecular, phylogenetic analyses based on cytochrome b DNA sequences indicate three different haplotypes detected for our study area (Boginda Forest area (10, BO), Awurada Valley (4, AW), Boka Wild Bamboo Forest (1, BA)) which are already known for this area and which complement specimens from Uganda, DR Congo and northwestern Tanzania. They can be further differentiated from central and southern rift olive baboons from eastern Ethiopia, Kenya and northern Tanzania.

3.2.2 *Galago senegalensis* ssp. *dunni*

The Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*) is currently the only recognized subspecies of *G. senegalensis* in Ethiopia (Butynski pers. comm.). We collected one sound recording of an individual from the Sheka Wild Coffee Forest (4, AW), a honk call, which resembles previous recordings of *G. senegalensis* ssp. dunni calls. Further analysis with sound recordings from other populations, as well as additional surveys, may reveal more information on the sub-species level.

3.2.3 *Cercopithecus mitis* ssp. *boutourlinii*

Boutourlini's blue monkey (*Cercopithecus mitis* ssp. *boutourlinii*) is currently the only recognized subspecies of *C. mitis* in Ethiopia (Butynski pers. comm.). We have video footage of a vocalising adult individual from the "Guesthouse Forest" (11, KDA GH) along with sightings in the Komba Forest (3, KO), reported to us by other team members. This *C. mitis* call sounded similar to calls by individuals from coastal and eastern Tanzania; however, it is shorter and more clipped (Perkins pers. comm.). Further analysis and surveys may reveal more details.

4. Conclusions and Recommendations for Conservation and Monitoring

We recorded all primate species currently described for southwest Ethiopia. The olive baboon occurs in every sample site we visited, as do guerezas and grivets. They are still very widespread and abundant, so it appears there are no major threats of range-wide population decline. All three species would make perfect study subjects for improved human-wildlife conflict management. They all raid and ruin crops to various degrees, and are therefore in constant conflict with small-scale farmers. There is great potential for future conservation activities that focus on participatory learning and action (PLA)-based workshops on human-wildlife conflict management. Activities should be tailored to farmers who rely on plant cultivation.

More importantly, we were also able to record primate species that are difficult to detect during a limited period in the field. We can therefore confirm that the Kafa BR provides suitable habitat conditions for primate species with very strict requirements, including Boutourlini's blue monkey, endemic to the western side of the Rift Valley, and De Brazza's monkey. Both are forest-oriented monkeys that avoid colonising forest patches and are thus dependent on wide and structured forests. As a result, they are strongly threatened by habitat destruction and human encroachment.

In contrast to the three generalist primate species, these two species are perfect candidates for future enhanced conservation activities and monitoring programmes. They will benefit from the BR and especially from the undisturbed and connected nature of the core zones. Long-term research and monitoring is particularly important for De Brazza's monkey, currently classified as 'Least Concern', as its conservation status in this, its northernmost range, is still insufficiently assessed.

The same is true for the remaining Boutourlini's blue monkey population in southwest Ethiopia. Future phylogenetic studies are extremely important for the conservation of this species, because its taxonomy is only very poorly understood. We recommend that both De Brazza's monkey and Boutourlini's blue monkey should be used as indicator species for the integrity of montane forests.
The habitat variation within Kafa BR is extremely interesting for galago research. Galagos have generally been less studied than other primates, and therefore hold potential for developing smart field research approaches for small, nocturnal, arboreal primate species. Here again, phylogenetic research is extremely important, because the taxonomic substructure of Galago senegalensis is still far from being understood.
We support the current choice of the guereza as flagship species for the Kafa BR. Unlike the other five primate species, the guereza meets all criteria for a flagship species: It is common, easy to recognize and popular, with a good reputation, unlike, e.g., the olive baboon.

The guereza is strongly influenced by habitat disturbances and habitat degradation (Chapman et al. 2000; Fashing 2002; Lwanga 2006; Harris & Chapman 2007); therefore, its flagship species status should be expanded to make it an indicator species for healthy, mostly undisturbed habitats.

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7. Appendix

7.1. Tables

Table 3: Primate species recorded during the biodiversity assessment in the Kafa BR (December 2014)

No.	Scientific name	Family	English name	Habitat/ forest type	Study sites	Distribution	IUCN threat status	CITES Appendix	Endemism
1	*Cercopithecus mitis* ssp. *boutourlinii*	Cercopithecidae	Boutourlini's blue monkey	Primary tropical deciduous and riverine forest at altitudes of 400-2000 m a.s.l.	11, KDA GH 3, KO	R. Endemic to southwest Ethiopia (western part of the Ethiopian Rift Valley).	vulnerable A2c, population decreasing	II	*
2	*Chlorocebus a.* ssp. *aethiops*	Cercopithecidae	Grivet	Savannah, montane forests (2000 m a.s.l.), woodland, riverine landscapes and cultivation mosaics or urban areas; depends on acacia, fig, foliage and gum (highly adapted).	1, BA 3, KO 10, BO 8, GO-wet	W. From Khartoum (Sudan) in the north to Mongalla in the south, and in Djibouti, Ethiopia and Eritrea, where it is found south of the River Omo and ranges as far east as the Ethiopian Rift Valley.	least concern, population stable	II	
3	*Colobus guereza*	Cercopithecidae	Guereza, black-and-white colobus	Wide ranging: montane forests, rainforest, acacia-dominated riverine galleries. Prefers secondary over primary forests.	4, AW 1, BA 11, KDA GH 3, KO 10, BO	W. Distributed in a band across the centre of Africa, from Nigeria and Cameroon east through the northern DR Congo, through southern Sudan to Ethiopia, Kenya and Uganda and south into northern Tanzania.	least concern, population trend unknown	II	
4	*Cercopithecus neglectus*	Cercopithecidae	De Brazza's monkey, Swamp monkey	River-oriented monkey, linear home range along river and streams; lowland, swamp forest (frequently flooded), semi-deciduous, acacia-dominated, montane forests (2100 m a.s.l.), lower montane galleries and bamboo forests.	10, BO	(R)W Rare in Ethiopia, only distributed in southern Ethiopia, otherwise distributed from Angola, Cameroon, Central African Republic, DR Conga, Guinea and in small patches in Ethiopia and Kenya.	least concern, population trend unknown	II	

No.	Scientific name	Family	English name	Habitat/ forest type	Study sites	Distribution	IUCN threat status	CITES Appendix	Endemism
						W.			
5	*Galago senegalensis* ssp. *Dunni*	Galagidae	Ethiopia lesser galago	Lowest level of mature primary forest, woodlands dominated by *Acacia*, *Isoberlinia*, *Combretum* and *Julbernardia*.	4, AW 1, BA	Distributed in a band across the centre of Africa, from Senegal in the west to Sudan, Somalia in the east as well as Kenya and Tanzania in the south.	least concern, population trend unknown	II	
6	*Papio anubis*	Cercopithecidae	Olive baboon, Anubis baboon	Most extensively distributed baboon species. Lowland into deep rain forest, occurs from 500-3000 m a.s.l., sometimes also above tree line. Seldom found more than 2 km into the forest. Benefits from recent climatic changes and seems to have no clear ecological boundary. Hybridises with hamadryas baboon (*P. hamadryas*), e.g., in the Awash region, Ethiopia, or with yellow baboon (*P. cynocephalus*), e.g., in the Amboseli National Park, Kenya.	4, AW 1, BA 11, KDA GH 10, BO 8, GO-wet	W. very widespread. Throughout Sahelian woodland from southern Mauritania and Mali to the Sudan and southwards to DR Congo and Tanzania. Outlying populations inhabit the Tibesti and Air massifs in the Sahara. In Eastern Africa, the distribution is actively changing due to hybrid zones.	least concern, population increasing	II	-

*Yalden et al. (1977); Butynski & Gippoliti (2008)

Table 4: DNA extraction using the First-DNA all tissue kit from GEN-IAL (GEN-IAL GmbH, Troisdorf, Germany)

Lysis	01	Use low-binding tubes and dual-filter pipette tips for all work steps. Change tips for every new sample.
	02	Switch on the sample heater and cool EtOH 70% and DTT at -20°C. Sample racks must be placed at +4°C and -20°C.
	03	Cut sample into tiny pieces and transfer it into a 2 ml tube.
	04	Add 1000 µl Lysepuffer 1, 100 µl Lysepuffer 2 and 20 µl Proteinase K (Enzyme).
	05	Add 10 µl 1 M DTT.
	06	Vortex samples.
	07	Incubate at 65°C at 1400 rpm for 1 hour on thermo mixer.
	08	Reduce temperature and incubate overnight at 37°C at 1000 rpm.
	09	Spin at maximal speed for 10 min until sample is dissolved.
	10	Use time to label new tube: 2x 2 ml tube, 1x 1.5 ml tube.
Separation	11	Transfer 1000 µl supernatant into a new 2 ml tube. A galantine mass may occur at the bottom of the tube. Be careful not to transfer this mass. Do not use more than 1000 µl to ensure that there is enough space for add-on substances.
	12	Add chloroform (80 % of volume, e.g., 400 µl for 500 µl supernatant).
	13	Invert several times in hand (8x).
	14	Spin at maximal speed for 10 min.
	15	Carefully transfer upper phase into a new 2 ml tube. Stop 1-2 mm before interface to avoid contamination.
	16	Add Lysepuffer 3 (75% of volume, e.g., 375 µl for 500 µl supernatant).
	17	Vortex for 20 sec.
	18	Incubate at -20°C for 5 min.
	19	Spin at maximal speed for 20 min.
Precipitation	20	Transfer 800 µl of supernatant into a new 1.5 tube.
	21	Add isopropanol (2-propanol 100%) (80% of volume, e.g., 640 µl for 800 µl supernatant).
	22	Invert several times in hand (8x).
	23	Incubate at +4°C for 30 min.
	24	Spin at maximal speed for 15 min.
	25	Remove supernatant by using a 1000 µl tip at least twice. Make sure not to touch or remove the pellet.
Purification	26	Wash pellet with 300 µl EtOH 70 % (-20°C).
	27	Spin at maximal speed for 5 min.
	28	Carefully remove supernatant by starting with a 1000 µl tip and proceeding with a 100 µl tip. Try to absorb all alcohol without touching or removing the pellet.
	29	Dry pellet for 30 min with lid open to allow evaporation. Sample is ready once tube is completely free of any drops of fluid. (To speed up this step, sample can be heated up to 37°C. Tube will remain open.)
Storage	30	Dissolve DNA in 50 µl HPLC water and freeze sample at -80°C. (If you expect a large amount of DNA, e.g., in tissue samples, elute DNA in 100 µl HPLC water).

7.2. Photos

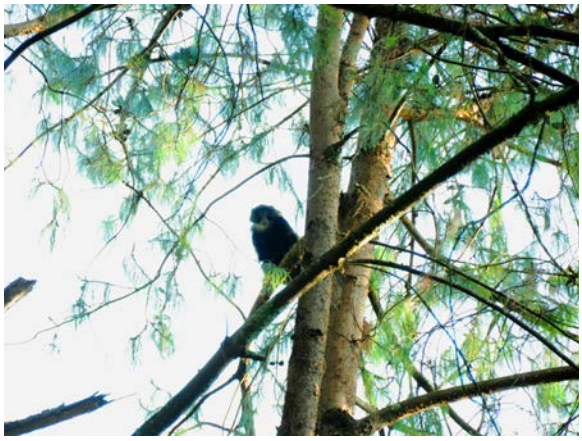

Figure 1: Boutourlini's blue monkey (*Cercopithecus mitis* ssp. *boutourlinii*) | IUCN vulnerable, CITES II, endemic to SW Ethiopia, "Guesthouse Forest" (11, KDA GH), 2014 (photo: Karina Schell)

(Audio recording available here: http://imperia.verbandsnetz.nabu.de/imperia/md/video/cercopithecus-mitis-kafa.mp4)

Figure 2: Boutourlini's blue monkey (*Cercopithecus mitis* ssp. *boutourlinii*) | IUCN vulnerable, CITES II, endemic to SW Ethiopia, Komba Forest (3, KO) (photo: Bernhard Walter)

Figure 3: Guereza or black-and-white colobus (*Colobus guereza* ssp. *guereza*) | IUCN least concern, CITES II, Waliso Negash Lodge (photo: Holger Meinig)

Figure 4: Guereza or black-and-white colobus (*Colobus guereza* ssp. *guereza*) | IUCN least concern, CITES II, Waliso Negash Lodge (photo: Holger Meinig)

Figure 5: Olive baboon or anubis baboon (*Papio anubis*) | IUCN least concern, CITES II (photo: Bernhard Walter)

Figure 6: Olive baboon or anubis baboon (*Papio anubis*) | IUCN least concern, CITES II (photo: Tom Kirschey)

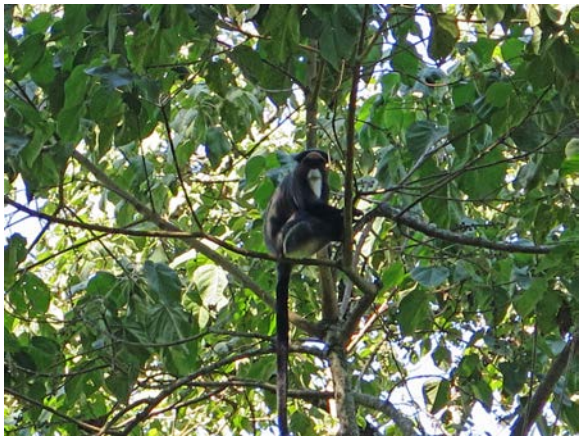

Figure 7: De Brazza's monkey or swamp monkey (*Cercopithecus neglectus*) | IUCN least concern, CITES II, Tulla Forest (10, BO), 2014, (photo: Fabio Kölbl)

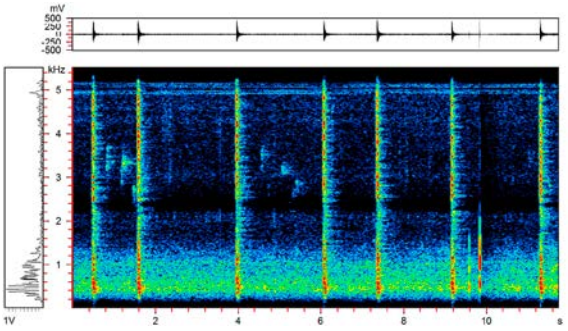

Figure 8: Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*) | IUCN least concern, CITES II, Audio recording from Sheka Wild Coffee Forest (4, AW), 2014 (recording: Karina Schell / Sonogram: Andrew Perkin)

(Audio recording available here: http://imperia.verbandsnetz.nabu.de/imperia/md/audio/galago-senegalensis-kafa.mp3)

Figure 9: Grivet (*Chlorocebus aethiops* ssp. *aethiops*) | IUCN least concern, CITES II, Kafa, 2008 (photo: Bruno D'Amicis)