Bats and fruit bats at the Kafa Biosphere Reserve

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Highlights

→ This is the first time a systematic bat assessment has been conducted in the Kafa BR.

→ We recorded four fruit bat species, one of which is new for the Kafa BR but not for Ethiopia.

→ We recorded 29 bat species by capture or sound recording. Four bat species are new for the Kafa BR but occur in other parts of Ethiopia.

→ We recorded calls of a new species in the horseshoe bat family for Ethiopia via echolocation. This data needs to be confirmed by capture, because there is a chance it could be a species of Rhinolophus new to science.

→ We suggest two flagship species: the long-haired rousette for the bamboo forest and the hammer-headed fruit bat for the Alemgono Wetland and Gummi River.

→ The bamboo forests had the most bat activity at night, but the Gojeb Wetland had the highest species richness due to its highly diverse habitats.

→ All caves throughout the entire Kafa BR should be protected as bat roosts.

→ It will be necessary to develop an old tree management concept for the biosphere reserve to protect and increase tree roosts for bats.

1. Introduction

Ethiopia has high megabat and microbat diversity, thanks to its special geographical position between the sub-Saharan region, East Africa and the Arabic Peninsula. In Africa, all megabats belong to the Old World fruit bat family (Pteropodidae). To date, 11 fruit bat species have been recorded in Ethiopia (Mammals of Africa Vol. IV 2013). All species are vegetarians and forage mainly on nectar, flowers, fruits or leaves. Like all megabats, they mainly roost in trees or caves. They have rudimentary echolocation, only producing broad-band clicks for orientation in caves; outside the caves their orientation is based on vision and smell. In contrast, microbats (bats) produce high frequency calls for both orientation and foraging. They are mainly insectivorous; only the members of the African false vampire family forage (Csaga 1996) sporadically on scorpions and centipedes. These bats roost in caves, hollow trees, under branches or a canopy or bridges or in buildings (except for the KDA Guesthouse at Bonga, there were no buildings suitable for bats at any of the study sites). So far, 70 bat species have been recorded in Ethiopia, five of them endemic to Ethiopia.

At a higher taxonomic level, the following families have been recorded in Ethiopia to date: one family of megabats (Pteropodidae with 11 species) and nine bat families (Rhinopomatidae, two species; Rhinolophidae, eight species; Hipposideridae, seven species; Emballonuridae, three species; Nycteridae, five species; Megadermatidae, two species; Molossidae, 12 species; Miniopteridae, three species; and Vespertilionidae, 28 species) (African Chiroptera Report 2014, see Appendix).

Only poor data exists for the Kafa BR at present, gathered during a Russian excursion (Lavrenchenko 2004) and recorded from few museum specimens.

Table 1: Bats and fruit bat species richness in Ethiopia (African Chiroptera Report 2014; Mammals of Africa Vol IV 2013 and own data)

	Species in Ethiopia	Species in the Kafa BR	New records for the Kafa BR (this study)
Bats	70	29	4 confirmed
Fruit bats	11	7	1 confirmed

Little is known about the habitat use and food preference of most African bat species. Very few publications comment on the distribution of bat species (type of habitat used and altitudinal distribution) or food preferences within Africa.

The presented survey is a first attempt to get a rough overview of the bat fauna in the Kafa BR. Despite the comparatively short time for the assessment, the data quality is high, as the records are not only based on captured animals or museum specimens. Our sound recording equipment allowed us to register even high-flying bats, which are generally underrepresented in surveys based on traditional recording methods such as mist netting (which biases surveys due to the small vertical trapping height of about 4 m). The high-flying bats we recorded mainly belonged to the Molossidae family. They have very loud echolocation calls, which can be recorded well over long distances or when they are flying high over habitats.

2. Materials und Methods

2.1 Study sites

We sampled at the following sites: Bamboo Forest (BA), Boka Forest (BK), Alemgono Wetland (AW), Gojeb Wetland (GO-wet), KDA Guesthouse and God's Bridge (near Bonga). Table 2 provides an overview of sampling dates and conditions at the sites.

Table 2: Sampling sites

Date	Location	No. of mist nets	Audio record	Altitude (m a.s.l.)	GPS data		Time	Temperature at 9 pm (°C)	Humidity	Moon
Bamboo Forest (BA)										
04.12.2014	Clearing	2	1	2595	7.240562°	36.452092°	1800-0000	11.6	53%	95%
	Roadside	1	0	2592	7.241319°	36.452568°	1800-0600			
	In the forest	0	1	2668	7.244722°	36.457697°	1800-0600			
Boka Forest (BK)										
05.12.2014	Forest border	1	1	2407	7.298308°	36.373251°	1800-2200	15.6	53%	100%
	In the forest	1	0	2445	7.298523°	36.372913°	1800-2200			
	Stream	0	1	2435	7.296747°	36.372911°	1800-2200			
Alemgono Wetland (AW)										
07.12.2014	Gummi River	3	1	1289	7.095167°	36.232394°	1800-0600	15		95%
	Coffee plantation	0	1	1299	7.094387°	36.227896°	1800-0000			
Gojeb Wetland (GO-wet)										
09.12.2014	House/garden	1	1	1550	7.566865°	36.049964°	1900-0600	15		85%
	Hedge	1	0	1558	7.563601°	36.047500°	1800-2200			
	River	0	1	1535	7.552917°	36.056020°	1800-0600			
10.12.2014	Carwash	1	1	1532	7.555848°	36.056959°	1800-2300	15	82%	80%
	Road – core area	1	0	2100	7.549455°	36.053231°	1800-2200			
	Forest fragment	0	1	1495	7.559498°	36.049623°	1800-0600			
11.12.2014	Bridge	2	1	1537	7.554960°	36.059750°	1800-2300	13.6	75%	75%
	Coffee plantation	0	1	1535	7.557583°	36.054940°	1800-0600			
Guesthouse Bonga (KDA)										
03.12.2014	In compound	3	0	1756	7.250151°	36.254611°	1800-2330	12.9	65%	75%
08.12.2014	Tree at the house	0	1	1760	7.251088°	36.254992°	1800-0600	no data	82%	
11.12.2014	Tree at the house	0	1	1760	7.251088°	36.254992°	1800-0600	no data	75%	
God's Bridge										
06.12.2014		0	1	807	7.182593°	36.268254°	1800-1930	20	no data	98%
08.12.2014		1	1	807	7.182593°	36.268254°	1800-1900	no data	82%	

2.2 Sampling methods

2.2.1 Mist nets

We used nylon mist nets with a total height of 2.5 m and widths of 3, 6 and 12 m. We carried out mist netting in all study areas. The nets were only mounted for the entire night on the riverside of the bamboo forest and at Gummi River. At all other sites, either the light of the full moon or the humidity disrupted bat activity, so we removed the nets before midnight. We measured all captured bats (length of forearm, fingers, ear or tail and weight (see Table 4)).

In addition to the body measurements, we took a tissue sample from each individual by taking a biopsy punch out of the upper wing membrane (diameter: 2 mm for bats, 5 mm for fruit bats). These samples were stored in 80% alcohol for DNA analysis at the Natural Museum of Berlin by Dr Frieder Mayer's group, who are experts in identifying bat and fruit bat species based on DNA sequences.

2.2.2 Audio recordings

To record bat echolocation signals, we used two batcorders (ecoObs®, Germany) with a frequency range of 14-200 kHz (sampling frequency, 500 kHz; amplitude, 36 dB) and one bat logger (Elekon®, Switzerland) with a frequency range of 12-155 kHz (sampling frequency, 312.5 kHz). Stationary recordings with the batcorder system were taken at nearly all study sites throughout the whole night. Sound recordings from captured bats were made with the bat logger. We used the same system for recordings on the Gojeb River and God's Bridge. The call sequences were stored on SDHC cards.

2.3 Data analysis

To identify individual bat species, we used identification keys (measurement data) from publications for captured bats. Species we were unable to identify to the species level were taken to Germany for further investigation. Samples were properly prepared and exported to Germany in accordance with the national regulations of the Ethiopian Biodiversity Institute (EBI), with the main objective of further identifying the species and completing the species list.

The DNA analysis of the tissue samples is still in process. The identification process is being performed in collaboration with Dr Frieder Mayer of the Museum of Natural History in Berlin, who is responsible for the DNA analysis. We are also collaborated with Dr Rainer Hutterer (Alexander Koenig Research Museum, Bonn), who is taking X-rays of the unknown pipistrelle/*Neoromicia* species to identify the form/shape of the bacula (penis bone). This new method will help us identify this species.

2.3.1 Identification via audio records

We identified the hammer-headed bat (*Hypsignathus monstrosus*) by its mating calls at the Gummi River. This was done based on personal acoustic experience and data identification results from scientific literature. We analysed the records using the Selena® application (Tuebingen University).

It is difficult to identify African bat species via echolocation calls, because the call parameters to distinguish certain species are often non-existent. The data on species' specific call frequencies differ between publications. This could be due to the use of different recording systems in the past and the varying quality of these recordings (Monadjem 2001; Collen 2012; van Cakenberghe & Seamark 2014).

In this study, we identified bat species using the start and end frequencies, duration and intervals of their echolocation calls. With the exception of the *Myotis*, and *Cardioderma* species, we used the constant frequency component of the sounds for classification. We did not use the best frequency, as this parameter is highly variable within each species and depends on echolocation tasks.

3. Results and Discussion

3.1 Bamboo Forest (BA)

Hunting activity was high at this site at the beginning of the night, both on the riverside and deep in the bamboo forest (Figure 3). Activity continued until morning, but only in the forest. The insect team found an abundance of mosquitoes, flies and beetles at this humid study site, which may explain the large number of bats.

Our echolocation data suggests that the recorded *Myotis* species (Table 4) could be *Myotis welwitschii*, which appears at an altitudinal range of about 2000 m a.s.l. But both *Myotis tricolor* and *Myotis scotii* (an endemic *Myotis* species for Ethiopia) can also be found at higher montane altitudes. Knowledge of the echolocation calls of all three species is sparse (Taylor 1999), and

the data from literature vary considerably. We also found different *Molossides* hunting above the forest, as well as bats from the subgenera *Scotophilus*, *Scotecus* and *Miniopterus*.

In addition to audio recording, we set up three mist nets. Two of the nets were located at the riverside and one along the road next to our campsite. No bat activity was recorded at the riverside after 9:30 pm, but we recorded hunting call sequences in and above the bamboo forest continuously from sunset to sunrise. This could be a consequence of the increasing brightness of the moon and/or the very low temperature (5°C) outside the forest at that time, since other studies have found that insect activity is influenced by temperature and that temperatures inside forests might be higher than those outside during the night.

In total, we captured two fruit bats, a long-haired rousette and five other bat individuals. Two of these were Geoffroy's horseshoe bats (*Rhinolophus clivosus*/ ssp. *acrotis*?), while the other three belonged to the subspecies *Pipistrellus*/*Neoromica* (Table 3). Tissue sample analysis is still ongoing.

3.2 Boka Forest (BK)

We set up our first mist net on the border of a primary forest. The second was placed inside the forest, 10 m from the forest edge.

The bat activity on both nets was very low; we registered only a few sound recordings. The temperature fell below 5°C, meaning the nets became wet and were detectable to hunting or commuting bats. The full moon illuminated the mist net set up outside of the forest.

Probably due to these conditions, we did not capture any bats, and recorded just ten bat sounds before removing the nets. While waiting for the bats, we recognised high nightjar activity in the valley, which were apparently in the mating season. One large owl flew over the net. In addition to the netting, we also installed a batcorder system on a tree on the banks of the small river which flows through the valley (Figure 5). The riverside vegetation is composed of shrubs and trees, none of which are higher than 5 m. Riverbanks and wetlands are used for cattle grazing. The acoustic system recorded a lot of activity from *Myotis* species, which were hunting over and along the small creek. The peak frequency of the calls suggested Welwitsch's Bat (*Myotis welwitschii*). We also recorded calls of the *Miniopterus*, *Chaerephon* and *Pipistrellus* species.

3.3 Alemgono Wetland – Gummi River (AW)

The habitat along the Gummi River appears to be mostly primary forest with some large *Ficus* trees, but about 100-150 m beyond the forest's edge we found coffee plantations (Participatory Forest Management (PFM) sites). We also found traps on the way to the riverside, so the area might not be entirely free of human disturbance. We spent the whole night at the riverside, as the temperature did not fall below 12°C. We installed three nets along the river (Figure 8). Within a minute we had captured a bat from the Nycteridae family. The species is not confirmed yet.

Although we observed some fruit bats crossing at dawn and in the morning, we did not record a high amount of bat activity at this study site. However, we got the first record of the hammer-headed bat in the Kafa area, a male which sang for over an hour. We tried to find him, but we only got a short glimpse of him before he disappeared and returned at 0300 to continue with his mating call. In addition to the netting, we made some audio recordings at the coffee plantation, where the bat activity was higher. We recorded the African giant free-tailed bat and some calls from Molossidae, *Myotis* and *Pipistrellus* species.

3.4 Gojeb Wetland (GO-wet)

This study site has very diverse habitats, so we spent three nights there. On the first night, we set up some nets in areas used for agriculture. In a net on a hilly hedgerow we captured two *Triaenops afer* specimens, a male and a female. On the second night, we put up a net by the side of the Gojeb River, in a small gap used by the locals to wash their cars, and a second net along the road in the hilly primary core zone forest. We took the nets down at 2300 as we had not captured any specimens by then and did not expect to, due to low bat activity. Later, however, we experienced high activity when crossing the bridge over the Gojeb River.

On the third night, we set up a net at the bridge. We placed another self-made net (3x3m) on the river's surface to catch the bats we had seen hunting the night before. Their behaviour matched that of Daubenton's bat in Europe, which hunts for insects above the water's surface. Unfortunately, the pole holding up the net disturbed the water, so the bat recognized it as an obstacle and avoided it.

The long mist net (Figure 10) along the bridge was more successful: We captured two fruit bats and a high flying Molossidae bat. The female Molossidae was a Chapin's free-tailed bat (*Chaerephon chapini*) and the fruit bats were a subspecies of the Egyptian fruit bat

(*Rousettus aegyptiacus* ssp. *leachii*). This was the first record of Chapin's free-tailed bat in the Kafa BR.

Stationary sound recordings were also carried out in a fragmented forest (Figure 11) area in the wetland, on a coffee plantation near the road and at the side of the Gojeb River.

Rivers are very attractive for bats for water intake, especially in the dry season when water availability is reduced. This explains why we found 20 bat species at this study side (Table 4). Some of our records matched species which are rarely recorded in Ethiopia, such as the large-eared free-tailed bat (*Otomops martiensseni*). Our data is the first record of *O. martiensseni* in the Kafa BR. Within the coffee plantation, we captured calls from a hunting African trident bat (*Triaenops afer*). We also found a high variety of *Myotis*, Molossidae and *Pipistrellus* species by the riverside.

3.5 KDA Guesthouse

We set up mist nets in the compound of the KDA Guesthouse in Bonga for one night. Two nets were set up in front of a mango tree in blossom, and other nets were placed on the north border of the compound. At midnight we captured two fruit bats in front of the mango trees, a male and female Peters' dwarf epaulleted fruit bat (*Micropteropus pusillus*). We also conducted some stationary sound recording on two nights (8th and 11th December). We recorded calls from several Molossidae, *Miniopterus* and *Pipistrellus* species.

3.6 God's Bridge

One of the area's tourist attractions is a natural stone bridge over the river near Bonga called God's Bridge (Figure 13). This cave-like structure is used as a roosting site by some fruit bat and bat species. We recorded echolocation calls from *Miniopterus*, *Pipistrellus* and *Myotis* species. In addition, we observed fruit bats circling under the bridge, but were unable to catch them. The bats leaving the cave recognized our mist net at the entrance and avoided it. We only had visual contact to some perch-hunting rhinolophids. All echolocation calls from hipposiderids or rhinolophids were distinguished by the cf part of their calls. We obtained records of Noack's roundleaf bat (*Hipposideros ruber*) and perhaps of Smithers' horseshoe bat (*Rhinolophus smithersi*). Taylor (2012) found four new species belonging to the *Rhinolophus hildebrandtii* complex in his southeast African study in 2012. Rh. smithersi is one of them. This species has never been recorded outside of Zimbabwe and must be confirmed by capture. As of now it is not clear whether *Rhinolophus* hildebrandii and/or *Rhinolophus eloquens* actually occur in Ethiopia.

Our echolocation results suggest that some earlier records of *Rhinolophus* species in Ethiopia actually belong to the new *Rhinolophus smithersi* (cf freq. 46 kHz) or to a new Rhinolophidae species.

4. Conclusions and Recommendations for Conservation and Monitoring

Since we mostly sampled the sites for just one night, we could not generate accumulation curves for any fruit bat or bat species. We propose the long-haired rousette (*Rousettus/Stenonycteris lanosus*) as a flagship species for the bamboo forest and the hammer-headed (fruit) bat (*Hypsignathus monstrosus*) for the Alemgono Wetland. For all other species, we can only make rough suggestions for conservation and further surveys in this region.

We gathered a large number of audio recordings and captured half of all bats with mist nets in the bamboo forest at a high altitude (2700 m a.s.l.). This may initially seem incredible, but it might be explained by our theory that this site had the greatest supply of roosting site and food in this region. Even the insect team found a high number of insects in the bamboo forest. The highest species richness was found in the Gojeb Wetland. Highly diverse habitats and a large variety of food (due to the warmer climate) could explain this result.

We confirmed four species of fruit bat and more than 29 different bat species (less than half of the known bat species in Ethiopia) in our short study period. Most of the echolocation records will need to be confirmed by capture, but nevertheless we recorded six new species for the Kafa BR and one new to Ethiopia. The *Rhinolophus* species we recorded at God's Bridge could be *Rhinolophus smithersi*, judging by the echolocation recordings, which has only been found in Zimbabwe until now. Or perhaps we recorded a new species of the family Rhinolophidae. It will be necessary to capture some individuals at God's Bridge to confirm this data.

4.1 Conservation and key species

The human activities that pose the greatest threats for bats in Africa include habitat loss and the use of pesti-

cides. There is very little information about the habitat use, food or roost preferences of most bat species. A key step to successfully protecting bat fauna is to ensure the supply of a large number of old, hollow trees or caves for roosting. Caves are important roosting sites for almost all bat species. Existing cave roosts should be protected. Especially at God's Bridge, which is a tourist attraction, the bats should be protected from people who could disturb the colonies during their visit. Installing an information board at the entrance could help protect the animals (bats and birds) which live in the cave.

To increase the number of tree roosting sites, it will be necessary to implement a management plan for old trees within the BR. Old dead trees are currently removed for use as firewood. Similarly, an abundance of insects is needed to improve roosting conditions. This could be supported by, for example, creating continuum corridors between managed and natural forests.

Fruit bats often roosts in caves, under palm branches or hanging from tree branches. The family Pteropodidae (fruit bats) need sufficient blossom or fruiting trees in an area to find enough food. Some fruit bat species migrate seasonally between habitats with profitable food sources, often over long distances. Plans to increase commercial fruit tree plantations could cause problems for bat conservation, as they will eat the fruit if there are not enough natural food resources left.

Further research is required in the area. To protect the very rare (long-haired rousette) or only scarcely dispersed hammer-headed bat flagship species, it would be useful to have more data on their behaviour, habitat use and roosting sites.

4.2 Future bat monitoring plan

Future studies should monitor bats throughout all seasons (dry-wet transition phase) and pay more attention to the lunar cycle, e.g., the influence of the full moon on bat activity. To gain an overview of the species composition of bat fauna in certain areas it would be helpful to first monitor caves and roosting sites before continuing with mist netting or bioacoustics. To ensure comprehensive and robust results, it is important to conduct a minimum of seven days of sampling/observation, across all seasons, at each study site. To confirm the new *Rhinolophus* species, it will be necessary to capture some specimens at God's Bridge for body measurements and tissue samples.

5. References

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6. Appendix

6.1. Tables

Table 3: Ethiopian bat list (IUCN category: NT= 'near threatened'; DD= 'data deficient'; LC= 'least concern'; V= 'vulnerable')

Family/ species	English name	Altitude (m a.s.l.)	Reported in Ethiopia	Reported in Kafa	IUCN category
Fruit bats: Pteropodidae					
Rousettus aegyptiacus ssp. *leachii*	Egyptian fruit bat	2500	x	x	LC
- lanosus	Long-haired rousette/Mountain fruit bat	2500	x	x	LC
Lissonycteris angolensis	Angolan soft-furred fruit bat	4000	x		LC
- angol. petraea ***	Petra fruit bat	2600	x	x	DD
Eidolon helvum	Straw-coloured fruit bat	1900	x		NF
Hypsignathus monstrosus	Hammer-headed bat	1200	x	New record	LC
Epomophorus gambianus	Gambian epauletted fruit bat	2150	x	x	LC
- labiatus	Ethiopian epauletted fruit bat	2500	x	(x)	LC
- minimus	East african epauletted fruit bat	Savannah	x	x	LC
- minor	Minor epauletted fruit bat	No data	x		Unknown
Micropteropus pusillus	Peter's dwarf epauletted fruit bat	1900	x	x	LC
Bats: Emballonuridae					
Taphozous perforatus	Egyptian tomb bat	1600	x	x	LC
- mauritianus	Mauritian tomb bat	500	x		LC
Coleura afra	African sheath-tailed bat	1700	x	x	LC
Hipposideridae					
Hipposideros caffer	Sundevall's roundleaf bat	2000	x	(x)	LC
- vittatus (marunguensis)	Striped leaf-nosed bat	Lowland	x		NT
- megalotis	Ethiopian large-eared roundleaf bat	2000	x		LC
- ruber	Noack's roundleaf bat	1900	x	x	LC
Triaenops afer	Persian trident bat	1700	x	x	LC
Asellia patrizii	Patrizi's trident leaf-nosed bat	1000	x		LC
- tridens	Trident bat	1000	x		LC
Megadermatidae					
Lavia frons rex	Yellow-winged bat	1400	x		LC
Cardioderma cor	Heart-nosed bat	1400	x	New record	LC
Miniopteridae					
Miniopterus natalensis	Natal long-fingered bat	2700	x	x	LC
- schreibersii smitianus	Schreibers' long-fingered bat	No data	x	(x)	NT
- inflatus	Greater long-fingered bat	3300	x		LC

Family/ species	English name	Altitude (m a.s.l.)	Reported in Ethiopia	Reported in Kafa	IUCN category
Nycteridae					
Nycteris aurita	Andersen's slit-faced bat	1500	x		LC
- hispida	Hairy slit-faced bat	1800	x	x	LC
- macrotis	Large-eared slit-faced bat	2200	x	(x)	LC
- parisii	Parisi's slit-faced bat	No data	x		DD
- thebaica	Egyptian slit-faced Bat	2400	x	x	LC
Molossidae					
Otomops martiensseni	Large-eared free-tailed bat	1300	x	New record	NT
Platymops setiger	Peters's flat-headed bat	900	x		LC
Mops condylurus	Angolan free-tailed bat	1700	x	(x)	LC
Mormopterus acetabulosus	Mauritian little mastiff bat	2000	x		V
Tadarida nanula	Dwarf free-tailed bat	500	x		LC
-ventralis	African giant free-tailed bat	1800	x	New record	DD
Chaerephon ansorgei	Ansorge's free-tailed bat	2500	x	(x)	LC
-bivittatus	Spotted free-tailed bat	2500	x		LC
-chapini	Chapin's free-tailed bat	1800	x	New record	LC
-leucogaster	Grandidier's free-tailed bat	No data	x	(x)	DD
-pumila	Little free-tailed bat	2200	x	x	LC
-nigeriae	Nigerian free-tailed bat	1100	x		LC
Rhinolophidae					
Rhinolophus clivosus ssp. *Acrotis*	Geoffroy's horseshoe bat	3000	x	(x)	LC
- blasii ssp. *andreinii*	Blasius's horseshoe bat	2000	x		LC
- eloquens	Eloquent horseshoe bat	No data	x		LC
- hildebrandtii	Hildebrandt's horseshoe bat	2400	x		LC
- fumigatus	Rüppell's horseshoe bat	2400	x		LC
- hipposideros ssp. *minimus*	Lesser horseshoe bat	1400	x		LC
-landeri lobatus	Lander's horseshoe bat	2200	x	x	LC
-simulator	Bushveld horseshoe bat	3000	x		LC
-smithersi	Smithers's horseshoe bat	No data	New re-cord	New record	DD
Rhinopoma hardwickii ssp. *cystops*	Lesser mouse-tailed bat	1000	x	(x)	LC
	Macinnes's mouse-tailed bat	1000	x		DD
Vespertilionidae					
Kerivoula lanosa	Lesser woolly bat	1000	x		LC
*-eriophora****	Ethiopian woolly bat	3300	x		DD
Myotis bocagii	Rufous mouse-eared bat	2400	x	x	LC
-morrisi	Morris' mouse-eared bat	900	x		DD
*-scotti****	Scott's mouse-eared bat	2500	x	x	V

Family/ species	English name	Altitude (m a.s.l.)	Reported in Ethiopia	Reported in Kafa	IUCN category
Vespertilionidae					
-tricolor	Cape hairy bat	2600	x		LC
-welwitschii	Welwitsch's bat	2200	x	x	LC
*Plecotus balensis***	Ethiopian big-eared bat	3300	x		V
Mimetillus moloneyi	Moloney's mimic bat	500	x	(x)	LC
Laephotis wintoni	De Winton's long-eared bat	1700	x	x	LC
Nycticeinops schlieffeni	Schlieffen's bat	900	x		LC
Scotophilus dinganii	Yellow-bellied house bat	2150	x	x	LC
*-ejetai****	Ejetas house bat	No data	x		DD
-leucogaster	White-bellied house bat	2200	x		LC
-viridis ssp. *nigritellus*	Greenish housed bat	Montane	x		LC
Scotoecus hirundo	Dark-winged lesser house bat	1500	x	(x)	LC
Scotoecus hindei	Hinde's lesser house bat	1800	x		DD
Glauconyncertis variegata	Variegated butterfly bat	1000	x		LC
Pipistrellus aero	Mount Gargues pipistrelle	2500	x		DD
-hesperidus	Dusk/African pipistrelle	3000	x	x	LC
-nanus ssp. *africanus/ N. ssp. nana*	Banana pipistrelle	2500	x	x	LC
-rusticus	Rusty pipistrelle	2100	x	x	LC
-rueppelli	Rüppell's pipistrelle	2500	x		LC
Neoromicia guineensis	Tiny serotine	1900	x		LC
-capensis	Cape serotine	600	x	x	LC
-somalicus	Somali serotine	1900	x	x	LC
-tenuipinnis	White-winged serotine	2300	x		LC
-zuluensis	Zulu pipistrelle	2600	x		LC

Table 4: Results from capture data and sound analysis

Family	Species name		BA	BK	AW		Go-wet			God's Bridge	KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplant.	Forest fragment	River	Meadow, Coffee plant		Bonga
Pteropodidae/ fruit bats											
	Hammer-headed fruit bat	*Hypsignathus monstrosus*			x[2]						
	Peters' dwarf ep-aulletted fruit bat	*Micropteropus pusillus*									x[1]
	Long-haired rousette	*Stenonycteris lanosus*	x[1]								
	Egyptian rousette	*Rousettus rous. leachii*						x[1]			
		Fruit bats spec								x	

Family	Species name	BA	BK	AW		Go-wet				KDA
		Bamboo Forest	Boka Forest	Gummi River	Coffeeplant.	Forest fragment	River	Meadow, Coffee plant	God's Bridge	Bonga
Emballonuridae										
	None									
Hipposideridae										
	Noack's roundleaf bat	*Hipposideros ruber*							x²	
	African trident bat	*Triaenops afer*				x²	x²	x¹		
Megadermatidea										
	Heart-nosed bat	*Cardioderma cor*					x²			
Miniopteridae										
		Min 45 [*Miniopterus inflatus*]	x							
		Min 52 [*Miniopterus natalensis*]	x	x			x			
		Min 56 [*Miniopterus spec*]	x					x	x	x	x
Molossidea										
	Long-eared giant mastiff bat	*Otomops martiensseni*						x²		
	Pale free-tailed bat	*Chaerephon chapini*	x³					x¹		
		T 15/16 [*Ch. nigeriae*]	x					x		
		T 17/18 [*Ch. ansorgei*]	x							
	African giant free-tailed bat	*Tadarida ventralis*	x²			x²				x²
		T 25 [*Ch. pumilus*]		x			x	x	x		x
		T 32/34 [*Momopterus acetabulosus*]						x			x
		Mol 18/20 [*Mops condylurus*]				x					
Nycteridae										
		N spec *(Nycteris hispida)*			x¹						
Rhinolophidae										
	Geoffroy's Horseshoe bat	*Rhinolophus clivosus a.*	x¹					x²	x²		
	???	**RH 46** [*Rhinolophus smithersi*]								x	
Rhinopomatidae										
	No Rhinopomatidae									
Vespertilionidae										
		Pip 32/34 [*Pip./Neoromica spec*]						x		
		Pip 35/36 [*Neoromica somalicus*]	x					x	x		x
		Pip 38/39 [*Neoromica capensis*]	x	x					x		
		Pip 42/44 [*Pipistrellus aero*]			x	x	x	x	x		x

Family	Species name		BA	BK	AW		Go-wet			God's Bridge	KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplant.	Forest fragment	River	Meadow, Coffee plant		Bonga
Vespertilionidae											
		Pip 50/52 [*Pipistrellus hesperidus*]					x	x		x	x
	Banana Pipistrelle	*Pipistrellus nanus/N. nana*					x²	x²	x²		x²
		Myo 28 [*Myotis bocagii*]				x		x	x		
		Myo 33 [*Myotis welwitschii*]	x	x		x		x			
		Myo 36 [*Myotis tricolor*]					x		x	x	
		S 30/32 [*Scotophilus dinganii or Scotophilus hirundo*]	x					x	x		
		S 36 [*Scotophilus hindei*]	x								
		# of species/site	14	4		7			22	6	9
		# of nights/site	1	1		1			3	1	3
		# of mistnets/site	3	2		3			6	1	3
		# of sound recording/site	3978	3	137	155	1280	1524	383	53	1574
				x1	confirmed by capture				[species]	not confirmed	
				x2	confirmed by echolocation calls						
				x3	not confirmed						

Legend: x1 confirmed by capture, x2 confirmed by echolocation calls, x3 not confirmed, [species] not confirmed

6.2. Photos

Figure 1: Mounting the mist net (photo: Ingrid Kaipf)

Figure 2: Stationary sound recording batcorder (photo: Ingrid Kaipf)

Figure 3: Map of bamboo forest study sites (Google Earth)

Figure 4: Stationary sound recording in the Bamboo forest (photo: Ingrid Kaipf)

Figure 5: Map of Boka Forest sample sites (Google Earth)

Figure 6: Stationary sound recording at the creek (BK) (photo: Ingrid Kaipf)

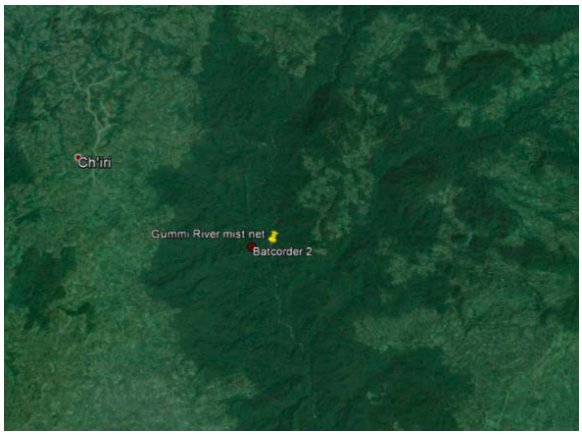


Figure 7: Map of Alemgono Wetland sample sites (Google Earth)

Figure 8: Mist net at Gummi River (photo: Ingrid Kaipf)

Figure 9: Map of Gojeb Wetland sample sites (Google Earth)

Figure 10: Mist net on Gojeb River Bridge (photo: Ingrid Kaipf)

Figure 11: Stationary sound recording at a forest fragment (photo: Ingrid Kaipf)

Figure 12: KDA Guesthouse sample site (Google Earth)

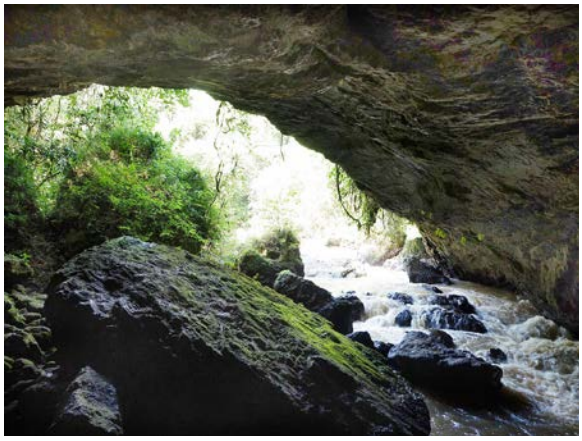


Figure 13: God's Bridge near Bonga (photo: Ingrid Kaipf)

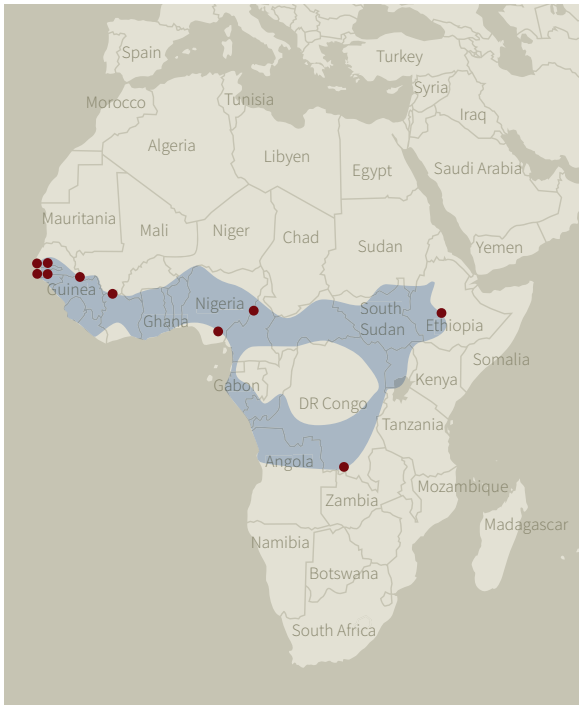
6.3. Confirmed fruit bat species and their distribution

Peter's dwarf epauletted fruit bat

Miniopteropus pusillus

Captured at: KDA Guesthouse

Figure 14: (photo: Holger Meinig)



Long-haired rousette / Mountain fruit bat

Rousettus lanosus

Captured at: Bamboo forest

Figure 15: (photo: Holger Meinig)

Egyptian fruit bat

Rousettus aegyptiacus (leachii)

Captured at: Gojeb Wetland

Figure 16: (photo: Holger Meinig)

Hammer-headed fruit bat

Hypsignathus monstrosus
Location: Alemgono Wetland, Gummi River
Acoustic confirmation: audible mating call

Figure 17: (photo: Jakob Fahr)

6.4. Captured bat species (distribution, echolocation calls)

Geoffroy's horseshoe bat

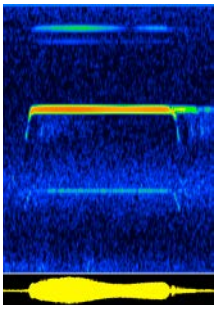
Rhinolophus clivosus (acrotis)
Captured at: Bamboo forest

Figure 18: (photo: Holger Meinig)

Echolocation

Sonagramm: (sound intensity color coded)

Long cf-signal at 92 kHz (female), sound duration 80 ms

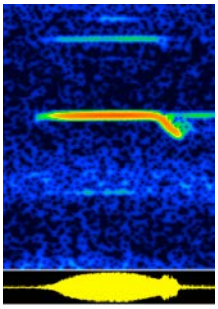


African trident bat

Triaenops afer

Captured at: Gojeb Wetland

Figure 19: (photo: Ingrid Kaipf)



Echolocation

Short cf signal
86 kHz female/
76 kHz male

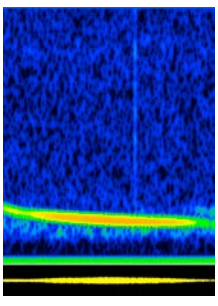
Sound duration 8 ms

Chapin's free-tailed bat

Chaerephon chapini

Captured at: Gojeb Wetland

Figure 20: (photo: Holger Meinig)



Echolocation

Long quasi-cf calls
end-freq. 20 kHz

Sound duration 8 ms

Nycteridae

Nycteris hispida

Location: Alemgono Wetland, Gummi River

Figure 21: (photo: Ingrid Kaipf)

Pipistrellus / *Neoromica* sp. 1

Species not confirmed yet

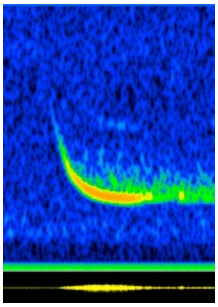
Captured at: Bamboo forest

Figure 22: (photo: Holger Meinig)

Echolocation

fm cf call, cf
frequency 39 kHz

Sound duration 4.5 ms



Pipistrellus / Neoromica sp. 2
Species not confirmed yet
Captured at: Bamboo forest

Figure 23: (photo: Holger Meinig)

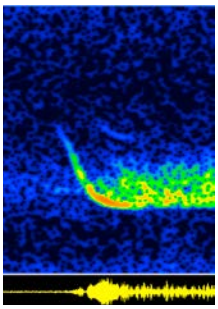
150 kHZ

Echolocation

Fm cf call, cf
frequency 37 kHz

Sound duration 3.5 ms

0 kHZ



6.5. Acoustic confirmed bat species (sonogram of echolocation calls)

Noack's roundleaf bat
Hipposideros ruber
Recorded at: God's Bridge
Acoustic confirmation: short cf signal

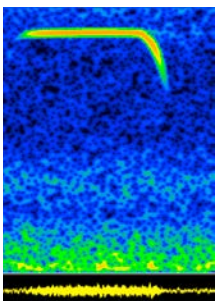
Acoustic confirmation

150 kHZ

cf frequency at
135 kHz

Sound duration 8 ms

0 kHZ



Large-eared free-tailed bat

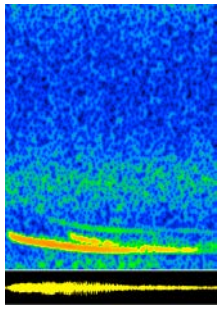
Otomops martiensseni

Recorded at: Gojeb Wetland

Acoustic confirmation

Long quasi cf signals at 9 kHz

Sound duration 10 ms



African giant free-tailed bat

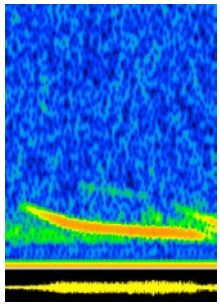
Tadarida ventralis

Recorded at: Gojeb Wetland

Acoustic confirmation

Long quasi cf fm signal 18 kHz

Sound duration 11 ms



Banana pipistrelle

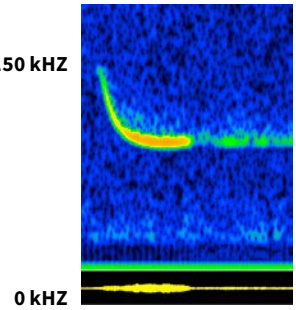
Pipistrellus nanus

Recorded at: KDA Guesthouse, Gojeb Wetland

Acoustic confirmation

fm cf signals
cf frequency at 71 kHz

Sound duration 5 ms



Smithers's horseshoe bat?

Rhinolophus smithersi? or a new species

Recorded at: God's Bridge

Acoustic confirmation

Long cf signal at
46kHz

Sound duration 45 ms