NABU's Biodiversity Assessment at the Kafa Biosphere Reserve

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NABU's Biodiversity Assessment at the Kafa Biosphere Reserve

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Organisational Profile

For 117 years, NABU (The Nature and Biodiversity Conservation Union) has promoted the interests of people and nature, drawing on its unwavering commitment, specialised expertise and the backing of its 600,000 members and supporters. Its members, among them 37,000 volunteers, are organised across more than 2,000 local groups and 15 federal associations.

The NGO, the largest of its kind in Germany, has clearly defined aims: providing environmental education, preserving habitat and species biodiversity, promoting sustainable agriculture, forestry and water management and enhancing the profile of nature conservation within society. NABU's work also includes combating global warming, promoting species conservation, providing sustainable policy on settlement, transport infrastructure and waste and protecting consumers. NABU headquarters' permanent staffs of around 160 people work in Berlin to represent environmental interests on a national and international level. A further 40 employees work in visitor centres, research institutes and project offices. NABU runs project offices in several countries in Africa, Central Asia and The Caucasus and has a permanent representative in Brussels. Africa, Asia and The Caucasus form the geographical focus of NABU's international commitment. NABU's work combines ecological and social efforts ranging from protecting the climate, conserving habitat and species diversity and promoting ecotourism and environmental education to building capacity, alleviating poverty and strengthening civil society.

NABU is the German partner of BirdLife International and supports partner organisations around the world. Together with its national partners and local and national stakeholders, NABU supports activities to conserve natural heritage. NABU is and experienced partner in this field, widely sought after by developmental aid organisations, government ministries and business.

In 2009, NABU founded the 'NABU International Foundation for Nature' to support NABU's international projects.

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We would like to express our thanks to the international team of Ethiopian, German and Dutch volunteer experts who participated in the fieldwork, contributed to the assessment and produced excellent reports. Sincere thanks go to Dr Juan Carlos Montero, who acted as the team leader on behalf of NABU, for planning and conducting the assessment and compiling the reports. In addition, we would like to thank the students, volunteers and many local supporters for making this assessment a success. Local guides, translators and assistants provided crucial support in the field, as did the NABU logistics team composed of the Project Office Bonga and Headquarters Berlin. The Kafa Development Association (KDA) Guesthouse hosted most of the participants and served as permanent headquarters for the assessment.

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Executive Summary

From December 3rd to December 13th 2014, NABU conducted an biodiversity assessment at the Ethiopian Kafa Biosphere Reserve (BR). A multidisciplinary team of 18 international and 12 Ethiopian experts supported by 23 local field guides carried out intense field work at selected sites at the Kafa BR.

The goal of the assessment was to specify and verify flora and fauna assessments, which have previously been conducted in the Kafa Zone, record and list species, identify indicator and flagship species and determine their threat status. This report presents the results from the **first in-depth assessment of biodiversity ever conducted in the Kafa BR**. By highlighting the main findings for various taxa, namely plants, birds, mammals, insects, amphibians, molluscs and fungi, this report is a major step forward in verifying and significantly expanding existing knowledge about species, their habitats and their major threats in the Kafa BR. By identifying indicator and flagship species, the biodiversity assessment establishes the basis for regular monitoring of the biodiversity in the Kafa BR, complementing the already established forest and carbon monitoring schemes.

Overall, the biodiversity assessment found **high biological diversity in the Kafa BR**, reflected by both high diversity at the habitat level and by species per habitat. The investigated habitats exhibit high heterogeneity, despite being only a short distance from each other. Particularly outstanding is the record of **approximately 50 species which are new to science or recorded for Kafa area for the first time**. Some of these are still under taxonomic analysis for final confirmation. The species comprise three fungi species (*Ascocoryne kafai* ined., *Cerinomyces bambusicola* ined., *Coniolepiota kombaensis* ined.), one mollusk species (*Pisidium* sp.), one species of Hyperoliidae (genus *Leptopelis*), two beetle species (*Pachysternum* sp. nov. *Tachinoplesius schoelleri* Schülke 2016), four fly species (family Diopsidae), one bee species (genus *Colletes*) and one species of *Rhinolophus* from the horseshoe bat family. At least further 40 insect species species new to science are to be expected.

Another remarkable result is the **extremely high rate of endemism** found in the Kafa BR. Most of the assessed taxa consist of about 30% endemic species, which were found in the area despite the extremely short timeframe of the fieldwork. This high degree of endemism can be explained by the area's vast and isolated highlands surrounded by dry lowlands, along with its geological and tectonic history. The high diversity at both the habitat and species level, the heterogeneity of the landscapes and the exceptionally high rate of endemism combine to make **Kafa BR an exceptional area for biodiversity protection**.

Based on expert knowledge and the subsequent analysis of the results, **29 indicator species and 17 flagship species** were selected from the recorded species. 13 out of 17 flagship species also serve as indicator species. Of the 29 indicator species, 15 were found for Afromontane, bamboo and floodplain forests (five trees, three birds, two tree frogs, two bats, two fungi and one primate) and 14 are indicators for wetland and river areas (nine birds, four insects and one mollusc). **Deforestation was assumed to be the major threat** for both indicator and flagship species occurring in forest areas, followed by habitat fragmentation and forest/habitat degradation. For river and wetland areas, **drainage activities**, **agricultural run-offs**, **fertiliser and domestic and urban waste** are identified as key threats to biodiversity. Further research is needed to specify and quantify these threats.

Some idea for practical conservation and monitoring action can be derived from the analysis of indicator and flagship species and their threats. We suggest establishing a monitoring system based on three components: **a) monitoring indicator species, b) monitoring threats, forest and land use and c) monitoring sites**. Monitoring at the species level should provide data on the abundance of each of the indicator species' in the Kafa BR. In addition, remote sensing techniques for deforestation, deteriorating activities such as fuelwood collection or fertiliser use should be applied as part of monitoring threats to biodiversity. Site monitoring should be based on a comparative and long-term analysis of the sites that were already investigated in this biodiversity assessment. More sites can be added over time. Rangers can perform this site monitoring with the support of local land users.

Basic conservation measures such as controlling the restrictions imposed on the different protection zones of the BR should be complemented by **threat-based conservation activities** such as promoting agro-forestry, improving cultivation techniques to avoid further expansion of agricultural areas, raising awareness of possible alternative tree species for fuelwood and timber and the promoting efficient cooking stoves. All such measures need to be planned and implemented by the local communities and facilitated through **participatory methods** for joint planning of conservation and sustainable livelihoods.

The biodiversity assessment is part of NABU's project 'Biodiversity under Climate Change: Community-Based Conservation, Management and Development Concepts for the Wild Coffee Forests' (2014-2017). This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.

Background and summary of findings

Juan Carlos Montero with contribution by Svane Bender-Kaphengst

1. Introduction

From the 3rd to the 13th of December 2014, NABU coordinated the biodiversity assessment at the Kafa Biosphere Reserve (BR). For this period, a team of 18 international and 12 Ethiopian experts supported by 23 local field guides conducted extensive field work on various taxa. The assessment was part of the NABU project ‘Biodiversity under Climate Change: Community-Based Conservation, Management and Development Concepts for the Wild Coffee Forests‘.

This report presents the results from the first in-depth assessment of biodiversity ever conducted in the Kafa BR. In highlighting the main findings for various taxa (amphibians, birds, fungi, insects, molluscs, mammals and plants), the report is a major step in verifying and significantly expanding existing knowledge about species, their habitats and their major threats in the Kafa BR. By identifying indicator and flagship species, this biodiversity assessment establishes the basis for regular monitoring of the biodiversity in the Kafa BR, complementing the already established forest and carbon monitoring schemes.

The report is structured as follows:

The introduction outlines the objectives of the assessment and its role and merits for NABU’s work in the Kafa region. It is followed by a description of the research area (Chapter 2). The analytical framework of the biodiversity assessment is outlined in the methodology section (Chapter 3). Chapter 4 highlights the overall results of the assessment, including the main findings of the individual taxa assessments, the recommended indicator and flagship species and the main threats to biodiversity. Chapter 5 summarises the key results and presents recommendations on future monitoring and conservation measures in the Kafa BR.

1.1 Objectives of the biodiversity assessment

The Kafa BR in southwest Ethiopia (SNNPR, Southern Nations, Nationalities and Peoples‘ Region) combines a distinctive richness of culture and biodiversity, which is unique among paleotropical regions. Kafa is located in the most ethnically and linguistically diverse region in Ethiopia and is also home of the last surviving cloud montane forests where the wild coffee tree with more than 50 varieties can be found. The highly diverse fauna and flora occurring in complex habitats are of international conservation value and of economic value to the local communities. Existing studies of the region’s flora, fauna, biomass and biodiversity have documented a high diversity of species (e.g., 300 species of mammals including 14 carnivores and 8 primates, 300 bird species, 244 plant species and more than 110 tree species) (NABU 2014). Such studies have also detected a high degree of endemism and species which are endangered according to the IUCN Red List and Ethiopia and Eritrea’s Red Lists (Vivero et al. 2005). A “Rapid Biodiversity Assessment for Kafa” published by EWNHS in 2008 was the first report on a broader range of flora and fauna species. The assessment concluded that, in order to conserve the threatened biodiversity, changes to habitat structure and their effects on landscape function must be regularly assessed.

However, the immense local biodiversity is still inadequately documented. Taxa such as bats, amphibians, fungi and dragonflies have never been assessed. The numerous complex and significant rivers and wetlands have barely been explored. Similarly, a large part of the montane dense forests have only been partially investigated. At the same time, the natural richness of the Kafa BR is heavily threatened by deforestation, habitat fragmentation and degradation.

Therefore, the main goal of the biodiversity assessment was to create a reference base for regular biodiversity monitoring in the Kafa BR. To achieve this, a systematic and comprehensive assessment of the abundance and characteristics of different taxa was conducted.

Besides verifying, updating and increasing knowledge of the various organisms in the region, flagship and indicator species from different taxa were identified. Flagship species are charismatic species used in a socio-political context to attract public attention and funding for larger environmental objectives, while indicator species are used to assess the magnitude of anthropogenic disturbances or to monitor population trends for a wider range of species (see Groves 2003). In the field, the experts tried to collect as much data on flora and fauna as possible in the available timespan, covering a great variety of habitats.

In summary, the goals of the assessment were:

- To verify and substantially increase knowledge of selected taxa of flora and fauna
- To identify indicator and flagship species as target species for monitoring and conservation
- To make recommendations for future conservation and monitoring

All the data on biodiversity will be incorporated into the existing forest and carbon monitoring schemes by NABU’s partner Wageningen University until end of 2016 the latest.

1.2 NABU's work in Kafa

NABU has supported people and nature in Ethiopia for more than 12 years. In close cooperation with NABU's Ethiopian BirdLife partner Ethiopian Wildlife and Natural History Society (EWNHS), small scale environmental education projects were started and endangered birds such as the common crane (*Grus grus*) are regularly monitored. This cooperation also involves livelihood support projects for local communities. From 2006 to 2010, NABU supported the development of Kafa BR from application up to recognition by UNESCO in a public-private partnership (PPP) project with other German partners such as DSW, GIZ, GEO Rainforest Conservation and Original Food. Due to its expertise, NABU supervised the development of a UNESCO biosphere reserve in Kafa. The concept opened new opportunities to the region and to the country as a whole: untouched core zones of nature, surrounding buffer zones and a large development zone, would offer room for conservation, research and development. After an official consultation at regional and community level, planning workshops were held and governmental staff became trained. Subsequently, "demarcation committees" were nominated and a time-consuming resource mapping with all affected local communities was conducted. When all stakeholders had agreed upon a zoning scheme, the actual demarcation work could be started. Incredibly, the process of zoning the biosphere reserve area with the aim of establishing an appropriate management scheme and ensuring the protection of the forests, took place with the support and involvement of more than 500 representatives of the region.

After the successful establishment of Kafa BR, NABU, the Ministry of Science and Technology (MoST) of the Federal Democratic Republic of Ethiopia and UNESCO signed a memorandum of understanding to establish further biosphere reserves in Ethiopia. In 2010, the Kafa BR was recognised by UNESCO as one of the first biosphere reserves in Ethiopia. To invigorate the Kafa BR, NABU expanded its activities in the region, including establishing an effective administration and increasing information campaigns and public relations in the reserve. Moreover, in 2009, NABU initiated a four-year project on "Climate Protection and Preservation of Primary Forests" funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) within the framework of the International Climate Initiative. According to Bender-Kaphengst (2011), the project supported the reforestation of 700 ha of natural forest with native tree species and the planting of 1,500 ha of fast growing trees in community forests next to the villages to ensure the population's wood supply. Furthermore, 10,000 wood-saving stoves were introduced in selected communities to reduce the communities' reliance on the forest resources. About 10,000 ha of natural forest were jointly identified by the Kafa Zone and the Kafa BR management following the principles of sustainable PFM. Tourist infrastructure such as hiking trails, wildlife and bird watching towers and a historical outdoor museum were built and locals were trained as guides. After the successful completion of the project, NABU continued its work at the Kafa BR with another three years project.

This follow-up project aims to conserve and restore the Afromontane cloud forests and wetlands in order to preserve the ecosystem's resilience and unique biodiversity. It also intends to avoid carbon dioxide emissions and secure ecosystem services for the local population. In collaboration with the local population, ecosystems will be explored and restored (e.g. reforestation, restoration of catchment areas), secured (e.g. real-time monitoring, rangers) and transferred to sustainable, participatory community management. In order to simultaneously create awareness for the effects of global warming on biodiversity and in order to promote regional development, targeted development programmes for crafts, ecotourism and regional products as well as educational programs for children and youths and energy-efficient stoves will be introduced. The project supports the implementation of Ethiopia's Climate-Resilient Green Economy Strategy, ties climate and biodiversity conservation to regional development and helps the local population to independently ensure the long-term conservation of nature and natural resources as basis of their livelihood. The biodiversity assessment is part of this project.

More information at:

www.kafa-biodiversity.com

www.international-climate-initiative.com/en/projects/projects/details/365/

2. Physical and Cultural Context of the Research Area

2.1 Geomorphology

Ethiopia's geological and tectonic characteristics are strongly shaped by the Ethiopian magma dome and the development of the East African Rift system. The soils originate from rocks formed during the tertiary period and the subsequent geomorphic processes. They are characterised as deep, red, brown-grey and brown-clay soils. The Ethiopian magma dome, shaped by a series of volcanic activity and geological formation in the Precambrian, Paleozoic, Mesozoic, Tertiary and Cenozoic periods, forms the foundation of the Ethiopian Highland (Dennis Moss Partnership 2009). As a result of these complex geological processes, the Ethiopian landscape is very diverse, ranging from vast plains to Alpine-like mountain ranges. Sometimes referred to as the "Roof of Africa", the Ethiopian Highlands form the largest continuous area of its altitude in the whole continent, with little of its surface falling below 1500 meters above sea level (m a.s.l.) and peaks of up to 4550 m a.s.l. The Kafa Zone situated in the Western plateau of these highlands is located on the Tertiary layers, consisting mainly of sandstone and limestone, and of Tertiary volcanic rocks.

The topography of the study area is characterised by a complex system of highlands, steep valleys and large flatlands, which drops to the lowlands in the south. The area's altitude ranges from 500 m a.s.l. in the south to 3300 m a.s.l. in the northeast. This great variety of landforms is responsible for highly diverse climate, soil and vegetation. The most remarkable highlands include the Gurgura Mountains, Shonga Mountains, Yatana Mountains and Gola Mountains, along with Koma Summit and Saja Summit. The most extensive wetlands are the Alemgono and the Gojeb wetlands. Mountains and wetlands are connected by numerous fertile valleys and lowlands, which extend mostly through the central part of the biosphere reserve (Figure 1).

According to the soil map produced by the WBISPP (2004), the dominant soils in the Kafa Zone are dystric nitosols (Nd). Adiyo, the southwestern part of Telo and north and northwest of the Gewata woredas are dominated by orthic acrisols (Ao). In addition, eutric fluvisols (Je), chromic luvisols (Lc), chromic vertisols (Vc) and pellic vertisols (Vp) can be found in the Kafa BR to varying degrees (EWNHS 2008).

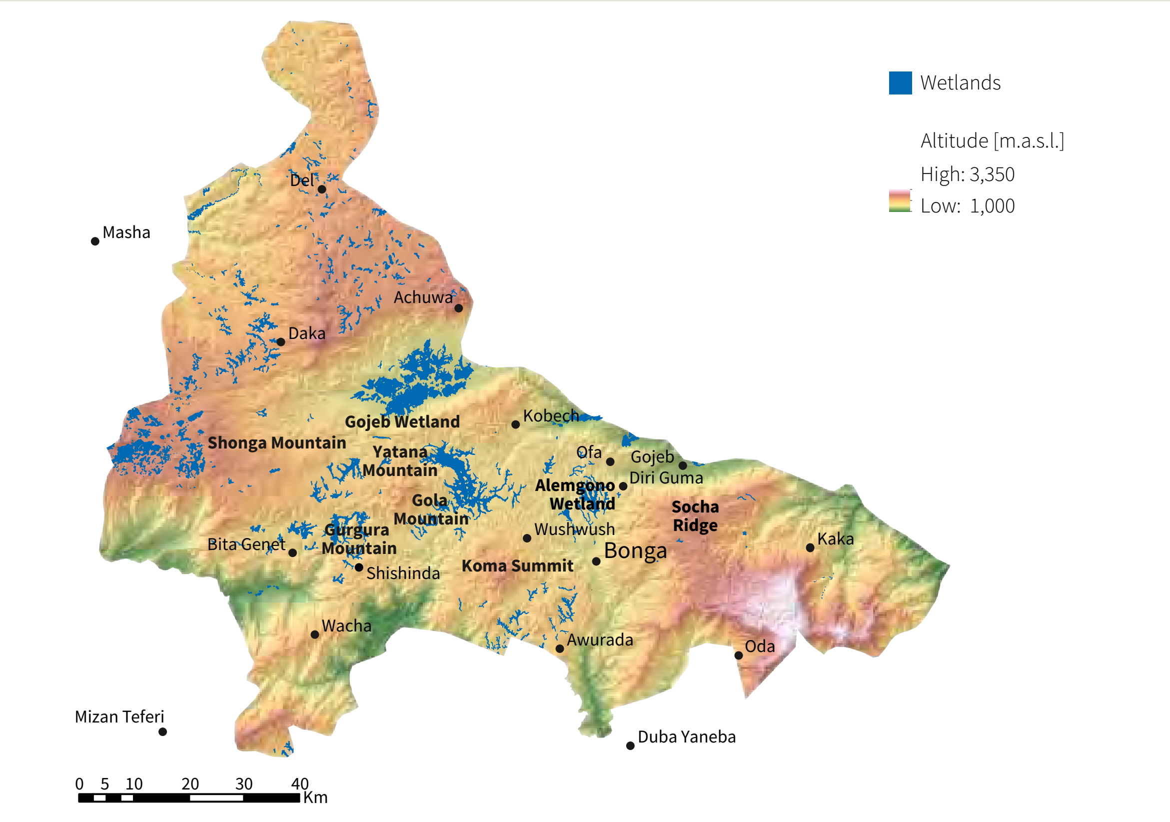

Figure 1: Topographic features of the Kafa Biosphere Reserve

2.2 Climate

In general, the climate is characterised by a bimodal rainfall pattern, with the main rainy season between June and September and a short rainy period from February to April. Kafa receives its rainfall from the Southwest monsoon, which reaches its maximum intensity during July and August. The average annual rainfall ranges from 1500 mm in the lowlands up to 2000 mm at the highest elevations (EWNHS 2008). Thus, the Kafa BR is in the most humid part of the country, with only two to four dry months in the year. According to Gamachu (1977), annual temperatures vary between 15 and 24°C. Due to the high variety of landscapes and altitudes within the Kafa BR, there are many microclimatic deviations from the usual rainfall patterns.

2.3 The Kafa Biosphere Reserve

The Kafa BR is located in the southwestern highland region of Ethiopia (Figure 2), in the Southern Nations, Nationalities and Peoples' Region (SNNPR). The Kafa Zone has a total area of around 10000 km² and a little over a million inhabitants.

According to a background study by Chernet (2008), the ethnic composition of the Kafa Zone is dominated by Kaffecho (81%), followed by Bench (6%), Amara (6%) and Oromo (2%). The remaining 5% also include marginalised groups like Manjo (Manja). The biggest religious group are Orthodox Christians (67%), followed by Protestants (20%) and Catholics (10%). There is also a small Muslim community (3%).

The overall population density of the Kafa BR is 98 inhabitants per km², ranging from 52 inhabitants per km² in the least densely populated woreda (Decha) to 210 inhabitants per km² in the most densely populated woreda (Chena). Subsistence farming plays a major role for local livelihoods. The people in the region mainly live from subsistence farming, the sale of wild coffee and the natural resources of their environment (e.g., forest, including food, burning/building materials, medicinal plants/spices, animal feed, honey). Over the centuries they have adapted their (land) use, traditions and customs to nature (NABU 2014). The most common livestock is cattle, followed by poultry, sheep and goats. Honey production (mainly using traditional techniques) and coffee cultivation are other important income sources (SNNPR 2013).

The region is characterised by Afromontane mountain cloud forests and rainforests, which contain wild *Coffea arabica*, bamboo forests, grasslands and shrublands (NABU 2014). Because of its relevance to national biodiversity and as catchment area, the Ethiopian government has put the area under partial national protection in the form of a Regional Forest Priority Area (RFPA). The area is particularly noteworthy for being the origin and centre of *Coffea arabica's* genetic diversity and therefore as a globally significant in situ gene bank (NABU 2014). The overall economic value of *Coffea Arabica* has been estimated at approximately 1.5 billion US$ (Hein & Gatzweiler 2006).

An outstanding event was the publication of photographic evidence of the African lion in 2012, documented in a rainforest for the first time (NABU 2014). Varied topography and high precipitation rates (2,000 mm annually) in an area of 26832 ha have led to a high diversity of wetlands. According to the Kafa Wetland Strategy (EthioWetland 2008), these include river margins, peatlands, riparian zones, extensive floodplains and alluvial plains, marshes/swamps as well as forest wetlands. They function as moisture and carbon reservoirs, and represent an important part of supraregional river basins (the rivers Gojeb/Omo, Baro-Akobo and others). Furthermore, they offer rare bird species (e.g., the Wattled Crane, Rouget's Rail) and large mammals (e.g., lions, Cape buffalos) the possibility to breed, retreat and feed. Species recordings have documented approximately 126 species of plants (e.g., *Cyperus latifolius*, *Anagallis serpens*), 106 species of birds and 21 species of mammals. Along with the forests, the aquatic habitats are the main suppliers of ecosystem services, and are used by the local population to produce water, food, animal feed, building materials and to generate income (e.g., medicinal plants, basketwork).

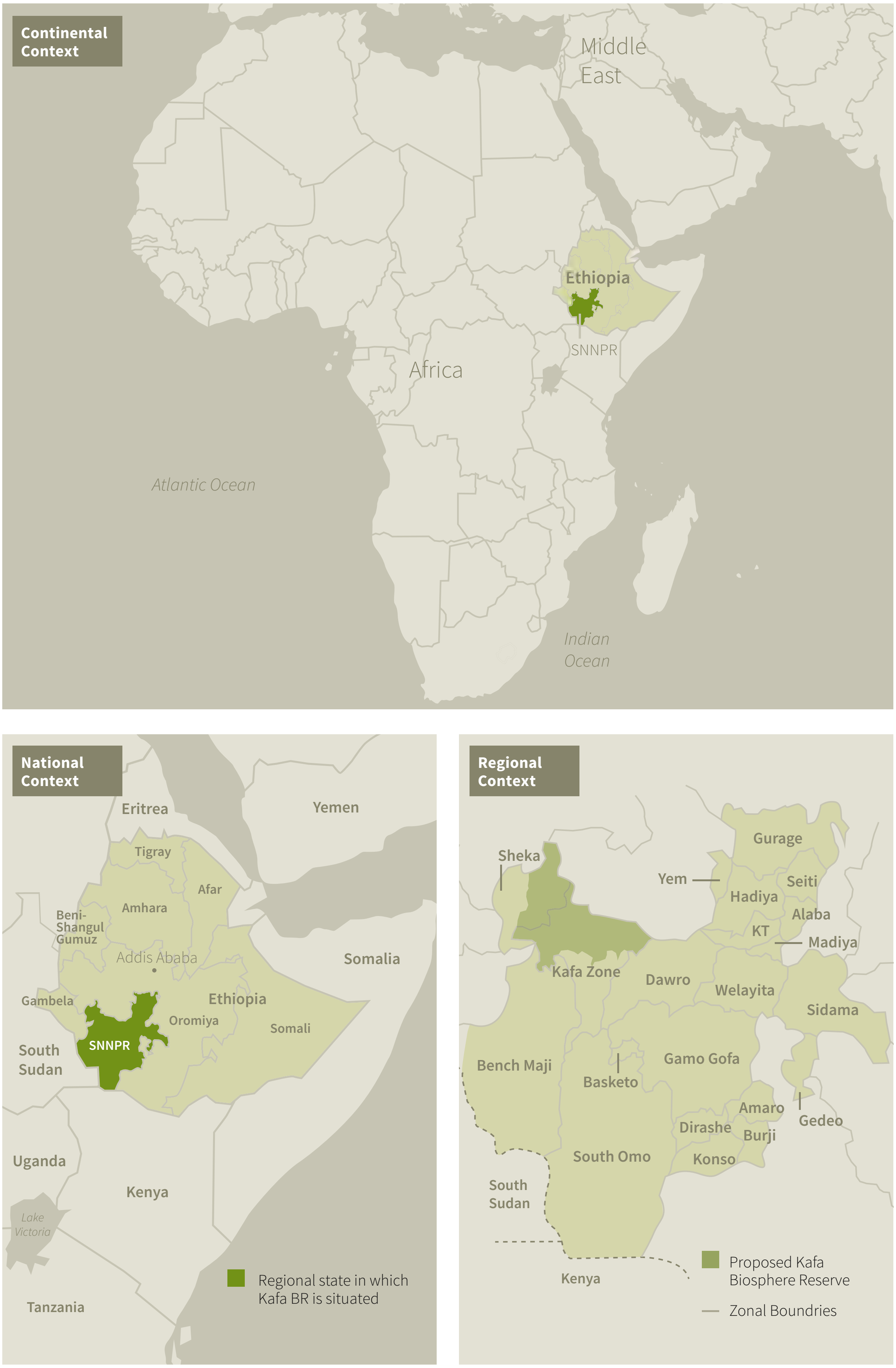

Figure 2: Location of the Kafa BR at a national and continental scale

Different political and demographic factors have driven changes in land use and land cover in the Kafa Zone. In the 1970s, major land redistribution occurred, followed by large-scale resettlement in the 1980s. The 1990s were shaped by the agricultural investment policy and the promotion of cereal production, along with the Ethiopian Forestry Action Plan. Finally, the 2000s were influenced by large-scale agricultural expansion, the establishment of National Forest Priority Areas, Participatory Forest Management (PFM) sites and ultimately the UNESCO biosphere reserve (Tadesse et al. 2014).

The Kafa BR covers an area of more than 7500 km², of which 47% is covered with forests. The average population density of the Kafa BR is 130.14 p/km². Administratively, the Kafa BR consists of ten woredas and 250 rural kebeles and 25 urban towns (SNNRP 2013).

Table 1 shows the distribution of the urban and rural population within the different kebeles and woredas in the Kafa BR. The data is based on one head counted per household, with males being the majority in most kebeles. The only exception is the woreda of Decha, in which females are the majority. This may be explained by the culture of the Kaffecho ethnic group who are mostly present in this woreda. A significant majority (>90%) of kebeles are in rural areas, while Gimbo woreda includes the most urban settlements.

Table 1: Distribution of rural and urban population in the woredas and kebeles of the Kafa BR (SNNPR 2013)

	Woreda	Number of kebeles			One head per household		
		Rural	Urban	Total	Male	Female	Total
1	Adiyo	27	1	28	13,205	1,294	14,499
2	Bita	24	1	25	11,599	877	12,476
3	Chena	42	2	44	18,360	3,302	21,662
4	Cheta	16	0	16	3,150	1,676	4,826
5	Decha	57	1	58	6,582	12,637	19,219
6	Gesha	24	1	25	11,675	2,457	14,132
7	Gewata	30	1	31	9,320	758	10,078
8	Gimbo	31	3	34	12,311	1,779	14,090
9	Saylem	21	1	22	6,375	866	7,241
10	Tello	24	1	25	6,024	5,412	11,436
11	Bonga	0	3	3	-	-	-
Total		**296**	**15**	**311**	**94,791**	**31,222**	**126,013**

Chena is the most densely populated woreda, with 210 habitants per km². This is followed by Tello, Gesha, Gimbo and Adiyo (159, 143, 129, and 121 habitants per km², respectively). Most of the core zones in the Kafa BR are located in these woredas, along with most of its characteristic habitats such as bamboo forests and wetlands.

Nevertheless, steady population growth, poverty, illegal immigration and agro-investment (e.g., tea, coffee) have led to an increasing pressure on the region's natural resources (NABU 2014). The transformation of forests and wetlands into agricultural land as well as selective clearing for timber and fire wood are leading to fragmentation, degradation and reduction of natural habitats. The illegal extraction of construction materials such as sand, stone and soil disturb ecosystems, and unsettled land use rights encourage overuse (overgrazing, clearing) and illegal land grabbing. At the same time, the effects of climate change are noticeable in form of irregular rainfalls, extreme weather events such as heavy rains or droughts, as well as the proliferation of pests. Especially Wild *Coffea arabica* is proven to be sensitive (Davis et al. 2012).

UNESCO biosphere reserves have the explicit purpose of reconciling people's needs with nature conservation. Thus, the aim is to bring ecological, social and economic factors together to create sustainable ways of living (Bridgewater 2002). In the Kafa BR, there are long traditions of using wild plants and animals for various purposes. However, traditional management techniques may no longer be sustainable due to pressures from population growth and resettlement programmes. New technologies and the economic interests of external actors have produced significant changes in land use management, with detrimental effects on biodiversity and ecosystem services. Preserving biodiversity requires new land management approaches and techniques. In this sense, it is essential to consider socio-cultural factors when developing feasible conservation strategies and management plans.

Successfully managing a biosphere reserve involves considering different interests and needs. This usually requires a high level of participation from local communities. However, others argue that as long as local people's needs are met, participation through consultation (no active participation) is sufficient (Wallner et al. 2007). In developing countries, external stakeholders with different cultural backgrounds are often involved in setting up biosphere reserves. Common ground must be identified in order to communicate and successfully collaborate with local stakeholders. Different socio-cultural backgrounds and their perceptions of conservation and livelihood strategies must be considered to gain a mutual understanding of key issues. In the case of the Kafa BR, local residents are mostly smallholders, and their perception of the landscape values can vary significantly (Gaston & Spicer 2013). A study by Wallner et al. (2007) shows that the main argument in favour of biosphere reserves is the potential economic benefits to locals. Local ecological knowledge is increasingly valued in wildlife conservation (Berkes et al. 2000).

As a biosphere reserve, the Kafa BR needs to adhere to the objectives of the UNESCO Man and Biosphere (MAB) programme. This is supported by the Seville Strategy for biosphere reserves, which includes the following as one of its principles: "Reinforce scientific research, monitoring, training and education in biosphere reserves, since conservation and rational use of resources in these areas require a sound base in the natural and social sciences as well as the humanities".[1]

More specifically, the Seville Strategy (1996a) recommends that individual biosphere reserves make inventories of fauna and flora [...] as the basis for sound site management and to develop a functional system of data management for rational use of research and monitoring. For the Kafa BR to maintain its UNESCO status, regular monitoring and assessment must be conducted. The Statutory Framework of the World Network of Biosphere Reserves (1996b) makes provision under Article 9 that "the status of each biosphere reserve should be subject to a periodic review every ten years, [...]. In order to meet the review criteria, regular research and monitoring intervals need to be carried out to gain a sufficient data base and to identify possible constraints early enough to adjust management and protection practice.

To this end, the biodiversity assessment is a centrepiece for achieving regional, national and international objectives in biodiversity conservation and management, and to adhere to the UNESCO standards for biosphere reserves.

The application document to UNESCO provides information on key functions, sizes and spatial configuration of the reserve, which is essential for management and projections (Table 3).

[1] See: http://www.unesco.org/mab/doc/brs/Strategy.pdf

Table 2: Zonation of Kafa BR showing main spatial features and functions (adapted from Dresen 2011)

BR Zones	Size (ha) and percentage	Forest area (ha)	Key functions	Priority for the biodiversity assessment
Core zone	28,172 (4%)	28,110	Serves as a refuge for various endemic and/or endangered species and provides opportunities for long- and short-term research and monitoring programmes, as well as non-consumptive use.	High
Candidate core zone	219,130 (28%)	174,482	Contains highly endangered habitats. Candidate core zones should be included into the core zones after feasibility assessment.	Medium to high
Buffer zone	161,351 (22%)	87,487	Connects conservation areas that have been isolated by human activities. Buffer zones should encourage a symbiotic relationship between conservation and nature-related economic activities.	Medium
Transition zone	336,069 (46%)	61,560	Enhances environmental integrity or rehabilitation of unused farmland and plantations. Used to restore and preserve sites and/or features of historical and cultural significance.	Low
Total	**744,919 (100%)**	**35,639**		

2.4 Main types of habitat and vegetation in the Kafa Biosphere Reserve

The Kafa BR is home to the last surviving moist evergreen montane forests in the eastern Afromontane biodiversity hotspot (Mittermeier et al. 2004). The area is also recognised as a key biodiversity area. The wild coffee tree, *Coffea arabica*, is indigenous to the understorey of Kafa's natural Afromontane forest. In some areas it is harvested without standardised management. In other areas, designated as PFM sites, the wild coffee is harvested in forest fragments, where farmers cut and thin out parts of the upper canopy and annually slash the forest understorey. This form of forest use is known to be structurally sustainable for the natural forest vegetation. However, it must still be evaluated to what extent PFM sites are also degrading, as the understorey slashing can hamper regeneration.

According to the IBC (2005), there are five main habitat types in the Kafa Zone:

1) **Evergreen montane forest and grassland complex**: This complex habitat occurs between altitudes of 1900 and 3300 m a.s.l. and covers 52% of the BR. It includes much of the highlands located within the proposed buffer area of the BR. This habitat occurs in areas which are often densely populated, leading to pressures from expansion of arable land.

2) **Moist evergreen montane forest**: This habitat occurs between 1500 and 2600 m a.s.l. and covers 26% of the BR. This type of forest is of global conservation significance due to the occurrence of wild *Coffea arabica*. In addition to deforestation for arable land, timber extraction is a major threat to this habitat (Figure 6).

3) **Wetlands**: A complex system of wetland habitats occurs between 900 and 2600 m a.s.l. covering 6.6% of the BR. These sensitive ecosystems are of utmost importance for the local communities, for example in providing materials for building shelter, for grazing and freshwater supply. At the same time wetlands are also increasingly under pressure due to intense grazing and other land uses.

4) **Combretum-Terminalia woodland**: IBC (2005) has classified some areas of the Kafa BR as Combretum-Terminalia woodland, which were later corrected to bamboo forests by Dresen (2014). Figure 3 shows the older classification (light green), while Figure 4 displays the habitat types distinguished in a land use/land cover map in 2014.

5) **Sub-Afroalpine habitat**: This habitat occurs at altitudes higher than 3200 m a.s.l. and covers only 0.3% of the total BR. This vegetation type is under severe threat due to agricultural expansion. Indigenous tree species such as *Hagenia abyssinica* are under high pressure.

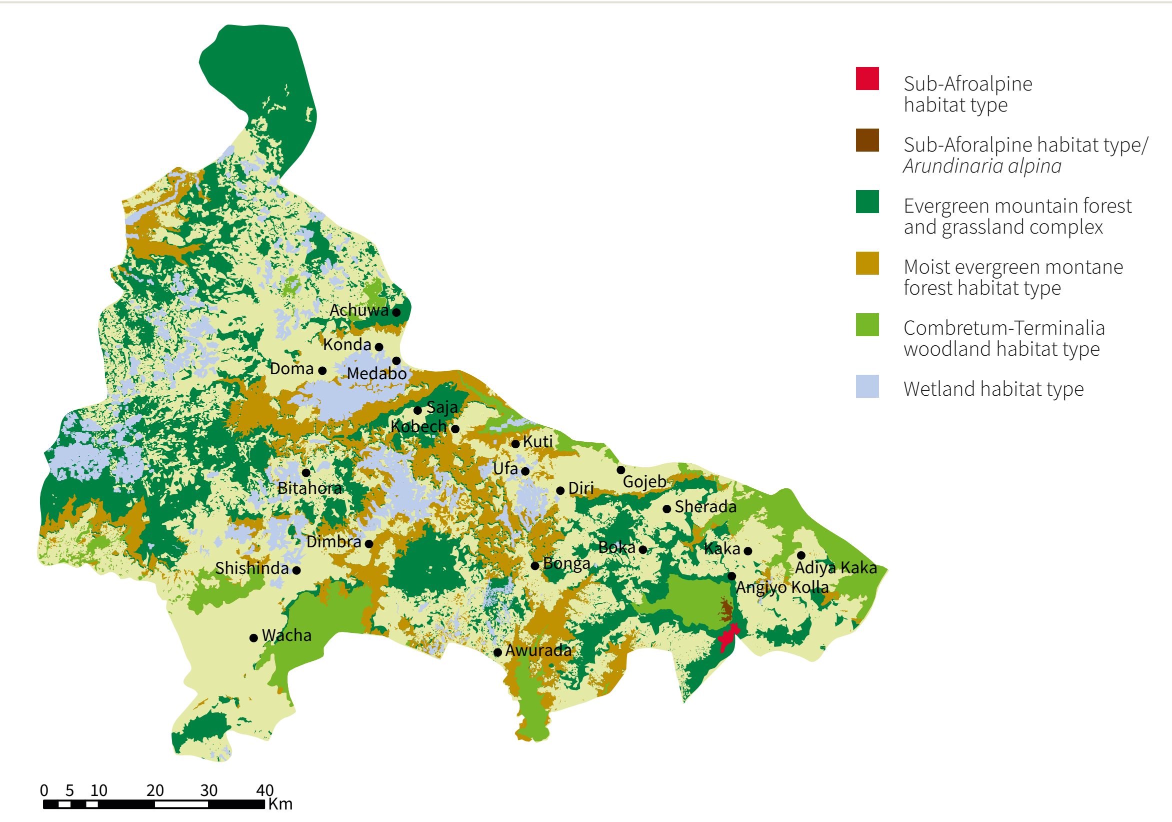

Figure 3: Habitat types in the Kafa BR as classified by the Institute of Biodiversity Conservation (IBC 2005), adapted by Dresen (2014)

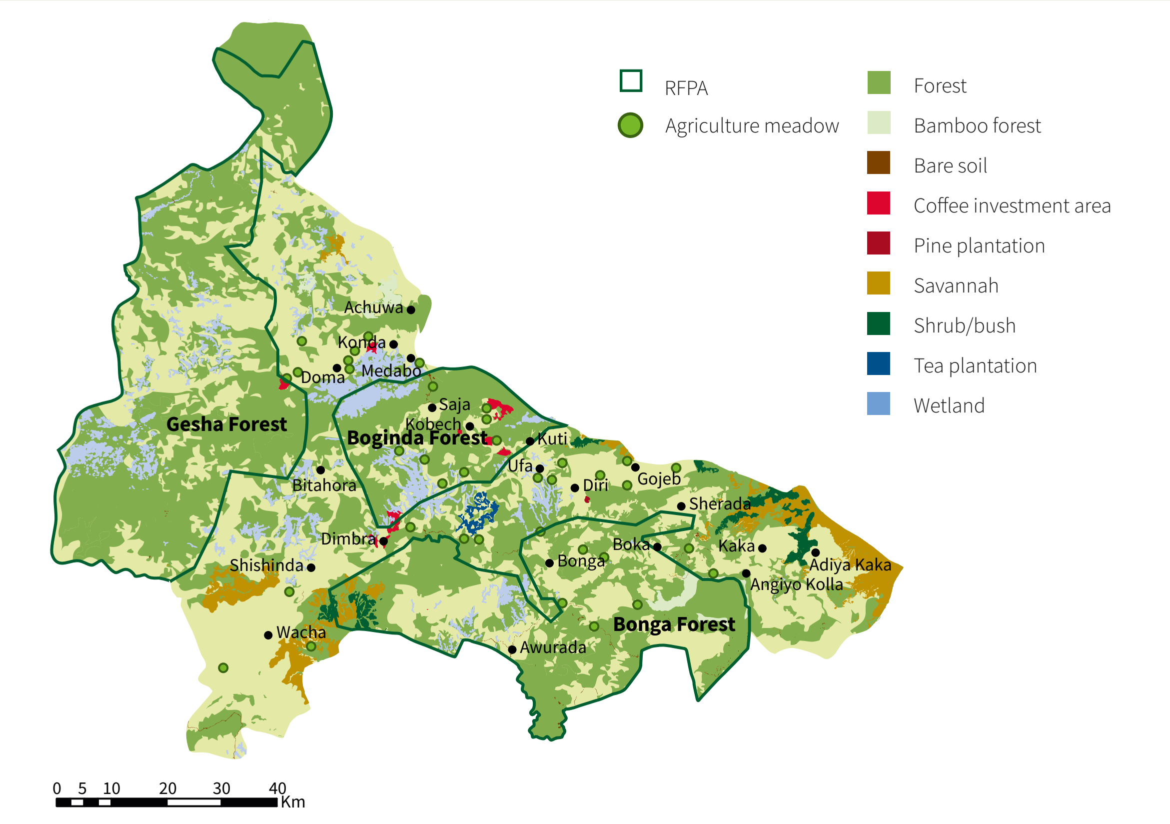

Figure 4: Regional Forest Priority Areas according to Million & Leykun (2001) (red lines) projected on land use and land cover at the Kafa BR, adapted by Dresen (2014)

The few existing vegetation studies conducted in the Kafa BR mainly concentrate on the PFM sites with *Coffea arabica*, analysing the undergrowth in disturbed habitats (Aerts et al. 2011; Denich & Schmitt 2006; Gobeze et al. 2009; Schmitt et al. 2009; Tadesse et al. 2014a, 2014b). These studies conclude that anthropogenic effects often lead to homogenisation of natural vegetation. In the biodiversity assessment, we therefore compared species composition between disturbed habitats (PFM sites) and undisturbed habitats (such as primary forests in the BR core zones).

A rapid biodiversity assessment in the Kafa Zone in 2007 recorded a total of 244 plants species in the three forest sites, representing 77 families. Of the 244 species recorded, 26.6% were trees, 27.9% were shrubs, 27.5% were herbs, 8.6% were climbers, 2.9% were epiphytes and 1.2% were grasses. The most abundant species in the Saja forest are *Oxanthus speciosus*, *Dracaena fragrans* and *Macaranga capensis*. The most abundant species in the Mankira forest are *Dracaena fragrans*, *Coffea arabica* and *Chionanthus mildbraedii*. In the Boka forest, bamboo (*Arundinaria alpina*) and *Schefflera volkensii* are dominant, with some understorey shrubs and herbs (EWNHS 2008).

A survey of three areas in Kafa BR (EWNHS 2008) classified 7 major land uses. The floristic inventories mainly focused on forested areas. Using transects and quadrates as sampling methods, the assessment recorded about 92 tree/shrub/liana species with a diameter of more than 10 cm at breast height across the three study sites. The Bonga area was the richest site with 70 species, followed by Boginda with 54 species and Mankira with 46 species. Bonga forest has the highest density of trees with a diameter of more than 10 cm followed by Boginda forest and Mankira forest (Nune 2008). The floristic composition of three sampled sites shows high heterogeneity of habitats. This is revealed by the lack of species shared by all three forest sites, indicating that each forest has a heterogeneous species composition. The most prevalent species are *Croton macrostachyus* in Mankira and *Millettia ferruginea* in Bonga and Boginda Forest. No single tree or shrub species was found in every sample plot across all three study sites, despite being separated by only a few kilometres (Nune 2008). These results highlight the high diversity of habitats in the Kafa BR. This study also found heavy exploitation of *Cordia africana*, *Pouteria adolfi-friederici* and *Prunus africana*, which are reported as endangered species.

Figure 5: Major habitat types in the Kafa BR: bamboo forest (photo: Juan Carlos Montero)

Figure 6: Major habitat types in the Kafa BR: bamboo forests (photo: Juan Carlos Montero)

Figure 7: Major habitat types in the Kafa BR: dense montane rain forests (photo: Anna Leßmeister)

Figure 8: Major habitat types in the Kafa BR montane rain forests (photo: Bruno D'Amicis)

Figure 9: Major habitat types in the Kafa BR: large wetlands and flood plains at Alemgono (photo: Juan Carlos Montero)

Figure 10: Major habitat types in the Kafa BR: large wetlands and flood plains at Alemgono (photo: Juan Carlos Montero)

Figure 11: Riverine vegetation at Gojeb River (photo: Juan Carlos Montero)

Figure 12: Riverine vegetation at Gummi River (photo: Juan Carlos Montero)

3. Methodological Approach

A great deal of complex administration was required prior to conducting the fieldwork to ensure compliance with Ethiopian law. The biodiversity assessment was conducted in close cooperation with the relevant Ethiopian authorities and research institutions, with agreements to use and share the information gained from the assessment.

In total, 18 international experts (17 Germans, 1 Dutch) and 12 Ethiopian experts were involved in the assessment. Among the Ethiopian experts, two were delegates of the Ethiopian Biodiversity Institute (EBI). The experts were assembled into seven different teams based on different taxa:

- Vascular plants (four Ethiopian, one German, one EBI delegate),
- Birds (four Germans, one Ethiopian),
- Insects (three Germans, three Ethiopian),
- Mammals (six Germans, one Dutch, one Ethiopian, one EBI delegate),
- Fungi (one German),
- Molluscs (one German), and
- Amphibian/reptiles (one German).

The names, contact information and current affiliations of each expert are provided in the participants section at the beginning of this report. The experts were supported by 23 local field guides and translators. Sampling sites were selected based on invaluable input from NABU staff like the Kafa BR rangers. Logistics and organisational support was provided by staff from NABU Headquarters Germany and NABU Ethiopia, along with 16 pick-ups and their drivers. In total, 80 people were involved in the assessment. The headquarters of the operation was at the KDA Guesthouse in Bonga.

3.1 Sampling site selection

Sampling sites were selected based on ecological parameters and the core objectives of the assessment. Thus, the most important criteria were:

(a) the presence and location of core and candidate core zones,
(b) access to the sites (e.g., distance from Bonga, road condition) and
(c) the presence of variable habitat types.

Areas were selected based on the regional forest priority areas in the Kafa BR proposed by Million & Leykun (2001), which consist of Bonga, Boginda and Gesha Forests (Figure 13). While Bonga and Boginda met the three selection criteria, Gesha Forest was too far from the operation headquarters.

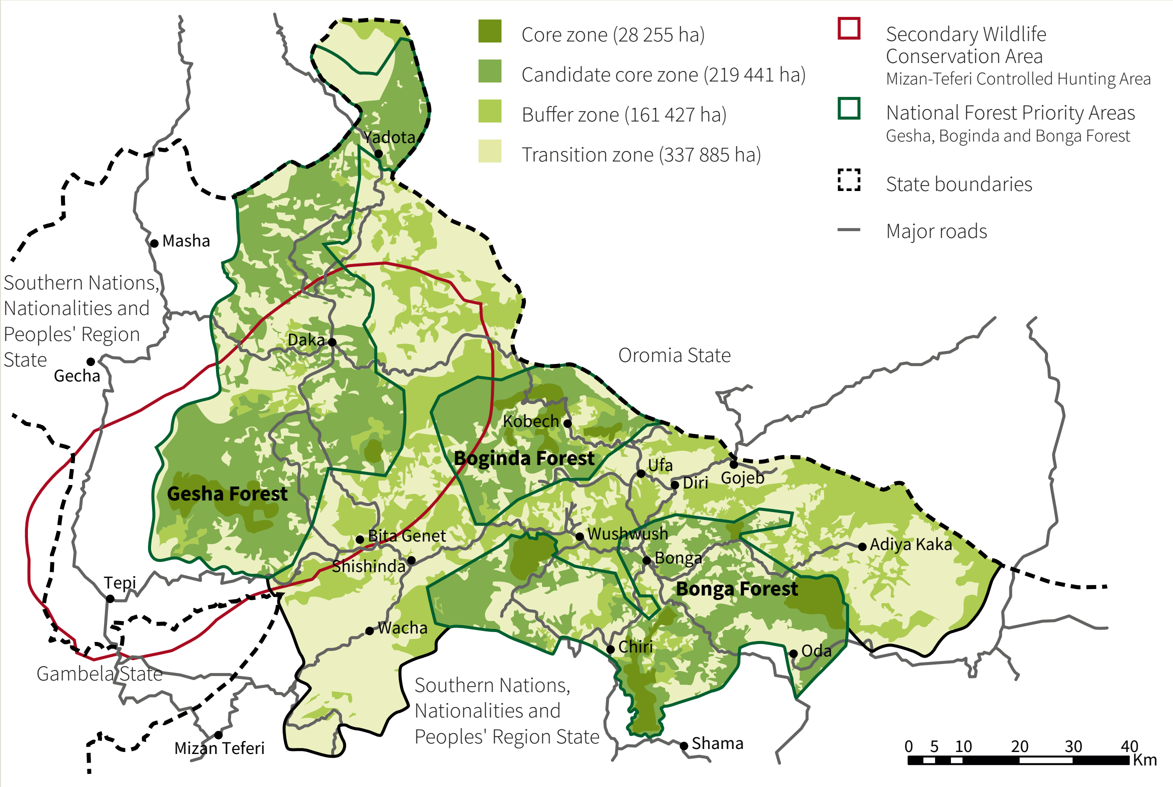

Figure 13: Regional forest priority areas within Kafa BR, showing the Bonga, Boginda and Gesha Forests (NABU 2016)

Table 3: Study areas priorities

Area	Total area (ha)	BR zones	Altitudinal range (m a.s.l.)	Priority
Afromontane forests	107393	Core/candidate core	1500-2600	High
Wetlands				
Floodplain forests	26832	Candidate and buffer	900-2600	High
Bamboo forests	ca. 10000	Core	2400-3050	High
Participatory Forest Management (PFM) sites	10000-15000	Candidate core	1500-2600	Medium to low

The chosen study sites can be further divided into those which are of particular ecological importance due to having near-to-intact forest ecosystems and those which are regularly used by humans, most importantly the PFM sites. These two types of area include different habitats, which are further specified below:

3.1.1 Areas of particular ecological importance

1.1 Bamboo forests: This extensive and unique vegetation in the Kafa BR occurs at altitudes between 2400-3050 m a.s.l. and is characterised by bamboo undergrowth either in pure stands or mixed with trees, including *Hagenia abyssinica*, *Myrsine melanophloeos* and *Hypericum revolutum* (Bekele 2003). A huge and unique patch is located in Adiyo woreda at the Eastern part of the Kafa BR.

1.2 Afromontane forests: These are characterised by dense vegetation, a complex understorey and distinctive tree layers where the emergent trees reach heights of around 25 m. They occur in hilly areas, shaped by depressions, streams and creeks. Along their altitudinal gradient, these forest areas are divided into two types:

a) Evergreen montane forest. This type of vegetation occurs between altitudes of 1900 to 3300 m a.s.l. and covers 52.1% of the Kafa BR

b) Moist evergreen montane forest: This habitat occurs between 1500 and 2600 m a.s.l. and covers 26% of the Kafa BR. This type of forest is of global conservation importance due to the presence of wild *Coffea arabica*.

Most previous inventories were conducted in the moist evergreen montane forests. For this assessment, the following woredas were selected:
- Decha, Tello, Gimbo and Chena in the Bonga Forest.
- Gawata in the Boginda Forest.

1.3 Wetlands: Based on NABU project activities on wetland restoration and community-based management, Alemgono and Gojeb Wetlands were selected for the assessment, along with the Shoriri Wetland. These habitats are complex systems mostly composed of flooded savannahs, forested islands and border zones which are inundated by an average water level of 30-60 cm for about three months of the year.

1.4 Floodplain forests-riverine areas: The study sites also included two areas which are periodically flooded by the Gummi and Gojeb Rivers. These floodplains are temporarily inundated during the rainy season from June to September, but flash floods also occur in the montane rainforest areas. In both cases the inundation period is comparably short (less than a month) and the water level oscillates between 30 cm and 1 m.

3.1.2 PFM sites

PFM sites were first established in Kafa in 2002. While PFM involves state forest departments to a certain extent, it ascribes particular relevance to local communities, their knowledge and their key role as forest managers. To date, Kafa has approximately 15000 ha of PFM sites with about 12000 members. The sites are mainly distributed across the montane forests (see above) of the Gawata, Decha and Gimbo woredas (Dresen 2011). These areas are spread throughout the Kafa BR.

Three areas were chosen for the assessment:
1. The Ufa PFM site, which covers around 1,200 ha and has 602 members. It is located in Decha woreda and forms a transition to the floodplain area formed by the Gummi River.

2. The Keja-Araba PFM site, which covers around 1,470 ha and has 620 members.

3. The Beta Chega PFM sites, for which no specific information is available.

11 sampling sites were selected among the different habitats outlined above. The sites are listed in Table 4. Each area was assigned a code for standardisation and data interpretation purposes. From these 11 sites, each working team chose the most suitable and effective sites for their sampling methods and assessments (further details can be found in the individual taxa reports).

Table 4: Sampling areas of NABU's biodiversity assessment at Kafa BR

Area	Site	Code	Habitat	Altitude (m a.s.l.)	Lat.	Long.
Bonga	Bamboo forests	BA	Bamboo forests dominated by *Arundinaria alpina*	2700	07°14'10.8" N	36°28'03.8" E
Bonga	Komba Forests	KO	Afromontane forests	1900	07°18'10" N	36°03'50" E
Bonga	Boka Forests	BK	Afromontane forests	2500	07°17'51.6" N	36°22'28.1" E
Bonga	Awurada Valley (Gummi River, PFM sites)	AW	Afromontane Forests/ riverine vegetation	1550	07°05'18.0" N	36°13'05.9" E
Bonga	Alemgono Wetland	AG	Wetland	1700	07°21'27.2" N	36°14'18.1" E
Bonga	Shoriri Wetlands	SHO	Wetland	1630	07°21'34.2" N	36°12'24.4" E
Boginda	Gojeb Wetland	GO-wet	Wetland	1600	07°33'13.6" N	36°02'99.4" E
Boginda	Gojeb River	GO-riv	River/floodplain forests	1550	07°37'04.5" N	36°03'10.5" E
Boginda	Boginda Forests	BO	Afromontane forests	2100	07°30'01.1" N	36°05'29.8" E
Bonga	Keja Araba (PFM sites)	KE-AB	Montane forests	1850	07°16'39.8" N	36°10'10.2" E
Bonga	Beta Chega (PFM sites)	BE-CH	Afromontane forests	2100	07°17'54.7" N	36°05'46.9" E
Bonga	KDA Guesthouse	KDA-GH	Urban settlement	1756	07°25'01.5" N	36°25'46.1" E

In a few cases, some teams also assessed areas outside the selected sampling sites. For example, the team assessing large mammals chose the Wushwush tea plantation and the bats team identified God's Bridge near Bonga as a suitable area. In addition, the area surrounding the KDA Guesthouse was used as a sample site, particularly by the insect and bat teams. Figure 14 shows the spatial distribution of each evaluated habitat in the Kafa BR used for sampling sites in the assessment.

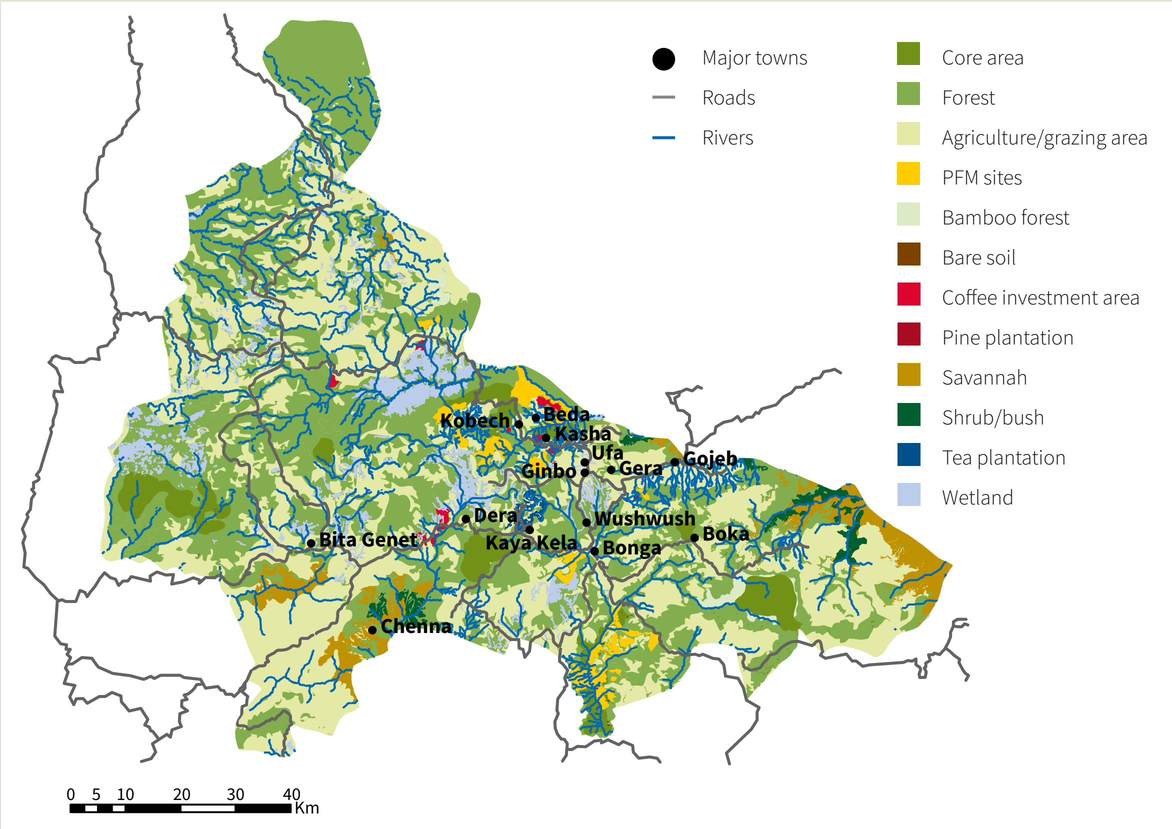

Figure 14: Sampling areas based on the coding system provided in Table 4 (Dresen 2011)

3.2 Data collection and information management

Due to the lack of baseline information and quantitative data on the studied taxa, data collection and management were largely based on expert experience and opinions. This was partially complemented with the limited literature available on Kafa and similar neighbouring habitats. To standardise approaches and understand NABU's objectives for the assessment, all experts were gathered for a meeting in Addis Ababa by Svane Bender-Kaphengst, NABU's Head of Africa Programme. During this meeting, the approaches to selecting indicator and flagship species and identifying threats were explained and discussed with the team leader Dr Juan Carlos Montero.

The data collection methods applied in the fieldwork follow standard protocols commonly used for these kinds of biodiversity assessments. They combine interviews, observations, transect/plot walking with modern tools and devices such as camera traps, call recordings and high-resolution microscopes, etc. Most teams worked during the day, apart from the mammal and bat teams, which conducted nocturnal observations and trapping. Due to the lack of suitable laboratories in Ethiopia, most samples were pre-processed and exported to Germany for specific identification. Each researcher signed a material transfer agreement (MTA), which obligates compliance with a number of criteria for exporting species to another country. Although the data collection and analysis processes differ between each taxon, the content and structure of the individual reports have been standardised for better comparison between the results and comprehensive presentation of the information acquired. Thus, a basic format for reporting was provided to the authors of each individual taxon. Further information on the sampling methods for each taxon can be found in the individual reports.

Immediately after completion of fieldwork, a workshop was held in Bonga, Kafa BR, to reflect on the methods applied, the preliminary results and suggestions for potential indicator and flagship species. In addition to the experts, rangers, field assistants and NABU staff participated in the workshop. The participants shared and validated the knowledge gained during the fieldwork about each taxon and major habitat that was assessed.

During this systematisation and analysis of the field data, the preliminary species determinations were confirmed, rejected or corrected based on literature and (additional) expert knowledge. The analysis behind the choice of indicator and flagship species is presented in 3.3.

Figure 15: (photo: Juan Carlos Montero)

Figure 16: (photo: Juan Carlos Montero)

Figure 17: (photo: Juan Carlos Montero)

Figure 18: (photo: Juan Carlos Montero)

Figure 15-18: Regular briefings, supply, logistics and catering took place at the assessment's headquarters, the KDA Guesthouse compound

Figure 19: The plant team selecting the plot site (photo: Juan Carlos Montero)

Figure 20: The plant team selecting the herborization of the material collected (photo: Juan Carlos Montero)

Figure 21: The insect teams using different catching methods in open areas (photo: Viola Clausnitzer)

Figure 22: The insect teams using different catching methods in open areas (photo: Tom Kirschey)

Figure 23: The insect teams using different catching methods in close dense forests (photo: Svane Bender-Kaphengst)

Figure 24: The insect teams using different catching methods in close dense forests (photo: Matthias Schöller)

Figure 19-24: Collection of field data and samples by the teams (1)

Figure 25: The birds team making observation on an open area (photo: Torsten Ryslavy)

Figure 26: The birds team making observation on an open area (photo: Torsten Ryslavy)

Figure 27: Recording instruments used by the Bats team (photo: Ingrid Kaipf)

Figure 28: Recording instruments used by the Bats team (photo: Ingrid Kaipf)

Figure 29: Fungi expert identifying in the headquarters the material collected in the field (photo: Ingrid Kaipf)

Figure 30: Fungi collected at the Afromontane forest sites (photo: Andreas Gminder)

Figure 25-30: Collection of field data and samples by the teams (2)

Figure 31: The dragonfly team (photo: Thies Geertz)

Figure 32: The mollusc and amphibian teams collecting on areas influenced by water bodies (photo: Tom Kirschey)

Figure 33: (photo: Viola Clausnitzer)

Figure 34: The mollusc and amphibian teams taking samples (photo: Viola Clausnitzer)

Figure 35: A record of an antelope "Dik Dik" (*Moloqua kirkii*) registered by the camera trap (photo: Hans Bauer)

Figure 36: Footprint of the Dafassa Waterbuck (*Kobus defassa*) registered in the Gojeb Wettland (photo: Hans Bauer)

Figure 31-36: Collection of field data and samples by the teams (3)

3.3 Identification of indicator and flagship species

Given the complexity and lack of information on local biodiversity, it is often difficult to measure and monitor the potential impact of conservation practices on all species in the area. This problem is particularly relevant at the Kafa BR. Selecting indicator species is a cost and time efficient tool to characterise the state of an ecosystem and monitor changes in observable biodiversity parameters such as species richness or composition (Urban et al. 2012). Focusing on a limited set of species can be very helpful as an alternative to comprehensive fauna and flora surveys (Urban et al. 2012).

Flagship species are symbols of major conservation projects. They are usually large, charismatic and well-known species that are used to gain public attention and support (Kafa BR, for example, wild coffee and lions). Although, they are commonly used for conservation purposes, they often have limited scientific value for achieving conservation targets. A lack of flagship species in an area does not automatically imply low conservation value. At the same time, focussing conservation efforts on a single (flagship) species is rarely successful. However, flagship species can be an effective tool for public relations and for conserving particular sites or areas (Groves 2003).

In the Kafa BR, identifying and monitoring indicator and flagship species should concretise conservation targets and measures. Identifying appropriate targets and measures requires interpreting the planning region within a broader biogeographic context. Examples of unique or distinct biological include the presence of threatened and endangered species or a high degree of endemism (Groves 2003).

Choosing species or guilds as indicators in the Kafa BR is hampered by the lack of biological information at specific taxa level (e.g., distribution, ecology, inventories). The concept of indicator species needs to be employed cautiously, as it can lead to unwarranted generalisations and misleading interpretation of monitoring results, with negative implications for conservation management. For example, frogs are widely regarded as sensitive to habitat change, and declines in their populations are often interpreted as an indicator of climate change. However, in most cases, their decline is a result of multiple temporal and spatial factors with different levels of relevance. These driving forces may be accelerated by anthropogenic interventions such as deforestation, and are not limited to climate change. Using indicator species in conservation management often assumes that the maintenance and conservation of a suitable habitat (e.g., a particular forest type) for a single indicator species would also benefit other taxa with similar requirements. However, this relationship does not always hold (Landres et al. 1988). In the Bolivian Andes, for example, the Andean bear (*Tremarctos ornatus*) was chosen to be a good indicator species for the conservation status of the montane cloud forests. This was later contradicted by conservationists, who were able to show that the presence of the bear was not correlated with the presence and/or abundance of other taxa in the same habitat.

A key habitat requirement for bats is the presence of hollow trees, which are used for nesting and den sites. Because the abundance of hollow trees is a factor limiting bat populations over large forest areas, it would be more logical to preserve a certain amount of hollow trees than monitor indicator species. However, protecting hollow trees might not be relevant for other taxa (Lindenmayer et al. 2000).

When using indicator species to monitor pollution, the behaviour of selected indicator species can even prove the opposite to what it was dedicated to show. In the Australian river systems, the bivalve mollusc *Velesunio ambiguous* was chosen as an indicator for the presence of heavy metals; however, long term research on the same species and river systems have proven that the uptake of heavy metals by *V. ambiguous* does not reflect the extent of pollution in the surrounding riverine systems. Thus, this species was unreliable and unsuitable as an indicator species (summarised in Lindenmayer et al. 2000).

Some researchers suggest that the response to disturbances by one member of a guild might precisely predict the responses of other members. For example, Thiollay (1992) found that the populations of five sympatric, closely related and morphologically similar rainforest bird species varied unevenly under the influence of selective logging. Thus, different species within the same guild may not predictably respond to change, even though they are closely related morphologically and genetically. There are ecological reasons to believe that different members of a guild respond differently to the same factors, such as specific competition strategies and niche arrangements exhibited by different species (Lindenmayer et al. 2000).

Despite these criticisms and limitations, choosing indicator species for conservation and monitoring purposes in a poorly investigated habitat is a very important tool for understanding and conserving large habitats such as the forests and wetlands in the Kafa BR. But selecting indicator species and identifying their major threats is only the first step; monitoring and more quantitative research of each selected taxa are crucial to adjust the conservation plan, confirm the indicators or find more reliable and suitable species or guilds.

As shown above, selecting indicator species is far from trivial. Specific criteria must be followed, since selecting "wrong" or inappropriate species can lead to misleading conservation results. The biodiversity assessment applied the following principles when selecting indicator species following Landres et al. (1988):

(1) use indicators only when other assessment options are unavailable,
(2) clearly state assessment goals,
(3) major habitats require urgent attention and basic biological information,
(4) presence of a high heterogeneity of habitats separated by short distances,
(5) choose indicator species based on explicitly defined criteria in accord with assessment goals,
(6) include all species that fulfil stated selection criteria,
(7) know the biology of the indicator in detail, and treat the indicator as a formal estimator in conceptual and statistical models,
(8) identify and define sources of subjectivity when selecting, monitoring and interpreting indicator species,
(9) direct research at developing an overall strategy for monitoring wildlife that accounts for natural variability in population attributes and incorporates concepts from landscape ecology.

Based on these principles, we delineated a common definition of "appropriate" indicator species for the biodiversity assessment at Kafa BR:
Indicator species should be taxonomically well known, easy to identify and occur in a specific habitat. The absence of indicator species in a certain habitat may indicate human-created abiotic conditions and reflect the intensity of a disturbance regime.

Different kinds of species can serve as indicators of the biodiversity of a specific area. Lindenmayer et al. (2000) distinguish two broad groups of biodiversity indicators:

A) biological or taxon-based indicators, particularly species and guilds,
B) structure-based indicators, (spatial) landscape features such as structural complexity, connectivity and heterogeneity.

Nowadays, species are often chosen as indicators if they:
(a) reflect structural or functional changes in the ecosystem,
(b) are sensitive to a particular property of an ecosystem,
(c) influence other species or taxa, or
(d) are a representative member of a guild (Urban et al. 2012).

The biodiversity assessment made exclusive use of taxon-based indicators, taking different meanings and interpretations into account. According to Lindenmayer et al. (2000), taxon-based indicators can include:

(1) a species whose presence may indicate the presence of a set of other species and whose absence indicates the lack of that entire set of species,

(2) a keystone species (*sensu* Terborgh 1986), which is a species whose addition to or loss from an ecosystem leads to major changes in the abundance or occurrence of at least one other species,

(3) a species whose presence indicates human-created abiotic conditions such as air or water pollution,

(4) a dominant species that provides much of the biomass or number of individuals in an area,

(5) a species that indicates particular environmental conditions such as particular soil, microhabitats or type of rock,

(6) a species thought to be sensitive to and therefore to serve as an early warning indicator of environmental changes such as global warming or invasive species and

(7) a management indicator species, which is a species that reflects the effects of a disturbance regime or the efficacy of efforts to mitigate disturbance effects.

Types (1), (2), and (4) have been proposed as indicators of biological diversity (Lindenmayer et al. 2000). However, due to the lack of long-term information on the studied taxa, we focussed the assessment at Kafa BR on indicator species showing changes in abiotic conditions and/or changes in ecological processes (types (3), (5), (6) and (7)). As monitoring activities in Kafa increase, the first types of indicators can be properly assessed.

Flagship species were selected partly based on the chosen indicator species. These and other species which could serve as flagships were chosen after in-depth discussion among the experts involved in the assessment.

4. Summary of Results

This section presents the highlights of the taxon assessments and the selection of indicator and flagship species. A more detailed description of the results for each taxon can be found in the individual reports.

Overall, the biodiversity assessment detected high biological diversity within the Kafa BR, reflected in high diversity at both the habitat level and the species in each habitat. The identified habitats exhibit high heterogeneity, despite being only a short distance from each other. Another important finding is the extremely high rate of endemism. Despite the extremely short timeframe for the assessment, most of the assessed taxa consist of about 30% endemic species. This high degree of endemism can be explained by the isolated vast highlands surrounded by dry lowlands, along with the area's geological and tectonic history (see Section 2.1). Combined with the exceptionally high rate of endemism, the high diversity at the habitat level and the heterogeneity of landscapes makes the Kafa BR an exceptional area for biodiversity protection.

4.1 Results at taxa level

4.1.1 Vascular plants

Anna Leßmeister, Kifle Kidane, Terefe Woldegebriel, Kitessa Hundera, Debela Hunde and Juan Carlos Montero

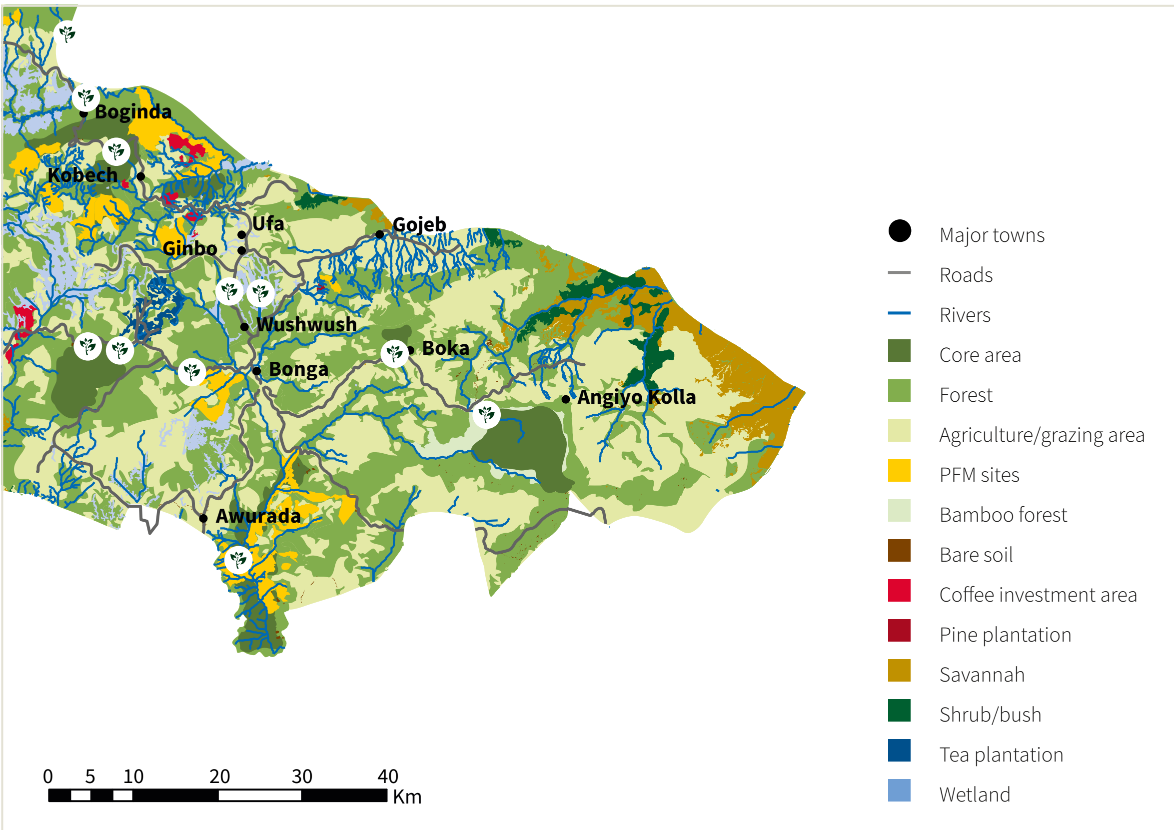

Figure 37: Sites sampled by the plant team at the Kafa Biosphere Reserve

Highlights

- Although there are data for a transitional bamboo-montane forest at Boka, this is the first quantitative study of the vegetation in the Kafa Biosphere Reserve's (BR) bamboo forests, along with the wetland and riverine forest patches.

- In total, 154 vascular plant species were recorded.

- Seven endemic species were recorded: *Aframomum corrorima*, *Bothriocline schimperi*, *Clematis longicaudata*, *Erythrina brucei*, *Millettia ferruginea*, *Tiliacora troupinii*, *Vepris dainellii*.

- 16 species are endangered or threatened: *Bothriocline schimperi* (LC), *Dracaena afromontana* (LC), *Erythrina brucei* (LC), *Ficus ovata* (LC), *Millettia ferruginea* (LC), *Pa-*

rochetus communis (LC), *Phaulopsis imbricata* (LC), *Vepris dainellii* (LC), *Canthium oligocarpum* (NT), *Coffea arabica* (VU), *Maytenus arbutifolia* (VU), *Ocotea kenyensis* (VU), *Pavetta abyssinica* (VU), *Prunus africana* (VU), *Tiliacora troupinii* (VU), *Cyathea manniana* (NT).

- The Afromontane forests are more species-diverse than the bamboo forest and wetlands. The latter, however, display high heterogeneity of habitats, thus increasing overall diversity.

- The floodplain forests and wetlands feature a higher diversity of plant species than Afromontane Participatory Forest Management (PFM) sites. Therefore, establishing core zones in the wetlands/floodplain forests would be advisable. More research is needed in this still poorly investigated habitat to extend species lists and investigate potential threats.

- The natural Afromontane forests show higher species diversity than the PFM Afromontane forests, as well as being home to considerably more species with high IVI values than the PFM sites. PFM techniques seem to decrease the natural regeneration of trees, resulting in a very low rate of species turnover.

- *Coffea arabica*, *Phoenix reclinata* and *Dracaena afromontana* are the flagship species.

- *Cyathea manniana*, *Dracaena afromontana* and *Hippocratea africana* are indicator species for primary montane forests susceptible to disturbances.

- *Pavetta abyssinica* and *Phoenix reclinata* are indicator species for floodplain forest and wetland forest patches.

- There is an urgent need for further investigation of other areas omitted from this assessment. For example, the western part of the reserve (Gesha and Bita areas) has complex patches of highland wetlands which certainly differ both structurally and compositionally from the investigated wetlands. The potential for discovering species new to science here is very high. Similarly, a huge, well-conserved patch of montane forest in the extreme northwest (Saylem) warrants detailed floristic study. At the other extreme, there is a lack of quantitative studies of the alpine vegetation northeast from Bonga (Adiyo), so more efforts are required in this area.

- Given the extreme importance of wetlands in Kafa, it is vital to typify their functions, processes, biochemistry and composition to aid further investigation. Some wetlands could be even nominated as Ramsar sites once sufficient information is available.

- Our results show that montane PFM sites exhibit lower diversity than the surrounding natural montane forests; therefore, there is an urgent need to investigate the vegetation (composition, diversity and ecology) at a spatial scale over time at both sites.

4.1.2 Fungi

Andreas Gminder

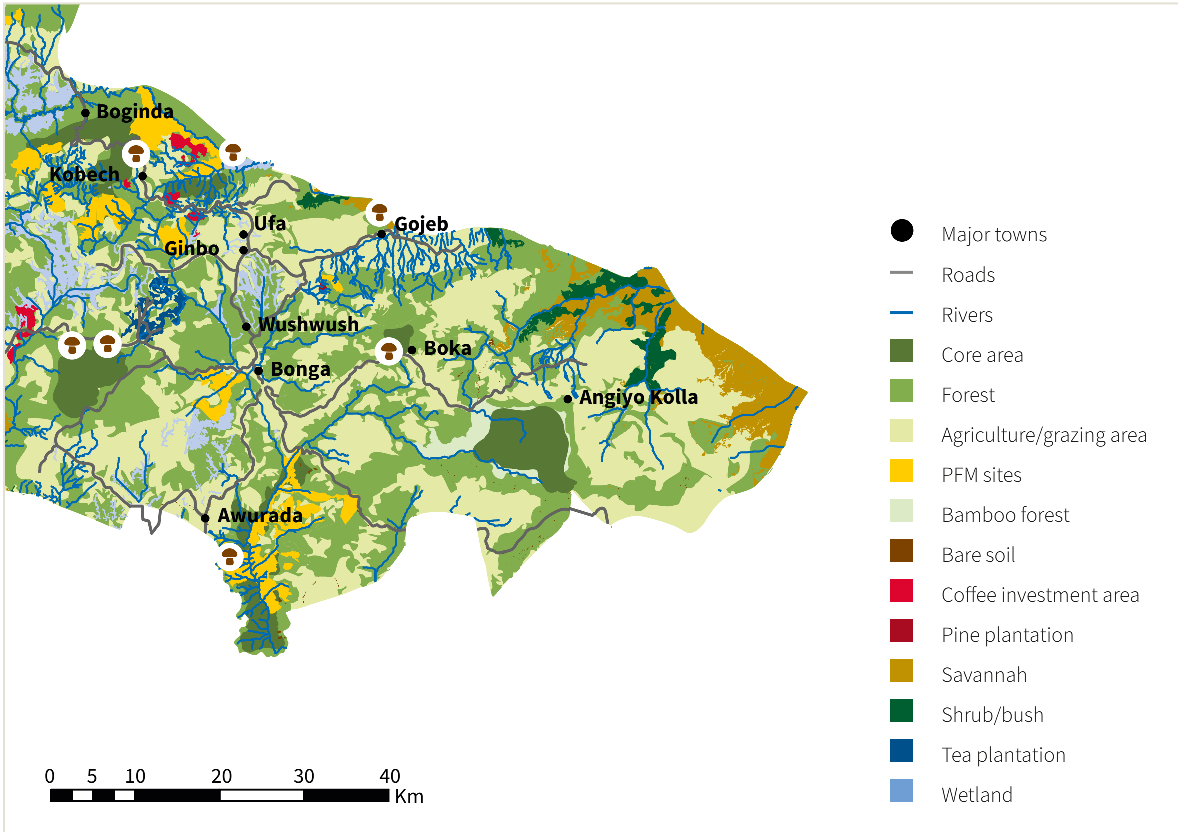

Figure 38: Sites sampled by the fungi team at the Kafa Biosphere Reserve

Highlights

- This is the first time a mycological survey has been conducted in the Kafa area.
- Nearly 350 species of fungi were recorded, but most were identified as morphospecies or could only be determined at the genus level.
- At least 30 species are new to Ethiopia, but this number may increase to more than 100 after all collections have been analysed.
- At least three species are already known to be new to science (*Ascocoryne kafai* ined., *Cerinomyces bambusicola* ined., *Coniolepiota kombaensis* ined.), but this number will most likely increase, at least in some genera of the Agaricales (*Cystolepiota*, *Entoloma*, *Psathyrella*) and Xylariales (*Hypoxylon* s. l.) orders.
- Two species are probably endemic to Ethiopia (*Cerinomyces bambusicola* ined., *Sarcoscypha* spec. nov. ined.).
- Many of the species are endangered by biotope loss, as they are believed to be confined to natural montane rain forests. The exact number cannot be estimated due to lack of comparative data.
- The bamboo forest seems to be home to several endemic species, but more studies are needed to confirm this.
- Compared to the wetlands and bamboo forests, the montane forests (coffee forests) at 1700 to 2000 m a.s.l. seem to be the most species-diverse biotope.
- *Sarcoscypha javanensis* and *Coniolepiota kombaensis* ined. could be a good indicator species for the status of natural montane cloud forests. *Cerinomyces bambusicola* ined. could serve as an indicator species for habitat quality in the bamboo forests. Finally, *Dentipellis fragilis* is an indicator for undisturbed forests in general.

4.1.3 Molluscs

Thies Geertz

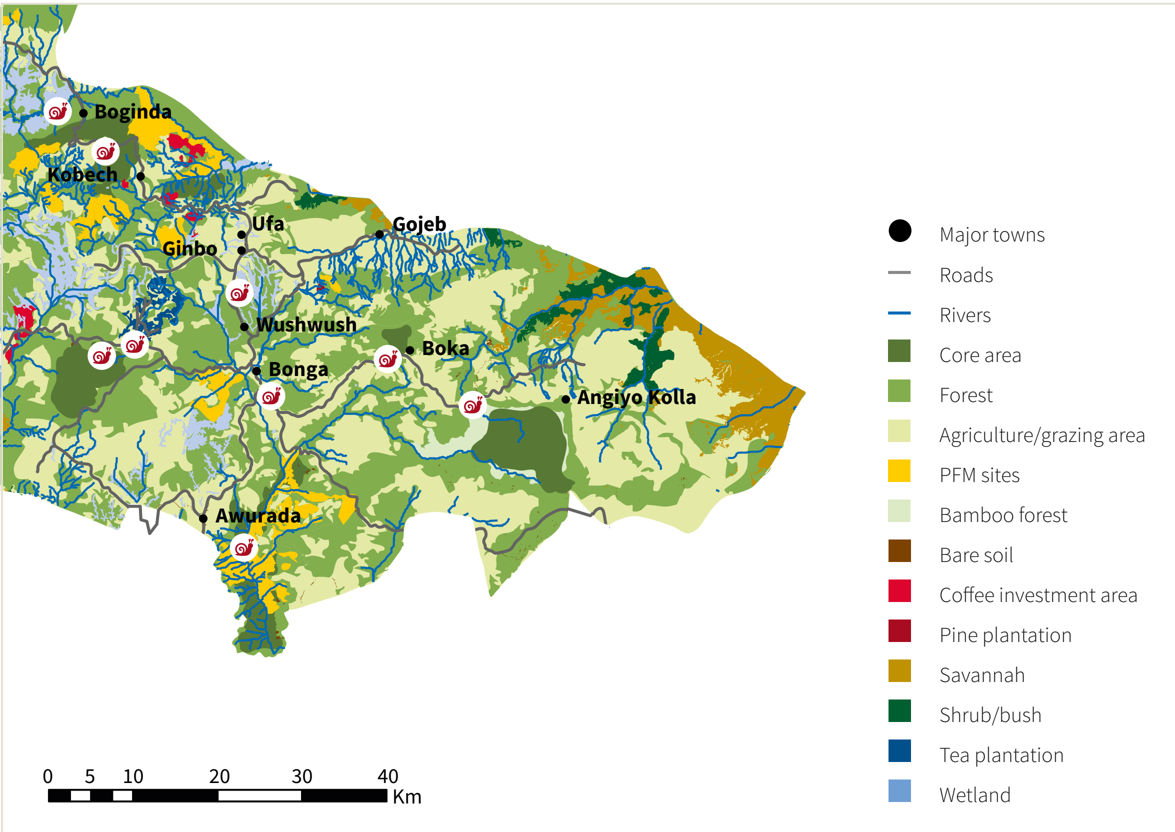

Figure 39: Sites sampled by the molluscs team at the Kafa Biosphere Reserve

Highlights

- As far as the author is aware, this is the first systematic assessment of terrestrial molluscs in an Ethiopian rainforest, if not the whole of Ethiopia.
- A total of 32 species of terrestrial molluscs were recorded.
- Knowledge of the ecology and conservation status of Ethiopian land snails is very poor at present. Further research is required to complete the checklist of land snails in the Kafa BR.
- None of the recorded species has been assessed by the IUCN Red List.
- Boginda Forest in the core zone was the most species-rich forest, with 16 recorded snail species.
- Freshwater molluscan diversity is very poor in the Kafa BR, with only nine species recorded in rivers, streams and ponds.
- One pea clam (*Pisidium* sp.) was discovered that is most probably new to science. Freshwater gastropods are absent from almost all investigated ponds and streams, despite seemingly good habitat conditions. This could be due to biogeographic factors or chemical water parameters and requires further research.
- Freshwater mussels (Unionoida) would be a good indicator group for the ecosystem health of streams and rivers.
- The carnivorous Streptaxidae are a potential indicator group for the ecological integrity of rainforests, although further research is required.
- Molluscs face an unprecedented rate of extinction, with 83% of East African land snails restricted to the endangered rainforests. Further research and conservation measures to curb deforestation are urgently required if these species are to survive.
- Future research should focus on identifying forest endemics in the Kafa BR, as these are potentially good indicator species and especially prone to extirpation.

4.1.4 Beetles with notes on other insects

Matthias Schöller, contribution on butterflies by Daniel Wiersborski

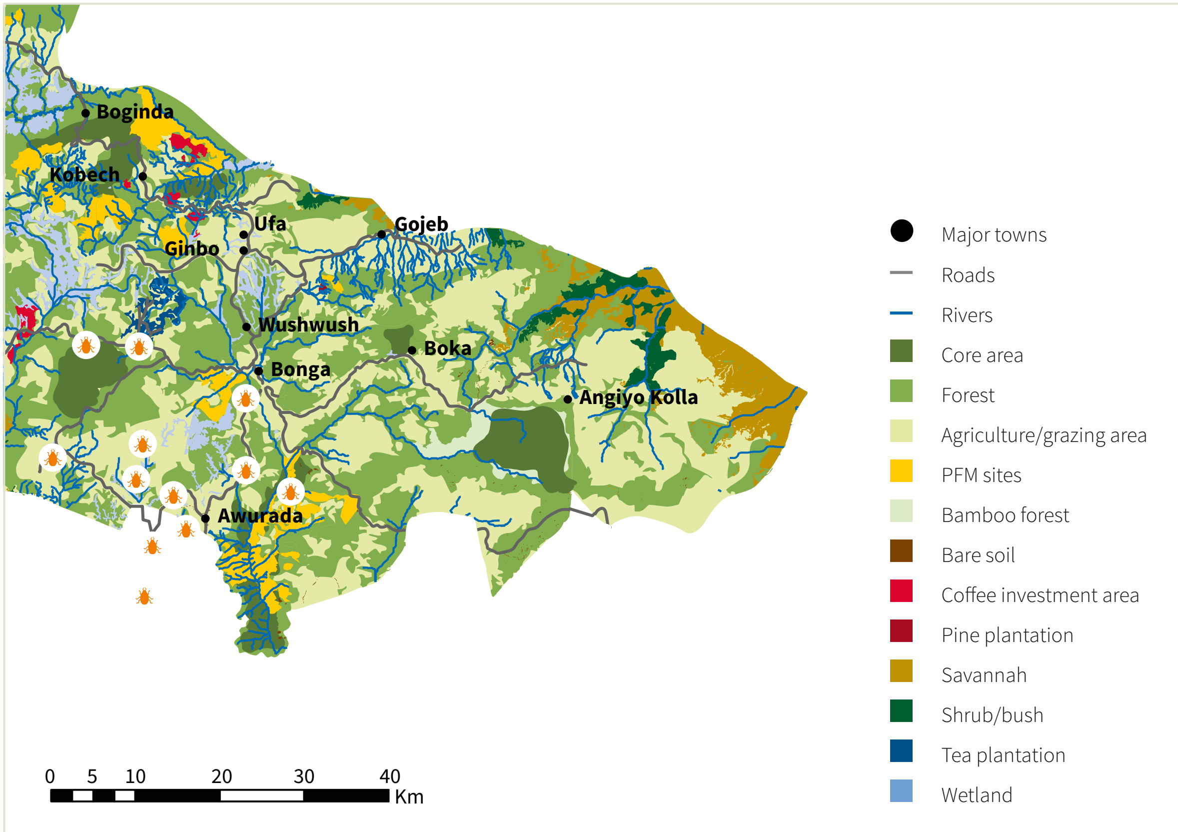

Figure 40: Sites sampled by the molluscs team at the Kafa Biosphere Reserve

Highlights

- This is the first time a comprehensive assessment of beetles has been conducted and reported at Kafa BR, covering a wide range of habitats and altitudinal gradients.
- The various sampling and trapping methods applied proved to be effective.
- 400 beetle species belonging to 79 families/subfamilies were recorded. Almost every major beetle family occurred at the sampled sites.
- Despite collecting during an unfavourable season, 164 Staphilinidae species were recorded within just 10 sampling days, out of approximately 530 known for Ethiopia (30%).
- Several species are new to science, e.g., a water beetle *Pachysternum* sp. nov., and the new species *Tachinoplesius schoelleri* Schülke 2016 was described. To date, determinations indicate 40 species are new to science; however, this number could increase as more determinations are completed. This process proved difficult due to a lack of specialists for many beetle groups.
- In the bamboo forests, phytotelmata were discovered, hidden in freshwater habitats. These are previously unknown for Ethiopia.
- Wetland habitats like the Shoriri Wetlands are in good condition. More research is needed in these areas.
- Species diversity in PFM forest sites benefits when the moisture in the ground layer is maintained by, e.g., the presence of large trees or microstructures such as climbing plants, tree holes or shrub and herb diversity.
- Leaf beetles in the genus *Altica* could be good indicators of wetland conservation status.

4.1.5 Flower-visiting insects

Hans-Joachim Flügel

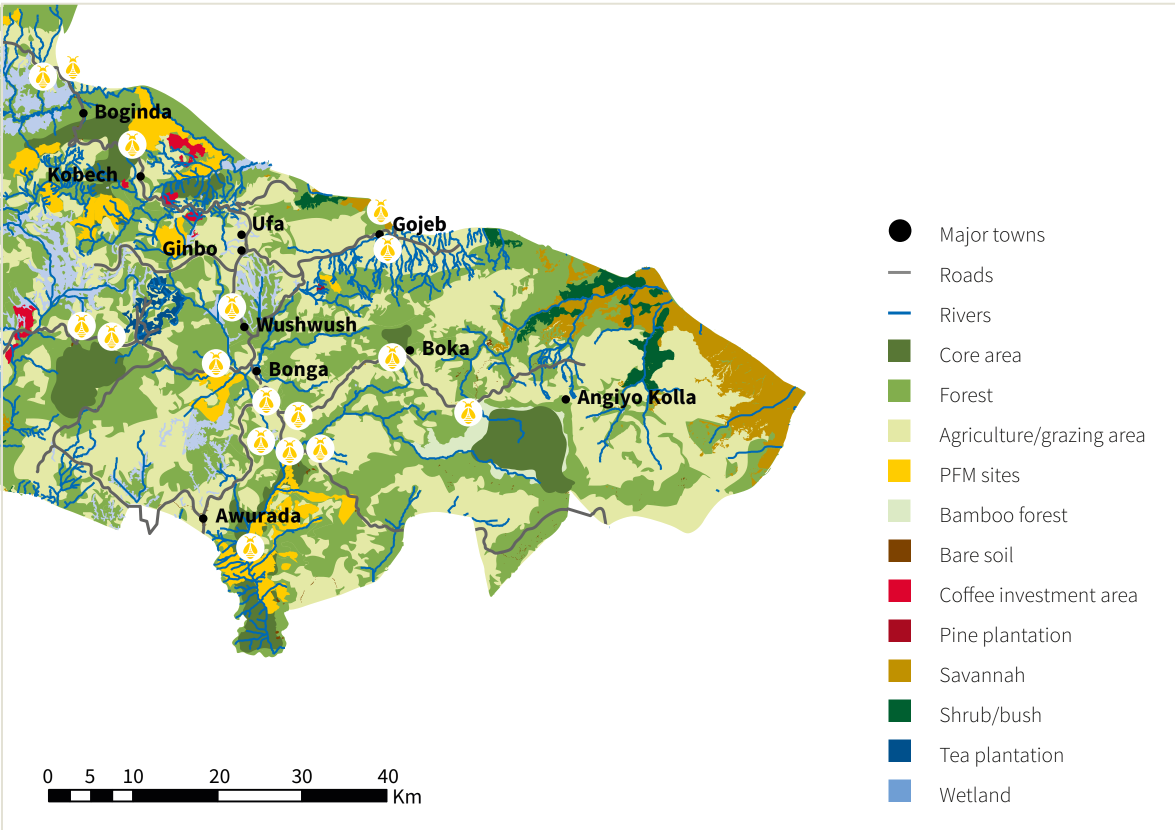

Figure 41: Sites sampled by the insect (flower-visiting insects) team at Kafa Biosphere Reserve

Highlights

- For the first time in the Kafa BR, an insect assessment was conducted with the focus on flower ecology.
- Approximately 300 insect specimens were recorded, of which approximately 50% could be determined to the species level.
- Identification to the species level was hampered by the absence of identification literature and reference collections for Ethiopian insects. Therefore, a more detailed statement on species composition and possible biodiversity highlights is currently not possible.
- The results of the assessment suggest that the Kafa BR is home to several endemic species, but more studies are needed to substantiate this finding. Most of the endemic species found seem to occur in the Afromontane rainforest.
- Ten species of the fly family Diopsidae were found, four of which are new to science.
- It is still unknown which insect species are the original pollinators of the coffee tree. This should be investigated by comparing wild *Coffea arabica* stands to cultivated stands, such as those found at Participatory Forest Management (PFM) sites.
- It is reasonable to assume that coffee production in plantations and PFM sites could be increased by introducing original pollinator species. Identifying the original coffee pollinators could thus considerably enhance coffee plant productivity at managed sites.

4.1.6 Dragonflies and damselflies (Odonata)

Viola Clausnitzer

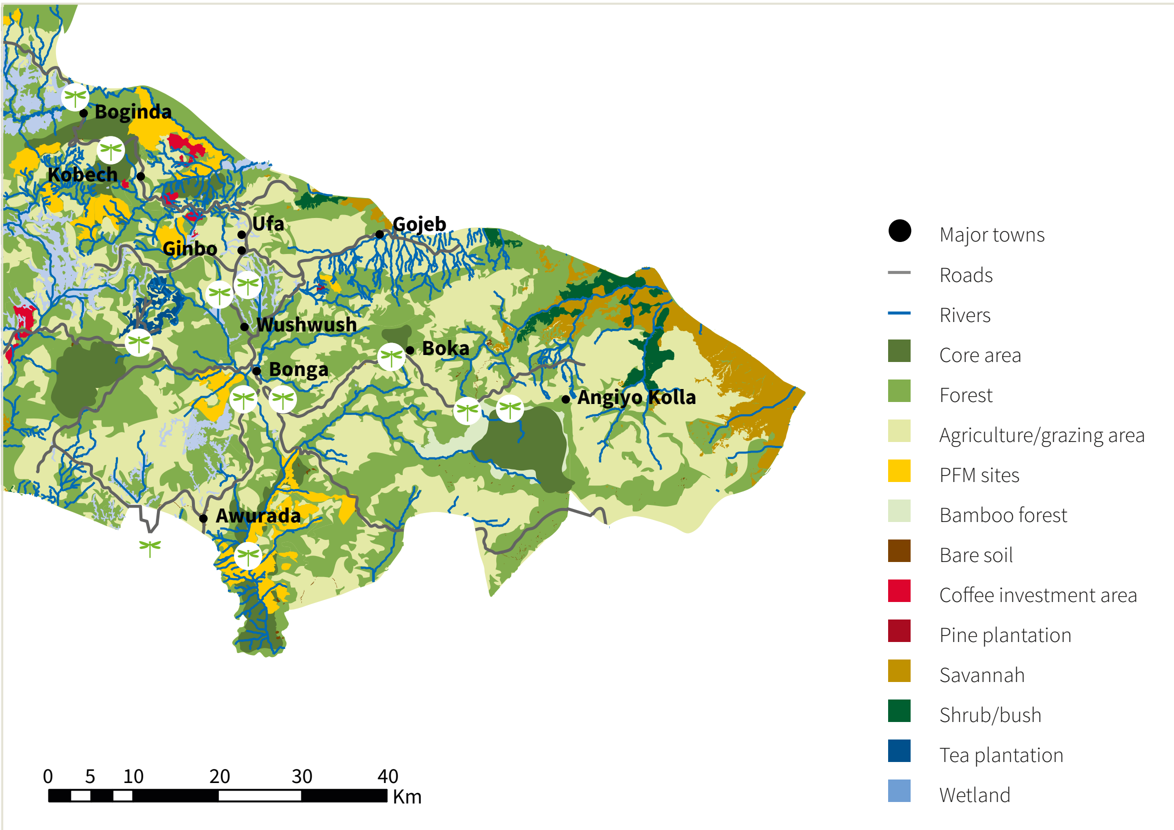

Figure 42: Sites sampled by the insect team (Odonata) at the Kafa Biosphere Reserve

Highlights

- A total of 33 Odonata (=dragonflies and damselflies, hereafter referred to as "dragonflies") species from seven families were recorded (31.1% of Ethiopia's dragonfly fauna and 65% of dragonfly fauna ever recorded in the Kafa BR).

- A total of 51 dragonfly species from nine families has ever been recorded in the Kafa BR.

- Three species are new to Ethiopia (*Aciagrion gracile*, *Tetrathemis polleni*, *Phyllomacromia* spec.).

- Twelve species were recorded the first time for the Kafa BR, including the endemic and endangered *Notogomphus ruppeli*.

- Eight of the recorded species are endemic to the Ethiopian highlands (*Pseudagrion guichardi*, *P. kaffinum*, *Notogomphus cottarellii*, *N. ruppeli*, *Atoconeura aethiopica*, *Orthetrum kristenseni*, *Palpopleura jucunda radiata*, *Trithemis ellenbeckii*).

- Five species are threatened according to the global IUCN Red List of Threatened Species (three 'vulnerable', two 'endangered'), all of them endemic to Ethiopia.

- Endemic species were only found in montane and submontane forest streams.

- The lower areas (wetlands) exhibit higher diversity, but no endemic species.

- The Ethiopian Highlander (*Atoconeura aethiopica*), the Ethiopian Sprite (*Pseudagrion guichardi*) and the Kaffa sprite (*Pseudagrion kaffinum*) are flagship species.

4.1.7 Herpetofauna (Amphibia, Reptilia)

Tom Kirschey

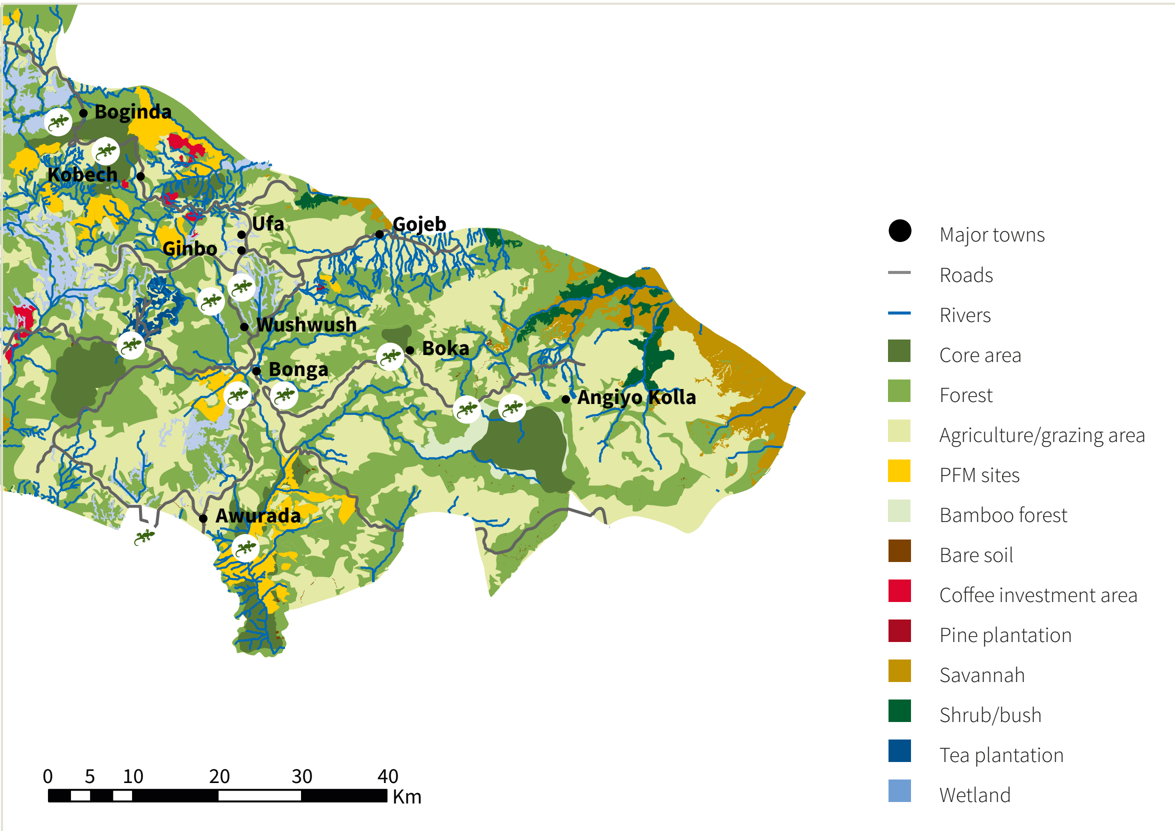

Figure 43: Sites sampled by the herpetofauna team at the Kafa Biosphere Reserve

Highlights

- A total of 17 amphibian species from four families were recorded (Table 2).
- A total of five squamate reptile species (two Sauria, three Serpentes) from four families were recorded (Table 3).
- One species of Hyperoliidae (genus *Leptopelis*) is probably new to science.
- Eight species of amphibians and two species of reptiles were recorded the first time for the Kafa BR (Amphibia: *Leptopelis ragazzii*, *Leptopelis* sp., *Hyperolius kivuensis*, *Phrynobatrachus inexpectatus*, *Ptychadena schillukorum*, *P. erlangeri*, *P. mascareniensis*, *Xenopus clivii*, Reptilia: *Trachylepis wingatii*, *Megatyphlops brevis*).
- Six (perhaps seven) of the recorded amphibian species are endemic to the Ethiopian Highlands (*Leptopelis ragazzii*, *L. vannutellii*, *L.* spec., *Afrixalus clarkeorum*, *A. enseticola*, *Phrynobatrachus inexpectatus*, *Ptychadena erlangeri*).
- One of the recorded reptile species is endemic to the southwestern Ethiopian Highlands (*Pseudoboodon boehmei*).
- Three species are threatened according to the updated global IUCN Red List of Threatened Species (two 'vulnerable', one 'endangered': *Leptopelis ragazzii*, *Afrixalus clarkeorum*, *A. enseticola*). All three are endemic to Ethiopia. Another species (*Leptopelis vannutellii*) was previously listed as 'vulnerable', but has been redesignated as 'least concern'.
- Beccari's giant frog (*Conraua beccarii*), Largen's dwarf puddle frog (*Phrynobatrachus inexpectatus*) and Clarke's banana frog (*Afrixalus clarkeorum*) are flagship species for amphibians.
- This report includes the first picture of the tadpole mouthpart of the previously undescribed and highly rheophile Beccari's giant frog (*Conraua beccarii*).
- Wetland sites, particularly inside or near the natural forest, show the highest level of diversity. The lowest diversity is found in the bamboo forest.
- Arboreal and running water habitats require more research.
- Endemic species are exclusively bound to forest habitats (canopy).

4.1.8 Bats and fruit bats

Ingrid Kaipf, Hartmut Rudolphi and Holger Meinig

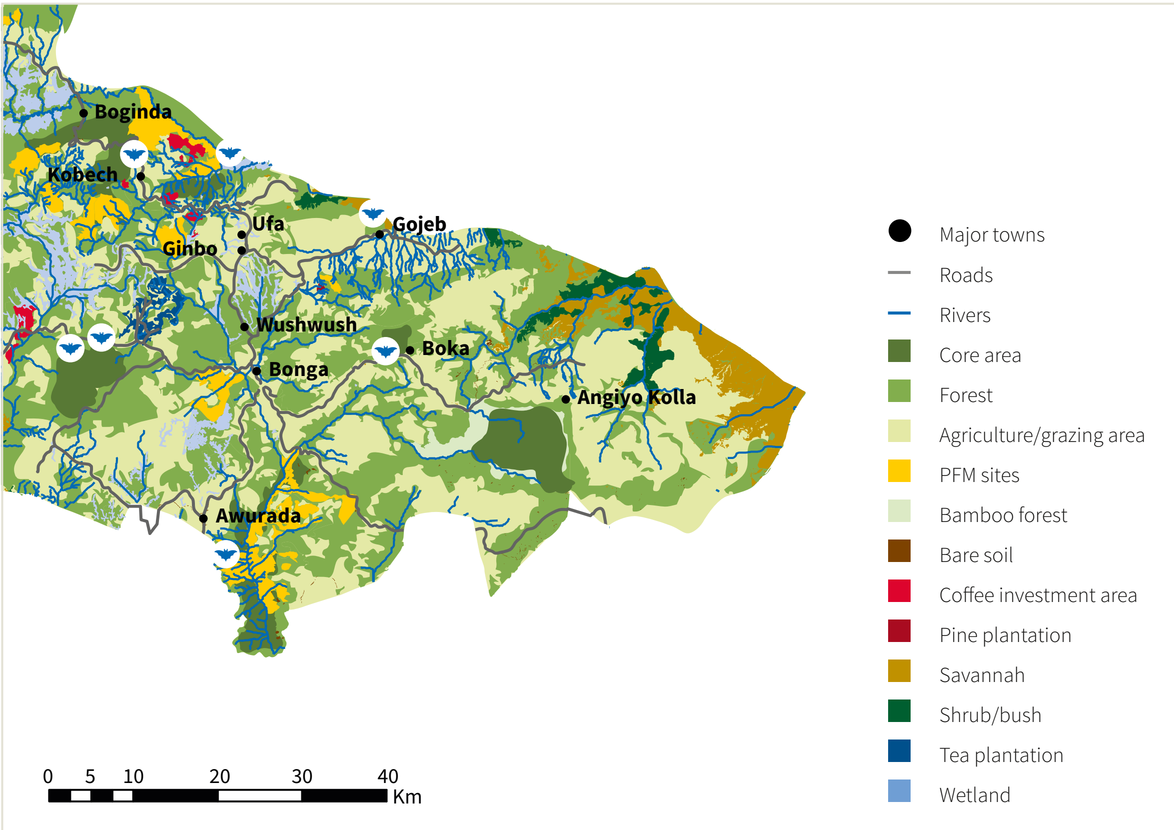

Figure 44: Sites sampled by the bat team at Kafa Biosphere Reserve

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.

4.1.9 Birds

Wolfgang Beisenherz, Bernhard Walter, Torsten Ryslavy and Yillma Dellelegn Abebe

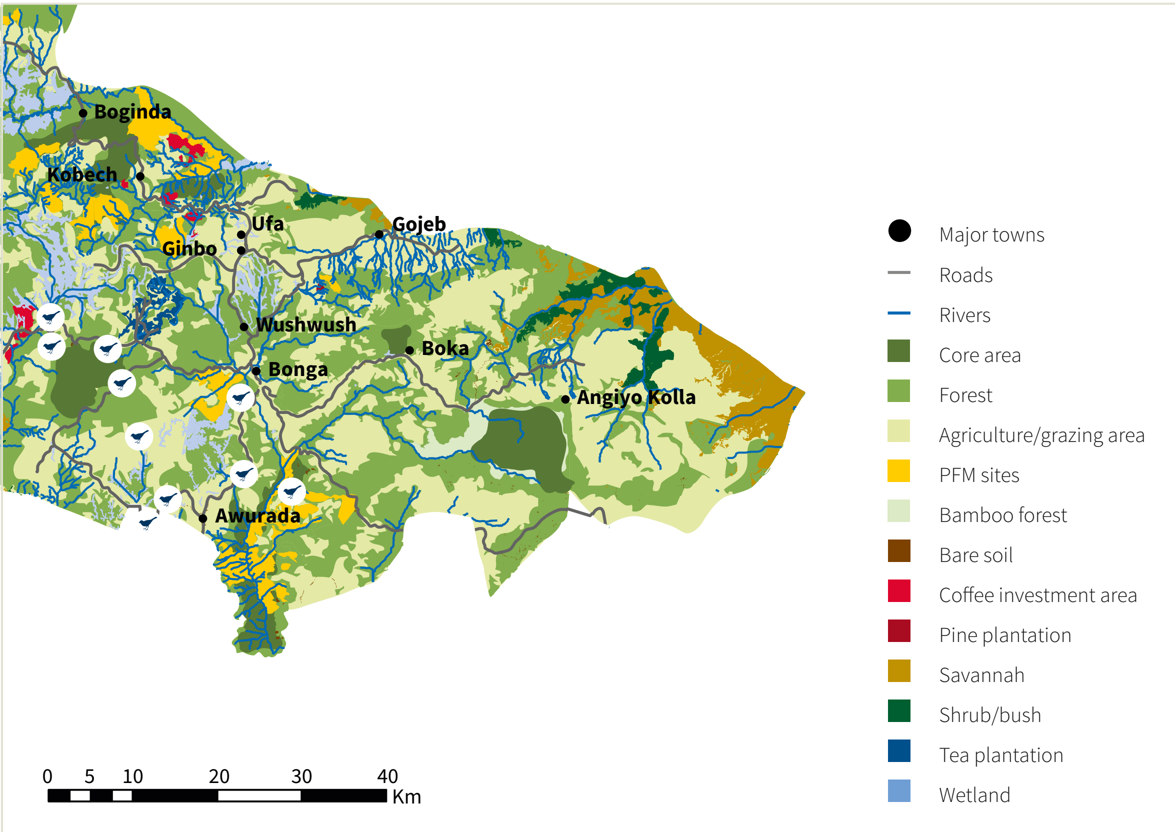

Figure 45: Sites sampled by the bird team at the Kafa Biosphere Reserve

Highlights

- 178 bird species were recorded.
- 25 species are restricted to the Afrotropical Highland biome.
- Two species are restricted to the Somali-Masai biome.
- Three species are endemic (Abyssinian Longclaw (*Macronyx flavicollis*), Abyssinian Catbird (*Parophasma galinieri*) and Yellow-fronted Parrot (*Poicephalus flavifrons*)).
- Seven species are near-endemic (Wattled Ibis (*Bostrychia carunculata*), Rouget's Rail (*Rougetius rougetii*), Black-winged Lovebird (*Agapornis taranta*), White-cheeked Turaco (*Tauraco leucotis*), Banded Barbet (*Lybius undatus*), Abyssinian Slaty Flycatcher (*Melaenornis chocolatinus*) and Thick-billed Raven (*Corvus crassirostris*). Thus, the Kafa BR is characterized by a high avian endemism.
- Eight species are endangered or threatened.
- A successful brood of the endangered Wattled Crane was found in Alemgono Wetland.
- Different broadleaf forests seem to exhibit similar diversity of bird species.
- The bamboo forests seem to be home to few bird species. There are no bird species specifically adapted to this habitat.
- The African Crowned Eagle (*Stephanoaetus coronatus*), Wattled Crane (*Bugeranus carunculatus*) and Black Crowned Crane (*Balearica pavonina*) can be considered flagship species.
- The African Crowned Eagle, White-cheeked Turaco and Sharpe's Starling (*Pholia sharpii*) could be good indicators of forest conservation status. The Black Crowned Crane, Abyssinian Longclaw and Rouget's Rail could prove good indicator species for wetland conservation status. Finally, the Finfoot (*Podica senegalensis*) and Half-collared Kingfisher (*Alcedo semitorquata*) could prove good indicator species for river conservation status. These species should be monitored regularly.

4.1.10 Primates

Andrea Schell & Karina Schell

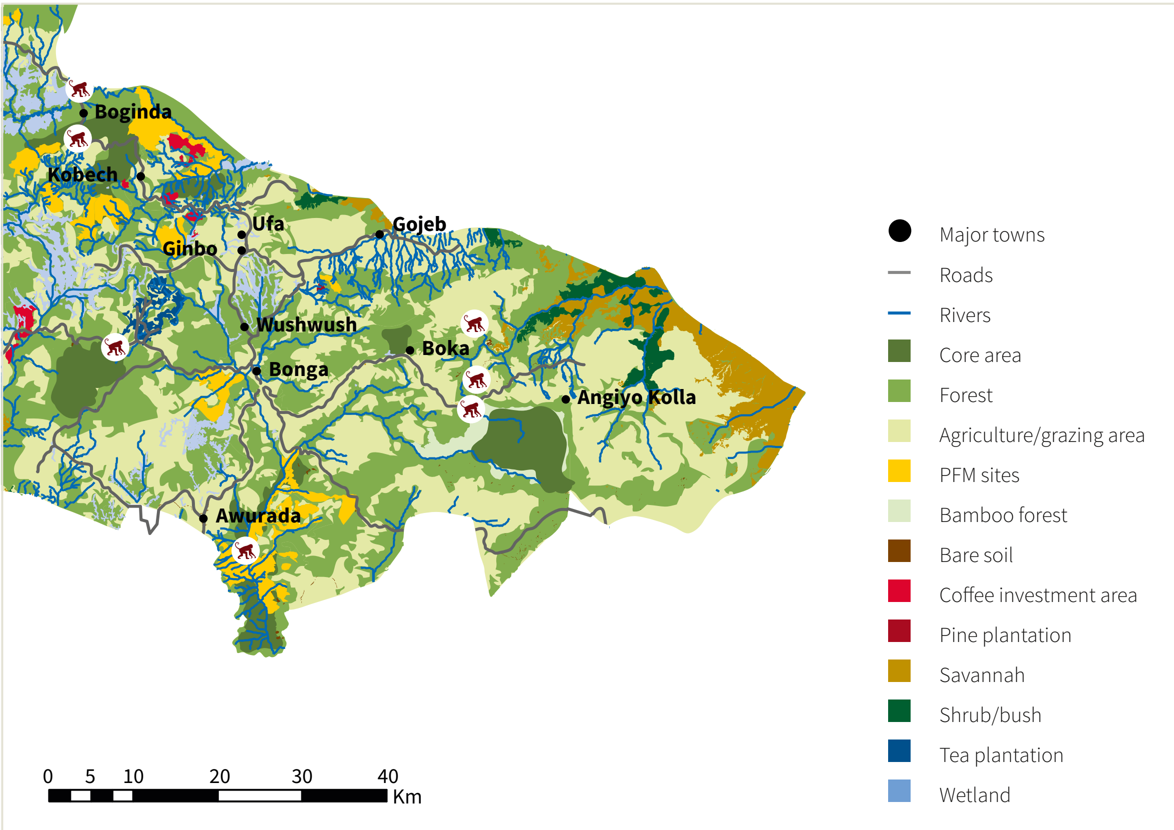

Figure 46: Sites sampled by the primates team at the Kafa Biosphere Reserve

Highlights

- This is the first broad assessment to determine the primate species composition of the Kafa Biosphere Reserve (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: *gureza*, 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.

4.1.11 Small- and medium-sized mammals (Soricomorpha, Lagomorpha, Rodentia, Procavidae)

Holger Meinig, Meheretu Yonas and Nicole Hermes

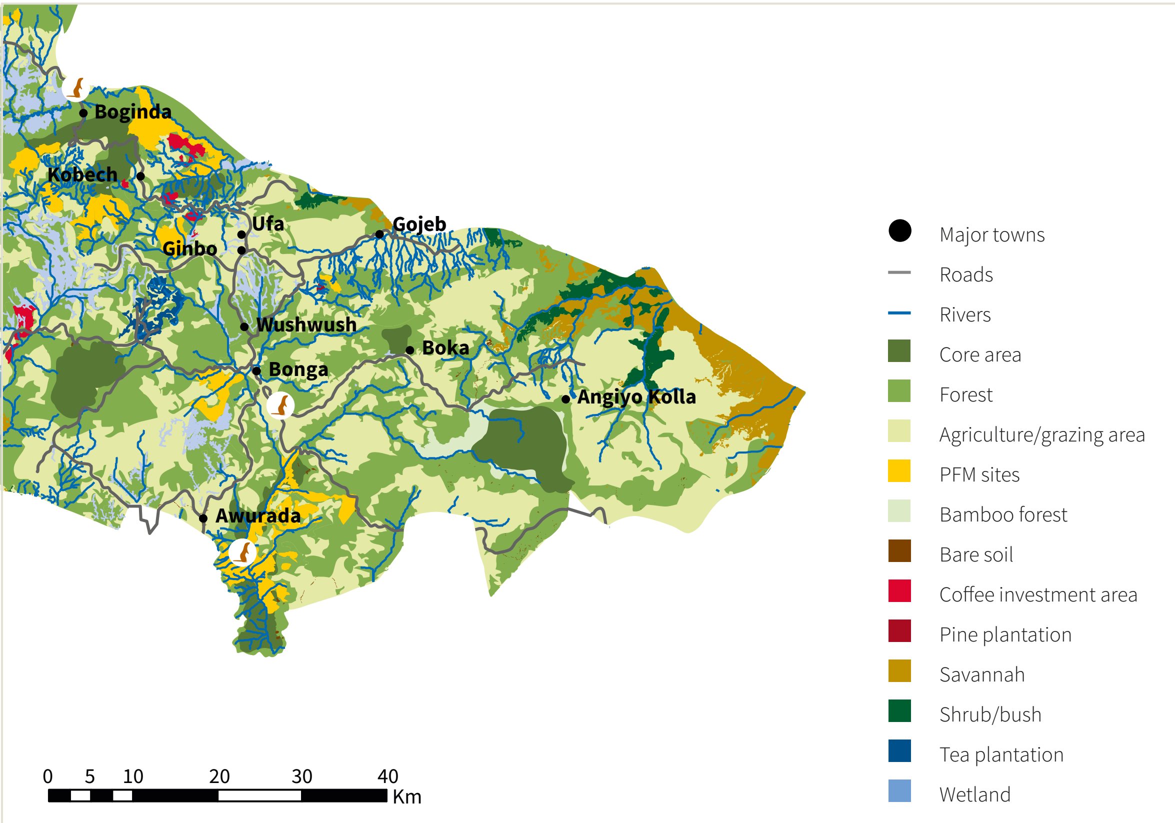

Figure 47: Sites sampled by the mammal (small- and medium-sized mammals) team at the Kafa Biosphere Reserve

Highlights

• The African pigmy mouse (Mus (*Nannomys*) mahomet), the Ethiopian hare (*Lepus* cf. *fagani*) and the Ethiopian meadow rat (*Stenocephalemys albipes*) are endemic to Ethiopia (the latter also occurs in neighbouring Eritrea).

• The forms of the East African mole-rat (*Tachyoryctes splendens* s.l.), brush-furred mouse (*Lophuromys flavopunctatus* s.l.), African marsh rat (*Dasymys* cf. *incomtus*) and Ethiopian vlei rat (*Otomys* cf. *typus*) encountered in this study could be endemic to Ethiopia, but this needs to be corroborated by genetic studies.

• The observed form of the Gambian sun squirrel (*Heliosciurus gambianus* ssp. (cf. *kaffensis*)) could also be an endemic subspecies or even entire species.

• The current study does not provide sufficient data to determine whether certain species are threatened or not.

• The wetlands surrounding the Gojeb River and adjacent habitats seem to be more species diverse than the other plots studied.

• The African clawless otter (*Aonyx capensis*) should be considered a flagship species. The species could be a good indicator for the status of river conservation and other natural/semi-natural waterbodies.

• Small mammals are sensitive to overgrazing and pollution from insecticides and herbicides as well as to intensification of agriculture in general. Regulations concerning future human land use should be implemented and controlled in order to protect their natural environment.

• Sewers should be constructed and maintained, particularly for villages in the wetlands and near streams, to prevent habitats from pollution from different sources.

4.1.12 Medium (esp. Carnivora and Artiodactyla) and large mammals

Hans Bauer

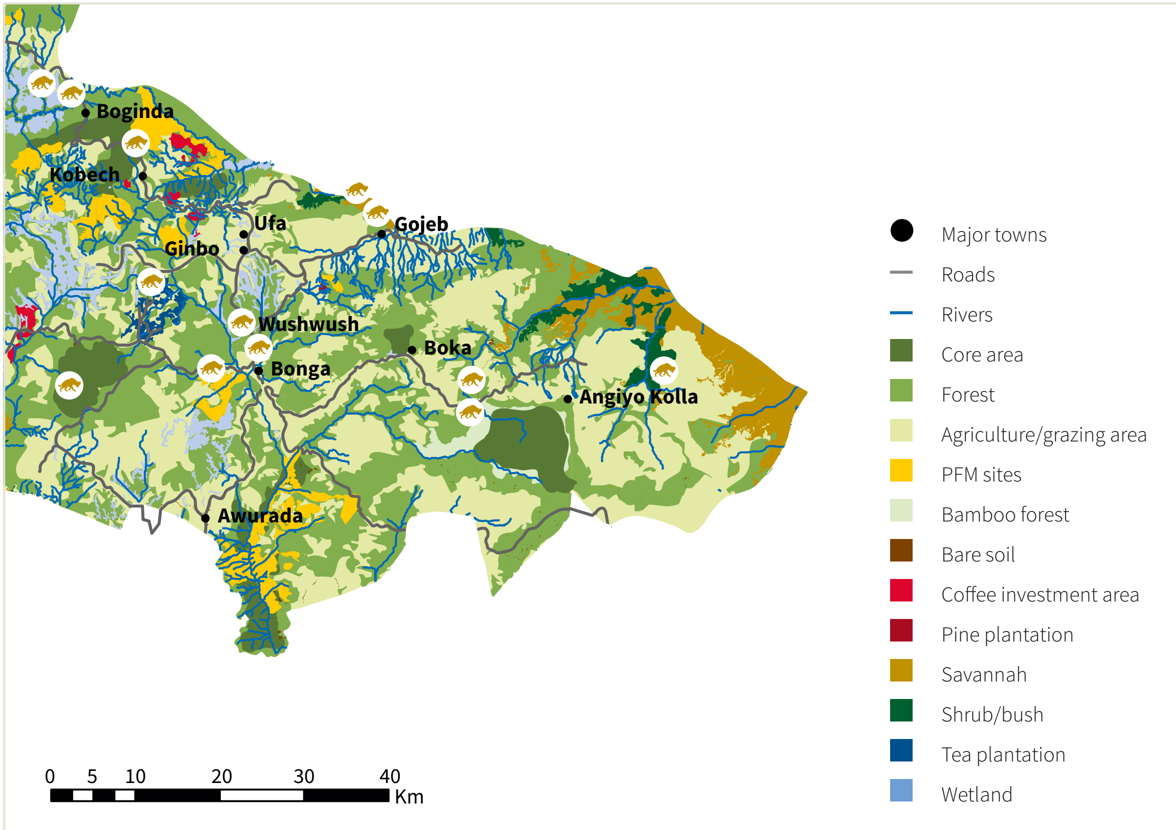

Figure 48: Sites sampled by the mammal (medium and large mammals) team at the Kafa Biosphere Reserve

Highlights

• 25 species were recorded.

• The presence of the endangered wild dog (*Lycaon pictus*) could not be confirmed; it is possible the species is locally extinct.

• The presence of lion (*Panthera leo*) was confirmed; this is the flagship species.

• Larger mammals are not useful as indicators of forest conservation status due to their very low densities.

• Camera trapping returned very low capture rates, indicating abnormally low mammal density. This should be confirmed and investigated.

• An additional survey six months later and on behalf of NABU revealed additional mammal species i.e. the leopard (*Panthera pardus*).

4.2 Results for indicator and flagship species

This section summarises the main results for indicator and flagship species and the threat analysis conducted for each species. In total, 29 indicator species and 18 flagship species have been identified and had their primary threats assessed based on expert knowledge. To facilitate a spatial interpretation of the results, the indicator species have been separated into three major habitat types: forest, wetlands and river areas. Many indicator species occur in more than one habitat type. 13 indicator species are also proposed as flagship species (see Tables 5 and 6).

4.2.1 Selection of indicator species

16 species have been selected for forested areas of the Kafa BR (montane, bamboo and floodplain forests): five tree species, four insect species, three bird species, two bat species and two fungus species.

The tree fern (*Cyathea manniana*), a giant fern forming very conspicuous patches in the dense forests, exclusively occurs in the montane forests, which qualifies it as an indicator species for this habitat. Similarly, the wild date palm (*Phoenix reclinata*) and the dragon tree (*Dracaena afromontana*) occur in the depressions (mostly) bordering waterbodies in dense montane and hilly dense forests, respectively. The endemic species *Pavetta abyssinica* is characteristic to the floodplain forests.

The four selected insect species belong to the Odonata group (dragonflies). All of them are endemic to the Ethiopian highlands. They are mostly present along freshwater bodies such as streams and small creeks in the montane forests. Ethiopia's endemic dragonflies are relatively tolerant to habitat disturbances, but they will nonetheless disappear if the damage to their habitats due to water pollution, water extraction and large-scale reforestation with eucalyptus continues. Thus, the montane forest gomphids Cottarelli's Longlegs (*Notogomphus cottarellii*) and Rüppell's longlegs (*Notogomphus ruppeli*) are particularly mentioned to be good indicators for the conservation status of the forests.

Of the nine selected bird species, three have been selected as indicators for the forest areas: the African crowned eagle (*Stephanoaetus coronatus*), which occurs along floodplains and in the montane forests, the white-cheeked turaco (*Tauraco leucotis*) and Sharpe's starling (*Pholia sharpii*). At present, these species are common and not threatened in Ethiopia, but they strongly depend on the existence of intact (montane) forests. The white-cheeked turaco is near endemic, Sharpe's starling is restricted to the canopy of high montane forests and thus not common throughout Africa. A decline in these currently common species would indicate a threat to their habitat.

Two bat and fungi species have been selected as indicators for forest areas. Of particular interest is the fruit bat *Rousettus lanosus* (long-haired rousette), which mostly occurs in the bamboo montane forests and in border zones. This species is very rare in lowlands and is restricted to East Africa, with only few records and observations in Ethiopia's neighbouring countries. The hammer-headed fruit bat (*Hypsignathus monstrosus*) is the largest African fruit bat, common in Central and West Africa, but rare in Ethiopia. It occurs along riversides or floodplain forests and is less present in montane forests.

Table 5: List of indicator species

Habitat type	Taxon	Scientific name	English name	Order
Wetland	Insect	*Altica* sp.	Not known	Coleoptera
River	Insect	*Pseudagrion guichardi*	Ethiopian sprite	Odonata
Wetland/river	Insect	*Orthetrum kristenseni*	Ethiopian skimmer	Odonata
River	Insect	*Notogomphus ruppeli*	Rüppel's longlegs	Odonata
River	Insect	*Atoconeura aethiopica*	Ethiopian Highlander	Odonata
River	Insect	*Notogomphus cottarellii*	Cottarelli's longlegs	Odonata
Montane forest	Fungi	*Sarcoscypha* spec. nov.	Red cup fungus	No Known
Bamboo				
forest	Fungi	*Cerinomyces bambusicola* spec. nov. ined.	Not known	Dacrymycetales
Wetland/flood-plain forests	Bat	*Hypsignathus monstrosus*	Hammer-headed fruit bat	Hypsignathus

Habitat type	Taxon	Scientific name	English name	Order
Bamboo forests and border zones	Bat	*Rousettus lanosus*	Long-haired rousette	Rousettus
Wetland	Bird	*Bugeranus carunculatus*	Wattled crane	Gruiformes
Wetland	Bird	*Balearica pavonia*	Black crowned crane	Gruiformes
Wetland	Bird	*Rougetius rougetii*	Rouget's rail	Gruiformes
Wetland	Bird	*Macronyx flavicollis*	Abyssinian longclaw	Passeriformes
River	Bird	*Alcedo torquata*	Half-collared kingfisher	Coraciiformes
River	Bird	*Podica senegalensis*	African finfoot	Gruiformes
Montane forest	Bird	*Stephanoaetus coronatus*	African crowned eagle	Falconiformes
Montane forest	Bird	*Tauraco leucotis*	White-cheeked turaco	Cuculiformes
Montane forest	Bird	*Pholia sharpii*	Sharpe's starling	Passeriformes
River	Molluscs	*Mutela rostrata*	Not known	Unionoida
Montane forest	Plant	*Cyathea manniana*	Giant tree fern	Cyatheales
Floodplain forest	Plant	*Pavetta abyssinica*	Not known	Gentianales
Montane forest	Plant	*Phoenix reclinata*	Wild date palm	Arecales
Montane forest	Plant	*Dracaena afromontana*	Dragon tree	Liliales
Forest	Plant	*Hippocratea africana*	Giant liana	Celastrales
Wetland/river/forest	Amphibia	*Afrixalus clarkeorum*	Clarke's banana frog	Anura
River/forest	Amphibia	*Leptopelis vannutellii*	Dime forest tree frog	Anura
Wetland/river/forest	Amphibia	*Leptopelis ragazzii*	Shoa forest tree frog	Anura
Montane forest	Primates	*Colobus guereza* ssp. *guereza*	Mantled guereza	Primates

The proposed fungi species are new records to science. *Cerinomyces bambusicola* spec. nov. ined is a saprophytic resupinate phleboid fungus which attaches to wood and grows in clumps. This fungus species is restricted to East African montane forests. According to available information, it only occurs in bamboo forests. The chosen species is *Sarcoscypha* spec. nov., which is a conspicuous red cup fungus which grows saprotrophically, mostly on fallen twigs of broad-leaved trees. It mostly occurs in montane forests and/or adjacent close forest habitats such as the PFM sites.

For the wetlands and river areas, six bird species were proposed as indicators. For the wetlands, the team selected the wattled crane (*Bugeranus carunculatus*), the black crowned crane (*Balearica pavonia*), Rouget's rail (*Rougetius rougetii*) and the Abyssinian longclaw (*Macronyx flavicollis*). For river areas, the team selected the half-collared kingfisher (*Alcedo torquata*) and the African finfoot (*Podica senegalensis*). All six species exclusively occur along wetlands, floodplains and riverine areas, and most are large and easy to recognise in the field.

Three frog species were chosen as indicators for wetlands, river and forests areas. The Shoa forest tree frog (*Leptopelis ragazzii*) is a relatively large tree frog endemic to montane areas of Ethiopia and lives in wetlands, river and forested areas influenced by waterbodies. The Dime forest tree frog (*Leptopelis vannutellii*) mostly occurs on trees along floodplain forests and/or forested areas near waterbodies. This large tree frog is endemic to the Ethiopian Highlands. It needs clear forest streams, but is less sensitive than *L. ragazzii* to slight habitat disturbances. Clarke's banana frog (*Afrixalus clarkeorum*) lives in different habitats, including floodplain forests, river areas and wetlands, but it is also present in human induced habitats such as crop fields and PFM sites. The aquatic (larvae) and terrestrial (adult) lifeforms can be detected in the axillae of false banana trees. However, the species is restricted to the Ethiopian Highlands.

The mollusc *Mutela rostrata* has been selected as an indicator for river areas. This species is a pan-African, sediment-dwelling, filter-feeding freshwater mussel will a shell up to 100 mm in size. Its larvae (Glochidia) parasitises on the gills of freshwater fish (exact species unknown). In Ethiopia, it has only been recorded in the lower Omo river basin.

4.2.2 Selection of flagship species

In addition to the mantled *gureza* (*Colobus guereza* ssp. *guereza*) and the coffee tree (*Coffea arabica*), which are already used as flagship species, 15 additional flagship species were identified for the Kafa BR (Table 6). They include four insect species (Odonata group), four bird species, three frog species, two mammal species (including primates) and two tree species.

For the dragonflies (Odonata), the Ethiopian Highlander (*Atoconeura aethiopica*), Ethiopian sprite (*Pseudagrion guichardi*), the Kaffa sprite (*Pseudagrion kaffinum*) and the Ethiopian skimmer (*Orthetrum kristenseni*) were chosen as flagship species. All of them mostly occur along wetlands, riverine areas and floodplain forests and to a lesser extent in adjacent areas such as PFM sites or secondary forests.

The Wattled Crane (*Bugeranus carunculatus*) and the Black Crowned Crane (*Balearica pavonia*) are bird flagship species for the wetlands. Both are characteristic of wetlands, large, attractive and easy to recognise. Wattled cranes are particularly rare in Ethiopia, with no contact to other populations of the species in Southern Africa. The African Crowned Eagle (*Stephanoaetus coronatus*) is a conspicuous bird species mostly present in forested montane areas. It is not restricted to Ethiopia, but also occurs in other Afromontane areas. The species can easily be distinguished by its call and observed when flying over forests.

The three chosen frog species are the Shoa forest tree frog (*Leptopelis ragazzii*), the Dime forest tree frog (*Leptopelis vannutellii*) and Clarke's banana frog (*Afrixalus clarkeorum*). They occur in wetlands, along rivers and in forest areas and are endemic to the Ethiopian Highlands.

For mammals, the African clawless otter (*Aonyx capensis*) was chosen as a flagship species. Due to their attractive appearance, otters are very popular in Europe and the United States and serve as an attraction to visitors in wetland and river areas. Otters were regularly observed in the Gojeb River. They are sensitive to water pollution and the destruction of dense vegetation structures on the banks of rivers and ponds, so they could potentially be good indicators of environmental status.

Table 6: List of flagship species

Habitat type	Taxon	Scientific name	English name	Order
Wetland/river	Insect	*Pseudagrion kaffinum*	Kaffa sprite	Odonata
Wetland/river	Insect	*Orthetrum kristenseni*	Ethiopian skimmer	Odonata
River	Insect	*Pseudagrion guichardi*	Ethiopian sprite	Odonata
River	Insect	*Atoconeura aethiopica*	Ethiopian highlander	Odonata
Wetland	Bird	*Bugeranus carunculatus*	Wattled crane	Gruiformes
Wetland	Bird	*Balearica pavonina*	Black crowned crane	Gruiformes
Montane forests	Bird	*Stephanoaetus coronatus*	African crowned eagle	Falconiformes
Montane forests	Bird	*Tauraco leucotis*	White-cheeked turaco	Cuculiformes
Montane forests	Mammal	*Panthera leo*	Montane forest lion	Mammalia
River	Mammal	*Aonyx capensis*	African clawless otter	Mammalia
Montane forest	Plant	*Phoenix reclinata*	Wild date palm	Arecales
Montane forest	Plant	*Dracaena afromontana*	Dragon tree	Liliales
Montane forest	Plant	*Coffea arabica*	Wild coffee	Rubiaceae
Wetland/river/forest	Amphibia	*Afrixalus clarkeorum*	Clarke's banana frog	Anura
River/forest	Amphibia	*Leptopelis vannutellii*	Dime forest tree frog	Anura
Wetland/river/forest	Amphibia	*Leptopelis ragazzii*	Shoa forest tree frog	Anura
Montane forests	Primates	*Colobus guereza* ssp. *guereza*	Mantled guereza	Mammalia

The observations and recordings during the assessment confirmed the presence of lions (*Panthera leo*). The mammal experts recorded new evidence such as footprints in areas previously not known for lion appearances, thus helping to understand its distribution in the area. Future ecological and molecular studies may determine whether this lion is the same as the savannah lion. In any case, having the lion as a flagship species for dense montane forests is a particular highlight for Kafa, and deserves special attention.

The two tree species selected as flagships only occur in montane dense forests. The wild date palm (*Phoenix reclinata*) is an elegant and unique palm which forms several patches in dense forests. It is widely domesticated, but its growth behaviour and presence in nature exhibit a slightly different form, one which is very attractive to visitors. Due to its unique physiognomy and spectacular shape, the Afromontane dragon tree (*Dracaena afromontana*) is also an ideal flagship species which can be easily observed in the montane forests.

5. Conclusions on future Biodiversity Monitoring and Conservation Measures

The biodiversity assessment presented in this report lays the foundation for effective biodiversity monitoring in the Kafa BR. The selection of 29 indicator species and 17 flagship species will facilitate targeted analysis of major anthropogenic threats to species and their habitats. Once the key drivers of habitat destruction and species deterioration in the Kafa BR are known, conservation measures can be (re-)directed to protect the biodiversity of Kafa BR more efficiently. This chapter outlines preliminary recommendations for the design of the biodiversity monitoring and provides suggestions for practical conservation actions.

5.1 Monitoring indicator species

Monitoring should provide information on the abundance of each of the indicator species as listed in 4.2.2 within the Kafa BR. Different methods need to be applied to different groups of species.

For the plant species (mainly *Cyathea manniana*, *Pavetta abyssinica*, *Phoenix reclinata Dracaena afromontana*, *Hippocratea africana*), monitoring can rely on observations by local community members and rangers in the BR, since all species are well known and easy to identify (see e.g., Danielsen et al. 2000). We suggest developing monitoring questionnaires for regular interviews (e.g., twice a year). The questionnaires should be filled out by rangers and used for interviews with locals who regularly access the relevant areas. For each species, changes in their abundance and the presumed reasons for this change should be investigated. Similar methods could be applied to mammal and bird indicator species that are locally well known. Seasonal variations in species visibility need to be taken considered, e.g., for acoustic monitoring of bird species.
Insects, amphibians and fungi can probably only be monitored when relevant experts visit the BR for a general monitoring e.g., every two years. It will be challenging to obtain robust data on abundance over time by direct monitoring.

5.2 Site monitoring

Monitoring can also be carried out through regular site visits and assessments by the BR rangers, particularly at sites which were part of this biodiversity assessment. Rangers should use the same site reporting forms that were designed for this assessment to ensure comparability with earlier visits. Additional sites may be identified and involved in the comparative assessment over longer periods. Site monitoring focuses on a broader range of species and threats and may therefore deliver more integrated information, complementing the information collected in the assessment thus far.

5.3 Identifying and monitoring major threats

Participants in this assessment discussed the major threats facing the Kafa BR, especially to indicator species and their habitats. Combined with existing knowledge and information on threats, some preliminary indications on threats can now be presented here. For forest species, the most obvious threats are deforestation, habitat fragmentation and forest/habitat degradation. Deforestation and habitat fragmentation are often monitored via remote sensing techniques. Rough information on canopy changes may also be obtained from, e.g., Global Forest Watch (GFW); however, for accurate monitoring internal analyses based on satellite imagery might be necessary. Degradation is more difficult to monitor. Remote sensing is generally unable to deliver the required data accuracy for the canopy. It may, however, be helpful for detecting small paths that are established for hunting or selective logging. One alternative to remote sensing is to develop a system based on the causes of degradation, such as fire, use of timber/fuelwood or coffee planting in natural forests. At Kafa BR a motioning has been developed by NABU's subcontractor, the Wageningen University. In addition to assessing reference emissions levels and estimating project impact on CO2 emissions, this monitoring also featured innovative ground-based monitoring with smartphones, where activity data continuously collected by the BR rangers were fed into an integrated monitoring system with WebGIS .

For wetlands and river species, the main threats are drainage activities, agricultural run-off and fertiliser, along with domestic and urban waste. Direct monitoring of these threats could entail regular measuring of water levels in wetlands/rivers and chemical analyses of water quality at critical sites. Such analyses may be part of the site monitoring (see above). Critical sites can be identified through interviews with locals conducted by rangers, asking about, e.g., patterns in fertiliser use. Other activities which potentially threaten specific species such as harvesting fuelwood or hunting should be included in regular monitoring efforts. A general analysis of the most pressing demands on natural resources such as timber extraction of slash and burn agriculture could also be useful. On behalf of NABU, geoSYS conducted the mapping and analysis of wetlands and rivers at Kafa BR. The pilot wetlands Gojeb and Alemgono were thoroughly studied according to their ecological status, threats and needs for conservation (see Dresen et al. 2015). Therefore, the results of this study should be taken into account for the future monitoring of the wetlands at Kafa BR.

5.4 Conservation measures

Basic protection of habitats is already established in the Kafa BR through the definition of zones with different restrictions and associated control mechanisms such as patrolling, etc. However, these measures are not necessarily effective, particularly outside the core zone. Conservation can therefore also be achieved by directly tackling critical threats and, more specifically, the uses of natural resources that are related to these threats. Deforestation and fragmentation may be reduced by restricting the expansion of agriculture in forested areas and, at the same time, increasing the sustainability of existing agricultural land use, for example by promoting agroforestry, with coffee as the primary product. Improving cultivation techniques for annual crops such as corn may also help reduce the need for further expansion.

Degradation is mainly caused by the extraction of fuelwood and timber. Efficient cooking stoves such as Mirt stoves which have been tested and introduced to selected households by NABU help reduce the demand for fuelwood. Further promotion of PFM sites and related capacity building provides a sustainable supply of both timber and fuelwood. Raising awareness about possible alternative tree species for fuelwood and timber could also reduce the pressure on primary forests. Water-related threats may be targeted by providing technical support for irrigation systems, wastewater treatment and fertiliser management.

To be successful, all these measures need to be planned and implemented by the local communities. Therefore, a common understanding and agreement about the major threats to biodiversity among the inhabitants is crucial. This can be achieved via participatory appraisals for joint planning of conservation and sustainable livelihoods as conducted by NABU for BR planning purpose, PFM planning or the community-based watershed management programme.

Moreover, awareness creation amongst the local community members on threatened fauna and flora is crucial for an effective monitoring. NABU has implemented a number of community awareness creation programmes in the past in Kafa BR which may be taken as a reference.

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Detailed reports

Vascular plants at the Kafa Biosphere Reserve

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Highlights

→ Although there are data for a transitional bamboo-montane forest at Boka, this is the first quantitative study of the vegetation in the Kafa BR bamboo forests, along with the wetland and riverine forest patches.

→ In total, 154 vascular plant species were recorded.

→ Seven endemic species were recorded: *Aframomum corrorima, Bothriocline schimperi, Clematis longicaudata, Erythrina brucei, Millettia ferruginea, Tiliacora troupinii, Vepris dainellii.*

→ 16 species are endangered or threatened: *Bothriocline schimperi* (LC), *Dracaena afromontana* (LC), *Erythrina brucei* (LC), *Ficus ovata* (LC), *Millettia ferruginea* (LC), *Parochetus communis* (LC), *Phaulopsis imbricata* (LC), *Vepris dainellii* (LC), *Canthium oligocarpum* (NT), *Coffea arabica* (VU), *Maytenus arbutifolia* (VU), *Ocotea kenyensis* (VU), *Pavetta abyssinica* (VU), *Prunus africana* (VU), *Tiliacora troupinii* (VU), *Cyathea manniana* (NT).

→ The Afromontane forests are more species-diverse than the bamboo forest and wetlands. The latter, however, display high heterogeneity of habitats, thus increasing overall diversity.

→ The floodplain forests and wetlands feature a higher diversity of plant species than Afromontane Participatory Forest Management (PFM) sites. Therefore, establishing core zones in the wetlands/ floodplain forests would be advisable. More research is needed in this still poorly investigated habitat to extend species lists and investigate potential threats.

→ The natural Afromontane forests show higher species diversity than the PFM Afromontane forests, as well as being home to considerably more species with high IVI values than the PFM sites. PFM techniques seem to decrease the natural regeneration of trees, resulting in a very low rate of species turnover.

→ *Coffea arabica*, *Phoenix reclinata* and *Dracaena afromontana* are the flagship species.

→ *Cyathea manniana*, *Dracaena afromontana* and *Hippocratea africana* are indicator species for primary montane forests susceptible to disturbances.

→ *Pavetta abyssinica* and *Phoenix reclinata* are indicator species for floodplain forest and wetland forest patches.

→ There is an urgent need for further investigation of other areas omitted from this assessment. For example, the western part of the reserve (Gesha and Bita areas) has complex patches of high-land wetlands which certainly differ both structurally and compositionally from the investigated wetlands. The potential for discovering species new to science here is very high. Similarly, a huge, well-conserved patch of montane forest in the extreme northwest (Saylem) warrants detailed floristic study. At the other extreme, there is a lack of quantitative studies of the alpine vegetation northeast from Bonga (Adiyo), so more efforts are required in this area.

→ Given the extreme importance of wetlands in Kafa, it is vital to typify their functions, processes, biochemistry and composition to aid further investigation. Some wetlands could be even nominated as Ramsar sites once sufficient information is available.

→ Our results show that montane PFM sites exhibit lower diversity than the surrounding natural montane forests; therefore, there is an urgent need to investigate the vegetation (composition, diversity and ecology) at a spatial scale over time at both sites.

1. Introduction

Kafa BR is home to the last surviving moist evergreen montane forests in Ethiopia, which form part of the Eastern Afromontane Biodiversity Hotspot (Mittermeier et al. 2004). The wild coffee tree, *Coffea arabica*, is indigenous to the understorey of Kafa's natural montane forest, and in some areas is harvested wild without management. In other areas, wild coffee is harvested in forest fragments where farmers cut and thin out parts of the upper canopy and annually slash the forest understorey on Participatory Forest Management (PFM) sites. This form of forest maintenance is believed to be sustainable for the natural forest vegetation in terms of structural vegetation. However, the degradation in PFM sites still needs to be evaluated, as understorey slashing hampers regeneration. In recent decades, human pressure on forest resources in Ethiopia has increased, destroying a significant part of Ethiopia's forest resources.

Large swaths of Kafa's forest resources are already dwindling due to deforestation for timber extraction, conversion to agricultural land and the establishment of plantations. This ongoing trend threatens both the genetic resources of the wild coffee tree but also the remarkable floristic diversity of the area in general. A study found higher species richness in PFM sites where wild coffee is collected and vegetation is cut and slashed. This can be explained by the fact that ruderal herbs, climbers and pioneer species are adapted to regeneration in disturbed habitats. In contrast, typical forest species requiring shade and humidity, mainly tree species, have declined in both number and abundance (Denich & Schmitt 2006). Typical climax vegetation species, including some Afromontane endemics, have considerably decreased, including *Elaeodendron buchananii*, *Pouteria adolfi-friederici*, *Prunus africana*, *Macaranga capensis*, *Ilex mitis* and *Olea welwitschii*. In contrast, pioneer species such as *Croton macrostachyus*, *Millettia ferruginea* and *Albizia gummifera* dominate the disturbed PFM forest (Aerts et al. 2011). Tree ferns (*Cyathea manniana*) and the Rubiaceae Psychotria orophila are also less abundant in disturbed areas and are therefore mainly found in natural forests (Schmitt et al. 2009).

The few existing vegetation studies (Aerts et al. 2011; Denich & Schmitt 2006; Gobeze et al. 2009; Schmitt et al. 2009; Tadesse et al. 2014a, 2014b) have mainly concentrated on the PFM sites with *Coffea arabica* (see Figure 3) in the undergrowth and therefore on disturbed habitats. These studies conclude that anthropogenic interference has homogenised the natural vegetation. Therefore, we sought to study the differences in species composition in different habitats, both disturbed and undisturbed habitats such as primary forests in the core zone of the biosphere reserve.

A dense bamboo forest (Figures 4 and 5) with very low species diversity can be found at a height of between 2400 and 3050 m a.s.l. in Bonga, but not in Boginda. It is dominated by bamboo (*Arundinaria alpina*), but species like *Hagenia abyssinica* (Figure 7) and *Schefflera volkensii* (Figure 8) are also found within the bamboo stands at high elevations (Nune 2008). This type of vegetation has no shrub layer. Bamboo is commonly used by local communities to construct houses and make utensils (Chernet 2008). A literature review of Kafa studies clearly shows that wetlands are regularly cited as being important habitats, but no further studies were conducted there.

In fact, few comprehensive floristic studies have been conducted in the area. A rapid biodiversity assessment was carried out in the Kafa Zone (EWNHS 2008a) with special emphasis on the Mankira, Saja and Boka forests. Based on an initial and detailed landscape characterization using Landsat Thematic Mapper (TM) satellite images, the study first classified the main units of analysis into land use/land cover classes. The plant inventory was carried out in verified vegetation types at each forest in Saja, Mankira and Boka. This assessment focused mainly on forested areas, employing a measure of presence/absence along with qualitative methods, and considering woody plants above 5 cm diameter at breast height, herbs/lianas and ferns. We recorded 244 plant species from 77 families throughout the three forest sites. Of the 244 recorded species, 26.6% were trees, 27.9% were shrubs, 8.6% were climbers, 27.5% were herbs, 2.9% were epiphytes and 1.2% were grasses. The most abundant species in the Saja forest are *Oxanthus speciosus*, *Dracaena fragrans* and *Macaranga capensis*. The most abundant species in the Mankira forest are *Dracaena fragrans*, *Coffea arabica* and *Chionanthus mildbraedii*. In the Boka forest, bamboo (*Arundinaria alpina*) and *Schefflera volkensii* are dominant, with some understorey shrubs and herbs (EWNHS 2008a).

In 2008, on behalf of GIZ, NABU and GEO, the EWNHS published the report "Baseline Survey on Land Use & Socio Economic, Flora and Fauna Biodiversity Status of Bonga, Mankira and Boginda Forests in Kafa Zone" (2008b). Although this study classified seven major uses of land, the floristic inventories mainly focused on forested areas. Using transects and quadrates as sampling methods, the assessment recorded about 92 tree/shrub/liana species with a diameter of more than 10 cm at breast height across the three study sites. The Bonga area was the richest site with 70 species, followed by Boginda with 54 species and Mankira with 46 species. Bonga forest has the highest density of trees with a diameter of more than 10 cm followed by Boginda forest and Mankira forest (Nune 2008). The floristic composition of three sampled sites shows high heterogeneity of habitats. This is revealed by the lack of species shared by all three forest sites, indicating that each forest has a heterogeneous species composition. The most prevalent species are *Croton macrostachyus* in Mankira and *Millettia ferruginea* in Bonga and Boginda Forest. No single tree or shrub species was found in every sample plot across all three study sites, despite being separated by only a few kilometres (Nune 2008). These results highlight the high diversity of habitats in the Kafa BR. This study also found heavy exploitation of *Cordia africana*, *Pouteria adolfi-friederici* and *Prunus africana*, which are reported as endangered species.

Various individual studies are also relevant here, for example the floristic surveys conducted by Schmitt et al. (2006) in areas near Bonga and the technical report on the diversity of woody species in Boginda Forest, conducted by the Forest Genetic Resources Conservation Project, a consortium formed by the GIZ and the Institute of Biodiversity Conservation and Research (IBCR) (GIZ 2011). Among them are at least 25 plant species which are endemic to Ethiopia, including *Erythrina brucei*, *Milletia ferruginea* (Figure 6), *Solanecio gigas*, *Hagenia abyssinica* (Figure 7), *Vepris dainellii* (Figure 9) and species such as *Milicia excelsa*, *Podocarpus falcatus* and *Prunus africana*, which are endangered according to the IUCN Red List and Ethiopia's and Eritrea's Red List, respectively.

According to the Institute of Biodiversity Conservation (2005) there are five main habitat types in Kafa Zone:

a) Sub-Afroalpine habitat: This habitat occurs at altitudes higher than 3200 m a.s.l. and covers only 0.3% of the total area of the Zone. This habitat is under severe threat due to agricultural expansion. Indigenous tree species such as *Hagenia abyssinica* are under high pressure.

b) Evergreen montane forest and grassland complex: This complex habitat occurs between an altitude of 1900 to 3300 m a.s.l. and cover 52.1% of the total area. It covers much of the highlands situated within the proposed buffer area of the BR. This habitat is generally highly populated and is also under pressure due to cereal-based agriculture.

c) Moist evergreen montane forest: The habitat occurs between 1500 and 2600 m a.s.l. and covers 26.1% of the total area of the BR. This type of forest is of global conservation significance due to the occurrence of wild *Coffea arabica* L. (Rubiaceae). In addition to deforestation for cereal-based agriculture, timber extraction is cause for great concern.

d) *Combretum-Terminalia* woodland: The IBC has probably mistakenly classified some areas of the Kafa BR as *Combretum-Terminalia* woodland, namely the coffee PFM sites in the Awurada Valley (Figure 12) and the bamboo forest. Figure 1 shows the mistaken classification (light green). Figure 2 shows the corrected habitat types in the BR as part of a land use/land cover map (Dresen 2014).

e) Wetlands: A complex system of wetland habitats occurs between 900 and 2600 m a.s.l. and covers 6.6% of the BR. These sensitive ecosystems are crucial for satisfying the basic human needs of the local communities (e.g., by providing materials for building shelter, grazing cattle, etc.). It is therefore also under intense development pressure.

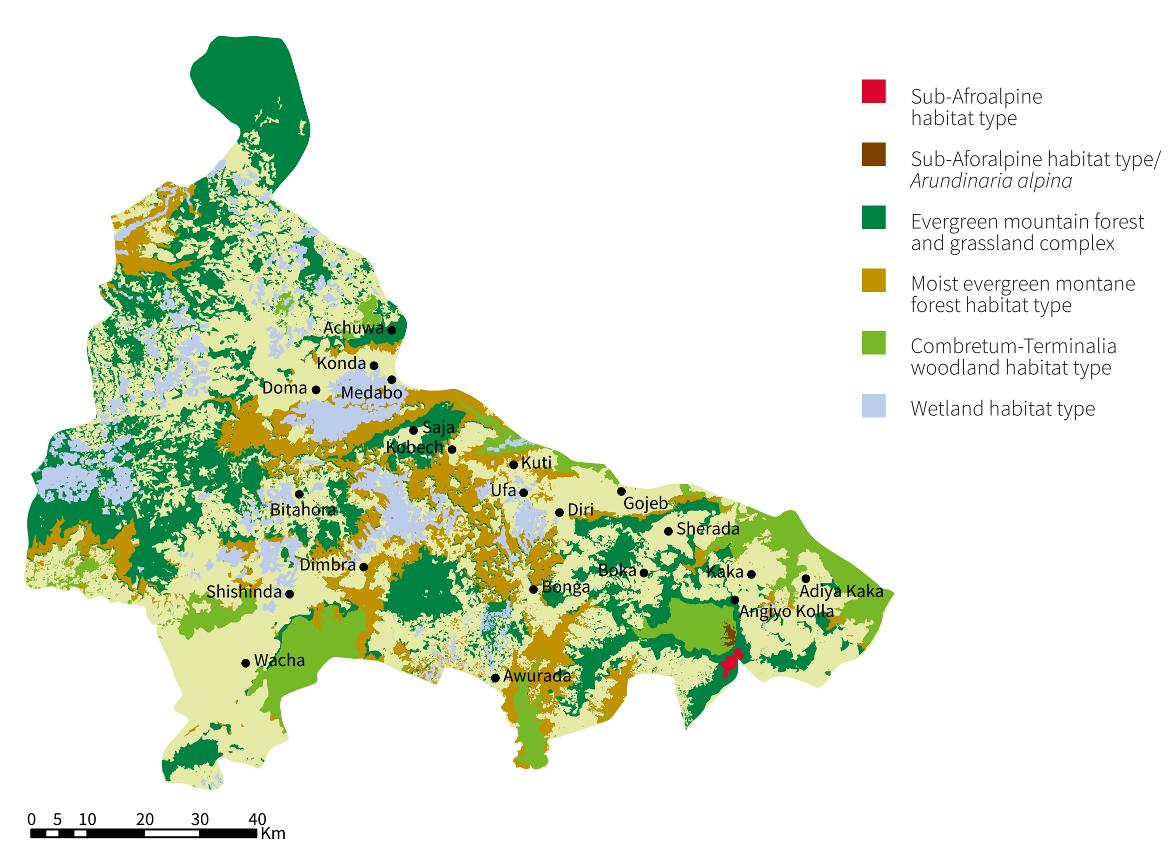

Figure 1: Habitat types in the Kafa BR according to the classification by the Institute of Biodiversity Conservation (IBC 2005), adapted by Elisabeth Dresen (2014)

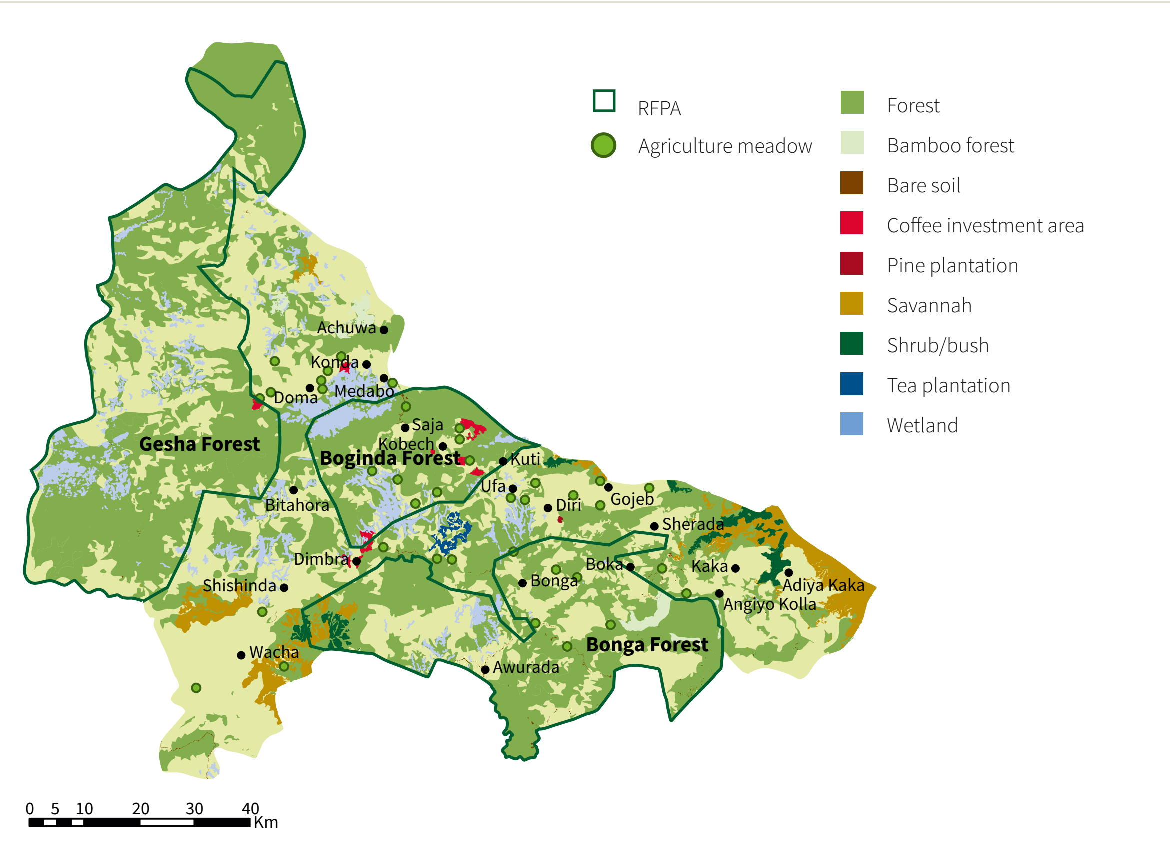

Figure 2: Regional Forest Priority Areas according to Million & Leykun (2001) (red lines) projected on land use and land cover at the Kafa BR. It shows the corrected habitat classifications for the bamboo forests, adapted by Elisabeth Dresen (2014)

2. Materials and Methods

2.1 Study area

The study areas were mostly core zones of the BR located around Bonga and the Gojeb Wetland, which is located approximately 80 km away from Bonga. The study included the following habitats: bamboo forests (BA), montane forests (Boka Forest (BK), Komba Forest (KO), Boginda Forest (BO), Awurada Valley (AW) (Figure 13)), wetlands (Alemgono (AG), Shoriri (SHO), Gojeb (GO-wet)) and river/floodplain forests (Gojeb River (GO-riv), Awurada Valley/Gummi River (AW)) (see Table 1).

2.1.1. Sites

We visited the Regional Forest Priority Areas within the Kafa BR proposed by Million & Leykun (2001), which were first created when the National Forest Priority Area was established in the 1980s. The authors suggest three priority areas in the Kafa zone: Bonga, Boginda and Gesha Forests. Following the main criteria for selecting sampling sites, we have assigned the Bonga and Boginda Forests high priority and the Gesha Forest medium to low priority. Due to time constraints, we only assessed the Bonga and Boginda Forests.

Table 1: Study areas in Bonga and Boginda

Area	Site	Code	Habitat	Alt.	Lat.	Long.
BONGA	Bamboo Forests	BA	Bamboo forests dominated by *Arundunaria alpina*	2700	07°14'10.8''	36°28'03.8''
BONGA	Komba Forests	KO	Montane forests	1900	07°18'10''	36°03'50''
BONGA	Boka Forests	BK	Montane forests	2500	07°17'51.6''	36°22'28.1''
BONGA	Awurada Valley (Gummi River, PFM sites)	AW	Montane forests/ riverine vegetation	1550	07°05'18.0''	36°13'05.9''
BONGA	Alemgono	AG	Wetland	1700	07°21'27.2''	36°14'18.1''
BONGA	Shoriri	SHO	Wetland	1630	07°21'34.2''	36°12'24.4''
BOGINDA	Gojeb Wetland	GO-wet	Wetland	1600	07°33'13.6''	36°02'99.4''
BOGINDA	Gojeb River	GO-riv	River/floodplain forests	1550	07°37'04.5''	36°03'10.5''
BOGINDA	Boginda Forests	BO	Montane forests	2100	07°30'01.1''	36°05'29.8''
BONGA	Keja Araba (PFM sites)	KE-AB	Montane forests	1850	07°16'39.8''	36°10'10.2''
BONGA	Beta Chega (PFM sites)	BE-CH	Montane forests	2100	07°17'54.7''	36°05'46.9''

Boginda and Bonga

Ecologically important areas – nearly intact forests

Bamboo forests

This extensive and unique vegetation within the BR occurs at altitudes between 2400 and 3050 m a.s.l. and is characterised by bamboo undergrowth, either in pure stands or in mixture with trees, including *Hagenia abyssinica* (Figure 7), *Myrsine melanophloeos* and *Hypericum revolutum* (Bekele 2003). A very large and unique patch of bamboo forest is located in the Woreda Adiyo, in the eastern part of the reserve.

Montane forests

See description of the main habitats in the BR. The following woredas were selected: Decha, Tello, Gimbo and Chena (Bonga Forest) and Gawata (Boginda Forest).

Wetlands

Based on NABU's pilot projects wetland sites, three sites were selected: Alemgono, Gojeb (see Figure 14) and Shoriri Wetlands. Constantly low air pressure and high precipitation rates (2000 mm annually) over an area of 26,832 ha have led to highly diverse wetlands, which have not been sufficiently studied. According to the Kafa Wetland Strategy (EthioWetlands and Natural Resources Association 2008), the wetlands include river margins, peatlands, riparian zones, extensive floodplains and alluvial plains, marshes/swamps and forest wetlands. They function as moisture and carbon reservoirs, and are an important part of supraregional river basins (for the Gojeb/Omo, Baro-Akobo Rivers and others).

2.1.2 PFM sites

The first PFM sites were established in the Kafa Zone in 2002. PFM is a forest management concept that uses particular techniques and processes in combination with state forest departments and local communities. PFM attaches particular relevance to local community education and their key role as forest managers. Thus, local knowledge and participation are crucial to the successful management and sustainability of PFM sites. To date, Kafa has approximately 15,000 hectares of PFM sites distributed mainly across montane forests in the Gawata, Decha and Gimbo woredas, with about 12,000 members (Dresen 2011). These areas cover the main biosphere reserve zones.

Our floristic assessments sampled the Ufa PFM site, which covers 1208.03 hectares and has 602 members. The site is located in Decha woreda and provides a transition to the floodplain area formed by the Gummi River. We also sampled the Keja-Araba and Beta Chega PFM sites. The former has 1,474.20 hectares and 620 members, and there is no data for the latter site.

2.2 Sampling methods

As we knew very little about the studied area and were working to a limited timeframe, we used a simple random sampling strategy. In most habitats, established 10x100 m (1000 m²) transects. Longer transects were not possible due to topographical limitations. The distances between transects varied: the smallest gap was 300 metres, but most were separated by more than 500 meters. In the very dense bamboo forest we used square plots (20x20 m). We sampled the major habitats in the Kafa BR. We established 16 transects in montane forests, covering 14000 m² (BO, 6000 m2; BK, 2000 m²; KO, 6000 m²). We set up five transects in montane forest PFM sites (5000 m²: AW, 3000 m² (Figure 12); KE-AB, 1000 m²; BE-CH 1000 m²). In floodplains/riverine forests we conducted nine transects (9000 m²: SHO, 3000 m²; GO-riv, 4000 m²). In the wetlands we performed one transect (see Figure 14) (GO-wet, 1000 m²), while we set up nine transects in bamboo forests (BA, 3600 m²).

We measured the major vascular groups such as trees, shrubs and lianas. Any species with a diameter at breast height (DBH) equal to or above 2.5 cm occurring in the transect/plot counted as an individual and was therefore recorded (Figure 16). DBH was measured using metric tapes. The heights of all individuals in the transect/plot were measured using a clinometer and by estimation. In each transect/plot, some dominant herb species were also recorded to complement the species list. Unfortunately, our timeframe was too limited for a complete herb layer inventory. Local and scientific species names were recorded and specimens were collected. Unknown species were herbarised (Figure 15) and either identified in the evenings with the help of the different editions of the flora of Ethiopia and Eritrea (Edwards et al. 1995, 1997, 2000; Hedberg et al. 1989, 2003, 2006) or were sent to the national herbarium at Addis Ababa University for identification. We also recorded general site information (site name, kebele, woreda, coordinates, altitude, habitat type, topography, reserve zone).

2.3 Data analysis

Plant species were identified with the flora of Ethiopia and Eritrea (Edwards et al. 1995, 1997, 2000; Hedberg et al. 1989, 2003, 2006) in the field and at the national herbarium at Addis Ababa University.

The floristic composition was evaluated by using the species Importance Value Index (IVI) (Curtis & McIntosh 1951), which summarises relative species density, dominance and frequency. Large numbers of small trees or unequal distributions of individual plants and species per plot do not affect the IVI. Species richness and various alpha-diversity coefficients were calculated for each plot and transect. Most of these, such as the Simpson and Shannon indices, have been widely used in tropical montane habitats. All data was entered into Excel and analysed in Excel and PAST (Hammer et al. 2001).

3. Results and Discussion

Overall, we assessed 30 1,000 m² transect and nine 400 m² plots with a total area of 3.3 ha. We recorded 154 plant species from 114 genera and 61 families. Of the 154 recorded plant species, 129 species were woody, of which 20 were climbers, 39 shrubs and 70 trees. We also collected 25 herbaceous species (18 herbs, five grasses, one fern) that were dominant in the understorey (see Table 4).

Table 2: Diversity indices for the different sampling sites

	Bamboo	PFM sites			Montane forest			Floodplain forest			Wetland
	BA	AW	BE-CH	KE-AB	KO	BK	BO	GO-riv	SHO	AG	GO-wet
Number of plots	9	3	1	1	6	2	6	4	3	3	1
Size (ha)	0.36	0.3	0.1	0.1	0.6	0.2	0.6	0.4	0.3	0.3	0.1
Species richness	6	24	27	14	60	27	72	50	33	32	21
Individuals in total	7,777	1,440	960	480	768	710	1,338	992	816	797	810
Dominance_D	0.99	0.32	0.09	0.24	0.06	0.07	0.05	0.14	0.09	0.17	0.16
Simpson_1-D	0.01	0.68	0.91	0.76	0.94	0.92	0.95	0.86	0.91	0.83	0.84
Shannon_H	0.04	1.91	2.8	1.94	3.24	2.82	3.47	2.77	2.74	2.27	2.31

The Simpson_1-D index measures species diversity within a community. The diversity is highest in Boka (BK), Boginda (BO) and Komba (KO) Forests (see Table 2), while the diversity is very low in the bamboo (BA) forest. The Simpson index is the complement of the dominance index, Dominance_D. The very high Dominance_D value for the bamboo forest (close to 1) shows that diversity is considerably low. The inverse is true for the three montane forests Boka (BK), Boginda (BO) and Komba (KO). The Shannon_H index shows a similar trend. Shannon's index accounts for both abundance and evenness of species. Again, the montane forests at Boka, Boginda and Komba show the highest values.

Our results show that diversity and evenness are much higher in undisturbed habitats (primary rainforest) than disturbed habitats (PFM sites) and the wetland and floodplain habitats. The lowest diversity is exhibited in the very dense bamboo forest, as it this is mainly dominated by a single species: bamboo (*Arundinaria alpina*). The primary rainforest is not only home to a greater number of species, but the individuals in the community are distributed more equally among these species.

Interestingly, diversity indices are also high in the wetlands (Alemgono (AG), Shoriri (SHO), Gojeb (GO-wet, Go-riv)). The Simpson and Shannon indices are both higher in the wetlands and floodplain forests than in the montane forest and PFM sites in Awurada (AW) and Keja Araba (KE-AB). This supports the hypothesis that PFM sites are degrading. The high diversity of plant species in the wetlands shows that is worth establishing core zones there.

To assess the relative dominance of species in our forest communities, we calculated an Importance Value Index (IVI). We calculated the overall IVI across all transects/plots (see Table 3) and a separate IVI for each site (see Table 3) to reflect different habitat types. The IVI is an essential tool for comparing the ecological significance of species within a habitat (Lamprecht 1989).

To generate an IVI ranking, all woody species registered were grouped into five IVI classes based on their total IVI values (Table 3). Species in the fifth IVI class (lowest IVI values) need high conservation efforts, while those in the first IVI class (highest IVI values) are considered stable. Based on this ranking, the following species were assigned the highest priority for conservation efforts: The climbers *Asparagus africanus*, *Clematis longicaudata*, *Ipomoea tenuirostris*, *Peponium vogelii*, *Tacazzea conferta*, *Oncinotis tenuiloba* and *Periploca linearifolia*, the shrubs *Myrsine africana*, *Piper umbellatum*, *Rumex abyssinicus*, *Lantana trifolia*, *Ocimum urticifolium*, *Ocimum lamiifolium*, *Clerodendrum myricoides*, *Triumfetta brachyceras* and *Rhamnus prinoides* and the tree *Diospyros abyssinica* (Table 5).

Species with the highest IVI are generally abundant, frequent and dominant in the forest (Curtis & McIntosh 1951). The following species received the highest IVI and hence require less conservation effort: *Arundinaria alpina*, *Olea welwitschii*, *Schefflera volkensii*, *Millettia ferruginea* (see Figure 6), *Phoenix reclinata*, *Croton macrostachyus*, *Syzygium guineense* subsp. *afromontanum*, *Coffea arabica*, *Schefflera abyssinica*, *Ficus sur*, *Elaeodendron buchananii*, *Vepris dainellii*, *Chionanthus mildbraedii*, *Sapium ellipticum*, *Dracaena steudneri*, *Ficus ovata*, *Mimusops kummel*, *Macaranga capensis*, *Trilepisium madagascariensis*, *Galiniera saxifraga*, *Ocotea kenyensis*, *Ilex mitis*, *Bersama abyssinica*, *Allophylus abyssinicus*, *Pouteria adolfi-friederici*.

Table 3: Importance Value Index (IVI) for all recorded species per habitat

Species	Floodplain forest			Wetland	Montane forest			Montane forest, PFM			Bamboo forest
	AG	GO-riv	SHO	GO-wet	BK	BO	KO	KE-AB	BE-CH	AW	BA
Acacia brevispica Harms						0.7					
Albizia grandibracteata Taub.			5.7	5.9						7.3	
Albizia gummifera (J.F.Gmil.) GA.Sm.	2.6			6.8		1.5	2.9				
Allophyllus abyssinicus (Hochst) Radlk.					23.1	5.6	4.4		6.6		
Apodytes dimidiata E. Mey. ex Arn.		1.4				5.5					
Arundinaria alpina K. Schum.											215.4
Asparagus africanus lam.				5.8							
Bersama abyssinica Fresen	16.2	6.7	4.7		3.3	3.7	1.0		4.9	3.2	
Bothrocline schimperi olivi & Hiern.			2.4								
Brucea antidysenterica J. F. Mill		1.7	2.3				1.0				
Canthium oligocarpum Hiern							2.0	9.7			
Cassipourea malosana (Baker) Alston		2.0									
Celtis africana Burm. f.							1.1			15.7	
Chionanthus mildbraedii (Gilg & Schellenb.) Stearn	2.6	12.5	10.4		3.3	12.8	7.8			5.7	
Clausena anisata (Willd.) Hook.f. ex Benth.					3.3	4.7	1.0		7.0		
Clematis longicaudata Steud ex A. Rich.						0.7					
Clerodendrum myricoides (Hochst) Vatke		1.4									
Coffea arabica L.	2.7	4.4	7.0			3.0	2.5	15.6	5.8	62.1	
Combretum paniculatum Vent.		3.3	2.3				1.0		4.8		
Cordia africana Lam.		2.6	5.8	5.9			2.8			2.7	
Croton macrostachyus Del.	24.1	7.4	36.2	9.7		15.9	8.9		8.5	8.0	
Cyathea manniana Hook.							1.0				
Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. ex Wild & Drummond					8.0	0.7					
Cyphostemma sp.						2.4					
Dalbergia lactea Vatke							1.0				
Deinbollia kilimandscharica Taub.		1.4				0.9					
Diospyros abyssinica (Hiern) F. White						0.7					
Dombeya torrida (J.F.Gmel.) Bamps					3.3						
Dracaena afromontana Mildbr.						1.2	4.7				
Dracaena fragrans (L.) Ker Gawl.			2.4	8.4			1.0		4.8	3.4	
Dracaena steudneri Engl.	7.3		66.5	8.4		0.7	3.7		6.2		
Ehertia cymosa Thonn.		1.7	10.5	14.2		2.6	2.4				
Ekebergia capensis Sparm	6.2						2.4			3.3	
Elaeodendron buchananii (Loes.) Loes.		29.2	2.4			3.9	9.0			17.1	
Embelia schimperi Vatke					12.9						6.0
Erythrina brucei Schweinf.	3.1										
Erythrococca trichogyne (Muell Arg.) Prain	3.6					2.9	1.0				
Euphorbia candelabrum Kotschy						0.8	1.0				
Ficus exasperata Vahl	2.6		7.2			2.7	1.0				
Ficus lutea Vahl	2.9	4.7									
Ficus ovata Vahl	2.6					3.5	2.9			31.7	
Ficus plamata Forssk.	3.1					1.5					
Ficus platyphylla Del.	6.7	6.4									
Ficus spec	2.6				9.2	4.0	3.6		8.8		

Species		Floodplain forest		Wetland		Montane forest			Montane forest, PFM		Bamboo forest
	AG	GO-riv	SHO	GO-wet	BK	BO	KO	KE-AB	BE-CH	AW	BA
Ficus sur Forssk.		12.4				4.3	1.0			33.1	
Ficus thonningi Blume		1.4				0.7			4.8		
Ficus vasta Forssk	12.6										
Galiniera saxifraga (Hochst.) Bridson	3.1	3.4	2.4		14.7	10.9	3.0	9.3	9.4		
Hagenia abyssinica (Bruce) J.F. Gmel.					3.3						7.5
Hippocratea africana (Willd.) Loes.						1.3	1.0				
Hippocratea goetzei Loes.	3.1	5.0	4.7		9.0	4.6	1.0		5.8		
Ilex mitis (L.) Radlk.		4.6	2.3		5.0	12.9	1.0	25.4			6.0
Ipomoea tenuirostris chelsy						0.7					
Jasminum abyssinicum Hochst. ex DC.		1.4			4.0						
Justicia schimperiana (Hochst. ex Nees) T. Anders		1.4					1.0				
Landolphia buchananii (Hallier f.) Stapf		3.7	2.3	5.8		6.6	2.0				
Lantana trifolia L.						0.7					
Lepidotrichilia volkensis (Gurke) Leory.		1.4	4.2		13.7	5.2	2.5		27.4		6.2
Macaranga capensis (Baill) Sim	45.0					11.8	3.3	9.2			
Maesa lanceolata Forssk.		3.4	5.6	7.4	15.2	4.6	2.0				
Maytenus arbutifolia (A. Rich.) Wilczek	2.7					10.8					
Maytenus graulipes Loes.			2.3				1.0				
Maytenus spp.					12.5	3.9			4.8		
Millettia ferruginea (Hochst.) Bak.	35.4	8.2	11.7	17.4		15.6	21.2	9.9	31.9	6.8	
Mimusops kummel A.DC.		39.2								20.3	
Myrsine africana L.					3.3						
Ocimum lamiifolium Hochst. ex Benth						0.7					
Ocimum urticifolium Roth						0.7					
Ocotea kenyensis (Chiov.) Robyns & Wilcze							1.0	138.6			
Olea welwitschii (Knobl) Gilg&Schellenb.					3.3	3.3	82.4		38.5	10.4	
Oncinotis tenuiloba Stapf.		1.4									
Oxyanthus speciosus DC.	3.1	3.1	5.2	10.1		2.8	3.3				
Oxyanthus speciosus DC. ssp. *globosus* (Sond.) Bridson		8.4		5.8			2.2	18.4	4.8	2.9	
Pavetta abyssinica Fresen.		1.4		5.8							
Pavetta oliveriana Hiern					10.1	7.1					
Pavonia urens Cav.	2.6					0.7					
Peponium vogelii (Hook.f.) Engl.						0.7					
Periploca linearifolia Quart.-Dill. & A. Rich.					3.3						
Phoenix reclinata Jacq.	50.5	55.1	16.9	44.6			6.7			7.2	
Phyllanthus reticulatus Poir.		2.8									
Piper umbellatum L.			0.4								
Pittosporum virdiflorum Sims			2.4			1.3	3.2		4.8		
Podocarpus falcata R.Br.									37.7		
Polyscias fulva (Hiern.) Harms						1.9	12.9	10.8	15.2	8.6	
Pouteria adolfi-friederici (Engl.) Baehni			3.2			15.9	2.0			8.8	
Premna schimperi Engl.							1.0				
Prunus africana (Hook.f.) kalkm	3.1		2.4		3.3	9.1	1.0				
Rhamnus prinoides L'Herit.		1.4									

Species	Floodplain forest			Wetland	Montane forest			Montane forest, PFM			Bamboo forest
	AG	GO-riv	SHO	GO-wet	BK	BO	KO	KE-AB	BE-CH	AW	BA
Ricinus communis L.			2.4								
Ritchiea albersii Gilg		2.0									
Rothmannia urcelliformis (Hiern.) Robyns		1.4	3.3			5.5	2.9		4.8	3.0	
Rumex abyssinicus Jacq.						0.7					
Rytigynia neglecta (Hiern) Robyns						2.9	2.3	9.2	12.5		
Sapium ellipticum (Hochst.) Pax.	14.1	14.1		65.2			6.8			12.6	
Schefflera volkensii (Engl.) Harms					87.0						58.0
Scheffleria abyssinica (Hochst.ex A. Rich) Harrms					15.8	7.7	21.6	11.0			
Solanecio mannii (hook f.) C. Jeffery	2.7										
Spathodae Sps						2.1	2.0				
ssp. 1						0.8			4.8		
ssp. 10		0.2									
ssp. 11						0.8					
ssp. 12					4.7						
ssp. 13						1.4					
ssp. 14						1.0					
ssp. 15		1.4									
ssp. 16						1.6					
ssp. 17		1.7				0.8	2.2				
ssp. 18		0.2									
ssp. 19							1.3				
ssp. 2	2.6										
ssp. 20		3.6									
ssp. 21		1.4				1.1					
ssp. 4						0.7					
ssp. 5						2.2					
ssp. 6						0.7					
ssp. 7				5.8							
ssp. 9					3.3						
Syzigium guineense (Willd.) DC. ssp. *afromontanum* F	9.5	6.1		8.7		32.8	11.0	12.1	7.6		
Tacazzea conferta N.E. Br.					3.3						
Teclea nobilis Del.						1.1	3.2				
Tiliacora troupinii Curod.		1.4				0.7	2.0				
Trichilia emetica Vahl	10.5	3.2		11.2						4.6	
Trilepisium madagascariense DC	4.5	5.8	23.5			3.0		11.6		16.7	
Triumfetta brachyceras Schum		1.4									
Urera hypselodendron (A. Rich.) Wedd.					12.6						
Vangueria apiculata K. Schum.		1.4									
Vepris dainellii (Pichi-serm) Kokwara		3.7	21.3	35.6		7.1	13.9	9.3	6.9	2.9	
Vernonia amygdalina Del.	5.8		13.8	5.8		1.9	1.0		4.8		
Vernonia auriculifera Hiern.						0.9	1.0		16.1		

Dividing the IVI scores by habitat (see Table 3), it is clear that the species *Millettia ferruginea* (see Figure 6), *Croton macrostachyus*, *Elaeodendron buchananii*, *Vepris dainellii*, *Dracaena steudneri*, *Syzygium guineense* ssp. *afromontanum*, *Ilex mitis*, *Trilepisium madagascariensis*, *Coffea arabica* and *Oxyanthus speciosus* ssp. *globosusare* are generalists, as they occur in different habitat types (wetlands in lower elevations and montane forests at higher elevations). The IVI for those species is very high (see Table 3).

Bersama abyssinica, *Hippocratea goetzei*, *Vernonia amygdalina*, *Oxyanthus speciosus*, *Prunus africana*, *Galiniera saxifraga*, *Chionanthus mildbraedii*, *Rothmannia urcelliformis* (Figure 18), *Lepidotrichilia volkensii*, *Maesa lanceolata*, *Combretum paniculatum*, *Landolphia buchananii*, *Dracaena fragrans* and *Cordia africana* are also generalists occurring in different habitats but with a lower IVI.

Olea welwitschii, *Allophyllus abyssinicus*, *Schefflera abyssinica*, *Polyscias fulva*, *Ocotea kenyensis*, *Pouteria adolfi-friederici*, *Ficus ovata* are species with a high IVI which occur in montane forest habitats but not in floodplain forests/wetlands.

Albizia gummifera, *Rytigynia neglecta*, *Clausena anisata*, *Maytenus ssp.* and *Pavetta oliveriana* are also exclusive to montane forests, but with lower IVI scores.

Vernonia auriculifera, *Cyathea manniana*, *Hippocratea africana*, *Dracaena afromontana*, *Teclea nobilis*, *Euphorbia candelabrum*, *Canthium oligocarpum* and *Spathodea* sp. *ehretia cymosa* are also exclusive to montane forests, but have low IVI scores.

For the bamboo habitat, only bamboo itself (*Arundinaria alpina*) and *Schefflera volkensii* have high IVI scores.

In the floodplain and wetland habitats, *Phoenix reclinata*, *Sapium ellipticum* (see Figure 11) and *Trichilia emetica* have high IVI scores and occur in both floodplain and wetland habitats. *Pavetta abyssinica* and *Albizia grandibracteata* have lower IVI scores, but also occur in floodplain/riverine and wetland habitats. In contrast, *Mimusops kummel*, which has a very high IVI, and *Ficus platyphylla* and *Ficus lutea*, which have lower but still high IVI scores, only occur in floodplain/riverine habitats and were not recorded in the wetland habitat.

In montane forest PFM sites, some of the species with a high IVI are the same as those found in natural montane forests (e.g., *Olea welwitschii*). The species *Albizia gummifera* and *Pavetta oliveriana* have high IVI scores and are found in the natural montane forests, but do not occur in the PFM sites, whereas *Ocotea kenyensis*, *Ficus sur* and *Ficus ovata* exhibit considerably higher IVI scores in the PFM sites compared to the natural habitats. *Podocarpus falcatus* only occurs in PFM sites and not in natural ones. *Coffea arabica* exhibits the highest IVI in PFM sites, which can be explained by the promotion of this species on these sites. These results show that there is a significant difference in species composition between PFM sites and natural montane forests. In general, it is very conspicuous that we found fewer species with high IVI values in PFM sites than in natural forest montane sites.

4. Conclusions and Recommendations for Conservation and Monitoring

Diversity indices show that the montane forests of Boginda, Komba and Boka have the highest species diversity and therefore require more studies and further protection. But the wetlands also exhibit very high species diversity (see Table 2). Since no core area has currently been established in the wetland and riverine forests, we recommend doing so to protect the high plant diversity in these habitats. This recommendation is based on both the high vascular plant diversity and the fact that we found a considerably different species composition in the wetlands compared to the other habitats.

The most famous plant species in the Kafa montane forest is *Coffea arabica* (Figure 3). It is popular due to its local cultural and economic significance, and because it originates from the montane cloud forests of Kafa and surrounding similar habitats. Therefore, the coffee tree should be the most important flagship plant species. Since *Coffea arabica* is the main income for many households in Kafa and is favoured by annually slashing other shrubs in the mountainous PFM sites (e.g., the Awurada PFM sites), *Coffea arabica* is currently not under threat and is well protected by local communities. Ethiopia is the centre of origin for the species, and the wild coffee varieties are only available in the southwest Ethiopian forests, with Bonga forest being one of the major sites. Hence, conservation of these forests is vital to preserve this wild coffee variety, as it can be the basis for improving the productivity and quality of coffee. Another flagship species could be *Phoenix reclinata* (Figure 19), which is abundant in the wetland areas of Kafa. It is a conspicuous, easily recognisable plant, known for its numerous uses, including food, medication and timber. The mature stems of the species are currently overexploited by the local community to construct traditional bridges and fences. As its regeneration is very slow, overexploitation may lead to a local reduction of the species.

Thanks to its conspicuous appearance, the African dragon tree (*Dracaena afromontana*) (Figure 20), could also be a flagship species for the Kafa BR, representing both a threatened plant species (Least Concern, IUCN Red List) and as a representative of natural primary forests in Kafa BR. The main threat to this species is habitat fragmentation and light penetration due to disturbance from deforestation, selective slashing or grazing.

The tree fern *Cyathea manniana*, an indicator for natural montane forests and a so-called "living fossil", could also be a flagship species. Even minimal selective forest thinning can prove a threat to this sensitive forest species, and it therefore needs to be carefully protected in undisturbed forests.

Both *Cyathea manniana* and *Dracaena afromontana* are adapted to natural and undisturbed habitats and are susceptible to disturbance. They were only found in the montane forests habitats and both had very low IVI scores. The liana *Hippocratea africana* is another species with a low IVI in the Afromontane forest in Kafa, but it is absent from all other habitats. It needs dense closed forest vegetation.

Since these species are susceptible to disturbance, they have been chosen as indicator species for primary and near to natural montane forests. This finding is partly in accordance with Schmitt et al. (2009), who found that tree ferns only appear in natural forests and need well-shaded and moist surroundings.

The rare tree species *Pavetta abyssinica* should be an indicator species for undisturbed wetlands and riverine forests. It is classified as Vulnerable by the IUCN. It is both rare and threatened, and was only found in the Gojeb Wetland during our survey. *Phoenix reclinata* (Figure 19) is significantly dominant in the riverine forest habitat, but does not occur in other habitats. Therefore, it is also chosen as an indicator species for wetland forest patches and floodplain forests. In the bamboo habitat, species diversity was very low. Only the bamboo itself (*Arundinaria alpine*) (Figure 4) had a high IVI. It was the only dominant species. Therefore, there is no point in choosing an indicator species for this habitat. Bamboo does not occur in the other habitats. Since it is a very dominant species with an IVI of 215, it is not endangered at all.

In conclusion, further investigations into vascular plant species are needed. The limited timeframe prevented us for investigating herbaceous vegetation and epiphytes. A more in-depth analysis should include these types of vegetation to better understand the impact of forest fragmentation through tree crown thinning, shrub slashing, clear cutting and deforestation. The reliability of habitat comparisons will also increase if more transects/plots are investigated. Riverine and wetland habitats have been particularly overlooked in this regard. They seem to be quite species rich, which reinforces the need for more in-depth analysis of the Kafa BR wetlands, particularly with the inclusion of herbaceous plant species, since wetlands often lack trees and shrubs.

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6. Appendix

6.1. Tables

Table 4: Vascular plant species recorded during the NABU biodiversity assessment (Life form: T: tree, Sh: shrub, C: climber, H: herb, G: grass. Distribution: w: wide, k: Kafa, r: rare, ni: no information. Endemism: e: endemic. Threat: E: extant, LC: least concern, LR: lower risk-near threatened, NE: not evaluated, VU: vulnerable)

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Acacia brevispica Harms	Fabaceae	Mengi garoo	C	97	Montane forests	BO	w		1	E
Acanthus pubescens (Oliv.) Engl	Acanthaceae	Pheco/gucino	H	Pc4	Wetlands	SHO	w			NE
Achyranthes aspera L.	Amaranthaceae	Shwudo	H	0	Montane forests	BK	w			NE
Achyrospermum schimperi (Hochst. ex Briq.) Perkins	Lamiaceae	Sheaddo	H	91	Montane forests/ Wetlands	AW/GO-wet	w			NE
Aframomum alboviolaceum (RidL.) K. Schum.	Zingiberaceae	Shexxo agiyo	H	88	Floodplain forests	GO-riv	w			NE
Aframomum corrorima (Braun) Jansen	Zingiberaceae	Ogiyo/Ofiyo	H	AL6	Floodplain forests	GO-riv	k	e		NE
Albizia grandibracteata Taub.	Fabaceae	Kadchino	T	19	Montane forests/ Wetlands	AW/GO-wet/SHO	w		8	E
Albizia gummifera (J.F.Gmil.) GA.Sm.	Fabaceae	Caatto	T	75	Montane forests/ Wetlands	AG/BO/GO-wet/KO	w		7	E
Alchemilla fischeri Engl.	Rosaceae	AL6	H	AL1	Bamboo forests	BA	w			NE
Allophyllus abyssinicus (Hochst) Radlk.	Sapindaceae	She'o	T	29	Montane forests	BE-CH/BK/BO/KO	w		32	NE
Apodytes dimidiata E. Mey. ex Arn.	Icacinaceae	Wundifo	T	AL13/689	Floodplain forests/Montane forests	GO-riv/BO	w		14	NE
Arthopteris monocarpa (Cordem) C.Chr.	Oleandraceae	Gixo	F	47	Montane forests	KO	w			NE
Arthraxon micans (Nees) Hochst	Poaceae	Doli moco	G	73	Floodplain forests/Montane forests	KO/GO-riv	w			NE
Arundinaria alpina K. Schum.	Poaceae	Chinato	T	3	Bamboo forests	BA	w		2787	NE
Asparagus africanus lam.	Asparagaceae	Ufoo	C	109	Wetlands	GO-wet	w		1	NE
Bersama abyssinica Fresen	Melianthaceae	Boqo	T	15	Floodplain forests/Montane forests/ Wetlands	AG/AW/BE-CH/BK/BO/GO-riv/KO/SHO	w		36	NE
Bothrocline schimperi olivi & Hiern.	Asteraceae	Yamesho	Sh	113	Wetlands	SHO	k	e	1	LC
Brucea antidysenterica J. F. Mill	Simaroubaceae	Nuqisho	Sh	PL2	Floodplain forests/Montane forests/ Wetlands	GO-riv/KO/SHO	w		4	NE

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of individuals	Threat (IUCN)
Canthium oligocarpum Hiern	Rubiaceae	Titidibo	T	71	Montane forests	KE-AB/KO	w		3	LR
Cassipourea malosana (Baker) Alston	Rhizophoraceae	Worallo	T	0	Floodplain forests	GO-riv	w		2	NE
Celtis africana Burm. f.	Ulmaceae	Ufo	Sh	0	Montane forests	AW/KO	w		31	NE
Chionanthus mildbraedii (Gilg & Schellenb.) Stearn	Oleaceae	Shigiyo	T	27	Floodplain forests/Montane forests/Wetlands	AG/AW/BK/BO/GO-riv/KO/SHO	w		134	NE
Clausena anisata (Willd.) Hook.f. ex Benth.	Rutaceae	Emicho	T	0	Montane forests	BE-CH/BK/BO/KO	w		26	NE
Clematis longicaudata Steud ex A. Rich.	Ranunculaceae	Shagee qombo	C	113	Montane forests	BO	w	e	1	NE
Clerodendrum myricoides (Hochst) Vatke	Lamiaceae	Agiiyo	Sh	96	Floodplain forests	GO-riv			1	NE
Coffea arabica L.	Rubiaceae	Bunoo	Sh	20	Floodplain forests/Montane forests/Wetlands	AG/AW/BE-CH/BO/GO-riv/KE-AB/KO/SHO	w		262	VU
Combretum paniculatum Vent.	Combretaceae	Bagee qombo	C	61	Floodplain forests/Montane forests/Wetlands	BE-CH/GO-riv/KO/SHO			7	NE
Commelina latifolia Hochst. ex A Rich.	Commelinaceae	AL1	H	AL9	Bamboo forests	BA	w			NE
Cordia africana Lam.	Boraginaceae	Di'o	T	51	Floodplain forests/Montane forests/Wetlands	AW/GO-riv/GO-wet/KO/SHO	w		15	NE
Croton macrostachyus Del.	Euphorbiaceae	Wago	T	6	Floodplain forests/Montane forests/Wetlands	AG/AW/BE-CH/BO/GO-riv/GO-wet/KO/SHO	w		130	E
Cyathea manniana Hook.	Cyatheaceae	Sheshino	T	45	Montane forests	KO	w		1	NT
Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. ex Wild & Drummond	Vitaceae	Cheecho	C	2	Montane forests	BK/BO	w		5	NE
Cyphostemma sp.	Vitaceae	Shudo	C	39	Montane forests	BO			13	0
Dalbergia lactea Vatke	Fabaceae	Bitibito	C	77	Montane forests	KO			1	NE
Deinbollia kilimandscharica Taub.	Sapindaceae	Qaqirecho	T	92	Floodplain forests/Montane forests	BO/GO-riv	w		3	NE
Desmodium repandum (Vahl) DC	Fabaceae	AL9	H	99	Montane forests	AW	w			NE
Diospyros abyssinica (Hiern) F. White	Ebenaceae	Gayo	T	117	Montane forests	BO	w		1	NE
Dissotis canescens Graham/hook.f.	Melastamaceae	Gashi gano	H	AL5	Floodplain forests	GO-riv	w			NE

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Dombeya torrida (J.F.Gmel.) Bamps	Sterculiaceae	Shawuko	S	Pc8	Montane forests	BK	w		1	NE
Dracaena afromontana Mildbr.	Dracanaceae	Coqimaxo	T	0	Montane forests	BO/KO	w		16	LC
Dracaena fragrans (L.) Ker Gawl.	Dracanaceae	Emo	Sh	66	Montane forests/ Wetlands	AW/BE-CH/ GO-wet/ KO/SHO	w		10	NE
Dracaena steudneri Engl.	Dracanaceae	Yudo	T	0	Montane forests/ Wetlands	AG/BE-CH/ BO/GO-wet/KO/ SHO	w		62	NE
Ehertia cymosa Thonn.	Boraginaceae	Wogamo	T	13	Floodplain forests/Mon-tane forests/ Wetlands	BO/GO-riv/ GO-wet/ KO/SHO	w		32	NE
Ekebergia capensis Sparm	Maliaceae	Ororoo	T	23	Montane forests/ Wetlands	AG/AW/KO	w		8	NE
Elaeodendron buchananii (Loes.) Loes.	Celastraceae	Washo	T	11	Floodplain forests/Mon-tane forests/ Wetlands	AW/BO/ GO-riv/KO/ SHO	w		80	NE
Embelia schimperi Vatke	Myrsinaceae	Dupho	T	33	Bamboo for-ests/Montane forests	BA/BK	w		13	NE
Erythrina brucei Schweinf.	Fabaceae	Beroo	Sh	70	Wetlands	AG		e	1	LC
Erythrococca trichogyne (Muell Arg.) Prain	Euphorbiaceae	Biceeri kucoo	Sh	34	Montane forests/ Wetlands	AG/BO/KO			12	NE
Euphorbia candelabrum Kotschy	Euphorbiaceae	Gacho	T	0	Montane forests	BO/KO	w		2	E
Ficus exasperata Vahl	Moraceae	Bu/caro mocero	T	24	Montane forests/ Wetlands	AG/BO/KO/ SHO	w		9	NE
Ficus lutea Vahl	Moraceae	Meello	T	PL3	Floodplain forests/ Wetlands	AG/GO-riv	w		2	E
Ficus ovata Vahl	Moraceae	Caroo	T	83	Montane forests/ Wetlands	AG/AW/BO/ KO	w		34	LC
Ficus plamata Forssk.	Moraceae	Shotto	T	54	Montane forests/ Wetlands	AG/BO			3	
Ficus platyphylla Del.	Moraceae	Opo	T	58	Floodplain forests//Wet-lands	AG/GO-riv	w		5	NE
Ficus spec.	Moraceae	Charo	T	31/94	Montane forests/ Wetlands	AG/BE-CH/ BK/BO/KO			13	
Ficus sur Forssk.	Moraceae	Naco caroo	T	25	Floodplain for-ests/Montane forests	AW/BO/GO-riv/KO	w		5	NE
Ficus thonningi Blume	Moraceae	Chigago	T	53	Floodplain for-ests/Montane forests	BE-CH/BO/ GO-riv	w		3	NE

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Ficus vasta Forssk	Moraceae	Capheero	T	60	Wetlands	AG	w		2	NE
Galiniera saxifraga (Hochst.) Bridson	Rubiaceae	Angrango	Sh	1	Floodplain forests/Montane forests/Wetlands	AG/BE-CH/BK/BO/GO-riv/KE-AB/KO/SHO			82	NE
Hagenia abyssinica (Bruce) J.F. Gmel.	Rosaceae	Koso	T	8	Bamboo forests/Montane forests	BA/BK	w		3	E
Hippocratea africana (Willd.) Loes.	Celastraceae	Phi'o	C	0	Montane forests	BO/KO	w		6	NE
Hippocratea goetzei Loes.	Celastraceae	Kawo	C	42	Floodplain forests/Montane forests/Wetlands	AG/BE-CH/BK/BO/GO-riv/KO/SHO	w		39	NE
Ilex mitis (L.) Radlk.	Aquifoliaceae	Qeto	T	17	Bamboo forests/Floodplain forests/Montane forests/Wetlands	BA/BK/BO/GO-riv/KE-AB/KO/SHO	w		73	NE
Impatiens hochstetteri Warb.	Balsaminaceae	AL5	H	AL4	Bamboo forests	BA	w			NE
Ipomoea tenuirostris chelsy	Convolvulaceae	Yimbiro	C	112	Montane forests	BO	w		1	NE
Jasminum abyssinicum Hochst. ex DC.	Oleaceae	Hawuto	C	0	Floodplain forests/Montane forests	BK/GO-riv	w		3	NE
Justicia schimperiana (Hochst. ex Nees) T. Anders	Acanthaceae	Sharisharo	Sh	114	Floodplain forests/Montane forests	GO-riv/KO	w		2	NE
Landolphia buchananii (Hallier f.) Stapf	Apocynaceae	Ceele yeemo	C	28	Floodplain forests/Montane forests/Wetlands	BO/GO-riv/GO-wet/KO/SHO	w		29	NE
Lantana trifolia L.	Verbenaceae	Shoboo	Sh	0	Montane forests	BO	w		1	E
Laportea alatipes Hook. f.	Euphorbiaceae	AL4	H	0	Bamboo forests	BA	w			NE
Leersia hexandra Sw.	Poaceae	Shavkirubo	G	AL3	Wetlands	SHO	w			NE
Lepidotrichilia volkensis (Gurke) Leory.	Meliaceae	Shahiyo	T	0	Bamboo forests/Floodplain forests/Montane forests/Wetlands	BA/BE-CH/BK/BO/GO-riv/KO/SHO	w		65	NE
Macaranga capensis (Baill) Sim	Euphorbiacae	Shakero	T	67	Montane forests/Wetlands	AG/BO/KE-AB/KO	w		108	NE
Maesa lanceolata Forssk.	Myrsinaceae	Caggo	T	0	Floodplain forests/Montane forests/Wetlands	BK/BO/GO-riv/GO-wet/KO/SHO	w		45	NE
Maytenus arbutifolia (A. Rich.) Wilczek	Celastraceae	Anami agixo	Sh	#NV	Montane forests/Wetlands	AG/BO			47	VU

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Maytenus graulipes Loes.	Celastraceae	Mach shiko	Sh	0	Montane forests/ Wetlands	KO/SHO			2	
Maytenus spp.	Celastraceae	Shiko	T/ Sh	0	Montane forests	BE-CH/BK/ BO			23	
Millettia ferruginea (Hochst.) Bak.	Fabaceae	Bibero	T	12	Floodplain forests/Mon-tane forests/ Wetlands	AG/AW/ BE-CH/BO/ GO-riv/GO-wet/KE-AB/ KO/SHO		e	220	LC
Mimusops kummel A.DC.	Sapotaceae	Gayo	T	36	Floodplain for-ests/Montane forests	AW/GO-riv	w		68	E
Monothecium glandulosum Hochst.	Acanthaceae	AL3	H	AL7	Bamboo forests	BA	w			NE
Myrsine africana L.	Myrsinaceae	Gexxoo	Sh	74	Montane forests	BK	w		1	NE
Ocimum lamiifolium Hochst, ex Benth	Lamiaceae	Damo	Sh	AL8	Montane forests	BO	ni		1	NE
Ocimum urticifolium Roth	Lamiaceae	Dame gaboo	Sh	0	Montane forests	BO	w		1	NE
Ocotea kenyensis (Chiov.) Robyns & Wilcze	Lauraceae	Najjo	T	5	Montane forests	KE-AB/KO	w		23	VU
Olea welwitschii (Knobl) Gilg&Schellenb.	Oleaceae	Yaho	T	0	Montane forests	AW/BE-CH/ BK/BO/KO	w		78	NE
Oncinotis tenuiloba Stapf.	Apocynaceae	Bayiree qombo	C	114	Floodplain forests	GO-riv			1	NE
Oxyanthus speciosus DC.	Rubiaceae	Aa'imato	Sh	43	Floodplain forests/Mon-tane forests/ Wetlands	AG/BO/ GO-riv/GO-wet/KO/ SHO	w		27	NE
Oxyanthus speciosus DC. ssp. *globosus* (Sond.) Bridson	Rubiaceae	Ophero	T	0	Floodplain forests/Mon-tane forests/ Wetlands	AW/BE-CH/ GO-riv/GO-wet/KE-AB/ KO	w		30	NE
Panicum subabidum Kunth	Poaceae	Shomeko	G	80	Wetlands	SHO				
Parochaetus communis D. Don	Fabaceae	AL7	H	AL11	Bamboo forests	BA	w			LC
Pavetta abyssinica Fresen.	Rubiaceae	Naxxachee gabo	T	0	Floodplain forests/ Wetlands	GO-riv/GO-wet	r		2	VU
Pavetta oliveriana Hiern	Rubiaceae	Aemato	T	65	Montane forests	BK/BO			40	NE
Pavonia urens Cav.	Malvaceae	Gahiijjoo	Sh	109	Montane forests/ Wetlands	AG/BO	w		2	NE
Peponium vogelii (Hook.f.) Engl.	Cucurbitaceae	Tojjo	C	82	Montane forests	BO	w		1	NE
Periploca linearifolia Quart.-Dill. & A. Rich.	Asclepiadaceae	Borimoo	C	0	Montane forests	BK	w		1	NE
Phaulopsis imbricata (Forssk.) Sweet	Acanthaceae	AL11	H	95	Montane forests	AW	w			LC

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Phoenix reclinata Jacq	Arecaceae	Yeeboo	T	10	Floodplain forests/Montane forests/ Wetlands	GO-riv/GO-wet	w		249	NE
Phyllanthus reticulatus Poir.	Euphorbiaceae	Meego	Sh	50	Floodplain forests	GO-riv	w		2	NE
Physalis peruviana L.	Solanaceae	Huqicho	H	90	Floodplain forests	GO-riv	w			NE
Piper capense L.f.	Piperaceae	Turifo	H	122	Floodplain forests/Montane forests	AW/GO-riv	w			NE
Piper umbellatum L.	Piperaceae	Turife gabo	Sh	119	Wetlands	SHO	w		1	NE
Pittosporum virdiflorum Sims	Pittosphoraceae	Shollo	T	79	Montane forests/ Wetlands	BE-CH/BO/ KO/SHO	w		11	NE
Podocarpus falcata R.Br.	Podocarpaceae		T	0	Montane forests	BE-CH	w		1	
Polyscias fulva (Hiern.) Harms	Araliaceae	Karesho	T	52	Montane forests	AW/BE-CH/ BO/KE-AB/ KO	w		52	E
Pouteria adolfi-friederici (Engl.) Baehni	Sapotaceae	Qareero	T	26	Montane forests/ Wetlands	AW/BO/KO/ SHO	w		9	E
Premna schimperi Engl.	Lamiaceae	Xumo	T	0	Montane forests	KO	w		1	NE
Prunus africana (Hook.f.) kalkm	Rosaceae	Omo	T	18	Montane forests/ Wetlands	AG/BK/BO/ KO/SHO	w		10	VU
Pycnostachs recurvata Rydiag	Lamiaceae	Boqeli kakkoo	H	48	Montane forests	BO	w			NE
Rhamnus prinoides L'Herit.	Rhamnaceae	Gesho	Sh	100	Floodplain forests	GO-riv	w		1	NE
Ricinus communis L.	Euphorbiaceae	Eho	Sh	0	Wetlands	SHO	w		1	NE
Ritchiea albersii Gilg	Capparidaceae	Uchee wamoo	Sh	85	Floodplain forests	GO-riv	w		3	NE
Rothmannia urcelliformis (Hiern.) Robyns	Rubiaceae	Diboo	Sh	35	Floodplain forests/Montane forests/ Wetlands	AW/BE-CH/ BO/GO-riv/ KO/SHO	w		33	NE
Rumex abyssinicus Jacq.	Polygonaceae	Ambaxxoo	Sh	106	Montane forests	BO			1	NE
Rytigynia neglecta (Hiern) Robyns	Rubiaceae	Natacho	T	16	Montane forests	BE-CH/BO/ KE-AB/KO	w		20	NE
Sanicula elata Buch.-Ham. ex D. Don	Apiaceae	Xepheleshe	H	AL16	Montane forests	KO	w			NE
Sapium ellipticum (Hochst.) Pax.	Euphorbiaceae	Sheddo	T	22	Floodplain forests/Montane forests/ Wetlands	AG/AW/ GO-riv/GO-wet/KO	w		24	NE
Schefflera volkensii (Engl.) Harms	Araliaceae	Komo	T	4	Bamboo forests/Montane forests/	BA/BK	w		24	E
Scheffleria abyssinica Hochst.ex A. Rich) Harrms	Araliaceae	Buttoo	T	9	Montane forests	BK/BO/KE-AB/KO	w		19	NE

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Snowdenia polystchya (Fresen.) Plig.	Poaceae	Cameroo	G	78	Wetlands	SHO				NE
Solanecio mannii (hook f.) C. Jeffery	Asteraceae	Amitibalo	Sh	32	Wetlands	AG			1	NE
Spathodae ssp.	Bignoniacea	Yayo	T	55	Montane forests	BO/KO			4	
ssp. 1		Chokmacho	T	41	Montane forests	BE-CH/BO			2	
ssp. 10		Shasheroo	Sh	0	Floodplain forests	GO-riv			1	
ssp. 11		Shekino	Sh	56	Montane forests	BO			1	
ssp. 12		Shinato	T	69	Montane forests	BK			3	
ssp. 13		Shino	T	0	Montane forests	BO			1	
ssp. 14		Shurato	T	0	Montane forests	BO			3	
ssp.15		Smirico	Sh	103	Floodplain forests	GO-riv			1	
ssp. 16		Titiroo	T	87	Montane forests	BO			3	
ssp. 17		Tushimo	Sh	44	Floodplain forests/Montane forests	BO/GO-riv/KO			7	
ssp. 18		Woyeello	C	Pc-7	Floodplain forests	GO-riv			1	
ssp. 19		Xixidebo	T	93	Montane forests	KO			2	
ssp. 2		Cikkoo	Sh	0	Wetlands	AG			1	
ssp. 20		Yagibaroo	Sh	0	Floodplain forests	GO-riv			9	
ssp. 21		Yeem gombo	T	0	Floodplain forests/Montane forests	BO/GO-riv			5	
ssp. 4		Kakusho	Sh	120	Montane forests	BO			1	
ssp. 5		Kereth	T	81	Montane forests	BO			1	
ssp. 6		Kombo	T	62	Montane forests	BO			1	
ssp. 7		Mechii majeech	Sh	46	Wetlands	GO-wet			1	
ssp. 9		Shaqo	C	105	Montane forests	BK			1	
Stellaria media (L.) Vill.	Caryophyllaceae	AL16	H	AL2	Montane forests	AW	w			NE
Streblochaete longiarista (A. Rich.) Pilg.	Poaceae	AL2	G		Bamboo forests	BA	w			NE
Syzigium guineense (Willd.) DC. ssp. *afromontanum* F	Myrtaceae	Yino	T	37	Floodplain forests/Montane forests/Wetlands	AG/BE-CH/BO/GO-riv/GO-wet/KE-AB/KO	w		107	NE

Species' scientific name	Family	Local name	Life form	Voucher no	Forest type	Site	Distribution	Endemism	Total no of Individuals	Threat (IUCN)
Tacazzea conferta N.E. Br.	Asclepiadaceae	Tugo	C	P3/10	Montane forests	BK			1	NE
Teclea nobilis Del.	Rutaceae	Shenigaro	T	57	Montane forests	BO/KO	w		11	NE
Tiliacora troupinii Curod.	Menispermacee	Caamo	C	63	Montane forests	KO	k	e	4	VU
Trichilia emetica Vahl	Meliaceae	Timo	T	49	Floodplain forests/Mon-tane forests/ Wetlands	AG/AW/GO-riv/GO-wet	w		4	NE
Trilepisium madagascariense DC	Moraceae	Gaboo	T	PS3	Floodplain forests/Mon-tane forests/ Wetlands	AG/AW/BO/ GO-riv/KE-AB/SHO	w		43	NE
Triumfetta brachycerask. Schum	Tiliaceae	Mogeco	Sh	103	Floodplain forests	GO-riv	w		1	NE
Urera hypselodendron (A. Rich.) Wedd.	Urticaceae	Emaamo	C	PT3	Montane forests	BK	w		10	NE
Vangueria apiculata K. Schum.	Rubiaceae	Gujjii machoo	Sh	76	Floodplain forests	GO-riv	w		1	NE
Vepris dainellii (Pichi-serm) Kokwara	Rutaceae	Mengorexo	T	7	Floodplain forests/Mon-tane forests/ Wetlands	AW/BE-CH/ BO/GO-riv/ GO-wet/ KE-AB/KO/ SHO		e	137	LC
Vernonia amygdalina Del.	Asteraceae	Girawo	T	30	Montane forests/ Wetlands	AG/BE-CH/ BO/GO-wet/KO/ SHO	w		27	NE
Vernonia auriculifera Hiern.	Asteraceae	Dangireto	T	0	Montane forests	BE-CH/BO/ KO	w		14	NE

Table 5: Overall Importance Value index. Life form: T: Tree, Sh: Shrub, C: Climber, H: Herb, G: Grass

Species' scientific name	Life form	Importance value	Rank	Rank class
ssp. 10	Sh	0.17	1	5
ssp. 9	C	0.17	1	5
Asparagus africanus lam.	C	0.17	1	5
Clematis longicaudata Steud ex A. Rich.	C	0.17	1	5
Ipomoea tenuirostris chelsy	C	0.17	1	5
Peponium vogelii (Hook.f.) Engl.	C	0.17	1	5
ssp. 18	C	0.17	1	5
Tacazzea conferta N.E. Br.	C	0.17	1	5
Myrsine africana L.	Sh	0.17	1	5
Piper umbellatum L.	Sh	0.17	1	5
Rumex abyssinicus Jacq.	Sh	0.17	1	5
ssp. 7	Sh	0.17	1	5
Lantana trifolia L.	Sh	0.17	1	5
ssp. 4	Sh	0.17	1	5

Species' scientific name	Life form	Importance value	Rank	Rank class
Ocimum urticifolium Roth	Sh	0.17	1	5
Oncinotis tenuiloba Stapf.	C	0.17	1	5
Ocimum lamiifolium Hochst. ex Benth	Sh	0.17	1	5
Diospyros abyssinica (Hiern) F. White	T	0.17	1	5
Clerodendrum myricoides (Hochst) Vatke	Sh	0.17	1	5
Triumfetta brachycerask. Schum	Sh	0.17	1	5
Rhamnus prinoides L'Herit.	Sh	0.17	1	5
ssp. 15	Sh	0.17	1	5
ssp. 2	Sh	0.17	1	5
ssp. 6	T	0.17	1	5
Periploca linearifolia Quart.-Dill. & A. Rich.	C	0.17	1	5
Dombeya torrida (J.F.Gmel.) Bamps	S	0.17	1	5
Ricinus communis L.	Sh	0.18	2	4
Acacia brevispica Harms	C	0.18	2	4
Vangueria apiculata K. Schum.	Sh	0.18	2	4
Dalbergia lactea Vatke	C	0.18	2	4
Bothrocline schimperi Oliv. & Hiern.	Sh	0.18	2	4
Cyathea manniana Hook.	T	0.18	2	4
ssp. 11	Sh	0.18	2	4
Solanecio mannii (hook f.) C. Jeffery	Sh	0.18	2	4
Premna schimperi Engl.	T	0.18	2	4
Erythrina brucei Schweinf.	Sh	0.19	3	4
ssp. 12	T	0.21	4	4
ssp. 14	T	0.21	4	4
Cassipourea malosana (Baker) Alston	T	0.21	4	4
Ritchiea albersii Gilg	Sh	0.22	5	4
ssp. 19	T	0.23	6	4
ssp. 13	T	0.25	7	4
ssp. 20	Sh	0.33	8	4
ssp. 5	T	0.34	9	4
Pavetta abyssinica Fresen.	T	0.35	10	4
Pavonia urens Cav.	Sh	0.35	10	4
Justicia schimperiana (Hochst. ex Nees) T. Anders	Sh	0.35	10	4
Phyllanthus reticulatus Poir.	Sh	0.35	10	4
Maytenus graulipes Loes.	Sh	0.35	10	4
ssp. 1	T	0.35	10	4
Jasminum abyssinicum Hochst. ex DC.	C	0.37	11	4
Deinbollia kilimandscharica Taub.	T	0.37	11	3
ssp. 16	T	0.37	11	3
Euphorbia candelabrum Kotschy	T	0.37	11	3
Cyphostemma sp.	C	0.40	12	3
ssp. 21	T	0.41	13	3
Hippocratea africana (Willd.) Loes.	C	0.43	14	3
Ficus thonningi Blume	T	0.52	15	3
Urera hypselodendron (A. Rich.) Wedd.	C	0.53	16	3
Brucea antidysenterica J. F. Mill	Sh	0.54	17	3
Ficus plamata Forssk.	T	0.55	18	3
Canthium oligocarpum Hiern	T	0.55	18	3
Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. ex Wild & Drummond	C	0.56	19	3

Species' scientific name	Life form	Importance value	Rank	Rank class
Ficus lutea Vahl	T	0.59	19	3
Ficus vasta Forssk	T	0.59	19	3
Tiliacora troupinii Curod.	C	0.70	20	3
Teclea nobilis Del.	T	0.72	21	3
Hagenia abyssinica (Bruce) J.F. Gmel.	T	0.73	22	3
Vernonia auriculifera Hiern.	T	0.76	23	3
ssp. 17	Sh	0.76	24	3
Spathodae ssp.	T	0.78	25	3
Embelia schimperi Vatke	T	0.87	26	3
Dracaena afromontana Mildbr.	T	0.87	26	3
Ekebergia capensis Sparm	T	0.95	27	3
Dracaena fragrans (L.) Ker Gawl.	Sh	0.96	28	3
Erythrococca trichogyne (Muell Arg.) Prain	Sh	1.00	29	3
Ficus platyphylla Del.	T	1.01	30	3
Combretum paniculatum Vent.	C	1.06	31	2
Pittosporum virdiflorum Sims	T	1.15	32	2
Albizia grandibracteata Taub.	T	1.17	33	2
Albizia gummifera (J.F.Gmil.) GA.Sm.	T	1.21	34	2
Ficus exasperata Vahl	T	1.23	35	2
Trichilia emetica Vahl	T	1.34	36	2
Apodytes dimidiata E. Mey. ex Arn.	T	1.34	36	2
Clausena anisata (Willd.) Hook.f. ex Benth.	T	1.43	37	2
Celtis africana Burm. f.	Sh	1.44	38	2
Cordia africana Lam.	T	1.46	39	2
Rytigynia neglecta (Hiern) Robyns	T	1.47	40	2
Maytenus spp.	T/Sh	1.49	41	2
Podocarpus falcata R.Br.	T	1.54	42	2
Maytenus arbutifolia (A. Rich.) Wilczek	Sh	1.63	43	2
Pavetta oliveriana Hiern	T	1.71	44	2
Oxyanthus speciosus DC. ssp. *globosus* (Sond.) Bridson	T	1.94	45	2
Ehertia cymosa Thonn.	T	1.98	46	2
Prunus africana (Hook.f.) kalkm	T	2.02	47	2
Rothmannia urcelliformis (Hiern.) Robyns	Sh	2.15	48	2
Vernonia amygdalina Del.	T	2.15	48	2
Oxyanthus speciosus DC.	Sh	2.26	49	2
Landolphia buchananii (Hallier f.) Stapf	C	2.46	50	2
Ficus spec.	T	2.58	51	2
Maesa lanceolata Forssk.	T	2.75	52	2
Hippocratea goetzei Loes.	C	2.75	52	2
Lepidotrichilia volkensis (Gurke) Leory.	T	3.27	53	2
Pouteria adolfi-friederici (Engl.) Baehni	T	3.38	54	1
Allophyllus abyssinicus (Hochst) Radlk.	T	3.45	55	1
Bersama abyssinica Fresen	T	3.54	56	1
Ilex mitis (L.) Radlk.	T	3.57	57	1
Polyscias fulva (Hiern.) Harms	T	3.67	58	1
Ocotea kenyensis (Chiov.) Robyns & Wilcze	T	4.10	59	1
Galiniera saxifraga (Hochst.) Bridson	Sh	4.32	60	1
Trilepisium madagascariense DC	T	4.65	61	1
Macaranga capensis (Baill) Sim	T	4.70	62	1

Species' scientific name	Life form	Importance value	Rank	Rank class
Mimusops kummel A.DC.	T	5.06	63	1
Ficus ovata Vahl	T	5.23	64	1
Dracaena steudneri Engl.	T	5.37	65	1
Sapium ellipticum (Hochst.) Pax.	T	5.55	66	1
Chionanthus mildbraedii (Gilg & Schellenb.) Stearn	T	5.79	67	1
Vepris dainellii (Pichi-serm) Kokwara	T	5.84	68	1
Elaeodendron buchananii (Loes.) Loes.	T	6.08	69	1
Ficus sur Forssk.	T	6.29	70	1
Scheffleria abyssinica Hochst.ex A. Rich) Harrms	T	7.31	71	1
Coffea arabica L.	Sh	7.44	72	1
Syzigium guineense (Willd.) DC. ssp. *afromontanum* F	T	7.95	73	1
Croton macrostachyus Del.	T	9.06	74	1
Phoenix reclinata Jacq	T	9.75	75	1
Millettia ferruginea (Hochst.) Bak.	T	10.59	76	1
Schefflera volkensii (Engl.) Harms	T	12.36	77	1
Olea welwitschii (Knobl) Gilg&Schellenb.	T	21.90	78	1
Arundinaria alpina K. Schum.	T	58.51	79	1

6.2. Photos

Figure 3: *Coffea arabica* at the Awurada PFM site (photo: Anna Leßmeister)

Figure 4: Dense bamboo forest dominated by the montane bamboo *Arundinaria alpina* (photo: Anna Leßmeister)

Figure 5: Bamboo forest understorey, dominated by the same few grass species and shrubs (photo: Viola Clausnitzer)

Figure 6: The endemic species *Milletia ferruginea* (photo: Anna Leßmeister)

Figure 7: *Hagenia abyssinica* (photo: Anna Leßmeister)

Figure 8: *Schefflera volkensii* (photo: Anna Leßmeister)

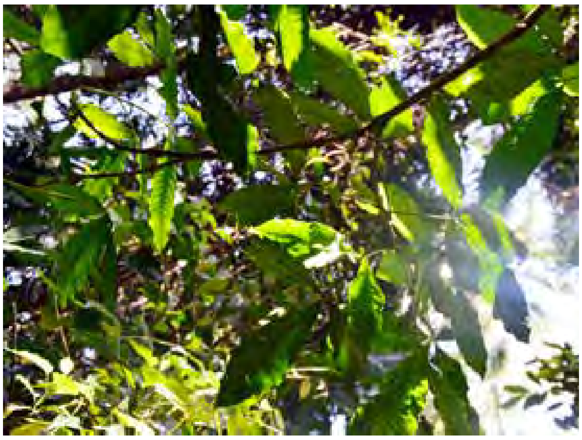

Figure 9: The endemic species *Vepris dainellii* (photo: Anna Leßmeister)

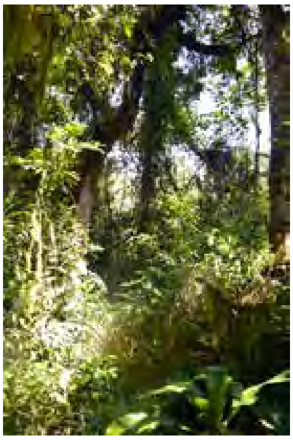

Figure 10: Gojeb riverine/floodplain habitats (photo: Anna Leßmeister)

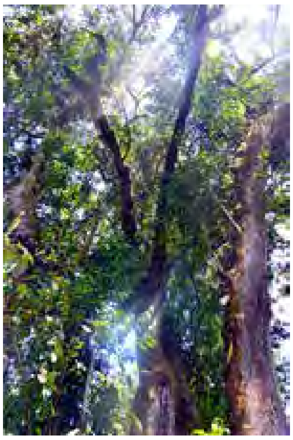

Figure 11: *Sapium ellipticum* in the floodplain forests (photo: Anna Leßmeister)

Figure 12: PFM site, Awurada (AW) (photo: Anna Leßmeister)

Figure 13: PFM site, Awurada (AW) (photo: Anna Leßmeister)

Figure 14: Gojeb Wetland (photo: Anna Leßmeister)

Figure 15: Herborisation of unknown species (photo: Anna Leßmeister)

Figure 16: Diameter at breast height (DBH) measurements in the Awurada Valley (photo: Anna Leßmeister)

Figure 17: Diameter at breast height (DBH) measurements in the Awurada Valley (photo: Anna Leßmeister)

Figure 18: *Rothmannia urcelliformis* (photo: Anna Leßmeister)

Figure 19: *Phoenix reclinata* at Gojeb River (GO-riv) (photo: Anna Leßmeister)

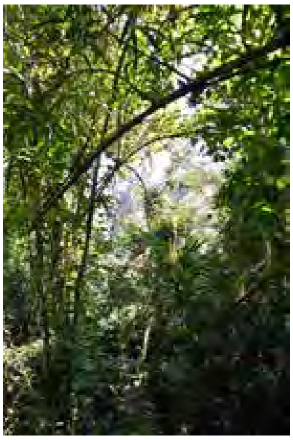

Figure 20: *Dracaena afromontana* in Boginda (BO) (photo: Anna Leßmeister)

Fungi at the Kafa Biosphere Reserve

Andreas Gminder

Highlights

- → This is the first time a mycological survey has been conducted in the Kafa area.
- → Nearly 350 species of fungi were recorded, but most were identified as morphospecies or could only be determined at the genus level.
- → At least 30 species are new to Ethiopia, but this number may increase to more than 100 after all collections have been analysed.
- → At least three species are already known to be new to science (*Ascocoryne kafai* ined., *Cerinomyces bambusicola* ined., *Coniolepiota kombaensis* ined.), but this number will most likely increase, at least in some genera of the Agaricales (*Cystolepiota, Entoloma, Psathyrella*) and Xylariales (*Hypoxylon* s. l.) orders.
- → Two species are probably endemic to Ethiopia (*Cerinomyces bambusicola* ined., *Sarcoscypha* spec. nov. ined.).
- → Many of the species are endangered by biotope loss, as they are believed to be confined to natural montane rain forests. The exact number cannot be estimated due to lack of comparative data.
- → The bamboo forest seems to be home to several endemic species, but more studies are needed to confirm this.
- → Compared to the wetlands and bamboo forests, the montane forests (coffee forests) at 1700 to 2000 m a.s.l. seem to be the most species-diverse biotope.
- → *Sarcoscypha javanensis* and *Coniolepiota kombaensis* ined. could be a good indicator species for the status of natural montane cloud forests. *Cerinomyces bambusicola* ined. could serve as an indicator species for habitat quality in the bamboo forests. Finally, *Dentipellis fragilis* is an indicator for undisturbed forests in general.

1. Introduction

Knowledge of fungi in tropical regions worldwide is very limited compared to the Mediterranean and boreal regions of the Northern hemisphere. Several scattered inventories exist for certain countries and areas, usually in the form of a commented list of fungi found over a number of years. However, there is currently no single publication offering deeper insight into the ecological needs of tropical fungi or the decline or increase of certain species and the reasons for such developments. Therefore, it is almost impossible to assess the status of most species in terms of being endangered, declining or as possible indicator species for natural and/or endangered habitats.

There are two older publications related to Ethiopia. The first is a checklist by Castellani & Cifferi (1938; 1950), who mainly collected in areas around Addis Ababa, the southeast and in Eritrea. The data from the western part of the country originates from Jimma. More recently, Hjortstam & Ryvarden (1996) listed some polyporoid and corticioid fungi, which provided the first step towards the recently published preliminary checklist of wood-inhabiting fungi in Ethiopia by Bitew & Ryvarden (2011). They collected at Lake Tana, in the Bale Mountains and in central Ethiopia. Lindemann collected in Ethiopia several times, beginning in 2008, but most of his records have not yet been published, nor is there a species list.

Further collections from Ethiopia are integrated into publications on the fungus flora of Eastern Africa, e.g., by Dring & Rayner (1967, gasteromycetes), Ash (1976, several agarics and gasteromycetes), Pegler (1977, agarics), Ryvarden & Johansen (1980, polypores) and Hjortstam (1983, 1987, corticoid fungi). Very few scattered data from Ethiopia can be found in contributions by Hennings (1901; 1904; 1905), but his identifications and descriptions should be viewed with a certain caution.

None of the publications listed above cover the Kafa region. The NABU assessment in December 2014 is the first time fungi have been researched in this area and in the Kafa BR. The assessment in the Kafa BR was carried out during the first two weeks of December, three months after the main rainy season. This explains the nearly complete lack of terrestrial fungi, and it was not surprising to find that 95% of all fungi found were growing on wood or plant debris. Terrestrial fungi were only found in the flood plains along the riverbanks of the Gummi River. Nevertheless, an interesting range of fungi was found in the forests, as the moist nights and limited rainfall during one day of the assessment helped keep the biotopes from drying out too much.

In the wetlands, the search for fungi was limited to two sample sites, both of which were very unsuccessful. The wetlands are either too wet for fungi (flooded areas), or intensely grazed by cattle, making it impossible for terrestrial fungi to develop. No fungi were found colonising dead remnants of grass or herbs lying on the wet ground. This is because grazing doesn't leave much dead plant material and the wetlands are disturbed by the hooves of cattle.

Fungal communities were expected to be similar across the different forests, even forests at different altitudes. Species composition is affected by the composition of the trees and plants in the forest, the development of the forest understory and above all the moistness of the ground far more than altitude. In this respect, the bamboo forests are an unusual biotope, being home to many species which do not occur in other habitats. However, this is probably because no terrestrial fungi were found, limiting the listing almost entirely to fungi growing on dead parts of bamboo stems or leaves, which are hardly likely to be found in other forest types.

In general, all forests in Kafa are threatened by intervention in various regards. Deforestation causes the most severe change in habitat, and will lead to an almost total loss of forest-inhabiting fungi. Management (removal) of the understory to stimulate the growth of young coffee plants, as performed in Participatory Forest Management (PFM) sites, will reduce species diversity. Forest fragmentation by infrastructure such as roads or partial deforestation leads to an unfavourable change in the microclimate, not only near the disturbed sites but also deep within the forest itself.

2. Materials and Methods

2.1 Study area

Fungi sampling was mainly carried out in forest sites, as the wetlands were found to be nearly free of fungi. The following areas were studied, sometimes in multiple locations:

Table 1: Sampling sites of the fungi assessment at Kafa BR

Code	Sites	Habitat	Altitude (m a.s.l.)	Coordinates	No. of sites
AW	Awurada Valley (Gummi River)	Riverine vegetation	1400	7° 05' 18.0" N 36° 13' 05.9'' E	1
AW	Awurada Valley (PFM sites)	Montane forests	1500-1900	7° 05.146' N 36° 12.468' E	1
BA	Bamboo forest	Bamboo forests	2600	7° 14.610' N 36° 27.388' E	2
BK	Boka Forest	Bamboo forests	2450	7° 17.711' N 36° 22.555' E	1
BO	Boginda Forest	Montane forests	1950	7° 30.30' N 36° 06.42' E	1
KO	Komba Forest	Montane forests	1970	7° 18' 32" N 36° 5' 11" E	2
KO	Komba Forest	Montane forests	1900	7° 18' 26" N 36° 3' 31" E	1
KO	Komba Forest	Montane forests	1900	7° 18' 45" N 36° 2' 40" E	1
MA	Mankira Forest	Montane forests	1700	7° 12' 151" N 36° 17' 012" E	2
SHO	Shoriri Forest	Montane forests	1700	7° 30' 486" N 36° 12' 538" E	1
--- [1]	KDA Guesthouse	Garden	1800	7° 36' 10" N 35° 59' 59" E	
--- [1]	Gojeb River, near Saja	Riverside	1600	7° 26' 11" N 36° 22' 4" E	

[1] In addition to the regular sampling sites, a few fungi were recorded around the KDA Guesthouse in Bonga and by the Gojeb River near Saja. These are not included in the analyses because no standardised sampling was carried out in these two locations.

2.2 Sampling methods

Fungus sampling for the NABU assessment was carried out by collecting fruit bodies visible in the field. No cultures of soil, leaves or other material were created during this field work, and no soil or root samples were collected for further DNA analysis. Even the few dung fungi found were already fruiting in the field and were not obtained via moist chamber culture, as is often the case.

In the field, sampling was conducted using a time-standardised search method. Each location (sampling site) was searched by three people (ranger, field guide and the author) for one hour by sight. The search area was not delimited – the collectors were free to search wherever they chose in the sampling site. In an unpublished study (Siemianowski pers. comm.), sampling to saturation in small plots of standardised size did not produce better results than sampling for the same time in larger and non-standardised areas. Based on this result, the more easily applied time-standardised method was used in Kafa.

Sampling smaller plots to saturation presupposes the previous evaluation and installation of representative plots in each location, which could not have been carried out in the short time available for our assessment. An exception to the "one hour per location" method was granted for the two bamboo forest sites, as these were harder to search. Collection time here was extended to two hours. In addition, Excursion 4 in Komba Forest is not included in the analyses, because the goal was to search for particular species rather than a general search for fungi as in the other excursions.

All fungal species found were collected in the necessary quantity and stored in numbered plastic boxes. If possible, the host was noted. In some cases photos were taken on-site, but light conditions were usually unfavourable. Sufficient sample material was collected to have extra to share with the authorities in charge and the herbarium at the University of Addis Ababa and to send to specialists where necessary. Some material was also kept back in case of future DNA analysis. No collections were determined macroscopically in the field – all fungi were sampled and verified via microscopic examination.

On returning to the camp, the day's samples were dried within a few hours, as many fungi begin to mould soon after collecting. Wherever possible, the fresh material was examined microscopically on the day of collection. An Olympus CH2 microscope and Breukhoven 125 stereo microscope were used for this purpose. The dried collections were split in two (one for the University of Addis Ababa, one for the author) and stored in airtight plastic bags.

2.3 Data analysis

The collected fungi were usually identified by microscopically examining the dried samples, which were properly prepared and exported following the regulations laid out by the Ethiopian Biological Institute (EBI). Half of each collection was exported to Germany, to continue the identification process and complete the species list. This standard, albeit somewhat inefficient, practice of determining species by comparing the microscopic details with the descriptions in scattered literature about tropical fungi from all parts of the world was sped up in some cases through collaboration with specialists in certain genera or other mycologists involved in researching tropical fungi (see list below). In several cases, DNA analyses have and will still be performed to receive a determination at the species or genus level. These analyses are carried out by Bálint Dima (Corvinus University, Budapest). In general, the ITS1 and ITS2 loci are used for fungi, although in some cases the LSU or rpb1 loci can also be of help. The obtained sequences will be matched against sequences in the GenBank database and/or with unpublished sequences acquired from specialists. The following mycologists collaborated in identifying parts of the collection:
Baral, H-O (Eberhard-Karls University, Tübingen); Lecuru, C (University of Lille); Lindemann, U (Ruhr-University Bochum); Melzer, A (Neukyhna); Ryvarden, L (University of Oslo); Stadler, M (Braunschweig Technical University); Vellinga, E (University of California, Berkeley); Forum AscoFrance.

Analysis of the species diversity and quality of the different sites can only be done with great restraint, as no comparative data is available for monitoring in tropical regions. Thus, while the sites visited in Kafa BR can be compared with each another to a certain extent, comparison of the whole area with other tropical areas is impossible. Nevertheless, some initial generalisations can be made (see Section 3.1).

3. Results and Discussion

3.1 Estimated species richness and diversity

Due to the small amount of data collected in this assessment, it is not possible to analyse species richness or diversity. At least 10 years of yearly monitoring at different times of year is necessary to be able to estimate the number of species in the selected forests. Even then it would be difficult to compare results, as there is no data from standard palaeotropical inventories, only scattered surveys for certain parts of tropical Africa. The work conducted by Einhellinger on a continental calcareous heathland biotope near Munich, Germany, exemplifies how time consuming fungal assessment can be. Einhellinger investigated this area for 25 years, making excursions at least every 14 days. After 10 years of inventories he had only found approximately 60% of the species he eventually recorded throughout his 25 years of research.

Bitew & Ryvarden (2011) mention approximately 250 species in their checklist of wood-inhabiting fungi, collected in several different sites in central and southeast Ethiopia since 1998, both in afromontane dry forests and montane cloud forests. In comparison, the approximately 300 to 350 different species we recorded in our 10-day fieldwork show a very high level of species richness in the montane cloud forests of Kafa. However, it must be admitted that only 50 of the 350 different species have been determined to date, and it is expected that only 150 to 200 will be determined in future. Still, this is nearly as many in 10 days as Bitew & Ryvarden (2011) collected over 12 years at different times of year and in more diverse biotopes. Therefore, we can at least conclude that the montane rainforests of Kafa exhibit exceptionally high species diversity and warrant further research.

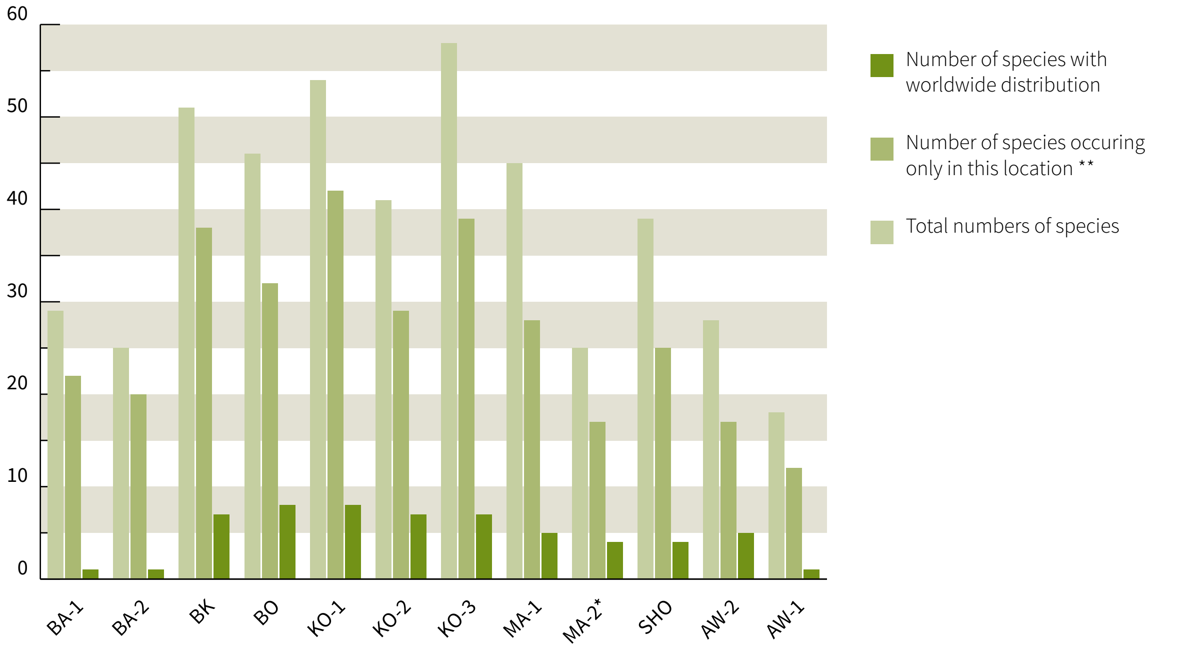

Figure 1: Species richness and composition of visited locations. * The low number of species in MA-2 is due to a) the loss of an excursion box containing approx. 10-12 collections and b) there being only two researchers there instead of the usual three. ** The inventories for BA-1, BA-2, KO-1, KO-2 and KO-3 were only compared to the inventories of the other areas, not with the excursion at the locations themselves.

Figure 1 shows that the montane cloud forests are home to significantly more species than the pure bamboo forests (BA-1, BA-2), the floodplain forest and the PFM site (AW-2). Site BK, at 2500 m a.s.l., which is split between bamboo forests and montane cloud forests, has the same high species diversity as the montane cloud forests at 1700 to 2000 m a.s.l., which supports the theory that differences in altitude are a much less important factor in species richness than differences in habitat.

3.2 Species composition

Identifying a constant, defined fungus community in a particular biotope requires many years of intense fieldwork. It is not possible to make even broad guesses about the typical species composition in certain biotopes. This is corroborated by the data from the three excursions in Komba Forest. Although the three locations were close to each other (approximately 1-2 km apart) and the research excursions were conducted within six days of each other, only seven of the 129 species found occurred in all three locations. Ten species were found in two of the three locations and nearly 90% were found in only one location. This suggests a high number of microhabitats across the three locations, although sites BO-1 and BO-2 looked superficially very similar. As fungi are often adapted to very narrow ecological niches, a high number of microhabitats will usually result in a high level of species diversity.

Nevertheless, two interesting results emerge when comparing the species composition of different locations. The first is that bamboo forests (e.g., BA-1) have more species unique to this biotope (see Figure 2). The second is that the number of species with worldwide distribution is very low (see Figure 3). Both results indicate the uniqueness of this biotope with regards to fungi. In addition, a comparatively high percentage of endemic fungi can be expected in the bamboo forest, not only because most of the species found there are obviously confined to bamboo as host, but because it seems they are also confined to the biotope itself, and do not occur in bamboo habitats in other parts of the world.

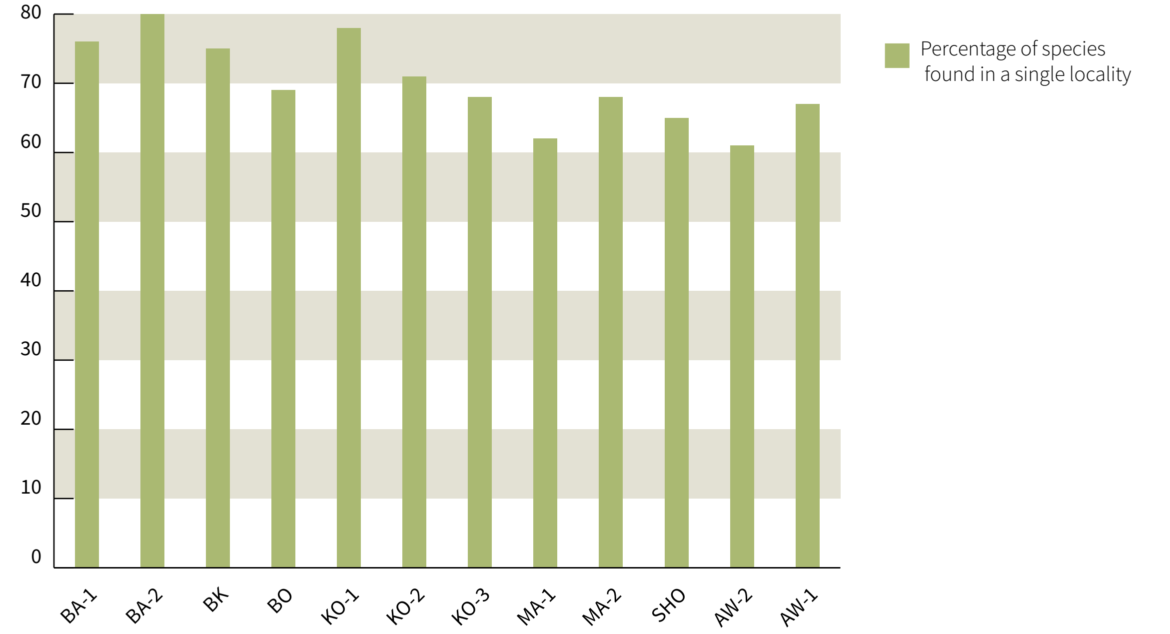

Figure 2: Comparison of species composition between areas

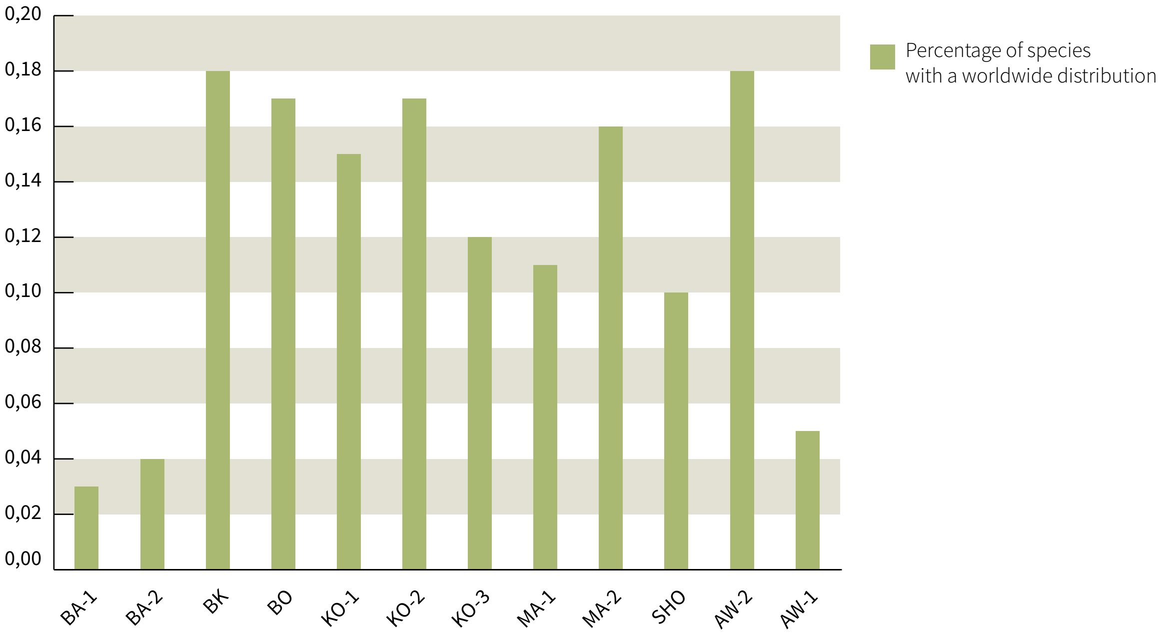

Figure 3: Species with worldwide distribution

Figure 3 suggests that both the bamboo forests and the floodplain vegetation are unique habitats, even at an international scale. But this information must be verified after more data for well-determined fungi are available for analysis. The small number of species on which this diagram is based may be causing an artificial unambiguity.

4. Conclusions and Recommendations for Conservation and Monitoring

4.1 Conclusions for the Kafa BR

Compared to the number of species found by other authors, overall biodiversity of fungi seems high to exceptionally high in the Kafa montane cloud forests. In addition, many species have been found which are not known to have a wide tropical distribution. Several of the species found are new to Africa, new to Ethiopia and even new to science. It is very likely that the near-natural montane cloud forests and even the very extensively managed coffee forests at Kafa BR (PFM sites) are hotspots of diversity for tropical fungi.

Conserving these last comparatively undisturbed forests is highly desirable, as over 90% of them have already been destroyed. A possible source of important fungal resources would vanish with these forests, without us ever having had knowledge of dozens or hundreds of undiscovered fungi species. Thus, it is essential to continue monitoring fungi here, at least in the forest core zones.

General threats to the forests include pressure of land use from the surrounding villages; the exploitation of the coffee forests and management of these forests to exclusively favour the coffee plants. The need for firewood is also a problem in the marginal forest zones, and in some cases (e.g., Komba) deeper inside. The bamboo forests in particular are seriously threatened by people cutting bamboo, changing the microclimate and thus threatening most of the fungi species which occur in this habitat, probably resulting in a dramatic decrease in species richness.

Fungi are very sensitive to environmental or climatic changes, so it is worth monitoring them in more detail. Continuing to monitor fungi in Kafa is very important. The species occurring there and their distribution in the Kafa forests cannot be evaluated in a single assessment, but require monitoring over several years, at different times and in different seasons. Without more knowledge of the species inventory of these forests and the ecological needs of these fungi, we cannot use them as indicator species.

4.2 Indicator species

There is a lack of publications on fungi species which could serve as indicator species for the status of tropical forest biotopes. Various monitoring programmes exist in different countries, mainly in South America, but these are mostly still in the species monitoring phase. Conclusions on species compositions and indicator species are yet to be drawn (or at least remain unpublished). Nevertheless, three species found during the Kafa assessment can be proposed as indicator species for its biotopes, with some prudence.

4.2.1 *Sarcoscypha javanensis*

The *Sarcoscypha* genus is distributed across the northern hemisphere, with approximately ten species occurring in Europe and North America. One species is endemic to Macaronesia. No tropical African species have been identified, apart from one recently described species from Tanzania (Tibuhwa 2010), *Sarcoscypha ololosokwaniensis*. It is unlikely that this is identical to our Ethiopian collections, but a type comparison is still pending, as the type collection has not been located yet.

This is chosen as an indicator species for undisturbed African montane rainforests because all species of *Sarcoscypha* are inhabitants of rich deciduous forests in a near-natural state. The central European species are often found in forests accompanied by threatened plants, e.g., *Leucojum vernum*, such as *Fraxino-Aceri pseudoplatani*, *Adoxo-Aceretum* or *Aceri-Tilietum platyphylli*. The Macaronesian *Sarcoscypha* macaronesica is confined to natural laurel forests. The species from North America are found in near-natural forest types, as is the African species *S. ololosokwaniensis*, which is reported to be found "in undisturbed habitats". This describes the Ethiopian locations. Therefore, it can be expected that *Sarcoscypha javanensis* is also confined to near-natural or natural, rich forests. The vivid scarlet fruit bodies are easy to find and the species (or at least the genus) is unmistakable.

The main threat to *Sarcoscypha javanensis* is disturbance to the ecosystem in which it occurs, especially in terms of humidity inside the forests. Tree felling, but also the construction of roads or even broad paths result in sun and wind encroaching into the forest, making the microclimate conditions drier. This prevents the fungus from fruiting and it is impossible for the mycelium to grow in dried-out wood. Any management of the locations involving fertilisers, pesticides and other chemicals is likely to immediately and drastically change the entire fungal system, turning it into a species-poor community of nitro-tolerant species.

4.2.2 *Cerinomyces bambusicola* spec. nov. ined.

Little is known about this as-yet-undescribed species. Nevertheless, it is chosen as an indicator species for the undisturbed bamboo forests, as it has been found several times in BA and in the bamboo forest part of

BK. Although it has also been collected on other hosts (most likely on *Hagenia abyssinica*) in BK, it has not been found at any other sites in Kafa. This implies that it is a species confined to the high-altitude bamboo forests, although without being specialised on bamboo as host. The new species is remarkable, with crust-like fruit bodies of several square decimetres in area, showing a bright orange merulioid to dentate surface.

The main threat to *Cerinomyces bambusicola* spec. nov. ined. is habitat loss or change through bamboo harvesting. Even if other hosts of this species are not affected directly, changes to the microclimate caused by bamboo harvesting will indirectly affect the substrate of this species.

4.2.3 *Dentipellis fragilis*

This rare species of cosmopolitan distribution is an indicator species for natural beech forests in Europe, and it is most likely confined to natural forest types in other parts of the world. The species develops long crusts (up to one metre long) on decaying voluminous hardwood and is characterised by a hymenium of long, tooth-like protrusions.

The characteristic species from Kafa BR is an indicator species for the undisturbed montane rainforests, containing a certain minimum amount of voluminous deadwood.

The main threat to *Dentipellis fragilis* – besides habitat loss caused by logging – is the removal of coarse stems or a shortage of coarse wood. As this species only inhabits stems or large branches with a minimum diameter of around 30 cm, it is an indicator species for extensive forest fragments.

4.3 Recommendations

The most important recommendation for these fungi is to keep the natural forests in the good condition they are in today. Harvesting wild coffee without site management seems to have not negative influenced these fungi. It is also important to maintain a certain quantity of deadwood of all qualities (standing and lying, fine and coarse). The forest sites must not be fragmented by roads, as this leads to a change in microclimate which is unfavourable for most of the fungi, including the three proposed indicator species. To increase our knowledge of these fungi, especially of the two as-yet-undescribed species, monitoring is necessary. All three proposed indicator species were chosen with this in mind, as they are comparatively easy to recognise.

One of the most important recommendations is to conduct regular inventories of the fungus flora of the Kafa BR.

- The bamboo forests and floodplain forest at the Gummi River strongly warrant an inventory, as these as completely unexplored habitats, even on a global scale, and it is possible that they contain many rare and endemic fungi.

- The montane cloud forests are also in urgent need of a thorough inventory, as it is important to have sound knowledge of species composition and species richness to be able to estimate changes and draw conclusions about the impact of management (comparison between undisturbed forests and PFM sites) on the habitat in general and the fungi in particular.
- Finally, there is no data available on the fungi occurring in African alpine vegetation and riverine shrub vegetation.

The assessment carried out in December 2014 was a first small step, but to obtain robust knowledge of the fungus composition across the different habitats, or simply to get a better impression of how many and which fungi exist at Kafa BR, further excursions must be made at different times of the year.

Table 2: Current status of the study areas at the Kafa BR

Study area	Habitat/forest type	Altitudinal range (m a.s.l.)	Degree of habitat degradation	Main observed threats	Taxonomic group or species indicating good condition	Taxonomic group or species indicating poor conditions	Proposed indicator species	Proposed monitoring for indicator species?
Bamboo forest (BA)	Montane forests	2500-2600	Medium	Fragmentation by paths, felling of bamboo	*Cerinomyces bambusicola* spec. nov. ined.	-	*Cerinomyces bambusicola* spec. nov. ined.	Yes
Boka Forest (BK)	Montane forests	2400-2500	Low	As above, additionally through grazing in the wetlands affecting the forest border	*Cerinomyces bambusicola* spec. nov. ined.	-	*Cerinomyces bambusicola* spec. nov. ined.	Yes
Komba Forest (KO)	Montane forests	1900-2000	Medium-low	Fragmentation by paths, logging, extensive coffee harvesting	*Sarcoscypha javanensis* *Cookeina colensoi, Coniolepiota bongaensis* spec. nov. ined., maybe *Fomitopsis carnea*	*Pycnoporus sanguineus*	*Sarcoscypha javanensis*	Yes
Awurada Valley (AW)	Flood-plain forest	1300-1400	Near undisturbed	Poaching				
Awurada Valley (AW)	Montane forests - PFM site	1500-1900	Medium	Poaching, logging, fragmentation by paths		*Pycnoporus sanguineus*		
Shoriri Forest (SHO)	Montane forests	1700	Medium	Fragmentation by paths, logging, extensive coffee harvesting				Yes
Mankira Forest (MA)	Montane forests	1700-1800	Medium-low	Fragmentation by paths, logging, cattle grazing	*Dentipellis fragilis*		*Dentipellis fragilis*	Yes
Boginda Forest (BO)	Montane forests	1900-2000	Medium-low	Unknown	*Pachyella pseudosuccosa*			Yes

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6. Appendix

6.1 Photos

Figure 4: Near-natural forest composition in a PFM site east of Ufa, showing a dense undergrowth of coffee plants and other shrubs, as well as trees in different age groups (photo: Andreas Gminder)

Figure 5: Fungi, lichens and plant epiphytes growing on an old tree at the PFM site between Ufa and the Gummi River (photo: Andreas Gminder)

Figure 6: Near-natural forest composition in a PFM site east of Ufa on the way down to the Gummi River, showing a dense undergrowth of coffee plants and other shrubs (photo: Andreas Gminder)

Figure 7: Floodplain forest at the Gummi River, east of Ufa (photo: Andreas Gminder)

Figure 8: Bamboo forest east of Boka at the river crossing on the road to Kaka, showing the northwest border of the core zone (photo: Andreas Gminder)

Figure 9: Searching for fungi in the bamboo forest east of Boka at the river crossing on the road to Kaka (photo: Andreas Gminder)

Figure 10: Natural montane cloud forest southeast of Saja, showing dense vegetation with a high deposit of deadwood in different stages of decomposition, resulting in a large number of microhabitats (photo: Andreas Gminder)

Figure 11: Creek in a natural montane cloud forest southeast of Saja, location of *Pachyella pseudosuccosa*, an indicator species for natural brooks and creeks (photo: Andreas Gminder)

Figure 12: Natural montane cloud forest southeast of Saja, showing dense vegetation covered by mosses and other epiphytes (photo: Andreas Gminder)

Figure 13: Southwest corner of the Boka Forest with highly disturbed wetland in front (photo: Andreas Gminder)

Figure 14: *Cymatoderma* cf. *elegans*, already known from African rain forests, but recorded for the first time in Ethiopia during this assessment (photo: Andreas Gminder)

Figure 15: *Cerinomyces bambusicola* spec. nov. ined., proposed indicator species for undisturbed bamboo forests in higher altitudes (> 2400 m a.s.l.) (photo: Andreas Gminder)

Figure 16: *Coniolepiota spongodes*, hitherto known only in Japan and Thailand, a potential indicator species for undisturbed montane cloud forests (photo: Andreas Gminder)

Figure 17: *Dentipellis fragilis*, indicator species for natural deciduous forests with cosmopolitan distribution (photo: Andreas Gminder)

Figure 18: *Dentipellis fragilis*, indicator species for natural deciduous forests with cosmopolitan distribution (photo: Andreas Gminder)

Figure 19: *Sarcoscypha* spec. nov. ined., proposed indicator species for natural montane cloud forests, showing the remarkable crenulate cup margin significant for this species (photo: Andreas Gminder)

Molluscs at the Kafa Biosphere Reserve

Thies Geertz

Highlights

- → As far as the author is aware, this is the first systematic assessment of terrestrial molluscs in an Ethiopian rainforest, if not the whole of Ethiopia.
- → A total of 32 species of terrestrial molluscs were recorded.
- → Knowledge of the ecology and conservation status of Ethiopian land snails is very poor at present. Further research is required to complete the checklist of land snails in the Kafa BR.
- → None of the recorded species has been assessed by the IUCN Red List.
- → Boginda Forest in the core zone was the most species-rich forest, with 16 recorded snail species.
- → Freshwater molluscan diversity is very poor in the Kafa BR, with only nine species recorded in rivers, streams and ponds.
- → One pea clam (*Pisidium* sp.) was discovered that is most probably new to science. Freshwater gastropods are absent from almost all investigated ponds and streams, despite seemingly good habitat conditions. This could be due to biogeographic factors or chemical water parameters and requires further research.
- → Freshwater mussels (Unionoida) would be a good indicator group for the ecosystem health of streams and rivers.
- → The carnivorous Streptaxidae are a potential indicator group for the ecological integrity of rainforests, although further research is required.
- → Molluscs face an unprecedented rate of extinction, with 83% of East African land snails restricted to the endangered rainforests. Further research and conservation measures to curb deforestation are urgently required if these species are to survive.
- → Future research should focus on identifying forest endemics in the Kafa BR, as these are potentially good indicator species and especially prone to extirpation.

1. Introduction

This assessment of molluscs in the Kafa BR sampled both aquatic and terrestrial habitats.

1.1 Terrestrial molluscs (land snails)

Very few publications exist on the terrestrial snail fauna of Ethiopia. In 1871, the German naturalist Jickeli conducted a survey of land snails in what was then called Abyssinia (Jickeli 1874). Although he described several terrestrial snail species, his research was primarily focused on the marine malacofauna of the Red Sea, and consequently he did not penetrate far into the hinterland of present-day Ethiopia. In 1883, Bourguignat described some species collected during an expedition to northern Ethiopia (Tigray) in 1881. Then, almost 50 years later, the British malacologist Connolly described several species new to science collected from the Ethiopian Rift Valley (Connolly 1928). Most noteworthy in the context of the present biodiversity assessment, however, is a publication by the German malacologist Johannes Thiele, who described land snails collected during an expedition to Ethiopia led by the German naturalist Oscar Neumann from 1899 to 1901 (Thiele 1933). Neumann passed through present-day Kafa Zone on his journey, close to the town of Bonga, and Thiele's account is the first scientific material on molluscs in this area. A detailed description of Neumann's itinerary to southwestern Ethiopia, including many ethnographic details, is given in Neumann (1902).

Apart from Thiele's work, there are very few publications with notes on particular species (e.g. Verdcourt 1956, 1960, 1976, 1980). In general, most knowledge of Ethiopian land snails, including type descriptions, are scattered across dozens of original papers in different languages, which are difficult to access. There is currently no synoptic treatment of Ethiopian land snails. In addition, the study of Ethiopian terrestrial gastropods is seriously hampered by the high number of synonyms for many taxa. This is partly because many early descriptions from the 19th century were based on very few available specimens, sometimes single empty shells.

Apart from Thiele's work, this study is the only work known to the authors covering land snails from the Southern Nations, Nationalities and Peoples' Region (SNNPR) of Ethiopia. However, the study is more systematic because Thiele described material collected opportunistically by Neumann, whose primary research objects were birds.

As far as the author is aware, there are currently no publications dealing with the land snail communities of specific ecosystems in Ethiopia, e.g., montane forests or wetlands. However, a few biogeography and ecology papers have been published in recent years describing land snail faunae in other African lowland and montane forest ecosystems, including some neighbouring countries (Tattersfield & Seddon 1998; Wronski & Hausdorf 2010; Wronski et al. 2014; Tattersfield et al. 2001a, 2006). Wronski et al., for instance, found a maximum of 44 snail species on a 20 x 20 m sampling plot in a montane rain forest in Uganda. The maximum number of snail species found in an entire montane forest in Uganda was 66, in the same study (Wronski & Hausdorf 2010). On Bioko Island (Equatorial Guinea), Wronski et al. (2014) found no significant correlation between altitude and species richness (maximum sampling altitude: 1830 m a.s.l.). However, species richness was positively correlated with leaf litter thickness on Bioko Island. In addition, the degree of endemism generally increased with altitude and annual rainfall in Ugandan rainforests, and decreased with soil acidity (Wronski & Hausdorf 2010; Wronski et al. 2014). In the former study, the authors also showed that more than 50% of all snail species collected in Ugandan rainforests are microgastropods with an adult shell size measuring less than 5 mm (Wronski & Hausdorf 2010).

In another study, Tattersfield et al. found a total of 68 snail species on four transects on Mt. Kenya. Over 64 plots, the number of species per plot (70 x 70 m) ranged from 6.75 to 23 (Tattersfield et al. 2001a). The study on Mt. Kenya also suggests that species richness and abundance decrease with altitude. Annual rainfall was found to be the most important factor (of those assessed) in the variation between the local, terrestrial snail communities on Mt. Kenya.

As several authors have shown, Ethiopian land snail faunae comprise a mixture of Palearctic faunal elements, e.g., representatives of the family Helicidae, and typical Afrotropical taxa, e.g., representatives of the family Achatinidae (Jickeli 1874; Haas 1936; Bacci 1948). In recent years, some significant contributions have been made to increase our understanding of the distribution patterns of land snails in a few selected areas in the African tropics. However, the ecology and lifecycles of African tropical land snails remain largely unknown, especially in comparison to other animal groups.

In any event, land snails are highly dependent on moisture and precipitation, so it is not surprising to find that the species diversity of terrestrial snails is comparatively high in tropical rainforests. Although land snails have developed mechanisms to survive short periods of drought, their diversity and abundance are expected to be highest in habitats that retain moisture even in periods of drought. These conditions can be found in primary forests with a closed canopy, a thick leaf litter layer and abundant decaying deadwood on the forest floor. Secondary forests and tree plantations exhibit significantly lower snail abundance and diversity (Tattersfield et al. 2001b). In general, terrestrial snails tend to be most abundant and diverse on limestone, while acidic soils tend to be less favourable (Sturm et al. 2006).

1.2 Aquatic molluscs (freshwater snails and bivalves)

In contrast, the freshwater molluscan fauna of Ethiopia has been studied quite extensively, with a number of eminent publications and synoptic treatments (e.g., Brown 1965). Itagaki et al. wrote a treatise on the freshwater snails and bivalves of Ethiopia with useful, pictorial determination keys (Itagaki et al. 1975), while Brown provides a complete overview on all African freshwater snails in his milestone work, including their medical importance, ecology and biogeography (Brown 1994). The imbalance in current knowledge between aquatic and terrestrial molluscs is due to the fact that the aquatic group features some genera of medical importance as intermediate hosts of human and livestock parasites, thus rendering the lifecycles and distribution patterns of aquatic snails an attractive research object.

Besides the medical importance of some freshwater molluscs, much attention has been given to the rich amount of mollusc fossils that have been preserved in the lacustrine deposits of the East African Rift System (EARS) over the past millions of years. Further insight into the origins and evolution of freshwater biota has been gained through the study of fossil molluscs from East African long-lived lakes, including Lake Turkana (e.g., Williamson 1981). In terms of families and species, Afrotropical freshwater molluscan fauna is generally much poorer than the terrestrial equivalent. The majority of freshwater mollusc species are found in long-lived lakes, which are absent from the study area. Riverine molluscan communities exhibit comparatively poor species diversity (Brown 1994). Itagaki et al. identified a total of 29 species of freshwater molluscs during an extensive nationwide survey conducted in Ethiopia between 1969 and 1971. They found 18 species which are widely distributed across East Africa and another eight which could not be determined to the species level (Itagaki et al. 1975). A literature review suggests that Ethiopian freshwater molluscan fauna is neither species-rich nor particularly rich in endemics.

1.3 Expectations of the mollusc assessment

The study area in Kafa BR comprises a huge variety of different habitat types and covers a significant altitudinal gradient, from 1300 to 2700 m a.s.l. Tattersfield et al. found indications that terrestrial snail species numbers peak at elevations between 1000 and 1500 m a.s.l. on Mt. Kenya (Tattersfield et al. 2001a). A similar pattern was expected in the Kafa BR. The most species-rich habitats were expected in primary forests at lower elevations. Primary forests have closed canopies, retaining moisture inside the forest even in periods of drought, and high structural diversity, with dead logs, abundant leaf litter and decaying wood on the forest floor. These features should promote diversity of the invertebrate communities on the forest floor, including terrestrial snails.

Secondary forests or tree plantations have been shown to be less species-rich (Tattersfield et al. 2001b). Likewise, bamboo forests are expected to be less species-rich due to their high elevation and poor forest floor structure, which is mainly composed of bamboo logs. Open wetlands are expected to exhibit a poorer terrestrial snail community than forests, as the soils tend to be acidic wetlands mostly lack important snail microhabitats such as dead logs and leaf litter.

The best time to collect land snails is during the rainy season, immediately after rainfall (Sturm et al. 2006). As the fieldwork was carried out in December 2014, during the dry season, conditions were expected to be poor. Nevertheless, some snails were expected to be dormant or hidden in the ground, under dead logs or in the cracks of the bark of larger trees, especially during periods of extended drought.

Expectations for freshwater molluscs were also rather low, as the riverine molluscan communities in East African montane rainforests tend to be species-poor. The main centres of freshwater molluscan biodiversity are in the larger standing waterbodies of the East African Rift System (EARS), outside the study area. Nevertheless, a number of pulmonate species in the family Planorbidae were expected to occur in the ephemeral ponds in the extended wetlands of the Kafa BR.

2. Materials and Methods

Table 1 provides an overview of the study and sampling sites along with their geographic coordinates. Broader areas representing a single habitat type or forest are termed "study sites" (e.g., Boginda Forest (BO), Gojeb River floodplain forest (GO-riv)) while localities where specific sampling sessions were carried out are termed "sampling sites". Thus a single study site can contain multiple sampling sites. Note that the study sites were subdivided into individual sampling plots.

2.1 Sampling methods

Two different habitat types were sampled: terrestrial habitats, including forests and river floodplains, and freshwater habitats, including rivers, streams and temporal ponds. Different habitat types required different sampling methods.

Terrestrial habitats were sampled semi-quantitatively (see Appendix: sampling methods) following the standard method described in Emberton et al. (1996), Wronski & Hausdorf (2010) and Wronski et al. (2014), with slight modifications. The standard method combines a visual search of a 20 x 20 m sampling plot for four person hours with soil-plus-litter sampling. To sample soil and litter for microgastropods (< 5 mm shell size), 5 l of soil and litter is collected in a bag, sieved, dried and searched. However, soil-plus-litter samples were not collected for the present study after an initial trial, due to time constraints in the field, low yield of microgastropods and the time-consuming process of determining microgastropods to the species level, which would have exceeded the time planned for the overall assessment.

Sampling effort was also reduced to three person hours to account for the low accessibility of some sampling sites and the ensuing time constraints. In doing this, overall comparability among sampling sites was ensured.

Freshwater habitats were qualitatively sampled via a visual search for gastropod shells along the shoreline, attached to floating vegetation, emerging plants, deadwood and leaves as well as on the surfaces of stones and rocks (if present). Separately, sediment was sieved, mainly for bivalves, using a metal sieve (mesh size 1 mm) attached to a telescopic stick. This method is useful for sampling at greater depths or in otherwise inaccessible sections (see Appendix: sampling methods). The low mesh size allows the capture of minute, sediment-dwelling bivalves of the genus *Pisidium*, which seldom exceed 3 mm in shell size. Quantitative sampling of freshwater habitats is labour intensive and requires sophisticated equipment and thorough planning; therefore, it was not considered feasible in the short timeframe available for this assessment.

In addition to live specimens, dead shells were also collected. For terrestrial molluscs, live specimens were drowned in water overnight and preserved in 80% ethanol the next morning. This procedure allows better examination of the soft body parts of the snail than immediate fixation in ethanol. For freshwater molluscs, specimens were directly fixed in ethanol, as this facilitates future DNA analyses. There is a considerable interest in such analyses from the Institute of Animal Ecology and Systematics at the Justus Liebig University Giessen. All specimens were collected in screwcap vessels, separated by sampling site and labelled accordingly. Locality datasheets were filled in for all sampling sites (plots) to capture additional information on vegetation and substrate, etc. Locality sheets for terrestrial habitats were specifically designed for this study. Sampling sites were not chosen at random but selected based on favourable habitat conditions.

2.1.1 Data analysis

In accordance with the national regulations of the Ethiopian Biodiversity Institute (EBI) and the Material Transfer Agreement (MTA), half of the specimens were brought to laboratories at the Institute of Animal Ecology and Systematics at the University of Giessen, Germany, for species identification and digital microscopic imaging, with the primary objective of completing the species list. The other half were handed over to the EBI. Terrestrial specimens were determined based on conchological characteristics, via comparison with images, original descriptions and the determination keys provided in Jickeli 1874, Bourguignat (1883), Pilsbry (1919), Haas (1936), Herbert & Kilburn (2004) and Cossignani (2014).

The presence of determined taxa in East Africa was checked using the revised list of non-marine Mollusca of East Africa (Verdcourt 2006). In addition, an expert on East African land snails, Torsten Wronski from the Hamburg University Zoological Museum, kindly helped determine some difficult specimens based on digital images. Unfortunately, we were unable to access Thiele's 1933 study, which contains several original descriptions of representatives of the genus *Cerastus*, as it is only available in hardcopy at the Frankfurt and Berlin University Libraries.

The single collected aquatic gastropod species was easily determined using the determination key provided in Itagaki (1975). Aquatic bivalves were determined using Mandahl-Barth (1954) and comparative specimens from the African mollusc collections at the University of Giessen. Pea clams of the genus *Pisidium* were determined by Ulrich Bößneck from the University of Giessen.

In cases where species determination was impossible, the morphospecies concept was used, and specimens were assigned provisional names derived from the genus or family plus a single letter, e.g., *Subulinidae* sp. A, *Cerastus* sp. B etc. In general, the nomenclature of Verdcourt (2006) was followed to assign species, genus and family names to collected specimens.

Digital images of selected, small specimens (< 10 mm shell size) were acquired using a Keyence VHX-2000 digital microscope (see Appendix: sampling methods). Larger shells were photographed using a Canon PowerShot G7 digital camera. All vouchers are currently stored in the African mollusc collection at the Institute of Animal Ecology and Systematics at the University of Giessen, Germany.

3. Results and Discussion

As part of a wider biodiversity assessment, nine sampling sites (or 20 x 20 m sampling plots) were sampled systematically for terrestrial molluscs, while seven sampling sites were sampled for aquatic molluscs (Table 1). For aquatic molluscs, some sites revealed no aquatic mollusc presence, despite sampling effort. These are not included in the count.

The data collected on terrestrial snails was supplemented by the results of visits to five sampling sites, from which the author and other colleagues from the biodiversity assessment collected additional specimens in an opportunistic, non-systematic manner. Because of their very different habitats, the following section treats terrestrial and aquatic molluscs separately.

Table 1: Overview of study sites and corresponding sampling sites and plots, with site description and geographic coordinates

Study site	Sampling site	Date of collection	Latitude	North/South	Longitude	East/West	Altitude (m a.s.l.)	Site description
BK	ETH14.002	04.12.14	7.29474	N	36.37632	E	2318	Hani River, on road bridge Bonga Kaka near Boka Forest
	ETH14.003	04.12.14	7.24119	N	36.45184	E	2596	Adiyo River near Boka Forest, river bridge on main road from Bonga to Kaka
	ETH14.004	04.12.14	7.24077	N	36.45202	E	2596	Boka, meadow near bridge over big river on main road from Bonga to Kaka, near Bamboo Forest
	ETH14.018	12.12.14	7.29449	N	36.37394	E	2300	Boka Forest, north of main road Bonga – Kaka
BA	ETH14.005	04.12.14	7.24462	N	36.45872	E	2686	Bamboo Forest on main road from Bonga to Kaka

Study site	Sampling site	Date of collection	Latitude	North/South	Longitude	East/West	Altitude (m a.s.l.)	Site description
AW	ETH14.006	05.12.14	7.09281	N	36.23154	E	1293	Awurada Valley, small creek near Gumi River, primary forest
AW	ETH14.007	05.12.14	7.09281	N	36.23154	E	1293	Awurada Valley, small creek near Gumi River, primary forest
AW	ETH14.AWU	05.12.14					1300-1500	Awurada Valley, coffee forest, Participatory Forest Management (PFM) site, no plot but opportunistic collection
AG	ETH14.008	06.12.14	7.36464-7.36409	N	36.22566-36.22580	E	1700	Alemgono Wetlands
SHO	ETH14.009	06.12.14	7.35706	N	36.20436	E	1615	Shoriri Wetlands, river
SHO	ETH14.010	06.12.14	7.36004	N	36.20761	E	1700	Shoriri Wetlands, secondary forest
KO	ETH14.011	07.12.14	7.30744	N	36.12192	E	1800	Wushwush, river on road bridge near Eukalyptus plantation
KO	ETH14.012	07.12.14	7.30268	N	36.0975	E	2070	Komba Forest core zone, south of main road from Bonga to Misa
KO	ETH14.013	07.12.14	7.29585	N	36.08855	E	2108	Komba Forest core zone south of main road from Bonga to Misa
GO-riv	ETH14.014	10.12.14	7.55341	N	36.05643	E	1500	Gojeb River floodplain forest, 20 m from river near bridge on main road Bonga – Medabo short before Medabo
GO-riv	ETH14.015	10.12.14	7.55547	N	36.05721	E	1500	Gojeb River, near bridge over Gojeb River on main road from Bonga to Medabo near Medabo
GO-wet	ETH14.GJE	10.12.14						Gojeb Wetlands, coffee planatation near road bridge over Gojeb River on main road Medabo – Bonga

Study site	Sampling site	Date of collection	Latitude	North/South	Longitude	East/West	Altitude (m a.s.l.)	Site description
BO	ETH14.016	10.12.14	7.50164	N	36.09260	E	2074	Boginda Forest, NABU campsite on main road Konda-Bonga short after Saja village
	ETH14.017	11.12.14	7.50054	N	36.09553	E	2136	Boginda Forest core zone, probably secondary forest
	ETH14.BOG	09.12.14	7.50176	N	36.09124	E	2000	Boginda Forest directly at NABU campsite near Saja village
KDA GH	ETH14.KDA	Dec 2014	7.25416	N	36.25768	E	1783	Small creek and meadow 500 m above KDA Guesthouse, Bonga

3.1 Terrestrial molluscs (land snails)

The 14 sampling sites studied systematically and opportunistically were situated in bamboo forest, montane rainforest and river floodplain forest and covered an altitudinal range from 1293 to 2686 m a.s.l. A total of 32 land snail species were collected. The sampling site with the highest number of species was located in the core zone of Boginda Forest (BO), and yielded 14 species. Boginda Forest was also the most species-rich study site, with 16 species recorded. The second most species-rich study site was Awurada Valley Forest (AW), with 12 species collected. Species richness at study sites with systematic sampling ranged from five in Boka Forest (BK) to 16 in Boginda Forest (Table 2).

The collected land snails could be assigned to nine families. The most species-rich family in this study were the Cerastidae, with eight species, followed by the *Subulinidae* with seven species and the Achatinidae with six species. The species diversity of the carnivorous Streptaxidae was comparatively low, at only three species. In contrast, Wronski and Hausdorf (2010) found the Streptaxidae to be the most species-rich family in Ugandan rainforests. However, the streptaxids have minute shells, and their species determination poses severe difficulties. Close to 200 species in the streptaxid genus *Gulella* have been described from East Africa alone (Verdcourt 2006). Differentiation is partly based on variation in the dentition pattern of the aperture, which is difficult to assess (Herbert & Kilburn 2004). In light of the difficulties of determining streptaxid species, the actual number of species from this family might be greatly underestimated in this study.
The following section presents the results by study site, including observations about the habitat conditions.

3.1.1 Bamboo Forest (BA)

Only one site was sampled in the Bamboo Forest (*Arundinaria alpina*), with a total of six species found. The structural diversity of the forest floor and understorey was low, with bamboo logs making up the bulk of dead matter on the ground. However, the sampling site was chosen to include one larger flowering tree (*Schefflera abyssinica*) with a trunk diameter of > 1.5 m. Many specimens were collected in the interspace of the roots of this tree, greatly contributing to the total species count on this plot. The leaf litter layer was almost devoid of snails. There were a few signs of moderate cutting of bamboo close by. The sampling site was located in the core zone of the Kafa BR.

3.1.2 Boka Forest (BK)

Only one site was sampled in Boka Forest, with a total of five species found, making it the least species-rich plot. The collected specimens consisted mainly of dead shells. A few live specimens were collected under decaying wood and in the interspace of the roots of a larger tree. Only a few large timber trees were present in this forest fragment, and the structural diversity of the forest floor was low, as larger decaying logs were absent. There was only about 50% canopy cover, and there was evidence of bamboo encroachment. This forest patch should be classified as secondary forest, as there was evidence of high human impact, both current and historical. Other patches of this fragmented forest were visited, but habitat conditions for snails were found to be even poorer upon visual inspection.

3.1.3 Komba Forest (KO)

Two sites were sampled in Komba Forest, both located in the core zone of the Kafa BR. The area was very difficult to access. Seven species were found at each sampling site. The combined species list for Komba Forest has ten snail species in total, making the forest an average study site in terms of species-richness. The habitat conditions were very dry, as evidenced by the discovery of several dormant snails which had developed a protective membrane (epiphragm) to endure the drought. There were clear signs of selective tree cutting and understorey clearing on both sites, and only very few timber trees with a diameter of > 2 m were found. Dead logs made up less than 10% of the forest floor cover at both sampling sites.

3.1.4 Awurada Valley Forest (AW)

At Awurada Valley Forest, one sampling site was systematically sampled, while additional snails were collected opportunistically in the forest during the hike, which included PFM sites. The systematic sampling site was very close to the Gummi River in the core zone of the Kafa BR. It was also the site with the lowest altitude (1293 m a.s.l.) and the second most species-rich sampling site of the entire assessment, with nine species in total. Habitat conditions were quite moist, and plenty of dead logs were present, covering about 30% of the forest floor. Canopy cover was about 90%. A comparatively high number of live specimens were found in the interstices of decaying logs and the leaf litter layer. No direct signs of human activity were found near this sampling site, except for a recently abandoned hunter camp.

The sampling site was very difficult to find, and even the local guides lost their way, so we had to cut our way through the dense thicket for about an hour to reach it. The dataset was complemented by snails collected along the way, yielding a total of 12 terrestrial snail species. This made Awurada Valley the second most species-rich forest after Boginda Forest (16 species).

3.1.5 Alemgono Wetlands (AG)

Only one terrestrial snail species (*Limicolaria chefneuxi*) was collected opportunistically in a small secondary forest patch. The Alemgono Wetlands were not sampled further for terrestrial snails. The focus here was on freshwater habitats.

3.1.6 Shoriri Wetlands (SHO)

After collecting aquatic molluscs in the wetlands, only a single site in a nearby secondary forest was sampled for terrestrial molluscs (ETH 14.010). Eight land snail species were collected at this sampling site, an average species-richness compared to the other sites. The forest featured only a few larger timber trees and abundant shrubs up to 4 m high, with wild coffee plants in the understorey. The canopy cover was about 70% and dead log cover was < 5%. Habitat conditions were very dry, and snails were found hidden deeply under decaying wood. There were indications of moderate human impact, as a path runs nearby and the forest seems to be used for harvesting wild coffee.

3.1.7 Gojeb Wetlands (GO-wet)

A single terrestrial snail species was collected opportunistically on a coffee plantation (see also GO-riv). This site was not sampled further for terrestrial molluscs.

3.1.8 Gojeb River floodplain forest (GO-riv)

Only one sampling site was studied in the floodplain forest very close to Gojeb River. Seven terrestrial snail species were found here, an average species-richness compared to the other sites. However, two additional freshwater species (*Radix natalensis* and *Corbicula* sp. A) were found on the forest floor in high numbers, indicating a recent flooding event. Taking this peculiarity into account, the total count of mollusc species in this forest was nine. This floodplain forest is a gallery forest mainly composed of palm trees and a few timber trees. The maximum diameter of trees at the sampling site was 1 m. Canopy cover was only about 40%, and the dead log cover on the forest floor was < 5%. The high number of dead *Corbicula* sp. shells and live *Radix natalensis* specimens indicate that the area is subject to inundation during a significant portion of the year.

3.1.9 Boginda Forest (BO)

Two sampling sites were investigated in Boginda Forest. Both sites were located within the core zone of the Kafa BR. One sampling site (ETH 14.016) yielded a total of 14 terrestrial snail species, making it by far the most species-rich site investigated. The other sampling site (ETH 14.017) yielded seven snail species. The total count was 16 species, making Boginda Forest the most species-rich forest in this study. Most strikingly, a comparatively high number of microgastropods could be collected by hand from the forest floor, contributing to the overall high diversity. None of the other study sites yielded such high numbers of small snails. The site with locality code ETH 14.016, had few large timber trees (up to 1.5 m diameter) in the vicinity. The canopy cover was about 80% and the cover of dead logs on the forest floor was < 5%. Heavy signs of selective logging were found nearby. The other sampling site (ETH14.017) is probably a secondary forest, with strong signs of human activity. The canopy cover was about 70%, while the cover of dead logs on the forest floor was about 10%. However, the largest tree in a 100 m perimeter around the sampling plot was only 0.6 m in trunk diameter. There was evidence of heavy selective logging, probably to clear access to beehives installed on several trees (Fig. 4). There was a particularly large number of army ants here, possibly indicating ecosystem disturbance.

3.1.10 KDA Guesthouse (KDA-GH)

Two terrestrial snail specimens were collected opportunistically on a nearby meadow. One was assigned to a species (*Limicolaria choana*) found at none of the other study sites.

Table 2: Summary of collected mollusc species in each study site

No.	Species	BA	BK	KO	AW	AG	SHO	GO-wet	GO-riv	BO	KDA GH
TERRESTRIAL MOLLUSCS											
Halolimnohelicidae											
1	*Vicariihelix mukulensis* (Pilsbry 1919)	1		1							
Cerastidae											
2	*Cerastus lymnaeiformis* (Haas 1936)		1				1		1	1	
3	*Cerastus* sp. A	1									
4	*Cerastus* sp. B				1						
5	*Cerastus* sp. C									1	
6	*Cerastus* sp. D		1								
7	*Edouardia* sp. A	1									
8	*Edouardia* sp. B						1				
9	*Edouardia* cf. *carinifera* (Melvill & Ponsonby 1897)			1						1	
Subulinidae											
10	*Bocageia germaini* (Pilsbry 1919)	1								1	
11	*Nothapalus paucispira* (Martens 1897)	1		1			1			1	
12	*Homorus antinorii* (Morelet 1872)			1	1		1		1	1	
13	*Subulinidae* sp. A				1						
14	*Subulinidae* sp. B						1				
15	*Subulinidae* sp. C								1		
16	*Subulina muzingeri* (Jickeli 1874)									1	
Maizaniidae											
17	*Maizania elatior* (Martens 1892)			1	1			1		1	
Veronicellidae											
18	*Laevicaulis natalensis* (Simroth 1913)				1		1		1	1	1
Urocyclidae											
19	*Urocyclidae* sp. A (slug)								1		
20	*Trochozonites* sp. A									1	
21	*Trochozonites* sp. B									1	
Vitrinidae											
22	*Vitrinia* sp. A	1	1	1	1				1	1	
23	*Vitrinia* sp. B				1					1	
Streptaxidae											
24	*Afristreptaxis* cf. *aethiopicus* (Thiele 1933)		1	1	1					1	
25	*Gullela* sp. A			1	1		1		1	1	
26	*Gullela* sp. B			1						1	

No.	Species	BA	BK	KO	AW	AG	SHO	GO-wet	GO-riv	BO	KDA GH
Achatinidae											
27	*Limicolaria* sp. A			1							
28	*Limicolaria martensiana* (Smith 1880)				1						
29	*Archachatina* cf. *ustulata* (Lamarck 1828)				1						
30	*Limicolaria dhericourtiana* (Bourguignat 1885)		1								
31	*Limicolaria chefneuxi* (Bourguignat 1885)				1	1	1				
32	*Limicolaria choana* (Bourguignat 1885)										1
AQUATIC MOLLUSCS											
Lymnaeidae											
33	*Radix natalensis* (Krauss 1848)					1			1		
Sphaeriidiae											
34	*Pisidium pirothi* (Jickeli 1881)		1	1	1		1				1
35	*Pisidium viridarium* (Kuiper 1956)					1					
36	*Pisidium casertanum/ethiopicum*		1	1	1						
37	*Pisidium* sp. A (spec. nov.)		1	1							
38	*Sphaerium hartmanni* (Jickeli 1874)		1	1		1					
Corbiculidae											
39	*Corbicula* sp. A								1		
Iridinidae											
40	*Mutela* sp. A								1		
41	*Etheria elliptica* (Lamarck 1807)								1		
TOTAL species count		**6**	**9**	**14**	**14**	**4**	**9**	**1**	**11**	**16**	**3**

As far as the author of this report is aware, this work is the only systematic assessment of terrestrial molluscs in a montane rainforest in Ethiopia, if not the whole of Ethiopia. Thus, it greatly contributes to the knowledge of invertebrate communities in the northernmost extension the Afrotropical rainforest. However, the results did not entirely meet our expectations, as the number of species found is only about 50% of that found in similar forests in Uganda (Wronski & Hausdorf 2010). In the Albertine Rift in Uganda, species richness ranged from 31 to 69 species in individual montane rainforests. However, more than 50% of snail species collected there were microgastropods (< 5 mm shell size), which in the current study were collected opportunistically rather than systematically assessed, due to time constraints in the field and the difficulties associated with their determination.

In another study, Wronski et al. (2014) collected 56 species by hand on 37 plots in rainforests on Bioko Island (Equatorial Guinea). This was a closer approach to that implemented in the current study, but three times more sampling plots were used. In any event, the molluscan fauna of a rainforest cannot be completely assessed with so few plots (Cameron & Pokryszko 2005). More sampling is required to compile a more complete checklist of terrestrial snails in Kafa BR.

It is not known whether the comparatively low number of species reflects the relative geographic isolation of the Ethiopian montane rainforests from the Congo-Basin and the Albertine Rift, where most of the characteristic Afrotropical land snail families and genera have undergone massive adaptive radiation (Pilsbry 1919). The assessment was carried out in the dry season. The general impression is that conditions were very dry and thus unfavourable for snail collection, and we saw no rainfall at all during the entire stay in the area. This impression is supported by the observation that most of the collected specimens were dead shells.

Many land snails, especially the smaller species, depend on decaying wood and abundant leaf litter in which to feed and endure dry periods. In the Awurada Valley forest, where conditions where relatively moist at the time of collection, a high number of live snails was collected in the interstices between massive, decaying logs on the forest floor. We were unable to find sites with a comparable structural diversity in the Boka, Komba and Boginda Forests. The general impression was that anthropogenic influence in the latter sites was comparatively high, as supported by clear signs of selective logging and understorey clearing. These activities can be assumed to have a negative effect on land snail diversity and abundance by reducing the structural diversity of the forest floor and the capacity to retain humidity retention.

A significant part of the African rainforest land snail community is composed of small and minute species (shell size < 5 mm) (Wronski & Hausdorf 2010; Tattersfield et al. 2001b). These land snails have very limited dispersal capability, are adapted to microenvironmental conditions and are thus especially vulnerable to environmental alterations like clear cutting (Tattersfield et al. 2001b). This is supported by the fact that only five snail species were found on the only sampling plot in Boka Forest, the least species-rich plot in the entire assessment. The structural diversity of the forest floor was very poor here compared to the other sites.

There were several specimens which could not be assigned to any species with certainty. The number of species which could not be determined to species level was especially high in the families Cerastidae, Streptaxidae and Subulinidae. Given the current poor knowledge of Ethiopian land snails, further studies should aim at clarifying their systematic status. Researchers should scrutinise original descriptions of same-genus species from East Africa and examine type material found in museum collections in Europe and North America. The possibility that this assessment collected species new to science cannot currently be ruled out. DNA sequence analysis could be a powerful method to shed light on the phylogenetic relationships and biogeographic history of the land and freshwater molluscs of the Kafa BR. It can also be assumed that the total number of collected species in the Kafa BR would greatly increase with higher sampling effort.

3.2 Aquatic molluscs (freshwater snails and bivalves)

The richness of mollusc species in aquatic habitats within the Kafa BR was very poor at the time of collection. However, a seasonal effect can be excluded, as no dead shells were collected in most waterbodies. Altogether, only nine mollusc species were collected at seven different sampling sites. The most species-rich sampling sites were the Gojeb River and Boka and Komba Forests with four species per site. However, variance between individual sampling sites was very low, ranging from one to four species. Several sampling sites showed no mollusc presence at all, despite apparently good habitat conditions and highly experienced collectors. Most striking is the absence of pulmonate snail species from almost all sampling sites. Pulmonates of the genera *Bulinus* and *Biomphalaria*, for instance, are known to tolerate a wide spectrum of different environmental conditions and are almost omnipresent in high numbers in other East African stagnant water bodies, such as temporal ponds and floodplains. A typical representative of the pulmonates, *Radix natalensis*, was found only in temporal ponds in Alemgono Wetlands and – atypically – in the floodplain forest of Gojeb River, apparently enduring the dry season on the forest floor. *R. natalensis*, however, is a wide-spread African snail which is known to act as the intermediate host of the liver fluke *Fasciola gigantica* – a parasite which severely affects livestock. Itagaki et al. (1975) found the human parasite *Schistosoma* prevalent along the Gojeb River. However, the presence of intermediate hosts from the genera *Bulinus* and *Biomphalaria* in the area could not be confirmed in this study, as neither live snails nor dead shells from these genera were found.

Apart from *R. natalensis*, all other collected freshwater molluscs were bivalves. The pea clam *Pisidium pirothi*, a widespread species with low habitat requirements, was present at most of the sampled freshwater sites. The Gojeb and Gummi Rivers were difficult to access due to dense riparian vegetation, deeply eroded river banks, in the case of the Gojeb River, a rocky bottom. They thus could not be sufficiently sampled. Unfortunately, only fragments of larger bivalves could be collected, even though we strongly expected to find several species of unionid or iridinid bivalves in the larger rivers. However, shells of the freshwater 'oyster' (*Etheria elliptica*) were found on the Gojeb River in April 2015 by Peter Tattersfield from Cardiff National Museum, United Kingdom. This finding is reported here. In addition to the widespread fingernail clam species *Sphaerium hartmanni*, one basket clam species of the genus *Corbicula* (Corbiculidae) was collected in the Gojeb River, which could not be determined to species level. Thus four bivalve families were represented in the freshwaters of the Kafa BR: Sphaeriidae, Corbiculidae, Etheriidae and Iridinidae. Another remarkable finding is the discovery of a species belonging to the genus *Pisidium* that is almost certainly new to science. This species was found in a small stream near to Boka Forest and in a larger stream close to Komba Forest.

At present, no plausible explanation can be given for the relatively poor freshwater molluscan fauna in the Kafa BR. The almost complete absence of snails in apparently suitable habitats with emerging plants, e.g., in the wetlands of Boka Forest, is especially striking. Altitudinal effects can be excluded, as pulmonate snails have been found at up to 3800 m a.s.l. in East Africa (Jackson Pool, Mt. Elgon, author's data). Further investigations are required to elucidate whether chemical water parameters or biogeographic factors play a role in shaping this striking biodiversity pattern.

4. Conclusions and Recommendations for Conservation and Monitoring

4.1 General issues

Molluscs, along with other animal and plant groups, are undergoing an unprecedented period of extinction. In fact, it has been claimed that molluscs are the animal group facing the highest extinction rate of all (Regnier et al. 2009). Especially prone to extirpation are narrow endemics, species with low dispersal capacities and species depending on climax vegetation (Kay 1995). It has been shown that molluscs with long lifespans and low fecundity are particularly threatened.

In East Africa, 83% of terrestrial snail species are believed to be restricted to rainforests. However, rainforests only cover around 2-3% of the surface area in East Africa (Seddon et al. 2005). Against this background, and in light of the high deforestation rate in East Africa and Ethiopia, there are serious concerns for the conservation of molluscs.

Unfortunately, at present very few studies have been published about the distribution patterns and ecology of African tropical land snails, and knowledge about their lifecycles is very limited. In a similar vein, knowledge about the conservation status of snail species found in this assessment is lacking, as proved by the fact that none of the terrestrial snail species collected has been assessed by the IUCN Red List. In light of the scarcity of information available, it is doubtful whether meaningful conservation measures targeting individual snail species or communities can be planned at present. This underlines the importance of further investigating the diversity and ecology of African tropical land snails and the need to design and implement effective conservation measures to ensure their survival. For the time being, however, it can be assumed that threatened snail species can greatly benefit from effective protection of other umbrella or surrogate species (e.g., forest birds) which are characteristic of the same types of macrohabitat.

One pattern that emerged from this study is the fact that sites with high structural diversity of the forest floor support a comparatively higher number of species. This is supported by another study in the Kenyan Kakamega Forest, which found that species-richness is 15-50% lower on tree plantations than in indigenous forest (Tattersfield et al. 2001b). The same authors also noted that some species are exclusively confined to indigenous forest. These species should be a research priority in the Kafa BR, as they will become (regionally) extinct if deforestation in the BR is not effectively halted. Due to the isolated geographic position of the rainforests in the Kafa BR, re-colonisation from other East African rainforests is unlikely.

The current assessment of molluscs has several shortcomings: First, species determination for terrestrial snails was extremely difficult due to the complete lack of determination keys and the synoptic treatment of Ethiopian land snails. Consequently, determination could not be completed for many specimens, especially within the families Cerastidae, Subulinidae and Streptaxidae. However, this is a common difficulty also encountered by other experts (Wronski & Hausdorf 2010). It cannot be ruled out that these families show a higher degree of 'cryptic' species diversity which could not be identified in this study.

Second, total forest assessment was impossible given the short duration of the fieldwork and the high heterogeneity of habitats.

Third, the timing of the fieldwork in the dry season was not ideal for collecting snails.

Finally, knowledge of the conservation status, ecology and lifecycles of Afrotropical land snails is fragmented at present, making developing conservation recommendations and monitoring schemes challenging and vague. Table 3 summarises the information available on the distribution and conservation status of the collected mollusc species.

Nonetheless, the present study represents a first, important contribution to knowledge of molluscs as representatives of the invertebrate forest floor community of the Kafa BR. However, the present assessment must be regarded as far from complete, and extensive research is needed to gain full insight into the species composition of the molluscan communities of Kafa BR.

Even though much more is known about the ecology and lifecycles of East African freshwater snails compared to land snails, too few freshwater mollusc species were collected to allow meaningful, detailed conclusions on habitat management and monitoring. In general, freshwater molluscan diversity was found to be very low in the streams, rivers and ponds of the Kafa BR. Five of the nine species which were found are common and widespread in East Africa, while the systemic positions of another three bivalve species could not be determined with certainty. One of those species exhibited intermediate morphological characteristics of the critically endangered *Pisidium ethiopicum* and the globally distributed *Pisidium casertanum*. In addition, one species belonging to the genus *Pisidium* is almost certainly new to science. Further studies should investigate whether environmental (e.g., water chemistry) and biogeographic factors (e.g., isolation from the Nile drainage) have led to the comparative poverty of the Kafa BR's freshwater molluscan communities. In addition, it should be examined whether molluscicides such as copper sulfate have been employed on a large scale in a putative attempt to eradicate snail-borne diseases such as schistosomiasis.

It has been established that deforestation leads to increased siltation and nutrient loads in adjacent rivers and standing waterbodies. A slightly increased siltation rate and nutrient load, however, can lead to an increase in freshwater molluscan biodiversity. Higher nutrient loads mainly benefit the freshwater snail group Pulmonata, whose representatives depend on aquatic vegetation for feeding and reproduction. However, as several representatives of Pulmonata transmit severe human and livestock diseases, deforestation and higher nutrient loads in freshwaters associated herewith are also likely to promote the incidence of severe snail-borne diseases such as schistosomiasis and tropical fascioliasis. In light of these adverse effects of higher nutrient loads in streams, rivers and ponds associated with reduction in forest cover, conservation measures should generally focus on curbing deforestation and halting erosion.

Freshwater molluscs play a key role in providing ecosystem services and are essential for wetland maintenance, mainly due to their contribution to water quality, nutrient cycling through filter-feeding and algal grazing and as a food source for other animals (Darwall et al. 2011). According to the IUCN pan-African assessment of freshwater molluscs, 22% of freshwater mollusc species in East Africa are threatened, while 38% are data deficient (Darwall et al. 2011). These high proportions of threatened and data-deficient molluscs indicate a clear need for urgent conservation measures to preserve Africa's last pristine wetlands and streams, and for further research into the distribution and conservation status of East African freshwater molluscs, including those of the large rivers and streams of the Kafa BR.

4.2 Indicator groups and species

4.2.1 Terrestrial habitats

Knowledge of the taxonomic status, conservation status, ecology and lifecycles of terrestrial land snails in Ethiopia is extremely scarce. Nonetheless, terrestrial snails represent an important invertebrate community of the forest floor, with potentially suitable indicator species for ecosystem health. Future research should focus on clarifying the taxonomic status of land snails in the Kafa BR, as well as on the study of their ecology and lifecycles.

Future investigations should specifically target species within the terrestrial gastropod family Streptaxidae. The streptaxids are typical inhabitants of the rainforest floor. As (almost) all representatives of this family are predators of other forest-floor-dwelling snails, they are a higher trophic level and are thus useful surrogates for the entire molluscan community of the rainforest floor. Therefore, the author suggests further investigating the suitability of the streptaxids as an indicator group or individual streptaxid species as indicator species for the ecosystem health of the invertebrate community of the rainforest floor. In a comparison between the land snail communities of primary forest versus tree plantations in Kenya, Tattersfield et al. showed that some snail species are restricted to indigenous forest (Tattersfield et al. 2001b). These species are probably good indicator species for the ecological integrity of primary forests. However, the number of sampling plots in the current study was too low to infer which species are exclusively restricted to primary forest. Therefore, future research should focus on identifying the snail species restricted to primary forest, with the goal of incorporating them into a monitoring scheme.

Table 3: Summary of collected mollusc species and corresponding information on habitat, distribution, conservation status and endemism ('x' indicates 'not applicable')

Voucher ID	Scientific name	Family
ETH14.005V	*Vicariihelix mukulensis* (Pilsbry 1919)	Halolimnohelicidae
ETH14.010C	*Cerastus lymnaeiformis* (Haas 1936)	Cerastidae
ETH14.005C	*Cerastus* sp. A	Cerastidae
ETH14.007C	*Cerastus* sp. B	Cerastidae
ETH14.016C	*Cerastus* sp. C	Cerastidae
ETH14.018C	*Cerastus* sp. D	Cerastidae
ETH14.005E	*Edouardia* sp. A	Cerastidae
ETH14.010E	*Edouardia* sp. B	Cerastidae
ETH14.016E	*Edouardia* cf. *carinifera* (Melvill & Ponsonby 1897)	Cerastidae
ETH14.005B	*Bocageia germaini* (Pilsbry 1919)	Subulinidae
ETH14.005N	*Nothapalus paucispira* (Martens 1897)	Subulinidae
ETH14.AWUH	*Homorus antinorii* (Morelet 1872)	Subulinidae
ETH14.007S	*Subulinidae* sp. A	Subulinidae
ETH14.010S	*Subulinidae* sp. B	Subulinidae
ETH14.014S	*Subulinidae* sp. C	Subulinidae
ETH14.016S	*Subulina muzingeri* (Jickeli 1874)	Subulinidae
ETH14.007M	*Maizania elatior* (Martens 1892)	Maizaniidae
ETH14.016L	*Laevicaulis natalensis* (Simroth 1913)	Veronicellidae
ETH14.014U	*Urocyclidae* sp. A (slug)	Urocyclidae
ETH14.017TA	*Trochozonites* sp. A	Urocyclidae
ETH14.017TB	*Trochozonites* sp. B	Urocyclidae
ETH14.005V	*Vitrinia* sp. A	Vitrinidae
ETH14.016V	*Vitrinia* sp. B	Vitrinidae
ETH14.016H	*Afristreptaxis* cf. *aethiopicus* (Thiele 1933)	Streptaxidae
ETH14.007G	*Gullela* sp. A	Streptaxidae
ETH14.017G	*Gullela* sp. B	Streptaxidae
ETH14.013L	*Limicolaria* sp. A	Achatinidae

Habitat/ forest type	Study sites	Distribution	IUCN Threat Status	CITES Appendix	Endemism
Bamboo forest, montane forest	BA, KO	East African montane forest	not assessed	x	x
Montane forest, river floodplain forest	BK, SHO, GO-riv, BO	East Africa	not assessed	x	x
Bamboo forest	BA	unknown	x	x	unknown
Mid - altitude forest	AW	unknown	x	x	unknown
Mid - altitude forest	BO	unknown	x	x	unknown
Mid - altitude forest with bamboo encroachment	BK	unknown	x	x	unknown
Bamboo forest	BA	unknown	x	x	unknown
Mid - altitude secondary forest	SHO	unknown	x	x	unknown
Mid - altitude forest	KO, BO	South East Africa	not assessed	x	x
Bamboo forest, montane forest	BA, BO	Uganda, Ruwenzor	not assessed	x	x
Bamboo forest, montane forest	BA, KO, SHO, BO	East Africa	not assessed	x	x
Montane forest, river floodplain forest	KO, AW, SHO, GO-riv, BO	Ethiopia	not assessed	x	Ethiopia
Mid - altitude forest	AW	unknown	x	x	unknown
Secondary mid - altitude forest	SHO	unknown	x	x	unknown
River floodplain forest	GO-riv	unknown	x	x	unknown
Montane forest	BO	Ethiopia	not assessed	x	Ethiopia
Montane forest, coffee plantation	KO, AW, GO-wet, BO	East Africa	not assessed	x	x
Montane forest, anthropogenic landscape	AW, SHO, GO-riv, KDA GH	Eastern and Southern Africa	not assessed	x	x
Floodplain forests	GO-riv	unknown	x	x	unknown
Montane forest	BO	unknown	x	x	unknown
Montane forest	BO	unknown	x	x	unknown
Bamboo forest, montane forest, floodplain forest	BA, BK, KO, AW, GO-riv, BO	unknown	x	x	unknown
Montane forest	AW, BO	unknown	x	x	unknown
Montane forest	BK, KO, AW, BO	Ethiopia	x	x	possibly Ethiopia
Montane forest, river floodplain forest	KO, AW, SHO, GO-riv, BO	unknown	x	x	unknown
Montane forest	BO, KO	unknown	x	x	unknown
Montane forest	KO	unknown	x	x	unknown

Voucher ID	Scientific name	Family
ETH14.AWUL	*Limicolaria martensiana* (Smith 1880)	Achatinidae
ETH14.AWUA	*Archachatina* cf. *ustulata* (Lamarck 1828)	Achatinidae
ETH14.018L	*Limicolaria dhericourtiana* (Bourguignat 1885)	Achatinidae
ETH14.AWUL1	*Limicolaria chefneuxi* (Bourguignat 1885)	Achatinidae
ETH14.KDAL	*Limicolaria choana* (Bourguignat 1885)	Achatinidae
ETH14.008R	*Radix natalensis* (Krauss 1848)	Lymnaeidae
ETH14.003Pp	*Pisidium pirothi* (Jickeli 1881)	Sphaeriidae
ETH14.008Pv	*Pisidium viridarium* (Kuiper 1956)	Sphaeriidae
ETH14.003PA	*Pisidium* sp. A (spec.nov.)	Sphaeriidae
ETH14.003Pc	*Pisidium casertanum/ethiopicum*	Sphaeriidae
ETH14.008S	*Sphaerium hartmanni* (Jickeli 1874)	Sphaeriidae
ETH14.015S	*Corbicula* sp. A	Corbiculidae
ETH14.015M	*Mutela* sp. A	Iridinidae
ETH15.GJE	*Etheria elliptica* (Lamarck 1807)	Etheriidae

For the time being, species from other animal groups where we have extensive knowledge of their habitat requirements (e.g., birds) should be used as surrogate species to design meaningful conservation measures and habitat-specific monitoring schemes.

4.2.2 Rivers and streams

Bivalves from the superfamily Unionoida (families Unionidae and Iridinidae) are potentially good indicators of ecosystem health in rivers and streams. The Unionoida are large freshwater mussels with are easily distinguishable from the Sphaeriidae and Corbiculidae by their much larger shell size (up to 150 mm). Adult Unionoida are benthic filter feeders with very low mobility, like all bivalves, and thus sensitive to siltation. Although very few facts have been established about the lifecycles of African tropical Unionoida, it can be assumed that they use the same intriguing dispersal strategy as their European relatives. Their larvae (Glochidia) are released into the water column and parasitise the gills or fins of certain fish species. The fish disperse the larvae and release them after a couple of months. The larvae then sink to the bottom of the water body before finally developing into adult, filter feeding bivalves. The complexity of the lifecycle of the Unionoida, combined with their low individual mobility, makes them susceptible to deterioration of physical and chemical water parameters and a simultaneous decline in their host fish population.

Habitat/ forest type	Study sites	Distribution	IUCN Threat Status	CITES Appendix	Endemism
River floodplain forest	AW	East Africa	not assessed	x	x
River floodplain forest	AW	Southern Africa	not assessed	x	x
Mid - altitude forest with bamboo encroachment	BK	Ethiopia	not assessed		Ethiopia
Mid - altitude forest, wetlands	AW, AG, SHO	Ethiopia	not assessed		Ethiopia
Anthropogenic landscape	KDA GH	Ethiopia-Sudan	x	x	Ethiopia-Sudan
Temporal ponds	AG	Pan-African	LC	x	x
Temporal ponds, streams, rivers	BK, AW, SHO, KO	Pan-African	LC	x	x
Temporal ponds	AG	global	not assessed	x	x
Streams, rivers	BK, KO	unknown	not assessed	x	unknown
Streams, rivers	BK, KO	only known from type locality	CR	x	Ethiopian Highlands
Temporal ponds, streams, Rivers	BK, KO, AG	Pan-African	LC	x	x
Rivers	GO-riv	unknown	x	x	unknown
Rivers	GO-riv	unknown	x	x	unknown
Rivers	GO-riv	Pan-African	LC	x	x

In Europe and North Africa, the decline and extinction of unionid bivalve populations is strongly correlated with anthropogenic alteration of the hydromorphology and chemical characteristics of rivers and streams. Hence, the author proposes the Ethiopian representatives of the Unionoida as good indicators of ecosystem health of running waters and larger standing waterbodies. They should be incorporated into a future monitoring scheme as a high spatial resolution component, in order to monitor the conservation status of the rivers and streams of the Kafa BR.

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6. Appendix

6.1 Photos

6.1.1 Mollusc species

Figure 1: *Afristreptaxis* cf. *aethiopicus* (BK) (photo: Thies Geertz)

Figure 2: *Bocageia germaini* (BK) (photo: Thies Geertz)

Figure 3: *Cerastus* sp. D (BK) (photo: Thies Geertz)

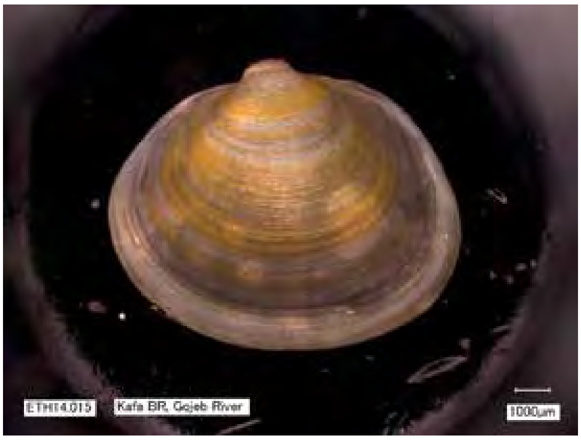

Figure 4: *Corbicula* sp. A (GO-riv) (photo: Thies Geertz)

Figure 5: *Edouardia* cf. *carinifera* (BO) (photo: Thies Geertz)

Figure 6: *Gullela* sp. A (GO-riv) (photo: Thies Geertz)

Figure 7: *Gullela* sp. B (KO) (photo: Thies Geertz)

Figure 8: *Homorus antinorii* (AW) (photo: Thies Geertz)

Figure 9: *Laevicaulis natalensis* (SHO) (photo: Thies Geertz)

Figure 10: *Limicolaria chefneuxi* (AG) (photo: Thies Geertz)

Figure 11: *Limicolaria* sp. A (KO) (photo: Thies Geertz)

Figure 12: *Maizania elatior* (GO-wet) (photo: Thies Geertz)

Figure 13: *Nothalapus paucispira* (BO) (photo: Thies Geertz)

Figure 14: *Pisidium pirothi* (BK) (photo: Thies Geertz)

Figure 15: *Radix natalensis* (AG) (photo: Thies Geertz)

Figure 16: *Sphaerium hartmanni* (BK) (photo: Thies Geertz)

Figure 17: *Subulina muzingeri* (BO) (photo: Thies Geertz)

Figure 18: *Subulinidae* sp. A (AW) (photo: Thies Geertz)

Figure 19: *Subulinidae* sp. A (AW) (photo: Thies Geertz)

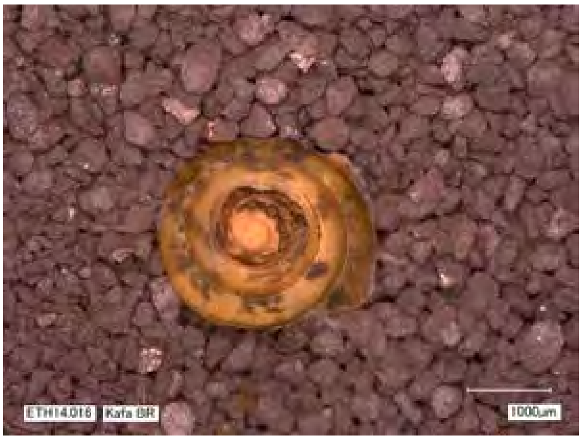

Figure 20: *Trochozonites* sp. A (BO) (photo: Thies Geertz)

Figure 21: *Trochozonites* sp. B (BO) (photo: Thies Geertz)

Figure 22: *Urocyclidae* sp. A (GO-riv) (photo: Thies Geertz)

Figure 23: *Vicariihelix mukulensis* (KO) (photo: Thies Geertz)

Figure 24: *Vitrinia* sp. A (GO-riv) (photo: Thies Geertz)

Figure 25: *Vitrinia* sp. A (KO) (photo: Thies Geertz)

Figure 26: *Vitrinia* sp. B (AW) (photo: Thies Geertz)

Figure 27: *Vitrinia* sp. B (BO) (photo: Thies Geertz)

6.1.2 Sampling methods

Figure 28: Sampling land snails near to Gojeb River (GO-riv) (photo: Thies Geertz)

Figure 29: Sampling aquatic molluscs (GO-riv) (photo: Thies Geertz)

Figure 30: Keyence VHX-2000 digital microscope (photo: Thies Geertz)

Figure 31: Evidence of selective logging in BO (Boginda Forest) (photo: Thies Geertz)

Figure 32: Access to the banks of the Gojeb River (GO-riv) was very difficult during the survey period (photo: Thies Geertz)

Figure 33: An apparently good habitat for snail fauna in the Boka Forest, but with extremely poor species richness (BK) (photo: Thies Geertz)

Beetles at the Kafa Biosphere Reserve, with notes on other insects

Matthias Schöller, contribution on butterflies by Daniel Wiersborski

Highlights

→ This is the first time a comprehensive assessment of beetles has been conducted and reported at Kafa BR, covering a wide range of habitats and altitudinal gradients.

→ The various sampling and trapping methods applied proved to be effective.

→ 400 beetle species belonging to 79 families/subfamilies were recorded. Almost every major beetle family occurred at the sampled sites.

→ Despite collecting during an unfavourable season, 164 Staphilinidae species were recorded within just 10 sampling days, out of approximately 530 known for Ethiopia (30%).

→ Several species are new to science, e.g., a water beetle *Pachysternum* sp. nov., and the new species *Tachinoplesius schoelleri* Schülke 2016 was described. To date, determinations indicate 40 species are new to science; however, this number could increase as more determinations are completed. This process proved difficult due to a lack of specialists for many beetle groups.

→ In the bamboo forests, phytotelmata were discovered, hidden in freshwater habitats. These are previously unknown for Ethiopia.

→ Wetland habitats like the Shoriri Wetlands are in good condition. More research is needed in these areas.

→ Species diversity in PFM forest sites benefits when the moisture in the ground layer is maintained by, e.g., the presence of large trees or microstructures such as climbing plants, tree holes or shrub and herb diversity.

→ Leaf beetles in the genus *Altica* could be good indicators of wetland conservation status.

1. Introduction

Information on the insect fauna of Ethiopia has never been reviewed. Thus, no checklist is available for the insects of Ethiopia. Occasionally, this information can be quickly extracted from existing catalogues or keys, but only for very few taxa (e.g., dragonflies). There is no national insect collection, so comparison with earlier collections is impossible. In addition, comparatively few specimens are available in European museums. Existing information (Selman 1973; Borowiec 1994; Medvedev 2000; Biondi et al. 2015) suggests that the insect fauna of Ethiopia differs considerably from that of neighbouring countries Sudan, South Sudan, Somalia and Kenya. However, only Kenyan insect fauna have received any significant study.

Consequently, information must be compiled from scattered original publications, typically revisions of insect taxa at the genus or species-group level. This cannot be provided even for the beetles during this assessment; it will have to be a long-term project, ideally coordinated by an Ethiopian institution. Such a checklist will only be able to provide broad information, because many of the descriptions from the 19th and early 20th centuries provide only vague descriptions of collection sites (e.g., "Abyssinia"). An example of such a checklist, compiled by the author, is given in the Appendix.

On the species level, the beetle fauna of Ethiopia is composed of Afrotropical and Palaearctic elements. However, a study of museum specimens of leaf beetles (Chrysomelidae) by the author suggests the presence of relatively few Palaearctic elements. Generally, lowland ecosystems were expected to exhibit greater diversity than montane forests. The assessment took place in December, but most Ethiopian beetles traced in museum collections were collected in April and March; therefore, an influence of seasonality was expected. The impact of settlements and habitat fragmentation on beetle species composition cannot be predicted yet, because the ecological demands of the different species are not yet known.

The beetles were sorted to the family level, in many cases to the genus level and partly to the species level.

2. Materials and Methods

2.1 Study area

Table 1 lists the study sites visited during the 10 days of the assessment. These include coffee forests (montane forests), bamboo forest, secondary forest, river banks, and wetlands.

Table 1: Study sites and characteristics

No.	Code	Area	Woreda	Habitat	Sites
1	BA	BONGA	Adiyo	Bamboo forest/ riverine vegetation	Bamboo forest
2	BK	BONGA	Adiyo	Montane forests	Boka Forests
3	KO	BONGA	Gimbo	Montane forests	Komba Forests
4	AW	BONGA	Decha	Montane forests/ riverine vegetation	Awurada Valley (Gummi River, PFM sites)
5	AG	BONGA	Gimbo	Wetland	Alemgono Wetland
6	SHO	BONGA	Gimbo	Wetland	Shoriri
7	MA	BONGA	Decha	Montane forests	Mankira forests
8	GO-wet	BOGINDA	Gawata	Wetland	Gojeb Wetland
9	GO-riv	BOGINDA	Gawata/Gimbo	River/floodplain forests	Gojeb River
10	BO	BOGINDA	Gawata	Montane forests	Boginda Forests
11	BG	BONGA	Guesthouse	Anthropogenic settlement	KDA Guesthouse and surroundings

2.2 Sampling methods

A variety of sampling methods and trap types were used. These are presented in the following sections.

2.2.1 Collection methods

Beating umbrella

A beating umbrella is used to catch insects found on foliage. The umbrella is held beneath the foliage while the collector strikes the foliage with a stick. Insects then fall into the umbrella. This is especially effective with tough and scrubby or spiny plants. One disadvantage is its openness, as some active insects can escape.

A special umbrella for insects (Fig. 1) can be obtained commercially in Europe, but regular umbrellas can be also used. However, these should be unicolour, so insects can be readily perceived. An aspirator is used to collect the insects from the umbrella.

Sifter

A sifter (Fig. 2) is used to sample accumulations of organic material such as leaf litter, and/or the top layer of soil. All typical arthropods on the top layer of soil are covered by this collection method. Only some very small arthropods may be missed.

In forest habitats, one square metre of leaf litter was sampled, along with the top layer of soil. This was repeated three times, i.e., a total of three square metres were sampled. In every forest, the following sieving sites were chosen: a relatively open site, a site close to the buttress root of a tree and a site close to decaying wood. Whenever possible, additional special microhabitats such as organic material in tree hollows or on aerial roots, bark and fungi were sampled.

Sweeping net

A sweeping net is used to catch insects present on herbs, grasses or flowers. A single piece of cloth or gauze is mounted on a metal frame held by a pole (Figs. 3 and 4).

Aerial insect car net

Many beetles fly between locations. Those beetles can be caught by aerial nets. In Kafa, an aerial insect car net was used, mounted on a four-wheel drive jeep (Fig. 5).

The net was constructed by the author, as such nets are not commercially available. The net was 2 m long, with a 0.5 m² opening and attenuated towards the end. A removable collecting bag was attached to the end of the net. The nylon material had a mesh width of 0.2 mm x 0.25 mm. The time and speed of collecting were standardised: one hour between 5:30 pm and 6:30 pm at a constant speed of 30 km/h, i.e., a distance of 30 km. GPS and altitude data were recorded at the start and end of the drive.

2.2.2 Traps

Barber pitfall trap

The Barber pitfall trap is a tool to quantitatively assess terrestrial arthropods. They primarily catch nocturnal insects. Barber traps were positioned in three forest sites and at the KDA Guesthouse in Bonga for a period of six days. A plastic cup was placed inside another plastic cup with a hole in the bottom to prevent drowning the trap during rain (Fig. 6). The outer cup was a quarter-filled with a mixture of two parts ethanol (75%) and one part glycerine. The cup was buried in the ground, with the upper rim carefully positioned level with the soil surface to avoid obstructing walking arthropods. A second type of Barber trap with a funnel placed above the collection vial was also tested. This design prevents vertebrates from falling into the trap.

Barber traps could only be placed in three sites (KDA Guesthouse, Mankira Forest, Komba Forest), because there was insufficient time to visit more places twice to collect the traps.

Flight intercept trap

Flight intercept traps are used to catch flying insects. They hit the glass window of the trap and fall through the funnel into a cup filled with the liquid killing agent, which is one part glycerine and two parts 75% ethanol (Fig. 7). Flying insects are generally caught at random.

Due to ease of transport, a small type of flight intercept trap was used in Kafa BR. It was modified by the author with a moth-funnel trap used for forest- and stored-product moths. Two forest sites and the area around the KDA Guesthouse were sampled. The traps were used continuously for a period of six days. Flight intercept traps could only be placed in three sites (BG, MA, KO, see Table 1), because there was insufficient time to visit more places twice to collect the traps.

Light trap

Many insects are attracted by light. When conditions are ideal, large numbers of insects can be caught. The ideal conditions are temperatures above 18°C, little or no moonlight and little wind. A variety of light sources can be used, such as white light or black light (ultraviolet light).

In Kafa, a light trap was provided by the Ethiopian insect team (Fig. 8). A generator was used to power white light bulbs, set in front of a white sheet and a gauze light tower brought from Germany. Insects were removed from the sheet using a collection vial and an aspirator. On one occasion, the energy for the light was provided by a car battery with the help of a power converter. Alligator clips were used to connect the converter to the light.

Yellow dish trap

Yellow dish traps mimic yellow flowers and attract flower-visiting insects (Fig. 9). These insects fall into the liquid killing agent. Sometimes flying insects not attracted by colour fall into the dishes by chance.

2.3 Data analysis

Following the national regulations of the Ethiopian Biodiversity Institute (EBI), samples were properly prepared and exported to Germany, with the main objective of further identifying the species and completing the species list. The rove beetles (Staphylinidae) were identified in collaboration with Michael Schülke, Berlin, and the water scavenging beetles (Hydrophilidae) with Martin Fikáček, Prague. The butterflies (Lepidoptera) collected by Daniel Wiersborski were identified by Dr Axel Hausmann, The Bavarian State Collection of Zoology (ZSM).

Insects were identified to the family level, and, where possible, information on subfamily, tribe, genus and (in a few cases) species are given. The number of species was estimated using morphospecies analysis. Table 4 classifies beetles according to the family group names proposed by Bouchard et al. (2011). Due to the lack of collection reference in European museums, a number of species are still being identified, which will take some time. Only a qualitative analysis was conducted.

3. Results and Discussion

3.1 Collection methods

Beating umbrella

All insect groups typically obtained with a beating umbrella were caught in Kafa: Blattodea, Neuroptera, Dermaptera, Ensifera, Caelifera, Coleoptera, Hemiptera like Heteroptera and Homoptera, Auchenorrhyncha, Psocoptera, Thysanoptera, Hymenoptera. Some spiders were also caught, but are not collected here.

The number of insects varied greatly by habitat type and plant species. However, the beating umbrella was one of the most effective collection tools. Phytophagous Coleoptera such as weevils (Curculionoidea) and leaf beetles (Chrysomelidae) were mainly collected via this method.

Sifter

Typical soil arthropods such as woodlice, Myriapoda, Millipedia and insects such as Collembola were found. However, the number of arthropods sieved was generally low. Few beetles were found, ranging from one to five per square metre. Numbers were too low to compare forest sites. Microhabitats such as organic material on aerial roots were more diverse, and cockroaches, rove beetles and ground beetles were found. No beetles were found on fungi.

The leaf litter and the top layer of soil were relatively dry. This could be due to the climatic conditions during the dry season. Use of the forests for coffee production could also be responsible for the dryness of the soil, e.g., due to the removal of decaying wood, herbs, shrubs and shading trees. The area should be investigated again at other times of the year, at least at the start of the rainy season

Sweeping net

By sweeping grasses and herbs, insects of the following orders were caught: Ensifera, Coleoptera, Heteroptera, Auchenorrhyncha, Hymenoptera and Lepidoptera.

In general comparatively few insects were obtained. The exception was some wetland sites, where several groups were abundant (e.g. leaf beetles in the genus *Altica* on *Rumex* plants). This classic collection method is especially recommended for the wetlands. In forest sites, spiny shrubs limit the application of sweeping nets.

Aquatic net and sieve

These techniques were used by the mollusca team. Water beetles belonging to the Dytiscidae and Hydrophilidae families were obtained. However, the number of individuals obtained was low.

Aerial insect car net

Insects in the following orders were obtained: Coleoptera, Hemiptera like Heteroptera and Homoptera Auchenorrhyncha, Psocoptera, Thysanoptera, Hymenoptera, Diptera Nematocera, Diptera Brachycera and Lepidoptera. Mites were also caught, and are presumably phoretic on the insects.

While handheld aerial nets have long been used to catch beetles, little data is available on aerial insect car nets. Experience from Germany and Costa Rica determined the chosen speed and time of day. At higher speeds, soft insects such as flies are squashed, but at lower speeds the net cannot be stretched to its full capacity. These observations were confirmed in Kafa BR. A large number of insects were obtained. However, compared to (unpublished) data from sampling in Germany, fewer insects were caught, in terms of number of both individuals and species. The factors affecting this method require more detailed study. The aerial insect car net is recommended for exploring insect diversity, as almost none of the species obtained with this method was obtained elsewhere. It also caught beetles that are difficult to collect by other methods, such as small myrmecophilous Staphylinidae.

3.2 Traps

Barber pitfall trap

Arthropods typically caught in Barber traps were also obtained in Kafa BR: beetles in the families Carabidae and Staphylinidae, springtails (Collembola) and some caterpillars. However, few individuals were caught. Barber traps should be used as a standard technique in the future. During the study period, the number of insects caught was too low to compare the forest sites. One problem is the presence of ants, which try to get liquid from the trap. Some traps contained large numbers of ants, which were hard to separate from the other arthropods. When Barber traps are used in future long-term assessments, they should be covered to shelter them from rain water.

Light trap

The following insect groups were obtained in Kafa BR by using light traps: Ensifera, Caelifera, Coleoptera, Heteroptera, Auchenorrhyncha, Lepidoptera, Hymenoptera, Diptera, Ephemeoptera, Isoptera and Plecoptera. Various beetle families such as Carabidae, Scarabaeidae, Hydrophilidae, Dytiscidae and Elmidae were also caught.

The full moon during the sampling period presumably diminished the success of the light trap. However, large numbers of insects were attracted to the trap at sites like the bridge near Enderach, showing the potential of this method. Light traps are the most important technique for collecting nocturnal Lepidoptera and should be used in future studies.

Flight intercept trap

The following insect groups were obtained in Kafa using the flight intercept trap: Coleoptera, Heteroptera, Auchenorrhyncha, Thysanoptera, Hymenoptera and Diptera. Flight intercept traps should be used as a standard technique in the future. Techniques should be developed to place these traps higher in the canopy. When placed in a particular plant, this trap type can trap insects specifically associated with that plant. When used over a longer period, seasonal effects on insect activity can also be monitored.

During the study period, the number of insects caught was too low to compare the forest sites. However, it was possible to show that insects actively fly in the relatively dark low mountain forest layers during the dry season.

Yellow dish trap

The yellow dish traps mainly caught Diptera. A few beetles and Hymenoptera were also trapped.

3.3 Habitats

Bamboo forest

The bamboo thickets are dominated by bamboo (*Arundinaria alpina*), but single rainforest trees are present, such as *Schefflera abyssinica*. An adjacent wetland was also sampled.

Few insects were obtained with the beating umbrella from bamboo and trees in the bamboo thicket. Only the different species of broad-nosed weevils (Entiminae) were remarkable. Sieving the ground layer revealed few beetle specimens, but ants were very abundant, indicating a disturbed habitat.

Even though the bamboo had few external feeders, holes in the stems were common (Figs. 10 and 11). Such holes are known to be produced by longhorn beetles (Cerambycidae) and butterflies (Lepidoptera). The holes in the bamboo in Kafa BR are probably caused by moths from the family Crambidae. The Ethiopian insect team found that Kafa BR is species-rich when it comes to this family (see Table 4).

Rainwater running down the stem enters these holes and partly fills up the internodes, producing phytotelmata, small temporary water habitats (Mogi 2004). Phytotelmata are small and hidden, and thus often overlooked by humans. The water in internodes cannot be seen from the outside. However, these hidden aquatic habitats support a rich aquatic fauna dominated by invertebrates (Fig.12).

The existence of such phytotelmata in Ethiopia was not previously known. In Eastern Africa, they are only known to occur in Kenya (Damir Kovac pers. com.). Six bamboo stems of different age and a diameter of ca. 15 cm with holes in them were cut above the level of the holes to extract the water they contained. Young stems contained clear water. Nematocera larvae were collected from stems of medium age. Old stems had cracks and no water remained.

In Southeast Asia, bamboo phytotelmata are known to contain species-rich microhabitats. The presence of holes and fly larvae indicate the possibility of the presence of more species associated with the phytotelmata in Kafa. However, this must be investigated when the young bamboo is growing, as in Southeast Asia most species are collected during this period. In Kafa BR, this period is expected to be in June.

The wetlands close to the bamboo thickets are bordered by pastures, i.e., grassland with *Hypericum* shrubs. Insects were abundant in these wetlands. Typical species include rove beetles in the genus Stenus on grasses and water beetles of the family Gyriniae in patches of open water. Grassland ants are very abundant close to the river, indicating a disturbed habitat. But the gallery forest is dominated by *Hagenia abbyssinica* and rich in climbing plants, so diverse phytophagous insects can be found there.

Moist evergreen montane forest containing wild *Coffea arabica*

Insects were sampled in the leaf litter and upper soil layer, as well as on herbs and shrubs (Fig. 13). Insects in fungi and in pieces of deadwood were also sampled. However, these structures exhibited poor species richness and a low number of individuals. The soil and litter was very dry, which could have been a seasonal effect. Observations on seasonality of soil invertebrates were published by Rybalov (1990) for Ethiopia, indicating that many species survive the dry season as diapausing eggs. The only exception was the Saja Forest. This forest and the forest adjacent to the Shori-ri Wetlands should be examined for possible higher diversity in the future.

The flight intercept traps and the aerial car net revealed typical forest beetles such as bark beetles (Scolytinae, 17 species) and their specialised predators, adapted Histeridae and Cleridae. More beetles, especially ground and rove beetles, were collected in microhabitats such as accumulations of organic material in and on trees. Moisture content was higher in these structures, as indicated by the presence of cockroaches. Phytophagous beetles were mainly collected from climbing plants and coffee trees. It is extremely difficult to identify beetle species characteristic of certain forest types, requiring a detailed knowledge of the forest ecosystem. Even in Central Europe, it has been difficult to identify indicator species for forests (Eckelt et al. 2014).

Wetlands

Characteristic flea beetles in the genus *Altica* (Fig. 14) were abundant on Rumex and Oentheraceae. Many *Altica* spp. are strongly female-biased, and this also proved true for the Ethiopian species. The presence of large populations could be a good indicator of an intact wetland habitat. As they feed on characteristic dicotyledonous plants in the wetlands, they indicate the structural diversity of this grass-dominated habitat. In addition, their absence could indicate possible herbicide impact, as herbicides can selectively kill dicotyledonous plants and potentially pollute the wetlands.

3.4 Beetle, Coleoptera

A total of 400 beetle species from 79 families/subfamilies were recorded. The number of beetles recorded at each collection site is listed in Table 3. The species numbers given for the different sites do not reflect differences in biodiversity, because it was not possible to expend the same collection effort across all sites. For example, traps could only be placed at three sites. However, the Mankira, Komba, Boka, Ufa and Alemgono sites are comparable, and around 100 species were found at each of these sites. Due to lack of literature, information on endemicity cannot be given at this time. None of the beetle species has IUCN threat status.

3.5 Other insect groups

The car aerial net revealed a rich fauna of parasitoid Hymenoptera, especially Chalcidoidea. This is interesting, because parasitoid Hymenoptera were thought to be comparatively poorly represented in tropical rainforests compared to temperate regions (Veijalainen 2012). This is theorised as the main reason why beetles are the most diverse insect group worldwide, rather than Hymenoptera (like in Central Europe). It would be interesting to investigate whether this species richness in Kafa is characteristic for moist evergreen montane forests, or if these results are due to the sampling method. A diverse array of Thysanoptera was also sampled, along with representatives of different ecological guilds, such as fungus-feeders and predators. Research on Lepidoptera is currently being conducted by the Ethiopian insect team, coordinated by Daniel Wiersborski (see Table 5 with determinations by Dr Axel Hausmann). Dragonflies and flower-visiting Hymenoptera are reported separately by Dr Viola Clausnitzer (see Chapter on dragonflies) and Hans-Joachim Flügel (see Chapter on flower-visiting insects).

4. Conclusions and Recommendations for Conservation and Monitoring

4.1 Recommendations for insect conservation

Most recommendations for insect conservation focus on habitat conservation. Insect communities reflect the status of their habitats, along with their richness in microstructures and plant diversity.

Reliable data on the vulnerability of insect species to extinction and their threats also requires robust biological monitoring of tropical ecosystems, which is typically limited to a few flagship species (Lawton et al. 1998). Therefore, multi-taxa assemblages, including functional guilds, must be considered in case insect responses to disturbance need to be properly assessed.

Within the Kafa BR, many natural ecosystems are altered to agro-ecosystems. This has created a mosaic landscape comprised of simple and complex agro-ecosystems and patchily distributed rainforest fragments of varying quality. The distance between these rainforest fragments should be minimised and connections between the different natural habitats should be established.

At present, the Afromontane moist forests where coffee grows as understorey trees are traditionally managed by thinning the shade tree canopy and slashing competing undergrowth (Hundera et al. 2015). In PFM sites with coffee forests, preservation of microhabitats such as climbing plants, accumulation of organic material in and on trees, decaying wood and shrubs other than coffee should be encouraged. Ideally, at least small exclosures should be created to allow the natural regeneration of the forest trees.

Some forest areas should be protected from all kinds of use, including agroforestry and cattle trespass. Screening for the potential natural composition of tree species should be followed up by screening of phytophagous insects on these trees. Recent studies like those by Biondi et al. (2015) use groups of beetles to characterize both the biogeography and ecology of the Afrotropical region, which could potentially be used to aid conservation biology. However, such groups must be well known, and there are only a few examples with representatives in Ethiopia (e.g., the genus *Chaetocnema*).

To work out more specific recommendations, the following tasks must be completed:
A monitoring scheme should be developed to sample insects in selected habitat types. Several of the techniques evaluated in this report are recommended for this, such as Barber pitfall traps, flight intercept traps, car aerial nets and beating umbrellas. Previous studies on Afrotropical insect diversity found that applying range of sampling methods yields more diverse material than high replication of any individual method (Missa et al. 2009). In addition, morphospecies composition in trap catches is more strongly influenced by habitat type than by sampling methods (Missa et al. 2009).

The insect fauna associated with different tree species should be studied. One promising method is fogging (Adis et al. 1998), which involves distributing a pyrethrum mist into the canopy. Insects are knocked down by the natural insecticide, and fall onto blankets distributed on the ground below the tree. Flight intercept traps can also be used for this task.

In the long run, research into biodiversity in the Kafa BR and other Ethiopian regions require a national infrastructure. A national Ethiopian insect collection should be established. A checklist of Ethiopian insects should be compiled. Wetlands should be preserved through buffer zones separating wetlands from agricultural land, to prevent pollution through pesticides and fertilizers. The presence of large populations of *Altica* (Fig. 14) could be monitored via flight intercept traps and/or standardised netting.

The degree of knowledge of Ethiopian beetle fauna is currently difficult to estimate, due to the lack of checklists and the absence of systematic monitoring. However, the results on the Staphylinidae from this expedition point to poor knowledge of the fauna: within 10 sampling days during an unfavourable season, 164 Staphylinidae species were recorded, out of approxmiately 530 known for Ethiopia (30%).

4.2 Suggestions for future studies

Future studies should last at least one year and should combine systematic trapping and sampling, along with exploration of potential primary forest and other little-disturbed habitats.

Fogging should be introduced to study the canopy fauna of the remaining rainforest trees shading the coffee (Adis et al. 1998). This method allows insects to be associated with particular tree species. Data for comparison with other Afrotropical sites is available.

Barber ground traps and flight intercept traps could be used to obtain data on both species richness and diversity, as well as to estimate sampling effort (i.e. species accumulation curves). It would also provide a dataset for future comparison with similar areas (e.g., Yayu BR, Bale National Park).

Based on the results of such studies, insect groups should be selected as indicator species for specific habitat structures and above- and belowground biodiversity. For the coffee forest, we suggest:

- Phytophagous beetles (Curculionidae and Chrysomelidae) for the canopy of specific tree species in different forests.
- Springtails (Collembola) for the forest floor soil fauna assemblages, the floor litter and the associated input of organic matter into the soil, which is a key factor linking the components of the tree-soil biodiversity system.

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6. Appendix

6.1 Tables

Table 2: List of collection sites for beetles by date. For codes, see Table 1

Date	Code	Geographical location	Altitudinal range (m a.s.l.)	Species number	Indicator species: *Altica*	Notes
2.12.2014	BG	07°15.032' N 36°15.306' E		8		Light trap
3.12.2014	BG	07°15.032' N 36°15.306' E		35		Barber traps, flight intercept traps, yellow dish traps
3.12.2014	KO	Start: 07°18.718' N 36°04.822' E End: 07°18.864' N 36°03.156' E	1680-1806	18		Aerial car net
3.12.2014	KO	07°16.839' N 36°11.426' E	1766	9		Light trap
4.12.2014	MA	07°18.936' N 36°03.092' E	1601	15		At stream
4.12.2014	MA	07°11.754' N 36°16.949' E	1640	4		Forest sieving site
4.12.2014	MA	Start: 07°11.986' N 36°16.198' E End: 07°11.157' N 36°18.224' E	1689-1906	103		Aerial car net
4.12.2014	MA	07°12.151' N 36°17.012' E	1606	32		Enderach, light trap on a bridge
4.12.2014	MA	07°11.997' N 36°16.625' E	1627	1		Enderach light trap above forest
5.12.2014	AW	07°05.146' N 36°12.468' E	1759	31		Ufa, PFM-site cof-fee forest
5.12.2014	AW	Start: 07°04.874' N 36°11.736' E End: 07°01.524' N 36°11.053' E	1910-1985	99		Aerial car net
6.12.2014	KO	07°10.176' N 36°13.277' E	1987	22		Barber traps, flight intercept traps
6.12.2014	KO	Start: 07°18.718' N 36°04.822' E End 07°18.864'N 36°03.156' E	1991-2103	51		Aerial car net
7.12.2014	BA	7°30.170' N 36°11.797' E	1864	25		Gichi river
7.12.2014	BA	07°14.610' N 36°27.388' E	2710	18		Bamboo
7.12.2014	BA	07°14.596' N 36°27.340' E	2668	33	Present	River bank
7.12.2014	BA	07°17.711' N 36°22.555' E	2414	41		Pasture, wetland
7.12.2014	BK-BG	Start: 07°17.711' N 36°22.555' E End 07°15.064' N 36°15.298' E	2668-1777	129		Aerial car net
8.12.2014	Go-riv	7°25.066'N 36°22.452' E	1291	9		Secondary forest / plantation
8.12.2014	BG-BK	Start: 07°15.064' N 36°15.298' E End 07°15.983' N 36°19.452' E	1777-2170	98		Aerial car net
9.12.2014	BO	7°30.281' N 36°06.375' E	2103	14		Saja Forest
10.12.2014	AG	7°21.754' N 36°13.275' E	1639	20	Present	Wetlands
10.12.2014	SHO	7°20.486' N 36°12.538' E	1640	5		Wet forest
10.12.2014	SHO	7°20.498' N 36°12.230' E	1607	33	Present	Wetlands
11.12.2014	BK	Start: 07°17.711' N 36°22.555' E End: 07°17.656' N 36°22.560' E	2668-2418	27	Present	Stream, wetland, pasture, bamboo
11.12.2014	BK	07°14.149' N 36°16.596' E	1956	8		Roadside
11.12.2014	AG	Start: 07°18.569' N 36°13.950' E End: 07°23.272' N 36°15.354' E	1758-1741	88		Aerial car net

Table 3: Checklist of Chrysomelidae, Cryptocephalinae, Cryptocephalini in Ethiopia and adjacent regions according to literature studies

Genus Cryptocephalus
Subgenus *Cryptocephalus*
adonis Pic, 1922: 12; **AFR**: Abyssinia, Republic Congo = var. *aruensis* Pic, 1930: 354 = var. *burgeoni* Pic, 1930: 354
aduanus Reineck, 1915: 431; **AFR**: Ethiopia = var. *viridepunctus* Pic, 1939: 35
arussi Gestro, 1895: 440; **AFR**: Abyssinia Gallaland
bouriensis Pic, 1933: 5; **AFR**: Ethiopia
bisbirufonotatus Pic, 1922: 11; **AFR**: Abyssinia
candezei Clavareau, 1913: 137 [Replacement Name]; **AFR**: Abyssinia = *ellipticus* Chapuis, 1876: 348 [Homonym]
decoratus Reiche, 1847: 406; **AFR**: Abyssinia Eritrea, Uganda = var. *chiaromontei* Pic, 1933: 129; **AFR**: Eritrea = var. *andreinii* Pic, 1933: 129; **AFR**: Eritrea = var. *ugriensis* Pic, 1933: 129; **AFR**: Eritrea
menelik Reineck, 1915: 402; **AFR**: Abyssinia
multicoloratus Gridelli, 1939: 575; **AFR**: South Abyssinia
quadrinotaticollis Pic, 1930: 356; **AFR**: Abyssinia
zavattarii Pic, 1939: 373; **AFR**: Ethiopia Abyssinia Ital. Somaliland
Subgenus *Anteriscus*
proteus Weise, 1906: 41; **AFR**: Abyssinia Keren
septemplagiatus Chapuis, 1876: 348; **AFR**: Abyssinia
tricoloraticollis Pic, 1915: 12; **AFR**: Africa Eritrea
trigeminus Chapuis, 1876: 346; **AFR**: Abyssinia Sudan
viator Suffrian, 1857: 140; **AFR**: Eastern Africa = *abyssiniacus* Jacoby, 1895: 174; **AFR**: Abyssinia = *contrarius* Chapuis, 1876: 347; **AFR**: Abyssinia
virideapicalis Pic, 1939: 35; **AFR**: Ethiopia

Table 4: Coleoptera collected in the Kafa BR during the biodiversity assessment

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Suborder ADEPHAGA														
Gyrinidae				spec. 1										1
Carabidae	Scaritinae			spec. 1					1					1
Carabidae	Scaritinae			spec. 2					1					
Carabidae	Trechinae	Bembidiini	Tachyina	cf. *Sphaerotachys* sp. 3			1							
Carabidae	Harpa¬linae	Harpalini		*Progonochaetus* (= *Dichaetochilus*) *planicollis* Putz					1					
Carabidae				spec.5					1					
Carabidae	Harpa¬linae	Lebiini	Lebiina	cf. *Phloezetheus Lebia* sp. 6		1								
Carabidae				spec. 7										1
Carabidae				spec. 8				1						
Carabidae				spec. 9	1									
Carabidae				spec. 10				1						
Carabidae	Trechinae	Bembidiini	Tachyina	cf. Sphaerotachys sp. 11				1			1			
Carabidae				spec. 12				1						
Carabidae	Trechinae			spec. 13				1						
Carabidae				spec. 14									1	
Carabidae				spec. 15									1	
Carabidae	Trechinae			spec. 16									1	
Dytiscidae				spec. 1	1									
Dytiscidae				spec. 2							1			
Dytiscidae				spec. 3										1
Dytiscidae				spec. 4						1				
Dytiscidae				spec. 5						1				
Dytiscidae				spec. 6	1									
Dytiscidae				spec. 7							1			
Suborder POLYPHAGA														
Hydrophilidae				*Cercyon* spec. 1			1							
Hydrophilidae				spec. 2			1							
Hydrophilidae				*Cercyon* spec. 3			1							
Hydrophilidae				spec. 4			1							
Hydrophilidae				*Helochares* spec. 1	1									
Hydrophilidae				*Hydrochara* spec. 1	1							1		
Hydrophilidae				*Cercyon* (*Paracercyon*) 1							1			
Hydrophilidae				*Coelostoma* spec. 1	1									
Hydrophilidae				*Enochrus* spec. 1	1									
Hydrophilidae				*Cercyon* spec. 4				1						
Hydrophilidae				*Cercyon* spec. 6		1								
Hydrophilidae				spec. 12								1		
Hydrophilidae				spec. 13								1		
Hydrophilidae				spec. 14				1						
Hydrophilidae				*Cercyon* spec. 2			1				1			
Hydrophilidae				*Cercyon* spec. 5		1								
Hydrophilidae				*Cercyon* spec. 7		1		1			1			

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Hydrophilidae				*Pachysternum capense*							1			
Hydrophilidae				*Pachysternum* sp. nov.							1			
Hydrophilidae				*Paracymus* spec. 1	1									
Hydrophilidae				*Cryptopleurum* spec. 1		1								
Hydrophilidae				*Pseucyon* spec. 1		1		1						
Hydrophilidae				*Pseucyon* spec. 2				1						
Histeridae				spec. 1	1									1
Histeridae				spec. 2							1			
Histeridae				spec. 3	1									
Hydraenidae				spec. 1							1			
Ptiliidae				gen. spec. 1		1					1			
Ptiliidae				gen. spec. 2		1					1			
Ptiliidae				gen. spec. 3		1								
Ptiliidae				gen. spec. 4							1			
Ptiliidae				gen. spec. 5							1			
Ptiliidae				gen. spec. 6			1							
Ptiliidae				gen. spec. 7							1			
Ptiliidae				gen. spec. 8		1								
Ptiliidae				gen. spec. 9							1			
Leiodidae				gen. spec. 1			1							
Leiodidae				gen. spec. 2										
Leiodidae	Cholevinae			gen. spec. 3				1			1			
Staphylinidae	Omaliinae	Omaliini		*Xylostiba* sp.				1			1			
Staphylinidae	Proteininae	Proteinini		*Megarthrus* spec.	1									
Staphylinidae	Pselaphinae	Euplectini		Euplectini gen. spec.				1			1			
Staphylinidae	Pselaphinae			Pselaphinae gen. spec. 1		1								
Staphylinidae	Pselaphinae			Pselaphinae gen. spec. 2				1						
Staphylinidae	Pselaphinae			Pselaphinae gen. spec. 3			1	1			1			
Staphylinidae	Pselaphinae			Pselaphinae gen. spec. 4									1	
Staphylinidae	Tachyporinae	Tachyporini		*Cilea* spec.		1								
Staphylinidae	Tachyporinae	Tachyporini		*Sepedophilus* spec.			1							
Staphylinidae	Tachyporinae	Tachyporini		*Tachinoplesius schoelleri* Schülke 2016		1								
Staphylinidae	Aleocharinae	Placusini		*Placusa* sp.	1		1							
Staphylinidae	Aleocharinae	Gyroph-aeinini		*Gyrophaena* spec. 1	1			1						
Staphylinidae	Aleocharinae	Gyroph-aeinini		*Gyrophaena* spec. 2		1		1			1			
Staphylinidae	Aleocharinae	Deremini		*Deremini* gen. spec. 1	1	1		1			1			
Staphylinidae	Aleocharinae	Deremini		*Deremini* gen. spec. 2				1			1			

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Staphylinidae	Aleocharinae	Deremini		*Derelina* cf. *ruhembeana* (Bernhauer)			1				1			
Staphylinidae	Aleocharinae			Bolitocharini gen. sp. 1		1		1			1			
Staphylinidae	Aleocharinae			Bolitocharini gen. sp. 2							1			
Staphylinidae	Aleocharinae	Deremini		Falagriini ? sp. (Deremini?)		1					1			
Staphylinidae	Aleocharinae	Falagriini		Falagriini cf. *Cordalia* sp.							1			
Staphylinidae	Aleocharinae	Falagriini		Falagriini gen. spec. 1	1	1		1			1			
Staphylinidae	Aleocharinae	Falagriini		Falagriini gen. spec. 2	1			1			1			
Staphylinidae	Aleocharinae	Falagriini		Falagriini gen. spec. 3	1			1						
Staphylinidae	Aleocharinae	Falagriini		Falagriini gen. spec. 4				1			1			
Staphylinidae	Aleocharinae	Falagriini		Falagriini ?? gen. spec. 5				1						
Staphylinidae	Aleocharinae	Falagriini		Falagriini spec. (*Borboropora* sp.)				1						
Staphylinidae	Aleocharinae	Falagriini		*Autalia* spec.			1	1			1			
Staphylinidae	Aleocharinae	Falagriini		*Falagria* spec. 1	1	1		1						
Staphylinidae	Aleocharinae	Falagriini		*Falagria* spec. 2	1	1	1	1						
Staphylinidae	Aleocharinae	Falagriini		*Falagria* spec. 3		1								
Staphylinidae	Aleocharinae	Falagriini		*Falagria* spec. 4				1						
Staphylinidae	Aleocharinae			*Stenomastax* ? spec.	1			1			1			
Staphylinidae	Aleocharinae	Homalotini		*Homalota* sp. 1		1								
Staphylinidae	Aleocharinae	Homalotini		*Homalota* sp. 2				1						
Staphylinidae	Aleocharinae	Homalotini		*Homalota* sp. 3							1			
Staphylinidae	Aleocharinae			Homalotini ? spec.		1		1			1			
Staphylinidae	Aleocharinae	Tachyusini		*Brachiusa* spec.	1	1	1	1			1			
Staphylinidae	Aleocharinae	Tachyusini		*Gnypeta* spec.	1									
Staphylinidae	Aleocharinae	Tachyusini		Tachyusini gen. spec.	1	1								
Staphylinidae	Aleocharinae	Tachyusini		*Tachyusa* spec.	1									
Staphylinidae	Aleocharinae			Aleocharinae gen. spec. (Tachyusini?)		1								
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 1	1	1		1						
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 2	1	1	1	1			1			
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 3	1			1			1			
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 4		1		1						
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 5	1			1						
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 6	1	1	1	1						
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 7		1		1						
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 8		1								
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 9		1								
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 10		1								
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 11	1									
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 12			1				1			

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 13	1	1								
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 14							1			
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 15	1									
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 16							1			
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 17							1			
Staphylinidae	Aleocharinae	Athetini		Athetini spec. 18							1			
Staphylinidae	Aleocharinae	Athetini		*Atheta coriaria* (Kraatz)				1						
Staphylinidae	Aleocharinae	Athetini		*Atheta* spec. 1	1	1	1	1						
Staphylinidae	Aleocharinae	Athetini		*Atheta* spec. 2	1	1	1	1			1			
Staphylinidae	Aleocharinae	Athetini		*Atheta* spec. 3			1							
Staphylinidae	Aleocharinae	Athetini		*Aloconota* spec. 1	1	1								
Staphylinidae	Aleocharinae	Athetini		*Aloconota* (?) spec. 2				1			1			
Staphylinidae	Oxypodini spec.			Athetini spec. 14	1									
Staphylinidae	Aleocharinae	Lomechusini		*Aenictonia anommatophila* Wasmann	1	1	1	1	1					
Staphylinidae	Aleocharinae	Lomechusini		*Myrmechusa* spec. 1				1	1					
Staphylinidae	Aleocharinae	Lomechusini		*Myrmechusa* spec. 2		1	1	1						
Staphylinidae	Aleocharinae	Lomechusini		*Trichodonia* spec. 1	1	1		1	1					
Staphylinidae	Aleocharinae	Lomechusini		*Trichodonia* spec. 2				1						
Staphylinidae	Aleocharinae	Lomechusini		*Trichodonia* ?? spec. 3							1			
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 1		1		1	1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 2		1		1	1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 3				1						
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 4			1							
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 5			1							
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 6		1		1	1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 7		1		1	1					
Staphylinidae	Aleocharinae	Lomechusini		Ocyplanus spec. (Lomechusini sp. 8)		1			1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 9					1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 10					1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 11					1					
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 12					1					
Staphylinidae	Aleocharinae	Lomechusini		*Zyras* spec. Lome-chusini gen. sp. 13					1		1			

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 14							1			
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 15							1			
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini gen. sp. 16							1			
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini ? sp. 1	1			1						
Staphylinidae	Aleocharinae	Lomechusini		Lomechusini ? sp. 2		1	1							
Staphylinidae	Aleocharinae	Lomechusini		*Rhoptrodinarda* sp.							1			
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 1		1								
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 2		1		1			1			
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 3			1	1			1			
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 4				1						
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 5				1						
Staphylinidae	Aleocharinae	Pygostenini		Pygostenini gen. sp. 6				1						
Staphylinidae	Aleocharinae	Aleocharini		Aleocharini gen. spec.			1							
Staphylinidae	Aleocharinae	Aleocharini		Aleocharini gen. spec.2 (Aleochara?)							1			
Staphylinidae	Aleocharinae	Aleocharini		*Amarochara* spec. 2				1						
Staphylinidae	Aleocharinae	Aleocharini		*Amarochara* spec. 1	1	1		1			1			
Staphylinidae	Scaphidiinae			Scaphidiinae gen. spec. 1				1			1			
Staphylinidae	Scaphidiinae			Scaphidiinae gen. spec. 1							1			
Staphylinidae	Scaphidiinae			Scaphidiinae gen. spec. 1							1			
Staphylinidae	Osoriinae	Eleusini		*Eleusis* spec. 1				1						
Staphylinidae	Osoriinae	Eleusini		*Eleusis* spec. 2				1						
Staphylinidae	Osoriinae	Osoriini		Osoriinae gen. sp. (cf. Holotrochus)	1		1	1			1			
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* spec. 1	1	1	1	1			1			
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* spec. 2	1									
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* spec. 3		1								
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* spec. 4	1						1			
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* ?? spec. 5				1			1			
Staphylinidae	Oxytelinae	Oxytelini		*Anotylus* spec. 6							1			
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* (?) spec. 1	1									
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 2	1	1		1			1			
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 3	1		1							
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 4		1		1						

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus bonghensis* Fagel	1	1	1	1						
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 6	1			1			1			
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 7	1			1						
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 8				1						
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 9	1			1						
Staphylinidae	Oxytelinae	Oxytelini		*Oxytelus* spec. 10	1			1			1			
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* sp. 1	1			1						
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* sp. 2	1	1		1						
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* sp. 3	1									
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* sp. 4	1									
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* (*Troginus*) spec. 5				1						
Staphylinidae	Oxytelinae	Thinobiini		*Carpelimus* spec. 6							1			
Staphylinidae	Scydmaeninae			*Euconnus* spec.			1				1			
Staphylinidae	Scydmaeninae			*Scydmaenus* spec. 1	1			1			1			
Staphylinidae	Scydmaeninae			*Scydmaenus* spec. 2	1			1						
Staphylinidae	Scydmaeninae			*Scydmaenus* spec. 3				1						
Staphylinidae	Paederinae	Paederini	Crypto-biina	*Cryptobiina* gen. spec.	1									
Staphylinidae	Paederinae	Paederini	Medonina	Medonina gen. spec. 1	1			1						
Staphylinidae	Paederinae	Paederini	Medonina	Medonina gen. spec. 2 (cf. *Litho-charis*)				1			1			
Staphylinidae	Paederinae	Paederini	Medonina	*Lithocharis* spec. 1				1						
Staphylinidae	Paederinae	Paederini	Medonina	*Lithocharis* spec. 2				1						
Staphylinidae	Paederinae	Paederini	Medonina	*Lithocharis* spec. 3							1			
Staphylinidae	Paederinae	Paederini	Medonina	*Lithocharis* spec. 4							1			
Staphylinidae	Paederinae	Paederini	Medonina	*Thinocharis* spec.				1						
Staphylinidae	Paederinae	Paederini	Paederina	*Paederus* spec.	1			1	1					
Staphylinidae	Paederinae	Paederini	Stilicina	*Rugilus* spec. 1	1		1	1			1			
Staphylinidae	Paederinae	Paederini	Stilicina	*Rugilus* spec. 2				1						
Staphylinidae	Paederinae	Paederini	Stilicina	*Rugilus* spec. 3							1			
Staphylinidae	Paederinae	Paederini	Scopaeina	*Scopaeus* spec. 1				1						
Staphylinidae	Paederinae	Paederini	Scopaeina	*Scopaeus brunnescens* Fagel				1			1			
Staphylinidae	Paederinae	Paederini	Scopaeina	*Scopaeus* spec. 3							1			
Staphylinidae	Staphylininae	Staphylin-inae	Tanyg-nathinina	*Atanygnathus* spec.		1		1			1			
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Erichsonius* spec. 1				1						
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Erichsonius* spec. 2				1						
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Gabrius* spec. 1				1						
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Gabrius* spec. 2				1						

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Gabronthus* spec. 1	1	1		1			1			
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Gabronthus* spec. 2							1			
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Neobisnius* spec.	1			1						
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Philonthus* spec. 1	1									
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Philonthus* spec. 2 (cf. turbidus)	1									
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Philonthus* spec. 3				1						
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Philonthus* spec. 4							1			
Staphylinidae	Staphylininae	Staphylin-inae	Philonthina	*Philonthus* spec. 5							1			
Staphylinidae	Staphylininae	Xantholinini		*Xantholinini* gen. spec. 1 (cf. Leptac-inus)	1		1				1			
Staphylinidae	Staphylininae	Xantholinini		*Xantholinini* gen. spec. 2	1	1		1			1			
Staphylinidae	Staphylininae	Xantholinini		*Xantholinini* gen. spec. 3							1			
Staphylinidae	Staphylininae	Xantholinini		*Xantholinini* gen. spec. 4							1			
Geotrupidae														
Scarabaeidae	Aphodiinae			spec. 1			1							
Scarabaeidae	Aphodiinae			spec. 2		1								
Scarabaeidae	Aphodiinae			spec. 3		1	1							
Scarabaeidae	Aphodiinae			spec. 4							1			
Scarabaeidae	Scarabaeinae	Coprini		*Onthophagus* sp.							1			
Scarabaeidae	Scarabaeinae	Coprini		spec. 2		1								
Scarabaeidae	Cetoniinae			spec. 1					1					
Scarabaeidae	Cetoniinae			spec. 2			1							
Scarabaeidae	Cetoniinae			spec. 3					1					
Scirtidae				spec. 1		1								
Scirtidae				spec. 2				1						
Scirtidae				spec. 3				1						
Dascillidae														
Rhipiceridae														
Elmidae	Elminae			spec. 1	1									
Elmidae	Elminae			spec. 2	1									
Elmidae	Elminae			spec. 3	1									
Elmidae	Elminae			spec. 4	1									
Eucnemidae														
Throscidae				spec. 1							1			
Elateridae				spec. 1		1								
Elateridae				spec. 2							1			
Elateridae				spec. 3	1									
Elateridae				spec. 4		1								
Lycidae				spec. 1		1								
Lycidae				spec. 2										1

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Lycidae				*Lycus* spec. 3	1									
Lycidae				spec. 4				1						
Lampyridae				spec. 1				1						
Cantharidae	Malthininae			spec. 1				1						
Bostrichidae	Bostrichinae			spec. 1				1						
Bostrichidae	Lyctinae			spec. 1		1								
Ptinidae	Ptininae			spec. 1		1								
Ptinidae	Anobiinae			spec. 1		1								
Ptinidae	Anobiinae			spec. 2		1								
Lymexylidae				spec. 1					1					
Cleridae				spec. 1	1									
Cleridae				spec. 2	1									
Melyridae	Dasytinae			spec. 1									1	
Monotomidae	Rhizophaginae			spec. 1		1								
Monotomidae	Rhizophaginae			spec. 2				1						
Monotomidae	Rhizophaginae			spec. 3				1						
Cryptophagidae	Cryptophaginae			spec. 1									1	
Silvanidae				spec. 1		1					1			
Silvanidae				spec. 2		1								
Silvanidae				spec. 3				1			1			
Cucujidae				spec. 1				1						
Cucujidae				spec. 2		1								
Cucujidae				spec. 3		1								
Laemophloeidae				spec. 1							1			
Laemophloeidae				spec. 2		1	1				1			
Laemophloeidae				spec. 3							1			
Laemophloeidae				spec. 4					1					
Nitidulidae	Carpophilinae			gen. spec. 1		1		1						
Nitidulidae	Carpophilinae			gen. spec. 2		1								
Nitidulidae				gen. spec. 3			1							
Nitidulidae				gen. spec. 4		1								
Nitidulidae				gen. spec. 5			1							
Nitidulidae				gen. spec. 6							1			
Nitidulidae				gen. spec. 7			1							
Nitidulidae				gen. spec. 8			1							
Nitidulidae				gen. spec. 9	1									
Coccinelidae	Coccinelinae			gen. spec. 1					1					
Coccinelidae	Coccinelinae			gen. spec. 2	1						1			
Coccinelidae	Coccinelinae			gen. spec. 3					1					
Coccinelidae	Coccinelinae			gen. spec. 4	1									
Coccinelidae	Coccinelinae			gen. spec. 5										1
Coccinelidae	Coccinelinae			gen. spec. 6	1									
Coccinelidae	Coccinelinae			gen. spec. 7	1									
Coccinelidae	Coccinelinae			gen. spec. 8										1
Coccinelidae	Coccinelinae			gen. spec. 9									1	1
Coccinelidae	Coccinelinae			gen. spec. 10	1									
Coccinelidae	Coccinelinae			gen. spec. 11									1	
Corylophidae	Corylophinae	Sericoderini		cf. *Sericoderus* spec. 1							1			

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Corylophidae	Corylophinae	Sericoderini		cf. *Sericoderus* spec. 2				1						
Latridiidae				gen. spec. 1	1				1					
Latridiidae				gen. spec. 2			1	1			1			
Latridiidae				gen. spec. 3				1			1			
Latridiidae				gen. spec. 4				1						
Mycetophagidae				spec. 1			1				1			
Mordellidae				spec. 1				1						
Zopheridae	Colydiinae			spec. 1				1						
Zopheridae	Colydiinae			spec. 2									1	
Tenebrionidae	Lagriinae			spec. 1					1					
Tenebrionidae	Lagriinae			spec. 5								1		
Tenebrionidae	Lagriinae			spec. 6										
Tenebrionidae	Tenebrioninae			spec. 2			1							
Tenebrionidae	Tenebrioninae			spec. 3		1								
Tenebrionidae	Diaperinae			spec. 4		1								
Tenebrionidae				spec. 5				1						
Anthicidae				spec. 1		1								
Anthicidae				spec. 2				1						
Anthicidae				spec. 3				1						
Scraptiidae	Anaspidinae			spec. 1			1							
Cerambycidae	Lamiinae			spec. 1										1
Cerambycidae	Lamiinae			spec. 2										1
Cerambycidae	Lamiinae			spec. 3		1								
Chrysomelidae	Bruchinae			spec. 1	1									
Chrysomelidae	Cassidinae			*Cassida* spec. 1			1							
Chrysomelidae	Cassidinae			spec. 2				1						
Chrysomelidae	Cassidinae			spec. 3						1				
Chrysomelidae	Cassidinae			*Conchyloctenia hybrida* (Bohemann 1854) sp. 4								1		
Chrysomelidae	Cassidinae			spec. 5				1						
Chrysomelidae	Chrysomelinae	Chrysomelini		spec. 1										1
Chrysomelidae	Chrysomelinae	Chrysomelini		spec. 2		1								
Chrysomelidae	Galerucinae	Alticini		gen. spec. 1					1					
Chrysomelidae	Galerucinae	Alticini		gen. spec. 2										1
Chrysomelidae	Galerucinae	Alticini		gen. spec. 3										1
Chrysomelidae	Galerucinae	Alticini		gen. spec. 4				1						
Chrysomelidae	Galerucinae	Alticini		gen. spec. 5									1	
Chrysomelidae	Galerucinae	Alticini		gen. spec. 6									1	
Chrysomelidae	Galerucinae	Alticini		*Psylliodes* sp. 1										
Chrysomelidae	Galerucinae	Alticini		*Orthocrepis* sp. 1										1
Chrysomelidae	Galerucinae	Alticini		*Nisotra* spec. 1	1				1					
Chrysomelidae	Galerucinae	Alticini		*Podagrica* spec. 1	1									
Chrysomelidae	Galerucinae	Alticini		*Altica* spec. 1		1			1	1	1			
Chrysomelidae	Galerucinae	Alticini		*Altica* spec. 2										1
Chrysomelidae	Galerucinae	Galerucini	Luperina	gen. spec. 1	1									
Chrysomelidae	Galerucinae	Galerucini		gen. spec. 1					1		1			
Chrysomelidae	Galerucinae	Galerucini		gen. spec. 2						1	1			
Chrysomelidae	Galerucinae	Galerucini	Mono-leptina	*Medythia* sp. 1	1				1					

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Chrysomelidae	Galerucinae	Galerucini	Mono-leptina	*Afrocandezea* spec. 1					1					
Chrysomelidae	Galerucinae	Galerucini	Mono-leptina	cf. *Afronaumannia* spec. 1										1
Chrysomelidae	Cryptocephalinae			gen. spec. 1			1							
Chrysomelidae	Eumolpinae						1					1		
Anthribidae	Anthribinae			gen. spec. 1	1									
Anthribidae	Anthribinae			gen. spec. 2									1	
Anthribidae	Anthribinae			gen. spec. 3					1					
Attelabidae	Apoderinae			gen. spec. 1								1	1	
Brentidae	Apioninae			gen. spec. 1				1				1		
Brentidae	Apioninae			gen. spec. 2										
Dryophthoridae				gen. spec. 1							1			
Dryophthoridae				gen. spec. 2								1		
Dryophthoridae				gen. spec. 3				1						
Curculionidae	Curculioninae	Rhamphini		gen. spec. 1		1								
Curculionidae				gen. spec. 1		1								
Curculionidae				gen. spec. 2		1								
Curculionidae				gen. spec. 3		1								
Curculionidae				gen. spec. 4		1								
Curculionidae				gen. spec. 5	1			1			1			
Curculionidae				gen. spec. 6		1								
Curculionidae				gen. spec. 7		1								
Curculionidae				gen. spec. 8					1					
Curculionidae				gen. spec. 9		1								
Curculionidae				gen. spec. 10	1									
Curculionidae				gen. spec. 11	1									
Curculionidae	Entiminae			gen. spec. 1					1					
Curculionidae	Entiminae			gen. spec. 2		1								
Curculionidae	Entiminae			gen. spec. 3		1								
Curculionidae	Entiminae			gen. spec. 4		1								
Curculionidae	Entiminae			gen. spec. 5	1									
Curculionidae	Entiminae			gen. spec. 6	1									
Curculionidae	Entiminae			gen. spec. 7	1									
Curculionidae	Entiminae			gen. spec. 8	1									
Curculionidae	Entiminae			gen. spec. 9	1									
Curculionidae	Entiminae			gen. spec. 10										1
Curculionidae	Entiminae			gen. spec. 11	1									
Curculionidae	Entiminae			gen. spec. 12	1									
Curculionidae	Entiminae			gen. spec. 13	1									
Curculionidae	Entiminae			gen. spec. 14									1	
Curculionidae	Scolytinae			gen. spec. 1		1								
Curculionidae	Scolytinae			gen. spec. 2							1			
Curculionidae	Scolytinae			gen. spec. 3							1			
Curculionidae	Scolytinae			gen. spec. 4							1			
Curculionidae	Scolytinae			gen. spec. 5		1	1	1						
Curculionidae	Scolytinae			gen. spec. 6		1	1	1						
Curculionidae	Scolytinae			gen. spec. 7		1								
Curculionidae	Scolytinae	Hylesinini		cf. *Hylesinopsis* spec. 8		1								

Family	Subfamily	Tribe	Subtribe	Taxon	MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
Curculionidae	Scolytinae			gen. spec. 9							1			
Curculionidae	Scolytinae			gen. spec. 10							1			
Curculionidae	Scolytinae			gen. spec. 11							1			
Curculionidae	Scolytinae			gen. spec. 12							1			
Curculionidae	Scolytinae			gen. spec. 13	1									
Curculionidae	Scolytinae			gen. spec. 14	1									
Curculionidae	Scolytinae			gen. spec. 15	1									
Curculionidae	Scolytinae			gen. spec. 16				1						
Curculionidae	Scolytinae			gen. spec. 17	1									
Curculionidae	Scolytinae	Hylesinini		gen. spec. 18				1						
Curculionidae	Platypodinae			gen. spec. 1		1								
Curculionidae	Platypodinae			gen. spec. 2		1								
Total: 409 species				104	103	52	132	35	5	112	9	14	18	

Table 5: Lepidoptera collected in the Kafa BR (determined by Dr Axel Hausmann)

Taxon	Number of species
Rhopalocera	6
Sphingidae	0
Saturniidae	0
Notodontidae	0
Lymantriidae	2
Limacodidae	1
Bombyces / Rest	0
Erebidae / Arctiinae	8
Erebidae / Hypeninae	5
Erebidae / Rest	4
Nolidae / Nolinae	6
Nolidae / Chloephorinae	0
Noctuidae / Noctuinae	19
Noctuidae / Plusiinae	5
Geometridae / Desmobathrinae	1
Geometridae / Sterrhinae	1
Geometridae / Larentiinae	8
Geometridae / Ennominae	4
Cossidae	0
Hepialidae	0
Pyraloidea (Pyralidae / Crambidae)	31
Tortricidae	3
Microlepidoptera / Rest	19
Total	**123**

6.1 Photos

Figure 1: Beating umbrella (photo: Matthias Schöller)

Figure 2: Sifter (photo: Matthias Schöller)

Figure 3: Sweeping net for butterflies and Hymenoptera (photo: Matthias Schöller)

Figure 4: Sweeping net for insects on grass and herbs (photo: Matthias Schöller)

Figure 5: Aerial insect car net (photo: Matthias Schöller)

Figure 6: Barber pitfall trap (photo: Matthias Schöller)

Figure 7: Flight intercept trap (photo: Matthias Schöller)

Figure 8: Light trap (photo: Matthias Schöller)

Figure 9: Yellow dish trap (photo: Matthias Schöller)

Figure 10: Holes in bamboo caused by insects (photo: Matthias Schöller)

Figure 11: Opened internode of bamboo larvae (photo: Matthias Schöller)

Figure 12: Water content concealed in internode with fly larvae (photo: Matthias Schöller)

Figure 13: Diverse microhabitats: climbing plants and dead plant material on trees (photo: Matthias Schöller)

Figure 14: *Altica* sp. on *Polygonum* sp. in the Shoriri Wetlands (photo: Matthias Schöller)

Figure 15: Tortoise beetle (*Conchyloctenia hybrida*) (photo: Matthias Schöller)

Flower-visiting insects at the Kafa Biosphere Reserve

Hans-Joachim Flügel

Highlights

- → For the first time in the Kafa BR, an insect assessment was conducted with the focus on flower ecology.
- → Approximately 300 insect specimens were recorded, of which approximately 50% could be determined to the species level.
- → Identification to the species level was hampered by the absence of identification literature and reference collections for Ethiopian insects. Therefore, a more detailed statement on species composition and possible biodiversity highlights is currently not possible.
- → The results of the assessment suggest that the Kafa BR is home to several endemic species, but more studies are needed to substantiate this finding. Most of the endemic species found seem to occur in the Afromontane rainforest.
- → Ten species of the fly family Diopsidae were found, four of which are new to science.
- → It is still unknown which insect species are the original pollinators of the coffee tree. This should be investigated by comparing wild *Coffea arabica* stands to cultivated stands, such as those found at Participatory Forest Management (PFM) sites.
- → It is reasonable to assume that coffee production in plantations and PFM sites could be increased by introducing original pollinator species. Identifying the original coffee pollinators could thus considerably enhance coffee plant productivity at managed sites.

1. Introduction

Literature on flower-visiting insects for Ethiopia is very scarce. Field guides for flower-visiting insects do not exist for Ethiopia; instead, we relied on guides to butterflies and thick-headed flies for the entire African continent and sub-Saharan Africa. The nomenclature and taxonomy of these books are partially outdated. Very few studies of flower-visiting insects have been conducted in Ethiopia, and there were no comprehensive inventories for the Kafa BR before this study (Berecha et al. 2015).

2. Materials and Methods

2.1. Study area

The study sites for flower-visiting insects included Afromontane forests (wild coffee forests), bamboo forests, secondary forest, ruderal vegetation, river banks and wetlands.

Table 1: Characteristics and nomenclature of the study areas within the Kafa BR

No.	Code	Area	Woreda	Habitat	Sites
1	BA	Bonga	Adiyo	Bamboo forest/riverine vegetation	Bamboo forest
2	BK	Bonga	Adiyo	Montane forest	Boka Forests
3	KO	Bonga	Gimbo	Montane forest	Komba Forests
4	AW	Bonga	Decha	Montane forest/riverine vegetation	Awurada Valley
5	AG	Bonga	Gimbo	Wetland	Alemgono Wetland
6	SHO	Bonga	Gimbo	Wetland	Shoriri Wetlands
7	MA	Bonga	Decha	Montane forest	Mankira Forest
8	GO-wet	Boginda	Gawata	Wetland	Gojeb Wetland
9	GO-riv	Boginda	Gawata/Gimbo	River/floodplain forests	Gojeb River
10	BO	Boginda	Gawata	Montane forests	Boginda forests
11	BG	Bonga	Gimbo	Settlement	KDA Guesthouse and surroundings

2.2 Sampling methods

We used a variety of sampling methods and trap types:

Sweeping net

A sweeping net is used to catch insects visiting herbs, grasses or flowers. A piece of solid cloth or gauze is mounted on a metal frame, which is attached to a pole. This is the most common method for detecting pollinating insects. To obtain a representative sample, all newly arriving visitors are intercepted on a group of flowering plants of the same species for a thirty-minute period.

Light trap

Many insects are attracted by light. When conditions are ideal, large numbers of insects can be caught. The ideal conditions are temperatures above 18°C, little or no moonlight and little wind. A variety of light sources can be used, such as white light or black light (ultraviolet light). For the assessment, a light trap was provided by the Ethiopian Insect Project. A generator was used to power white light bulbs, set in front of a white sheet and a gauze light tower brought from Germany. Insects were removed from the sheet using a collection vial and an aspirator.

Yellow dish trap

Yellow dish traps mimic yellow flowers and attract flower-visiting insects. These insects fall into the liquid killing agent. Sometimes flying insects not attracted by colour fall into the dishes by chance.

Malaise trap

Malaise traps are a special kind of flight interception trap for collecting insects with positive phototropism. Malaise traps are one of the first choices for an extended survey such as an ATBI (all-taxa biodiversity inventory), targeting a wide range of taxa. If properly placed for several weeks or months in the right season, malaise traps can provide a representative sample of the flying insects in the area.

Following the national regulations and protocols of the Ethiopian Biodiversity Institute (EBI), samples were prepared and exported to Germany, with the main objective of further identifying the species and completing the species list.

2.3 Data analysis

The samples collected during the field expedition contained insects of almost all taxonomic ranks. Samples were further identified via a systematic process. First, the samples were sorted by specimen and labelled with information on the circumstances under which they were collected, such as locality, habitat type, biotope, coordinates, altitude, capture time, etc. If possible, the genitals of the insects were prepared before needling, along with body parts such as legs, wings, mouths, etc., so they were clearly visible for the determination process. After this process, the samples were sorted by order, family and, if possible, by genera and species.

Due to the lack of information, none of the Ethiopian Hymenoptera Terebrantia (apart from the Chalcidoidea), none of the Diptera Nematocera and only a minority Diptera Brachycera were able to be determined through morphological characteristics alone. Captive specimens from these groups will undergo genetic analysis at a later date in collaboration with Dr Axel Hausmann from the Bavarian State Collection of Zoology (Munich).

To determine the remaining groups, the following international experts will be consulted.

For Diptera Brachycera:

- Conopidae: Dr J.-H. Stuke, Oldenburg University,
- Diopsidae: H.R. Feijen, Naturalis Biodiversity Centre, Leiden, Netherlands
- Pipunculidae: Dr C. Kehlmaier, Zoological Museum Dresden, Germany
- Psychodidae: Dr R. Wagner, Institute for Biology, Kassel, Germany
- Syrphidae: Dr A. Symank, Federal Agency for Nature Conservation, Bonn, Germany
- Sarcophagidae: J. Velterop, Enschede, Netherlands
- Tephritidae: Dr A. Freidberg, Department of Zoology, Tel Aviv, Israel

For Hymenoptera Aculeata:

- Apoidea, Apidae, Andrena: E. Scheuchl, Ergolding, Germany
- Colletes: Dr M. Kuhlmann, Department of Life Science, Natural History Museum, London, UK,
- Halictinae: A. Pauly, Royal Belgium Institute of Natural Science, Department of Entomology, Brussels, Belgium
- Xylocopa: G. Hölzler, Vienna, Austria, Apoidea, Vespidae: Dr J. Gusenleitner, Biologiezentrum Linz, Austria
- Hymenoptera Terebrantia, Chalcidoidea: Dr L. Krogmann, Stuttgart State Museum of Natural History, Germany
- Hymenoptera Symphyta: Dr R. Koch, Naturkundemuseum Berlin, Germany

For other groups:

- Coleoptera, Staphylinidae: M. Schülke, Berlin, Germany
- Lepidoptera (only moths): Dr A. Hausmann, Zoologische Staatssammlung München, Germany
- Heteroptera (partim): Dr J. Deckert, Naturkundemuseum Berlin, Germany

Due to the lack of relevant literature and collection references for Ethiopian insects, a significant number of species will have to be identified at a later date, which is likely to take some time.

3. Results and Discussion

The presence of entomofauna depends on a variety of factors such as seasonality, habitat fragmentation and human settlements. The fact that the excursion was conducted during dry season, the short duration of the fieldwork and the high variability of habitats precluded gathering extensive results and drawing definite conclusions about flower-visiting insects in the Kafa BR. A study of the canopy layer of the Afromontane rainforest could provide new and valuable findings for the Kafa BR, but we were unable to conduct one due to time constraints.

We found that the area outside the core zones is dominated by ruderal flora; habitats with other flowering plants and associated visitors were scarce.

3.1. Results classified as per collection methods

Sweeping net

Compared to other collection methods, in most habitats relatively few insects were caught near sweeping grasses and herbs. These included Ensifera, Coleoptera, Heteroptera, Auchenorrhyncha, Hymenoptera and Lepidoptera. However, specimens from several highly abundant groups were collected at wetland sites, e.g. leaf beetles of the genus *Altica* on *Rumex*, Diopsidae (Diptera) and *Tetrix* (Orthoptera). Hence, this classic collection method is especially recommended for open landscapes such as wetlands. In forest sites, spiny shrubs limit the application of sweeping nets.

Light trap

The following insect groups were caught in Kafa BR by using light traps: Ensifera, Caelifera, Coleoptera, Heteroptera, Auchenorrhyncha, Lepidoptera, Hymenoptera, Diptera, Ephemeoptera, Isoptera and Plecoptera. Various moth families were also caught.

Despite the full moon during the sampling period, which presumably diminished the effect of the light trap, large numbers of insects were attracted to the trap at various sites, for example at the bridge near Enderacha. Light traps are the most important technique for collecting nocturnal Lepidoptera, and we recommend using them in future studies.

Yellow dish trap

Yellow dish traps are used for insects that visit yellow flowers in particular. The yellow dish traps mainly caught Diptera Brachycera (e.g., Syrhidae, Sarcophagidae, Muscidae), beetles and Hymenoptera Aculeata.

3.2 Results classified as per habitats

Bamboo forest

The bamboo thickets are dominated by bamboo (*Arundinaria alpina*) interjected with individual rainforest trees. Many flies were detected in the layers of ground vegetation, mainly Tipulidae (Diptera Nematocera) and Syrphidae (Dipt. Brachycera) of the genus *Melanostoma*. Other insect groups were very rare.

Wetlands near bamboo forest

The wetlands close to the bamboo thickets are adjoined by pastures (i.e., grassland) with *Hypericum* shrubs and large herbs from *Bothriocline schimperi* (Asteraceae). Insects were abundant in this habitat. Some bees from the genus *Colletes* were found on cf. *Lotus discolor*. They are oligolectic to this plant species and may be new to science.

Moist evergreen montane forest containing wild *Coffea arabica*

Clearings and forest edges in particular exhibited rich (flowering) herbaceous vegetation, attracting numerous insects. Diurnal butterflies were mostly found at waterholes for their mineral intake. The Afromontane forests seem to be home to far more diverse insect species than the other investigated habitats, but the number of individuals is much lower. This might be due to the low density of certain plant species and the distance between them.

Wetlands

All the investigated wetlands exhibited a rich array of Orthoptera, Diptera and Heteroptera, but we were unable to find many Hymenoptera Aculeata due to the lack of flowering plants.

Disturbed habitats

The fallow areas and disturbed habitats contained numerous flowering herbaceous plants, which greatly helped our study. The yellow flowering Asteraceae *Guizotia scabra* was dominant in the open fallow land, while *Bothriocline schimperi*, a purple flowering Asteraceae, mostly occurred at the forest edges. The flowering vegetation, and hence the pollinating insects, were richest in areas where shrubs had already settled, providing higher structural diversity.

3.3 Recorded insect groups

There are likely to be about 300 species among the acquired specimens from identifiable groups. First results can be presented for nine species of wasp (Vespidae) and four species of thick-headed fly (Conopidae). Table 4 provides a list of insect families and estimated number of species. The dominant species was the honeybee subspecies *Apis mellifera* ssp. *simensis* (Meixner et al. 2011). The honeybee is mainly cultivated in the Kafa BR in a traditional manner (Shenkute et al. 2012). In addition, numerous hoverfly (Syrphidae) species were detected on flowers. Methods such as the sweeping net and light trap revealed other insects such as beetles (Coleoptera), bugs and Cicadinae.

4. Conclusions and Recommendations for Conservation and Monitoring

To properly assess flower-visiting insects in the Kafa BR, the relationship between certain plant species and their pollinators must be further investigated. Individual plant species for which a close relationship with specific pollinators can be assumed should be especially monitored during the flowering period. It is now clear that the coffee flower is a typical moth flower. But night-time investigations of coffee blossoms still need to be made. The flowers of Cucurbitaceae species are very unique, suggesting they might be visited by highly specialised insects. In addition, many specialised flowers were found on a number of tree species in the Afromontane rainforest. These should be investigated in future, which will require special methods and equipment.

However, a variety of flowering plants, especially in cleared areas, also provides food sources for several non-specialised flower-visiting insects. As a result, monitoring activities cannot be restricted to studies on individual plant species, but should complement the investigation of flower-insect relationships to improve understanding of pollination of wild plants and crops. In addition to using sweeping nets on selected herbaceous plant species, flight intercepting traps, light traps, pheromones and photo traps can improve the quality of results, especially in higher woody and climbing flowering plant species.

According to the preliminary results presented in this report, many highly specialised species and most of the species new to science occur in the Afromontane forests, which are home to diverse and fragile relationships between different flower-visiting species. We therefore recommend protecting the montane rainforests from disturbance as far as possible. Furthermore, to identify the original pollinators of the coffee tree (*Coffea arabica*), pollinators in both plantations and the natural habitats of *Coffea arabica* require extensive investigation and monitoring during both day and night.

Due to the current lack of ecological background information on the flower-visiting insects we found, we cannot propose any indicator species. Potential indicator species should be easy to identify, however, which makes butterflies or carpenter bees (e.g., *Xylocopa* species) good candidates. These species belong to flower-visiting insect groups that are closely connected to a particular habitat and/or plant species. Indicator species should only be chosen after thorough observations.

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6. Appendix

6.1 Tables

Table 2: Overview of observation sites at the Kafa BR

Code	Alt. (m a.s.l.)	Lat.	Long.	Biotope	Date
AG	1,724	07°21’47” N	036°13’11” E	Wetland	10-Dec-14
AG	1,737	07°21’48” N	036°13’19” E	Wetland	10-Dec-14
AG	1,727	07°21’48” N	036°13’08” E	Wetland	10-Dec-14
AG	1,716	07°21’40” N	036°13’19” E	Wetland	10-Dec-14
AG	1,722	07°21’44” N	036°13’13” E	Wetland	10-Dec-14
AW	1,630	07°05’67“ N	036°13’57” E	Rainforest	05-Dec-14
AW	1,314	07°05’56“ N	036°13’91“ E	Rainforest	05-Dec-14
BA	2,621	07°14’28” N	036°27’08” E	Stream valley	07-Dec-14
BA	2,673	07°14’40” N	036°27’22” E	Bamboo forest	07-Dec-14
BG	1,756	07°15’04” N	036°15’24” E	Fallow	03-Dec-14
BG	1,739	07°14’57” N	036°15’11” E	Fallow	06-Dec-14
BG	1,624	07°36’10” N	035°59’59” E	Garden	09-Dec-14
BG	1,765	07°15’03” N	036°15’17” E	Guesthouse	02-Dec-14
BG	1,755	07°15’02” N	036°15’14” E	Edge of woods	12-Dec-14
BG	1,765	07°15’03” N	036°15’17” E	Outdoor, lamps	04-Dec-14
BG	1,765	07°15’03” N	036°15’17” E	Outdoor, lamps	08-Dec-14
BG	1,765	07°15’03” N	036°15’17” E	Outdoor, lamps	09-Dec-14
BG	1,765	07°15’03” N	036°15’17” E	Outdoor, lamps	11-Dec-14
BG	1,762	07°15’02” N	036°15’17” E	Meadow	03-Dec-14
BG	1,759	07°15’02” N	036°15’16” E	Meadow	06-Dec-14
BG	1,761	07°15’02” N	036°15’16” E	Meadow	12-Dec-14
BK	2,439	07°18’05” N	036°22’29” E	Boka Forest	11-Dec-14
BK	2,418	07°17’43” N	036°22’32” E	Wetland	07-Dec-14
BK	2,426	07°17’43” N	036°22’35” E	Wetland	07-Dec-14
BK	2,428	07°17’57” N	036°22’21” E	Wetland	11-Dec-14
BK	2,436	07°17’49” N	036°22’22” E	Wetland	11-Dec-14
BK	1,955	07°14’09” N	036°16’36” E	Roadside	11-Dec-14
BO	2,116	07°30’24” N	036°06’18” E	Edge of woods	11-Dec-14
BO	2,001	07°30’30“ N	036°06’42” E	Edge of woods	09-Dec-14
GO-R	1,403	07°26’11” N	036°22’04” E	Disturbed habitats	08-Dec-14
GO-R	1,330	07°24’41” N	036°22’09” E	Disturbed habitats	08-Dec-14
GO-R	1,329	07°24’42” N	036°22’08” E	Disturbed habitats	08-Dec-14
GO-W	1,577	07°34’48” N	036°02’24” E	Wetland	09-Dec-14
GO-W	1,577	07°34’38” N	036°01’34” E	Wetland	09-Dec-14
KO	1,988	07°18’59” N	036°05’17“ E	Rainforest	06-Dec-14
KO	1,766	07°16’84“ N	036°11’43“ E	Edge of woods	03-Dec-14
KO	1,988	07°18’59“ N	036°05’17“ E	Edge of woods	06-Dec-14
KO	1,988	07°18’59“ N	036°05’17“ E	Edge of woods	06-Dec-14
KO	1,988	07°18’59” N	036°05’17“ E	Edge of woods	06-Dec-14
KO	1,921	07°18’90“ N	036°03’52“ E	Edge of woods	06-Dec-14
KO	1,921	07°18’90” N	036°03’52“ E	Edge of woods	06-Dec-14
KO	1,921	07°18’90“ N	036°03’52“ E	Edge of woods	06-Dec-14
KO	1,921	07°18’90” N	036°03’52“ E	Edge of woods	06-Dec-14
MA	1,601	07°12’00“ N	036°16’20“ E	Stream valley	04-Dec-14

Code	Alt. (m a.s.l.)	Lat.	Long.	Biotope	Date
MA	1,628	07°11'87" N	036°15'13" E	Edge of woods	04-Dec-14
MA	1,628	07°11'87" N	036°15'13" E	Edge of woods	04-Dec-14
MA	1,620	07°12'00" N	036°16'63" E	Edge of woods	04-Dec-14
MA	1,628	07°11'87" N	036°15'13" E	Edge of woods	12-Dec-14
SHO	1,745	07°20'65" N	036°12'71" E	Field edge	10-Dec-14
SHO	1,753	07°20'41" N	036°12'44" E	Edge of groves	10-Dec-14
SHO	1,607	07°20'51" N	036°12'28" E	Shoriri Wetlands	10-Dec-14
SHO	1,753	07°20'41" N	036°12'44" E	Edge of woods	12-Dec-14

Table 3: Plants on which floral-ecological observations were carried out at the Kafa BR

Code	Family	Observed plant species with flower visits
GO	Acanthaceae	*Hygrophila schulli* (Hamilt.) MR. & S.M Almeida
KO	Acanthaceae	*Hypoestes forskaolii* (Vahl) R. Br.
GO	Acanthaceae	*Justicia bizuneshiae Ensermu*
GO	Amaranthaceae	*Cyathula uncinulata* (Schrad.) Schinz
KO, MA	Asteraceae	*Bothriocline schimperi* Olivo & Hiern ex Benth.
BK	Asteraceae	*Cineraria deltoidea* Sond.
AG, MA	Asteraceae	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore
BG, BK, BO, KO	Asteraceae	*Guizotia scabra* (Vis.) Chiov.
GO	Asteraceae	*Vernonia leopoldi* (Sch. Bip. ex Walp.) Vatke
AG, GO, KO, MA, SHO	Fabaceae	*Caesalpinia decapetala* (Roth) Alston
	Fabaceae	*Crotalaria fascicularis* Polhill
GO	Fabaceae	*Desmodium uncinatum* (Jacq.) DC
BA	Fabaceae	*Lotus* cf. *discolor* E. Mey.
BK	Fabaceae	*Senna septemtrionalis* (Viv.) Irwin & Barneby
BK	Hypericaceae	*Hypericum revolutum* Vahl
MA	Lamiaceae	*Ocimum gratissimum* L.
MA, SHO	Lamiaceae	*Plectranthus longipes* Baker

Table 4: Insect groups sampled during the floral-ecological investigation of the study areas at the Kafa BR and their determination probabilities

Order	Family/genus	Species estimated	Species determined	Identification support by	Determination probability (%)
Diptera	Asilidae	5		Unknown	?
Diptera	Bombyliidae	1		Unknown	?
Diptera	Conopidae	5	4	J.-H. Stuke	100
Diptera	Diopsidae	6		H. R. Feijen	100
Diptera	Pipunculidae	4		Dr C. Kehlmaier	90
Diptera	Psychodidae	8		Dr R. Wagner	100
Diptera	Sepsidae	12		Unknown	?
Diptera	Syrphidae	40		Dr A. Ssymank	50
Diptera	Sarcophagidae	4		J. Velterop	70
Diptera	Tabanidae	2		Unknown	?

Order	Family/genus	Species estimated	Species determined	Identification support by	Determination probability (%)
Diptera	Tachinidae	15		Unknown	?
Diptera	Tephritidae	10		Dr A. Friedberg	100
Diptera	All other families	50		Unknown	?
Heteroptera	Bugs	50		Dr J. Deckert	40
Auchenorrhyncha	Cicadinae	20		Unknown	?
Coleoptera	Staphylinidae	10		M. Schülke	100
Coleoptera	All other families	80		Different persons	70
Lepidoptera	Night active butterflies	20		Dr A. Hausmann	90
Lepidoptera	Day active butterflies	70		Unknown	?
Hymenoptera	Chalcid wasp	10		Dr L. Krogmann	80
Hymenoptera	Gasteruptiidae	2		Unknown	?
Hymenoptera	Symphyta	3		Dr F. Koch	70
Hymenoptera	Vespidae	10	9	J. Gusenleitner	90
Hymenoptera	Sphecidae	15		Unknown	?
Hymenoptera	Pompilidae	6		Unknown	?
Hymenoptera	Chrysididae	3		Unknown	?
Hymenoptera	Xylocopa	7		G. Hölzler	100
Hymenoptera	Andrena	1		E. Scheuchl	100
Hymenoptera	Colletes	2		Dr M. Kuhlmann	100
Hymenoptera	Other Apidae	22		Alain Pauly	50

Table 5: Insects caught during the flower ecological studies and other observations at the Kafa BR (Sex: f = female, m = male) which were identified before the 25/02/2015

Conopidae species	Sex	Date	Biotope	Flower type or catching method	Code
Dacops kaplanae (Camras 2001)	f	11.12.2014	Roadside	*Guizotia scabra*	BK
Physocephala bimarginipennis (Karsch 1887)	f	04.12.2014	Edge of woods	*Bothriocline schimperi*	MA
Physocephala halterata (Brunetti 1925)	f	04.12.2014	Edge of woods	*Bothriocline schimperi*	MA
Thecophora pilosa (Kröber 1916)	m	10.12.2014	Edge of woods	Sweeping net	AG
Thecophora pilosa (Kröber 1916)	f	04.12.2014	Edge of woods	Sweeping net	MA
Vespidae species					
Afreumenes melanosoma (Sauss.)	1f,1m				
Ancistrocerus andreinii G.S.	2m				
Antepipona mucronata (Sauss.)	2f,6m				
Belonogaster j. juncea (F.)	4f,2m				
Belonogaster meneliki Grib.	3f,1m				
Delta e. emarginatum (L.)	1f				
Micreumenes kelneria G.S.	2f				
Polistes marginalis F.	4f,1m				
Pseudonortonia rufoquadripustulata (Cam.)	1f				

6.2 Photos

Figure 1: Many insects occur in the wetlands like the Shoriri Wetland (photo: Hans-Joachim Flügel)

Figure 2: Asteraceae *Guizotia scabra*, on which honeybees and other flower-visiting insects could always be found, was numerous in many fallow fields and along the roads in December (photo: Hans-Joachim Flügel)

Figure 3: Lush, but species-poor herbaceous vegetation can be found between the bamboo rods, it was primarily inhabited by flies and gnats (photo: Hans-Joachim Flügel)

Figure 4: A species-rich flora, inhabited by many different insect species, can be found along the edges of the bamboo forest (photo: Hans-Joachim Flügel)

Figure 5: Many different microhabitats and flowering plants exist in cleared wasteland (photo: Hans-Joachim Flügel)

Figure 6: Numerous herbaceous and shrubby flowering plants grow in the woodland clearings and at the forest edges, these are particularly good places for floral-ecological observations (photo: Hans-Joachim Flügel)

Figure 7: Representatives of the syrphid genus *Phytomia* can often be found on the inflorescences of the frequent Asteraceae *Guizotia scabra* near rainforest (photo: Hans-Joachim Flügel)

Figure 8: Stingless bees of the genus *Meliponula*, possibly the species *M. beccarii* (Gribodo), were occasionally found, although one fifth of the honey harvested by the local bee-keepers is supposed to come from stingless bees (photo: Hans-Joachim Flügel)

Figure 9: Most honeybees are still traditionally kept in tubes suspended from tall *Euphorbia* trees (photo: Hans-Joachim Flügel)

Dragonflies and damselflies (Odonata) at the Kafa Biosphere Reserve

Viola Clausnitzer

Highlights

- → A total of 33 Odonata (=dragonflies and damselflies, hereafter referred to as "dragonflies") species from seven families were recorded (31.1% of Ethiopia's dragonfly fauna and 65% of dragonfly fauna ever recorded in the Kafa BR).
- → A total of 51 dragonfly species from nine families has ever been recorded in the Kafa BR.
- → Three species are new to Ethiopia (*Aciagrion gracile*, *Tetrathemis polleni*, *Phyllomacromia* spec.).
- → Twelve species were recorded the first time for the Kafa BR, including the endemic and endangered *Notogomphus ruppeli*.
- → Eight of the recorded species are endemic to the Ethiopian highlands (*Pseudagrion guichardi*, *P. kaffinum*, *Notogomphus cottarellii*, *N. ruppeli*, *Atoconeura aethiopica*, *Orthetrum kristenseni*, *Palpopleura jucunda radiata*, *Trithemis ellenbeckii*).
- → Five species are threatened according to the global IUCN Red List of Threatened Species (three 'vulnerable', two 'endangered'), all of them endemic to Ethiopia.
- → Endemic species were only found in montane and submontane forest streams.
- → The lower areas (wetlands) exhibit higher diversity, but no endemic species.
- → The Ethiopian Highlander (*Atoconeura aethiopica*), the Ethiopian Sprite (*Pseudagrion guichardi*) and the Kaffa Sprite (*Pseudagrion kaffinum*) are flagship species.
- → In addition to these flagship species, the montane forest gomphids Cottarelli's Longlegs (*Notogomphus cottarellii*) and Rüpell's Longlegs (*Notogomphus ruppeli*) could be good indicators of the status of conservation of the forests.
- → These findings show the great significance of the natural habitats within the Kafa BR for maintaining Ethiopia's diversity and high level of endemism and the importance of conserving the remaining natural and semi-natural sites.

1. Introduction

The degree of endemism in Ethiopia's flora and fauna is exceptionally high. This is largely the result of the vast highlands being isolated by the surrounding dry lowlands. Only the most versatile and mobile species tend to be found in both Ethiopia and the rest of tropical Africa. These are mainly montane species. Most of Ethiopia's endemic species also belong to the Afrotropical Highlands biome (Kingdon 1989). Despite the many species endemic to Ethiopia, conservation efforts and even knowledge of their habitats are virtually non-existent. The highlands are among the most densely populated areas in Africa, and only small fragments of semi-natural vegetation remain. This loss of natural habitats has taken place over many centuries in the northern and central highlands, but is a more recent phenomenon in the southwest.

The most comprehensive overview of Ethiopian dragonfly fauna is provided by Clausnitzer and Dijkstra (2005), while Consiglio (1978a) provides a review of the history of dragonfly research in Ethiopia. In general, Ethiopian dragonflies were largely neglected in the second half of the 20th century, although Italian scientists undertook a zoological expedition in the early 1970s (Brignolin et al. 1978). The results, published by Consiglio (1978a, 1978b) and Pinhey (1982), include the description of three endemic dragonfly species.

When it comes to dragonflies, Ethiopia is species poor but rich in endemics. Kenya and Uganda have 170 and 228 recorded species, respectively, while Ethiopia has only 106 (Dijkstra & Clausnitzer 2014). This indicates a data deficiency in Ethiopia's southern and southwestern areas, especially the Gambela area, but also reflects the impoverished forest fauna of Ethiopia due to long-term isolation and a history of strong climatic and habitat changes. Comparing the dragonfly communities of Kenyan and Tanzanian highlands to those from Ethiopia, two main patterns emerge: openland species are generally shared but scarcer in Ethiopia; Ethiopia has much fewer forest species, none of which are shared (see also Clausnitzer & Dijkstra 2005). Most of the species common in open habitats in the Kenyan and Tanzanian highlands above 1450 m a.s.l. are common in Ethiopia and were also recorded during this expedition: *Pseudagrion spernatum*, *Proischnura subfurcata* and *Orthetrum julia* are dominant species in both areas. *Platycypha caligata*, *Ceriagrion glabrum*, *Anax imperator*, *Crocothemis erythraea* and *Pantala flavescens* are also generally widespread in both areas, while species such as *Pseudagrion kersteni*, *Trithemis arteriosa*, *T. annulata*, *Nesciothemis farinosa* and *Crocothemis sanguinolenta* are scarce in upland Ethiopia compared with Kenya and Tanzania. One important factor might be seasonality; fieldwork should be carried out during the rainy season in April and May, especially in the lower wetlands, when one would expect to find more Afrotropical species than currently recorded (including new records for the Ethiopian dragonfly fauna). The heterogeneous habitats of the floodplain and inundation zones around the Gojeb River should support higher dragonfly diversity than currently reported.

2. Materials and Methods

2.1 Study area

Dragonflies were recorded at different study sites: core zones, PFM sites and wetlands. The sample sites were selected based on the presence of aquatic habitats (streams, rivers, headwaters, swamps, etc.).

2.2 Sampling methods

Our team consisted of Thies Geertz, collecting land and freshwater molluscs, Tom Kirschey, surveying amphibians and reptiles, and field assistants Tizita Tamiru, Mitiku Gebremariam and Admasu Asefa. Adult dragonflies were collected using a sweep net at each sample site (Fig. 5). The weather was always good (full sunshine) and sampling was done between 10 am and 6 pm. Dragonfly larvae were also collected from the water, supplemented by catches from Thies Geertz and Tom Kirschey. In most cases, dragonflies were identified in the field using a hand lens and the identification book by Dijkstra & Clausnitzer (2014).

Table 1: Sample localities. KBR zone: cz: core zone; bz: buffer zone; ccz: candidate core zone. All dates are for December 2014.

Area	Site	KBR	PFM	Code	Date	Habitat	Alt.	Lat.	Long.
Bonga	Bonga	-	-	BG1	03.12.	Small stream behind guesthouse	1832	7.25420°N	36.25762°E
Bonga	Bonga	-	-	BG2	03.12.	Hill behind guesthouse	1980	7.25358°N	36.22633°E
Boka	Boka	cr	-	BK1	04.12.	Stream in wetlands below Boka Forest	2414	7.29467°N	36.37604°E
Boka	Boka	cr	-	BK2	04.12.	Swamp along stream below Boka Forest	2414	7.29467°N	36.37604°E
Bamboo	Bamboo	cr	-	BA1	04.12.	River in bamboo forest	2595	7.24118°N	36.45182°E
Bamboo	Bamboo	cr	-	BA2	04.12.	River in bamboo forest	2650	7.24331°N	36.49564°E
Bonga	Awurada Valley	cr	yes	AW1	05.12.	Gummi River, large river	1293	7.09281°N	36.23154°E
Bonga	Awurada Valley	cr	yes	AW2	05.12.	Floodplain (swampy forest) along Gummi River	1293	7.09281°N	36.23154°E
Bonga	Alemgono	bz	-	AG	06.12.	Wetland, heavily grazed	1706	7.36428°N	36.22602°E
Bonga	Shoriri	bz	yes	SHO1	06.12.	Wetland, undisturbed	1626	7.35707°N	36.20437°E
Bonga	Shoriri	bz	yes	SHO2	06.12.	Stream along forest edge and Shoriri Wetlands	1626	7.35707°N	36.20437°E
Komba	Komba Forest	cz	-	KO1	07.12.	Clear stream in Komba Forest	1847	7.30803°N	36.12201°E
Komba	Komba Forest	-	-	KO2	06.12.	Forest edge	1900	7.10176°N	36.13277°E
Boginda	Gojeb Wetlands	ccz	-	GO-wet1	09.12.	Large river	1530	7.55448°N	36.05687°E
Boginda	Gojeb Wetlands	ccz	-	GO-wet2	09.12.	Gallery forest and wetlands along Gojeb	1530	7.55448°N	36.05687°E
Boginda	Gojeb Wetlands	bz	-	GO-wet3	10.12.	Swampy floodplain north of Gojeb	1516	7.55444°N	36.05209°E
Boginda	Gojeb Wetlands	ccz	-	GO-wet4	10.12.	Stream in floodplain south of Gojeb	1518	7.55442°N	36.05213°E
Boginda	Boginda Forest	cz	-	BO	11.12.	Stream with swamps in Boginda Forest, partly open (grazed glades)	2074	7.50175°N	36.09118°E

2.3 Data analysis

Data analysis was performed using the PAST software package (Hammer et al. 2001). Genetic analysis will be performed in cooperation with Dr K-D Dijkstra from Naturalis, Leiden. Samples were properly prepared and exported in accordance with the national regulations of the Ethiopian Biodiversity Institute (EBI), with the main objective of further identifying species and completing the species list. Collected specimens were put in acetone for 1-2 hours, dried and then kept in labelled envelopes. For genetic analysis, a leg from the specimen was immersed in pure alcohol. The voucher specimens were labelled and kept in the dry collection, as described above. The barcoding gene COI has already been sequenced for over 1,700 dragonfly species globally as part of the All Odonata Barcode Initiative at Naturalis: more than 4,260 sequences for 585 African species were completed as of 2015 (Dijkstra & Stokvis 2012; Dijkstra et al. 2015). COI is suitable for phylogeographic analysis, and the results from the material collected in Ethiopia will be compared with material from across Africa.

3. Results and Discussion

A total of 33 species were recorded, which is 31.1% of those previously reliably recorded in the country plus three new records for Ethiopia, making a total of 106 dragonfly species recorded in Ethiopia to date (Dijkstra & Clausnitzer 2014 and this report). This is also 65% of the species reliably recorded for the Kafa BR (Tables 4 and 5). Twelve species were recorded in the Kafa BR for the first time, including the endemic *Notogomphus ruppeli*, which is listed as an endangered species. The species accumulation curve indicates the heterogeneity in species composition among the sites, along with a correlation between sampling effort and number of species found (Fig. 1).

The 33 species recorded in December 2014 include eight endemic species (out of 11 known endemics in Ethiopia). The collected larvae were identified to the genus level and genetic analysis will be done at Naturalis, Leiden, to see whether they match species in the DNA database.

The sites with the highest number of recorded species were Gojeb, Shoriri and Boginda, while the sites with the highest number of endemic species (Fig. 2a) were Boka (Fig. 6a and b), Bamboo (Fig. 6c), Komba (Fig. 6d) and Boginda. The sample sites with the highest number of species (ten, nine and eight species, respectively) were Boginda Forest (BO), the open wetlands in the Gojeb River floodplain (GO-wet2) and the Gichi River in Komba Forest (KO1) (Fig. 2b). These were followed by three sites with seven species each: the site at Alemgono (AG) and the two sites in the Shoriri Wetlands (SHO1 and SHO2) (Fig. 2b).

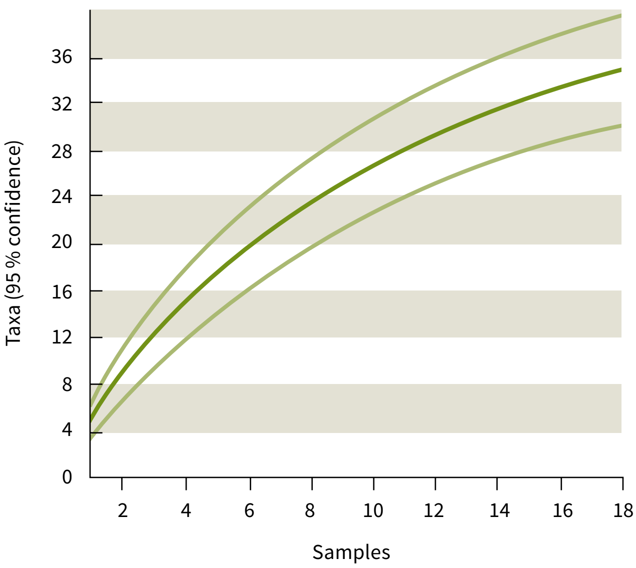

Figure 1: Species accumulation curve (Mao tau) for the 18 sampling sites (see Table 1), blue line indicating the 95% confidence interval

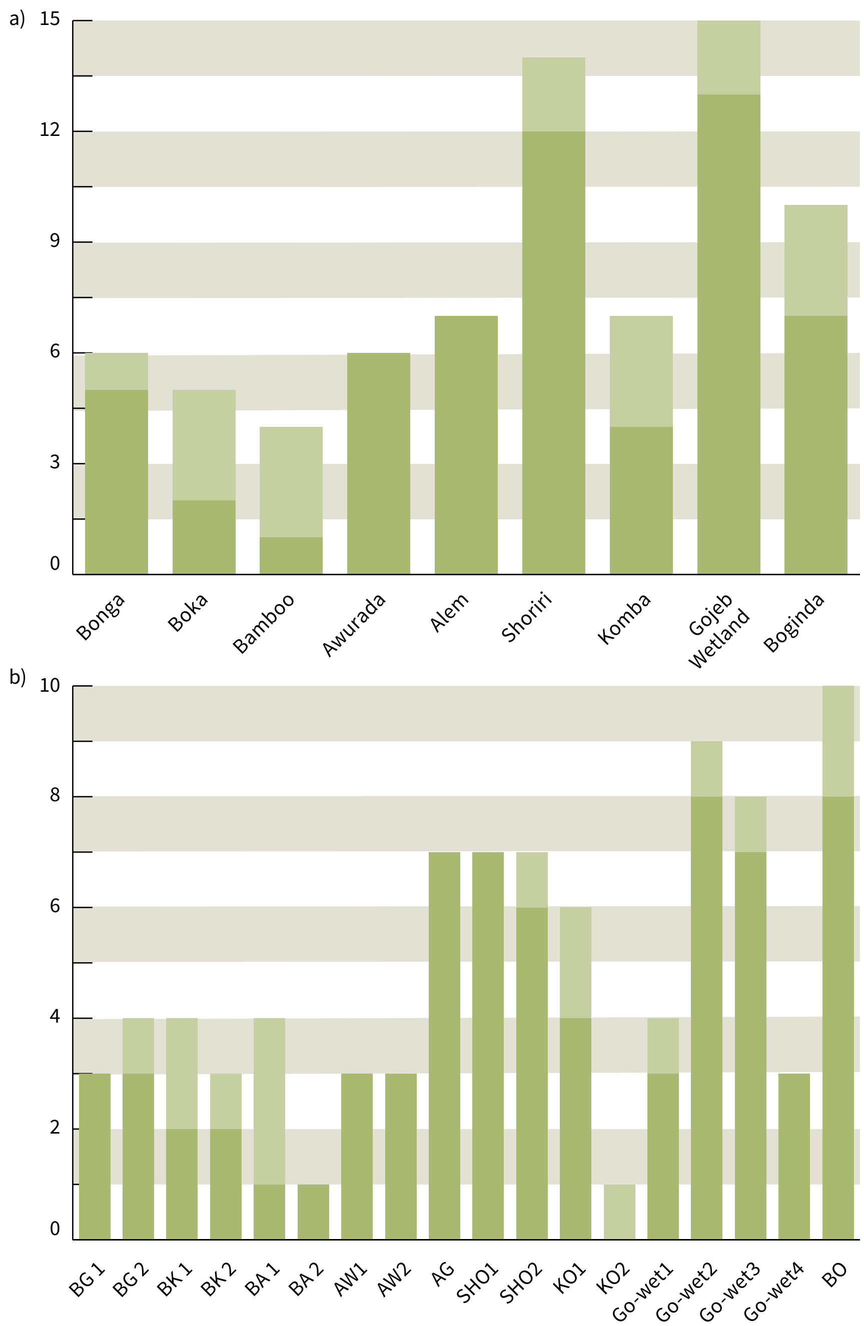

Figure 2: Total number of species (light green: Ethiopian endemics) a) per study site, b) per sampling site

Similar to what has been noted by Dijkstra & Clausnitzer (2005) the following points are notable:

- The high proportion of endemic species recorded (24.2%).
- The low total number of species recorded (33).
- The low average of 4.9 species recorded per locality (Table 3).
- The low average proportion of sites at which each species was recorded (2.8%). 32.4% of species were found at a single site.
- The scarceness of species known to be common in similar habitats further south (Kenya, Uganda, Tanzania, and Malawi).

As already discussed by Clausnitzer & Dijkstra (2005), this might be an effect of the season, so a survey during the rainy season in April or May is needed urgently. Nevertheless, the general pattern of a species-poor but endemic-rich fauna and flora is most likely a result of the area's geological history and present-day isolation. The Ethiopian highlands have undergone heavy volcanism and climatic changes, which might be responsible for the relatively high level of adaptiveness.

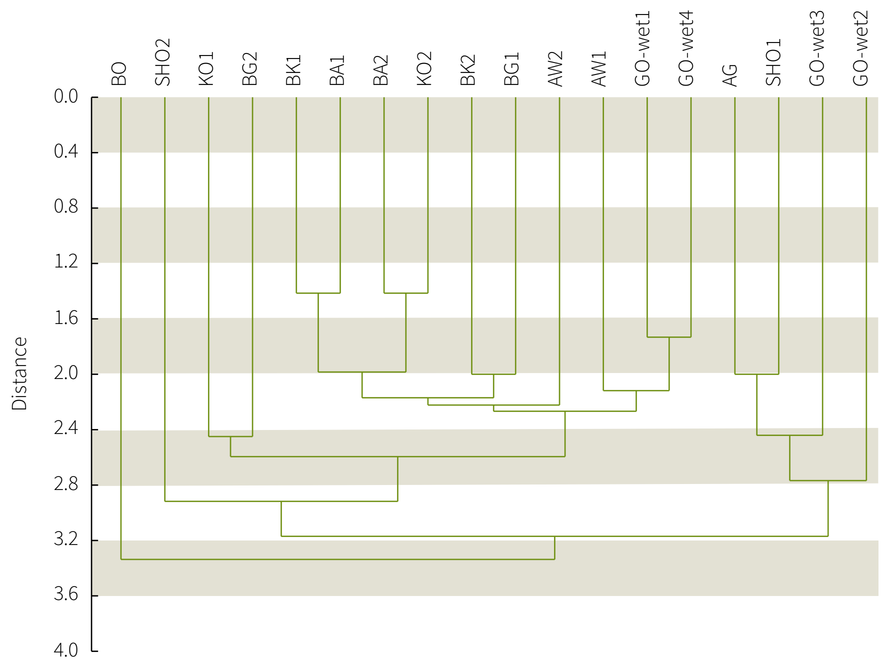

Figure 3: Cluster analysis (Euclidean distance) for the different sampling sites

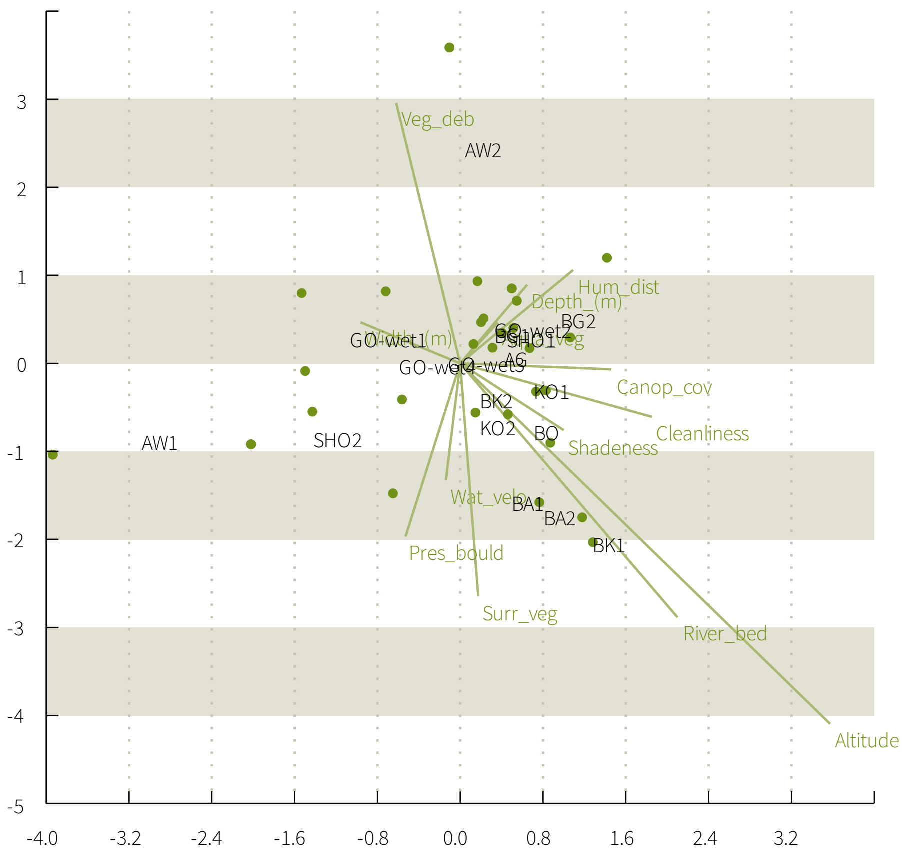

Figure 4: CCA showing sampling sites (see Table 1) and environmental variables

The mostly natural plots (BA1, BA2, BK1, KO2) are clustered together (Fig. 3), mostly due to altitude, water quality and surrounding vegetation (Fig. 4). Likewise, wetlands with stagnant bodies of water only cluster with each other (AG, SHO1, GO-wet2, GO-wet3). The undisturbed stream in the Shoriri Wetlands, which is a PFM site (SHO2), is a long way from any other plot (Fig. 3). SHO2 is at a comparatively low altitude and hence has a high number of common and widespread species, in addition to endemic species otherwise found only in undisturbed habitats at higher elevations. This suggests that the endemic species may have once been more widespread, but nowadays largely survive in the relatively natural refugia of higher elevations.

Endemism

While species numbers in Ethiopia are low, endemism is high (12%, versus between 1 and 3% for each of Kenya, Tanzania and Uganda). Most of Ethiopia's endemic species originate from genera which are dominant in tropical Africa, in terms of both species and individual numbers. The forests of Ethiopia are more impoverished than similar biomes elsewhere, for example Kenya. Similar patterns – deviant species sets due to impoverishment, a high level of endemism and extra-Afrotropical elements – have been reported for Ethiopia's flora (Hedberg 1969, Q. Luke, pers. com.), butterflies (Carcasson 1964; de Jong et al. 1993) and montane forest avifauna (Stuart et al. 1993). All show fewer affinities to the central African forests than would be expected. Ethiopian montane forest butterfly and bird fauna do not group closely with those of any other Afrotropical area (de Jong & Congdon 1993; Stuart et al. 1993). The greatest phytogeographical disjunction in the eastern African montane flora occurs between Ethiopia and more southern sites (Hedberg 1969).

Ethiopia's endemic Odonata seem to be relatively tolerant to anthropogenic habitat change, although the level of deforestation may be unprecedented. The habitat changes to the Ethiopian Highlands due to climate changes, volcanism and long-term human impact seem to have encouraged these species to adapt to shifts in habitat.

4. Conclusions and Recommendations for Conservation and Monitoring

Deforestation and environmental degradation due to human disturbance, along with a drastic increase in water pollution due to economic growth, even in remote areas, pose a major threat to Ethiopia's environmental wealth. With few exceptions, the natural landscape has been turned into agricultural land. Around 95% of Ethiopia's original forest has already been lost to agriculture and human settlements (Gordon & Carillet 2003). As explained above, Ethiopia's endemic dragonflies are relatively tolerant to habitat disturbance. But even species adaptable to altered landscapes, such as the Kaffa Sprite or Ethiopian skimmer, will disappear in the face of ongoing loss of their habitats due to water pollution, water extraction and large-scale reforestation with eucalyptus.

The endemic species which require forested and clear rocky streams or rivers, such as the Ethiopian Sprite (Fig. 7a), Cottarelli's Longlegs (Fig. 7b), Rüppell's Longlegs (Fig. 7c) and the Ethiopian Highlander (Fig. 7d) are of conservation concern and can act as monitoring species for the core zones of the Kafa BR. Because they are easy to see and endemic to the montane habitats, the Ethiopian Highlander, Ethiopian Skimmer (Fig. 7e), Ethiopian Sprite (Fig. 7a) and Kaffa Sprite could act as flagship species for the Kafa BR.

Table 2: Species suggested as monitoring and flagship species (see Table 5 for author and family)

Genus	Species	English name	Endemic	RL	Monitoring species	Flagship species
Atoconeura	*aethiopica*	Ethiopian Highlander	Yes	VU	Yes	Yes
Notogomphus	*cottarellii*	Cottarelli's Longlegs	Yes	EN	Yes	No
Notogomphus	*ruppeli*	Rüppell's Longlegs	Yes	EN	Yes	No
Orthetrum	*kristenseni*	Ethiopian Skimmer	Yes	LC	No	Yes
Pseudagrion	*guichardi*	Ethiopian Sprite	Yes	VU	Yes	Yes
Pseudagrion	*kaffinum*	Kaffa Sprite	Yes	VU	No	Yes

As can be seen in Figures 2a and 2b, the study sites with the highest number of species are not the same as those with the highest number of endemic species. Most species found at disturbed sites are common and widespread across tropical Africa, whereas the montane forest sites are home to a set of globally threatened and locally endemic species.

Conservation efforts in the Kafa BR have thus far largely focused on the threatened montane upland habitats, which explains why core zones have not yet been established in the wetlands. The huge wetlands of the Gojeb River should be considered a core zone, as well as the wetlands in the Afroalpine zone, i.e. beyond Boka Forest.

Further studies

The most important goal for future studies is to conduct surveys in different seasons. The rainy season from April to May could be perfect, and would likely increase the number of species recorded at all sites, especially in the Awurada Valley and Gojeb Wetland. Two British odonatologists were scheduled join an expedition in April 2015 and sample the same habitats as in this study.

5. Conserving, Restoring and Monitoring Wetlands: The Global Challenge for the 21st Century

Globally, freshwater habitats are being disturbed, polluted and destroyed at an alarming rate. Access to clean water is essential to human health, with the United Nations declaring it a fundamental human right in 2010. Freshwater habitats are some of the most threatened ecosystems globally (Vörösmarty et al. 2010). They containing 10% of all known species in an area making up just 1% of the earth's surface (Strayer & Dudgeon 2010) and provide ecosystem services valued at several trillion USD per year (Postel & Carpenter 1997). More than half of the earth's wetlands have been degraded (Russi et al. 2013), and more than two-thirds of our upland watersheds remain unprotected (Thieme et al. 2010). In general, protection for terrestrial ecosystems is much better than for wetlands, because conservation efforts mainly focus on large terrestrial mammals.
Wetlands and their associated watersheds provide valuable ecosystem services such as water catchment, retention and purification, provide habitats for a large range of specialised flora and fauna and serve as important longitudinal and transversal corridors for dispersal of biota (Alvarez-Mieles et al. 2013). Freshwater ecosystems and freshwater biodiversity are in great peril, and urgent measures are needed (Garcia-Moreno et al. 2014). Wetlands need to be protected, and their status must be monitored. This is especially true for countries like Ethiopia, where the economy is growing despite water sanitation being virtually non-existent, vastly increasing the pollution and destruction of wetlands and their ecosystem services.

Due to their popularity, manageable diversity and relatively well-resolved taxonomy, dragonflies are the only insect order for which a global status assessment has been performed (Clausnitzer et al. 2009) and for which conservation actions can been outlined beyond the local level (Clausnitzer et al. 2012). Because of their amphibiotic ecology, dragonflies reflect the diversity of both freshwater (molluscs, crabs, fishes, amphibians) and terrestrial (birds, mammals) groups. Recent studies on the continental scale in Africa have shown that dragonflies in Africa display remarkably similar patterns for diversity and centres of threatened species to other freshwater groups such as fish, molluscs and crabs (Darwall et al. 2011a), while congruence with birds has also been recorded (Tushabe et al. 2006). Hence, dragonflies are a good tool for assessing aquatic systems and have been used as indicators of ecological health (Carle 1979; Clausnitzer 2003; Sahlen & Ekestubbe 2001; Trevino 1997), ecological integrity (Clark & Samways 1996; Von Ellenrieder 2000; Smith et al. 2007) and environmental changes such as climatic change (Bush et al. 2013). They are therefore valuable indicators for prioritising conservation planning across Africa's freshwater systems and can help minimise or mitigate the impact of future development (Darwall et al 2011b; Dijkstra et al. 2011; Simaika et al. 2013). Species-level dragonfly assessments can be used to monitor climate change and be correlated with more labour- and expertise-intensive macroinvertebrate surveys (Bush et al 2013, Simaika & Samways 2011).

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7. Appendix

7.1. Tables

Table 3: Odonata species recorded during the December 2014 NABU survey of the Kafa BR (in alphabetical order)

Genus	Species	English name	Endemic	New	Bonga	Boka	Bamboo	Awurada	Alemgono	Shoriri	Komba	Gojeb Wetlands	Boginda
Anax	*imperator*	Blue Emperor			0	0	0	0	1	1	0	0	0
Atoconeura	*aethiopica*	Ethiopian Highlander	Yes		1	0	0	0	0	0	1	0	0
Crocothemis	*erythraea*	Broad Scarlet			0	0	0	0	0	1	0	0	0
Gynacantha	*nigeriensis*	Yellow-legged Duskhawker			0	0	0	1	0	0	0	0	0
Gynacantha	*villosa*	Brown Duskhawker			0	0	0	0	0	0	1	1	1
Notogomphus	*cottarellii*	Cottarelli's Longlegs	Yes		0	0	1	0	0	1	0	0	0
Notogomphus	*ruppeli*	Rüppell's Longlegs	Yes		0	1	1	0	0	0	0	0	0
Notogomphus	spec. (larvae)	? Longlegs			0	0	0	0	0	0	0	0	1
Orthetrum	*abbotti*	Little Skimmer			0	0	0	0	1	0	0	1	0
Orthetrum	*caffrum*	Two-striped Skimmer			0	0	0	0	1	0	1	0	1
Orthetrum	*julia*	Julia Skimmer			1	0	0	1	0	0	0	1	1
Orthetrum	*kristenseni*	Ethiopian Skimmer	Yes		0	1	0	0	0	0	0	0	1
Orthetrum	*stemmale*	Tough Skimmer			0	0	0	0	0	1	0	0	0
Palpopleura	*jucunda radiata*	Ethiopian yellow-veined Widow	Yes		0	0	0	0	0	0	1	1	0
Palpopleura	*lucia*	Lucia Widow			0	0	0	0	1	1	0	1	0
Palpopleura	*portia*	Silver-winged Widow			1	0	0	0	1	1	0	1	1
Phyllomacromia	spec.	? African Cruiser		Yes	1	0	0	0	0	0	0	0	1
Phyllomacromia	spec. (larvae)	? African Cruiser		Yes	0	0	0	0	0	0	0	0	1
Tetrathemis	*polleni*	Black-splashed Elf		Yes	0	0	0	1	0	0	0	0	0
Trithemis	*arteriosa*	Red-veined Dropwing			0	0	0	0	0	1	0	1	0
Trithemis	*furva*	Navy Dropwing			0	0	0	0	0	0	0	1	0
Trithemis	*ellenbeckii*	Ethiopian Dropwing	Yes		0	0	0	0	0	1	0	0	0
Nesciothemis	*farinosa*	Eastern Blacktail			0	0	0	0	0	1	0	0	0
Trithemis	*stictica*	Jaunty Dropwing			0	0	0	0	0	1	0	0	0
Zosteraeschna	*ellioti*	Northern Highland Hawker			1	0	0	0	0	0	1	0	0
Zygonyx	*torridus*	Ringed Cascader			0	0	0	1	0	0	0	0	0
Aciagrion	*gracile*	Graceful Slim			0	0	0	0	0	0	0	1	0
Ceriagrion	*glabrum*	Common Waxtail			0	0	0	0	1	1	0	1	0
Lestes	*virgatus*	Smoky Spreadwing			0	0	0	0	0	0	0	1	0
Platycypha	*caligata*	Common Dancing-jewel			0	0	0	1	0	1	0	1	0
Proischnura	*subfurcata*	Fork-tailed Bluet			1	1	0	0	1	1	0	1	1
Pseudagrion	*guichardi*	Ethiopian Sprite	Yes		0	1	1	0	0	0	1	0	1
Pseudagrion	*kaffinum*	Kaffa Sprite	Yes		0	0	0	0	0	0	0	1	0
Pseudagrion	*kersteni*	Powder-faced Sprite			0	0	0	1	0	0	0	0	0
Pseudagrion	*spernatum*	Highland Sprite			0	1	1	0	0	1	1	1	0

Table 4: Odonata species reliably recorded for the Kafa BR. **Record** (only most recent is given): **1**: obtained by the author in December 2014, **2**: old record (Clausnitzer & Dijkstra 2005); **Red List**: IUCN Threat Status according to the global Red List of Threatened Species (LC: Least Concern, NT: Near Threatened, V: Vulnerable, EN: Endangered, CR: Critically Endangered,); **Endemism**: E=Endemic to Ethiopia; **New for KBR**: First record at the Kafa BR

Family	Species	Author	Record	Red List	Endemism	New for KBR
Calopterygidae	*Phaon iridipennis*	Burmeister 1839	2	LC		
Chlorocyphidae	*Platycypha caligata*	Selys 1853	2	LC		
Lestidae	*Lestes virgatus*	Burmeister 1839	1	LC		
Platycnemididae	*Elattoneura pasquinii*	Consiglio 1978	2	VU	E	
Coenagrionidae	*Aciagrion gracile*	Sjöstedt 1909	1	LC		1
Coenagrionidae	*Africallagma elongatum*	Pinhey 1950	2	LC		
Coenagrionidae	*Africallagma subtile*	Ris 1921	2	LC		
Coenagrionidae	*Agriocnemis exilis*	Selys 1872	2	LC		
Coenagrionidae	*Ceriagrion glabrum*	Burmeister 1839	1	LC		1
Coenagrionidae	*Pinheyschna waterstoni*	Peters & Theischinger 2011	2	NT		
Coenagrionidae	*Proischnura subfurcata*	Selys 1876	1	LC		
Coenagrionidae	*Pseudagrion gamblesi*	Pinhey 1978	2	LC		
Coenagrionidae	*Pseudagrion guichardi*	Kimmins, 1988	1	VU	E	
Coenagrionidae	*Pseudagrion kaffinum*	Consiglio 1980	1	VU	E	
Coenagrionidae	*Pseudagrion kersteni*	Gerstäcker 1869	1	LC		
Coenagrionidae	*Pseudagrion spernatum*	Hagen in Selys 1885	1	LC		
Aeshnidae	*Anax ephippiger*	Burmeister 1839	2	LC		
Aeshnidae	*Anax imperator*	Leach 1815	1	LC		
Aeshnidae	*Anax speratus*	Hagen 1867	2	LC		
Aeshnidae	*Gynacantha nigeriensis*	Gambles 1956	1	LC		
Aeshnidae	*Gynacantha villosa*	Grünberg, 1902	1	LC		1
Aeshnidae	*Zosteraeschna ellioti*	Kirby 1896	1	LC		
Gomphidae	*Notogomphus cottarellii*	Consiglio 1978	1	EN	E	
Gomphidae	*Notogomphus dorsalis*	Sélys 1857	2	LC		
Gomphidae	*Notogomphus ruppeli*	Sélys 1858	1	EN	E	1
Gomphidae	*Onychogomphus indet.*		2			
Gomphidae	*Paragomphus alluaudi*	Martin 1915	2	LC		
Gomphidae	*Paragomphus crenigomphoides*	Clausnitzer & Dijkstra 2005	2	DD	E	
Libellulidae	*Atoconeura aethiopica*	Kimmins 1958	1	VU	E	
Libellulidae	*Chalcostephia flavifrons*	Kirby 1889	2	LC		
Libellulidae	*Crocothemis erythraea*	Brullé 1832	1	LC		1
Libellulidae	*Nesciothemis farinosa*	Förster 1898	1	LC		1
Libellulidae	*Orthetrum abbotti*	Calvert 1892	1	LC		
Libellulidae	*Orthetrum caffrum*	Burmeister 1839	1	LC		
Libellulidae	*Orthetrum guineense*	Ris 1910	2	LC		
Libellulidae	*Orthetrum julia*	Kirby 1900	1	LC		
Libellulidae	*Orthetrum kristenseni*	Ris 1911	1	LC	E	
Libellulidae	*Orthetrum stemmale*	Burmeister 1839	1	LC		
Libellulidae	*Palpopleura jucunda radiata*		1	LC	E	1
Libellulidae	*Palpopleura lucia*	Drury 1773	1	LC		
Libellulidae	*Palpopleura portia*	Drury 1773	1	LC		
Libellulidae	*Pantala flavescens*	Fabricius 1798	2	LC		
Libellulidae	*Tetrathemis polleni*	Selys 1869	1	LC		1

Family	Species	Author	Record	Red List	Endemism	New for KBR
Libellulidae	*Trithemis aconita*	Lieftinck 1969	2	LC		
Libellulidae	*Trithemis arteriosa*	Burmeister 1839	1	LC		1
Libellulidae	*Trithemis ellenbeckii*	Förster 1906	1	LC	E	
Libellulidae	*Trithemis furva*	Karsch 1899	1	LC		
Libellulidae	*Trithemis stictica*	Burmeister 1839	1	LC		
Libellulidae	*Zygonyx natalensis*	Martin 1900	2	LC		
Libellulidae	*Zygonyx torridus*	Kirby 1889	1	LC		1
Macromiidae	*Phyllomacromia picta*	Hagen in Selys 1871	2	LC		
Macromiidae	*Phyllomacromia* spec.		1			1

Table 5: Reliable Odonata records for the Kafa BR (for family, Red List status and endemism, see Table 4)

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Aciagrion gracile	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Africallagma elongatum	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Africallagma elongatum	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Africallagma elongatum	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Africallagma elongatum	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Africallagma elongatum	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Africallagma elongatum	20.03.2004	March	2004	Bonga, 5 km N	1710		7.31626°N	36.24148°E	collection
Africallagma elongatum	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Africallagma subtile	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Africallagma subtile	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Africallagma subtile	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Agriocnemis exilis	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Agriocnemis exilis	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Anax ephippiger		September	1885	Scioa Ghimira			6.9666667°N	35.7666667°E	literature
Anax imperator	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Anax imperator	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Anax imperator	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Anax speratus	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Anax speratus	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Atoconeura aethiopica	26.10.1973	October	1973	Deccio Forest, W of Bonga, loc. 20	1840	20 km	7.28032°N	36.19031°E	literature
Atoconeura aethiopica	17.03.2004	March	2004	Gecha, stream near Gecha			7.08333°N	35.5°E	collection
Atoconeura aethiopica	17.03.2004	March	2004	Gecha			7.5589415°N	35.445515°E	literature
Atoconeura aethiopica	17.03.2004	March	2004	Baro-Tepi, near Gecha	1630		7.876°N	35.479°E	collection
Atoconeura aethiopica	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Atoconeura aethiopica	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Atoconeura aethiopica	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Atoconeura aethiopica	17.03.2004	March	2004	Baro river			7.9189224°N	35.4561132°E	literature
Atoconeura aethiopica	19.03.2004	March	2004	Wushwush tea plan-tation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Atoconeura aethiopica	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Atoconeura aethiopica	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	literature
Atoconeura aethiopica	21.03.2004	March	2004	Borkana River near Yayu	1290		8.37093°N	35.8847°E	collection
Atoconeura aethiopica	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Atoconeura aethiopica	21.03.2004	March	2004	Borkana river			8.3795591°N	35.8605468°E	literature
Atoconeura aethiopica	03.12.2014	December	2014	Bonga, hill W of Bonga	1980		7.25358°N	36.226332°E	collection
Atoconeura aethiopica	04.12.2014	December	2014	Boka Forest, stream in wetlands below Boka Forest	2414		7.29467°N	36.37604°E	collection
Ceriagrion glabrum	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Ceriagrion glabrum	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Ceriagrion glabrum	09.12.2014	December	2014	Gawata, Gojeb Wet-lands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Ceriagrion glabrum	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Chalcostephia flavifrons	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Chalcostephia flavifrons	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Crocothemis erythraea	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Elattoneura pasquinii	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Elattoneura pasquinii	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Gynacantha nigeriensis	16.03.2004	March	2004	Gaba Forest, 35 km W of Bedele	1507		8.36872°N	36.03405°E	collection
Gynacantha nigeriensis	21.03.2004	March	2004	Bedele, forest near Gaba River	1510		8.3652°N	36.0348°E	collection
Gynacantha nigeriensis	05.12.2014	December	2014	Awurada Valley, floodplain (swamp forest) along Gummi River	1293		7.09281°N	36.23154°E	observa-tion
Gynacantha villosa	07.12.2014	December	2014	Komba Forest, clear and rocky forest stream in Komba Forest	1847		7.30803°N	36.12201°E	collection
Gynacantha villosa	09.12.2014	December	2014	Gawata, Gojeb Wet-lands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Gynacantha villosa	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Lestes virgatus	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Lestes virgatus	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Lestes virgatus	09.12.2014	December	2014	Gawata, Gojeb Wet-lands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Nesciothemis farinosa	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Notogomphus cottarellii	28.10.1973	October	1973	Bonga	1710	10 km	7.264216°N	36.251372°E	literature
Notogomphus cottarellii	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Notogomphus cottarellii	19.03.2004	March	2004	Forest close to Wush-wush tea plantation			7.3036039°N	36.1308388°E	not specified
Notogomphus cottarellii	04.12.2014	December	2014	Bamboo Forest, River in Bamboo Forest	2595		7.24118°N	36.45182°E	observa-tion

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Notogomphus cottarellii	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Notogomphus cottarellii		April	1947	Abessinien, Gore			8.1496°N	35.5355°E	collection
Notogomphus dorsalis	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Notogomphus ruppeli	04.12.2014	December	2014	Bamboo Forest, River in Bamboo Forest	2595		7.24118°N	36.45182°E	collection
Notogomphus ruppeli	04.12.2014	December	2014	Boka Forest, stream in wetlands below Boka Forest	2414		7.29467°N	36.37604°E	collection
Notogomphus spec. (larvae)	04.12.2014	December	2014	Bamboo Forest, River in Bamboo Forest	2650		7.24331°N	36.49564°E	collection
Notogomphus spec. (larvae)	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Onychogomphus indet.	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	literature
Onychogomphus indet.	18.03.2004	March	2004	Tepi, between Tepi and Mizan Tafari (M. Tefari)			7.08333°N	35.5°E	literature
Orthetrum abbotti	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Orthetrum abbotti	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Orthetrum caffrum	25.10.1973	October	1973	Baca, Jimma-Bonga Road, loc. 16	1730	10 km	7.393049°N	36.253403°E	literature
Orthetrum caffrum	27.10.1975	October	1975	Bedelle Forest, loc 77	1747	5 km	8.449572°N	36.475853°E	literature
Orthetrum caffrum	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Orthetrum caffrum	07.12.2014	December	2014	Komba Forest, clear and rocky forest stream in Komba Forest	1847		7.30803°N	36.12201°E	collection
Orthetrum caffrum	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Orthetrum caffrum		November	1885	Scioa Ghimira			6.9666667°N	35.7666667°E	literature
Orthetrum guineense	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature
Orthetrum julia	26.10.1973	October	1973	Amaia Road, near Anderrica, loc. 19	2231	20 km	7.167305°N	36.3213°E	literature
Orthetrum julia	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Orthetrum julia	26.10.1973	October	1973	Deccio Forest, W of Bonga, loc. 20	1840	20 km	7.28032°N	36.19031°E	literature
Orthetrum julia	27.10.1973	October	1973	Bonga mission, loc. 17	1710	10 km	7.282654°N	36.242887°E	literature
Orthetrum julia	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Orthetrum julia	20.03.2004	March	2004	Bonga, 5 km N	1710		7.31626°N	36.24148°E	collection
Orthetrum julia	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Orthetrum julia	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Orthetrum julia	03.12.2014	December	2014	Bonga, stream near Bonga Town	1832		7.2542°N	36.25762°E	collection
Orthetrum julia	03.12.2014	December	2014	Bonga, hill W of Bonga	1980		7.25358°N	36.226332°E	collection
Orthetrum julia	05.12.2014	December	2014	Awurada Valley, floodplain (swamp forest) along Gummi River	1293		7.09281°N	36.23154°E	collection
Orthetrum julia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Orthetrum julia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Orthetrum julia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1518		7.55442°N	36.05213°E	collection
Orthetrum julia	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Orthetrum kristenseni	25.10.1973	October	1973	Baca, Jimma-Bonga Road, loc. 16	1730	10 km	7.393049°N	36.253403°E	literature
Orthetrum kristenseni	28.10.1973	October	1973	2km W of Baca, Jimma-Bonga Road, loc. 21	1779	5 km	7.398385°N	36.232171°E	literature
Orthetrum kristenseni	17.03.2004	March	2004	Masha, near Masha			7.08333°N	35.5°E	collection
Orthetrum kristenseni	17.03.2004	March	2004	Baro-Tepi, near Masha	1630		7.73333°N	35.4833°E	collection
Orthetrum kristenseni	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Orthetrum kristenseni	04.12.2014	December	2014	Boka Forest, swamp along stream below Boka Forest	2414		7.29467°N	36.37604°E	collection
Orthetrum kristenseni	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Orthetrum stemmale	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Orthetrum stemmale	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Palpopleura jucunda radiata	06.12.2014	December	2014	Komba Forest, forest edge	1900		7.10176°N	36.13277°E	collection
Palpopleura jucunda radiata	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Palpopleura lucia	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Palpopleura lucia	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Palpopleura lucia	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Palpopleura lucia	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Palpopleura lucia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Palpopleura lucia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Palpopleura portia	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature
Palpopleura portia	27.10.1973	October	1973	Bonga mission, loc. 17	1710	10 km	7.282654°N	36.242887°E	literature
Palpopleura portia	03.12.2014	December	2014	Bonga, stream near Bonga Town	1832		7.2542°N	36.25762°E	collection
Palpopleura portia	06.12.2014	December	2014	Alemgono Wetland, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Palpopleura portia	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Palpopleura portia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Palpopleura portia	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Palpopleura portia	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Pantala flavescens	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Paragomphus alluaudi	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Paragomphus crenigomphoides	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Paragomphus sp.		October	1973	Kaffa, forest between Belleta and Bonga	1630	10 km	7.3707°N	36.3591°E	literature
Phaon iridipennis	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Phaon iridipennis	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Phyllomacromia picta	21.03.2004	March	2004	Borkana River near Yayu	1290		8.37093°N	35.8847°E	collection
Phyllomacromia spec.	03.12.2014	December	2014	Bonga, hill W of Bonga	1980		7.25358°N	36.226332°E	observation
Phyllomacromia spec.	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Phyllomacromia spec. (larvae)	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Pinheyschna waterstoni	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Platycypha caligata	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature
Platycypha caligata	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection
Platycypha caligata	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Platycypha caligata	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Platycypha caligata	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Platycypha caligata	05.12.2014	December	2014	Awurada Valley, Gummi River, large river	1293		7.09281°N	36.23154°E	observation
Platycypha caligata	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Platycypha caligata	09.12.2014	December	2014	Gawata, Gojeb Wetlands, Gojeb River, large river	1515		7.55448°N	36.05688°E	observation
Platycypha caligata	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1518		7.55442°N	36.05213°E	collection
Proischnura subfurcata	25.10.1973	October	1973	Baca, Jimma-Bonga Road, loc. 16	1730	10 km	7.393049°N	36.253403°E	literature
Proischnura subfurcata	26.10.1973	October	1973	Amaia Road, near Anderrica, loc. 19	2231	20 km	7.167305°N	36.3213°E	literature

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Proischnura subfurcata	26.10.1973	October	1973	Deccio Forest, W of Bonga, loc. 20	1840	20 km	7.28032°N	36.19031°E	literature
Proischnura subfurcata	27.10.1973	October	1973	Bonga Mission, loc. 17	1710	10 km	7.282654°N	36.242887°E	literature
Proischnura subfurcata	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Proischnura subfurcata	20.03.2004	March	2004	Bonga, 5 km N	1710		7.31626°N	36.24148°E	collection
Proischnura subfurcata	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Proischnura subfurcata	03.12.2014	December	2014	Bonga, stream near Bonga Town	1832		7.2542°N	36.25762°E	collection
Proischnura subfurcata	04.12.2014	December	2014	Boka Forest, swamp along stream below Boka Forest	2414		7.29467°N	36.37604°E	collection
Proischnura subfurcata	06.12.2014	December	2014	Alemgono Wetlands, wetlands, heavily grazed	1706		7.36428°N	36.22602°E	collection
Proischnura subfurcata	06.12.2014	December	2014	Shoriri Wetlands, wetlands, undisturbed	1626		7.35707°N	36.20437°E	collection
Proischnura subfurcata	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Proischnura subfurcata	09.12.2014	December	2014	Gawata, Gojeb Wetland, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Proischnura subfurcata	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion gamblesi	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion guichardi	27.10.1973	October	1973	Bonga mission, loc. 17	1710	10 km	7.282654°N	36.242887°E	literature
Pseudagrion guichardi	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Pseudagrion guichardi	19.03.2004	March	2004	Wushwush tea plantation	1900		7.3036039°N	36.1308388°E	collection
Pseudagrion guichardi	19.03.2004	March	2004	Wushwush			7.3036039°N	36.1308388°E	not specified

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Pseudagrion guichardi	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Pseudagrion guichardi	04.12.2014	December	2014	Bamboo Forest, river in Bamboo Forest	2595		7.24118°N	36.45182°E	collection
Pseudagrion guichardi	04.12.2014	December	2014	Boka Forest, stream in wetlands below Boka Forest	2414		7.29467°N	36.37604°E	collection
Pseudagrion guichardi	07.12.2014	December	2014	Komba Forest, clear and rocky forest stream in Komba Forest	1847		7.30803°N	36.12201°E	collection
Pseudagrion guichardi	11.12.2014	December	2014	Boginda Forest, stream with swamps in Boginda Forest, partly open (grazed glades)	2074		7.50175°N	36.09118°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Pseudagrion kaffinum	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Pseudagrion kaffinum	09.12.2014	December	2014	Gawata, Gojeb Wetlands, Gojeb River, large river	1515		7.55448°N	36.05688°E	collection
Pseudagrion kaffinum	09.12.2014	December	2014	Gawata, Gojeb Wetlands, gallery forest and wetlands along Gojeb	1530		7.55448°N	36.05687°E	collection
Pseudagrion kersteni	18.03.2004	March	2004	Tepi, between Tepi and Mizan Tafari (M. Tefari)			7.08333°N	35.5°E	collection
Pseudagrion kersteni	18.03.2004	March	2004	Tepi to Mizan Tafari	1000		7.112°N	35.428°E	collection
Pseudagrion kersteni	05.12.2014	December	2014	Awurada Valley, floodplain (swamp forest) along Gummi River	1293		7.09281°N	36.23154°E	collection
Pseudagrion spernatum	25.10.1973	October	1973	Baca, Jimma-Bonga Road, loc. 16	1730	10 km	7.393049°N	36.253403°E	Literature
Pseudagrion spernatum	26.10.1973	October	1973	Amaia Road, near Anderrica, loc. 19	2231	20 km	7.167305°N	36.3213°E	Literature
Pseudagrion spernatum	16.03.2004	March	2004	Gaba River, 35 km W of Bedele	1467		8.36387°N	36.04116°E	collection

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Pseudagrion spernatum	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Pseudagrion spernatum	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion spernatum	17.03.2004	March	2004	Baro River between Gordomo and Masha	1630		7.87622°N	35.4788°E	collection
Pseudagrion spernatum	19.03.2004	March	2004	Wushwush tea plantation, 13 km W of Bonga	1845		7.3036039°N	36.1308388°E	collection
Pseudagrion spernatum	20.03.2004	March	2004	Bonga, 5 km N	1710		7.31626°N	36.24148°E	collection
Pseudagrion spernatum	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Pseudagrion spernatum	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Pseudagrion spernatum	04.12.2014	December	2014	Bamboo Forest, River in Bamboo Forest	2595		7.24118°N	36.45182°E	collection
Pseudagrion spernatum	04.12.2014	December	2014	Boka Forest, swamp along stream below Boka Forest	2414		7.29467°N	36.37604°E	collection
Pseudagrion spernatum	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Pseudagrion spernatum	07.12.2014	December	2014	Komba Forest, clear and rocky forest stream in Komba Forest	1847		7.30803°N	36.12201°E	collection
Pseudagrion spernatum	09.12.2014	December	2014	Gawata, Gojeb Wetlands, Gojeb River, large river	1515		7.55448°N	36.05688°E	collection
Pseudagrion spernatum	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1518		7.55442°N	36.05213°E	collection
Tetrathemis polleni	05.12.2014	December	2014	Awurada Valley, Gummi River, large river	1293		7.09281°N	36.23154°E	observation
Trithemis aconita	21.03.2004	March	2004	Borkana River near Yayu	1290		8.37093°N	35.8847°E	collection
Trithemis aconita	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Trithemis arteriosa	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Trithemis arteriosa	09.12.2014	December	2014	Gawata, Gojeb Wetlands, swampy floodplain N of Gojeb	1516		7.55444°N	36.05209°E	collection
Trithemis ellenbeckii	26.10.1973	October	1973	Amaia Road, near Anderrica, loc. 19	2231	20 km	7.167305°N	36.3213°E	literature
Trithemis ellenbeckii	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature
Trithemis ellenbeckii	28.10.1973	October	1973	2km W of Baca, Jimma-Bonga Road, loc. 21	1779	5 km	7.398385°N	36.232171°E	literature

Species	Date	Month	Year	Locality	Altitude	Accuracy	Latitude	Longitude	Record
Trithemis ellenbeckii	17.03.2004	March	2004	Gore, between Gore and Gordomo	1775		8.0594°N	35.5238°E	collection
Trithemis ellenbeckii	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Trithemis ellenbeckii	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Trithemis ellenbeckii		November	1885	Scioa Ghimira			6.9666667°N	35.7666667°E	literature
Trithemis furva	26.10.1973	October	1973	Anderrica Forest, loc. 18	1660	20 km	7.195405°N	36.285317°E	literature
Trithemis furva	21.03.2004	March	2004	Borkana River near Yayu	1290		8.37093°N	35.8847°E	collection
Trithemis furva	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Trithemis furva	09.12.2014	December	2014	Gawata, Gojeb Wetlands, Gojeb River, large river	1515		7.55448°N	36.05688°E	observation
Trithemis stictica	17.03.2004	March	2004	Gore to Gordomo, 10 km S of Gore	1775		8.05941°N	35.52376°E	collection
Trithemis stictica	06.12.2014	December	2014	Shoriri Wetlands, stream along forest edge and Shoriri Wetlands	1626		7.35707°N	36.20437°E	collection
Zosteraeschna ellioti	20.03.2004	March	2004	Bonga, N	1727		7.32987°N	36.24733°E	collection
Zosteraeschna ellioti	20.03.2004	March	2004	Bonga, stream near Bonga	1730		7.32988°N	36.2473°E	collection
Zosteraeschna ellioti	03.12.2014	December	2014	Bonga, hill W of Bonga	1980		7.25358°N	36.226332°E	observation
Zosteraeschna ellioti	07.12.2014	December	2014	Komba Forest, clear and rocky forest stream in Komba Forest	1847		7.30803°N	36.12201°E	collection
Zosteraeschna ellioti			1887	Scioa Ghimira			6.9666667	35.7666667°E	literature
Zygonyx natalensis	17.03.2004	March	2004	Gordomo-Masha, Baro River, 30 km S of Gore	1630		7.87622°N	35.4788°E	collection
Zygonyx natalensis	21.03.2004	March	2004	Meta, 35 km E, Borkana River	1288		8.37094°N	35.88472°E	collection
Zygonyx torridus	05.12.2014	December	2014	Awurada Valley, Gummi River, large river	1293		7.09281°N	36.23154°E	observation

Table 6: Current status of the study areas at the Kafa BR

Study areas	Habitat/forest type	Degree of habitat degradation	Main observed threats	Taxonomic group or species indicating good conditions
Bamboo Forests (BA)	Streams in bamboo	Little to none	None	*Notogomphus cottarelli*
Boka Forests (BK)	Wetlands beyond BK Forest	Little (grazing by livestock resembles grazing by game in former times)	Ongoing deforestation along the stream	*Notogomphus ruppelli, Pseudagrion guichardi*
Komba forests	Clear river in forest/ secondary forest	Selective logging, water pollution (washing of clothes, people and vehicles in river)	Water pollution, selective logging	*Atoconeura aethiopica, Pseudagrion guichardi-*
Awurada valley	Floodplain	Considerable	Clear cutting of the understory and heavy poaching	*Gynacantha nigeriensis*
Alemgono	Wetlands	Large	Heavy grazing	none
Shoriri (SHO)	Undisturbed wetlands	little	Little grazing	*Notogomphus cottarelli*
Mankira (MA)				
Gojeb Wetlands (GO-wet)	Wetlands	Low	Grazing	
Gojeb River (GO-riv)				
Boginda (BO)	Forest	Medium	Selective logging	

Taxonomic group or species indicating poor conditions	Proposed indicator species	Proposed conservation measures for indicator species	Proposed monitoring for indicator species
None	*Notogomphus cottarelli*	Do not disturb	Larvae sampling (high densities in stream), observation of adults (potentially seasonal)
None	*Notogomphus ruppelli, Pseudagrion guichardi*	Do not enlarge open areas	Observation of adults
Many army ants	*Atoconeura aethiopica, Pseudagrion guichardi*	Water sanitation (raising awareness, washing areas should be further away from the river)	Observation of adults
Many army ants	*Gynacantha nigeriensis*	Stop poaching and understorey clear cutting	Observation of adults
A lot of widespread openland species	none	Do not increase grazing intensity	
		Leave as it is, perhaps extensive grazing could help retain high habitat diversity	
		Leave a broad riparian forest area along the river – no selective logging, clear cutting, fire or poaching	
High number of army ants		Stop selective logging, poaching and any other encroachment	

7.2. Photos

7.2.1 Sampling methods

Figure 5: Collecting dragonflies (here the Red-veined Dropwing, *Trithemis arteriosa*) in the Shoriri Wetlands (photo: Viola Clausnitzer)

7.2.2 Sampled habitats

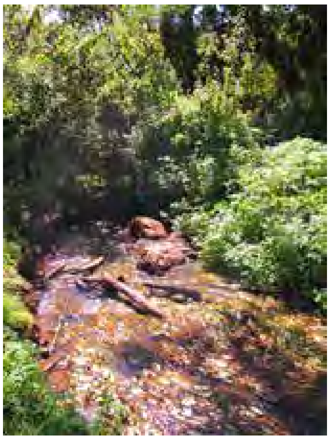

Figure 6a: Forest stream in Boka Forest. This stream is populated by the Ethiopian Sprite (*Pseudagrion guichardi*) and Rüppell's Longlegs (*Notogomphus ruppeli*), both endemic to the southern Ethiopian highlands (photo: Viola Clausnitzer)

Figure 6b: Valley below Boka Forest (in the background), swampy areas are home to the endemic Ethiopian Skimmer (*Orthetrum kristenseni*) (photo: Viola Clausnitzer)

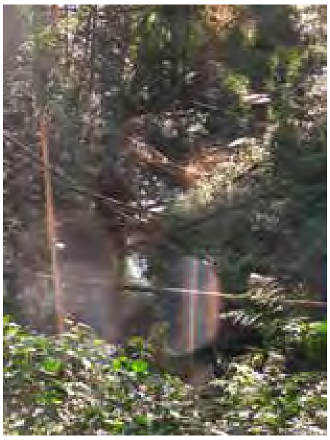

Figure 6c: Stream in the Bamboo Forest, where many larvae of the endemic Cottarelli's Longlegs (*Notogomphus cottarellii*) were found (photo: Viola Clausnitzer)

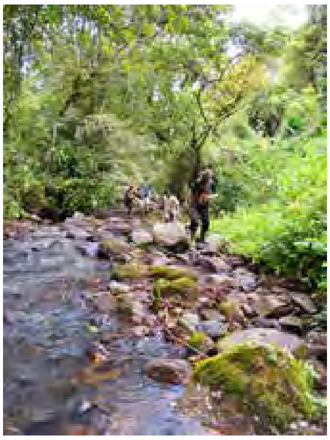

Figure 6d: Stream in Komba Forest with a good population of the Ethiopian Highlander (*Atoconeura aethiopica*) (photo: Viola Clausnitzer)

7.2.3 Species suggested for flagship and monitoring species

Figure 7a: The endemic Ethiopian Sprite (*Pseudagrion guichardi*), Boka. Suggested as a flagship and monitoring species (photo: Viola Clausnitzer)

Figure 7b: The endemic Cottarelli's Longlegs (*Notogomphus ruppeli*), Boka. Suggested as a flagship and monitoring species (photo: Viola Clausnitzer)

Figure 7c: The endemic Rüppell's Longlegs (*Notogomphus ruppeli*), Boka. Suggested as a flagship and monitoring species (photo: Viola Clausnitzer)

Figure 7d: The Ethiopian Highlander (*Atoconeura aethiopica*), Komba Forest (photo: Viola Clausnitzer)

Figure 7e: The Ethiopian Skimmer (*Orthetrum kristenseni*), Boginda. A widespread and common species in Ethiopia's highlands which would serve as a good flagship species for water quality (photo: Viola Clausnitzer)

7.2.3 Evidence of human encroachment into the core zone

Figure 8a: Awurada Floodplain: poached forest pig (5/12/2014) (photo: Viola Clausnitzer)

Figure 8b: Awurada Floodplain: understorey clearing for poaching? (5/12/2014) (photo: Viola Clausnitzer)

Figure 8c: Awurada Floodplain: poachers' fire (5/12/2014) (photo: Viola Clausnitzer)

Figure 8d: Boginda Forest: selective logging (11/12/2014) (photo: Viola Clausnitzer)

Figure 8e: Boginda Forest: small clearings, probably for beekeeping (11/12/2014) (photo: Viola Clausnitzer)

Figure 8f: Komba Forest: selective logging (7/12/2014) (photo: Viola Clausnitzer)

Figure 8g: Boginda forests: selective logging (photo: Viola Clausnitzer)

Figure 8h: Boginda forests: selective logging (photo: Viola Clausnitzer)

Figure 8i: Komba forest (core zone): selective logging (photo: Viola Clausnitzer)

Herpetofauna (Amphibia, Reptilia) at the Kafa Biosphere Reserve

Tom Kirschey

Highlights

→ A total of 17 amphibian species from four families were recorded (Table 2).

→ A total of five squamate reptile species (two Sauria, three Serpentes) from four families were recorded (Table 3).

→ One species of Hyperoliidae (genus *Leptopelis*) is probably new to science.

→ Eight species of amphibians and two species of reptiles were recorded the first time for the Kafa BR (Amphibia: *Leptopelis ragazzii*, *Leptopelis* sp., *Hyperolius kivuensis*, *Phrynobatrachus inexpectatus*, *Ptychadena schillukorum*, *P. erlangeri*, *P. mascareniensis*, *Xenopus clivii*, Reptilia: *Trachylepis wingatii*, *Megatyphlops brevis*).

→ Six (perhaps seven) of the recorded amphibian species are endemic to the Ethiopian Highlands (*Leptopelis ragazzii*, *L. vannutellii*, *L.* spec., *Afrixalus clarkeorum*, *A. enseticola*, *Phrynobatrachus inexpectatus*, *Ptychadena erlangeri*).

→ One of the recorded reptile species is endemic to the southwestern Ethiopian Highlands (*Pseudoboodon boehmei*).

→ Three species are threatened according to the updated global IUCN Red List of Threatened Species (two ‘vulnerable’, one ‘endangered’: *Leptopelis ragazzii*, *Afrixalus clarkeorum*, *A. enseticola*). All three are endemic to Ethiopia. Another species (*Leptopelis vannutellii*) was previously listed as ‘vulnerable’, but has been redesignated as ‘least concern’.

→ Beccari’s giant frog (*Conraua beccarii*), Largen’s dwarf puddle frog (*Phrynobatrachus inexpectatus*) and Clarke’s banana frog (*Afrixalus clarkeorum*) are flagship species for amphibians.

→ This report includes the first picture of the tadpole mouthpart of the previously undescribed and highly rheophile Beccari’s giant frog (*Conraua beccarii*).

→ Wetland sites, particularly inside or near the natural forest, show the highest level of diversity. The lowest diversity is found in the bamboo forest.

→ Arboreal and running water habitats require more research.

→ Endemic species are exclusively bound to forest habitats (canopy).

1. Introduction

According to Kingdon (1990) there are four major centres of endemism in Africa: the Cape flora, the moist coasts flora and fauna, the arid zone flora and fauna and the mountain flora and fauna. In Eastern Africa, the Afromontane ecosystems show an exceptionally high degree of endemism. For example, the degree of endemism among frogs in Ethiopia is 40%. This is largely due to the vast highlands being isolated by the surrounding dry lowlands. Biogeographically, there are several different speciation centres between the two vertebrate classes within Ethiopia. There are several provinces within the so-called "Intertropical Montane Region"[1] , of which the Ethiopian Highlands form the largest Afromontane area. The Ethiopian Intertropical Montane Region and the rest of tropical Africa tend to only share the most versatile and mobile species. These are mainly montane species. Most of Ethiopia's endemic species also belong to the Afrotropical Highlands biome (Kingdon 1990). The most comprehensive and up-to-date overview of Ethiopian herpetofauna is provided by Largen & Spawls (2010). Mazuch (2013) focuses on the Eastern Ethiopian regions, where savanna and other Afromontane dryland habitats predominate.

[1] The term "intertropical" is not used in the cartographic sense, but describes the mountainous areas in the Tropics which are not tropical according to climatic criteria (see Poynton 1999).

More than 30 amphibian and reptile species new to science have been described from Ethiopia (and Eritrea) since 1970, indicating that knowledge of Ethiopian herpetofauna has improved substantially in recent decades; however, apart from the taxonomical identification of species, very little is known about the distribution, biology and ecology of a significant portion of the known taxa. Thus there is still huge potential for new distribution records and discovery of new species.

In spring 2015, another survey was conducted by a Russian and Kazakh team (Milto et al. 2015), confirming several records and observing some species which were not detected in the biodiversity assessment. This report does not include the analysis of all the collected material, e.g., most tadpoles from the genus *Ptychadena* still need to be analysed, and their microhabitat data has not been sufficiently processed. The preserved collection material is split between the Ethiopian Biodiversity Institute (EBI) and the Alexander Koenig Zoological Research Museum (ZFMK) in Bonn and could be used for further research. The author is grateful to the EBI for research and export permits for samples, which allowed species to be identified. The survey likely only covered a range of herpetofaunal diversity in the Kafa BR (especially for reptiles). During the rainy season, the detectability of nearly all species should increase significantly.

2. Materials and Methods

2.1 Study area

Amphibians and reptiles were recorded at different study sites according to the project's needs: core zones, Participatory Forest Management (PFM) sites and wetlands (Tab. 1). Our Wetland Taxagroups Team consisted of Dr Viola Clausnitzer, collecting dragonflies and damselfies, Thies Geertz, collecting land and freshwater molluscs, and the field assistants Tizita Tamiru, Mitiku Gebremariam and Admasu Asefa. The sample sites were usually selected based on the presence of aquatic habitats (streams, rivers, headwaters, swamps, etc.). This report contains one species which was not seen personally but for which there is photographic evidence.

2.2 Sampling methods

Visual encounter surveys (VESs) are primarily used to inventory the presence of taxa at particular sites. Visual and auditory sampling of adult and subadult/juvenile animals at the sample sites, including tadpole sampling, was conducted with bare hands, snake hooks and a sweep net. With minor modifications, our methods followed contemporary standard methods for sampling reptiles (McDiarmid et al. 2012) and amphibians (Heyer et al. 1994; Olson et al. 1997). The time of year (dry season) was not ideal for surveying herpetofauna. The weather (full sunshine, no rain at all) also made the search for herpetofauna difficult. The sampling was conducted between 5 am and 9 pm. It was highly

Table 1: Sample localities. KBR zone: cz: core zone, bz: buffer zone, ccz: candidate core zone. The number of species recorded at each locality is given. All dates are for December 2014.

Area	Site	KBR	PFM	Code	Date	Habitat	Alt.	Lat.	Long.
Bonga	Bonga	-	-	BG1	03.12.	Small stream behind KDA Guesthouse	1832	7.25420°N	36.25762°E
Bonga	Bonga	-	-	BG2	03.12.	Hill behind KDA Guest-house	1980	7.25358°N	36.22633°E
Bonga	Bonga	-	-	BG3	entire period	KDA Guesthouse area	1955	7.24235°N	36.24090°E
Boka	Boka	cr	-	BK1	04.12.	Stream in wetland below Boka Forest	2414	7.29467°N	36.37604°E
Boka	Boka	cr	-	BK2	04.12.	Swamp along stream below Boka Forest	2414	7.29467°N	36.37604°E
Bamboo	Bamboo	cr	-	BA1	04.12.	River in bamboo forest	2595	7.24118°N	36.45182°E
Bamboo	Bamboo	cr	-	BA2	04.12.	River in bamboo forest	2650	7.24331°N	36.49564°E
Bonga	Awurada Valley	cr	Yes	AW1	05.12.	Gummi River, large river	1293	7.09281°N	36.23154°E
Bonga	Awurada Valley	cr	Yes	AW2	05.12.	Floodplain (swampy forest) along Gummi River	1293	7.09281°N	36.23154°E
Bonga	Alemgono	bz	-	AG	06.12.	Wetland, heavily grazed	1706	7.36428°N	36.22602°E
Bonga	Shoriri	bz	Yes	SHO1	06.12.	Wetland, undisturbed	1626	7.35707°N	36.20437°E
Bonga	Shoriri	bz	Yes	SHO2	06.12.	Stream along forest edge and Shoriri Wetlands	1626	7.35707°N	36.20437°E
Komba	Komba Forest	cz	-	KO1	07.12.	Clear stream in Komba Forest	1847	7.30803°N	36.12201°E
Komba	Komba Forest	-	-	KO2	06.12.	Forest edge	1900	7.10176°N	36.13277°E
Boginda	Gojeb Wetlands	ccz	-	GO-wet1	09.12.	Large river			
Boginda	Gojeb Wetlands	ccz	-	GO-wet2	09.12.	Gallery forest and wetlands along Gojeb River	1530	7.55448°N	36.05687°E
Boginda	Gojeb Wetlands	bz	-	GO-wet3	10.12.	Swampy floodplain north of Gojeb	1516	7.55444°N	36.05209°E
Boginda	Gojeb Wetlands	ccz	-	GO-wet4	10.12.	Stream in floodplain south of Gojeb	1518	7.55442°N	36.05213°E
Boginda	Boginda Forest	cz	-	BO	11.12.	Stream with swamps in Bo-ginda Forest, partly open (grazed glades)	2074	7.50175°N	36.09118°E

valuable that supplementary bycatches, mostly from the Wetland Taxagroups Team, especially by Dr Viola Clausnitzer and Thies Geertz, were available for this assessment. The daytime survey was suboptimal but necessary because of logistic limitations (drivers who were used to working during the day were unable and unwilling to work at night). In addition, the entire expedition group reported herpetofauna roadkill, and several samples were collected at roads between the study sites (incidental road riding, no dedicated road riding), which proved highly valuable for the report, especially for the reptile sample.

For amphibians, forensic *Batrachochytrium dendrobatidis* (Bd) samples were taken from most specimens. The prevalence analysis is still unfinished. Knowledge about the prevalence and impact of Bd on species has important conservation implications, as the fungus has brought several amphibian taxa to extinction worldwide and has been classified as one of the major threats to worldwide amphibian populations.

2.3 Nomenclature and data analysis

Except for using the scincid genus name *Trachylepis* (instead of *Mabuya*) for both *maculilabris* and *wingatii*, the nomenclature follows Largen & Spawls (2010), but uncertainties in the taxonomic status of several taxa remain and are further described below. Data on the presence/absence of species were insufficient for a more detailed analysis of the sample sites, but clustering them allowed a gradient of forest cover and site occupancy of some wetland complexes to be demonstrated.

3. Results and Discussion

A total of 22 species (17 amphibians, five reptiles) was recorded. Eight species of amphibians and two species of reptiles were recorded the first time at the Kafa BR (Amphibia: *Leptopelis ragazzii*, *Leptopelis* sp., *Hyperolius kivuensis*, *Phrynobatrachus inexpectatus*, *Ptychadena schillukorum*, *P. erlangeri*, *P. mascareniensis*, *Xenopus clivii*, Reptilia: *Trachylepis wingatii*, *Megatyphlops brevis*).

3.1 Amphibia

Of the 65 Amphibia species recorded in Ethiopia, these records only represent 26.2%. Excluding species with strong geographic restrictions in other parts of Ethiopia and considering methodological problems such as weather and season, this is a remarkably good result; however, it also has several notable gaps, e.g., not a single Bufonid was recorded. Local villagers and guides have affirmed that the Aleku caecilian (*Sylvacaecilia grandisonae*) occurs in the area and is found frequently in gardens and agricultural land, but the species was not found during our assessment. We were also unable to record shovel-nosed frogs from the genus Hemisus or the foam-nest building Keller's frog (*Chiromantis kelleri*), both of which are said to occur in the area. In Bonga City, local traders apparently offer frogs for consumption, but the author was unable to find any. Table 2 shows all recorded amphibian species. The endemic species which are newly recorded in the Kafa BR and threatened species according to IUCN Red List are described further below.

Table 2: Recorded amphibian species

No.	Species	Family	Status
01	*Leptopelis ragazzii*, Boulenger 1896	Arthroleptidae	VU, endemic, new record for Kafa BR
02	*Leptopelis vannutellii*, Boulenger 1898	Arthroleptidae	Reclassified from VU to LC, endemic
03	*Leptopelis* sp.	Arthroleptidae	?, new record for Kafa BR
04	*Hyperolius viridiflavus*, Duméril & Bibron 1841	Hyperoliidae	LC
05	*Hyperolius kivuensis*, Ahl 1931	Hyperoliidae	LC, new record for Kafa BR
06	*Hyperolius nasutus*, Günther 1864	Hyperoliidae	LC
07	*Afrixalus clarkeorum*, Largen 1974	Hyperoliidae	Reclassified from VU to EN, endemic
08	*Afrixalus enseticola*, Largen 1974	Hyperoliidae	VU, endemic
09	*Conraua beccarii*, Boulenger 1911	Ranidae	LC
10	*Phrynobatrachus minutus*, Boulenger 1895	Ranidae	LC
11	*Phrynobatrachus inexpectatus*, Largen 2001	Ranidae	LC, endemic, new record for Kafa BR
12	*Phrynobatrachus natalensis*, Smith 1849	Ranidae	LC
13	*Ptychadena erlangeri*, Ahl 1924	Ranidae	LC, endemic, new record for Kafa BR
14	*Ptychadena schillukorum*, Werner 1907	Ranidae	LC, new record for Kafa BR
15	*Ptychadena mascareniensis*, Duméril & Bibron 1841	Ranidae	LC, new record for Kafa BR
16	*Ptychadena neumanni*, Ahl 1924	Ranidae	LC
17	*Xenopus clivii*, Peracca 1898	Pipidae	LC, new record for Kafa BR

3.1.1 Arthroleptidae

Ragazzi's tree frog or the Shoa Forest tree frog (*Leptopelis ragazzii*) was not seen as an adult during the survey, but could be identified in the form of tadpoles. This underlines the value of combined methods (searches for both terrestrial stages and larval aquatic stages). It is endemic to the Ethiopian Mountains and strictly bound to forests at elevations of about 1900 to 3100 m a.s.l. Massive deforestation in Ethiopia has destroyed suitable habitats, and some previously identified populations are declining or have been already become extinct. Thus it has been listed as 'vulnerable' (IUCN SSC 2013) on the IUCN Red List. It is also one of the species which was recently detected as a Bd host (Gower et al. 2012), but its impact is still unknown. The taxonomic status of this species is still a matter for discussion. Recent molecular data suggest that *L. ragazzii* comprises two or more distinct taxa. Remarkably, this is the first record of this species south of the Gojeb River and west of the Omo River. This species was also confirmed by Milto et al. (2015) as occurring at the Barta Waterfall, Barta River and in Mankira Forest.

A single female specimen of the Dime forest tree frog, or Vannutelli's tree frog (*Leptopelis vannutellii*), was discovered on a leaf in the garden of the KDA Guesthouse. *L. vannutellii* is also a prevalent species for Bd (see Gower et al. 2012). Its occurrence has been previously confirmed in the Kafa BR (pers. comm. S. Loader 2012, cited in IUCN SSC 2013) and subsequently found by Milto et al. (2015) in the Alemgono Wetlands. A photograph by Bianca Schlegel at the Alemgono Wetlands confirms the presence of the species there. Unfortunately, the specimen collected during the expedition escaped after being photographed and could not be recaptured.

L. ragazzii is endemic to Ethiopian Highland forests, and was previously classified as 'vulnerable' due to its limited known range and its vulnerability to deforestation. Nowadays it is classified as 'least concern' on the IUCN Red List (IUCN SSC 2013), a classification which the author disagrees with. No major new data on the distribution and status of recorded subpopulations was assessed, and it has been proven to be a strictly forest-bound species. Habitat loss due to forest clearance, human settlement, and both small- and large-scale agricultural encroachment puts a heavy and continued pressure on known populations.

The most exciting finding was a single tree frog specimen, which was distinguished as an Arthroleptidae by its size and appearance. It probably belongs to the genus *Leptopelis*, but some characteristics (especially the very special dorsal ornamental skin sculpturation and colour patterns) do not fit any of the species mentioned above, nor do they match *L. bocagii*, *L. gramineus* or *L. susanae*. It was found in the Boka Forest Wetlands on the very last day of the survey. In email correspondence with several colleagues (including Stephen Spawls) the author learnt that this type of tree frog had never been seen before, and probably represents an undescribed taxon. It is likely that this taxon is also endemic, because most of the people contacted for identification are experienced at least with Eastern African and especially with Afromontane amphibians. Unfortunately, as with the *L. vannutellii* specimen, the tree frog escaped after the picture was taken. Therefore, the author expresses his considerable interest in continuing the search for this frog.

The tadpole samples from the Boka Forest Wetlands also contained one species which could not be identified, but samples were taken and stored in ZFMK. So it is hoped that the tadpole from this species was found and it might be possible to characterise it both morphologically also using molecular methods.

3.1.2 Hyperoliidae

Clarke's banana frog (*Afrixalus clarkeorum*) is an endemic only known from moist tropical forest in southwestern Ethiopia (Largen 1974). According to Largen and Spawls (2010), the preferred terrestrial microhabitat of this species is the leaf axils of Ensete ventricosum plants found in forest clearings and tall grasses and reeds in recently flooded hollows at the edge of the forest. As an arboreal species, it is naturally bound to forests. Because the emendation by Largen (2001) is not accepted or described as "unjustified" by some databases, it is often named *Afrixalus clarkei*, e.g., in the IUCN Red List, where it is listed as 'endangered'. This species was found in or near BK2 and SHO1, but only in higher vegetation (bushes and shrubs). Deforestation and overgrazing by cattle seem to have a strong impact on this species, as it was not found in the intensively used Alemgono and Gojeb Wetlands. Milto et al. (2015) also managed to find this species in the Gojeb Wetlands, in the gallery riparian forest remnants near one of the small rivers. It was recently detected as a Bd host (Gower et al. 2012), but its impact on this species is still unknown.

The Ethiopian banana frog (*Afrixalus enseticola*) is another endemic of the Ethiopian Highland forests, but it also occurs in and around the Bale Mountains National Park on the other side of the Rift Valley. It was also described by Malcom Largen in 1974. The species is characterized as essentially sylvicolous, and all known breeding sites are in or close to forest glades. Its microhabitat is similar to that of *Afrixalus clarkeorum*. Both species exhibit site sympatry and syntopy. This supports the theory that they are distinct taxa and further research is necessary to define each species' ecological niche.

One of the species was recently detected as a Bd host (Gower et al. 2012), but its impact is still unknown. Because of its larger known distribution, it is listed as 'vulnerable' on the IUCN Red List. *A. enseticola* was found in the Boka Forest Wetlands, Alemgono and Shoriri Wetlands and in the Gojeb Wetlands. In the Gojeb Wetlands, it was found during daytime in the higher shrub and tree vegetation of the riparian galleries, but at night, numerous specimens were observed sitting on highly overgrazed wet meadows in small (300 mm high) shrubs. It was confirmed by Milto et al. (2015) to occur in the Alemgono Wetlands and was also found near Barta Waterfall.

Records for the Lake Kivu reed frog (*Hyperolius kivuensis*) were not expected in Kafa BR, as this was only the third record for this species in Ethiopia and was also approximately 100 km away from the known localities at the very southwestern edge of the country. Our occurrence data represent a huge extension of the most northeasterly part of its distribution range. It was only found in the Gojeb Wetlands and was confirmed by Milto et al. (2015) for the same locality.

The long-snouted reed frog (*Hyperolius nasutus* s.l.) and the variable reed frog (*Hyperolius viridiflavus* s.l.) are two abundant Hyperoliid species found at nearly all sample sites.

3.1.3 Ranidae

Beccari's giant frog (*Conraua beccarii*) was another species only recorded as a tadpole, which again shows the importance of tadpole searches to complete a site inventory. This was challenging, as there is no description of larval characteristics in literature to date (see Channing et al. 2012), even though this species has a very recognisable tadpole. The author was grateful to Mark-Oliver Rödel, from the Berlin Natural History Museum, who helped with the determination of the tadpole. Because of its highly rheophilous larval preference, and because it is reported to be eaten by the locals (which could lead to overexploitation of its natural population), it is proposed as a good indicator species for water quality, deforestation (which leads to unsuitable water temperatures) and the sustainable use of natural resources. Tadpoles of Beccari's giant frog were found in the Komba Forest stream and Bamboo Forest stream. This species ought to be distributed much more widely in the area, as Milto et al. (2015) reported it for several localities including a river near the KDA Guesthouse in Bonga, Barta Waterfall, God's Bridge and a river in Mankira Forest.

Largen's dwarf puddle frog (*Phrynobatrachus inexpectatus*) was described by Malcom Largen in 2001. It is an Ethiopian mountain endemic, which was previously only known from the terrain typical near Bore at 2650 m a.s.l. and a second population near Dorse in the margins of pools surrounded by *Schefflera-Hagenia* forests. It was found in sympatry with *P. minutus* in the Boka Forest Wetlands and Shorori Wetlands. These records are remarkable because they are the first from the west of Rift Valley and approximately 100 km northwest of the known distribution records near Arba Minch. Both of the other two *Phrynobatrachus* species – *P. natalensis* and *P. minutus* – were also recorded in the Kafa BR. Interestingly, *P. inexpectatus* was found in high abundance in a very special microhabitat, the headwaters mire formed by liverworts in the Boka Forest Wetlands on a site smaller than a hectare. A limited number of Ethiopian dwarf puddle frogs (*Phrynobatrachus minutus*) were recorded in this particular microhabitat. They seemed more abundant in reeds or near the small waterbodies, including the shores of the river itself. *P. minutus* was the predominant puddle frog in all the other wetland and forest sites, except for the Gojeb Wetlands, where *P. natalensis* predominated.

3.1.4 Pipidae

We recorded Peracca's clawed frog (*Xenopus clivii*) for the first time in Kafa BR, though this cannot be classified as a range extension due to the lack of previous distribution data.

3.2 Reptilia

Of the 214 reptile species known to occur in Ethiopia, only four were observed during the survey, plus one other determined based on a photograph taken by a member of the expedition. These five species represent only 2.34% of Ethiopian reptile fauna and 5.49% of the expected reptile diversity of the KBR. The paucity of results was mainly due to the season and the limited timeframe, but also because the study did not include any savanna and dryland habitats. In addition, several species seem to aestivate during the dry season.

The speckle-lipped skink (*Trachylepis maculilabris*) reaches the northwestern border of its range in Ethiopia. It inhabits a great variety of habitats, from urban areas to pristine natural habitats. It was found in relatively high abundance, including around the KDA Guesthouse by rocks and walls, near bushes and shrubs and on roofs. We also found several specimens in Boginda Forest, Awurada Valley and on riparian palm trees in the Gojeb Wetlands. A single specimen of Wingate's skink (*Trachylepis wingatii*) was recorded in the Boka Forest Wetlands, in relatively dry grassland at the edge of the forest. However, this does not seem to reflect a habitat preference, as it is known to inhabit a broad variety of habitats, from forest clearings to moist savanna (Largen & Spawls 2010). Böhme's Ethiopian snake (*Pseudoboodon boehmei*) was found by the mammal team as a single roadkill specimen on the road heading north to the bamboo forest east of Bonga.

Table 3: Recorded reptilian species

No.	Species	Family	Status
01	*Trachylepis maculilabris*, Gray 1845	Scincidae	LC
02	*Trachylepis wingatii*, Werner 1907	Scincidae	LC, new record for Kafa BR
03	*Pseudoboodon boehmei*, Rasmussen & Largen 1992	Colubridae	Endemic
04	*Megatyphlops brevis*, Scortecci 1929	Typhlopidae	LC, new record for Kafa BR
05	*Naja melanoleuca*, Hallowell 1857	Elapidae	LC

The habitat this road crosses is characterised by intact forest with dense canopy. The Somali giant blind snake (*Megatyphlops brevis*) was found as a roadkill specimen on the road crossing the Gojeb Wetlands. This was the first report of this species for the Kafa BR.

The forest cobra (*Naja melanoleuca*) is the only species mentioned as a proper record in this report, although it was not seen by the author. It was determined with full certainty from a mobile phone picture taken by a member of the expedition. It was spotted crossing a small river to the Gojeb Wetlands, while the ichthyology team was capturing fish. According to Largen & Spawls (2010), it should be common in southwestern Ethiopia.

4. Conclusions and Recommendations for Conservation and Monitoring

Deforestation and environmental degradation due to human disturbance, along with a drastic increase in water pollution due to economic growth, even in remote areas, pose a major threat to Ethiopia's environmental wealth. With few exceptions, the natural landscape has been turned into agricultural land. Around 95% of Ethiopia's original forest has already been lost to agriculture and human settlements.

Most Ethiopian Highlands forest endemics are extremely sensitive to changes in their habitat. Endemic species which require forested and clear rocky streams or rivers, such as Ragazzi's tree frog, Clarke's banana frog, the Ethiopian banana frog, the Ethiopian dwarf puddle frog and Largen's Dwarf puddle frog are a conservation concern and can act as monitoring species for the core zones of the Biosphere Reserve. Unfortunately, the survey did not find some of the expected charismatic species such as the Ethiopian mountain adder (*Bitis parviocula*), and they therefore cannot be suggested as flagship species. Because they are easy to recognize and endemic to the montane habitats, only tree frogs such as *Leptopelis ragazzii*, *Leptopelis vannutellii* or the two banana frog species of the genus *Afrixalus* can act as flagship species for the Kafa BR. The more abundant and widely distributed species often are relatively tolerant to habitat disturbance. But even species quite adaptable to altered landscapes, such as Baccari's giant frog or the Natal dwarf puddle frog, will disappear with the ongoing loss of their habitats due to water pollution, water extraction and large scale reforestation with eucalyptus and pine trees.

The wetlands have thus far been neglected in the Kafa BR zonation. A protected zone should be established covering the huge wetlands of the Gojeb River as well as the wetlands in the Afroalpine zone, e.g., beyond Boka Forest.

4.1 Conserving, restoring and monitoring wetlands: the global challenge for the 21st century

Globally, freshwater habitats are being disturbed, polluted and destroyed at an alarming rate. Access to clean water is essential to human health, with the United Nations declaring it a fundamental human right in 2010. Freshwater habitats are some of the most threatened ecosystems globally. They containing 10% of all known species in an area making up just 1% of the Earth's surface, and provide ecosystem services valued at several trillion USD per year (Butchart et al. 2005). More than half of the earth's wetlands have been degraded, and more than two-thirds of our upland watersheds remain unprotected. In general, protection for terrestrial ecosystems is much better than for wetlands, because conservation efforts mainly focus on large terrestrial mammals. Wetlands and their associated watersheds provide valuable ecosystem services such as water catchment, retention and purification, provide habitats for a large range of specialised flora and fauna and serve as important longitudinal and transversal corridors for dispersal of biota. Freshwater ecosystems and freshwater biodiversity are in great peril,

Table 4: Species suggested as monitoring and flagship species

Species	Endemic	Red List	Monitoring species	Flagship species
Leptopelis ragazzii	Yes	VU	Yes	Yes
Leptopelis vannutellii	Yes		Yes	Yes
Leptopelis sp.	?	-	?	?
Afrixalus clarkeorum	Yes	EN	Yes	Yes
Afrixalus enseticola	Yes	VU	Yes	Yes
Conraua beccarii	No		Yes	No
Phrynobatrachus minutus	Yes		Yes	No
Phrynobatrachus inexpectatus	Yes		Yes	No
Ptychadena erlangeri	Yes		No	No
Pseudoboodon boehmei	Yes		No	No

and urgent measures are needed. Wetlands need to be protected, and their status must be monitored. This is especially true for countries like Ethiopia, where the economy is growing despite water sanitation being virtually non-existent, vastly increasing the pollution and destruction of wetlands and their ecosystem services.

Amphibians and reptiles are among the most threatened taxa groups worldwide. Because of their joint aquatic and terrestrial ecology, amphibians in general are good indicators for freshwater and terrestrial habitats. The Kafa BR is one of the last remnants of Afromontane forest in Ethiopia, and only stronger conservation efforts for the cluster of wetlands and forests can secure favourable conservation status of endemic and typical herpetofauna assemblages.

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6. Appendix

6.1. Photos

Figure 1: *Leptopelis ragazzii* tadpole mouthpart, 1st anterior labial tooth row not visible, Komba Forest (photo: Tom Kirschey)

Figure 2: *Leptopelis vannutellii*, KDA Guesthouse, Bonga (photo: Tom Kirschey)

Figure 3: *Leptopelis* spec., Boka Forest Wetlands (photo: Tom Kirschey)

Figure 4: *Leptopelis* spec., Boka Forest Wetlands (photo: Tom Kirschey)

Figure 5: *Hyperolius kivuensis*, Gojeb Wetlands (photo: Tom Kirschey)

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Bats and fruit bats at the Kafa Biosphere Reserve

Ingrid Kaipf, Hartmut Rudolphi and Holger Meinig

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 broadband 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 epauletted 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 pesticides. 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.

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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				KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplant.	Forest fragment	River	Meadow, Coffee plant	God's Bridge	Bonga
Pteropodidae/ fruit bats											
	Hammer-headed fruit bat	*Hypsignathus monstrosus*			x[2]						
	Peters' dwarf epaulletted 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*								x^2	
	African trident bat	*Triaenops afer*					x^2	x^2	x^1		
Megadermatidea											
	Heart-nosed bat	*Cardioderma cor*						x^2			
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*						x^2			
	Pale free-tailed bat	*Chaerephon chapini*	x^3					x^1			
		T 15/16 [*Ch. nigeriae*]	x					x			
		T 17/18 [*Ch. ansorgei*]	x								
	African giant free-tailed bat	*Tadarida ventralis*	x^2			x^2					x^2
		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*)			x^1						
Rhinolophidae											
	Geoffroy's Horseshoe bat	*Rhinolophus clivosus a.*	x^1					x^2	x^2		
	???	**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				KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplant.	Forest fragment	River	Meadow, Coffee plant	God's Bridge	Bonga
Vespertilionidae											
		Pip 50/52 [*Pipistrellus hesperidus*]					x	x		x	x
	Banana Pipistrelle	*Pipistrellus nanus/N. nana*					x^2	x^2	x^2		x^2
		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)

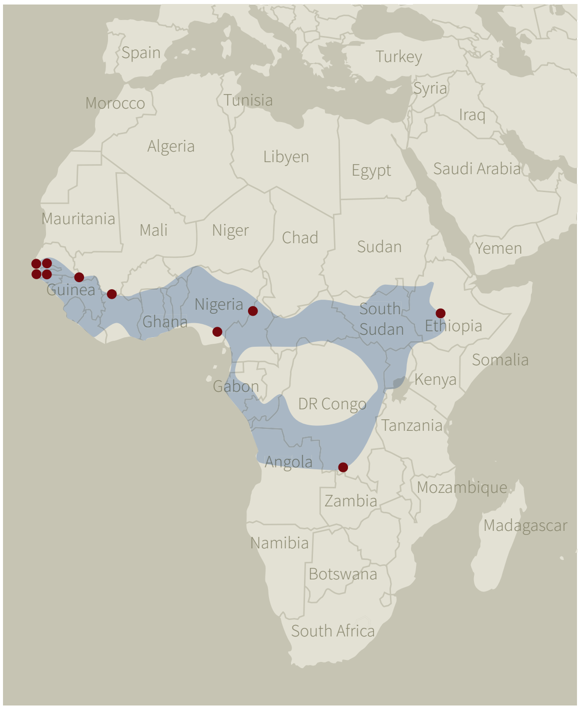
6.3. Confirmed fruit bat species and their distribution

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

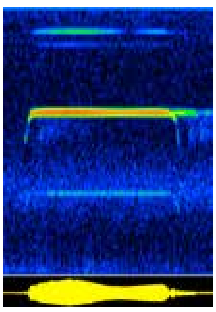
Figure 18: (photo: Holger Meinig)

Echolocation

Sonagramm: (sound intensity color coded)

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

150 kHZ



0 kHZ

African trident bat

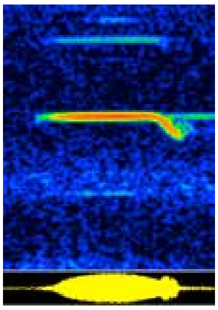
Triaenops afer

Captured at: Gojeb Wetland

Figure 19: (photo: Ingrid Kaipf)

Echolocation

150 kHZ



0 kHZ

Short cf signal
86 kHz female/
76 kHz male

Sound duration 8 ms

Chapin's free-tailed bat

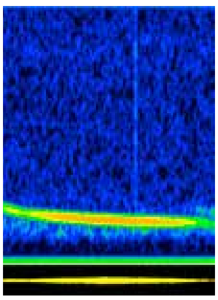
Chaerephon chapini

Captured at: Gojeb Wetland

Figure 20: (photo: Holger Meinig)

Echolocation

150 kHZ



0 kHZ

Long quasi-cf calls
end-freq. 20 kHz

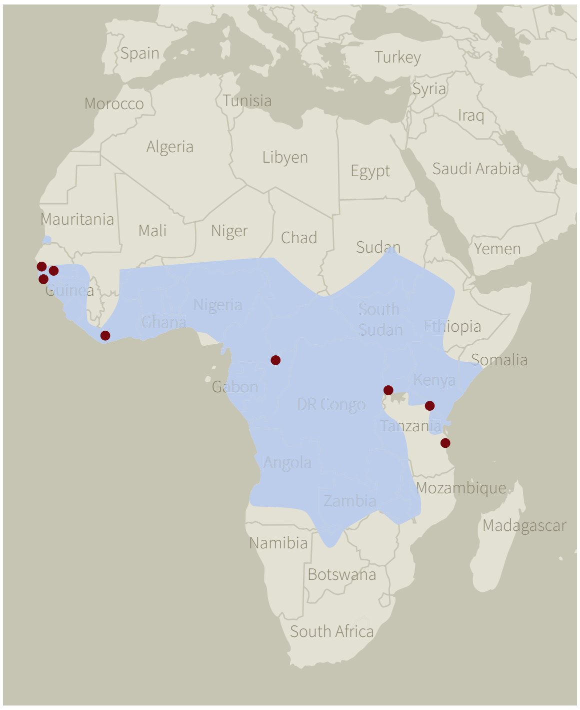
Sound duration 8 ms

Nycteridae

Nycteris hispida

Location: Alemgono Wetland, Gummi River

Figure 21: (photo: Ingrid Kaipf)



Pipistrellus / *Neoromica* sp. 1

Species not confirmed yet

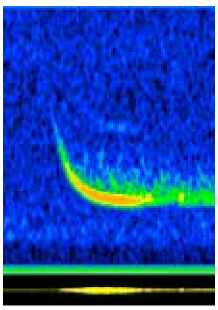
Captured at: Bamboo forest

Figure 22: (photo: Holger Meinig)

Echolocation

fm cf call, cf
frequency 39 kHz

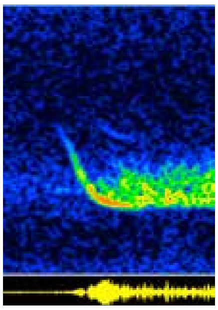
Sound duration 4.5 ms



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

Figure 23: (photo: Holger Meinig)

150 kHZ



0 kHZ

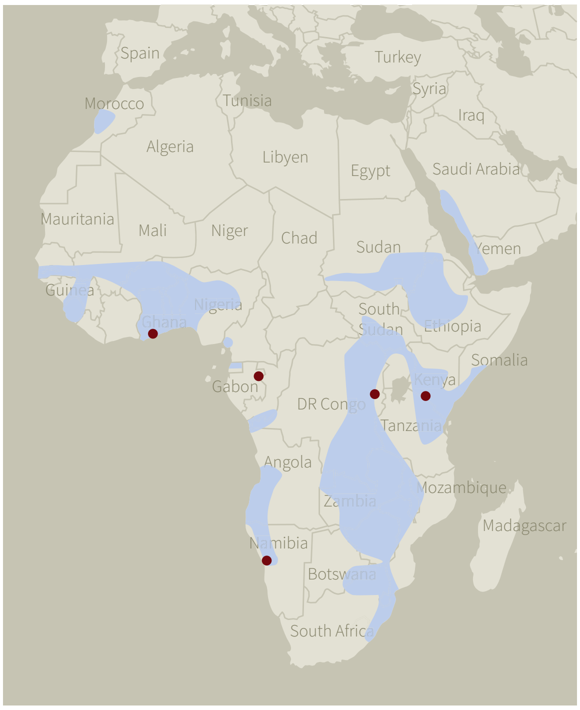
Echolocation

Fm cf call, cf frequency 37 kHz

Sound duration 3.5 ms

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

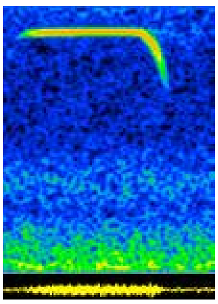


Acoustic confirmation

cf frequency at 135 kHz

Sound duration 8 ms

150 kHZ

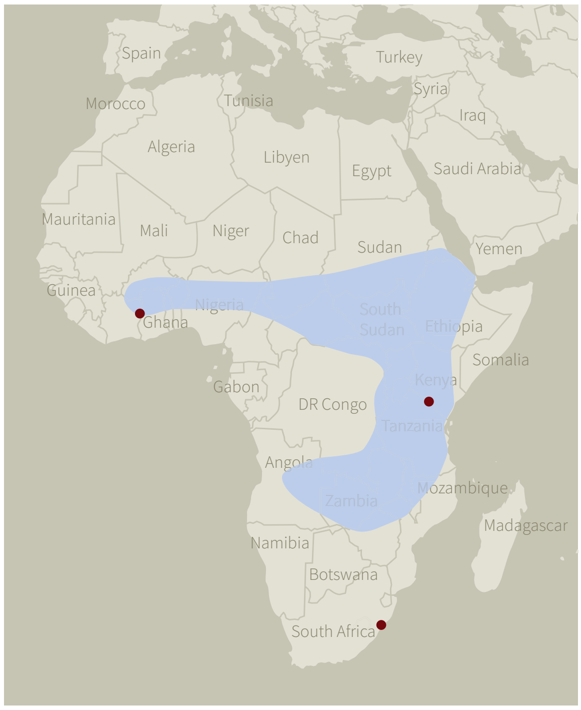


0 kHZ

Large-eared free-tailed bat

Otomops martiensseni

Recorded at: Gojeb Wetland

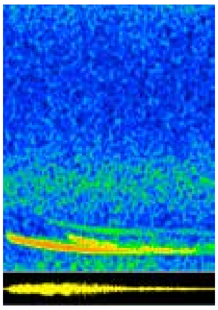


Acoustic confirmation

Long quasi cf signals at 9 kHz

Sound duration 10 ms

150 kHZ



0 kHZ

African giant free-tailed bat

Tadarida ventralis

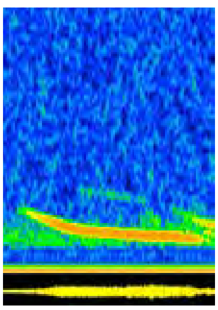
Recorded at: Gojeb Wetland

Acoustic confirmation

Long quasi cf fm signal 18 kHz

Sound duration 11 ms

150 kHZ



0 kHZ

Banana pipistrelle

Pipistrellus nanus

Recorded at: KDA Guesthouse, Gojeb Wetland

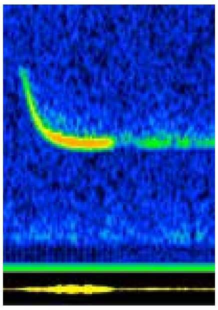
Acoustic confirmation

fm cf signals

cf frequency at 71 kHz

Sound duration 5 ms

150 kHZ



0 kHZ

Smithers's horseshoe bat?

Rhinolophus smithersi? or a new species

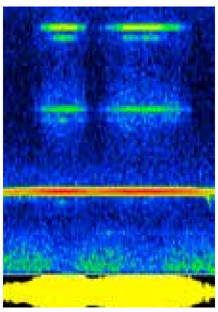
Recorded at: God's Bridge

Acoustic confirmation

Long cf signal at 46kHz

Sound duration 45 ms

150 kHZ



0 kHZ

Birds at the Kafa Biosphere Reserve

Wolfgang Beisenherz, Bernhard Walter, Torsten Ryslavy and Yillma Dellelegn Abebe

Highlights

- → 178 bird species were recorded.
- → 25 species are restricted to the Afrotropical Highland biome.
- → Two species are restricted to the Somali-Masai biome.
- → Three species are endemic (Abyssinian Longclaw (*Macronyx flavicollis*), Abyssinian Catbird (*Parophasma galinieri*) and Yellow-fronted Parrot (*Poicephalus flavifrons*)).
- → Seven species are near-endemic (Wattled Ibis (*Bostrychia carunculata*), Rouget's Rail (*Rougetius rougetii*), Black-winged Lovebird (*Agapornis taranta*), White-cheeked Turaco (*Tauraco leucotis*), Banded Barbet (*Lybius undatus*), Abyssinian Slaty Flycatcher (*Melaenornis chocolatinus*) and Thick-billed Raven (*Corvus crassirostris*). Thus, the Kafa BR is characterized by a high avian endemism.
- → Eight species are endangered or threatened.
- → A successful brood of the endangered Wattled Crane was found in Alemgono Wetland.
- → Different broadleaf forests seem to exhibit similar diversity of bird species.
- → The bamboo forests seem to be home to few bird species. There are no bird species specifically adapted to this habitat.
- → The African Crowned Eagle (*Stephanoaetus coronatus*), Wattled Crane (*Bugeranus carunculatus*) and Black Crowned Crane (*Balearica pavonina*) can be considered flagship species.
- → The African Crowned Eagle, White-cheeked Turaco and Sharpe's Starling (*Pholia sharpii*) could be good indicators of forest conservation status. The Black Crowned Crane, Abyssinian Longclaw and Rouget's Rail could prove good indicator species for wetland conservation status. Finally, the Finfoot (*Podica senegalensis*) and Half-collared Kingfisher (*Alcedo semitorquata*) could prove good indicator species for river conservation status. These species should be monitored regularly.

1. Introduction

The importance of the Kafa BR for birdlife is clear. The Bonga Forest, part of the BR, is classified as an Important Bird Area in Ethiopia (Fishpool & Evans 2001). Knowledge of the distribution and the abundance of bird species in Ethiopia had increased greatly over the last few years. The general checklist of Ethiopian birds published by Ash & Atkins (2009) provides a good overview, though only on a broad scale. It is based on observations by the authors and on previous publications (e.g., Urban & Brown 1971). However, the scale of the maps is very small, which limits its applicability to specific area such as the Kafa BR. Thus, an up-to-date annotated checklist of birds within the Kafa BR is urgently needed. This would allow an assessment of the abundance of different bird populations and possible threats to specific species. This, in turn, would form the basis for conservation plans and protective measures for these species.

Therefore, we set out to compile a list of bird species occurring in the Kafa BR and determine their habitat requirements and possible threats. We also developed protective measures for endangered species and selected species for regular monitoring.

2. Material and Methods

2.1 Study area

Our study area includes most of the sampling sites selected for the biodiversity assessment (BA: bamboo forest, BK: Boka Forest (and wetland), KO: Komba Forest, AG: Alemgono, SHO: Shoriri, GO-wet: Gojeb Wetlands, GO-riv: Gojeb River/floodplain forest, BO: Bodinga Forest, KDA-GH: KDA Guesthouse (including the area around the Bonga Waterfall). We also visited a wetland near Bonga (Yeba Wetland) and the gallery forest and savannah near the bridge over the Gojeb River on the road from Bonga to Jimma to search for key species like cranes.

Table 1: Study sites

Area	Site	Code	Habitat	Alt. (m a.s.l)	Lat.	Long.
BONGA	Bamboo Forest	BA	Bamboo forest dominated by *Arundinaria alpina*	2617	7°15'35" N	36°27'50" E
BONGA	Komba Forest	KO	Montane forests	2079	7°18'01" N	36°05'27" E
BOGINDA	Gojeb Wetland	GO-wet	Wetland	1564	7°33'14" N	36°02'58" E
BOGINDA	Doma Wetland	GO-wet	Wetland	1568	7°31'59" N	35°54'59" E
BOGINDA	Gojeb Wetland	GO-riv	River	1553	7°33'17" N	36°03'34" E
BOGINDA	Gojeb Wetland	GO-riv	Gallery forest	1571	7°32'15" N	36°02'47" E
BONGA	Boka Forest and wetland	BK	Montane forest. wetland	2425	7°17'52" N	36°22'70" E
BONGA	Alemgono Wetland	AG	Wetland	1723	7°21'43" N	36°13'24" E
BONGA	Shorori Wetland	SHO	Wetland	1615	7°21'31" N	36°12'23" E
BONGA	Yeba Wetland		Farmland. wetland	1961	7°12'56" N	36°13'04" E
BONGA	KDA Guesthouse	KDA-GH	Village. farmland	1746	7°15'01" N	36°15'15" E
BOGINDA	Path to the hot springs	BO	Montane forest	1813	7°26'55" N	36°10'56" E
BOGINDA	Medabo Forest Road	BO	Montane forest	2082	7°30'28" N	36°03'51" E
ADIYO	Gojeb/Amiyo		River. savanna	1331	7°25'29" N	36°22'24" E

2.2 Sampling methods

The bird survey was carried out from December 3rd to 11th, 2014. Bird species were determined using the guide by Redman et al. (2009). During the assessment, bird species were counted in different habitats such as montane forests, wetlands, agricultural areas and villages of the Kafa BR. As the habitats were very diverse, the line transect method and timed fixed point observations were used (Sutherland et al. 2005). In forests with restricted access, small paths, game trails or sometimes even streets were taken as transect trails. Most wetland counts were made from the higher-lying peripheral areas of the wetlands. Whenever possible we entered the wetlands, too. Start points and endpoints were recorded using GPS data.

Surveys were conducted between 6 am and 7 pm. Birds were located by visual encounter using binoculars (10 x 40) and a scope (40-60x) or by means of their distinctive songs or calls. Unknown songs and calls were checked using a tape recorder. Reference songs and calls were taken from www.xeno-canto.org in advance. In a few cases, we checked the identity of a hidden bird specimen via voice playback.

2.3 Data analysis

Information on bird abundance is normally derived from the number of specimens counted over a period of several days or even weeks (Sutherland et al. 2005). As we visited most of our study sites only once, no reliable estimate is possible for methodological reasons. In addition, our study took place in the dry season, so we can draw no conclusions about the situation in other seasons. Nevertheless, we considered species common if they were counted at several study sites or 10 or more specimens were found at a single study site.

3. Results

3.1 Forest sites

We studied five different forest sites: the bamboo forest (Table 2), the Boka Forest (Table 3), the Komba Forest (Table 4), the Boginda Forest (Table 5, 6) and the gallery forest at the Gojeb River (Table 7). Bird species characteristic to forests were also monitored in wetlands adjacent to and influenced by upland forest surroundings, e.g., Alemgono and Shorori. Some bird species were typically found in larger forested habitats, including the African Crowned Eagle, African Olive Pigeon, White-cheeked Turaco, Silvery-cheeked Hornbill, Robin-chat, Brown Woodland Warbler, African Paradise Flycatcher, Brown-throated Wattle-eye, Abyssinian Catbird, Ethiopian Boubou, and Sharpe's Starling.

3.1.1 Bamboo Forest (BA)

1) **Date**: 06.12.2014
GPS position: 07° 15' 35" N / 036° 27' 50" E, 2617 m a.s.l.
Habitat: bamboo forest, pasture/meadow, nearby bamboo forest

2) **Date**: 06.12.2014
GPS position: 07° 18' 46" N / 036° 04' 50" E 1852 m a.s.l.
Habitat: forest with 80-100% bamboo

3) **Date**: 06.12.2014
GPS position: 07° 14' 36" N / 036° 27' 23" E - 07° 14' 36" N / 036° 27' 34" E

Table 2: List of birds recorded at the Bamboo Forest (BA)

Common name	Scientific name	Specimens counted	Remarks
African Black Duck	*Anas sparsa*	1	On the river, observed by Holger Meinig
Augur Buzzard	*Buteo augur*	1	
African Crowned Eagle	*Stephanoaetus coronatus*	1	
Chestnut-naped Francolin	*Pternistis castaneicollis*	1, v	
African Olive Pigeon	*Columba arquatrix*	2	
White-cheeked Turaco	*Tauraco leucotis*	2, v	
Black Saw-wing	*Psalidoprogne pristoptera*	>30	
Grey Wagtail	*Motacilla cinerea*	2	
Common Bulbul	*Pycnonotus barbatus*	>10	
Rüppell's Robin-chat	*Cossypha semirufa*	1	
Willow Warbler	*Phylloscopus trochilus*	1, v	

Common name	Scientific name	Specimens counted	Remarks
Common Chiffchaff	*Phylloscopus collybita*	3, v	
Brown Woodland Warbler	*Phylloscopus umbrovirens*	3, v	
Blackcap	*Sylvia atricapilla*	1	
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	2	
Abyssinian Catbird	*Parophasma galinieri*	1	
Abyssinian Black-headed Oriole	*Oriolus monacha*	2, v	
Thick-billed Raven	*Corvus crassirostris*	5	
Sharpe's Starling	*Pholia sharpii*	v	
Tacazze Sunbird	*Nectarinia tacazze*	3	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	4	
Montane White-eye	*Zosterops poliogastrus*	2, v	
Yellow-fronted Canary	*Serinus mozambicus*	4	
African Citril	*Serinus citrinelloides*	>6	
Streaky Seedeater	*Serinus striolatus*	2	

3.1.2 Boka Forest (BK) and adjacent wetlands

1) **Date**: 06.12.2014 1500 - 1800
GPS position: 07° 17' 52" N / 036° 22' 70" E 2425 m a.s.l.
Habitat: wetland, edge of forest, forest

2) **Date**: 07.12.2014 0700 - 0930
GPS position: 07° 17' 40" N / 036 22'34" E - 07° 17' 54" N / 036° 22' 47" E 2477 m a.s.l.
Habitat: wetland, edge of forest, forest

Table 3: List of birds recorded at Boka Forest (BK) and adjacent wetlands

Common name	Scientific name	Specimens counted	Remarks
Hadada Ibis	*Bostrychia hagedash*	2	Feeding in the wetland
Yellow-billed Kite	*Milvus aegyptius*	2	
African Goshawk	*Accipiter tachiro*	1	Flying
African Crowned Eagle	*Stephanoaetus coronatus*	2	Aerial display
Augur Buzzard	*Buteo augur*	3	1 immat.
Common Buzzard	*Buteo Buteo*	1	
Chestnut-naped Francolin	*Francolinus castaneicollis*	3	
Rouget's Rail	*Rougetius rougetii*	>10	Foraging in the grazed wetland near the road
Dusky Turtle-dove	*Streptopelia lugens*	1	In trees at the edge of the wetland
African Olive Pigeon	*Colomba arquatrix*	5	In the canopy
White-cheeked Turaco	*Tauraco leucotis*	2	In the forest
African Emerald Cuckoo	*Chrysococcyx cupreus*	1	In the forest
Abyssinian Nightjar	*Caprimulgus poliocephalus*	x	Heard at night by Ingrid Kaipf
Silvery-cheeked Hornbill	*Bycanistes brevis*	2	In the forest
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	1	In the forest
Grey-headed Woodpecker	*Dendropicos spodocephalus*	1	
Black Saw-wing	*Psalidoprogne pristoptera*	>10	
Grey Wagtail	*Motacilla cinerea*	1	
Mountain Wagtail	*Motacilla clara*	2	

Common name	Scientific name	Specimens counted	Remarks
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>20	Mostly at the forest edge
Rüppell's Robin-chat	*Cossypha semirufa*	1	
Stonechat	*Saxicola torquatus*	2	
Pied Wheatear	*Oenanthe pleschanka*	1	
Mountain Thrush	*Turdus olivaceus*	>10	In the forest and at the forest edge
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	6	At the forest edge
Common Chiffchaff	*Phylloscopus collybita*	5	At the forest edge
Willow Warbler	*Phylloscopus trochilus*	1	
Brown Woodland Warbler	*Phylloscopus umbrovirens*	2	In the forest
Blackcap	*Sylvia atricapilla*	1	
Singing Cisticola	*Cisticola cantans*	1	At the forest edge
Tawny-flanked Prinia	*Prinia subflava*	1	
African Dusky Flycatcher	*Muscicapa adusta*	2	
Brown-throated Wattle-eye	*Platysteira cyanea*	1	In the forest
Ethiopian Boubou	*Laniarius aethiopicus*	4	At the forest edge
Abyssinian Black-headed Oriole	*Oriolus monacha*	5	In the forest
Thick-billed Raven	*Corvus crassirostris*	>10	Flying over the wetland
Sharpe’s Starling	*Pholia sharpii*	>10	3-4 flocks in the forest canopy
Abyssinian Catbird	*Parophasma galinieri*	6	in the forest
Tacazze Sunbird	*Nectarinia tacazze*	>10	
Variable Sunbird	*Cinnyris venustus* ssp. *Fazoqlensis*	>20	In flowers at the forest edge and in trees in the grazed wetland
Mountain White-eye	*Zosterops poliogastrus*	>10	
Common Waxbill	*Estrilda astrild*	6	In farmland
Bronze Mannikin	*Lonchura cucullate*	8-10	
Black-and-white Mannikin	*Lonchura bicolor*	4	At the edge of the wetland
Yellow-fronted Canary	*Serinus mozambicus*	2	In trees at the edge of the wetland
African Citril	*Serinus citrinelloides*	2	In trees at the edge of the wetland
Streaky Seedeater	*Serinus striolatus*	4	In trees at the edge of the wetland

3.1.3 Komba Forest (KO)

1) **Date**: 04.12.2014 0655-0755
GPS position: 07° 18‘ 18“ N / 036° 05‘ 22“ E, 2038 m a.s.l.
Habitat: montane forest, 100% canopy closing

2) **Date**: 04.12.2014 0830-0930
GPS position: 07° 18‘ 01“ N / 036° 09‘ 09“ E, 2079 m a.s.l.
Habitat: montane forest, 100 - 20% canopy closing

3) **Date**: 12.12.2014 0730-0830
GPS position: 07° 18‘ 46“ N / 036° 04‘ 50“ E, 1852 m a.s.l.
Habitat: edge of montane forest, big, old trees

4) **Date**: 05.12.2014 0800-1000
GPS position: 07° 09' 50" N / 036° 03' 47" E, 1902 m a.s.l.
Habitat: montane forest

Table 4: List of birds recorded at Komba Forest (KO)

Common name	Scientific name	Specimens counted	Remarks
Woolly-necked Stork	*Ciconia episcopus*		3
Hadada Ibis	*Bostrychia hagedash*		3
Yellow-billed Kite	*Milvus aegyptius*		3
Long-crested Eagle	*Lophaetus occipitalis*	1	4
African Crowned Eagle	*Stephanoaetus coronatus*	1	1
Scally Francolin	*Francolinus squamatus*	1	
Tambourine Dove	*Turtur tympanistria*		1,2,3
Blue-spotted Wood-dove	*Turtur afer*		1,2
Red-eyed Dove	*Streptopelia semitorquata*		3
Black-winged Lovebird	*Agapornis taranta*	(heard)	1
White-cheeked Turaco	*Tauraco leucotis*		1,2,3,4
Klaas's Cuckoo	*Chrysococcyx klaas*	1	3
Silvery-cheeked Hornbill	*Bycanistes brevis*		1,2,3
Crowned Hornbill	*Tockus alboterminatus*	3	3
Broad-billed Roller	*Coracias glaucurus*	1	4
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*		1,2,3
Grey-headed Woodpecker	*Dendropicos spodocephalus*	1	3
Grey Wagtail	*Motacilla cinerea*	2	3
Mountain Wagtail	*Motacilla clara*	2	3
Grey Cuckooshrike	*Coracina caesia*	1	4
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*		1,2,3
Red-capped Robin-chat	*Cossypha natalensis*	3	1,4
Mountain Thrush	*Turdus olivaceus*		4
Common Chiffchaff	*Phylloscopus collybita*		1,2,3,4
Brown Woodland Warbler	*Phylloscopus umbrovirens*		1,4
Singing Cisticola	*Cisticola cantans*	1	3
Grey-backed Camaroptera	*Camaroptera brachyura*		1,2,3
African Dusky Flycatcher	*Muscicapa adusta*		3
African Paradise Flycatcher	*Terpsiphone viridis*		1,2,3,4
Brown-throated Wattle-eye	*Platysteira cyanea*	3	4
Northern Puffback	*Dryoscopus gambensis*		2
Ethiopian Boubou	*Laniarius aethiopicus*		1,2,3,4
Abyssinian Black-headed Oriole	*Oriolus monacha*		1,2,3,4
Sharpe's Starling	*Pholia sharpii*		1
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*		3
Mountain White-eye	*Zosterops poliogastrus*		3
Red-cheeked Cordon-bleu	*Uraeginthus bengalus*		1,2,3
Yellow-bellied Waxbill	*Coccopygia quartinia*	2	3
Black-and-white Mannikin	*Lonchura bicolor*	2	3
Streaky Seedeater	*Serinus striolatus*		1,2

3.1.4 Boginda (BO)

Boginda path to the hot springs

1) **Date**: 09.12.2014 0715-1045
GPS positions along a transect: 07° 26' 25" N / 036° 10' 56" E – 07° 26' 55" N / 036° 10' 56" E – 07° 28' 04" N / 036° 10' 58" E, 1813 m – 1746 m – 1463 m a.s.l.
Habitat: montane forest, clearing

Table 5: List of birds recorded at Boginda (BO) on the path to the hot springs

Common name	Scientific name	Specimens counted	Remarks
Woolly-necked Stork	*Ciconia episcopus*	1	Flying, near hot springs
Long-crested Eagle	*Lophaetus occipitalis*	1	Near the clearing
Black Crowned Crane	*Balearica pavonina*	3	Flying
Tambourine Dove	*Turtur tympanistria*	>10	Seems to be more common than other species below this in the table
Blue-spotted Wood-dove	*Turtur afer*	>10	
Red-eyed Dove	*Streptopelia semitorquata*	~10	Particularly in degraded forest and near clearings
White-cheeked Turaco	*Tauraco leucotis*	>10	Regularly heard and seen
Blue-headed Coucal	*Centropus monachus*	2	
Speckled Mousebird	*Colius striatus*	>10	Some groups
Silvery-cheeked Hornbill	*Bycanistes brevis*	8-10	Pairs
Crowned Hornbill	*Tockus alboterminatus*	5	1 group
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	>10	Regularly heard
Cardinal Woodpecker	*Dendropicos fuscescens*	1	
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>10	Regularly heard and seen
Rüppell's Robin-chat	*Cossypha semirufa*	2	
Snowy-headed Robin-chat	*Cossypha niveicapilla*	1	
Mountain Thrush	*Turdus olivaceus*	>10	Especially in fruiting trees
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	<10	Singing
Brown Woodland Warbler	*Phylloscopus umbrovirens*	4-5	Singing
Blackcap	*Sylvia atricapilla*	8-10	In fruiting trees
Grey-backed Camaroptera	*Camaroptera brachyura*	>10	Regularly heard
African Dusky Flycatcher	*Muscicapa adusta*	~10	Regularly seen
African Paradise Flycatcher	*Terpsiphone viridis*		Regularly heard and seen
Brown-throated Wattle-eye	*Platysteira cyanea*	3	Heard
Black-headed Batis	*Batis minor*	2	1 pair near hot springs
White-rumped Babbler	*Turdoides leucopygia* ssp. *omoensis*	>10	1 flock
Northern Puffback	*Dryoscopus gambensis*	3	Heard and seen
Ethiopian Boubou	*Laniarius aethiopicus*	>10	Regularly heard and seen
Abyssinian Black-headed Oriole	*Oriolus monacha*	~8	Heard and seen
Thick-billed Raven	*Corvus crassirostris*	4	Near hot springs
Sharpe's Starling	*Pholia sharpii*	4-6	Heard
Abyssinian Catbird	*Parophasma galinieri*	2	Heard
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	1	
Tacazze Sunbird	*Nectarinia tacazze*	2	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	>10	Regularly where there were flowers
Mountain White-eye	*Zosterops poliogastrus*	>10	3-4 flocks

Boginda (BO) Medabo Forest Road

1) **Date**: 11.12.2014 0645-0945
GPS positions along a transect: 07° 30' 31" N / 036° 03' 28" E – 07° 30' 28" N / 036° 03' 51" E – 07° 30' 35" N / 036° 03' 42" E – 07° 31' 11" N / 036° 03' 29" E, 2125 m – 2082 m – 2030 m – 1888 m a.s.l.
Habitat: montane forest, roadside

Table 6: List of birds found at BO Medabo Forest Road

Common name	Scientific name	Specimens counted	Remarks
Rufous-breasted Sparrowhawk	*Accipiter rufiventris*	1	
Tambourine Dove	*Turtur tympanistria*	>10	Singing, most commonly heard
Blue-spotted Wood-dove	*Turtur afer*	~10	Singing, common but fewer than Tambourine Dove
Red-eyed Dove	*Streptopelia semitorquata*	<10	Singing
African Olive Pigeon	*Colomba arquatrix*	5-8	1 singing
White-cheeked Turaco	*Tauraco leucotis*	>10	Regularly seen or heard along the transect
Speckled Mousebird	*Colius striatus*	~5	1 group seen
Silvery-cheeked Hornbill	*Bycanistes brevis*	10	5 pairs, very noisy, defending territories?
Crowned Hornbill	*Tockus alboterminatus*	6	3 pairs?
Little Bee-eater	*Merops pusillus*	8-10	1 flock
European Bee-eater	*Merops apiaster*	>10	Flocks heard
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	>10	Regularly heard along the transect
Black Saw-wing	*Psalidoprogne pristoptera*	>10	Flocks
Grey Wagtail	*Motacilla cinerea*	2	1 pair on the road
Mountain Wagtail	*Motacilla clara*	2	1 pair on the road
Grey Cuckooshrike	*Coracina caesia*	1	Seen here in 2011
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>10	Regularly seen and heard along the transect
Rüppell's Robin-chat	*Cossypha semirufa*	2	Not singing
Mountain Thrush	*Turdus olivaceus*	~8	3 on the road, ~5 feeding on a fruiting tree
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	>10	Regularly heard in the roadside vegetation
Common Chiffchaff	*Phylloscopus collybita*	4-6	Seen, not singing
Willow Warbler	*Phylloscopus trochilus*	1	1 singing, birds we could see were chiffchaffs
Brown Woodland Warbler	*Phylloscopus umbrovirens*	8-10	Singing
Blackcap	*Sylvia atricapilla*	3	Seen
Grey-backed Camaroptera	*Camaroptera brachyura*	>10	Regularly heard in the roadside vegetation
Northern Black Flycatcher	*Melaenornis edolioides*	2	Individual birds
African Dusky Flycatcher	*Muscicapa adusta*	7	Regularly seen
African Paradise Flycatcher	*Terpsiphone viridis*	~8-10	Regularly seen or heard along the transect
Brown-throated Wattle-eye	*Platysteira cyanea*	2	2 heard
Northern Puffback	*Dryoscopus gambensis*	4-6	1 group

Common name	Scientific name	Specimens counted	Remarks
Ethiopian Boubou	*Laniarius aethiopicus*	>10	Regularly seen or heard along the transect
Abyssinian Black-headed Oriole	*Oriolus monacha*	10	Regularly seen or heard along the transect
Slender-billed Starling	*Onychognathus tenuirostris*	>20	3 flocks flying
Stuhlmann's Starling	*Poeoptera stuhlmanni*	4	1 pair flying
Sharpe's Starling	*Pholia sharpii*	>5	1 singing, some more calling
Abyssinian Catbird	*Parophasma galinieri*	3	3 singing, none seen
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	6-8	Seen at flowering plants
Mountain White-eye	*Zosterops poliogastrus*	>10	2 groups

3.1.5 Gojeb Gallery Forest (GO-riv)

1) **Date**: 11.12.2014 1340-1540
GPS position: 07° 32' 15" N / 036° 03' 56" E – 07° 32' 15" N / 036° 02' 47" E – 07° 32' 16" N / 036° 02' 36" E – 07° 33' 32" N / 036° 02' 33" E 1586 m – 1571 m – 1564 m a.s.l.
Habitat: gallery forest, river

Table 7: List of birds found at Gojeb Gallery Forest (GO-riv)

Common name	Scientific name	Specimens counted	Remarks
Little Grebe	*Tachybaptus ruficollis*	2	
Hamerkop	*Scopus umbretta*	1	Flying
Woolly-necked Stork	*Ciconia episcopus*	1	
Western Banded Snake-eagle	*Circaetus cinerascens*	1	
Chestnut-naped Francolin	*Francolinus castaneicollis*	1	Heard in the wetland
Tambourine Dove	*Turtur tympanistria*	4	Seen and heard in the forest
Red-eyed Dove	*Streptopelia semitorquata*	>5	Seen and heard at the forest edge
Striped Kingfisher	*Halcyon chelicuti*	4	In a clearing in the forest
African Pygmy Kingfisher	*Ceyx pictus*	1	
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	>6	Heard
Barn Swallow	*Hirundo rustica*	5-8	
Black Saw-wing	*Psalidoprogne pristoptera*	>10	
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>8	In the forest
Mountain Thrush	*Turdus olivaceus*	2	Seen at the forest edge
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	1	Heard at the forest edge
Grey-backed Camaroptera	*Camaroptera brachyura*	3	Seen and heard at the forest edge
African Dusky Flycatcher	*Muscicapa adusta*	3	Seen at the forest edge
African Paradise Flycatcher	*Terpsiphone viridis*	2	In the forest
Ethiopian Boubou	*Laniarius aethiopicus*	x	Heard in the forest
Thick-billed Raven	*Corvus crassirostris*	x	Flying
Red-winged Starling	*Onychognathus morio*	1	
Copper Sunbird	*Cinnyris cupreus*	1	
Olive Sunbird	*Cinnyris olivaceus*	1	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	4-5	In flowers at the forest edge and in the forest
Mountain White-eye	*Zosterops poliogastrus*	6-8	
Fan-tailed Widowbird	*Euplectes axillaris*	~10	1 flock

3.2 Wetlands

Five wetlands were monitored: Boka (Table 3), Alemgono (Table 8), Gojeb (Table 9, 10), Shoriri (Table 11) and Yeba (Table 12). The bird species of Boka, Shoriri and Yeba Wetlands were particularly influenced by their surroundings; thus, there are a lot of species on these lists which are typical for forested areas. Some of the wetlands are dominated by dense plant stands of reed and *Cyperus latifolius*, others are surrounded by short grazed meadow-like areas. Key wetland species include the Black Crowned and Wattled Cranes, Rouget's Rail and the Red-collared and Fan-tailed Widowbirds.

3.2.1 Alemgono (AG)

1) **Date**: 04.12.2014 1600-1820
GPS position: 07° 21' 47" N / 036° 13' 05" E 1723 m a.s.l.
Habitat: farmland to wetland transitional area, wetland: dense stands of *Cyperus latifolius* surrounded by heavily grazed areas

2) **Date**: 07.12.2014 1820-1900
GPS position: 07° 21' 43" N / 036° 13' 24" E 1720 m a.s.l.

3) **Date**: 12.12.2014 11.00 – 12.30 h
GPS position: 07° 21' 47" N / 036° 13' 05" E 1723 m a.s.l.

Table 8: List of birds found at Alemgono Wetland (AG)

Common name	Scientific name	Specimens counted	Remarks
Hadada Ibis	*Bostrychia hagedash*	8	Feeding in the wetland
Yellow-billed Kite	*Milvus aegyptius*	2	
Western Marsh-harrier	*Circus aeruginosus*	1	
African Goshawk	*Accipiter tachiro*	1	Flying overhead with prey
Augur Buzzard	*Buteo augur*	1	
Greater Spotted Eagle	*Aquila clanga*	1	Flying overhead
Long-crested Eagle	*Lophaetus occipitalis*	1	
Helmeted Guineafowl	*Numida meleagris*	~20	At the edge of farmland
Chestnut-naped Francolin	*Francolinus castaneicollis*	1	Heard in the wetland
Black Crowned Crane	*Balearica pavonina*	10	
Wattled Crane	*Bugeranus carunculatus*	5	2 pairs, 1 juv.
Rouget's Rail	*Rougetius rougetii*	2-4	Heard
Black Crake	*Amaurornis flavirostra*	1	In dense *Cyperus* vegetation
African Wattled Lapwing	*Vanellus senegallus*	2	In heavily grazed areas
Wood Sandpiper	*Tringa glareola*	2	
Green Sandpiper	*Tringa ochropus*	1	
Common Snipe	*Gallinago gallinago*	1	
Tambourine Dove	*Turtur tympanistria*	2-4	Heard at the edge of farmland
Blue-spotted Wood-dove	*Turtur afer*	1	Heard at the edge of farmland
Red-eyed Dove	*Streptopelia semitorquata*	~8	heard at the edge of farmland
Blue-headed Coucal	*Centropus monachus*	3	Seen in the wetland
Abyssinian Nightjar	*Caprimulgus poliocephalus*	3	Heard after sunset from surrounding farmland
Speckled Mousebird	*Colius striatus*	6-8	Seen at the edge of farmland
Little Bee-eater	*Merops pusillus*	>40	At the edge of farmland
White-throated Bee-eater	*Merops albicollis*	2	
Silvery-cheeked Hornbill	*Bycanistes brevis*	2	At the edge of farmland
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	2	Heard at the edge of farmland

Common name	Scientific name	Specimens counted	Remarks
Double-toothed Barbet	*Lybius bidentatus*	1	Seen at the edge of farmland
Barn Swallow	*Hirundo rustica*	>40	
Common Sand Martin	*Riparia riparia*	>10	
Banded Martin	*Riparia cincta*	1	
Yellow Wagtail	*Motacilla flava*	~10	In heavily grazed areas
Abyssinian Longclaw	*Macronyx flavicollis*	10	5 pairs, in heavily grazed areas
African/Grassland Pipit	*Anthus cinnamomeus*	2	In heavily grazed areas
Red-throated Pipit	*Anthus cervinus*	>100	Migrating flock, in heavily grazed areas
Common Bulbul	*Pycnonotus barbatus* ssp. *Schoanus*	>10	Seen and heard at the edge of farmland
Whinchat	*Saxicola rubetra*	2	In *Cyperus* stands
Common Stonechat	*Saxicola torquatus*	1	In *Cyperus* stands
Grey-backed Camaroptera	*Camaroptera brachyura*	2	Heard at the edge of farmland
White-rumped Babbler	*Turdoides leucopygia* ssp. *Omoensis*	>4	1 group, at the edge of farmland
Greater Blue-eared Starling	*Lamprotornis chalybaeus*	2	In heavily grazed areas
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	5	In flowers at the edge of farmland
Ethiopian Boubou	*Laniarius aethiopicus*	2	
Common Fiscal	*Lanius collaris*	6-8	In heavily grazed areas
Thick-billed Raven	*Corvus crassirostris*	2	
Swainson's Sparrow	*Passer swainsonii*	<10	At the edge of farmland
Village Weaver	*Ploceus cucullatus*	>20	At the edge of farmland
Red-collared Widowbird	*Euplectes ardens*	>20	2 flocks, roosting in *Cyperus* stands
Fan-tailed Widowbird	*Euplectes axillaris*	50-100	1 flock, roosting in *Cyperus* stands
Black-and-white Mannikin	*Lonchura bicolor*	2	
Bronze Mannikin	*Lonchura cucullata*	>10	At the edge of farmland

3.2.2 Gojeb Wetland

Gojeb Wetland (GO-wet)

1) **Date**: 10.12.2014 0630-1145
GPS position: 07° 33' 26" N / 036° 03' 58" E – 07° 33' 14" N / 036° 02' 58" E – 07° 33' 31" N / 036° 02' 42" E – 07° 33' 32" N / 036° 02' 33" E 1555 m – 1564 m – 1561 m a.s.l.
Habitat: wetland, edge of forest

Table 9: List of birds found at Gojeb Wetland (GO-wet)

Common name	Scientific name	Specimens counted	Remarks
Black-headed Heron	*Ardea melanocephala*	2	
Hamerkop	*Scopus umbretta*	1	Flying
Woolly-necked Stork	*Ciconia episcopus*	4	
Hadada Ibis	*Bostrychia hagedash*	8-10	Feeding in the wetland
Yellow-billed Kite	*Milvus aegyptius*	5	
African Fish-eagle	*Haliaeetus vocifer*	1	Heard from Gojeb River
Hooded Vulture	*Necrosyrtes monachus*	2	Attracted by offal
Lappet-faced Vulture	*Torgos tracheliotus*	1	Attracted by offal
White-headed Vulture	*Trigonoceps occipitalis*	1	Attracted by offal
White-backed Vulture	*Gyps africanus*	14	Attracted by offal
Rüppell's Vulture	*Gyps rueppellii*	1	Attracted by offal
African Crowned Eagle	*Stephanoaetus coronatus*	1	Flying
Augur Buzzard	*Buteo augur*	2	
Common Quail	*Coturnix coturnix*	1	
Chestnut-naped Francolin	*Francolinus castaneicollis*	>4	Heard in the wetland
Black Crowned Crane	*Balearica pavonina*	>50	3 pairs with 1 juvenile each, a flock of >40
Rouget's Rail	*Rougetius rougetii*	1-2	Heard
Green Sandpiper	*Tringa ochropus*	1	
Tambourine Dove	*Turtur tympanistria*	>6	Seen and heard at the forest edge
Blue-spotted Wood-dove	*Turtur afer*	x	Seen and heard at the forest edge
Speckled Pigeon	*Columba guinea*	2	
Red-eyed Dove	*Streptopelia semitorquata*	>8	Seen and heard at the forest edge
Blue-headed Coucal	*Centropus monachus*	2	Seen at the forest edge
Speckled Mousebird	*Colius striatus*	>10	Seen at the forest edge
African Pygmy Kingfisher	*Ceyx pictus*	1	
European Bee-eater	*Merops apiaster*	x	Migrating flock
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	>6	Seen and heard at the forest edge
Barn Swallow	*Hirundo rustica*	>40	
Yellow Wagtail	*Motacilla flava*	>30	
Abyssinian Longclaw	*Macronyx flavicollis*	2	1 pair
Red-throated Pipit	*Anthus cervinus*	>100	Migrating flock
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>10	Seen and heard at the forest edge
Whinchat	*Saxicola rubetra*	2	
Mountain Thrush	*Turdus olivaceus*	2	Seen at the forest edge

Common name	Scientific name	Specimens counted	Remarks
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	>8	Seen and heard at the forest edge
Common Chiffchaff	*Phylloscopus collybita*	3	Seen and heard at the forest edge
Stout Cisticola	*Cisticola robustus*	4	2 pairs
Grey-backed Camaroptera	*Camaroptera brachyura*	>8	Seen and heard at the edge of forest
African Dusky Flycatcher	*Muscicapa adusta*		Seen at the forest edge
Brown-throated Wattle-eye	*Platysteira cyanea*	1	Heard at the forest edge
Black-headed Batis	*Batis minor*	2	Seen at the forest edge
White-rumped Babbler	*Turdoides leucopygia omoensis*	>4	1 group
Northern Puffback	*Dryoscopus gambensis*	2	Heard at the forest edge
Ethiopian Boubou	*Laniarius aethiopicus*	6-8	Heard at the forest edge
Cape Crow	*Corvus capensis*	4	Feeding in the wetland
Thick-billed Raven	*Corvus crassirostris*	6-8	Flying
Greater Blue-eared Starling	*Lamprotornis chalybaeus*	>100	3-4 flocks
Red-billed oxpecker	*Buphagus erythrorhynchus*	5-7	Accompanying cattle
Copper Sunbird	*Cinnyris cupreus*	2	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	4-5	In flowers at the forest edge
Common Fiscal	*Lanius collaris*	1	
Red-collared Widowbird	*Euplectes ardens*	>10	2 flocks
Fan-tailed Widowbird	*Euplectes axillaris*	>20	1 flock
Bronze Mannikin	*Lonchura cucullata*	>10	2 flocks
Pin-tailed Wydah	*Vidua macroura*	1	1 male
Village Indigobird	*Vidua chalybeata*	1	1 male
African Citril	*Serinus citrinelloides*	3	

Doma Wetland as part of Gojeb Wetland

1) **Date**: 10.12.2014 1530-1700
   GPS position: 07° 32’ 41” N / 035° 54’ 41” E – 07° 31’ 59” N / 035° 54’ 59” E 1592 m – 1568 m a.s.l.
   Habitat: wetland, transitional area from farmland and degraded forest to wetland

Table 10: List of birds found at Doma Wetland as part of Gojeb Wetland

Common name	Scientific name	Specimens counted	Remarks
Black-headed Heron	*Ardea melanocephala*	1	
Woolly-necked Stork	*Ciconia episcopus*	12	1 flock of 8 specimens
White Stork	*Ciconia ciconia*	1	
Yellow-billed Kite	*Milvus aegyptius*	2	
European Honey-buzzard	*Pernis apivorus*	1	
Western Marsh-harrier	*Circus aeruginosus*	3	2 males, 1 female
Augur Buzzard	*Buteo augur*	2	
Common Kestrel	*Falco tinnunculus*	2	
Black Crowned Crane	*Balearica pavonina*	5	1 pair with 1 juv.
African Wattled Lapwing	*Vanellus senegallus*	2	
Blue-spotted Wood-dove	*Turtur afer*	3	Seen and heard in the BR’s transition zone

Common name	Scientific name	Specimens counted	Remarks
Red-eyed Dove	*Streptopelia semitorquata*	>5	Seen and heard in the BR's transition zone
Speckled Mousebird	*Colius striatus*	6	Seen in the BR's transition zone
European Bee-eater	*Merops apiaster*	x	Migrating flock heard
White-throated Bee-eater	*Merops albicollis*	>4	In the transitional area
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	3	Seen and heard in the BR's transition zone
Cardinal Woodpecker	*Dendropicos fuscescens*	1	In the BR's transition zone
Barn Swallow	*Hirundo rustica*	>10	
Yellow Wagtail	*Motacilla flava*	>8	
Grassland Pipit	*Anthus cinnamomeus*	2	
Red-throated Pipit	*Anthus cervinus*	>20	Migrating flock
Common Bulbul	*Pycnonotus barbatus schoanus*	5	Seen and heard in the BR's transition zone
African Stonechat	*Saxicola torquatus* ssp. *Albofasciatus*	2	
Whinchat	*Saxicola rubetra*	1	
Blackcap	*Sylvia atricapilla*	1	In the BR's transition zone
Ethiopian Cisticola	*Cisticola lugubris*	2	1 pair
Grey-backed Camaroptera	*Camaroptera brachyura*	4	Seen and heard in the BR's transition zone
African Dusky Flycatcher	*Muscicapa adusta*	3	Seen in the BR's transition zone
Ethiopian Boubou	*Laniarius aethiopicus*	4	Heard in the transitional area
Copper Sunbird	*Cinnyris cupreus*	1	In the BR's transition zone
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	4	In flowers in the BR's transition zone
Swainson's Sparrow	*Passer swainsonii*	>5	In the BR's transition zone
Village Weaver	*Ploceus cucullatus*	6	In the BR's transition zone
Red-collared Widowbird	*Euplectes ardens*	>10	2 flocks
Bronze Mannikin	*Lonchura cucullata*	>10	2 flocks
Pin-tailed Wydah	*Vidua macroura*	1	1 male
Streaky Seedeater	*Serinus striolatus*	2	In the BR's transition zone

3.2.3 Shoriri Wetland (SHO)

1) **Date**: 05.12.2014 1545-1710
GPS positions along a transect: 07° 21' 49" N / 036° 12' 55" E – 07° 21' 31" N / 036° 12' 23" E 1725 m – 1615 m a.s.l.
Habitat: degraded montane forest in transition zone farmland to wetland, wetland

Table 11: List of birds found at Shoriri Wetland (SHO)

Common name	Scientific name	Specimens counted	Remarks
Hadada Ibis	*Bostrychia hagedash*	8	At the edge of the wetland
Yellow-billed Kite	*Milvus aegyptius*	3	
African Green-pigeon	*Treron calvus*	12	In a fruiting tree
Tambourine Dove	*Turtur tympanistria*	5	
Red-eyed Dove	*Streptopelia semitorquata*	3	
White-cheeked Turaco	*Tauraco leucotis*	8	Heard and seen in the forest
Speckled Mousebird	*Colius striatus*	2	
Striped Kingfisher	*Halcyon chelicuti*	1	
European Bee-eater	*Merops apiaster*	1	Flying overhead
Silvery-cheeked Hornbill	*Bycanistes brevis*	2	In a fruiting tree
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	1	Heard
Moutain Wagtail	*Motacilla clara*	6	
Common Bulbul	*Pycnonotus barbatus schoanus*	1	Heard and seen
Rüppell's Robin-Chat	*Cossypha semirufa*	1	
Mountain Thrush	*Turdus olivaceus*	1	In a fruiting tree
Tawny-flanked Prinia	*Prinia subflava*	1	
Brown Woodland Warbler	*Phylloscopus umbrovirens*	4	Heard
African Paradise Flycatcher	*Terpsiphone viridis*	3	Heard
Northern Puffback	*Dryoscopus gambensis*	3	Courting
Ethiopian Boubou	*Laniarius aethiopicus*	6	Heard
Abyssinian Black-headed Oriole	*Oriolus monacha*	4	Heard
Violet-backed Starling	*Cinnyricinclus leucogaster*	2	In a fruiting tree
Slender-billed Starling	*Onychognathus tenuirostris*	4	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	3	Heard and seen
Red-collared Widowbird	*Euplectes ardens*	8	In the wetland
Fan-tailed Widowbird	*Euplectes axillaris*	9	In the wetland

3.2.4 Yeba Wetland (Bonga)

1) **Date**: 07.12.2014 1515-1700
GPS positions along a transect: 07° 12' 58" N / 036° 13' 23" E – 07° 12' 56" N / 036° 13' 04" E 2026 m – 1961 m a.s.l.
Habitat: transition zone farmland to wetland, wetland

Table 12: List of birds found at Yeba Wetland (Bonga)

Common name	Scientific name	Specimens counted	Remarks
Augur Buzzard	*Buteo augur*	1	Flying
White-backed Vulture	*Gyps africanus*	1	
Tambourine Dove	*Turtur tympanistria*	4-5	Heard
White-cheeked Turaco	*Tauraco leucotis*	3	Heard and seen in the forest
Speckled Mousebird	*Colius striatus*	>5	
Silvery-cheeked Hornbill	*Bycanistes brevis*	4	2 pairs
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	2-4	Heard
Banded Barbet	*Lybius undatus*	1	
Lesser Honeyguide	*Indicator minor*	1	
Black Saw-wing	*Psalidoprogne pristoptera*	>10	1 flock in the farmland
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>6	Heard and seen
Rüppell's Robin-Chat	*Cossypha semirufa*	1	
Mountain Thrush	*Turdus olivaceus*	3	
African Yellow Warbler	*Chloropeta natalensis*	1	1 seen
Common Chiffchaff	*Phylloscopus collybita*	3	Seen
Singing Cisticola	*Cisticola cantans*	1	
Tawny-flanked Prinia	*Prinia subflava*	1	
Grey-backed Camaroptera	*Camaroptera brachyura*	2-3	Heard
Abyssinian Slaty Flycatcher	*Melaenornis chocolatinus*	1	
African Dusky Flycatcher	*Muscicapa adusta*	4	Seen
Ethiopian Boubou	*Laniarius aethiopicus*	2	
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	>5	Heard and seen
Thick-billed Raven	*Corvus crassirostris*	4	Flying
Baglafecht Weaver	*Ploceus baglafecht*	5	In the farmland
Bronze Mannikin	*Lonchura cucullata*	8	
Pin-tailed Wydah	*Vidua macroura*	3	2 males, 1 female in the farmland
Yellow-fronted Canary	*Serinus mozambicus*	2	
African Citril	*Serinus citrinelloides*	4	In the farmland
Streaky Seedeater	*Serinus striolatus*	2	In the farmland

3.2.5 Gojeb River (GO-riv)

The Gojeb River is a unique habitat, which we assessed in the area surrounding the bridge near Medabo. We found Little Grebe, Reed Cormorant, African Fish-eagle, African Finfoot, Half-collared Kingfisher, Malachite Kingfisher, Pied Kingfisher, Giant Kingfisher and Mountain Wagtail, which are all species bound to open water.

1) **Date**: 09.12.2014 1730-1830
GPS position: 07° 33' 17" N / 036° 03' 34" E 1,553 m a.s.l.
Habitat: river, degraded gallery forest

2) **Date**: 10.12.2014 0750-900

3) **Date**: 11.12.2014 1020-1030

Table 13: List of birds found at Gojeb River (GO-riv), Gojeb Bridge

Common name	Scientific name	Specimens counted	Remarks
Little Grebe	*Tachybaptus ruficollis*	1	1 / on the river
Reed Cormorant	*Phalacrocorax africanus*	1	1 / flying
Striated Heron	*Butorides striata*	1	2 / in riparian vegetation
Black-headed Heron	*Ardea melanocephala*	1	2 / overflying
Hadada Ibis	*Bostrychia hagedash*	2	1
Yellow-billed Kite	*Milvus aegyptius*	2	2 / overflying
African Fish-eagle	*Haliaeetus vocifer*	2	1,3
White-headed Vulture	*Trigonoceps occipitalis*	2	3 / overflying
White-backed Vulture	*Gyps africanus*	3	3 / overflying
Augur Buzzard	*Buteo augur*	1	1 / overflying
Black Crowned Crane	*Balearica pavonina*	3	1 / flying
African Finfoot	*Podica senegalensis*	1	1 / 1 female
Common Sandpiper	*Actitis hypoleucos*	1	2
Blue-spotted Wood-dove	*Turtur afer*	2	3 / heard
Speckled Pigeon	*Columba guinea*	2	1 / at the bridge
Red-eyed Dove	*Streptopelia semitorquata*	3-4	1 / calling nearby
Blue-headed Coucal	*Centropus monachus*	1	1
Little Swift	*Apus affinis*	>10	1 / 1 flock overflying
Malachite Kingfisher	*Alcedo cristata*	1	
Half-collared Kingfisher	*Alcedo semitorquata*	2	1,2,3 / presumably breeding
Pied Kingfisher	*Ceryle rudis*	3	2
Giant Kingfisher	*Megaceryle maxima*	2	
Banded Martin	*Riparia cincta*	2-3	2
Lesser Striped Swallow	*Cecropis abyssinica*	>10	2,3 / 1 roosting flock
Wire-tailed Swallow	*Hirundo smithii*	4-5	1,2
Barn Swallow	*Hirundo rustica*	>20	1
Black Saw-wing	*Psalidoprogne pristoptera*	>10	3
Mountain Wagtail	*Motacilla clara*	2	1,2 / resident
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	3-5	1 / heard and seen in nearby vegetation
Grey-backed Camaroptera	*Camaroptera brachyura*	2	2 / heard in nearby vegetation
White-rumped Babbler	*Turdoides leucopygia* ssp. *omoensis*	5	1,2 / 1 flock
Ethiopian Boubou	*Laniarius aethiopicus*	2	1 / heard in nearby vegetation
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	2-4	1 / in nearby flowers
Mountain White-eye	*Zosterops poliogastrus*	5-6	2 / heard and seen in nearby vegetation

Common name	Scientific name	Specimens counted	Remarks
Swainson's Sparrow	*Passer swainsonii*	3	2
Black-and-white Mannikin	*Lonchura bicolor*	2	2 / seen in nearby vegetation

3.2.6 Gojeb River and savannah near Amiyo

We studied an area at the bridge over the Gojeb River, at the road from Bonga to Jimma which was marked as savannah, a habitat otherwise very rare in the biosphere reserve. As the so called savannah was not grazed by cattle, the plant stand was very dense and high. We also include species we found in the nearby village, in the gallery forest and at the river itself in our bird list (Table 14).

1) **Date**: 08.12.2014 0730-1200
GPS position: 07° 25' 04" N / 036° 22' 26" (1286 m a.s.l., village) – 07° 25' 32" N / 036° 22' 31" E (1297 m a.s.l., river) – 07° 25' 29" N / 036° 22' 24" E (1331 m a.s.l., savannah) – 07° 25' 47" N / 036° 22' 27" (1357 m a.s.l., savannah) – 07° 24' 49" N / 036° 22' 31" E (1313 m a.s.l., old bridge)
Habitat: village, farmland, gallery forest (shrub), savannah (high vegetation), river

Table 14: List of birds found at Gojeb River near Amiyo

Common name	Scientific name	Specimens counted	Remarks
Reed Cormorant	*Phalacrocorax africanus*	2	At the river
Black-headed Heron	*Ardea melanocephala*	1	Near the village
Wattled Ibis	*Bostrychia carunculata*	3	Near the village
Hadada Ibis	*Bostrychia hagedash*	3	Near the village
Yellow-billed Kite	*Milvus aegyptius*	5	
African Fish-eagle	*Haliaeetus vocifer*	1	Heard, at the river
Hooded Vulture	*Necrosyrtes monachus*	4	Near the village
White-backed Vulture	*Gyps africanus*	6	Near the village
Bateleur	*Terathopius ecaudatus*	1	Flying, over savannah
Common Sandpiper	*Actitis hypoleucos*	1	At the river
Green Sandpiper	*Tringa ochropus*	2	At the river
Blue-spotted Wood-dove	*Turtur afer*	3-5	
Speckled Pigeon	*Columba guinea*	4-6	
Red-eyed Dove	*Streptopelia semitorquata*	>8	
Lemon Dove	*Aplopelia larvata*	1	Near the old bridge
Little Swift	*Apus affinis*	>10	Near the old bridge
Speckled Mousebird	*Colius striatus*	>10	
Striped Kingfisher	*Halcyon chelicuti*	2	Eucalyptus forest near village
White-throated Bee-eater	*Merops albicollis*	3	Eucalyptus forest near village
Silvery-cheeked Hornbill	*Bycanistes brevis*	2	Fruiting trees in the savannah
Wire-tailed Swallow	*Hirundo smithii*	8-10	Near the old bridge
Barn Swallow	*Hirundo rustica*	>15	Near the old bridge
Black Saw-wing	*Psalidoprogne pristoptera*	>10	Near the old bridge
African Pied Wagtail	*Motacilla aguimp*	2	At the river
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>10	
African Thrush	*Turdus pelios*	2	
Mountain Thrush	*Turdus olivaceus*	>8	

Common name	Scientific name	Specimens counted	Remarks
Blackcap	*Sylvia atricapilla*	3	Fruiting trees in the savannah
Grey-backed Camaroptera	*Camaroptera brachyura*	>5	
Northern Black Flycatcher	*Melaenornis edolioides*	4	Eucalyptus forest near village
African Paradise Flycatcher	*Terpsiphone viridis*	2	
Mountain White-eye	*Zosterops poliogastrus*	5-6	
Abyssinian White-eye	*Zosterops abyssinicus*	4	
Ethiopian Boubou	*Laniarius aethiopicus*	5	
Abyssinian Black-headed Oriole	*Oriolus monacha*	2	
Violet-backed Starling	*Cinnyricinclus leucogaster*	5	Fruiting trees in the savannah
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	>10	
Swainson's Sparrow	*Passer swainsonii*	>10	
Baglafecht Weaver	*Ploceus baglafecht*	>10	
Village Weaver	*Ploceus cucullatus*	4-6	
Red-billed Firefinch	*Lagonosticta senegala*	>10	
Bronze Mannikin	*Lonchura cucullata*	>10	
Pin-tailed Wydah	*Vidua macroura*	2	
Village Indigobird	*Vidua chalybeata*	3	
African Citril	*Serinus citrinelloides*	2	Savannah
White-rumped Seedeater	*Serinus leucopygius*	2	Savannah

3.2.7 KDA Guesthouse and surroundings

As birds are highly mobile, our bird list for the KDA compound includes species we monitored in the surrounding villages and even those we found at the waterfall in Bonga (Table 14, 15). We think that this compilation gives a more accurate idea of the birds which may be expected in and around the KDA compound. As the environment is dominated by trees, we found many species bound to forest.

KDA Guesthouse

1) **Date**: 02.12.2014 – 11.12.2014
GPS position: 07° 15' 01" N / 036° 15' 15" E 1746 m a.s.l.
Habitat: gardens, hedges and wooded areas in the nearby village

Table 15: List of birds found at the KDA Guesthouse (KDA-GH)

Common name	Scientific name	Specimens counted	Remarks
Hadada Ibis	*Bostrychia hagedash*	2-4	Flying
Yellow-billed Kite	*Milvus aegyptius*	4-6	Flying
Hooded Vulture	*Necrosyrtes monachus*	2-3	Flying
Augur Buzzard	*Buteo augur*	1	Flying
Tambourine Dove	*Turtur tympanistria*	>5	Seen and heard in wooded area of the village
Blue-spotted Wood-dove	*Turtur afer*	2-3	Seen and heard in wooded area of the village
Red-eyed Dove	*Streptopelia semitorquata*	>5	Seen and heard
White-cheeked Turaco	*Tauraco leucotis*	2-4	In wooded areas
African Emerald Cuckoo	*Chrysococcyx cupreus*	1	In wooded area of the village
Abyssinian/Montane Nightjar	*Caprimulgus poliocephalus*	1	Seen at night

Common name	Scientific name	Specimens counted	Remarks
Speckled Mousebird	*Colius striatus*	6-8	In shrub and hedges in the compound and village
African Pygmy kingfisher	*Ceyx pictus*	1	By a creek in the village
Little Bee-eater	*Merops pusillus*	2-4	In the village
Silvery-cheeked Hornbill	*Bycanistes brevis*	2	Flying
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	2-4	Seen and heard
Banded Barbet	*Lybius undatus*	1	Seen
Lesser Honeyguide	*Indicator minor*	1	Seen and heard in the compound
Barn Swallow	*Hirundo rustica*	>10	Flocks
Black Saw-wing	*Psalidoprogne pristoptera*	>10	Flocks
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>6	Seen and heard in the compound and village
Rüppell's Robin-chat	*Cossypha semirufa*	3-4	In shrub and hedges in the compound and village
Mountain Thrush	*Turdus olivaceus*	3-4	In shrub, hedges and wooded areas in the com-pound and village
Common Chiffchaff	*Phylloscopus collybita*	2-3	Seen and heard
Blackcap	*Sylvia atricapilla*	1-2	
Tawny-flanked Prinia	*Prinia subflava*	1	In a hedge of the village
Grey-backed Camaroptera	*Camaroptera brachyura*	2-4	In shrub and hedges in the compound and village
African Dusky Flycatcher	*Muscicapa adusta*	4-6	In the compound and village
African Paradise Flycatcher	*Terpsiphone viridis*	2-3	In wooded area of the village
Black-headed Batis	*Batis minor*	1	
Ethiopian Boubou	*Laniarius aethiopicus*	2-4	Heard in wooded areas of the village
Abyssinian Black-headed Oriole	*Oriolus monacha*	2-4	In wooded areas of the village
Thick-billed Raven	*Corvus crassirostris*	4	Flying
Tacazze Sunbird	*Nectarinia tacazze*	2-4	In flowers in the compound and village
Scarlet-chested Sunbird	*Chalcomitra senegalensis*	2	In flowers in the compound and village
Copper Sunbird	*Cinnyris cupreus*	2-3	In flowers in the com-pound and village
Variable Sunbird	*Cinnyris venustus fazoqlensis*	>10	In flowers in the compound and village
Mountain White-eye	*Zosterops poliogastrus*	>6	In flowers in the compound and village
Violet-backed Starling	*Cinnyricinclus leucogaster*	2	In fruiting trees
Swainson's Sparrow	*Passer swainsonii*	>4	In shrub and hedges in the compound and village
Baglafecht Weaver	*Ploceus baglafecht*	>4	In shrub and hedges in the compound and village
Spectacled Weaver	*Ploceus ocularis*	2	1 pair in shrub and hedges in the compound and village

Common name	Scientific name	Specimens counted	Remarks
Village Weaver	*Ploceus cucullatus*	>4	In shrub and hedges in the compound and village
Red-billed Firefinch	*Lagonosticta senegala*	6-8	In shrub and hedges in the compound and village
Bronze Mannikin	*Lonchura cucullata*	6-8	in shrub and hedges of the compound and village
Black-and-white Mannikin	*Lonchura bicolor*	4	At the edge of shrub
African Citril	*Serinus citrinelloides*	4-5	
Streaky Seedeater	*Serinus striolatus*	2	In shrub at the village edge

Bonga Waterfall

1) **Date**: 08.12.2014 1530-1735
GPS position: 07° 16' 00" N / 036° 15' 35" E – 07° 16' 05" N / 036° 16' 15" E, 2026 m – 1840 m a.s.l.
Habitat: village, farmland, shrub, forest, waterfall

Table 16: List of birds found at Bonga Waterfall (Bata Waterfall)

Common name	Scientific name	Specimens counted	Remarks
Hadada Ibis	*Bostrychia hagedash*	4	Flying
Tawny Eagle	*Aquila rapax*	1	Flying
Ayres's Hawk Eagle	*Hieraaetus ayresii*	2	1 pair, mobbing a tawny eagle
Tambourine Dove	*Turtur tympanistria*	3	Heard
White-cheeked Turaco	*Tauraco leucotis*	3	Heard and seen in the forest
Speckled Mousebird	*Colius striatus*	>5	1 flock
Blue-breasted Bee-eater	*Merops variegatus*	3	In farmland
Little Bee-eater	*Merops pusillus*	5	In the village
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	2-3	Heard
Black Saw-wing	*Psalidoprogne pristoptera*	>10	1 flock in the farmland
Common Bulbul	*Pycnonotus barbatus* ssp. *schoanus*	>5	Heard and seen
Rüppell's Robin-chat	*Cossypha semirufa*	3	Wooded areas
Mountain Thrush	*Turdus olivaceus*	3-5	Wooded areas
Abyssinian Ground Thrush	*Zoothera piaggiae*	1	Wooded area at the edge of the village
African Dusky Flycatcher	*Muscicapa adusta*	4	Seen
Brown-throated Wattle-eye	*Platysteira cyanea*	1	Heard
Ethiopian Boubou	*Laniarius aethiopicus*	2-3	Heard
Abyssinian Black-headed Oriole	*Oriolus monacha*	2	heard
Tacazze Sunbird	*Nectarinia tacazze*	4	In farmland, shrub
Variable Sunbird	*Cinnyris venustus* ssp. *fazoqlensis*	>5	Heard and seen
Mountain White-eye	*Zosterops poliogastrus*	>5	At the forest edge
Thick-billed Raven	*Corvus crassirostris*	4	Flying
Swainson's Sparrow	*Passer swainsonii*	5	Heard and seen in farm-land
Bronze Mannikin	*Lonchura cucullata*	6	In the village
Pin-tailed Wydah	*Vidua macroura*	2	2 males, 1 female in farmland

Common name	Scientific name	Specimens counted	Remarks
Village Indigobird	*Vidua chalybeata*	1	In the village
Yellow-fronted Canary	*Serinus mozambicus*	4	In the village

4. Discussion

During our assessment of biodiversity in the Kafa BR, 178 bird species were recorded (Table 16). Twenty-one of these species are Palearctic or African migrants which do not breed in Ethiopia. At least 61 additional species were reliably reported by other sources (Gove et al. 2008; Vinke & Brinkmeier 2010) (Table 17). All in all, at least 239 bird species can be found in the Kafa BR. Berhan (2008) listed 210 bird species for the Kafa BR. Ash & Atkins (2009) show further species in their maps which may occur in the Kafa BR, but it is not feasible to assign them exactly. As we assessed the birds for only about two weeks in the dry season, outside the breeding time of most bird species, our list is undoubtedly incomplete. Most bird species, including rails, fruit and insect eaters, weavers and finches, mate and breed at the beginning or during the rainy season and can be recorded best at that time. Intra-tropical migrants will also be present then, whereas Palearctic migrants will be absent.

For the same reasons, a precise assessment of the abundance of bird populations is impossible (s. Urban & Brown 1971). But for estimation purposes we consider species to be common if they were counted in several study sites or 10 or more specimens were found in a single study site. Twenty-seven of the documented species are restricted to the Afrotropical Highland biome and two to the Somali-Masai biome (Table 18). Thus, many species are restricted to Afrotropical highlands, of which the next closest example is in Kenya, e.g., Mount Kenya and the Aberdare Mountains. We were able to confirm the species listed by EWNHS for the Afrotropical Highland Biome (2008).

Two of the recorded species are endemic to Ethiopia (Abyssinian Longclaw, Abyssinian Catbird), seven are near-endemic (Wattled Ibis, Rouget's Rail, Black-winged Lovebird, White-cheeked Turaco, Banded Barbet, Abyssinian Slaty Flycatcher, Thick-billed Raven) (African Bird Club 2015). A further endemic species, the Yellow-fronted Parrot, has been found by other researchers and should be added to the list. Thus, nearly a third of all endemic and near-endemic bird species in Ethiopia were recorded during our study, and we presume that even more of these species, e.g., the Abyssinian Woodpecker and the White-winged Cliff Chat, occur in the Kafa BR. This once again shows the importance of the area.

Eight of the recorded species are endangered or threatened (BirdLife International 2015) (Table 19) and should be given special attention. The greatest risk to vultures is poisoning, so dead vultures should be sent for toxicology tests. Vulture breeding sites should be strictly protected. Lange (2013) reported a breeding site of different species of vultures on a cliff about 40-50 km east of Bonga.

The presence of the endangered Wattled Crane confers a particular responsibility. During the assessment a successful brood of this impressive bird species was found in Alemgono. This was our only finding for this species across the monitoring sites in Kafa. The exact number of Wattled Cranes in Ethiopia is unknown, and may be less than 200 individuals (Beilfuss 2007). Therefore, we recommend assigning them special protection.

In Africa, the richness of bird species in forested regions, especially in montane forests, is lower than in other areas of the world (Moreau 1966, Grove et al. 2013). The diversity of bird species in the sampled sites of the different montane forests seems to corroborate this. We found few ground-dwelling species, e.g., robin-chats. Most species inhabit the forest canopy. Common species from the upper stratum of the forest include the near-endemic White-cheeked Turaco, the Silvery-cheeked Hornbill, the Crowned Hornbill and Sharpe's Starling. The latter is rare in Ethiopia (Table 16) and is restricted to forest canopies in the African highlands. The occurrence of this species in the bamboo forest clearly depends on the presence of broadleaved trees.

The fact that we found the rare African Crowned Eagle in all larger forests is of special interest. As this species is a large predator, we assume that it mainly feeds on Guerezas (*Colobus polykomos*) (Del Hoyo et al. 1994). Pure bamboo forests seem to be home to few bird species. The number of bird species significantly increases whenever shrub and broadleaved trees grow among the bamboo. Unlike the bamboo forests in South and Southeast Asia or South America, Kafa's bamboo forests have no specialised bird species.

Except for the Gojeb Wetland, the studied wetlands were all influenced by the nearby forests or farmlands. Due to the high mobility of birds, the bird lists for most wetlands include species which are atypical for this habitat. According to our studies, the Gojeb and Alemgono Wetlands are of particular importance for birds. The breeding Wattled Cranes (Alemgono), Black Crowned Cranes, the near-endemic species Rouget's Rail and the Abyssinian Longclaw were all found in these wetlands, thus highlighting the importance of this habitat.

5. Recommendations for Conservation and Monitoring

All kinds of forests are dwindling in Ethiopia for various reasons, e.g., demand for wood, charcoal and farmland as a result of overpopulation. Therefore, all remaining forests should be protected, as they provide diverse ecosystem functions. One of these functions is to conserve a region's water balance.

Wetlands provide an equally important contribution to the water balance; however, they are under threat of drying up and then being converted into farmland. Destruction of the remaining forests and wetlands would be an incalculable threat to the environment. It is therefore important to protect these habitats and monitor their status. A proven method for monitoring the ecological status of habitats is to conduct regular reviews based on indicator species. Birds are particularly suitable as indicator species, because they show changes to habitats on a larger scale. Indicator species should generally be common, typical to the habitats being monitored, and not too difficult to observe and identify.

The African Crowned Eagle, the Wattled Crane and the Black Crowned Crane are recommended as flagship species. These species are large and easy to recognise. The African Crowned Eagle is a forest species. It is not restricted to Ethiopia, but it is rare throughout Africa. The species can be easily noted when calling and is easily seen when flying over forests.

The Wattled Crane and Black Crowned Crane are attractive wetland species. Wattled Cranes are threatened (Table 19), particularly rare in Ethiopia and the population of Ethiopian Wattle Cranes probably has no contact with other populations of the species in southern Africa. Therefore, special attention should be paid to this species. Even though the Black Crowned Crane is not judged to be threatened at this time, this may be necessary in future due to political developments in the area of distribution outside of Ethiopia.

The White-cheeked Turaco and Sharpe's Starling could be good indicator species for monitoring forest conservation status, while the Black Crowned Crane and Rouget's Rail could be good indicator species for wetlands. These species are currently common and not threatened in Ethiopia, but they are dependent on their unique habitat. The White-cheeked Turaco and Rouget's Rail are near endemic, while Sharpe's Starling is restricted to the canopy of high montane forests and is thus uncommon throughout Africa. A decline in these currently common species would show a particularly pronounced threat to their habitat.

The African Finfoot and Half-collared Kingfisher are candidate indicator species for rivers. A decline in the Half-collared Kingfisher would indicate problems with the water quality and structure of the river. The occurrence of the African Finfoot can provide information about disturbances and changes in the structure of the river and its surroundings. However, monitoring this species will be difficult, as the African Finfoot is elusive, not vocally active and mostly hidden in the riparian vegetation.

Even though primary montane forests exhibit a certain tolerance against degradation into wild coffee forest without losing bird species diversity (Gove et al. 2008, 2013), undisturbed forest blocks must be conserved as retreat areas and spread areas of disturbance-sensitive species. Big trees should also be preserved to offer breeding sites for the large cavity-nesting breeders, e.g. hornbills. Old fruit trees are important for offering nourishment to parrots, hornbills, turacos and guereza monkeys. Their continued existence in the Kafa BR can be guaranteed by including forest sites in the core zones.

A survey should be dedicated to the occurrence of the yellow-fronted parrot, which we did not find during our study, but which was observed by others some weeks later. As the species is endemic, it deserves special attention and protection.

The same is true for the wattled crane, which is not endemic but threatened. Our study showed that the species breeds in the Kafa BR, but we do not know how many pairs live there at present, which wetlands they can be found in, where they perform local migrations and what threats they are exposed to.

Finally, vulture breeding sites should be checked and protected, as mentioned above.

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7. Appendix

7.1. Tables

Table 17: List of birds recorded in December 2014 in the Kafa BR, supplemented by birds observed in 2011 by Walter, Schröder and Beisenherz

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Little Grebe *Tachybaptus ruficollis*	RB, c-a	1		Gojeb River
Reed Cormorant *Phalacrocorax africanus*	RB, c-a	1		Gojeb River
Striated Heron *Butorides striata*	RB, fc	1		Gojeb River
Black-headed Heron *Ardea melanocephala*	RB, vc	1		Gojeb Wetland, farmland
Hamerkop *Scopus umbretta*	RB, vc-a	1		Gojeb Wetland, farmland
White Stork *Ciconia ciconia*	PW, c	1		Gojeb Wetland
Woolly-necked Stork *Ciconia episcopus*	RB/AM, fc	2	1	Gojeb Wetland
Hadada Ibis *Bostrychia hagedash*	RB, vc	2		Gojeb Wetland, farmland
Wattled Ibis *Bostrychia carunculata*	RB, E, locally vc	1		On farmland by the road to Jimma near the bridge over the Gojeb River
Egyptian Goose *Alopochen aegyptiaca*	RB, a	1		Wetland
African Black Duck *Anas sparsa*	RB, c	1		On river in the bamboo forest (Holger Meinig)
Yellow-billed Kite *Milvus aegyptius*	RB, a	3		Widespread and common, a recent split from the black kite (*Milvus migrans*)
European Honey-buzzard *Pernis apivorus*	PW/PM, uc		1	
African Fish-eagle *Haliaeetus vocifer*	RB, c	1		At the bridge across the Gojeb River
Hooded Vulture *Necrosyrtes monachus*	RB, c-vc	2		Bonga, Gojeb Wetland
Lappet-faced Vulture *Torgos tracheliotus*	RB, fc	1		One of a flock of vultures in Gojeb Wetland
White-headed Vulture *Trigonoceps occipitalis*	RB, uc	1		One of a flock of vultures in Gojeb Wetland
White-backed Vulture *Gyps africanus*	RB/M, a	2		More than 10 in a flock of vultures in Gojeb Wetland
Rüppell's Vulture *Gyps rueppellii*	RB, c-vc	1		One of a flock of vultures in Gojeb wetland
Western Banded Snake-eagle *Circaetus cinerascens*	RB, uc	1		1 in the gallery forest in Gojeb wetland
Short-toed Snake-eagle *Circaetus gallicus*	PW, fc		1	
Bateleur *Terathopius ecaudatus*	RB, c	1	1	1 in savannah near street to Jimma, 1 near bamboo forest (Holger Meinig)
Western Marsh-harrier *Circus aeruginosus*	PW, c	1		In Gojeb wetland

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Montagu's Harrier *Circus pygargus*	PW/PM, c	1		Overflying
African Goshawk *Accipiter tachiro*	RB, a	1		In forests of Komba, Boka, at the trail to the hot springs, near bamboo forest
Rufous-breasted Sparrowhawk *Accipiter rufiventris*	RB, uc	1		Forest at Medabo Forest road
Augur Buzzard *Buteo augur*	RB, vc	2		Widespread and common
Common Buzzard *Buteo buteo*	PW/PM, locally a	1		1
Greater Spotted Eagle *Aquila clanga*	PW/PM, uc	1		1
Tawny Eagle *Aquila rapax*	RB, vc	1		2
Steppe Eagle *Aquila nipalensis*	PW/PM, vc-a	1		1
Ayres's Hawk-eagle *Hieraaetus ayresii*	RB, uc	1		A pair attacking a tawny eagle at the waterfall near Bonga
Long-crested Eagle *Lophaetus occipitalis*	RB, c- vc	1		1 near Komba Forest, 1 at the trail to the hot springs, 1 in Alemgono
African Crowned Eagle *Stephanoaetus coronatus*	RB, uc-r	1		Several above forests: Komba, Boka, bamboo forest, Boginda
African Hobby *Falco cuvierii*	RB, uc	1		1
Common Kestrel *Falco tinnunculus*	RB/PW, c	1		In Gojeb Wetland
Helmeted Guineafowl *Numida meleagris*	RB, c-a	2		A flock in Alemgono
Common Quail *Coturnix coturnix*	PW/RB, c-a when present	1		In Gojeb Wetland
Chestnut-naped Francolin *Francolinus castaneicollis*	RB, locally c	1	1	In the bambolo forest, Alemgono and in Gojeb Wetlands
Scally Francolin *Francolinus squamatus*	RB, lc	1		In Komba Forest
Rouget's Rail *Rougetius rougetii*	RB, E, vc	2	2	In Gojeb Wetland, Alemgono and Boka Wetlands
Black Crake *Amaurornis flavirostra*	RB, c-vc	1		1 in Alemgono
African Rail *Rallus caerulescens*	RB, uc	1		1 in Alemgono
Wattled Crane *Bugeranus carunculatus*	RB, r	1	1	Alemgono: 2 pairs, 1 juv.
Black Crowned Crane *Balearica pavonina*	RB, c-locally a	2		Wetlands (e.g. Alemgono, Gojeb) at least 5 pairs with juveniles
African Finfoot *Podica senegalensis*	R, uc-r			1 female at bridge over river in Gojeb Wetland
African Wattled Lapwing *Vanellus senegallus*	RB, c	1		Wetlands (e.g. Alemgono, Gojeb)
Green Sandpiper *Tringa ochropus*	PW/PM, c	1		In Alemgono Wetland
Wood Sandpiper *Tringa glareola*	PW/PM, c	1		At Gojeb River near road to Jimma, Gojeb Wetland, Alemgono
Common Sandpiper *Actitis hypoleucos*	PW/PM, vc	1		At Gojeb River near road to Jimma, at bridge over river in Gojeb Wetland

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Common Snipe *Gallinago gallinago*	PW/PM, vc	1		In Alemgono Wetland
African Green-pigeon *Treron calvus*	RB, uc	1		In forest near Shoriri Wetland
Bruce's Green-pigeon *Treron waalia*	RB, c	1		1 in Komba Forest
Speckled Pigeon *Columba guinea*	RB, c	2		Villages, edge of forests
African Olive Pigeon *Columba arquatrix*	RB, locally c	1		Broadleaved forest
Tambourine Dove *Turtur tympanistria*	RB, fc-vc	2	1	Widespread and common
Blue-spotted Wood-dove *Turtur afer*	RB, c-vc	2	1	Widespread and common
Dusky Turtle-dove *Streptopelia lugens*	RB, c	1		Villages
Red-eyed Dove *Streptopelia semitorquata*	RB, c-vc	2		Widespread and common
Lemon Dove *Aplopelia larvata*	RB, uc-locally c	1		Near Gojeb bridge on road to Jimma
Black-winged Lovebird *Agapornis taranta*	RB, E, c	1		Komba Forest, heard
White-cheeked Turaco *Tauraco leucotis*	RB, c-locally vc	3	1	Broadleaved forest
African Emerald Cuckoo *Chrysococcyx cupreus*	RB, locally c	1		Heard on KDA compound and in Boka Forest
Klaas's Cuckoo *Chrysococcyx klaas*	RB, c	1		1 in Komba Forest
Blue-headed Coucal *Centropus monachus*	RB, c-vc	1		In Alemgono and Gojeb Wetlands
African Wood Owl *Strix woodfordii*	RB, r	1		Heard at the KDA Guesthouse
Abyssinian/Montane Nightjar *Caprimulgus poliocephalus*	RB, uc	1		2 heard in Alemgono, 1 seen on road from Bonga to Boka Forest
Little Swift *Apus affinis*	RB, locally c	2		Old bridge across Gojeb River on road to Jimma, Gojeb Wetland
Speckled Mousebird *Colius striatus*	RB, a	3		Widespread and common
Striped Kingfisher *Halcyon chelicuti*	RB, c	1		Gallery forest on road to Jimma, Shoriri Wetland
Malachite Kingfisher *Alcedo cristata*	RB, fc	1		At Gojeb River
African Pygmy Kingfisher *Ceyx pictus*	RB, c	1		near KDA Guessthouse compound, in Gojeb Wetland
Half-collared Kingfisher *Alcedo semitorquata*	RB, uc	1		At the bridge over Gojeb River, breeding (?)
Grey-headed Kingfisher *Halcyon leucocephala*	RB/AM, a		1	
Pied Kingfisher *Ceryle rudis*	RB, c-vc	1		At Gojeb River
Giant Kingfisher *Megaceryle maxima*	RB, fc	1		At Gojeb River
Little Bee-eater *Merops pusillus*	RB, c	2		Widespread and common

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Blue-breasted Bee-eater *Merops variegatus*	RB, c	1		Forest clearing at the trail to hot springs, in KDA compound
White-throated Bee-eater *Merops albicollis*	AM, c	1	2	Farmland in Gojeb Wetland, Alemgono
European Bee-eater *Merops apiaster*	PW/P, vc	2	3	Several flocks seen and heard
Northern Carmine Bee-eater *Merops nubicus*	RB, vc	1		1 / flying
Broad-billed Roller *Coracias glaucurus*	RB, fc	1		1 / Komba Forest
African Grey Hornbill *Tockus nasutus*	RB/AM, c	1		Overflying KDA Guesthouse
Crowned Hornbill *Tockus alboterminatus*	RB, uc	1		In forest on the trail to the hot springs, forest at Medabo road, Komba Forest
Silvery-cheeked Hornbill *Bycanistes brevis*	RB, c	2		Widespread and common in forests
Yellow-fronted Tinkerbird *Pogoniulus chrysoconus*	RB, uc	2		Widespread in trees in villages and forests
Banded Barbet *Lybius undatus*	RB, E, fc	1		1 in trees on KDA compound, Komba Forest
Double-toothed Barbet *Lybius bidentatus*	RB, uc		1	
Greater Honeyguide *Indicator indicator*	RB, c-fc	1		1 in Komba Forest
Lesser Honeyguide *Indicator minor*	RB, fc	1		1 on KDA compound, more heard in forests, e.g. Komba
Eurasian Wryneck *Jynx torquilla*	PM, fc		1	
Nubian Woodpecker *Campethera nubica*	RB, c	1		1 in Komba Forest
Grey-headed Woodpecker *Dendropicos spodocephalus*	RB, fc	1		1 in Komba Forest, recent split from grey wood-pecker (D. goertae)
Cardinal Woodpecker *Dendropicos fuscescens*	RB, c	1	1	in gallery forest in Gojeb Wetland, in forest on the trail to the hot springs
Common Sand Martin *Riparia riparia*	PW, c-vc	2		Several in mixed flocks of swallows
Banded Martin *Riparia cincta*	RB/AM, locally c	1		Few in mixed flocks of swallows
Lesser Striped Swallow *Cecropis abyssinica*	RB, locally vc	2		Night roost at the bridge across the Gojeb River
Wire-tailed Swallow *Hirundo smithii*	RB, locally c	1	2	Some at the bridge across the Gojeb River and on the road to Jimma crossing the Gojeb River
Barn Swallow *Hirundo rustica*	PW/PM, a	3		Most common swallow
Black Saw-wing *Psalidoprogne pristoptera*	RB, c	2		Several flocks at different locations
Yellow Wagtail *Motacilla flava*	PW/PM, vc-a	3-4		Widespread on farmland and in wetlands, if there were grazed areas
Grey Wagtail *Motacilla cinerea*	PW, c	1	1	Widespread at rivers, only few specimens
Mountain Wagtail *Motacilla clara*	RB, c	1		Widespread near water
African Pied Wagtail *Motacilla aguimp*	RB, fc	1	1	Only 1 at Gojeb River

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
African/Grassland Pipit *Anthus cinnamomeus*	RB, c	2	1	On grazed areas in Alemgono and Gojeb Wetlands
Red-throated Pipit *Anthus cervinus*	PW/PM, vc-a	3		Flocks in wetlands if there were short grazed areas
Abyssinian Longclaw *Macronyx flavicollis*	RB, E, c	2	2	At least 5 pairs in Alemgono Wetland and 5 specimens in Gojeb Wetland
Grey Cuckooshrike *Coracina caesia*	RB, locally c	1	1	In Komba Forest, recorded in 2011 in forest on Medabo Forest Road
Common Bulbul *Pycnonotus barbatus schoanus*	RB, a	3		Widespread and common in villages and forests
Rüppell's Robin-chat *Cossypha semirufa*	RB, c	2		Widespread: common in gardens, less common in forests
Red-capped Robin-chat *Cossypha natalensis*	RB, uc-locally c	1		Three times in Komba Forest
Snowy-headed Robin-chat *Cossypha niveicapilla*	RB, locally c	1		Only 1 in the forest on the trail to the hot springs
Common Stonechat *Saxicola torquatus*	RB/PW, c	2		In Alemgono, Gojeb (ssp. *maura*) and Boka Wetlands, on farmland near Boka (ssp. *albofasciatus*)
Whinchat *Saxicola rubetra*	PW/PM, c	1		Some in wetlands
Pied Wheatear *Oenanthe pleschanka*	PW/PM, vc	1		Some on farmland
Abyssinian Ground Thrush *Zoothera piaggiae*	RB, uc-locally fc	1		Near waterfall in Bonga, in the forest on trail to hot springs, in savannah by Gojeb River
Mountain Thrush *Turdus olivaceus*	RB, c-sometimes vc	2		Most common thrush, very common in fruiting trees
African Thrush *Turdus pelios*	RB, c	1		1 in savannah at Gojeb River
Cinnamon Bracken Warbler *Bradypterus cinnamomeus*	RB, c	2		Commonly heard in scrub and at edges of forests
Dark-capped Yellow Warbler *Chloropeta natalensis*	RB, uc	1		Twice: savannah at Gojeb River and at the edge of forest in Boka
Willow warbler *Phylloscopus trochilus*	PW/PM, c-a	1		Singing twice
Common Chiffchaff *Phylloscopus collybita*	PW/PM, c	2		Most common Phylloscopus warbler
Brown Woodland Warbler	RB, fc	2		Common in forests: Komba, Boka, forest on the trail to the hot springs, forest at Medabo Forest road, parts of bamboo forest
Blackcap *Sylvia atricapilla*	PW/PM, locally vc	2	1	Mostly individuals, 1 feeding flock in the forest on the trail to the hot springs
Lesser Whitethroat *Sylvia curruca*	PW/PM, c	1		Once
Singing Cisticola *Cisticola cantans*	RB, fc	1		2 at the edge of forest at Komba and Boka
Ethiopian Cisticola *Cisticola lugubris*	RB, c, nE	1		1 pair in Doma Wetland
Stout Cisticola *Cisticola robustus*	RB, c	1		2 pairs in Gojeb Wetland
Tawny-flanked Prinia *Prinia subflava*	RB, c	1		Widespread: gardens, edge of forests
Grey-backed Camaroptera *Camaroptera brachyura*	RB, vc	2	1	Widespread and common: hedges, edge of forests, shrub

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Abyssinian Slaty Flycatcher *Melaenornis chocolatinus*	RB, E, c	2		Several around Bonga, in gardens, at edge of forests and in Alemgono, Boka Forest and Komba Forest, on KDA compound
Northern Black Flycatcher *Melaenornis edolioides*	RB, c	1		1 flock (family ?) in gallery forest at Gojeb River on the road to Jimma, in gallery forest near Gojeb Wetland, and in Komba Forest
African Dusky Flycatcher *Muscicapa adusta*	RB, c	2		Widespread and common
African Paradise Flycatcher *Terpsiphone viridis*	RB, vc	2		Widespread and common
Brown-throated Wattle-eye *Platysteira cyanea*	RB, locally fc	2		Moderately common in most forests
Black-headed Batis *Batis minor*	RB, c	2		In wooded areas, forests
White-rumped Babbler *Turdoides leucopygia omoensis*	RB, c	2		Surroundings of Alemgono, Gojeb Wetlands and Komba Forest
Abyssinian Catbird *Parophasma galinieri*	RB, E, uc-locally vc	1		Komba and Boka Forest, near bamboo forest, forest on trail to hot springs, more often heard than seen
Scarlet-chested Sunbird *Chalcomitra senegalensis*	RB, c	1		Some specimens near and in Bonga, surroundings of Komba Forest
Tacazze Sunbird *Nectarinia tacazze*	RB, c	2		Widespread and common
Olive Sunbird	RB, uc	1		1
Variable Sunbird *Cinnyris venustus* ssp. *fazoqlensis*	RB, c-vc	3		Widespread and common if there were flowers, most common sunbird
Copper Sunbird *Cinnyris cupreus*	RB, locally uc-vc	1	1	Mostly near or in Bonga, e.g., KDA compound
Mountain White-eye *Zosterops poliogastrus*	RB, c	2		Widespread and common
Abyssinian White-eye *Zosterops abyssinicus*	RB, c	1		Village and savannah by Gojeb River
Common Fiscal *Lanius collaris*	RB, c-vc	1		KDA compound, near Komba forest, at Boka Wetland, in Alemgono Wetland
Northern Puffback *Dryoscopus gambensis*	RB, c	1	1	Forest near Shoriri Wetland, forest at Medabo Forest road, Komba Forest, Boka Forest, forest at Gojeb Wetland
Ethiopian Boubou *Laniarius aethiopicus*	RB, c-locally vc	2		Widespread and common
Abyssinian Black-headed Oriole *Oriolus monacha*	RB, E, fc	2		Widespread and common
Cape Crow *Corvus capensis*	RB, c	1		Only some in farmland
Thick-billed Raven *Corvus crassirostris*	RB, E, c	2		Most common Corvidae
Stuhlmann's Starling *Poeoptera stuhlmanni*	RB, locally fc	1		2 birds in forest on Medabo Forest road
Slender-billed Starling *Onychognathus tenuirostris*	R, locally c	2	2	Several flocks near waterfall in Bonga and in the forest on Medabo Forest road
Red-winged Starling *Onychognathus morio*	RB, c	1		Few flocks
Greater Blue-eared Starling *Lamprotornis chalybaeus*	RB, vc	3		Large flocks in Gojeb Wetland

Name	Status in Ethiopia (Ash & Atkins 2009)	Number of occurrences in 2014	Number of occurrences in 2011	Remarks
Violet-backed Starling *Cinnyricinclus leucogaster*	RB, c-sometimes vc	1		On KDA compound, savannah by Gojeb River, Shoriri Wetland
Sharpe's Starling *Pholia sharpii*	RB, uc	2		In canopy of broadleaved forests: Boka, forest on Medabo Forest Road, forest on trail to the hot springs; in bamboo forest where there were broadleaved trees between the bamboo
Red-billed Oxpecker *Buphagus erythrorhynchus*	RB, c	1		Accompanying cattle in Gojeb Wetland
Swainson's Sparrow *Passer swainsonii*	RB, c-vc	2		Widespread in villages and farmland
Baglafecht Weaver *Ploceus baglafecht*	MB, vc	2		In villages, on farmland and at edge of forest
Spectacled Weaver *Ploceus ocularis*	RB, c	1		Individual pairs near villages
Village Weaver *Ploceus cucullatus*	R, vc	3		Most common weaver
Red-collared Widowbird *Euplectes ardens*	RB, c	2		In wetlands: Alemgono, Gojeb, Shorori
Fan-tailed Widowbird *Euplectes axillaris*	RB, uc	3		In wetlands: Alemgono, Gojeb, Shorori
Crimson Waxbill *Estrilda rhodopyga*	RB, c	1		Surroundings of Komba Forest and KDA Guesthouse
Common Waxbill *Estrilda astrild*	RB, locally c	2	1	On farmland at the edge of Boka Forest
Yellow-bellied Waxbill *Coccopygia quartinia*	RB, c	1		1
Red-cheeked Cordon-bleu *Uraeginthus bengalus*	RB, c-vc	2		Widespread and common in villages and on farmland
Red-billed Firefinch *Lagonosticta senegala*	RB, vc	2		Widespread and common in villages and on farmland
Bronze Mannikin *Lonchura cucullata*	RB, c-vc	2		widespread and common
Black-and-white Mannikin *Lonchura bicolor*	RB, very locally c	1		Pairs and small flocks in wetland and at edge of forest
Pin-tailed Wydah *Vidua macroura*	RB, c	1		Few near wetlands
Village Indigobird *Vidua chalybeata*	RB, c	1		Few in villages in which red-billed firefinches were also found
African citril *Serinus citrinelloides*	RB, uc	2		Widespread and common
Yellow-fronted Canary *Serinus mozambicus*	RB, c-vc	2		In bamboo forest and savannah at Gojeb River
White-rumped Seedeater *Serinus leucopygius*	RB, uc-c	1		Savannah at Gojeb River
Streaky Seedeater *Serinus striolatus*	RB, c-vc	2		Around Bonga, surroundings of Alemgono and Gojeb Wetlands
Brown-rumped Seedeater *Serinus tristriatus*	RB	1		Only once

Abbreviations:

A = Africa
B = Breeding confirmed
M = Migrant
P = breeds in Palaearctic
R = Resident
W = winters
E = endemic or near endemic
a = abundant
vc = very common
c = common
fc = fairly common
uc = uncommon
r = rare
1 = 1-10 Ex.
2 = 11-100 Ex.
3 = 101-1000 Ex.

Table 18: List of additional bird species found in the Kafa BR by other investigators: 1) Gove, et al. (2008) 2) Vinke & Brinkmeier (2010) 3) Putze, Miersch & Winkler (2014)

English name	Scientific name	Cited publication
Darter	*Anhinga rufa*	2
Cattle Egret	*Bubulcus ibis*	2
Great White Egret	*Ardea alba*	2
Grey Heron	*Ardea cinerea*	2
Abdim's Stork	*Ciconia abdimii*	2
White-faced Whistling-duck	*Dendrocygna viduata*	3
Yellow-billed Duck	*Anas undulata*	2
African harrier-hawk	*Polyboroides typus*	1, 2
Black Sparrowhawk	*Accipiter melanoleucus*	2, 3
Red-chested Flufftail	*Sarothrura rufa*	3
African Snipe	*Gallinago nigripennis*	2
Emerald-spotted Wood-dove	*Turtur chalcospilos*	1
African Mourning Dove	*Streptopelia decipiens*	2
Yellow-fronted Parrot	*Poicephalus flavifrons*	1, 2, 3
Jacobin Cuckoo	*Clamator jacobinus*	1
Red-chested Cuckoo	*Cuculus solitaries*	1, 2
Black Cuckoo	*Cuculus clamosus*	2
Senegal Coucal	*Centropus senegalensis*	1
Verreaux's Eagle-owl	*Bubo lacteus*	2
Narina Trogon	*Apaloderma narina*	1, 2
Nyanza Swift	*Apus niansae*	2
Woodland Kingfisher	*Halcyon senegalensis*	2
Cinnamon-chested Bee-eater	*Merops oreobates*	2
Abyssinian Ground-hornbill	*Bucorvus abyssinicus*	2
Red–fronted Barbet	*Tricholaema diademata*	1
Black-billed Barbet	*Lybius guifsobalito*	1, 2
Red-throated Wryneck	*Jynx ruficollis*	2
Bearded Woodpecker	*Dendropicos namaquus*	1
African Sand Martin	*Riparia paludicola*	2
Mosque Swallow	*Hirundo senegalensis*	2
Red-rumped Swallow	*Hirundo daurica*	2
African Rock Martin	*Hirundo fuligula*	2
House Martin	*Delichon urbicus*	2
African Pied Wagtail	*Motacilla aguimp*	2
Red-shouldered Cuckooshrike	*Campephaga phoenicea*	1, 2
Black Cuckooshrike	*Campephaga flava*	2
Ground-scraper Thrush	*Psophocichla litsipsirupa*	2
White-browed Robin Chat	*Cossypha heuglini*	1, 2
Northern Wheatear	*Oenanthe oenanthe*	2
Isabelline Wheatear	*Oenanthe isabellina*	2
Hill Chat	*Cercomela sordida*	2
Red-faced Cisticola	*Cisticola erythrops*	1, 2
Red-fronted Warbler	*Urorhipis rufifrons*	2
Grey-headed Batis	*Batis orientalis*	2
Spotted Creeper	*Salpornis spilonotus*	1, 2
Collared Sunbird	*Hedydipna collaris*	1
Marsh Tchagra	*Tchagra minutus*	1, 2

English name	Scientific name	Cited publication
Black-crowned Tchagra	*Tchagra senegallus*	2
Grey-headed Bushshrike	*Malaconotus blanchoti*	2
Sulphur-breasted Bushshrike	*Telophorus sulfureopectus*	2
Fan-tailed Raven	*Corvus rhipidurus*	2
Red-winged Starling	*Onychognathus morio*	1, 2
Lesser Masked Weaver	*Ploceus intermedius*	2
Black-headed Weaver	*Ploceus melanocephalus*	2
Red-billed Quelea	*Quelea quelea*	2
Northern Red Bishop	*Euplectes franciscanus*	2
Black Bishop	*Euplectes gierowii*	2
Red Bishop	*Euplectes orix*	2
Yellow-mantled Widowbird	*Euplectes macroura*	2
Swee Waxbill	*Estrilda melanotis*	2

Table 19: Biome-restricted species in Ethiopia (according to Ash & Atkins 2009) which were observed in the Kafa BR

English name	Scientific name
Afrotropical Highland Biome	
Chestnut-naped Francolin	*Francolinus castaneicollis*
Rouget's Rail	*Rougetius rougetii*
Dusky Turtle-dove	*Streptopelia lugens*
Black-winged Lovebird	*Agapornis taranta*
Yellow-fronted Parrot	*Poicephalus flavifrons*
White-cheeked Turaco	*Turaco leucotis*
Abyssinian/Montane Nightjar	*Caprimulgus poliocephalus*
Banded Barbet	*Lybius undatus*
Abyssinian Black-headed Oriole	*Oriolus monacha*
Thick-billed Raven	*Corvus crassirostris*
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*
Brown Woodland Warbler	*Phylloscopus umbrovirens*
Abyssinian Catbird	*Parophasma galinieri*
Montane White-eye	*Zosterops poliogastrus*
Slender-billed Starling	*Onychognathus tenuirostris*
Stuhlmann's Starling	*Poeoptera stuhlmanni*
Sharpe's Starling	*Pholia sharpii*
Abyssinian Ground Thrush	*Zoothera piaggiae*
Rüppel's Robin-chat	*Cossypha semirufa*
Abyssinian Slaty Flycatcher	*Melaenornis chocolatinus*
Tacazze Sunbird	*Nectarinia tacazze*
Swainson's Sparrow	*Passer swainsonii*
Baglafecht Weaver	*Ploceus baglafecht*
Abyssinian Longclaw	*Macronyx flavicollis*
African Citril	*Serinus citrinelloides*
Brown-rumped Seedeater	*Serinus tristriatus*
Streaky Seedeater	*Serinus striolatus*
Somali-Masai Biome	
White-rumped Babbler	*Turdoides leucopygia*
Abyssinian White-eye	*Zosterops abyssinicus*

Table 20: Threat categories according to BirdLife International species fact sheets (January 2015)

English name	Scientific name	Threat category
Hooded Vulture	*Necrosyrtes monachus*	endangered
Lappet-faced Vulture	*Torgos tracheliotus*	vulnerable
White-headed Vulture	*Trigonoceps occipitalis*	vulnerable
White-backed Vulture	*Gyps africanus*	endangered
Rüppell's Vulture	*Gyps rueppellii*	endangered
Bateleur	*Terathopius ecaudatus*	near threatened
Greater Spotted Eagle	*Aquila clanga*	vulnerable
Wattled Crane	*Bugeranus carunculatus*	vulnerable

Table 21: List of birds recorded in December 2014 in the Kafa BR, threat status and endemism

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Tachybaptus ruficollis	Podicipedidae	Little Grebe	river	GO-riv	On Gojeb River			
Phalacrocorax africanus	Phalacrocoracidae	Reed Cormorant	river	GO-riv	On Gojeb River			
Butorides striata	Ardeidae	Striated Heron	river	GO-riv	At Gojeb River			
Ardea melanocephala		Black-headed Heron	wetland, farmland	GO-wet	In Gojeb Wetland, on farmland			
Scopus umbretta	Scopidae	Hamerkop	wetland, farmland		Wetland, farmland			
Ciconia ciconia	Ciconiidae	White Stork	wetland	GO-wet	In Gojeb Wetland			
Ciconia episcopus		Woolly-necked Stork	wetland	GO-wet	In Gojeb Wetland			
Bostrychia hagedash	Threskiornithidae	Hadada Ibis	wetland, farmland	GO-wet, AG	In Alemgono, Gojeb Wetlands, farmland			
Bostrychia carunculata		Wattled Ibis	farmland, river	AG	On farmland by the road to Jimma near bridge over Gojeb River, Alemgono			near-endemic
Alopochen aegyptiaca	Anatidae	Egyptian Goose	wetland		Wetland			
Anas sparsa		African Black Duck	river	BA	On river in the bamboo forest (Holger Meinig)			
Milvus aegyptius	Accipitridae	Yellow-billed Kite			Widespread and common		2	
Pernis apivorus		European Honey-buzzard					2	
Haliaeetus vocifer		African Fish-eagle	river	GO-riv	At the bridge across the Gojeb River		2	
Necrosyrtes monachus		Hooded Vulture		GO-wet	In Bonga, in Gojeb Wetland	endan-gered	2	
Torgos tracheliotus		Lappet-faced Vulture		GO-wet	One in a flock of vultures in Gojeb Wetland	vulnerable	2	

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Trigonoceps occipitalis		White-headed Vulture		GO-wet	One in a flock of vultures in Gojeb Wetland	vulnerable	2	
Gyps africanus		White-backed Vulture		KO, GO-wet	More than 10 in a flock of vultures in Gojeb Wetland	endan-gered	2	
Gyps rueppellii		Rüppell's Vulture		GO-wet	1 in a flock of vultures in Gojeb Wetland	endan-gered	2	
Circaetus cinerascens		Western Banded Snake-eagle		GO-riv	1 in the gallery forest in Gojeb Wetland		2	
Circaetus gallicus		Short-toed Snake-eagle			Seen in 2011		2	
Terathopius ecaudatus		Bateleur		BA	1 in savannah near road to Jimma, 1 near bamboo forest (Holger Meinig)	near threat-ened	2	
Circus pygargus		Montagu's harrier	farmland	KDA-GH	Overflying		2	
Circus aeruginosus		Western Marsh-harrier	wetland	AG, GO-wet	In Alemgono, Gojeb wetlands		2	
Accipiter tachiro		African Goshawk	forests	KO, BK, BA	In forests of Komba, Boka, on the trail to the hot springs, near bamboo forest		2	
Accipiter rufiventris		Rufous-breasted Sparrowhawk	forest	BO	Forest by Medabo Forest road		2	
Buteo augur		Augur Buzzard			Widespread and common		2	
Buteo buteo		Common Buz-zard		BK	1		2	
Aquila clanga		Greater Spotted Eagle			1	vulnerable	2	
Aquila rapax		Tawny Eagle		KDA-GH	2		2	
Aquila nipalensis		Steppe Eagle			1		2	
Hieraaetus ayresii		Ayres's Hawk-eagle		KDA-GH	A pair attacking a tawny eagle at the waterfall near Bonga		2	
Lophaetus occipitalis		Long-crested Eagle		KO, BO, AG	1 near Komba For-est, 1 on the trail to the hot springs		2	
Stephanoaetus coronatus		African Crowned Eagle	forests	KO, BK, BA, GO-wet	Several above for-ests: Komba, Boka, bamboo forest		2	
Falco cuvierii	Falconidae	African Hobby		GO-wet	1		2	
Falco tinnunculus		Common Kestrel	wetland, farmland	GO-wet	In Gojeb Wetland		2	
Numida meleagris	Numididae	Helmeted Guin-eafowl		AG	A flock in Alemgono			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Coturnix coturnix	Phasianidae	Common Quail	wetland, farmland	GO-wet	In Gojeb Wetland			
Francolinus casta-neicollis		Chestnut-naped Francolin	bamboo forest, wetland	BA, AG, GO-wet	in the bamboo forest and in Gojeb Wetland			
Francolinus squamatus		Scally Francolin	forest	KO	In Komba Forest			
Rallus caerulescens	Rallidae	African Rail	wetland	AG				
Rougetius rougetii		Rouget's Rail	wetland	GO-wet, BK, AG	In Gojeb Wetland, Alemgono and Boka Wetlands			near-endemic
Amaurornis flavirostra		Black Crake	wetland	AG	1 in Alemgono			
Bugeranus carunculatus	Gruidae	Wattled Crane	wetland	AG	Alemgono: 2 pairs, 1 juv.	vulnerable	2	
Balearica pavonina		Black Crowned Crane	wetland	AG, GO-wet	Wetlands (e.g., Alemgono, Gojeb) at least 5 pairs with juv.		2	
Podica senegalensis	Heliornithidae	African Finfoot	river	GO-riv	1 female at bridge over river in Gojeb Wetland			
Vanellus senegallus	Charadriidae	African Wattled Lapwing	wetland	GO-wet, AG	Wetlands (e.g., Alemgono, Gojeb)			
Tringa ochropus	Scolopacidae	Green Sand-piper	wetland	AG	In Alemgono Wetland			
Tringa glareola		Wood Sandpiper	wetland	GO-wet, AG	At Gojeb River near road to Jimma			
Actitis hypoleucos		Common Sand-piper	wetland	GO-wet	At Gojeb River near road to Jimma, at bridge over river in Gojeb Wetland			
Gallinago gallinago		Common Snipe	wetland	AG				
Treron calvus	Columbidae	African Green-pigeon	forest	SHO	In forest near Shoriri Wetland			
Treron waalia		Bruce's Green-pigeon	forest	KO	1			
Columba guinea		Speckled Pigeon	villages, forest	KDA-GH	Villages, forest			
Colomba arquatrix		African Olive Pigeon	broadleaf forest	BA, BO	Broadleaf forest			
Turtur tympanistria		Tambourine Dove			Widespread and common			
Turtur afer		Blue-spotted Wood-dove			Widespread and common			
Streptopelia lugens		Dusky Turtle-dove	village					
Streptopelia semitorquata		Red-eyed Dove			Widespread and common			
Aplopelia larvata		Lemon Dove	forest		At Gojeb River near road to Jimma			
Agapornis taranta		Black-winged Lovebird	forest	KO	Heard		2	near-endemic

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Tauraco leucotis	Musophagidae	White-cheeked Turaco	broadleaf forest		Widespread and common		2	near-endemic
Chrysococcyx cupreus	Cuculidae	African Emerald Cuckoo		KDA-GH, BK	Heard on KDA compound and in Boka Forest			
Chrysococcyx klaas		Klaas's Cuckoo		KO	1 in Komba Forest			
Centropus monachus		Blue-headed Coucal		AG, GO-wet	In Alemgono and Gojeb Wetlands			
Strix woodfordii	Strigidae	African Wood-owl		KDA-GH	Heard at night			
Caprimulgus poliocephalus	Caprimulgidae	Abyssinian/ Montane Nightjar		AG, BK	2 heard in Alemgono, 1 seen on road from Bon-ga to Boka Forest			
Apus affinis	Apodidae	Little Swift		GO-riv	Old bridge across Gojeb River on road to Jimma			
Colius striatus	Coliidae	Speckled Mousebird			Widespread and common			
Halcyon leucocephala	Alcedinidae	Grey-headed Kingfisher			Seen in 2011			
Halcyon chelicuti		Striped King-fisher		GO-riv, SHO	Gallery forest on road to Jimma			
Alcedo cristata		Malachite King-fisher		GO-riv	1			
Ceyx pictus		African Pygmy Kingfisher	edge of forest	KDA-GH, GO-wet	Near KDA com-pound, in Gojeb Wetland			
Alcedo semitorquata		Half-collared Kingfisher	river	GO-riv	On bridge over Gojeb River, breeding (?)			
Megaceryle max-ima		Giant Kingfisher		GO-riv	Once			
Ceryle rudis		Pied Kingfisher	river	GO-riv	By Gojeb River and Gojeb Wetland			
Merops pusillus	Meropidae	Little Bee-eater			Widespread and common			
Merops variegatus		Blue-breasted Bee-eater		KDA-GH, KO	1, forest clearing on the trail to hot springs			
Merops albicollis		White-throated Bee-eater	farmland, wetland	GO-wet, AG	Farmland at Gojeb Wetland, Gojeb on the road to Jimma			
Merops apiaster		European Bee-eater		GO-wet	Several flocks seen and heard			
Merops nubicus		Northern Car-mine Bee-eater			1, flying			
Coracias glaucurus	Coraciidae	Broad-billed Roller		KO	1, Komba Forest			
Tockus alboterminatus	Bucerotidae	Crowned Hornbill	forest	BO, KO	In forest on the trail to the hot springs, forest by Medabo Forest road, Komba Forest			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Tockus nasutus		African Grey Hornbill		KDA-GH	1, overflying			
Bycanistes brevis		Silvery-cheeked Hornbill	forest		Widespread and common in forests			
Pogoniulus chrysoconus	Ramphastidae	Yellow-fronted Tinkerbird			Widespread and common in trees in villages and forests			
Lybius undatus		Banded Barbet		KDA-GH, KO,	1 in trees on KDA compound			near-endemic
Lybius bidentata		Double-toothed Barbet			Seen in 2011			
Indicator indicator	Indicatoridae	Greater Honey-guide		KO	1			
Indicator minor		Lesser Honey-guide		KDA-GH, KO, GO-riv	1 on KDA com-pound, some more heard in forests, e.g., Komba			
Jynx torquilla	Picidae	Eurasian Wryneck			Seen in 2011			
Campethera nubica		Nubian Wood-pecker		KO	1			
Dendropicos spodocephalus		Grey-headed Woodpecker	forest	KO	1 in Komba Forest			
Dendropicos fuscescens		Cardinal Woodpecker	forest	GO-riv, BO	In gallery forest in Gojeb Wetland, in forest on the trail to the hot springs			
Riparia riparia	Hirundinidae	Common Sand Martin	wetland	AG	Several in mixed flocks of swallows			
Riparia cincta		Banded Martin		AG, GO-riv	Few in mixed flocks of swallows			
Cecropis abyssinica		Lesser Striped Swallow		GO-riv	A night roost at the bridge across the Gojeb River			
Hirundo smithii		Wire-tailed Swallow		GO-riv	Some at the bridge across the Gojeb River and at Gojeb River on the Bonga – Jimma road			
Hirundo rustica		Barn Swallow			Most common swallow			
Psalidoprogne pristoptera		Black Saw-wing		GO-riv, KO	Several flocks			
Motacilla flava		Yellow Wagtail	farmland, wetlands		Widespread and common on farmland and in wetlands, if there were grazed areas			
Motacilla cinerea		Grey Wagtail	rivers	BA, BK, KO, GO-riv	Widespread at rivers, only few specimens			
Motacilla clara		Mountain Wagtail		BK, GO-riv	Widespread near water			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Motacilla aguimp		African Pied Wagtail			Only 1 at Gojeb River			
Anthus cinnamomeus		African/ Grassland Pipit	grazed areas in wetland	AG, GO-wet	In Alemgono and Gojeb Wetlands			
Anthus cervinus		Red-throated Pipit	wetlands	AG, GO-wet	Flocks in wetlands if there were short grazed areas			
Macronyx flavicollis		Abyssinian Longclaw	wetland	AG, GO-wet	At least 5 pairs in Alemgono and 5 specimens in Gojeb Wetland			endemic
Coracina caesia	Campephagidae	Grey Cuck-ooshrike	forest	KO, BO	In Komba Forest, recorded in 2011 in forest by Medabo Forest road			
Pycnonotus bar-batus								
ssp. *schoanus*	Pycnonotidae	Common Bulbul			Widespread and common in villag-es and forests			
Cossypha semirufa	Turdidae	Rüppell's Rob-in-chat	gardens, forests		Widespread: com-mon in gardens, less common in forests			
Cossypha natalensis		Red-capped Robin-chat	forest	KO	Only three times in Komba Forest			
Cossypha niveica-pilla		Snowy-headed Robin-chat	forest	BO	Only once in the forest on the trail to the hot springs			
Saxicola torquatus		Common Stone-chat	wetlands, farmland	AG, GO-wet, BK	In Alemgono (ssp. maura), Gojeb and Boka Wetlands, on farmland near Boka (ssp. albofas-ciatus)			
Saxicola rubetra		Whinchat	wetland	AG, GO-wet	Some in wetlands			
Oenanthe pleschanka		Pied Wheatear	farmland		Some on farmland			
Zoothera piaggiae		Abyssinian Ground Thrush	forest	KDA-GH	Near waterfall in Bonga, in the forest on trail to hot springs, in savannah at Gojeb River			
Turdus olivaceus		Mountain Thrush	fruiting trees		Most common thrush, very common in fruiting trees			
Turdus pelios		African Thrush			1 in savannah at Gojeb River			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Bradypterus cinnamomeus	Sylviidae	Cinnamon Bracken Warbler	scrub, edges of forests		Commonly heard in scrub and at edges of forests			
Chloropeta natalensis		Dark-capped Yellow Warbler	edge of forest	BK	2, savannah by Gojeb River and at the edge of forest in Boka			
Phylloscopus trochilus		Willow Warbler			Singing only twice			
Phylloscopus collybita		Common Chiffchaff			Most common Phylloscopus warbler			
Phylloscopus umbrovirens		Brown Woodland Warbler	forests	KO, BK, BO, BA	Common in forests: Komba, Boka, forest on the trail to the hot springs, forest by Medabo Forest road, parts of bamboo forest			
Sylvia atricapilla		Blackcap		BO	Mostly individuals, 1 feeding flock in the forest on the trail to the hot springs			
Sylvia curruca		Lesser Whitethroat			1			
Cisticola cantans	Cisticolidae	Singing Cisticola	edge of forest	KO, BK	2 at the edge of Komba and Boka Forests			
Cisticola lugubris		Ethiopian Cisticola	wetland	GO-wet	1 pair			near-endemic
Cisticola robustus		Stout Cisticola	wetland	GO-wet	2 pairs in Gojeb Wetland			
Prinia subflava		Tawny-flanked Prinia	gardens, edge of forests		Widespread: gardens, edge of forests			
Camaroptera brachyura		Grey-backed Camaroptera	hedges, edge of forests,		Widespread and common: hedges, edge of forests,			
Melaenornis chocolatinus	Muscicapidae	Abyssinian Slaty Flycatcher	gardens, edge of forests	KO, BK, AG, KDA-GH	Several around Bonga, in gardens, at edge of forests			near-endemic
Melaenornis edolioides		Northern Black Flycatcher		BO, GO-riv	Also 1 flock (family ?) in gallery forest by Gojeb River on the road to Jimma			
Muscicapa adusta		African Dusky Flycatcher			Widespread and common			
Terpsiphone viridis	Monarchidae	African Paradise Flycatcher			Widespread and common			
Platysteira cyanea	Platysteiridae	Brown-throated Wattle-eye	forest		Moderately common in forest			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Batis minor		Black-headed Batis	wooded areas, forests	KDA-GH				
Turdoides leucopygia omoensis	Timaliidae	White-rumped Babbler		KO, AG, GO-wet	Surroundings of Alemgono and Gojeb Wetlands, at the edge of Komba Forest			
Parophasma galinieri		Abyssinian Catbird	forest	KO, BK, BO	Komba and Boka Forests, near bamboo forest, forest on trail to hot springs, more often heard than seen			endemic
Chalcomitra senegalensis	Nectariniidae	Scarlet-chested Sunbird		KO	Some specimens near and in Bonga and at the edge of Komba forest			
Nectarinia tacazze		Tacazze Sunbird			Widespread and common			
Cinnyris olivaceus		Olive Sunbird			1			
Cinnyris venustus								
fazoqlensis		Variable Sunbird			Widespread and common if there were flowers, most common sunbird			
Cinnyris cupreus		Copper Sunbird		KDA-GH	Mostly near or in Bonga (e.g., KDA compound)			
Zosterops poliogastrus	Zosteropidae	Mountain White-eye			Widespread and common			
Zosterops abyssinicus		Abyssinian White-eye			Village and savannah at Gojeb River on the road to Jimma			
Lanius collaris	Laniidae	Common Fiscal		KDA-GH, KO, BO, BK, AG	KDA compound, near Komba forest, in Boka Wetland, in Alemgono wetland			
Laniarius aethiopicus	Malaconotidae	Ethiopian Boubou	forest	SHO, BO, KO, BK, GO-wet	Forest near Shoriri wetland, forest by Medabo Forest road, Komba Forest, Boka Forest, forest by Gojeb Wetland			
Dryoscopus gambensis		Northern Puffback		SHO, BO	Widespread and common			
Oriolus monacha	Oriolidae	Abyssinian Black-headed Oriole			Widespread and common			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Corvus capensis	Corvidae	Cape Crow	farmland	AG	Only some on farmland and at the edge of Alemgono			
Corvus crassirostris		Thick-billed Raven		KDA-GH, BK, BA, GO-wet, AG	Most common Corvidae			near-endemic
Poeoptera stuhlmanni	Sturnidae	Stuhlmann's Starling	forest	BO, SHO	2 birds in forest by Medabo Forest road, Shoriri Wetland			
Onychognathus tenuirostris		Slender-billed Starling		KDA-GH, KO, BO	Several flocks near waterfall in Bonga and in the forest by Medabo Forest road			
Onychognathus morio		Red-winged Starling		BO, GO-riv				
Lamprotornis chalybaeus		Greater Blue-eared Starling		GO-wet	Large flocks in Gojeb Wetland			
Cinnyricinclus leucogaster		Violet-backed Starling		KDA-GH, SHO	On KDA compound, savannah by Gojeb River			
Pholia sharpii		Sharpe's Starling	in canopy of broadleaf forests	BK, BO, BA	In canopy of broadleaf forests: Boka, forest by Medabo Forest road, forest on trail to the hot springs; in bamboo forest where there were broadleaf trees between the bamboo			
Buphagus erythrorhynchus		Red-billed Oxpecker		GO-wet	Accompanying cattle in Gojeb Wetland			
Passer swainsonii	Passeridae	Swainson's Sparrow	villages, farmland		Widespread in villages			
Ploceus baglafecht	Ploceidae	Baglafecht Weaver	villages, farmland, edge of forest		In villages, on farmland and at edges of forest and wetlands			
Ploceus ocularis		Spectacled Weaver	near villages	KDA-GH	Single pairs near villages			
Ploceus cucullatus		Village Weaver			Most common weaver			
Euplectes ardens		Red-collared Widowbird	wetlands	AG, SHO, GO-wet	In Alemgono, Gojeb Wetlands			
Euplectes axilliaris		Fan-tailed Widowbird	wetlands	AG, SHO, GO-wet	In Alemgono, Gojeb Wetlands			

Scientific name	Family	English name	Habitat	Study sites	Distribution	Threat status	CITES Appendix	Endemism
Estrilda rhodopyga	Estrildidae	Crim-son-rumped Waxbill	farmland, edge of forest	KDA-GH, KO				
Estrilda astrild		Common Waxbill	farmland, edge of forest	BK	On farmland at the edge of Boka Forest			
Coccopygia quartinia		Yellow-bellied Waxbill		KO	Edge of Komba Forest			
Uraeginthus bengalus		Red-cheeked Cordon-bleu	villages, farmland		Widespread and common in villag-es and on farmland			
Lagonosticta senegala		Red-billed Firefinch	villages, farmland		Widespread and common in villag-es and on farmland			
Lonchura cucullata		Bronze Mannikin			Widespread and common			
Lonchura bicolor		Black-and-white Mannikin	wetland, edge of forest	KO, AG, GO-wet	Pairs and small flocks in wetland and at edge of forest			
Vidua macroura		Pin-tailed wydah	farmland					
Vidua chalybeata	Viduidae	Village Indigobird	villages		Few in villages where there were red-billed fire-finches			
Serinus citrinelloides	Fringillidae	African Citril			Widespread and common			
Serinus mozambicus		Yellow-fronted Canary	forest, savannah	BA	In bamboo forest and savannah at Gojeb River			
Serinus l eucopygius		White-rumped Seedeater	savannah		Savannah at Gojeb River			
Serinus striolatus		Streaky Seedeater		KDA-GH	Around Bonga, surroundings of Alemgono and Gojeb Wetlands			
Serinus tristriatus		Brown-rumped Seedeater			Only 1			

7.2. Photos

Figure 1: The colobus monkey (*Colobus guereza*) is one of the primary preys of the African Crowned Eagle (*Stephanoaetus coronatus*) (photo: Holger Meinig)

Figure 2: The Silvery-cheeked Hornbill (*Bycanistes brevis*) is bound to old fruit trees for nesting and feeding (photo: Bernhard Walter)

Figure 3: The Black Crowned Crane (*Balearica pavonina*) is a proposed flagship species for the wetlands (photo: Bernhard Walter)

Figure 4: Black Crowned Crane with chick in the Alemgono Wetland (photo: Wolfgang Beisenherz)

Figure 5: The endangered Wattled Crane (*Bugeranus carunculatus*) was confirmed as a breeding bird in Alemgono Wetland (photo: Bernhard Walter)

Figure 6: The Abyssinian Longclaw (*Macronyx flavicollis*) is endemic to the Ethiopian high-altitude wetlands (photo: Bernhard Walter)

Figure 7: The near-endemic Rouget's Rail (*Rougetius rougetii*) can be found in swampy areas and ditches with some coverage (photo: Bernhard Walter)

Figure 8: The Woolly-necked Stork (*Ciconia melanocephala*) appears in the wetlands consuming amphibians and crickets (photo: Bernhard Walter)

Figure 9: The Half-collared Kingfisher (*Alcedo semitorquata*) was found at the Gojeb River near the bridge (photo: Bernhard Walter)

Figure 10: The endemic Wattled Ibis (*Bostrychia carunculata*) (photo: Bernhard Walter)

Figure 11: Variable Sunbird (*Cinnyris venustus fazoqlensis*) (photo: Bernhard Walter)

Figure 12: Rüppell's Robin-chat (*Cossypha semirufa*) (photo: Bernhard Walter)

Figure 13: African Paradise Flycatcher (*Terpsiphone viridis*) (photo: Bernhard Walter)

Figure 14: Banded Barbet (*Lybius undatus*) (photo: Bernhard Walter)

Figure 15: The endemic Yellow-fronted Parrot (*Poicephalus flavifrons*) (photo: Bernhard Walter)

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 f orest 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)

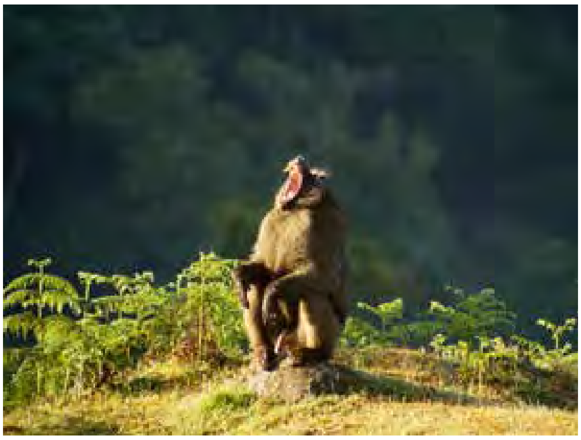

Figure 6: Olive baboon or anubis baboon (*Papio anubis*) | IUCN least concern, CITES II (photo: Tom Kirschey)

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

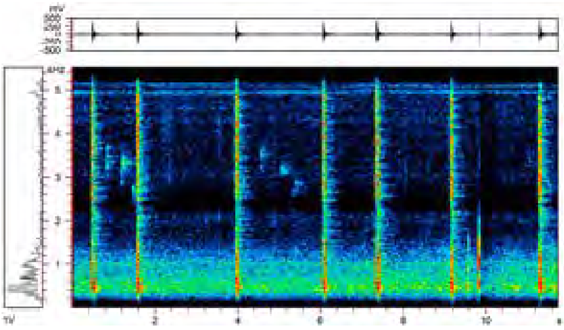

Figure 8: Ethiopia lesser galago (*Galago senegalensis* ssp. *dunni*) | IUCN least concern, CITES II, Audio recording from Sheka Wild Coffee Forest (4, AW), 2014 (recording: Karina Schell / Sonogram: Andrew Perkin)

(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)

Small- and medium-sized mammals (Soricomorpha, Lagomorpha, Rodentia, Procavidae) at the Kafa Biosphere Reserve

Holger Meinig, Meheretu Yonas and Nicole Hermes

Highlights

- → The African pigmy mouse (*Mus* (*Nannomys*) *mahomet*), the Ethiopian hare (*Lepus* cf. *fagani*) and the Ethiopian meadow rat (*Stenocephalemys albipes*) are endemic to Ethiopia (the latter also occurs in neighbouring Eritrea).
- → The forms of the East African mole-rat (*Tachyoryctes splendens* s.l.), brush-furred mouse (*Lophuromys flavopunctatus* s.l.), African marsh rat (Dasymys cf. incomtus) and Ethiopian vlei rat (*Otomys* cf. *typus*) encountered in this study could be endemic to Ethiopia, but this needs to be corroborated by genetic studies.
- → The observed form of the Gambian sun squirrel (*Heliosciurus gambianus* ssp. (cf. *kaffensis*)) could also be an endemic subspecies or even entire species.
- → The current study does not provide sufficient data to determine whether certain species are threatened or not.
- → The wetlands surrounding the Gojeb River and adjacent habitats seem to be more species diverse than the other plots studied.
- → The African clawless otter (*Aonyx capensis*) should be considered a flagship species. The species could be a good indicator for the status of river conservation and other natural/semi-natural waterbodies.
- → Small mammals are sensitive to overgrazing and pollution from insecticides and herbicides as well as to intensification of agriculture in general. Regulations concerning future human land use should be implemented and controlled in order to protect their natural environment.
- → Sewers should be constructed and maintained, particularly for villages in the wetlands and near streams, to prevent habitats from pollution from different sources.

1. Introduction

Ethiopia's geographical location, altitude range, rainfall pattern and soil variability have resulted in immense ecological diversity and a huge wealth of biological resources (Kassa & Bekele 2008). Ethiopia is also notable for containing 50% the Afrotropical region's land above 2000 m a.s.l. (Yalden 1983). This unique situation is due to repeated glaciations and tectonic events. In Eastern Africa, rodents account for 28% of the total mammalian fauna (Kingdon 1989). The insectivore fauna, particularly shrews, is also incredibly diverse, with 140 species (Hutterer & Yalden 1990).

Ethiopia's fauna and flora include many species endemic to the country. There are also many unidentified species. The real wealth of species in Ethiopia has not yet been fully assessed, due to a lack of studies in many regions. For example, the Kafa region in southwestern Ethiopia has seen very few studies providing reliable data on small mammals (summarized in Berhan 2008).

Most small mammal species are only rarely observed, but they play a crucial role in their ecosystems. They produce a lot of biomass compared to other vertebrates of the same size. They are the base of food chains for small- and medium-sized carnivores, as well as birds of prey such as raptors and owls. They are responsible, to a certain degree, for the dispersal of plant species through selective feeding, spreading of seeds and concentration of nutrition by using latrines. They also promote ventilation and bioturbation of soil and drainage after rainfall. On a more negative note, they are important vectors for diseases and can become pests in agricultural cultures.

The diversity of small mammals depends on the habitat type (Glennon & Porter 2007; Garratt et al. 2012), where habitats with higher floral diversity and ground cover support more diversity than those with lower floral diversity and ground cover (Mulungu et al. 2008; Pearson et al. 2001). Hence, small mammal assessment is an important component of broader assessments of ecosystem diversity, because they are strong indicators of habitat conditions.

This assessment of small mammals in the Kafa BR was carried out during the dry season, between 03/12/2014 and 12/12/2014, in different types of habitats and altitudinal ranges. We expected different species compositions in different kinds of habitats (different types of forests, arable land, moister and drier stands). The short study period resulted in an incomplete species list for each sampling site, making comparison to other long-term studies of small geographical areas (e.g., Habtamu & Bekele 2008; Kassa & Bekele 2008; Yonas et al. 2014) impossible. However, we can compare the results from the different study sites with each another.

As the assessment took place in the dry season, there were lower densities of small mammals compared to the wet and early dry seasons, because most small mammal populations rise following reproduction during the wet season, when there is greater food availability (e.g., Delany 1986). It should also be mentioned that there was extraordinarily heavy precipitation in the study area a few days before our study started, resulting in the flooding of lower areas, especially near rivers.

2. Materials and Methods

2.1 Study area

We were unable to study the small mammal fauna at every sampling site in the biodiversity assessment. Trapping was conducted in the surroundings of the bamboo forest and the northern areas of arable land bordering small forest stands (1 BA). Sampling also took place in the montane coffee forest (Ufa Forest – 4 AW) and the riverine vegetation at the Gummi River. The Gojeb Wetland and its surroundings was extensively sampled (8 GO-wet, 9 GO-riv). The final site investigated was the area around the KDA Guesthouse in Bonga (11 KDA GH).

2.2 Sampling methods

Small mammals where sampled using mouse- and rat-sized snap traps and Sherman LFA live traps (7.5 x 9.0 x 23.0 cm, HB Sherman Trap Inc., Tallahassee, USA) baited with peanut butter mixed with canned fish. Sampling was performed in two to three lines per locality; in each line the three types of trap were set by alternating one after the other in lines up to 400 m long. A variety of traps was used following the suggestion that trap type and size can determine the types of small mammals captured (Thompson & Macauley 1987; Slade et al. 1993; Lee 1997). Each trapping line held 50-75 traps (depending up on the habitat condition), each five meters apart. Trapping was conducted mostly in edge habitats representing denser natural habitats and cultivated/disturbed fields. Traps were set before dusk (between 1700 and 1800) and inspected early in the morning (between 0700 and 0800) to prevent ant damage.

2.3 Data analysis

Before skinning, the standard external morphological measurements (body mass, head-body, tail, hind foot, and ear lengths) were recorded for each specimen and the reproductive status of the hosts determined (see Table 1). The carcasses were then preserved in alcohol for later skin and skull/skeleton study. Spleen and kidney samples were taken and preserved in 96% ethanol for genetic analysis, and blood samples were collected on calibrated, pre-punched filter paper (LDA 22, Ploufragan, France) for later serological and/or molecular screening for RNA viruses.

Following the national regulations of the Ethiopian Biodiversity Institute (EBI), samples were properly prepared and exported to Germany, with the objective of further identifying the species and completing the species list. We obtained the genetic data of three of the small mammals; analysis of the rest of the specimens, with one exception, will be performed in collaboration with Dr J. Bryja in Brno (Institute of Vertebrate Biology, Czech Republic). A tissue sample of a hare (genus *Lepus*) found as roadkill in the Gojeb Wetland (8 GO-wet) will be analyzed in collaboration with Dr F. Suchentrunk (Research Institute of Wildlife Ecology, Vienna University of Veterinary Medicine, Austria), an internationally acknowledged hare specialist, who is already working in Ethiopia.

To maximise the information gathered, skulls and skeletons will be cleaned using the larvae of dermestid beetles to prevent damage of delicate structures that might occur through faster but rougher cleaning methods (procedure ongoing).

This analysis also includes additional material obtained from local people, roadkill and observations/photos.

Except for the *Crocidura*, *Dasymys* and *Otomys* genera, this report only provides preliminary identification results based on morphological data, as the genetic analysis requires more time. We were supported by Dr R. Hutterer, the retired former head of the mammal collections at the Alexander Koenig Research Museum (Zoologisches Forschungsmuseum Alexander Koenig – ZFMK), Bonn during the first steps of species determination, who also provided us with new and rare literature. First results based on DNA sequencing of *Crocidura*, *Dasymys* and *Otomys* were provided by Dr J. Bryja. Except where more recent studies have more differentiated results applicable to our material, the taxonomy follows Wilson & Reeder (2005) and Happold (2013).

3. Results and Discussion

3.1 Records

The taxonomic status and ecological requirements of the species recorded during the short-time survey are described below. Where available, we have also included information on reproductive status and parasite loads.

3.1.1 Soricomorpha

African giant shrew (*Crocidura olivieri*)

Three individuals from a single shrew species were collected in the Gojeb Wetland (8 GO-wet). No shrews were obtained at any other sampling site. The species is a dark brown colour morph of the widespread African giant shrew, which occurs in almost every part of sub-Saharan Africa and the Upper Nile Valley in Egypt, except in the very south of the continent. The species was formerly known as *C. flavescens*, a name now restricted to a smaller species occurring in South Africa (Churchfield & Hutterer 2013). It is also possible that this shrew is the species described as *C. fulvastra* in the species list of the faunal diversity study of the Kafa Afromontane Coffee Forest by Berhan (2008). The population in the study area was previously described under the name *C. olivieri* ssp. *hansruppi* by Hutterer (1980), who studied six animals from four different sites in the Kafa region, because of their long and densely haired tails and their unusual coloration compared to other samples of the species from Ethiopia. Biochemical studies have shown that *C. olivieri* is a highly variable species (Maddalena 1990), and the known colour morphs do not represent subspecies or even species (Churchfield & Hutterer 2013). One out of two females had active mammae (10/12/2014), and was also infected with cestodes. The testes of the male specimen were inactive.

Figure 1: Distribution of *C. olivieri* in Africa (source: IUCN Red List of Threatened Species 2014)

3.1.2 Lagomorpha

Ethiopian hare (*Lepus*)

Hares were frequently observed in open habitats in the study area. According to the maps provided by the IUCN, *Lepus fagani* is the only species that occurs in the area. Dr F. Suchentrunk (hare specialist, University of Vienna) suggested that the Ethiopian Highland hare (*Lepus starcki*) could also occur (pers. communication), but *L. fagani* is the more probable species.

The taxonomic status of the three hare species occurring in Ethiopia (in addition to the two endemic species mentioned above, the more widespread Abyssinian hare (*L. habessinicus*) also occurs in Ethiopia) is not yet resolved. There seem to be bidirectional ancestral and

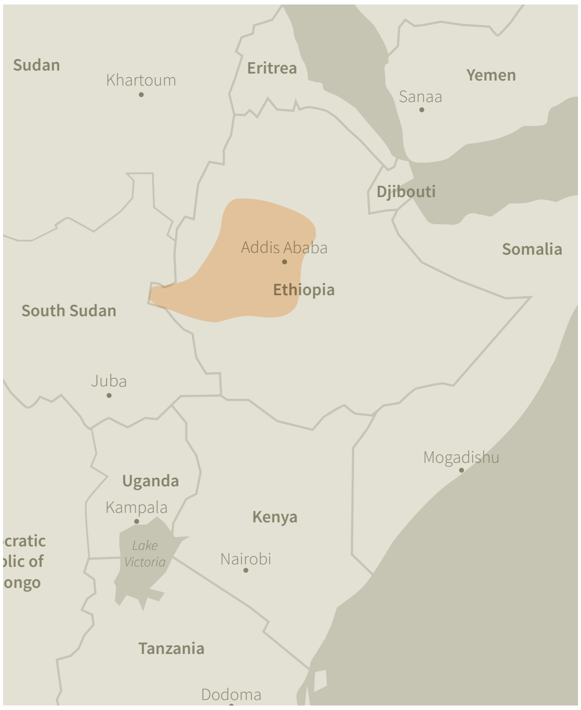

Figure 2: Distribution of the Ethiopian endemic *Lepus fagani* (source: IUCN Red List of Threatened Species 2014)

actual introgressions in zones of sympatric occurrences (Tolesa et al. 2013).

Tissue samples and a piece of fur from a hare found as roadkill were collected in the Gojeb Wetland on 11/12/2014. The tissue sample will be analysed in collaboration with Dr F. Suchentrunk as part of a running project on Ethiopian hares.

3.1.3 Rodentia

Gambian sun squirrel
(*Helioscirus gambianus* ssp. (cf. *kaffensis*))

The faunal diversity study by Berhan (2008) does not mention a single representative of this arboreal squirrel genus. The only squirrel known to this author is *Xerus rutilus*, a ground squirrel. The Gambian sun squirrel is widespread in sub-Saharan Africa (Fig. 3). This species is typically associated with savannah woodland. Populations have also been observed in riparian forest and in savannah areas. It is generally absent from closed forest habitats. This species is commonly found in agricultural areas. *Heliosciurus gambianus* probably represents a complex of several similar species. Further studies are needed to clarify the taxonomic status of populations/subspecies currently allocated to this species (see Grubb & Ecué 2008). As the species was described based on specimens from West Africa (Gambia), it is very probable that Ethiopian animals are a different species.

Figure 3: Distribution of *Heliosciurus gambianus* in Africa (source: IUCN Red List of Threatened Species 2014)

The subspecies name *kaffensis* seems to be applicable for the individuals observed in the study area. They differ from other populations known in and outside Ethiopia in their pelage colouration, especially the reddish colouration on the border between back and belly (author's observation) (Figs. 10-12). Further taxonomic precision would require at least a tissue sample for DNA analysis. It is possible that the animals in the Kafa BR belong to an endemic species. However, currently only the occurrence of the endemic subspecies *H. g. kaffensis* can be confirmed.

East African root-rat (*Tachyoryctes splendens* s.l.)

The taxonomy of this subterranean rat is still not clear. Provisionally, eleven species from this complex (*Tachyoryctes*) confined to higher altitudes of east African montane grasslands are currently recognized (e.g., Kingdon 1997; Musser & Carleton 2005). According to these references, populations occurring in the Bonga biosphere should be recognized as *T. splendens* s.l. According to a new study based on genetic and cytoge-

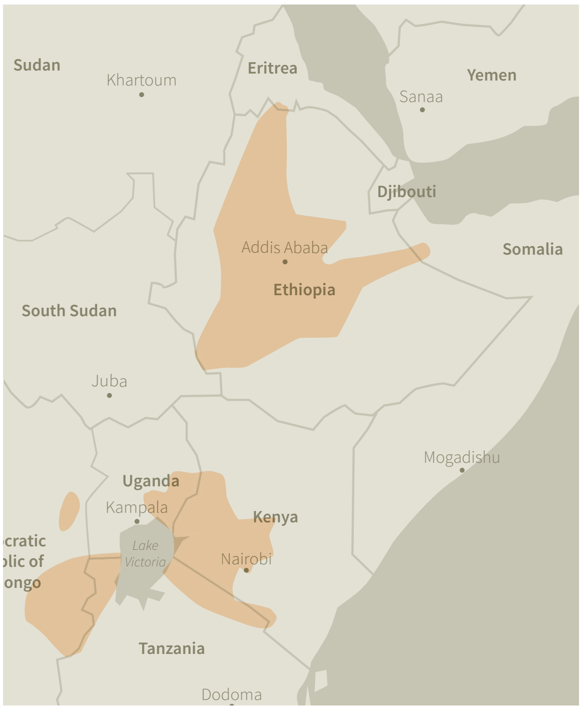

Figure 4: Geographic range of *Tachyoryctes splendens* s.l. (source: IUCN Red List of Threatened Species 2014)

netic characteristics (Lavrenchenko et al. 2014), at least four species are lumped under the name *T. splendens* in Ethiopia alone. Animals from the Bonga region belong to members of the so-called "northern clade", named by the authors on the basis of eight specimens collected from the surroundings of Masha, a village 100 km northwest of Bonga. The geographic limits of these animals are not yet known. Subterranean mammal species occurring in grasslands are often endangered through intensification of agriculture, as recently shown by Csorba et al. (2015) for a European species-complex of blind mole-rats (genera *Spalax* and *Nannospalax*), a group closely related to *Tachyoryctes* of the family Spalacidae, with very similar ecological requirements. The replacement of extensive livestock farming and pasture farming with intensive monocultures will lead to the decline, fragmentation and, in many cases, complete eradication of grasslands. Root-rats, today sometimes regarded as a pest, will become endangered. The species feeds on grass and dicotyledonous plants (Yalden 1975 for *T. macrocephalus*), so a decline in the richness of grassland plant species can also be assumed to harm root-rat populations. As long as the species limits of the *Tachyoryctes* group remain unclear and the geographical distribution and limits of the taxa are insufficiently investigated, it will be difficult to judge whether a form is endangered or not.

Typical mounds for the species were observed in the area around the KDA Guesthouse in Bonga (N 11, KDA GH) and in open grasslands bordering the Bamboo Forest (N 1, BA). The species is hunted as a pest by local people because it consumes cultivated plants, particularly the staple enset or false banana (*Ensete ventricosum*), widely cultivated as a food plant in the area. Three individuals (two males, one female, Fig. 13) were obtained from local people around the bamboo forest, caught using snares (Fig. 14) set in the species' running paths. *T. splendens* occasionally goes aboveground to feed on the surface during the night. None of the three individuals was sexually active.

Brush-furred mouse (*Lophuromys flavopunctatus* s.l.)

According to a study by Lavrenchenko et al. (2007), *Lophuromys* is the rodent genus with the most endemic species in Ethiopia: nine in total. They include species that can easily be recognized by the ratio of head and body/tail lengths, such as *L. brevicaudatus* in the Bale Mountains. (see Fig. 15). Other species are more difficult to recognize.

On the basis of morphological data (preliminary to the results of the DNA analyses), all *Lophuromys* caught in our survey are regarded as *L. flavomaculatus* s.l. Members of this species mostly feed on insects (ants are preferred). The specimens were caught in different lo-

Figure 5: Distribution of *Lophuromys flavopunctatus* s.l. in Africa (source: IUCN Red List of threatened Species 2014)

calities near the Bamboo Forest (1 BA), in the montane forests near Decha (4 AW) and in the Gojeb Wetland (8 GO-wet). None of the four females caught was sexually active. Two of the five males captured had scrotal, active testes. Two individuals were infected by parasites (one male with nematodes, one female with cestodes).

Ethiopian vlei rat (*Otomys* cf. *typus*)

The vlei rat is believed to be a species complex consisting at least of six species (Taylor et al. 2008). In Ethiopia, this species is recorded in montane areas of the highlands (1900 to 4100 m a.s.l.) (Taylor et al. 2008). The species inhabits mesic grassland, montane grasslands and alpine heaths. The species is known to occur in grasslands and heaths of the highlands of Ethiopia, Kenya, Malawi, Tanzania and Uganda from 1800 m a.s.l. upwards (Taylor et al. 2008). The current determination of the three *Otomys* specimens collected near the Bamboo Camp (2) and in the Gojeb Wetland (1) is preliminary based on DNA analysis. It is possible the specimens represent the taxon *Otomys fortior*, a name used for specimens collected in the Charada Forest (Prov. Kafa) and near Jimma (Taylor et al. 2011). The species complex as a whole is evaluated as 'Least Concern' by the IUCN, although it is believed to be dwindling (Taylor et al. 2008). As there are several species subsumed under the name *O. typus*, species limits and the area each covers should be properly investigated to decide whether any species are more threatened than others and to develop strategies to protect endangered forms. One of the males from the Bamboo Camp was subadult, the other sexually inactive. The female from the Gojeb Wetland was carrying one embryo close to birth (crown length: 48 mm).

Ethiopian white-footed mouse (*Stenocephalemys albipes*)

The genus *Stenocephalemys* is almost endemic to Ethiopia, the only species also occurring outside Ethiopia in neighbouring Eritrea being *Stenocephalemys albipes* (Fig. 7). There are currently four species recognised in this genus, related to the other African Muridae genera, such as *Mastomys*, *Praomys* and *Myomyscus* (Musser & Carleton 2005). *Stenocephalemys albipes* was the most abundant species in the study area. Of the 51 terrestrial mammals collected, 20 were *S. albipes*. The species was caught at all sites except on the banks of the Gummi River, where no animals entered the traps, and the area around the KDA Guesthouse in Bonga. Except for one, all male individuals captured in the Gojeb Wetland (n=10) had active testes. Of the 10 females captured, two were pregnant, one showed active mammae, and two had not previously been sexually active. The remaining were adult but showed no signs of sexual activity when they were caught. Many individuals showed scars on their ears, indicating intraspecific aggression due to high population densities. Two individuals were infect-

Figure 6: Geographic range of *Otomys* cf. *typus* (source: IUCN Red List of threatened Species 2014)

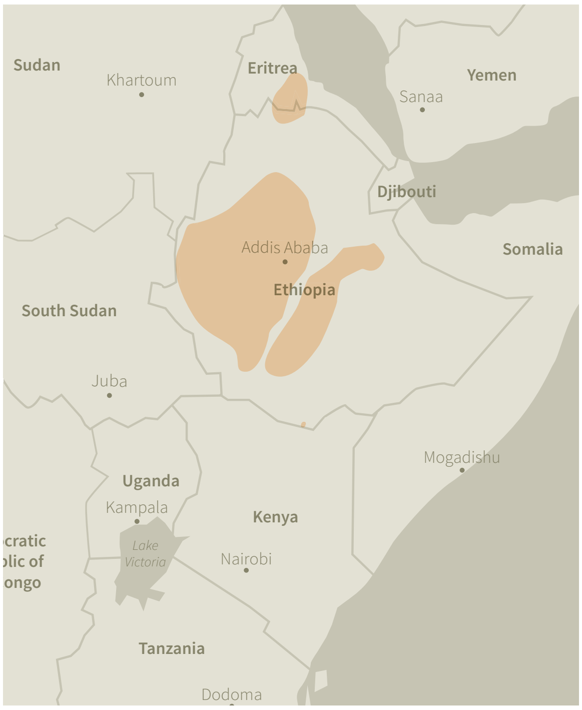

Figure 7: Geographic range of *Stenocephalemys albipes* (source: IUCN Red List of Threatened Species 2014)

ed by cestodes, and one male from the Gojeb Wetland was infected by a warble fly larva under its head skin (genus *Oestromyia*).

African pygmy mouse (*Mus (Nannomys) mahomet*)

Mice of the subgenus *Nannomys* are widespread throughout Africa. According to the recent study by Bryja et al. (2014), eight different forms of the subgenus occur in Ethiopia, six of which are endemic to the country. Among these is *Mus mahomet* (Fig. 17), which is restricted to the Ethiopian Plateau and not conspecific with pigmy mice from Kenya and Uganda as previously supposed (e.g., Musser & Carleton 2005). This study includes material from Bonga and Jimma (Fig 18); hence the determination of the animals caught during our study is supported by genetic data from the same area. Twelve individuals were trapped in our study (one at the KDA Guesthouse, five at the Bamboo Camp, six at Gojeb Wetland). Ten of these were females, four of which were pregnant, one with embryos close to birth (Gojeb Wetland 10/12/2014) with a crown length of 18.2 mm. This might be the species mentioned by Berhan (2008) under the name M. triton.

The genus *Dasymys* is widespread throughout sub-Saharan Africa and follows a savannah distribution (Mullin et al. 2005). Its natural habitats are moist savannah, seasonally wet or flooded lowland grassland and swamps. One individual in this species, a subadult (M3 was just breaking through in both the lower and the upper jaw) female, was trapped in the Gojeb Wetland (11/12/2014). We were unable to identify the specimen morphologically in the field, even to the genus level, but preliminary DNA analysis indicated the specimen's identity. The animal has very dense soft fur, a relatively long tail (longer than in *Arvicanthis* and shorter than in *Stenocephalemys*), very hairy ears and black sole markings (Fig. 20). Further confirmatory determination will follow, using genetic analysis combined with a skull and tooth investigation. Mullin et al. (2005) reported that two chromosomal forms of *Dasymys* (*Dasymys* cf. *incomtus*: 2n = 40, NF = 44 from the Bale Mountains and 2n=38, NF=44 from Harenna Forest) and one distinct morphological form (*D. griseifrons* known only from Lakes Tana and Jigga) occur in Ethiopia. According to the authors all of them distinctly differ from the nominate incomtus material from South Africa.

Dasymys populations have been decreasing since the 1960s in southern Africa due to desiccation and destruction of wetlands (Mugo et al. 1995). Ethiopian populations are also likely to be sensitive to these factors.

Figure 8: Geographic range of *Dasymys* cf. *incomtus* (source: IUCN Red List of Threatened Species)

3.1.4 Procavidae

Yellow-spotted hyrax (*Heterohyrax brucei*)

A latrine typical for hyraxes was found in an old tree near the Bamboo Camp (7°14'36" N, 36°27'27" E) by T. Kirschey and V. Clausnitzer on 05/12/2014 (Fig. 23). As rock hyraxes (genus *Procavia*) are usually restricted to areas with rocks and there were no rocks in the vicinity, the latrine was concluded to be used by yellow-spotted bush hyrax (Fig. 23). The determination was confirmed by DNA analysis of scats by A. and K. Schell. The species, widespread in eastern Africa, is known to occur in our study area (Berhan 2008). There are around 25 recognized subspecies within *H. brucei*, and Ethiopia is known as a type locality for three of them: *H. b. brucei*, *H. b. princeps* and *H. b. rudolfi* (Barry & Hoeck 2013).

3.2 Evaluation of short-term study results

The study area with the highest number of trapped species (6) was the border of arable land and forest stands in the Gojeb Wetland, around the bridge south of the campsite. It was the only place where shrews were caught. Shrews prefer moister habitats because of the higher densities of insects as food compared to drier habitats. A single subadult female African marsh rat was also caught here. Signs of the occurrence of the root-rat such as typical mounds were absent, perhaps because the ground water level there is too high to construct deep burrows.

The Ethiopian vlei rat is also bound to moister habitats; it was only trapped in the riverine habitats near the bamboo camp and the wetlands at Gojeb River. Unexpectedly, no successful trapping occurred on the banks of the Gummi river, even though 25 traps were set in dense vegetation 20-50 m from the embankment. It is possible the flooding after the heavy rainfall of the weeks preceding the study temporarily cleared the area of small mammals. The brush-furred mouse and Ethiopian white-footed mouse were recorded at higher altitudes in the forest.

Specimens of the brush-furred mouse, Ethiopian white-footed mouse and African pigmy mouse were caught in most locations. This seems to be the regular species composition throughout the Kafa BR. The root-rat also proved to be a common species in the area, encountered in four out of nine trapping sites. It was the only small mammal species besides the African pigmy mouse to be caught in the area around the KDA Guesthouse (one animal in 30 traps, a further animal having been caught in a pitfall trap for insects).

Trapping sites were between 1287 m a.s.l. (Gummi river) and 2593 m a.s.l. (Bamboo Camp). The species composition of East African small mammals changes at altitudes above 3000 m a.s.l. (cf. Clausnitzer & Kityo 2001). A different species composition with more high altitude specialists can therefore be expected in the biosphere in areas south and southeast of Bolla at altitudes above 3000 m a.s.l.

The list of species is shorter than expected. Long-term studies would have yielded more species (e.g., further shrew species, multimammate rats (*Mastomys*) or zebra mice (*Lemniscomys*)).

4. Conclusions and Recommendations for Conservation and Monitoring

This short-term study of small- and medium-sized mammals during the dry season yielded only a fraction of the results needed to fully understand the species composition of different habitat types. The greatest problems are caused by the still unsolved problems of systematics and taxonomy in Ethiopian mammals. In the future, long-term studies during other seasons should be carried out to understand the ecology and requirements of these species and to gather more material to solve the taxonomic problems. These studies should be carried out during consecutive years for the same plots, as many species of small mammals show cyclic population changes over periods of three to four years. There might be important species in some habitat types that went undetected during our study because their densities were temporarily too low.

Except in some very rare occasions (e.g., the giant root-rat (*Tachyoryctes microcephalus*) in Bale National Park) small mammals are unsuited to being flagship species, because they are normally almost invisible. In addition, many people consider rodents to be pests. However, they should be kept in mind during monitoring, as they play an important role in ecosystems. Small mammals are sensitive to overgrazing and pollution from insecticides and herbicides as well as to the intensification of agriculture in general. Where they vanish, many species depending on them as food will decline or switch to other endangered species such as the Abyssinian longclaw (*Macronyx flavicollis*) or plovers (*Vanellus*) as food.

Dasymys cf. *incomtus* may be affected by the desiccation and destruction of wetlands as well as pollution of streams and ponds by detergents and pesticides.

To overcome problems caused by intensifying land use, regulations governing the extent and type of land use should be implemented and controlled in certain areas. Sewers should be constructed and maintained for villages in the wetlands and near streams to protect water-bound habitats from destruction by pollution from fertilisers, detergents, and pesticides.

The African clawless otter (*Aonyx capensis*) would be a suitable flagship species. Due to their endearing appearance, otters are very popular in Europe and the United States and could become an attraction in the wetlands and river areas. Otters were observed regularly during three consecutive evenings in the Gojeb River. The species also seems to occur in other parts of the biosphere, as shown by pictures taken by B. Walter in 2009 (Figs. 24 and 25). Otters are sensitive to water pollution and the destruction of dense vegetation structures on the banks of rivers and ponds, so they are a good indicator of environmental health.

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7. Appendix

7.1. Tables

Table 1: Small and medium sized mammal species recorded during the biodiversity assessment in Kafa BR, their preferred habitat types, distribution type, and IUCN Red List Category

No.	Scientific name	Family	English name	Habitat/ forest type	Study sites	Distribution	IUCN threat status	CITES Appendix	Endemism
At 39, At 41, At 55	*Crocidura olivieri*	Soricidae	African giant shrew	Wetland	5 AG	Widespread	LC	-	-
No no., skin, tissue sample	*Lepus* cf. *fagani*	Leporidae	Ethiopian hare	Wetland	5 AG	Western Ethiopia	DD	-	Ethiopia
No no., observa-tions	*Heliosciurus gambianus* cf. *kaffensis*	Sciuridae	Gambian sun squirrel	Savannah with trees and bushes		Prov. Kaffa	LC	-	subspe-cies: western Ethiopia
At 6, At 25, At 26	*Tachyoryctes splendens* s.l., *"northern clade"*	Spalaci-dae	East African root-rat	Bamboo forest, arable land, garden	1 BA, 11 KDA GH	(as *Tach-yoryctes splendens* s.l.) wide-spread	LC	-	maybe endemic species
At 8, At 10, At 15, At 16, At 19, At 23, At 31, At 37, At 42,	*Lophuromys flavopunctatus* s.l.	Muridae	Brush-furred mouse	Bamboo forest, arable land, riv-erine habitats, wetland	1 BA, 4 AW, 8 GO-wet, 9 GO-riv	Widespread	LC	-	maybe endemic species
At 21, At 24, At 48	*Otomys* cf. *typus*	Muridae	Ethiopian vlei rat	Bamboo forest, wetland	1 BA, 8 GO-wet	Ethiopia + Eritrea	LC	-	Ethiopia + Eritrea
At 7, At 13, At 14, At 18, At 20, At 27, At 28, At 29, At 30, At 34, At 35, At 36, At 43, At 44, At 49, At 50, At 51, At 52, At 53, At 54	*Stenocephalemys albipes*	Muridae	Ethiopian meadow rat	Bamboo forest, montane forest, wetland	1 BA, 4 AW, 8 GO-wet, 9 GO-riv	Ethiopia + Eritrea	LC	-	Ethiopia + Eritrea
At 1, At 9, At 11, At 12, At 17, At 22, At 32, At 33, At 38, At 45, At 46, At 47	*Mus (Nannomys) mahomet*	Muridae	African pigmy mouse	Bamboo forest, arable land, wetland	1 BA, 11 KDA GH	Ethiopia	LC	-	Ethiopia
At 40	*Dasymys* cf. *incomptus*	Muridae	African marsh rat	Wetland	8 GO-wet	Widespread	LC	-	maybe endemic species
No no. observa-tion	*Heterohyrax brucei*	Procavi-dae	Yellow-spotted hyrax	Bamboo forest	1 BA	Widespread	LC	-	-

Table 2: Species at sample sites recorded during the biodiversity assessment in Kafa BR (only rodents and shrews)

Species/ sample site	***Crocidura olivieri***	***Tachyoryctes splendens* s.l.**	***Lophuromys flavomaculatus* s.l.**	***Otomys* cf. *typus***	***Stenocephalemys albipes***	***Mus (Nannomys) mahomet***	***Dasymys incomptus* s.l.**	**Number of species**
Bamboo forest, camp site north of road		+	+		+	+		4
Bamboo forest, camp site south of road		+	+	+	+	+		5
Bamboo forest, arable land / forest edges 3 km north of campsite		+	+		+	+		4
Ufa montane forest			+		+			2
Gummi River floodplain								-
Wetland, 8 GO-wet			+		+	+		3
Gimbo River, 9 GO-riv			+		+	+	(s.l.)	3
Border arable land / forest south of campsite in wetland Gimbo River	+		+	+	+	+	+	6
Vicinity of KDA Guesthouse, Bonga, 11 KDA GH		+				+		2

Table 3: Morphological data of registered species at Kafa BR

Genus	**Species**	**Date**	**Field No.**	**Locality**	**Gazetteer**	**Sex**	**HB**	**T**	**HF**	**Ear**	**Weight**	**Remarks**
Mus (Nannomys)	*mahomet*	04.12.2014	At 1	KDA Guest-house, Bonga, 1756 m a.s.l.	07°15'01" N, 36°15'15" E	F	73.5	53	14	12		
Tachyoryc-tes	cf. *splendens*	05.12.2014	At 6	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	F	238	82	32	16	405	Lactating
Stenoce-phalemys	*albipes*	05.12.2014	At 7	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	F	130	146	28.7	20.7	62	n.p.
Lophuromys	*flavopunctatus* (s.l.)	04.12.2014	At 8	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	M	124	74	21	19.5	49	Testes abdominal
Mus (Nannomys)	*mahomet*	04.12.2014	At 9	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	F	60	45	13.2	10.5	4	Juvenile
Lophuromys	*flavopunctatus* (s.l.)	04.12.2014	At 10	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	F	125		22	20.5	55	
Mus (Nannomys)	*mahomet*	04.12.2014	At 11	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14'25" N, 36°27'08" E	F	68	53	14	11.2	12	

Genus	Species	Date	Field No.	Locality	Gazetteer	Sex	HB	T	HF	Ear	Weight	Remarks
Mus (Nannomys)	*mahomet*	04.12.2014	At 12	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	86	52	14	11	15	
Stenoce-phalemys	*albipes*	04.12.2014	At 13	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	140	176	28	21.8	65	Lactating, cestodes
Stenoce-phalemys	*albipes*	04.12.2014	At 14	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	131.5	173.5	27	20.8	66	Gravid 6/7
Lophuromys	*flavopunctatus* (s.l.)	04.12.2014	At 15	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	122.5	75.5	20	16	48	Not repro-ductive
Lophuromys	*flavopunctatus* (s.l.)	04.12.2014	At 16	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	M	124.5	72.5	21	17	49	Testes abdominal
Mus (Nannomys)	*mahomet*	04.12.2014	At 17	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	76	52	12.8	10		
Stenoce-phalemys	*albipes*	04.12.2014	At 18	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	136	157	27.8	22.2	67	Testes active: 17 X 10 mm
Lophuromys	*flavopunctatus* (s.l.)	04.12.2014	At 19	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	130		22.2	17.3	49	
Stenoce-phalemys	*albipes*	04.12.2014	At 20	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	127	160	28.7	22.4	48	
Otomys	cf. *typus*	04.12.2014	At 21	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	M	146	91	29	12.6	69	Subadult
Mus (Nannomys)	cf. *mahomet*	04.12.2014	At 22	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	68	51	15	10.9	12	
Lophuromys	*flavopunctatus* (s.l.)	06.12.2014	At 23	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	F	118	70	12	18.3	45	
Otomys	cf. *typus*	06.12.2014	At 24	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	M	154	78	27			

Genus	Species	Date	Field No.	Locality	Gazetteer	Sex	HB	T	HF	Ear	Weight	Remarks
Tachyoryctes	*splendens*	06.12.2014	At 25	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	M	254	78	34	15	420	
Tachyoryctes	*splendens*	06.12.2014	At 26	Bamboo Camp SW Bolla, near Bonga, 2593 m a.s.l.	07°14’25” N, 36°27’08” E	M	237	70	34.5	11.5	363	
Stenocephalemys	*albipes*	08.12.2014	At 27	Ufa Forest SE Chi’ri, S’Bonga, 1448 m a.s.l.	07°05’34” N, 36°13’27” E	F	89	103	22	18	24	
Stenocephalemys	*albipes*	08.12.2014	At 28	Ufa Forest SE Chi’ri, S’Bonga, 1448 m a.s.l.	07°05’34” N, 36°13’27” E	M	131	176	27	22	76	Testes active: 15 X 9.5 mm
Stenocephalemys	*albipes*	08.12.2014	At 29	Ufa Forest SE Chi’ri, S’Bonga, 1448 m a.s.l.	07°05’34” N, 36°13’27” E	M	137	177	27	22.8	82	Testes active: 15.8 X 10 mm
Stenocephalemys	*albipes*	08.12.2014	At 30	Ufa Forest SE Chi’ri, S’Bonga, 1448 m a.s.l.	07°05’34” N, 36°13’27” E	M	138	184	27		84	Testes active: 14 X 10 mm
Lophuromys	*flavopunctatus* (s.l.)	08.12.2014	At 31	Ufa Forest SE Chi’ri, S’Bonga, 1448 m a.s.l.	07°05’34” N, 36°13’27” E	M	135	91	22	19	22	Testes active: 11.5 X 9 mm
Mus (Nannomys)	*mahomet*	10.12.2014	At 32	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33’50” N, 36°03’06” E	F	79	47		12.5	10	Gravid 3/3
Mus (Nannomys)	*mahomet*	10.12.2014	At 33	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33’50” N, 36°03’06” E	F	83.5	51.5	13	12.7		Gravid 3, CR length 18.2 mm
Stenocephalemys	*albipes*	10.12.2014	At 34	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33’50” N, 36°03’06” E	F	133	180	27		50	Lactating
Stenocephalemys	*albipes*	10.12.2014	At 35	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33’50” N, 36°03’06” E	M	124		27	22	44	Testes active: 15 X 8 mm
Stenocephalemys	*albipes*	10.12.2014	At 36	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33’50” N, 36°03’06” E	M	123	154	28	22.5	42	Testes active: 16.5 X 9 mm

Genus	Species	Date	Field No.	Locality	Gazetteer	Sex	HB	T	HF	Ear	Weight	Remarks
Lophuromys	*flavopunctatus* (s.l.)	10.12.2014	At 37	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	143	80	23	18.7	46	Testes active: 17 X 10.5 mm, nematodes
Mus (Nannomys)	*mahomet*	10.12.2014	At 38	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 3 6°03'06" E	F	79		14	11.5	8	Gravid 3/3
Crocidura	*olivieri*	10.12.2014	At 39	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 3 6°03'06" E	F	119	86	20	12.3	20	Lactating, cestodes
Dasymys	cf. *incomtus*	11.12.2014	At 40	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	112	106	27	19.2	50	Subadult, n.p., stomach contained only vegetables, no insects
Crocidura	*olivieri*	11.12.2014	At 41	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	131	86	20	13	32	
Lophuromys	*flavopunctatus* (s.l.)	11.12.2014	At 42	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M		76	22	19.2	66	
Stenocephalemys	*albipes*	11.12.2014	At 43	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	129	174	27	22	74	Testes active
Stenocephalemys	*albipes*	11.12.2014	At 44	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	130	171	28	21.5	76	Testes active
Mus (Nannomys)	*mahomet*	11.12.2014	At 45	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	88.5	53	14	11	8	
Mus (Nannomys)	*mahomet*	11.12.2014	At 46	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	72.5	47.5	14	12	7.5	
Mus (Nannomys)	*mahomet*	11.12.2014	At 47	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	76		14.5	11.3		

Genus	Species	Date	Field No.	Locality	Gazetteer	Sex	HB	T	HF	Ear	Weight	Remarks
Otomys	cf. *typus*	11.12.2014	At 48	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	158		29	20.5		Mammae active, gravid 1/0
Stenocephalemys	*albipes*	11.12.2014	At 49	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	120	156	25.5	20.5		
Stenocephalemys	*albipes*	11.12.2014	At 50	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	141	170	30.5	24.3		Testes active
Stenocephalemys	*albipes*	11.12.2014	At 51	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	123	156	26.3			
Stenocephalemys	*albipes*	11.12.2014	At 52	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	133	171	27	22.2		
Stenocephalemys	*albipes*	11.12.2014	At 53	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	132	174	27.2	24.2		
Stenocephalemys	*albipes*	11.12.2014	At 54	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	M	132		27	23.3		Parasited by a fly larva (warble fly) under the head skin, *Oestromyia*
Crocidura	*olivieri*	11.12.2014	At 55	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E	F	128	94	21	10.5	34	
Lepus	cf. *fagani*	11.12.2014	No no.	Gojeb Wetland, Meda Abo, Gewata, NW Bonga, 1531 m a.s.l.	07°33'50" N, 36°03'06" E							Roadkill, only peace of fur
Mus (Nannomys)	*mahomet*	12.12.2014	No no.	KDA Guesthouse, Bonga, 1756 m a.s.l.	07°15'01" N, 36°15'15" E	M						

M – male, F – female, HB – head and body, T – Tail, Hf – hind foot. All measurements in millimetres, except weight (in grams).

7.2. Photos

Figure 9: Specimens of male *C. olivieri* from Ethiopia (left: Gojeb Wetland, 11/12/2014, right: the more widespread savannah colour morph from Bahir Dar, Lake Tana, 07/04/2011) (photo: Holger Meinig)

Figure 10: *Heliosciurus gambianus* ssp. *(*cf. *kaffensis),* 8/12/2014 (photo: Holger Meinig)

Figure 11: *Heliosciurus gambianus* ssp. *(*cf. *kaffensis)* from south Gind Aba (07°27'13.3" N, 37°11'040.0" E), 11/12/2014 (photo: Holger Meinig)

Figure 12: Colouration of *Heliosciurus gambianus* ssp. from Lake Awassa, 29/03/2010 (photo: Holger Meinig)

Figure 13: *Tachyoryctes splendens* s.l. from the Bamboo Forest, 06/12/2014 (photo: Bernhard Walter)

Figure 14: Snare for catching *Tachyoryctes*, bamboo camp, 06/12/2014 (photo: Holger Meinig)

Figure 15: Comparison of body proportions of Ethiopian *Lophuromys*. Left: female *L. flavopunctatus* s.l from Bamboo Camp, 06/12/2014, right: male *L. brevicaudatus* from Wahoro village, Bale Mts., 04/04/2010 (photo: Holger Meinig)

Figure 16: *Otomys* cf. *typus* from the Sanetti Plateau, Bale Mts., 14/04/2010 (photo: Holger Meinig)

Figure 17: *Stenocephalemys albipes* from the Bale Mts. near Dodola, 09/04/2010 (photo: Holger Meinig)

Figure 18: *Mus mahomet* from the Bamboo Camp, 05/12/2014 (photo: Holger Meinig)

Figure 19: Section of samples identified as *M. mahomet* from the phylogeny of the *Nannomys* group by Bryja et al. (2014), among others, presenting material from the study area (Bonga, Jimma)

Figure 20: Body proportions of *Stenocephalemys albipes* (above) and *Dasymys* cf. *incomtus* (below) (photo: Holger Meinig)

Figure 21: Body proportions of *Stenocephalemys albipes* (above) and *Dasymys* cf. *incomtus* (below) (photo: Holger Meinig)

Figure 22: Characteristic black sole markings of *Dasymys* cf. *incomtus* from the Gojeb Wetland, 11/12/2014 (photo: Holger Meinig)

Figure 23: Yellow-spotted hyrax from Waliso Negash (photo: Holger Meinig)

Figure 24: Clawless otter near Bonga, 2009 (photo: Bernhard Walter)

Figure 25: Clawless otter near Bonga, 2009 (Photo: Bernhard Walter)

Medium (esp. Carnivora and Artiodactyla) and large mammals at the Kafa Biosphere Reserve

Hans Bauer

Highlights

- → 25 species were recorded.
- → The presence of the endangered wild dog (*Lycaon pictus*) could not be confirmed; it is possible the species is locally extinct.
- → The presence of lion (*Panthera leo*) was confirmed; this is the flagship species.
- → Larger mammals are not useful as indicators of forest conservation status due to their very low densities.
- → Camera trapping returned very low capture rates, indicating abnormally low mammal density. This should be confirmed and investigated.
- → An additional survey six months later and on behalf of NABU revealed additional mammal species i.e. the leopard (*Panthera pardus*).

1. Introduction

Ethiopia is known for high levels of biodiversity and endemism, especially in the highland areas. This is also true for mammals, although levels of endemism are higher in most other taxa. Still, endemic larger mammals include species such as the walia ibex, the Ethiopian wolf, the mountain nyala and the gelada. None of these are known to occur in the Kafa zone, but Kafa is known for other important species, such as lion and buffalo.

Several previous expeditions published mammal lists; the most recent is presented below (Yalden 1976, 1980, 1984, 1986; Hillman 1993 as summarised in EWNHS 2007):

Table 1: Checklist of mammals as summarised in EWNHS (2007)

Order	Family
Carnivora	**Mustelidae**
	Aonyx capensis Clawless otter
	Mellivora capensis Honey badger
	Canidae
	Canis aureus Common jackal
	Canis mesomelas Black-backed jackal
	Felidae
	Felis silvestris African wildcat
	Felis serval Serval
	Panthera leo Lion
	Panthera pardus Leopard
	Viverridae
	Atilax paludinosus Marsh mongoose
	Ichneumia albicauda White-tailed mongoose
	Herpestes ichneumon Egyptian mongoose
	Herpestes sanguineus Slender mongoose
	Civettictis civetta African civet
	Hyaenidae
	Crocuta crocuta Spotted hyena
Hyracoidea	**Procaviidae**
	Heterohyrax brucai Yellow-spotted hyrax
	Procavia capensis Rock hyrax
Lagomorpha	**Leporidae**
	Lepus habissinicus Abyssinia hare
Tubulidentata	**Orycteropodidae**
	Orycteropus afer Aardvark
Artiodactyla	**Hippopotamidae**
	Hippopotamus amphibius Hippopotamus
	Bovidae
	Kobus defassa Defassa waterbuck
	Redunca redunca Bohor reedbuck
	Sylvicapra grimmia Common duiker
	Syncerus caffer Buffalo
	Tragelaphus scriptus Common bushbuck
	Suidae
	Hylochoerus meinertzhageni Giant forest hog
	Phacochoerus africanus Common Warthog
	Potamochoerus larvatus Bush pig

We expected to confirm the presence of most, if not all, of these species. We were particularly interested in large carnivores, since these are usually the first species to become extinct in the gradual process of biodiversity erosion (MacDonald et al. 2010). We were particularly interested in the lion and the wild dog, two apex predators that are well known for their enormous home range, low density and propensity for conflict with humans, making them species of particular concern for conservation (Woodroffe & Sillero 2012; Bauer et al. 2015).

2. Materials and Methods

2.1 Study area

We focused on the following study sites:

- Boka/Adiyo (bamboo forest, highland forest)
- Kaka/Adiyo (lowland savannah)
- Wushwush (tea plantation and core zone forest)
- Gojeb Valley downstream (lowland, around the town of Gimbo)
- Gojeb Wetland upstream (wetland and Boginda/Gewata core zone forests)

Additional camera trapping sessions were organised in May 2016, outside the scope of the biodiversity assessment. We report some of the results here, since some additional species were captured that should definitely not be omitted from the present study. Those sessions were as follows:

- 10 nights with 12 cameras (Bushnell Trophy Cam) in the Yecha valley around Boka Forest
- Nine nights with 10 cameras (Bushnell Trophy Cam) in the Yebita patch in Kumba Forest

Table 2: Locations of camera traps (CT) and other important waypoints are indicated below

Area	Site	Code	Habitat	Object	Alt. (m)	Lat. (N)	Long. (E)
BONGA	Bamboo forests	BA	Bamboo forests dominated by *Arundinaria alpina*				
BONGA	Alemgono Wetlands	GO-wet	Wetlands				
BONGA	Boka Forests	BK	Montane forests	CT, porcupine scat	2597	7.24094	36.45224
BONGA	Boka Forests	BK	Montane forest	CT, jackal scat, hare	2508	7.2631	36.45378
BONGA	Boka Forests	BK	Lowland	Interviews	1600	7.26233	36.647
BONGA	Awurada Valley (Gummi River, PFM sites)	AW	Montane forests/ riverine vegetation				
BONGA	Alemgono	AG	Wetland				
BOGINDA	Gojeb Wetlands	GO-wet	Wetland	Buffalo and waterbuck tracks	1567	7.55372	36.04739
BOGINDA	Gojeb Wetlands	GO-wet	Wetland	CT, leopard picture	1562	7.55154	36.04663
BOGINDA	Gojeb River	GO-riv	River/floodplain forests	CT	1604	7.56214	36.02321
BOGINDA	Boginda Forests	BO	Montane forests	CT	2086	7.5072	36.11194

Area	Site	Code	Habitat	Object	Alt. (m)	Lat. (N)	Long. (E)
BONGA	Wushwush forest core area	WW-F	Montane forests	CT	1795	7.27848	36.19352
BONGA	Wushwush tea plantation	WW-T	Tea plantation	CT, duiker picture	1828	7.36835	36.12787
BONGA peri-urban	Outskirts of town	PU	Mixed use	CT, hippo tracks	1731	7.31785	36.24127
BONGA peri-urban	Outskirts of town	PU	Mixed use	Call-up	1694	7.30169	36.23618
GOJEB Bridge	Bridge on main road to Jimma	GB	Lowland	Interviews	1430	7.43676	36.36898
GOJEB Bridge	Bridge on main road to Jimma	GB	Lowland	Interviews	1322	7.46678	36.35624
BOKA	Yecha Valley	BK	Forest, midland	CT, leopard picture	1780	7.30784	36.49982

2.2 Sampling methods

Our methods consisted of camera traps, direct observations, transect walking, scat analysis, tracks and signs (footprints, calls) and interviews with key informants based on a guidebook with pictures of all African mammals (Kingdon 2004).

2.3 Data analysis

Camera trap pictures were identified by the author, after consultation with other group members in case of doubt. Group members working on other taxa reported opportunistic encounters with mammals, and these reports were included. We attempted to use calling stations to assess hyena density (e.g., Bauer 2007), but this was unsuccessful.

The chapter on primates provides a detailed explanation of DNA analysis procedures and protocols, as well as our supporting institutions and experts.

During this and previous trips, the correct identification of the smaller antelopes went unresolved. We recently sought advice from the world's leading experts in this field, the co-chairs of the IUCN SSC Antelope Specialist Group, Dr David Mallon and Dr Philippe Chardonnet. The antelope we had observed and photographed and had tentatively identified as an oribi (*Ourebia ourebi*) was identified as a female bushbuck (*Tragelaphus scriptus*) – although oribi is also likely to occur in the area and was indeed observed in the nearby Omo National Park. We also confirmed the occurrence of common duiker (*Sylvicapra grimmia*) from a DNA sample. The antelopes on the camera trap pictures were all identified as duikers, but from two different species: Weyns's duiker (*Cephalophus weynsi*) for all individuals with a black facial and/or dorsal stripe, and Harvey's duiker (*C. harveyi*) for uniformly coloured individuals. These species have not been previously officially recorded in Ethiopia, and these observations will therefore be used as documentation to extend the known range of these species in Africa. In our tentative field report, we misidentified some pictures as dik-dik and klipspringer; the presence of these species is unlikely, and they should not be included in the checklist of the Kafa BR mammals.

3. Results and Discussion

Medium and large mammals live at very low densities compared to other species; therefore, the number of observations is low, making quantitative assessment fundamentally difficult. Despite 56 'trapping days/nights' (number of days or nights x number of cameras), we only collected 15 animal pictures. Data are too scarce to conduct any statistical analysis or make firm statements, but a success rate this low would generally indicate densities far below natural levels, i.e., indicative of severe human disturbance.

3.1 Interview and photo identification in four different local communities

Table 3: Results from interviews and photo identification in local communities

	Kaka (Adiyo lowlands) (1)	Duma/Gojeb Wetlands and Gewata/Boginda forest (non-exhaustive) (2)	Gojeb town (Gimbo lowlands) (3)	Wushwush and Bonga Forest (non-exhaustive) (4)
Porcupine	+			
Hyena	+	+	+	+
Jackal	+	+	+	+
Warthog	+	+	+	+
Bushpig	+	+	+	+
Common duiker	+		+	
Klipspringer	+			
Bushbuck	+		+	
Rock hyrax	+			
Civet	+		+	+
Caracal	+			
Honey badger	+			
Lion	-	Occasionally	-	Historical, not at present
Wild dog	-	Historically present, present status uncertain	-	-
Leopard	-	+	+	
Cheetah	-		-	
Serval	-		-	
Genet	-		+	
Buffalo	-	+	-	
Giraffe	-			
Defassa waterbuck		+	Uncertain	
Hippopotamus			+	
Clawless otter			+	
Bohor reedbuck			+	
Weyns' duiker (*Cephalophus weynsi*)			+	
Harvey's duiker			+	

1: very little natural habitat in this ecosystem, very heavy agricultural encroachment
2: rich natural habitat in this ecosystem, only slightly used for unsupervised grazing
3: very little natural habitat in this ecosystem, very heavy agricultural encroachment
4: rich natural habitat patches in the tea plantation, though the natural Bonga Forest appears rather degraded

3.2 Synthesis: mammal presence confirmed

Table 4: Occurrence of mammals confirmed during the field study

Common name	Scientific name	Observation during assessment
Olive baboon	*Papio anubis*	Common everywhere
Guereza	*Colobus guereza*	Common everywhere
Grivet	*Chlorocebus aethiops*	Common everywhere
Spotted hyena	*Crocuta crocuta*	Heard almost everywhere, DNA
African wolf and/ or common jackal	*Canis lupaster* and/or *Canis aureus*	CT and scat Boka
Common genet	*Genetta genetta*	CT Awurada
Rusty-spotted genet	*Genetta maculata*	DNA
Lion	*Panthera leo*	PC: resident in Adiyo, transient elsewhere
Leopard	*Panthera pardus*	Skull and picture in Gojeb, DNA, CT Boka
Wild dog	*Lycaon pictus*	PC: possibly in Gewata/Gojeb, elsewhere recently extirpated
Clawless otter	*Aonyx capensis*	Obs and scat Gojeb
Civet	*Civettictis civetta*	Roadkill Bonga, DNA
Slender mongoose	*Herpestes sanguineus*	CT Boka
Rock hyrax	*Procavia capensis/ Heterohyrax brucai*	CT Boka, DNA
Hare	*Lepus* sp.	CT and Obs Boka and Gojeb, common everywhere
Crested porcupine	*Hystrix cristata*	Tracks and scat Boka, DNA
Hippopotamus	*Hippopotamus amphibius*	Tracks in Gojeb Wetland, skull in Gojeb town, heard in Bonga, DNA
Warthog	*Phacochoerus aethiopicus*	Tracks Gojeb
Bushpig	*Potamochoerus larvatus*	Tracks Gojeb, DNA
Bushbuck	*Tragelaphus scriptus*	Obs Bonga
Duiker Grey	*Sylvicapra grimmia*	CT Boka, DNA
Weyns's duiker	*Cephalophus weynsi*	CT Boka
Harvey's duiker	*Cephalophus harveyi*	CT Boka
Defassa waterbuck	*Kobus ellipsiprymnus*	Track, scat and horns Gojeb
Bohor reedbuck	*Redunca redunca*	PC Adiyo
Buffalo	*Syncerus caffer*	CT Boka, Tracks Gojeb

CT= caught on camera trap
PC= personal communication from local community
Obs= live specimen observed by team member
DNA= scat analysis

4. Conclusions and Recommendations for Conservation and Monitoring

Because of their low densities, larger mammals make very poor indicator species. Probability of detection is low, and intensive research would be necessary to detect changes over time. Therefore, none of the listed species qualify as indicator species. However, many of the larger mammal species qualify as flagship species. Undoubtedly the most enigmatic among them is the lion ('vulnerable' on the Red List; Bauer et al. in press), but primates and large ungulates like hippopotamus and buffalo are also candidates.

The main threat to the flagship species, the lion, is undoubtedly conflict with farmers. Previous studies (Brhane Beraki 2014; Gebresenbet et al. in press) have demonstrated that livestock depredation is a common phenomenon, and that the lions in the Kafa BR derive a substantial portion of their dietary requirements from livestock depredation. Due to the tolerant nature of the locals and the immense respect for lions in local culture, this has so far led to very limited retaliatory killing. However, since the population is small it is also very sensitive; a single targeted poisoning event could potentially wipe out all lions.

Through PhD research conducted by Fikirte Gebresenbet, University of Oklahoma, supervised by Hans Bauer, University of Oxford, and conducted with the full support and collaboration of NABU, we expect there to be sufficient research and monitoring effort in the short and medium term. However, NABU is advised to develop a long-term strategy for the sustainable management and monitoring of lions in the Kafa BR. The highly endangered wild dog may be locally extinct. This species is not popular with locals and the general public, and therefore not considered a great loss by the uninformed layman. However, for a zoologist, the disappearance of the species with the highest demands on habitat quality rings an alarm bell. The processes that have led to this situation may only affect this sensitive species at first, but other species may be similarly affected over time. It is therefore important to conduct further research into the status of the wild dog, how it is threatened and on the potential mitigation of those threats.

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6. Appendix

6.1. Photos

Figure 1: Camera trap: common duiker (*Sylvicapra grimmia*), montane forest – bamboo forest, Boka (BK) (photo: Hans Bauer)

Figure 2: Camera trap: hare (*Lepus sp.*), montane forest – bamboo forest, Boka (BK) and Gojeb (GO) (photo: Hans Bauer)

Figure 3: Camera trap: Weyns's duiker (*Cephalophus weynsi*), montane forest – bamboo forest, Boka (BK) (photo: Hans Bauer)

Figure 4: Camera trap: common jackal (*Canis aureus*), montane forest – bamboo forest, Boka (BK) (photo: Hans Bauer)

Figure 5: Buffalo (*Syncerus caffer*), scat, Gojeb Wetland (GO) (photo: Hans Bauer)

Figure 6: Buffalo (*Syncerus caffer*), camera trap, Boka (BK) (photo: Hans Bauer)

Figure 7: Spotted hyena (*Crocuta crocuta*), footprint, montane forest, Komba (KO) (photo: Hans Bauer)

Figure 8: Hippopotamus (*Hippopotamus amphibius*), skull, Gojeb Wetland (GO) (photo: Hans Bauer)

Figure 9: Leopard (*Panthera pardus*), skull, Gojeb Wetland (GO) (photo: Hans Bauer)

Figure 10: Leopard (*Panthera pardus*), camera trap, Boka (BK) (photo: Hans Bauer)

Figure 11: Waterbuck (*Kobus defassa*), horns, Gojeb Wetland (GO) (photo: Hans Bauer)

Figure 12: Waterbuck (*Kobus defassa*), scat, Gojeb Wetland (GO) (photo: Hans Bauer)

Figure 13: Lion (*Panthera leo*), bamboo forest (photo: Bruno D'Amicis)

Figure 14: Lion (*Panthera leo*), bamboo forest (photo: Bruno D'Amicis)

Perceptions and expectations on biodiversity of three focus groups (small farmers, local personnel and scientists) at the Kafa Biosphere Reserve

Maria Hänsel, Olef Koch, Benno Böer and Juan Carlos Montero

Summary

Stakeholders from different backgrounds engage and interact in UNESCO biosphere reserves (BRs), so it is essential for all parties to understand each others' views and values. We studied perceptions and expectations on biodiversity in the Kafa BR, Ethiopia. Semi-structured interviews (n = 85) were conducted with three focus groups: small farmers, local personnel and scientists. The groups displayed substantial differences in their definition of biodiversity, its perceived value and the benefit for local communities. In contrast, there was a shared understanding of the main risks (population pressure) and threats (expanding agriculture). Frequently cited necessary steps to protect biodiversity included community involvement and benefits. The need for stricter law enforcement is debated. Views on biodiversity were found to be strongly influenced by underlying value systems. Means of comparison is suggested as one major factor for varying understanding and valuing of biodiversity. When defining conservation goals, different backgrounds should be carefully considered.

1. Introduction

UNESCO biosphere reserves (BRs) are explicitly designed to reconcile people's needs with conservation pressures. Thus, the aim is to integrate ecological, social and economic goals, creating sustainable ways of living (Bridgewater 2002). To successfully manage a BR, different interests and needs must be considered. A certain level of participation from local communities is generally seen as essential. The level of participation required to create a well-functioning BR is still debated (Wallner et al. 2007). Some argue that, provided local people's interests are met, participation through consultation only (no active participation) is sufficient. Different stakeholders from diverse backgrounds usually jointly engage in the work associated with BRs; therefore, they have to find common grounds for communication to successfully collaborate. This is especially true for BRs in developing countries where external stakeholders from different cultural backgrounds are involved. To agree on common goals, it is essential to have a sound understanding of the background of each party.

In recent years, much attention has been paid to the massive loss of biodiversity worldwide. This is of human concern, as it also relates to a loss of ecosystem services which humanity profits from (Cardinale et al. 2012). However, in many cases it is difficult to quantify specific benefits and their exact impacts, and the issue is fraught with uncertainty (Balvanera et al. 2014). A major aim of BRs is to preserve a diverse environment. Biodiversity is therefore one of the key terms to be communicated. Ideally, the different actors involved should have a good understanding of their respective interpretations.

Most value systems surrounding nature and its use or protection are anthropocentric. According to Duelli et al. (2007), to understand human behaviour it is important to consider both intrinsic motivation (based on value systems) and extrinsic incentives (such as economic benefit). For example, appreciating and valuing a landscape depends on many factors, including cultural background and individual knowledge, interest and experience. Likewise, personal motivation to protect biodiversity can vary greatly, both in extent and underlying justification. Different stakeholders may also have a different understanding of the causes of dwindling biodiversity and of how biodiversity should be protected (if at all). Knowing each party's perspective and values is not only crucial for successfully implementing conservation measures – it also provides an opportunity for a process of mutual understanding, collaboration and, possibly, inspiration.

The Kafa Zone, located in southwestern Ethiopia, lies in one of the few areas of Ethiopia which still has substantial forest cover. Nationwide, Ethiopia's forest cover has been reduced to less than 2.5%, whereas within Kafa Zone around 50% of the land cover is still forest (Pratihast et al. 2014). Nonetheless, there has been a significant loss of forests in the Kafa Zone in recent decades (Tadesse et al. 2014). To preserve the remaining forest with diverse species including wild coffee, efforts were made by different governmental and non-governmental parties like NABU to establish a biosphere reserve. Finally, in 2011 UNESCO designated most of the Kafa Zone the Kafa Biosphere Reserve. Since then, NABU has been one of the major external actors in the Kafa BR, financing a NABU branch office in Bonga (administrative centre of the Kafa Zone) and ten rangers through funding from the German government. The Kafa BR is therefore an exemplary project that brings together many different stakeholders from diverse backgrounds. Through its work, NABU not only tries to enhance conservation through different activities implemented by their staff (all local personnel are originally from the area) but also brings in external actors, mainly for research activities.

UNESCO requires research and monitoring activities to be carried out in all biosphere reserves (Bridgewater 2002). Scientists therefore play an important role in evaluating the current environmental status of the area, including its biodiversity. Their value system and interpretation of biodiversity will influence the outcome of their assessment. This might possibly determine what indicators are chosen to measure biodiversity (Duelli et al. 2007). For example, there could be either a focus on high local species richness (alpha diversity) or a high regional or national diversity (beta or gamma diversity). Different researchers' perspectives on meaningful conservation methods and the overall concept of biosphere reserves are equally important. They may hope that establishing a biosphere reserve might help conserve species or preserve "wilderness" (which might be contradictory in itself, see Duelli et al. 2007). The two most common approaches to biodiversity management have been (a) the exclusion of humans and strict law enforcement and (b) a participatory and community-based approach (Stoll-Kleemann et al. 2010). The latter is strongly advocated by the ethos behind UNESCO biosphere reserves (Bridgewater 2002).

In the case of the Kafa BR, local residents, mostly small farmers, will most likely perceive the landscape quite differently. Therefore, their judgment of its quality might also differ. They might be more interested in direct-use values such as food and medicine and indirect-use values such as ecosystem functions than in non-use values. These three value categories were defined by Gaston and Spicer (2013). A study by Wallner et al. (2007) on locals' perception and evaluation of biosphere reserves showed that the main arguments in favour of establishing a biosphere reserve were economic. Local ecological knowledge is increasingly valued in wildlife conservation (Berkes et al. 2000). This knowledge is the result of a long history of interaction between local people with their environment. In the Kafa BR, there is a long tradition of using wild plants and animals for various purposes. However, traditional management techniques may no longer be sustainable due to pressure through population growth and resettlement programmes. New techniques, along with pressure and influence driven by external interests, have likewise altered land use and management. To preserve biodiversity in the long run, new concepts and methods or shifts in management strategies might be necessary.

The ideas of scientists and other external stakeholders are communicated to local residents by local personnel engaged in nature protection activities. In the Kafa BR these are mainly the rangers employed by NABU, who see raising awareness among local communities as one of their main tasks. Their interpretation of biodiversity and its value will influence locals' understanding of it, along with their perceptions of the importance of biosphere reserves. In a global survey on the effectiveness of UNESCO biosphere reserve management, Stoll-Kleemann et al. (2010) showed that community-based management is on the rise. Its success, however, largely depends on proper adaptation to the local context. Local employees know the cultural and historical background of the area well, and are informed about people's needs. Being simultaneously in close exchange with external stakeholders, they have the opportunity to bridge the gap between different perspectives.

To account for the different levels of stakeholders in the Kafa BR, three focus groups were chosen: (i) small farmers, (ii) local personnel, working in the context of the biosphere reserve, and (iii) scientists (involved in NABU's biodiversity assessment at the Kafa BR). The goal of this study is to gain a better understanding of each party's perceptions of biodiversity, its value, threats and the best ways to protect it in the context of the Kafa BR. Understanding each group's position on these issues will not only help avoid misconceptions; it can also reveal common ground on which future activities can be built.

2. Materials and Methods

2.1 Study area

According to a background study by Chernet (2008), the ethnic composition of the Kafa Zone is dominated by Kaffecho (81%), followed by Bench (6%), Amara (6%) and Oromo (2%). The remaining 5% also include marginalised groups like Manjo (Manja). The biggest religious group are Orthodox Christians (67%), followed by Protestants (20%) and Catholics (10%). There is also a small Muslim community (3%).

The overall population density of the Kafa BR is 98 inhabitants per km², ranging from 52 inhabitants per km² in the least densely populated woreda (Decha) to 210 inhabitants per km² in the most densely populated woreda (Chena).

In total, the Kafa Zone has an area of around 10,000 km² and a human population of a little over one million inhabitants. The Kafa BR itself has an area of around

7,500 km². The natural vegetation is mostly classified as moist Afromontane forest (Friis 1992). Different political and demographic factors have driven changes in land use and land cover in the Kafa Zone. In the 1970s, major land redistribution occurred, followed by large-scale resettlement in the 1980s. The 1990s were shaped by the agricultural investment policy and the promotion of cereal production, along with the Ethiopian Forestry Action Plan. Finally, the 2000s were influenced by large-scale agricultural expansion, the establishment of National Forest Priority Areas, Participatory Forest Management (PFM) projects and ultimately the UNESCO biosphere reserve (Tadesse et al. 2014).

Subsistence farming is very important for local livelihoods. The most common livestock is cattle, followed by poultry, sheep and goats. Honey production (mainly using traditional techniques) and coffee cultivation are other important sources of income (Department of Finance and Economic Development 2012).

2.2 Data collection

Semi-structured interviews were conducted with three different focus groups: Small farmers (n = 43), on-site personnel (n = 15) involved in nature conservation and scientists (n = 27) participating in a biodiversity assessment in the Kafa BR in December 2014. Most interviews were held between 3rd and 21st of December 2014 within the Kafa BR. Time constraints made it necessary to interview some scientists via telephone. Interviews with small farmers were conducted in five different kebeles (situated in three different woredas). The kebeles were chosen because of their proximity to both core zones and the study sites of other groups involved in the assessment (Table 1). Households for most interviews were chosen randomly, but with a preference for a gender-balanced sample. Interviews were held such that they only represent the opinion of a single household member. Wherever possible, the kebele leader and kebele manager of each kebele were interviewed.

Table 1: Sampled kebeles and their main features for the small farmer focus group

Kebele	Angiokolla	Boka	Michiti	Ufa	Ufudo
Woreda	Adiyo	Adiyo	Gimbo	Decha	Gimbo
Habitat of the area	Bamboo forest	Montane forest	Montane forest	Montane forests / riverine vegetation	Wetland
No. of households*	85	311	38	157	209
Walking distance to market [h]**	2.5	< 0.5	0.75	1	< 0.5
Walking distance to core zone [h]**	3	0.5	1.25	1.5	2

* As stated by the respective kebele leader or manager

** Mean value of statements by interviewees of the respective kebele

The personnel interviewed on-site were mostly NABU staff. This included most rangers employed by NABU as well as staff at the NABU branch office in Bonga. Two more people involved in nature conservation work in Bonga were also interviewed. 27 of the 34 participants of the biodiversity assessment were interviewed. Around a third of them were affiliated with Ethiopian institutions. The remaining scientists were affiliated with European universities or institutions.

2.3 Interview design

Interviews were structured in two parts. Part one tackled specific biodiversity issues, mostly directly linked to the Kafa BR. Since most farmers were not familiar with the term "biodiversity", a short explanation was provided before further biodiversity-related questions were asked. Part two consisted of more general questions about BRs and their influence. Due to time constraints, these questions were only put to two of the focus groups (scientists, local personnel). To ensure comparable results, some questions (n = 13) were asked to all focus groups, although sometimes with minor changes. To allow interviewees' specialist knowledge to be considered, some questions (n = 19) were only asked to one or two of the focus groups. Since there is no term for biodiversity in any local language, the English term "biodiversity" was used when interviewing farmers. Rangers reported that they had also used the English term when giving training sessions.

2.4 Background information on interviewees

The ethnic composition and religion of interviewed farmers roughly matched the overall mean for the Kafa Zone (Chernet 2008) being clearly dominated by Kaffechos and Orthodox Christians. One of the minorities (Manja) was overrepresented with a share of 19%, because one of the sampled kebeles (Michete) is only inhabited by Manja. The gender ratio among farmers was about equal. The educational level between sexes was significantly different, with women only attending school for three years on average (Figure 1a). 30% of interviewees were members of participatory forest management (PFM) sites, while 56% had received training. There were no major differences between sexes in these two categories (see Table 2 and Figure 1b). The most common sources of training were NABU (28%) and the agricultural department (21%).

Table 2: Background information for interviewed farmers (overall and by kebele)

	Total	Kebele				
		Angiokolla	Boka	Michete	Ufa	Ufodo
No. of interviewees	43	5	11	7	10	10
Age [mean ± sd]*	34 ± 14.3	36 ± 9.6	28 ± 7.2	32 ± 6.6	27 ± 6	47 ± 21.8
No. of school years [mean ± sd]	5 ± 4.1	3 ± 3	7 ± 3.1	6 ± 3.2	5 ± 5	4 ± 4.9
Property size in ha [mean ± sd]**	2 ± 1.4	2 ± 1.5	2 ± 1.2	2 ± 1.7	1 ± 1	2 ± 1.8
No. of household members [mean ± sd]	5 ± 3.3	8 ± 3.3	5 ± 2.6	5 ± 3.7	4 ± 2.5	5 ± 3.2
Received training [%]	56	80	82	14	70	30
Higher education [%]	5	0	0	14	10	0
PFM member [%]	30	100	27	14	40	0

* Age values must be treated with caution, as interviewees were often unsure of their exact age

** Because of fears of taxation, stated property sizes are very likely underestimates

The gender ratio was less balanced among personnel, being clearly dominated by men (87%). The mean age (34 years) was the same as for the farmers, but the range was smaller. Mean work experience (10 years) was significantly less than for the scientists (15 years). Interviewees mostly worked as rangers employed by NABU (67%). Only personnel not working as rangers held Master's degrees.

The scientist group was older (mean = 44) and more experienced than the personnel. It was likewise dominated by men (70%), with females tending to be younger with less work experience. Just over half of the scientists said they were familiar with Ethiopia to some extent, but only 30% were Ethiopian by nationality. Scientists with experience in management and nature conservation were less likely to have doctoral degrees (19% vs. 50%) or be acquainted with Ethiopia (40% vs. 78%). In general, more Ethiopians than non-Ethiopians had worked for a governmental institution (57% vs. 8%) but the reverse was true for non-government organizations (38% vs. 73%).

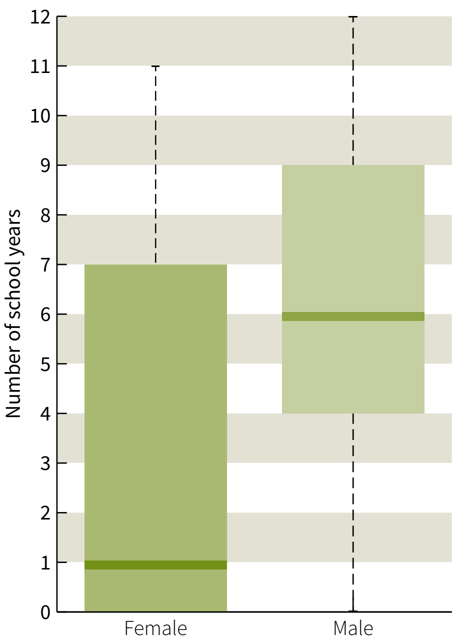

Figure 1a: Number of school years by gender

Figure 1b: Training received by kebele and gender

2.5 Data analysis

First, answers were tentatively categorised to allow for comparison and aggregation. Responses were checked to see whether they covered the most common topics. Whenever reasonable, answers to different questions were considered simultaneously. Lines of argument and general concepts were then analysed and grouped. Statistical analysis was performed using R version 3.1.2 (R core Team 2014).

3. Results

3.1 General perception of biodiversity

All three focus groups were asked to define the term "biodiversity" (see Figure 2a). The farmers' understanding matched the most common answer given by personnel, and equated biodiversity with ecosystems, and sometimes only with forests. The standard textbook definition of biodiversity, which includes three levels of diversity (genetics, species and ecosystems/landscapes) was given by 20% of the personnel and 56% of scientists. Around 25% of scientists and 7% of personnel mentioned additional qualities of biodiversity, mostly focusing on the diversity of biological relations or interactions. Around 33% of scientists reduced biodiversity to diversity at the species level. For the majority of scientists, species were the most important element of biodiversity and therefore the focus.

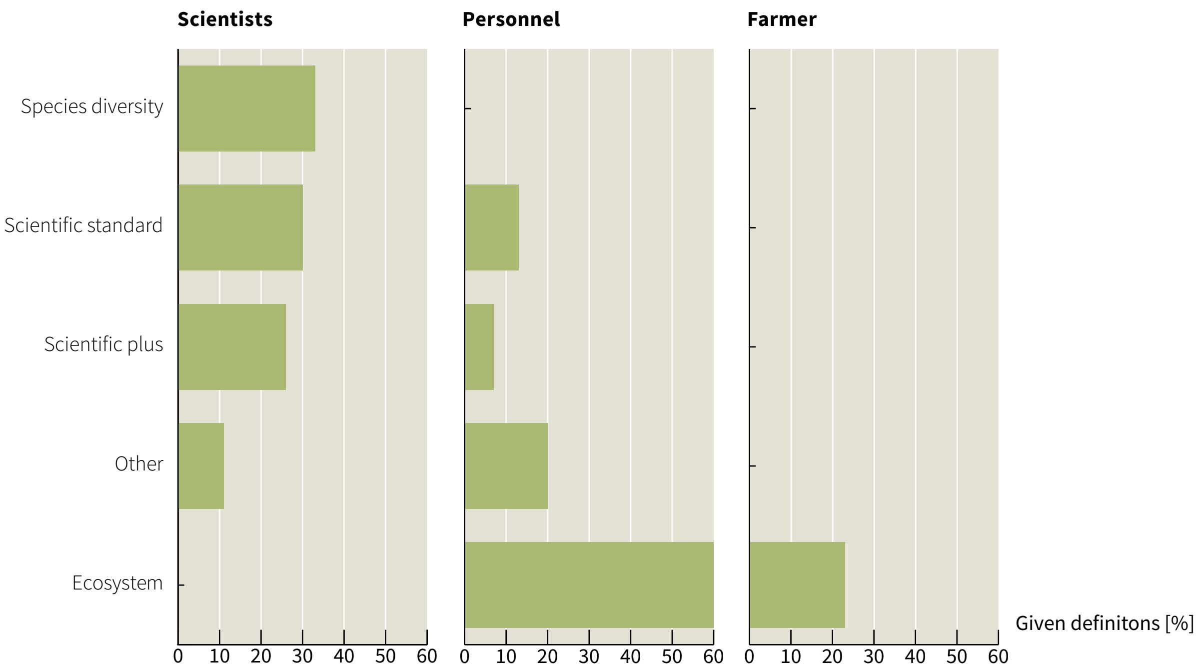

Figure 2a: Definitions of biodiversity given by all focus groups

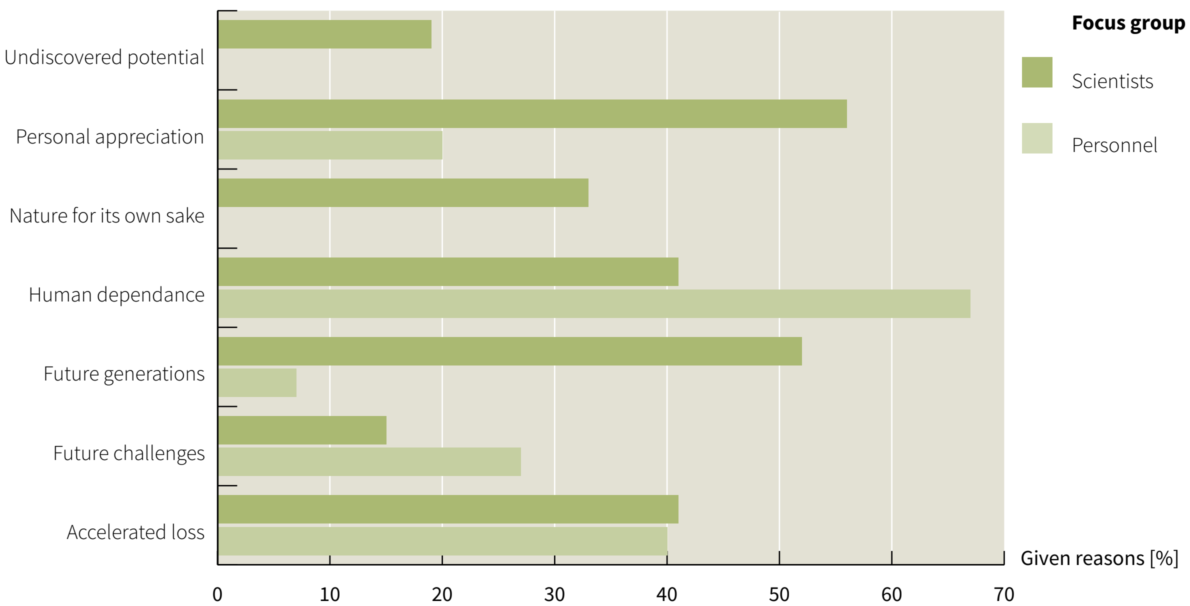

Figure 2b: Personal motivations to protect biodiversity as given by scientists and personnel

When asked about personal reasons to protect biodiversity, the most common answer for scientists was personal appreciation of the diversity of nature, followed by the wish to preserve it for future generations (Figure 2b). In contrast, human dependence was the single most important reason for personnel, followed by motivation due to recent accelerated loss of biodiversity. This reason was given by the scientists about as frequently. To be prepared for future challenges was a comparatively rare personal motivation for scientists (15%), but the third most important motivator for personnel (20%). Only scientists mentioned protecting biodiversity for its own sake, ensuring every species' right to exist independent of any human benefit. This was also true for the undiscovered potential of biodiversity, e.g., future medicinal discoveries.

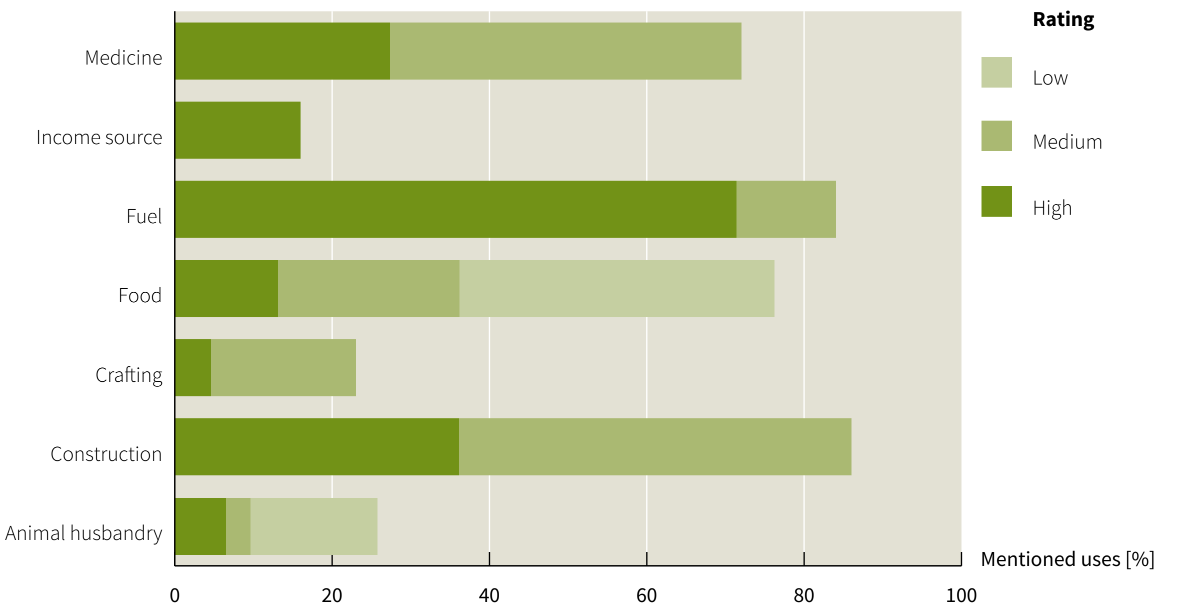

Figure 2c: Uses of wild species mentioned by farmers and their importance

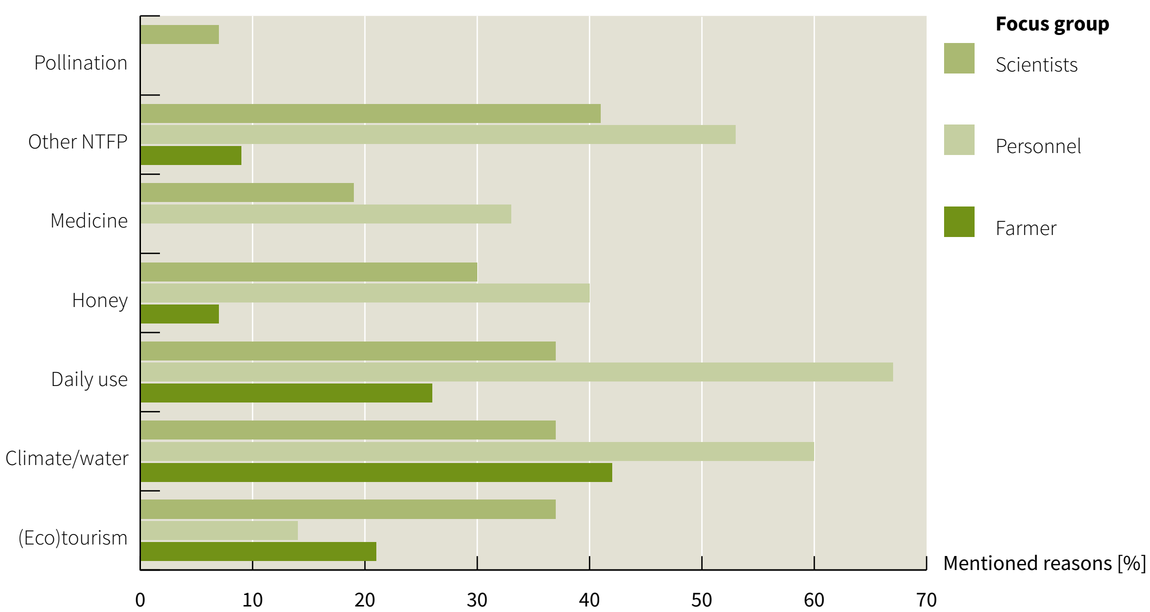

Figure 2d: Reasons to protect biodiversity for the local community, according to all groups

The most important stated use of wild species for farmers was fuel, which was rated as highly important and commonly used (Figure 2c). Using wild plants for construction and medicinal purposes were also viewed as important, but the majority of interviewees only attributed medium importance to it. Wild species are commonly used as food, but this was generally perceived as being of low importance. Some people mentioned that this might be more important after a poor harvest. Few people (16%) mentioned wild species as an important source of income, but for those who did, this was rated as highly important. Generally, only wild plants were regarded as useful. Animals, especially mammals, were often seen as competitors for crops; their only perceived use was as a tourist attraction. When specifically asked if they also valued wild species for some other reason beyond their usefulness, less than half of the interviewed farmers agreed. For those who agreed, the most common reason given was beauty. The mantled guereza (*Colobus guereza*) was often mentioned in this context. Sacred forest sites were also mentioned. Some farmers were asked if they would be willing to protect a species that was endemic to their forest (a bird was given as an example) but which was ugly and of no use to them. Besides surprise at the question, the immediate reaction was that they would not. However, after reflection some people later stated that the species might be of future use and therefore worth protecting.

Many scientists found it difficult to name ways in which biodiversity would benefit local communities, especially when asked to specifically identify benefits from a diverse environment rather than general ecosystem services provided by forests. The most commonly cited reasons were climate and water regulation, making use of different species in daily life, especially from non-timber forest products (NTFP), and tourism as a source of income (see Figure 2d). Of the scientists who saw ecotourism as a possible way to benefit from biodiversity, some also stated associated risks and challenges, the most important being distributing profits and the limited quality of tourist infrastructure and associated services. Honey and coffee were perceived as the most important forest products. The majority of scientists (65%) rated the importance of biodiversity for the livelihood of local communities as high. Still, 13% of interviewees thought of it was of low importance to local communities. The remaining 22% assigned medium importance to it.

When asked the most important reason to protect biodiversity, the most common response from farmers involved ecosystem services such as climate regulation and water supply (Fig. 2d). Daily use, the second most common answer, was only mentioned by 26% of respondents. This is probably because, even after being provided with an explanation of the term, biodiversity was seen as related to forests and protection was seen as implying non-use. Surprisingly, none of the farmers mentioned medicinal plants as a reason to maintain a diverse environment, even though 72% mentioned using them and 38% assigned them high importance. Some farmers explained how strict protection of areas that excluded any use made no sense. Others also expressed that "biodiversity should be balanced", expressing the fear that if there were too many wild animals they would feed on their crops. 88% said that biodiversity was very important to people's wellbeing, while the rest assigned it medium importance.

In contrast, 67% of personnel cited daily use as a benefit of biodiversity for the local community, the most common answer. This was followed by climate and water regulation. NTFP, especially honey and medicinal plants, were also often mentioned. Of the three focus groups, the personnel mentioned possible benefits of tourism the least (14%). All interviewed personnel said biodiversity was very important for the well-being of local communities.

3.2 Biodiversity – What makes the Kafa BR special?

Overall, scientists rated the richness of the Kafa BR as high (Fig. 3a). However, of the three focus groups, scientists were the more likely to assign medium richness to it (22%). This was only true for non-Ethiopian participants (32%). More than a quarter of scientists (and 50% of Ethiopian scientists) emphasized Kafa's high biodiversity, especially in comparison with other parts of Ethiopia. In addition, almost half of the scientists mentioned its undiscovered potential in terms of new species.

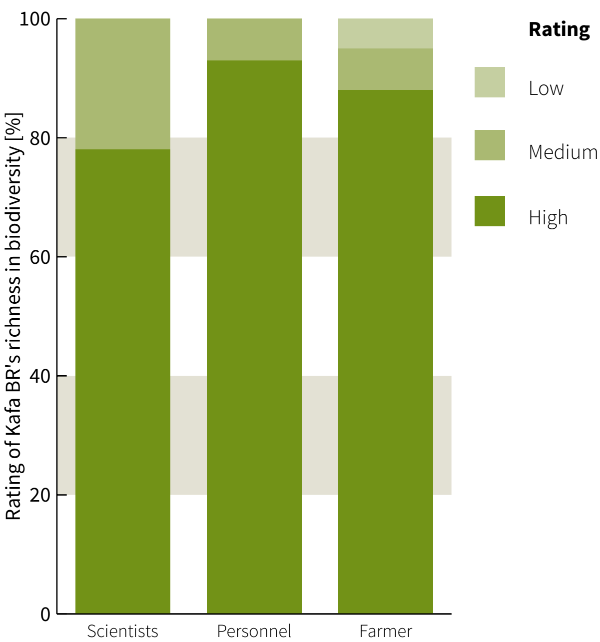

Figure 3a: Rating of the richness of Kafa BR's biodiversity by all focus groups

Figure 3b: Rare species most commonly mentioned by farmers and personnel and suitable flagship species according to scientists

Generally, farmers said they were very familiar with wild species (67%). Responses varied by gender and PFM membership, but not by training received, indicating that knowledge of species is indigenous knowledge than rather than taught by external actors. Some women (13%) explained their low familiarity with species by explaining how they mostly stayed within a certain radius of their property. Most interviewed farmers had never travelled outside of the Kafa Zone. Often, they were only familiar with their area within Kafa. In total, 88% of interviewed farmers saw the Kafa Zone as being highly rich in species. When asked, what they based this rating on, respondents mostly explained that they heard this from other people or through the media about other parts of the country. Some respondents also claimed that the Kafa Zone is rich because of its evergreen forest. One individual stated that the Kafa area was species poor. However, he later confessed that he gave this answer to discourage interest in protecting the Kafa area.

All three focus groups were asked to name special animals. For the scientists, the focus was on suitable flagship species, whereas for farmers and personnel the main criterion was rarity. Surprisingly, about 40% of farmers were unable to name any rare species (see Fig. 3b). The most commonly cited animal was the bushbuck (*Tragelaphus sylvaticus*) at around 20%, followed by the lion (*Panthera leo*). It was unclear whether by "bushbuck" people were referring to *Tragelaphus sylvaticus* or a "deer-like" animal in general. The personnel mentioned lions most often as rare species (60%), followed by *Cordia africana* (40%). The existing flagship species of the Kafa BR, the mantled guereza (*Colobus guereza*) and coffee (*Coffea arabica*), were generally supported by scientists. More than 20% also suggested adding the lion as an additional flagship species. Scientists also named possible flagship species from their own disciplines.

3.3 Risks and threats to the Kafa BR's biodiversity

Changes in species abundance had been noticed by 87% of personnel and 70% of farmers, respectively. Increases and decreases were cited about equally, and around a third of each focus group had noticed changes in both directions. Personnel most frequently cited the increase in the monkey population (36%) and decreasing number of lions (29%). They also reported that secondary and understorey species are benefiting from selective logging of large hardwood trees. The general feedback from personnel was that the biggest losses had already happened in the past, mainly due to the resettlement program in the 1980s. The development of forest cover and animal populations in past years was seen predominantly positive. According to one respondent, the increase in monkeys is due to changes in law. Between 1970 and 1990, hunting monkeys was regulated. According to some personnel, this led to increased conflict with farmers, who then tried to kill monkeys to avoid crop loss. This is supported by the feedback from farmers on which species had the biggest negative impact on their farming activities, with 86% of respondents mentioning monkeys (Figure 4b). However, most people, being aware of the government regulation, said they would only try and chase them away, not kill them. The mantled guereza was an exception to this negative view, due to its different feeding habits (mostly leaves). Other animals often seen as a problem included wild pigs (65%) and rats (37%) eating from food storage. Carnivores attacking livestock were only mentioned by 16% of farmers.

Biodiversity loss was seen as a severe problem by most people in all three focus groups (see Figure 4a). Personnel were the most likely (20%) to ascribe low importance to the problem. This is because they saw recent developments as being positive, as mentioned above. Personnel and farmers saw the pressure on wetlands as predominantly low (only farmers living near to wetlands were asked this question). Overall, scientists rated the pressure as medium (Figure 4a). Both underlying risks (e.g., population pressure, climate change, investors) and actual threats (e.g., agricultural expansion, hunting) were mentioned as drivers of biodiversity loss (Figure 4c). The threats of expanding agriculture and (illegal) logging were most frequently mentioned by farmers and scientists. Personnel ascribed higher priority to (illegal) hunting over logging. Every focus group saw population pressure as the biggest risk. Investors were mentioned as a risk by about 20% of both scientists and personnel. Only scientists mentioned the risk of increased biodiversity loss through increasing wealth, bringing with it new technologies and lifestyles with higher environmental impact. When asked about drivers in general, only personnel mentioned climate change. However, when scientists were asked specifically to rate the possible impact of climate change on biodiversity, 28% said they saw it as a current driver (see Figure 4e). Nonetheless, the majority did not rate it as a current driver, and only possibly as a future driver. Many scientists felt that the local effects of climate change are too complex to allow for predictions.

Both farmers and personnel were asked whether they had experienced changes in weather in recent years. Changed or unclear seasonality (unseasonal rain) was the most frequently cited trend in weather conditions. This was reported by 28% of farmers, but results were sometimes contradictory, even within the same village. 64% of personnel mentioned shifts in seasonality and 43% mentioned increased rain intensity. Signs of increasing temperature were mentioned by less than 10% of interviewees in both focus groups.

Interviewees were also asked to name plant species which are vulnerable to changing weather conditions. Increased rain intensity, long dry spells and shifts in seasonality were given as examples to help explain the question. Only a little more than 20% of farmers and 50% of personnel were able to name such a species. This was most commonly associated with prolonged dry conditions.

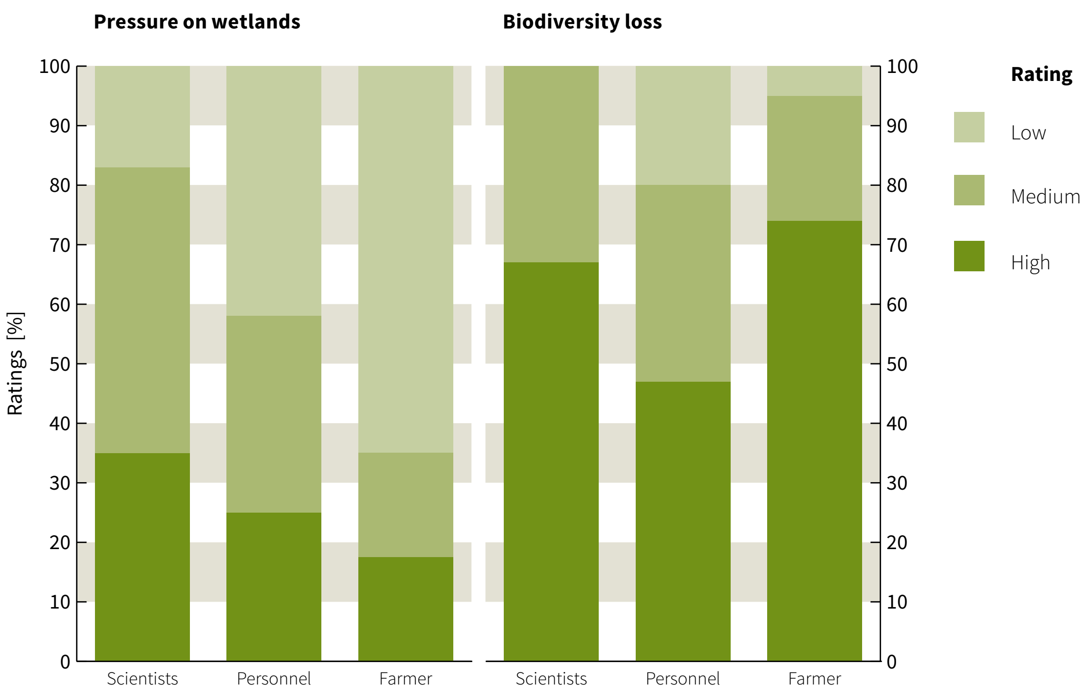

Figure 4a: Ratings by all three focus groups on the pressure on wetlands and the problem of biodiversity loss

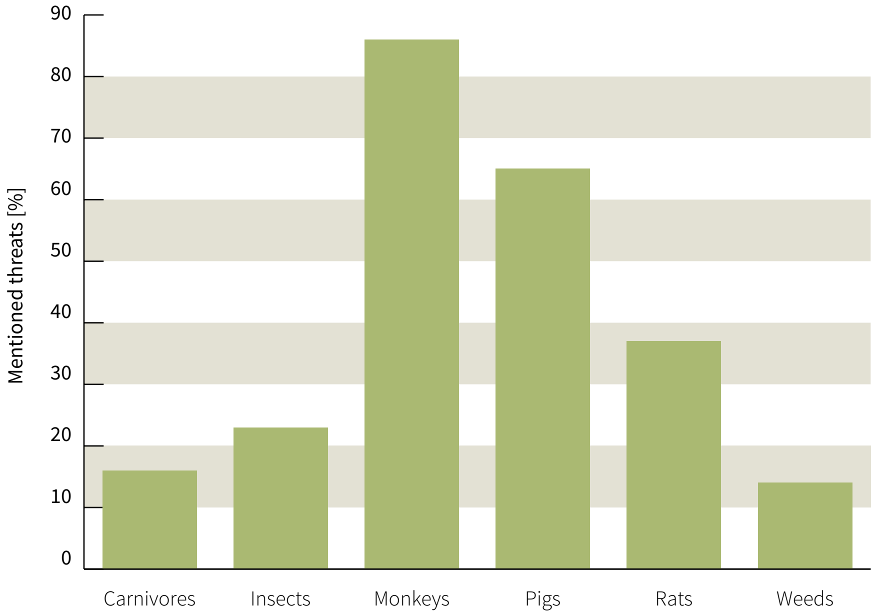

Figure 4b: Wild species commonly perceived as threats by farmers to their farming activities

Figure 4c: Most commonly mentioned drivers of biodiversity loss for all focus groups

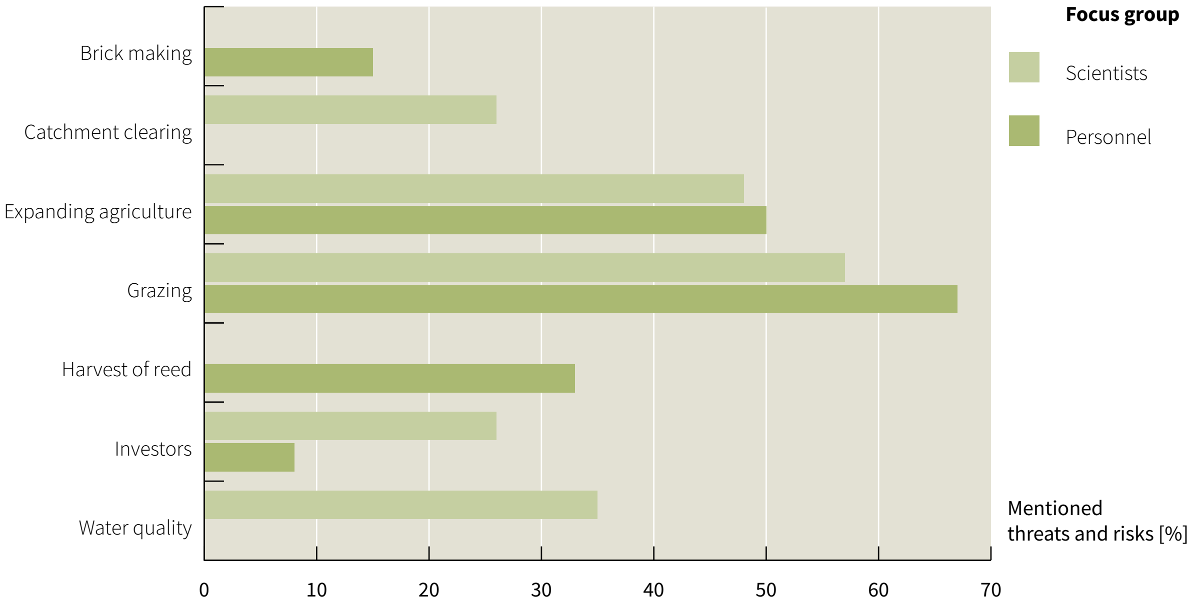

Figure 4d: Commonly mentioned risk and threats to wetlands by scientists and personnel

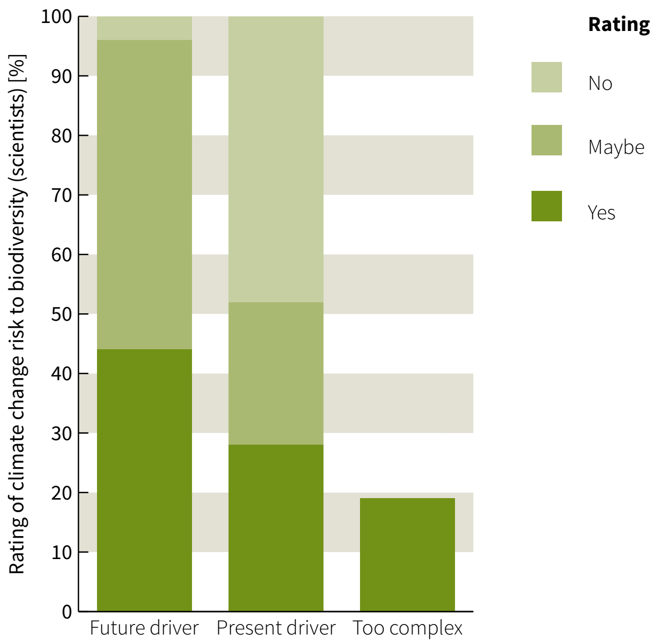

Figure 4e: Ratings for the risk of climate change affecting biodiversity by scientists

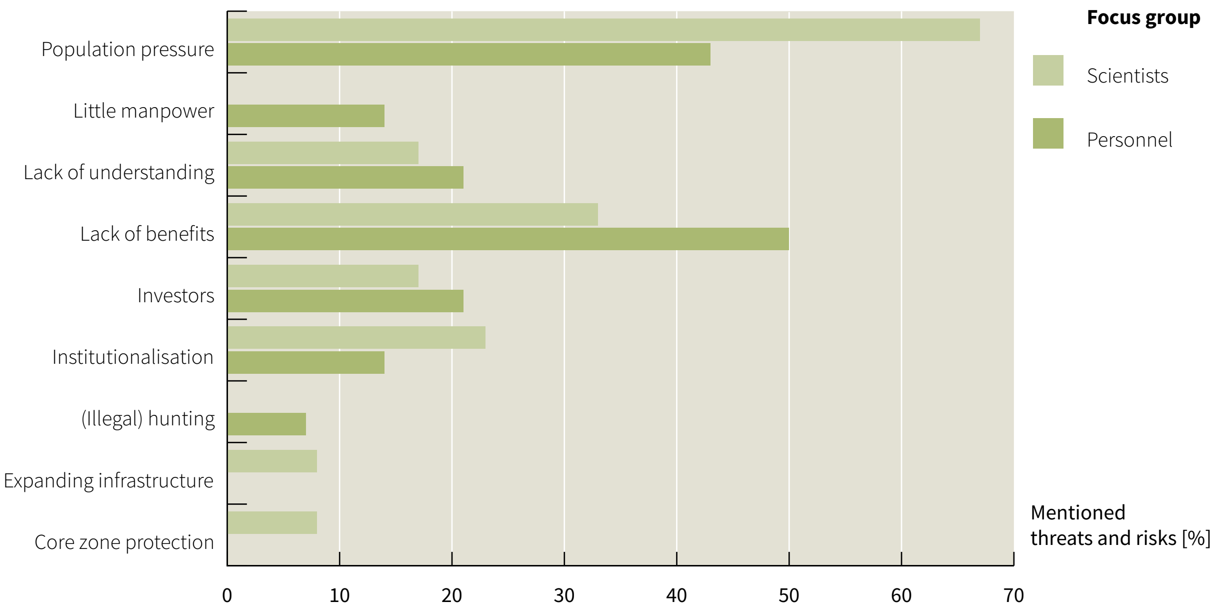

Figure 4f: Commonly mentioned risk and threats for the future of the Kafa BR by scientists and personnel

Wetlands are traditionally used for grazing, especially during dry season, and to harvest reed for roofs and as decoration for celebrations. Farmers saw grazing as the most important use of wetlands by far, followed by the collection of reed for roofs. When scientists were asked about the importance of wetlands to achieving conservation goals, the main reason given was the provision of habitats to wetland species (65%). Regulation of water and microclimate were also mentioned. Wetlands were seen as being very important for conservation (96%). Grazing and expanding agriculture were seen as the biggest pressures on wetlands, both by personnel and scientists (Figure 4d). Harvesting reeds and brickmaking were only mentioned by personnel. Scientists also worried about threats such as water pollution (sediments, chemical), catchment clearing and the risk of large-scale impact by investors.

Scientists generally viewed the relationship between development goals and nature conservation as problematic. Still, 20% thought that they were compatible, since long-term development is only possible by considering environmental issues. This perspective was only supported by non-Ethiopians (26%). Likewise, only non-Ethiopians (28%) stated that conservation should be prioritised over development (28%). The idea of balanced use, with some areas set aside for development (e.g., intensive agriculture) and others for environmental protection was mainly proposed by Ethiopians and interviewees who had no stated background in management.

The biggest challenges seen for the future of the Kafa BR exhibited significant overlap with the mentioned drivers of biodiversity loss (see Figure 4f). The risk of population pressure and its associated threats was once again mentioned frequently by both scientists and personnel. However, the challenge most frequently mentioned by personnel (50%) was the lack of benefit to local communities from the Kafa BR. This argument was also supported by 33% of scientists. Both focus groups mentioned risks due to a lack of understanding by different communities and risks due to investors about equally. Challenges associated with the institutionalisation process which require the government to take over responsibility for managing the BR were pointed out by more scientists (23%) than personnel (14%). Only personnel mentioned the lack of manpower and resources in BR management.

3.4. Proposed measures to protect the biodiversity of the Kafa BR

Around half of the farmers saw their activities as contributing to conserving biodiversity. Specific reasons included diverse home gardens, planting or maintaining of trees on their properties and, occasionally, planting flowering plants for beekeeping (Figure 5a). Scientists and personnel both mentioned that Kafa's inhabitants have a unique culture based around protecting nature. Some proposed measures to protect biodiversity were similar to the contributions mentioned by farmers, e.g., planting or maintaining of trees. Education about ways to protect resources and their proper use was also seen as important (26%).

Almost all farmers said they were interested in the results of the study and the biodiversity assessment. Scientists explicitly mentioned education (58%) and general development of the area, including infrastructure (21%). Most farmers (70%) saw the community as responsible for protecting biodiversity, while a little over half thought this lies with the government (see Figure 5b). Generally, male farmers mentioned both bodies more often. Interviewees who had received training or were PFM members tended to see the community as more strongly in charge of protecting biodiversity. About 60% of scientists were aware of at least some of NABU's activities since establishing the Kafa BR. Measures aiming to raise awareness among local communities, PFM sites and the distribution of stoves were the most commonly known. The majority of scientists saw communities as playing a central role in the success of future biodiversity conservation (Figure 5c). Around 50% of scientists suggested raising community awareness, ways to allow communities to profit from biodiversity through benefits or compensation and community involvement. A little under half of scientists saw government involvement as crucial. This was also mentioned by the personnel, with the biggest difference being the frequency of mentioning raising community awareness (93%). External financial or personal input was suggested more frequently by scientists (22%) than personnel (14%). This was also true for family planning. Only scientists mentioned improving management strategies, sustainably increasing agriculture and implementing waste and sewage management. Only personnel mentioned product marketing and better protection through increased ranger capacity, especially for transportation. Scientists and personnel were both broadly against enforcing punishments in the region, e.g., to protect the core zones (see Figure 5d). However, more scientists (33%) were in favour of this measure than personnel (25%). Most scientists saw the need for future research in further biodiversity assessments (81%). Research into improved management or agricultural techniques were mentioned by around 40% of scientists.

While describing the general concept of BRs, 60% of personnel and 81% of scientists emphasised the aim of combining human use with protecting nature. Around 30% of scientists saw zonation as helpful in this regard. Scientists saw loss of sovereignty and specifically land access rights as the biggest disadvantages for local communities associated with establishing a BR (56%). The long-term preservation of a basis for livelihoods was seen as the biggest advantage (64%). Adding value to an area by promoting it as a tourist destination, especially while competing with other places, was also mentioned (40%). Around 10% supported the view that the positive and negative effects would balance out. Overall, scientists rated the effects of BRs on local communities as positive (84%).

Figure 5a: Farmers' perceived contributions to biodiversity and suggested measures to protect biodiversity

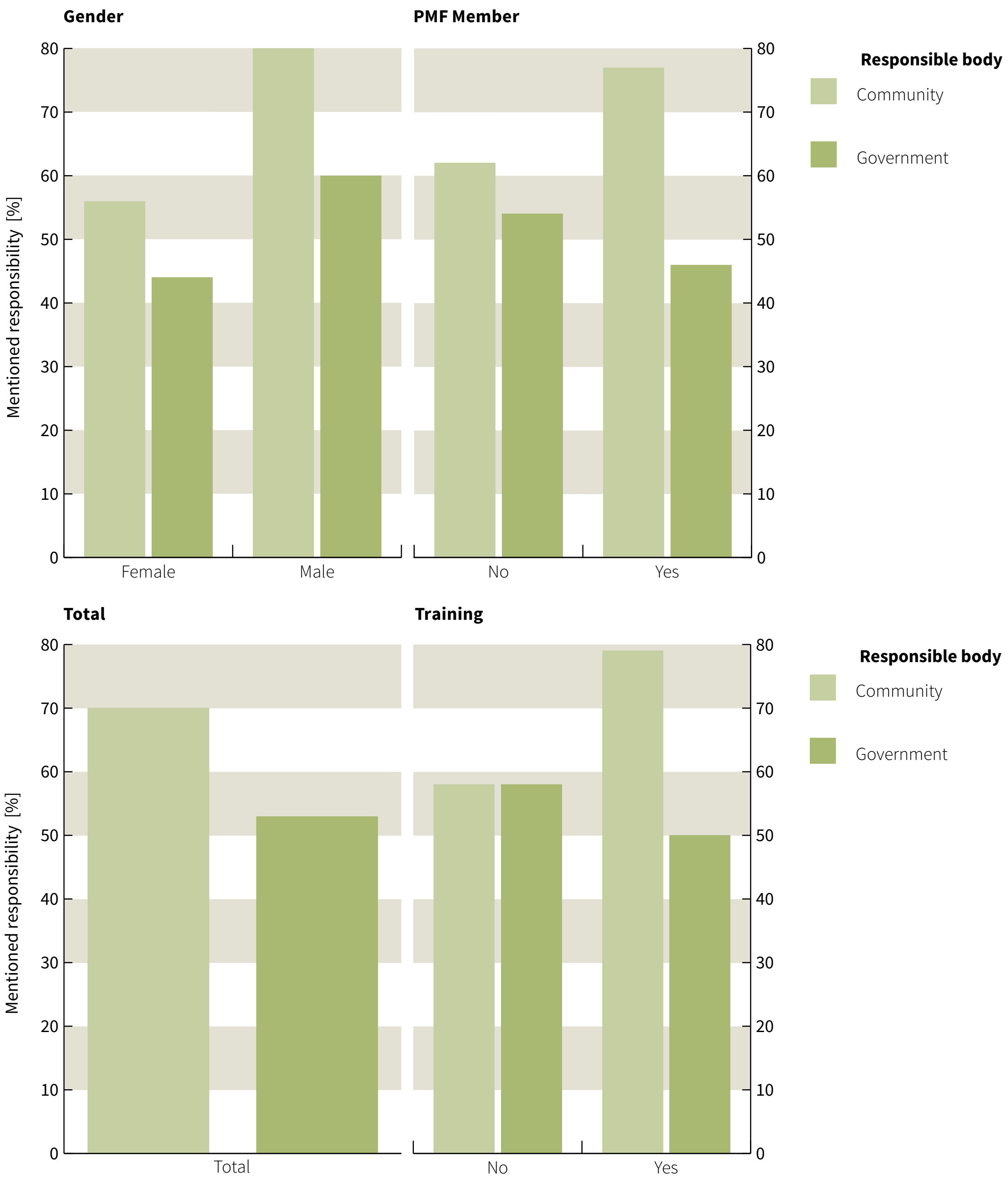

Figure 5b: Bodies seen as responsible for biodiversity conservations by farmers (also grouped by gender, PFM membership and level of training)

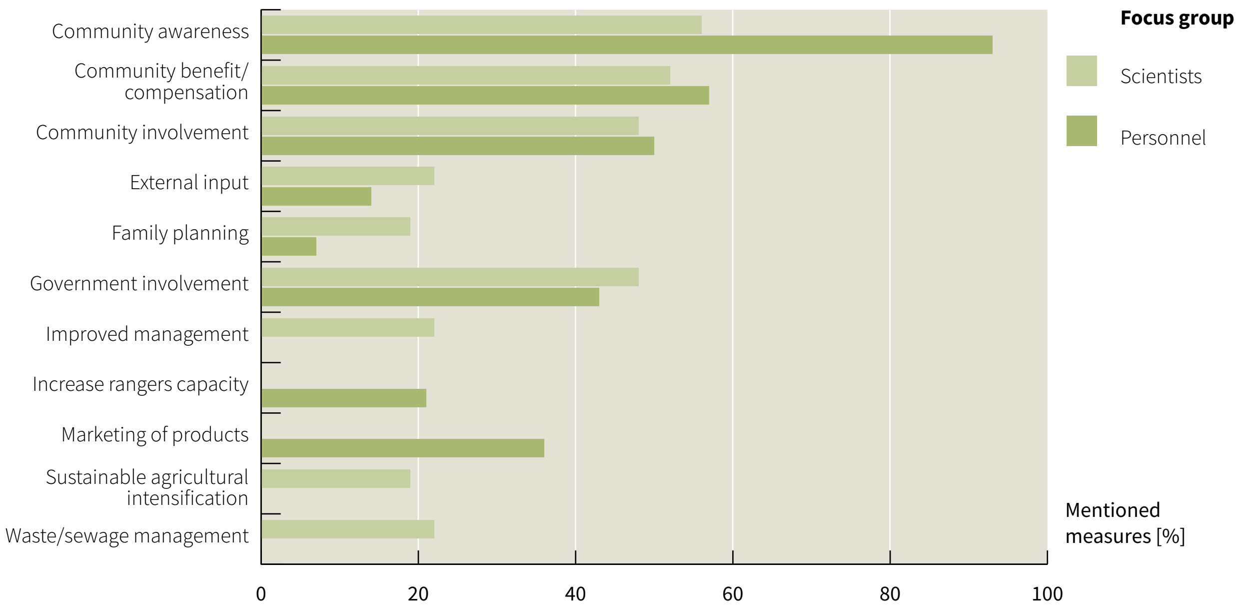

Figure 5c: Measures for biodiversity conservation in Kafa, as suggested by scientists and personnel

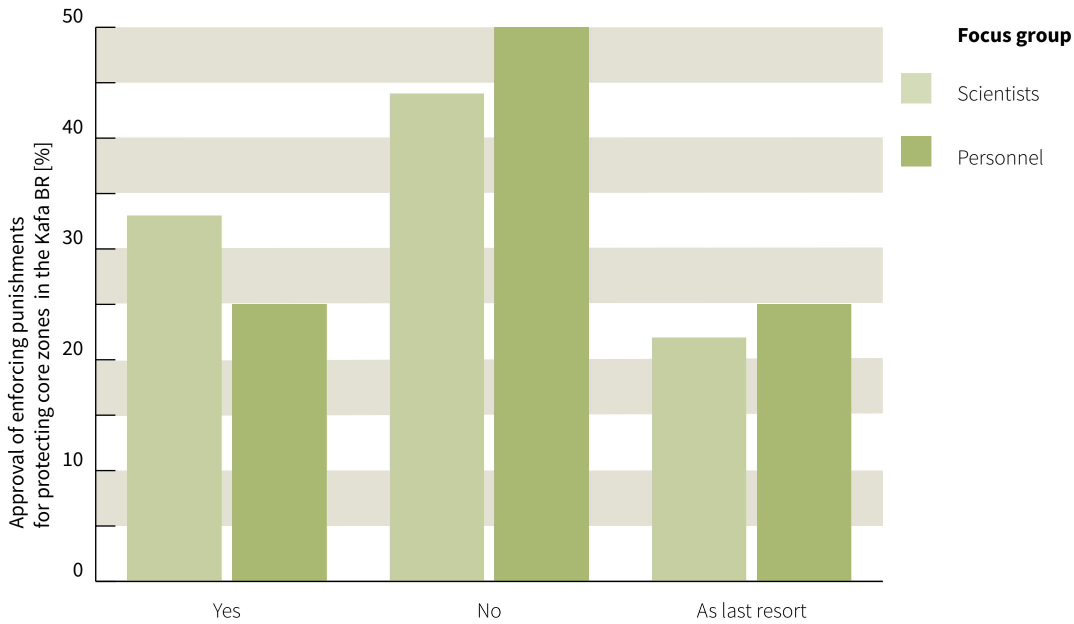

Figure 5d: Opinion on the necessity of enforcing punishments to protect core zones in Kafa, as given by scientists and personnel

4. Discussion

4.1 Biodiversity – a concept understood in diverse ways

The three different focus groups had substantially different understandings of biodiversity. This is due to both education and individual interests. Even the definition of biodiversity is influenced by value systems, which can be both cultural and individual. The term is used with diverging understanding even within scientific contexts (Duelli et al. 2007). This was also true for the focus group of scientists in this study, who provided varying definitions of the term. The clearest overall difference in the definitions was in terms of level of abstraction. When equated with ecosystems or even more simplistically with forests (farmers, personnel), biodiversity becomes a very tangible concept, at the expense of the relevant of diversity. Reducing biodiversity to the species level (personnel, scientists) still simplifies variety to the level that is the most accessible to humans. The standard textbook definition reduces "diversity of life" into three defined categories. The extended scientific definition, given mostly by scientists but also occasionally by personnel, also mentions a diversity of relations and interactions related to the concept of a "balance of nature". This concept of ecological resilience, put forward by Pimm (1991), stresses that the more species there are, the more diverse their roles within an ecosystem. This, in addition to intraspecies diversity, promotes "ecological stability", because adaptation is more likely without major shifts.

Semi-structured interviews are not sufficient to explore the relationship between farmers and their environment in any great depth. The main focus was on understanding predefined (scientific) concepts. Methods like participatory rural appraisal are better suited to allowing people to develop appropriate concepts to describe their views (Chambers 1994). Due to time constraints, it was unfortunately not possible to use these methods for this study. Thus, the meaning of biodiversity for people in local communities may have not been properly assessed. Even so, this study demonstrated that, although farmers mostly focus on practical uses of wild species, a significant number also assigned them non-use importance.

Similarly, personal motivations to maintain a diverse environment varied considerably across the different focus groups. There was a generally good shared understanding of the importance of natural resources to local livelihoods. But the extent to which this can be directly related to biodiversity was again subject to debate. In principle, the value of biodiversity can be grouped into three basic categories: (a) direct-use values such as food, medicine and biological control, (b) indirect-use values such as ecosystem functions and (c) non-use values (Gaston & Spicer 2004). When asked about personal motives to protect biodiversity, each focus group mentioned a different category most frequently. Personnel most frequently cited direct-use values, farmers indirect-use values and scientists non-use values.

4.2 What is needed to value distinctiveness?

Systems of value are influenced by many factors. This is also true when it comes to judging the value of biodiversity. What is regarded as special depends on points of comparison, either through personal experience or other sources of information. In judging Kafa's richness of biodiversity, the interviewed scientists usually cited two different underlying criteria: rarity (e.g., endemic species) and contrast (e.g., to the amount of forest remaining in the rest of Ethiopia). The farmers have not travelled outside of their immediate environment, and thus have no points of direct comparison from their own experience. They are thus completely reliant on external reports. Unlike the scientists, the farmers did not seem to view rarity as having distinct value. Around 40% of farmers were unable to name even a single rare species. Assuming this was not due to methodological limitations (e.g., farmers' fear of acknowledging something possibly unwanted), this supports the argument that recognising (and valuing) rarity is related to points of comparison.

Scientists sometimes argue that non-use qualities of nature can only be appreciated after experiencing their loss. The farmers were most in proximity to relatively "intact" ecosystems, since most chosen kebeles were close to core zones. Still, some had noticed changes in species abundance. This recent accelerated loss of species was an important argument for protecting biodiversity for both the scientists and the personnel. Most personnel had at least travelled to some extent within Ethiopia and had access to information through their education and work.

Still, there was a consensus across all three groups that the Kafa BR is a diverse place (for farmers, this was simplified to rich in species). Farmers often expressed themselves via superlatives, e.g., "Kafa is the richest in the world." Scientists, the group with the best means to compare Kafa with other places, where the most likely (22%) to view the Kafa BR as exhibiting medium species richness. This was especially true for the non-Ethiopians (32%), who are presumably the most likely to be able to contrast Kafa with other environments. Interestingly, the underlying reason for rating the biodiversity as medium was often the level of human disturbance. This indicates that biodiversity was being linked to "wilderness" or "naturalness". Objectively, however, these need not correlate with measures of biodiversity such as high alpha diversity (Duelli et al. 2007).

There are various underlying motivations to maintain a diverse environment. To illustrate this, biodiversity in the Kafa BR can be seen in two different contexts: Its contribution to (i) national or global diversity, e.g., through a high diversity of *Coffea arabica* varieties or endemic species and (ii) a high local or regional diversity (alpha or gamma diversity). Here, according to the medium disturbance hypothesis, agricultural activity can even increase diversity (Kershaw & Mallik 2013). The first context relates to species conservation and involves valuing rarity, as discussed above. The second relates to ecological resilience of diverse systems (see above) and the provision of ecosystem services (Duelli & Obrist 2003). According to Duelli et al. (2007), these two contexts can be in conflict when choosing indicators for biodiversity conservation.

One of the flagship species of the Kafa BR, *Coffea arabica*, was well-chosen in that it is linked with both concepts discussed above. It is a distinct feature of the region, but contributes to global diversity with its diverse gene pool, which can also be seen as possible insurance for the future. If diverse varieties exist, successful adaptation to changing environmental factors is more likely. Farmers additionally value the species, since they directly profit from it.

4.3 Common ground on risk and threats to biodiversity

There was generally a good common understanding of the most important drivers of loss of biodiversity across all three focus groups. This was true despite biodiversity being defined in different ways. The biggest threat was generally seen from agriculture, predominantly small-scale farming (expanding agriculture). The second most important threat category was the use of biological resources, mainly through small-scale logging (logging). Population pressure was unanimously seen as the biggest underlying risk for the loss of biodiversity and for the future of the Kafa BR. This agreement is probably at least partly due to available information, which was in this case provided by NABU to both local personnel and scientists participating in the biodiversity assessment.

There were diverse views on the effects of climate change. Perception of risks and threats depends on both knowledge and experience. When it comes to judging the extent of changes in climate, there are a lot of constraining factors (Eguavoen & zur Heide 2012). First, it is often difficult to differentiate the effects of climate change from other effects such as changes in land use, for example deforestation. Interviewees who already saw climate change as a driving force in biodiversity loss in the Kafa BR mainly made arguments based on availability of water. However, the loss of forests also alters water retention and local climate conditions. For farmers in particular, the perception of climatic events is strongly linked to relevance to their daily lives. For example, a drought leading to a major crop failure is more likely to be remembered and rated as severe. A study by Meze-Hausken (2004) comparing measured precipitation data and weather conditions as perceived by farmers in northern Ethiopia showed no correlation between the two. This could explain the inconsistency in farmers' responses about changing weather conditions in this study. Nonetheless, locally reported changes can provide valuable information, especially as a supplement to measured meteorological data. A study by Schliep et al. (2008) evaluated the perceived risk of climate change among biosphere reserve managers. One of the results of this worldwide study was that risk perceptions of climate change are lower in countries with lower gross national income. In contrast, in Kafa the personnel focus group was the only one to mention climate change as a current driver of biodiversity loss without being specifically asked about it. The personnel involved in the Kafa BR at the management level particularly viewed climate change as a severe risk to biodiversity.

A remarkably small percentage of interviewees saw investors as a potential risk to biodiversity. Ethiopia has a recent history of large-scale agricultural investment, often leading to vast monoculture fields (Lavers 2012). This was not mentioned at all by farmers, and in the other two groups on a little over 20% mentioned this as either a threat or driver of loss. Those who did mention investors as a risk were mainly personnel involved at the management level and Ethiopian scientists (and those who claimed good familiarity with Ethiopia). This suggests that a certain level of education and access to information influences the perception of investments as a risk. According to a study by Tadesse et al. (2014), investment areas were seen as a driver for deforestation by 75% of focus group participants in Decha woreda in Kafa. Some scientists mentioned that the area's BR status might prevent major investments of this kind.

4.4 Partial agreement on best measures to protect biodiversity

The three focus groups were in partial agreement over the best measures to protect biodiversity. Many participants stated involvement, creation of benefits and knowledge transfer for the local communities as important. Both personnel and scientists also saw government involvement as essential. There was disagreement over the need for strict enforcement of protection measures (punishments). A study by Stoll-Kleemann and Welp (2008) showed that, according to a global survey, biosphere reserve managers see environmental education as the most important factor for the success of BRs. Collaboration with local authorities was the second most important factor in this context, while community participation was ranked sixth. Stoll-Kleemann and Welp (2008) propose that BRs can become sites for participatory and integrated management approaches, thus becoming a place for mutual learning including bureaucratic institutions.

Other studies showed a positive relationship between level of education and support for biodiversity conservation (Vodouhê et al. 2010). Of the farmers interviewed in this study, female participants were significantly less educated. Their overall input and comprehension of questions was also lower. Participants (of both genders) who had received training had an increased feeling of responsibility towards protecting nature. Remarkably, even farmers who contribute very little to other questions usually suggested some measures to protect biodiversity (e.g., tree planting).

According to a study by Durand and Lazos (2008) in a Mexican BR, attitudes towards conservation were negative as it was understood as a top-down enforcement process. Participants in the current study cited the need for a sense of responsibility and inclusion. This was especially true for participants who strongly opposed punitive measures, which they felt would alienate local communities in the long run.

Wallner et al. (2007) identified economic benefits as the main positive outcome local residents are hoping for when a BR is established. In contrast, the scientists interviewed for this study saw the preservation of a foundation for their livelihoods as the biggest advantage for local communities. Interestingly, even though population pressure was unanimously seen as the biggest risk across all three focus groups, very few people suggested family planning as a measure to prevent further biodiversity loss.

5. Conclusion

Biodiversity was defined in various ways both within and between the different focus groups. If biodiversity is to be used to promote environmental protection, it is therefore necessary to be clear about the different perspectives of involved parties. Concentrating on the benefits of biodiversity seems advisable in encouraging nature conservation. Pinning down the concrete use of (a) species conservation or (b) a diverse environment can be quite difficult. Conservation goals related to biodiversity should be carefully defined with a good understanding of underlying value systems. One of the most important factors in being able to appreciate the unique features of a place is available points of comparison. These are very limited for the farmers living in the Kafa BR.

Generally, there was a strong shared conception of risk and threats to biodiversity in the Kafa BR. The threats perceived as most important were small-scale interventions in agriculture and the use of biological resources. There was less agreement surrounding the effects of climate change and large-scale investment areas.

Suggested measures to protect biodiversity were partly agreed on, especially regarding the important role of local communities. However, the need for punishments to reach conservation goals was strongly contested.

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7. Appendix

7.1 Interview questions: Scientists

1. Interviewee details

Profession/educational background:
Expertise in their field/work experience:
Acquainted with Ethiopia?
Familiar with BR concept?
Experience in nature conservation (Mgmt.):

Part I – Biodiversity

2.1 How would you define biodiversity?

2.2 Why would you personally try to prevent biodiversity loss (personal motivation)?

2.3 How would you rate the natural richness of the Kafa BR?

2.4 What are your suggestions for flagship species in the Kafa BR?

2.5 What are the main reasons for biodiversity loss in the Kafa BR? How severe would you rate the biodiversity loss?

2.6 Do you believe that climate change is a driving force of biodiversity loss? If yes, how?

2.7 Do you see wetland zones as being at risk in the Kafa BR? If yes, what are the main drivers?

2.8 How important are the wetland areas to achieving conservation goals in the Kafa BR?

2.9 Do you know what measures to enhance nature conservation have been implemented in the Kafa BR?

2.10 Is preserving or increasing biodiversity important for the Kafa BR and the wellbeing of the people who live there? Why?

2.11 What measures do you believe are necessary to protect biodiversity in the Kafa BR?

2.12 Do you have any other suggestions for further development/projects in the Kafa BR (besides biodiversity-related issues)?

2.13 What is the relationship between development goals and nature/biodiversity conservation in Ethiopia?

2.14 Where do you see the need for further research?

Part II – Biosphere Reserves

3.1 What do BRs mean to you? What is your general opinion about them?

3.2 What potential benefits/negative effects for the local community do you see by establishing BRs and what has been the case for the Kafa BR?

3.3 What do you see as the most challenging issues for the Kafa BR?

3.4 Do you have any suggestions what Ethiopia can learn from the experiences of the Kafa BR and its projects?

3.5 What potential do you see for BRs in Ethiopia (including wish lists for BRs)?

7.2 Interview questions: Local personnel

1. Interviewee details

Education level:
Profession/Main activity:
Training/Education in BR context:
Location of workplace:
Familiar BR parts:

Part I – Biodiversity

2.1 How would you define biodiversity?

2.2 For what reason would you try to prevent biodiversity loss (personal motivation)?

2.3 How would you rate the natural richness of the Kafa BR?

2.4 What is the most rare/unusual species occurring in the Kafa BR (flora and fauna)? Discuss this question highlighting the importance of these species as a flagship species.

2.5 Have you noticed any changes in the presence/availability of certain species? (If yes: how? In your opinion, what are the reasons for this?)

2.6 Is the loss of biodiversity a major problem in the Kafa BR? Why? What are the main reasons?

2.7 Do you know about the climate vulnerability of certain species? Have you noticed any recent changes?

2.8 Have there been any climatic extreme events? Have the frequency and intensity of events changed?

2.9 Do you see wetland zones at risk in the Kafa BR? If yes, what are the main drivers of this risk? Have there been recent land-use changes/increased pressure on wetlands?

2.10 Is preserving or increasing biodiversity important for the Kafa BR and the wellbeing of the people who live there? Why?

2.11 What measures do you believe are necessary to protect biodiversity?

2.12 What have been your experiences in conveying the importance of biodiversity/nature conservation to the local community?

2.13 Do you see conflicts with the local community in establishing certain wetland areas as core zones? If yes: why and where? What could be possible solutions?

Part II – Biosphere Reserves (optional)

3.1 Can you describe what the concept of BRs means to you? What is your general opinion about it?

3.2 What measures to enhance nature conservation or local livelihood in the Kafa BR have had the best results? Why? What has been the effect for the local community?

3.3 Do you have any suggestions what Ethiopia can learn from the experiences of Kafa BR and its projects?

3.4 What do you see as the most challenging issues for the Kafa BR?

3.5 What are your suggestions for further development /projects in the Kafa BR?

7.3 Interview questions: Small farmers

1. Interviewee details

Age; Gender; Ethnic group; Religious belief; Education level (No. of school years); Size and type of property; No. of household members; Main activity/Livelihood strategies

2. Location
Size of village:
Distance to core zone:
Infrastructure / distance to market:

Part I - Biodiversity

3.1 How would you define biodiversity (if you are familiar with the term biodiversity)?

3.2 How familiar are you with the natural richness of the Kafa BR? Is the reserve poor or rich in term of species?

3.3 Do you use wild plants? If yes, for what purpose (e.g., food, medicine)? To what extent?

3.4 Do certain species have a meaning to you beyond being useful (e.g., religious beliefs, beauty)?

3.5 Do certain species have a negative effect on you or your farming activities? Do you apply certain measures to get rid of them?

3.6 Do you use wetland areas? If so, how? What use is essential for you? (Question only asked close to wetlands.)

3.7 What is rarest / most unique species occurring in the Kafa BR (flora and fauna)?

3.8 Have you noticed any changes in the availability of certain species? If yes, does this change matter to you?

3.9 Is the loss of biodiversity a major problem in the Kafa BR? Why? What are the main reasons?

3.10 Do you think the wetland zones in the Kafa BR are at risk? If yes, what are the main drivers or this risk? (Question only asked close to wetlands.)

3.11 Do you know about climate vulnerability of certain species? Have you noticed recent changes?

3.12 Have there been any climatic extreme events? Have the frequency and intensity of events changed?

3.13 Is preserving or increasing biodiversity important for the Kafa BR and the wellbeing of the people who live there? Why? For what reason would you try and prevent biodiversity loss?

3.14 What measures do you believe are necessary to protect biodiversity?

3.15 How does your farm/household contribute to biodiversity?

3.16 What is your opinion on scientists coming to the Kafa BR to do research?

3.17 Have you been informed about the results of previous studies? (If no: are you interested?)

Part of the NABU biodiversity assessment team at Kafa BR (photo: Torsten Ryslavy)

In 2014, NABU, The Nature and Biodiversity Conservation Union, conducted a **Biodiversity Assessment** at the Ethiopian Kafa Biosphere Reserve. The **Kafa Biosphere Reserve** in Ethiopia's southwest is home to the last Afromontane cloud- and rainforests with wild arabica coffee populations.

The assessment was the first in-depth assessment of biodiversity ever at Kafa Biosphere Reserve. A multidisciplinary team of 18 international and 12 Ethiopian experts supported by 23 local field guides carried out intense field work. By highlighting the main findings for various taxa, this book is a major step forward in verifying and significantly expanding existing knowledge about species, their habitats and their major threats in the Kafa Biosphere Reserve. Particularly outstanding is the record of approximately 50 species which are new to science or recorded for the Kafa area for the first time.

The Biodiversity Assessment is part of NABU's project 'Biodiversity under Climate Change: Community-Based Conservation, Management and Development Concepts for the Wild Coffee Forests' (2014-2017).

NABU, The Nature and Biodiversity Conservation Union, has promoted the interests of people and nature for more than 100 years drawing on its unwavering commitment, specialised expertise and the backing of its 600,000 members and supporters. The NGO is the largest of its kind in Germany.

This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.

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