Small- and medium-sized mammals (Soricomorpha, Lagomorpha, Rodentia, Procavidae) at the Kafa Biosphere Reserve

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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

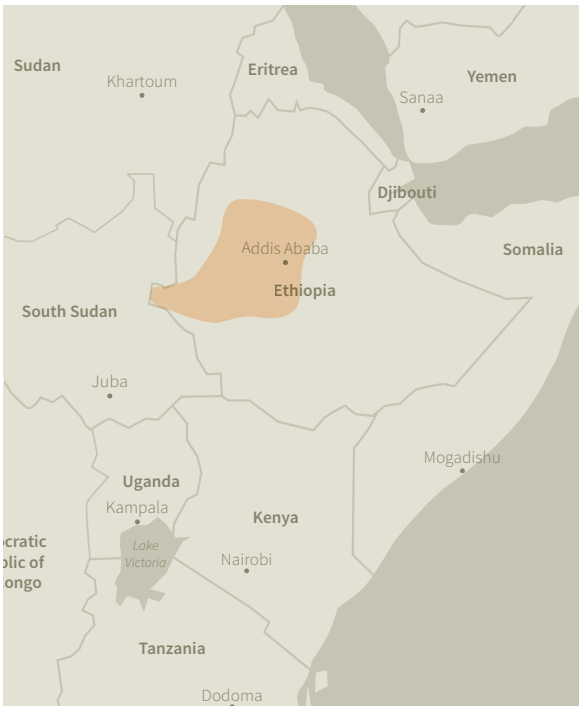

Figure 2: Distribution of the Ethiopian endemic *Lepus fagani* (source: IUCN Red List of Threatened Species 2014)

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 (*Heliosciurus 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.

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 3: Distribution of *Heliosciurus gambianus* in Africa (source: IUCN Red List of Threatened Species 2014)

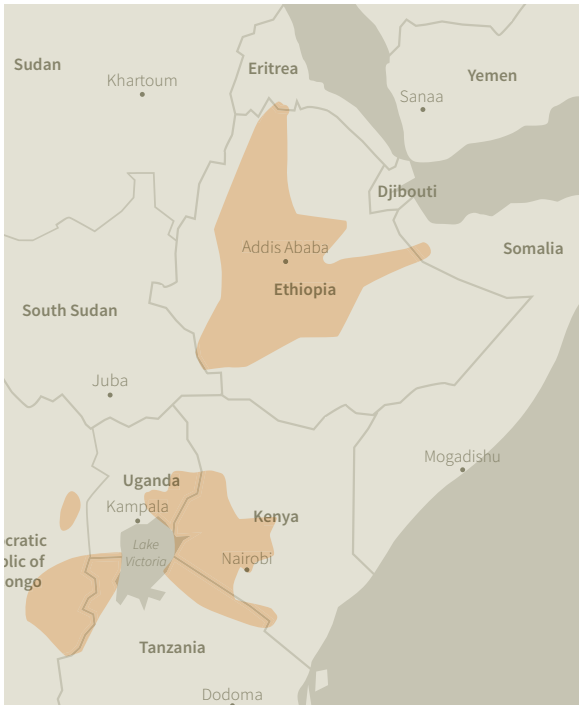

Figure 4: Geographic range of *Tachyoryctes splendens* s.l. (source: IUCN Red List of Threatened Species 2014)

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).

Figure 6: Geographic range of *Otomys* cf. *typus* (source: IUCN Red List of threatened Species 2014)

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-

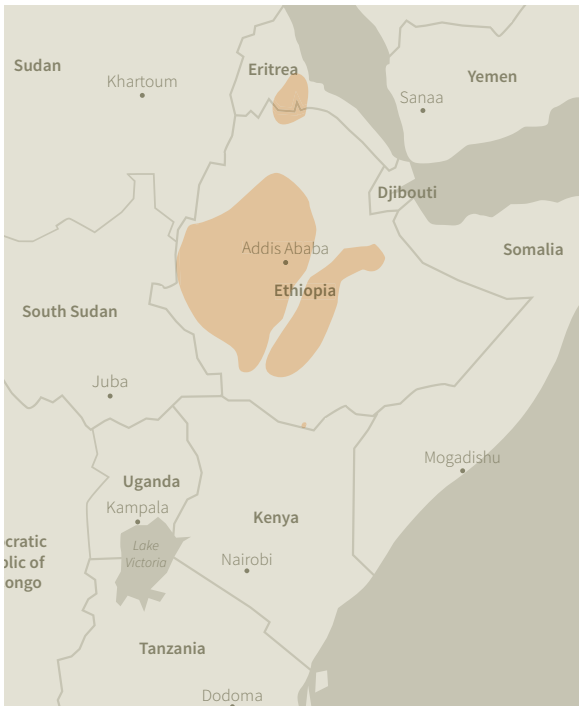

Figure 7: Geographic range of *Stenocephalemys albipes* (source: IUCN Red List of Threatened Species 2014)

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.

5. Acknowledgements

We would like to thank Dr Rainer Hutterer (Alexander Koenig Research Museum, Bonn) for his help with species determination and Dr Josef Bryja (Institute of Vertebrate Biology, Czech Academy of Sciences, Brno) for rapidly processing DNA samples of *Crocidura*, *Dasymys* and *Otomys*. Tom Kirschey (Berlin), Andrea and Karina Schell (Göttingen) and Bernhard Walter (Borgholzhausen) provided photos.

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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., observations	*Heliosciurus gambianus* cf. *kaffensis*	Sciuridae	Gambian sun squirrel	Savannah with trees and bushes		Prov. Kaffa	LC	-	subspecies: western Ethiopia
At 6, At 25, At 26	*Tachyoryctes splendens* s.l., *"northern clade"*	Spalacidae	East African root-rat	Bamboo forest, arable land, garden	1 BA, 11 KDA GH	(as *Tachyoryctes splendens* s.l.) widespread	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, riverine 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. observation	*Heterohyrax brucei*	Procavidae	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 Guesthouse, Bonga, 1756 m a.s.l.	07°15'01" N, 36°15'15" E	F	73.5	53	14	12		
Tachyoryctes	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
Stenocephalemys	*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)