NABU's Follow-up Biodiversity Assessment at the Kafa Biosphere Reserve, Ethiopia

Amphibians of the Kafa Biosphere Reserve

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Highlights

→ A total of 18 amphibian species from six different families were recorded.

→ Nine of the recorded species of amphibians are endemic to Ethiopia: *Leptopelis* cf. *ragazzi*, *Leptopelis* cf. *vannutellii*, *Leptopelis sp.*, *Hemisus microscaphus*, *Afrixalus clarkei*, *Paracassina obscura*, *Phrynobatrachus minutus*, *Phrynobatrachus inexpectatus*, *Ptychadena erlangeri*.

→ One species of Tree Frog, genus *Leptopelis*, appears to be new to science and narrowly distributed within the Kafa Biosphere Reserve.

→ The previously undescribed tadpoles of *Afrixalus clarkei*, *Conraua beccarii*, *Leptopelis sp.*, *Phrynobatrachus minutus* and *Xenopus clivii* were collected and are being formally described.

→ Besides the already recognized flagship species, Beccari's Giant Frog (*Conraua beccarii*), Largen's Puddle Frog (*Phrynobatrachus inexpectatus*) and Clarke's Banana Frog (*Afrixalus clarkei*), the as yet undescribed Tree Frog, *Leptopelis sp.*, would appear to make an ideal flagship species to highlight conservation needs and efforts at the Kafa Biosphere Reserve.

→ Within the Kafa Biosphere Reserve, Beccari's Giant Frog (Conraua beccarii) seems to be most dependent on forest habitats and would make the most suitable indicator species for forest and stream quality.

→ Wetlands within or close to natural forest and grassland areas showed the highest diversity and should receive conservation priority.

1. Introduction

In virtually every respect – biologically, culturally, historically – Ethiopia is a special place in Africa. Almost the entire country falls within two of Africa's eight recognized global biodiversity hotspots (30 in total worldwide). These are the Horn of Africa hotspot, which covers all of Ethiopia's north-eastern, eastern and southern lowlands, and the Eastern Afromontane hotspot, which comprises the Ethiopian highlands east and west of the Great Rift Valley (GRV). From an amphibian perspective, the Ethiopian highlands are by far the most diverse region and although Ethiopia is home to 'only' 72 species of amphibians, a number that seems comparatively small compared to other African countries, over 40% of these are endemic to Ethiopia (Largen & Spawls, 2010). Overall, the true diversity of Ethiopia's amphibian fauna is understood very insufficiently and severely undersampled, which is largely a result of the huge size of the country combined with an infrastructure which has been in a relatively poor state until recently. However, over the last decade, Ethiopia has seen a renewed interest in its amphibian fauna and surveys on a broader geographical scale have uncovered previously unrecognized diversity in several anuran groups (Reyes-Velasco et al., 2018a,b) and new species are being described (Gouette et al., 2019).

At the same time, the Ethiopian highland is one of the most densely settled areas in Africa and the pressure on the environment is immense. Several species have experienced dramatic declines in the Bale Mountains (Gower et al., 2013) and, as a consequence, a number of endemics are critically threatened with extinction. The large-scale habitat modification and destruction, especially the clearing of forests for agriculture, dramatically increases the risk of extinction. This is especially the case in endemics which are distributed quite narrowly and in Ethiopia in particular, we currently run the risk of losing species before their discovery and description. In addition, for many species we lack even the most basic data on their ecology, which makes it in turn difficult to assess their habitat requirements etc., which forms the basis for any informed conservation measure. A case in point are larval anurans – tadpoles – which are unknown for almost half of all known Ethiopian frog species.

In our survey, we addressed these issues by focussing on three main objectives. During the first survey a single specimen of an unusual and presumably undescribed Tree Frog (*Leptopelis sp.*) was discovered (Kirschey, 2017). The single specimen was juvenile, which precluded an assessment of its taxonomic status. Finding and assessing this potentially new species was a main objective of our work. In addition, we targeted larval amphibians in particular. The identities of many Ethiopian tadpoles are unknown. However, tadpoles are often rather conspicuous and easy to sample, which would make them potentially more suitable to target in surveys than adults (Müller, 2019). That potential is currently not realized because of our insufficient knowledge of tadpole identities. In addition, we aimed to collect the little known Ethiopian endemic Caecilian *Sylvacaecilia grandisonae*, which had not been found in recent surveys conducted in south-western Ethiopia.

2. Materials and methods

2.1 Study area

The study sites are listed in Table 1. The study sites visited during the 12 working days included primarily sites already visited during the first assessment (e.g. coffee forests (montane forests), bamboo forests, secondary forests, riverbanks and wetlands). The field team consisted of Abeje Kassie, Admasu Assefa, Girma Kebede, Tariku Woldemichael and the two authors.

Table 1: Study sites and characteristics

Code	Area	Latitude	Longitude	Habitat	Site
BK1	Boka	7.291778	36.375889	Boka Wetland	Forest and stream within forest
BK2	Boka	7.291778	36.375889	Boka Wetland	Grassland and swampy sections
BK3	Boka	7.291778	36.375889	Boka, small roadside clay pit wetland	Waterfilled clay pit next to road, bordering natural fores
BK4	Boka	7.241139	36.452278	Bamboo Forest, Boka	River and small tributaries in bamboo forest
KO1	Komba	7.309861	36.067722	Komba Forest	Clear stream and surrounding natural forest
KO2	Komba	7.310306	36.075861	Komba Forest roadside quarry/clay pit	Small but relatively deep ponds next to the road in a former quarry
KO3	Komba	7.310306	36.075861	Large forest quarry	Large, partly flooded quarry inside forest, bordering stream and natural forest
AL1	Alemgono	7.362472	36.220556	Alemgono Wetland	Large, grassy valley bottom with several ponds and swampy sections, surrounded mostly by agricultural areas and degraded woodland
SH1	Shorori	7.360500	36.208444	Shorori quarry	Number of differently sized, waterfilled quarry and clap pits
SH2	Shorori	7.360500	36.208444	Shorori Wetland	Large, grassy swamp at valley bottom and surrounding coffee forest with small streams
GU1	Gumi	7.243306	36.409611	Gumi River near Bonga	Primary forest along the riverbanks and small tributary streams
GO1	Gojeb	7.563889	36.101667	Meda Abo, Gojeb Wetland	

2.2 Sampling methods

The main sampling methods were visual encounter surveys (VES) where a targeted area and its micro-habitats were systematically searched for amphibian and reptile specimens. This included searches of bushes and tree branches, leaf litter and other debris, turning over logs and generally walking through the habitat in search for specimens. Most searches were done during the day, but especially Boka Forest was also searched during the late evening and early night hours using head lamps or hand-held torches. However, due to logistic and administrative restrictions, it was not possible to extend searches beyond about 9.30 pm. This was somewhat unfortunate as most amphibians are most active at night, especially during the breeding season when we visited. For night searches we prioritized Boka in search of specimens of a putative new species of *Leptopelis* (3.1) and to also obtain potential data on its biology. In addition, we used dip netting in aquatic habitat to collect tadpoles and also aquatic species such as African Clawed Frogs (*Xenopus*). To sample burrowing amphibians and reptiles, and especially to sample Caecilians, we also dug the soil in various places in the forest (stream banks, around trees, between tree buttresses, under rotting vegetation/fallen logs) with a hoe. Sampling methods followed standard established practice (Heyer et al., 1994).

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 to further identify the species and complete the species list. Specimens were provisionally identified in the field using standard literature (e.g. Largen & Spawls, 2010; Channing et al., 2012, and references therein) and portable field equipment (Bresser Biorit ICD LL stereo microscope; hand-held magnifying lens). Adult and larval specimens were killed by administering a lethal dose of the anaesthetics MS222 (for larvae) or Orajel (for adults), fixed with formalin, and subsequently transferred to 70% ethanol. Prior to fixation, fresh tissue samples (liver, tail tips) were collected from selected specimen and stored in 99% ethanol for subsequent deoxyribonucleic acid (DNA) analyses. Tadpoles were anaesthetized and photographed using a small aquarium.

Since the specimens were exported to Germany, we have begun with the in-depth examination of the material. Some specimen identifications have been revised following more detailed examination using microscopy (Zeiss SteREO Discovery V12), this work is still ongoing. For selected specimens, DNA will be extracted from collected tissue samples and sequences of the 12S rRNA, COI, and/or 16S rRNA genes amplified and sequenced following standard procedures (Vences et al., 2005; Fouquet et al., 2007). Tadpoles will be staged followed Gosner (1960); standard measurements and labial tooth row formula are taken following Altig and McDiarmid (1999) and description of buccopharyngeal morphology follows Wassersug (1976). Drawings will be prepared with the aid of a camera lucida attached to a Zeiss V12 SteREO Discovery microscope. For inspection of the buccopharyngeal morphology, representative specimens will be dissected, dehydrated and critical point dried (Emitech K850 Critical Point Dryer), sputter coated (Emitech K500) with gold-palladium and investigated using a Phillips XL30 ESEM scanning electron microscope with a digital image capture system.

3. Results and discussion

3.1 Amphibia

We recorded 18 species of amphibians, although identification is still preliminary for some of them (see below). This represents 25% of the species reported for Ethiopia (72 in total; Amphibiaweb 2019). While this may sound like a comparatively small percentage, one has to bear in mind that Ethiopia is a large country characterized by a great diversity of habitats and strong regional endemism (Largen & Spawls, 2010). Considering south-western Ethiopia, our species tally represents about 70% of the species that could be expected within the forested highlands, which is a reasonable result in line with expectation given the length and nature of the survey.

3.1.1 Arthroleptidae

At several localities we collected Tree Frogs of the genus *Leptopelis* that were identified as either *L. ragazzii* or *L. vannutellii* (Figure 2). Both species are variable in coloration but otherwise very similar in their overall meristic and morphometric characteristics, including call and tadpole morphology (Largen, 1977; Channing et al., 2012; Tiutenko & Zinenko, 2019), which complicates a reliable identification. Traditionally, *L. ragazzii* has been considered to be restricted to the east of the GRV, whereas *L. vannutellii* was thought to occur only west of the GRV (Largen, 1977). Over the years, a number of studies have reported *L. ragazzii* also from west of the GRV (e.g. Largen & Spawls, 2010) and it was also reported from the Bonga area during the first assessment. A recent study (Reyes-Velasco et al., 2018b), however, provided well-supported evidence that *L. vannutellii* and *L. ragazzii* are indeed separated by the GRV, with the former restricted to the west and the latter to the east, which highlights the need for an in-depth revision of these two species. At present, we tentatively chose to report both species for the Bonga area, but this is preliminary at best.

Table 1: List of recorded amphibians

No	Species	Family	Status
1	*Leptopelis cf. ragazzi* (Boulenger, 1896)	Arthroleptidae	VU, endemic
2	*Leptopelis cf. vannutelli* (Boulenger, 1896)	Arthroleptidae	VU, endemic
3	*Leptopelis sp.*	Arthroleptidae	not assessed, probably endemic to Kafa BR
4	*Conraua beccarii* (Boulenger, 1911)	Conrauidae	LC
5	*Hemisus microscaphus (*Laurent, 1972)	Hemisotidae	LC, endemic
6	*Afrixalus clarkei (*Largen, 1974)	Hyperoliidae	EN, endemic
7	*Hyperolius* cf. *acuticeps*	Hyperoliidae	Unknown
8	*Hyperolius viridiflavus* s.l. (Duméril & Bibron, 1841)	Hyperoliidae	LC
9	*Hyperolius sp.*	Hyperoliidae	Unknown
10	*Paracassina obscura* (Boulenger, 1895)	Hyperoliidae	LC, endemic
11	*Phrynobatrachus minutus* (Boulenger, 1895)	Phrynobatrachidae	LC, endemic
12	*Phrynobatrachus inexpectatus* (Largen, 2001)	Phrynobatrachidae	DD, endemic
13	*Phrynobatrachus* cf. *natalensis* (Smith, 1894)	Phrynobatrachidae	LC
14	*Ptychadena erlangeri* (Ahl, 1924)	Ptychadenidae	NT, endemic
15	*Ptychadena mascareniensis* (Duméril & Bibron, 1841)	Ptychadenidae	LC
16	*Ptychadena neumanni* (Ahl, 1924)	Ptychadenidae	LC
17	*Ptychadena schillukorum* (Werner, 1907)	Ptychadenidae	LC
18	*Xenopus clivii (*Peracca, 1898)	Pipidae	LC

A far more exciting find was an adult specimen and several juvenile and metamorphic frogs as well as several series of tadpoles, of an apparently undescribed species of *Leptopelis* (Figure 1e). This species was already reported during the first assessment, based on a single specimen that was photographed but not collected at the time. The new material supports the first assessment in so far as it likely represented a new species. Unfortunately, despite repeated, systematic searches we only obtained a single adult specimen, which probably indicates a somewhat more cryptic lifestyle compared to the sympatric *Leptopelis* cf. *ragazzii* found at the same site. Morphologically, the putative new species is characterised by very conspicuous epidermal ridges and grooves that run along the dorsal and dorsolateral sides of the body in all examined metamorphosed specimens. In addition, the tadpoles tentatively assigned to this species differ in overall shape and the morphology of the oral disc from the *L.* cf. *ragazzii* found at the same locality (Figures 1d and e).

Moreover, the two species seem to be microspatially segregated in their breeding habitats and tadpoles of the new *Leptopelis* species were only found in small, isolated puddles within the swampy parts of the grassland and forest edge adjacent to the montane forest at Boka. In contrast, tadpoles of *L.* cf. *ragazzi* were restricted to stream habitats. We only recorded this species at two different localities, but fairly close to Boka. Further investigations (morphological and molecular) are currently underway to establish the specific identity of these specimens and describe them as new to science. If these specimens are confirmed as belonging to an undescribed species, which seems likely at present, it will appear to be narrowly distributed and should receive immediate attention and be targeted for conservation measures.

3.1.2 Conrauidae

Beccari's Giant Frog or Filfil Slippery Frog (*Conraua beccarii*) is the only member of this genus and family found in Ethiopia, where it occurs from south-western Ethiopia all the way up north to Asmara, Eritrea. Other members of the genus are exclusively found in West and Central Africa and include the well-known Goliath Frog (*Conraua goliath). Conraua beccarii* is the second largest species within the genus and also the largest frog known from Ethiopia. This species was only recorded as a tadpole from a stream in Komba Forest. Other streams where this species was collected in 2014 were too fast-flowing to be accessible for sampling. The tadpole of *C. beccarii* is currently undescribed but resembles other known tadpoles of the genus and can thus be unambiguously identified (Figures 1 and 5). It is highly adapted to fast-flowing streams and the presence of such habitats is likely a key requirement for the survival of the species. Beccari's Giant Frog is reportedly widespread (Milto et al., 2015) and common in the general area of Bonga (Largen & Spawls, 2010), and currently listed as Least Concern by IUCN (2013). It should nonetheless be included in future monitoring efforts as it is likely a very important indicator species, given its dependence on forests and especially clear and fast-flowing streams for reproduction and its unlikely tolerance of large-scale forest degradation and deforestation. Species of *Conraua* are furthermore important in the West African bushmeat trade (e.g. Schäfer et al., 2019). At present, it is unknown whether *C. beccarii* are hunted in Ethiopia for human consumption, which may increase their vulnerability. As with other *Conraua*, very little is known about the general biology of this species, which, given its size, might perhaps resemble that of *C. goliath* (Schäfer et al., 2019).

3.1.3 Hemisotidae

We recorded several specimens of *Hemisus* from Komba Forest, Meda Abo/Gojeb, the Komba Forest quarry and Alemgono Wetland (from the last two localities only in the form of tadpoles). Two species of *Hemisus* are known from Ethiopia, the endemic *H. microscaphus* and the more widespread *H. marmoratus* (Largen & Spawls, 2010). An initial assessment in the field identified the metamorphosed specimens as *H. marmoratus*, which would have been a substantial range extension, but subsequent closer analysis revealed these to be the Ethiopian endemic *H. microscaphus* (Figure 3), which also fits better with our current understanding of the ecology and distribution of both species (Largen, 1997a). However, it also reveals *H. microscaphus* to be more variable in its meristic and morphometric characters than previously thought. At Alemgono and the roadside quarry in Komba Forest we collected tadpoles and a single metamorphic specimen, which indicates that this species metamorphoses at comparably very large sizes and undergoes only moderate post-metamorphic growth.

3.1.4 Hyperoliidae

Clarke's Banana Frog (*Afrixalus clarkei*) is an Ethiopian endemic with a relatively narrow distribution centred in the Bonga area (but perhaps more widespread than currently known, see Mertens et al., 2016; Foquet et al., 2019). As a follow-up to the first survey, we recorded this species from a number of additional localities, including more anthropogenically influenced sites like Alemgono, where it was not recorded in 2014. The tadpole of this species is also currently undescribed, but we obtained a number of specimens from Boka Swamp, where *A. clarkei* was particularly abundant (Figure 1a), and are currently preparing a formal description.

The Tree Frog genus *Hyperolius* is the most species-rich African anuran taxon and *Hyperolius* are found throughout almost the entire sub-Saharan African

continent (Schiøtz, 1999). One common species that we recorded from several localities is *Hyperolius viridiflavus* s.l., which comprises a number of species distributed through much of sub-Saharan Africa. Species delimitation among members of the complex is hampered by the extreme variability shown by members of this group and genetic data will need to be analysed as part of a geographically broader taxonomic revision of this group. The same applies to specimens of *Hyperolius* cf. *acuticeps*, which we recorded from a number of localities. These small Tree Frogs are part of the widespread *nasutus* group, the sole Ethiopian representative of which was until recently considered to be *H. acuticeps*. Channing et al. (2013), however, restricted *H. acuticeps* to Malawi and the status of Ethiopian populations is in need of revision. At the roadside quarry in Komba Forest, we also collected *Hyperolius* tadpoles that are currently undetermined (Figure 1c). These will be barcoded to determine their specific identity.

One species recorded for the first time during the follow-up survey is *Paracassina obscura*, a species and genus endemic to Ethiopia. *Paracassina obscura* is part of a group of ground-dwelling Tree Frogs, and as such is more difficult to sample in surveys as they are usually strictly nocturnal and fairly secretive. However, males emit a very characteristic advertisement call and the species also has very distinct tadpoles (Figure 1g). A record of *Kassina senegalensis* by Milto et al. (2016) might represent a misidentified *Paracassina obscura*. We recorded it from a number of different localities (see Appendix 1) and although it is primarily a forest-dwelling species, it seems to be rather adaptable and was found in a number of habitats which are considerably influenced anthropogenically.

3.1.5 Phrynobatrachidae

Puddle Frogs of the genus *Phrynobatrachus* are also found in most of sub-Saharan Africa and occur in a number of different habitats. One widespread species that was recorded at a number of different localities is *Phrynobatrachus natalensis*, a comparatively large and ecologically adaptable species. It was most prominent in Shorori and Alemgono Wetlands. Studies have shown that specimens currently assigned to *P. natalensis* comprise a species complex (Zimkus et al., 2010). Ethiopian populations of *P.* cf. *natalensis* undoubtedly represent an unnamed taxon (Zimkus et al., 2010), especially considering that the type locality of *P. natalensis* is Natal, South Africa.

The most widespread Puddle Frog within the Kafa Biosphere Reserve (Kafa BR) is *Phrynobatrachus minutus*, a small Ethiopian endemic, which was found in considerable numbers in almost all localities visited during this survey. As for many other Ethiopian species, the tadpole of *P. minutus* is currently unknown, but we collected a series of tadpoles that probably belong to this species (Figure 1f). Final confirmation via DNA evidence is currently outstanding. The presence of the second Ethiopian endemic Puddle Frog (*P. Inexpectatus)*, which was reported for the first survey, could not be unambiguously confirmed at present. We collected some specimens at a single locality (a small roadside pond near Boka), which may represent *P. inexpectatus*, but further investigation is necessary to confirm this. The main problem here is the very small adult size of *P. inexpectatus*, which makes them difficult to distinguish from immature *P. minutus*. The recent discovery of a new and very distinct species of *Phrynobatrachus* (Guette et al., 2019) from Gura Ferda, south-western Ethiopia highlights that new species are likely to be discovered through fieldwork and a critical reassessment of specimens, especially in taxa such as Phrynobatrachus.

3.1.6 Ptychadenidae

A number of Rocket or Grass Frogs of the genus *Ptychadena* has been reported and described from Ethiopia (Largen, 1997b) and includes species endemic to Ethiopia and species that are far more widespread through other parts of Africa. *Ptychadena* are relatively conservative in their overall morphology, which complicates species identification. Also, several of the more widespread species, like *P. schillukorum* or *P. mascareniensis* are suspected or known to comprise a complex of cryptic species (e.g. Vences et al., 2004) and more revisionary work is needed on this group. We recorded a number of different species of *Ptychadena* that we tentatively assigned to the species recorded during the first assessment.

3.1.7 Pipidae

We recorded *Xenopus clivii* from several different localities as both adults and tadpoles (see Appendix 1). Like other species of *Xenopus*, *X. clivii* is strictly aquatic but adult and juvenile frogs are seemingly possible to migrate over considerable distances in order to colonise various aquatic habitats, from forest streams, rivers and wetlands, to a number of manmade ponds and other such structures, which makes it probably the most resilient local amphibian species provided it has access to aquatic habitats. As for other anurans, the tadpole of *X. clivii* has not been described so far. We obtained a number of tadpole specimens (Figure 1h) and a formal description is in preparation. A preliminary investigation revealed it to be very similar to other known tadpoles of *Xenopus*. This preliminary assessment also enabled us to document some natural history observations on the tadpoles of this species, including the first recorded predation by a Fishing Spider (cf. *Nilus sp.*, Pisauridae; Figure 7).

4. Conclusions and recommendations for conservation and monitoring

4.1 Recommendations for amphibian conservation

The largest threats to Ethiopia's biodiversity appear to be deforestation and environmental degradation due to human disturbance, combined with a drastic increase in water pollution resulting from economic growth. These threats do not evenly affect all areas of the country, but are a factor even in remote areas. Around 95% of Ethiopia's original forest has already been cleared for agriculture and human settlements.

This is also apparent at the Kafa BR, where parts of the natural landscape have been turned into agricultural land. Especially the area around Boka seems largely deforested, and this seems to have occurred rather recently. Forest clearance particularly affects species that are primarily associated with this habitat. Even in areas where stands of forest are left intact, forest endemics are often severely impacted nonetheless because of a decline in water quality of the streams that these species depend on for reproduction.

This is particularly the case in the endemic Beccari's Giant Frog and the forest associated Tree Frog. Other species, such as Clarke's Banana Frog, the Ethiopian Banana Frog, the Ethiopian Dwarf Puddle Frog and Largen's Dwarf Puddle Frog are somewhat less dependent on streams for breeding but still require healthy, unpolluted wetlands for their continued survival. All these species are of conservation concern and could act as monitoring species for the core zones of the biosphere reserve.

Especially the Tree Frogs such as *Leptopelis ragazzii*, *Leptopelis vannutellii* and the newly discovered, undescribed species as well as the two Banana Frog species of the genus *Afrixalus* are relatively conspicuous and easily identified and can therefore act as flagship species for the Kafa BR. Beccari's Giant Frog (*Conraua beccarii*), is shy and difficult to collect, which makes working with this species more difficult. However, these large frogs cannot be confused with other species within the Kafa BR and their presence could simply be visually surveyed. They also have very conspicuous and easily identified tadpoles that should make it easier to monitor this species. Tadpoles might generally be more suitable for surveying at least some of the species of concern here. Tadpole-based surveys could also be carried out during the day, which could potentially increase the efficiency of amphibian survey and monitoring work within the Kafa BR, especially when carried out by local rangers.

Wetlands should be included in any future zonation work within the Kafa BR. If not already done, a protected zone should be established covering the huge wetlands of Gojeb River as well as the wetlands in the Afroalpine zone, e.g. beyond Boka Forest. Smaller, more intensively used wetlands such as Alemgono, however, are also vital for maintaining local amphibian diversity.

Globally, freshwater habitats are being disturbed, polluted and destroyed at an alarming rate, even though 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 on a global level. Even though wetlands only make up 1% of the Earth's land area, they contain 10% of all known species and provide ecosystem services valued at several trillion USD per year (Butchart et al., 2005). All over the world, more than half of all 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, 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 while at the same time systems for wastewater do not exist, thus wetlands and their ecosystem services are significantly affected. Amphibians 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 a more favourable conservation status of endemic and typical herpetofauna assemblages.

4.2 Suggestions for future studies

One clear priority for future studies is the new Tree Frog species of the genus *Leptopelis* from the Boka area, once its status is confirmed. From our work so far, it seems to be associated with montane grassland and not occurring within the neighbouring indigenous forests. Montane grasslands are under particularly strong pressure from cattle grazing and other uses and are also dependent on the surrounding forests for regulating the water table. The new *Leptopelis* seems to be dependent on this type of habitat and we did not find it in other similar habitats outside the Boka area.

At present knowledge, it seems to be only narrowly distributed and would likely qualify for a high conservation status (Vulnerable, Endangered or Critically Endangered) following current IUCN assessment criteria (IUCN 2019). More and more targeted fieldwork is urgently needed to better understand its distribution and basic ecological needs to initiate informed conservation measures. Another priority should be the Aleku Caecilian, *Sylvacaecilia grandisonae*. *Sylvacaecilia grandisonae* is the only species of caecilian known to occur in Ethiopia, is an Ethiopian endemic, and holds a key position in our understanding of the evolution of higher Caecilians (San Mauro et al., 2014; Theska et al., 2019) because of its breeding biology. It was described as a new species by Taylor (1970) as a member of the West African *Geotrypetes* and subsequently transferred to the newly erected genus Sylvacaecilia by Wake (1987). Few additional specimens have been collected since Largen et al. (1972) obtained a series of specimens from a number of localities throughout south-western Ethiopia in the early 1970s. Over the last decade, concerted efforts have been made to relocate the species, but these have so far been unsuccessful (DJ Gower & SP Loader, pers. comm.). Given its singular status, efforts should be made to relocate this species. The most promising area for such efforts would be Komba Forest, which is one of the most extensive remaining stands of natural forest in the area.

Search efforts should include digging for the species in suitable habitats as well as a more people-focussed approach. We did interview people about the presence of *S. grandisonae*, with mixed and somewhat inconclusive results, but a directed search using a public awareness campaign is likely to be the most promising effort to relocate this species. Both *S. grandisonae* and the new Leptopelis would make excellent flag-ship species to raise awareness for and also promote the conservation goals and measures of NABU within the Kafa BR and Ethiopia in general.

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6. Annex

6.1 Appendices

Appendix 1: Amphibians collected at the Kafa BR during the biodiversity assessment.
*precise localities were not recorded because of unclear species identification

Family	Genus	Species	Endemic	BK1	BK2	BK3	BK4	KO1	KO2	KO3	AL1	SH1	SH2	GU1	GO1
Arthroleptidae	*Leptopelis*	*cf. ragazzii*	E	1	0	0	1	0	0	0	0	0	0	1	0
	Leptopelis	*cf. vannutellii*	E	0	0	0	0	1	0	1	0	0	0	0	0
	Leptopelis	*sp.*	E	0	1	1	0	0	0	0	0	0	0	0	0
Conrauidae	*Conraua*	*Beccarii*		0	0	0	0	1	0	0	0	0	0	0	0
Hemisotidae	*Hemisus*	*Microscaphus*	E	0	0	0	0	1	1	0	1	0	0	0	1
Hyperoliidae	*Afrixalus*	*Clarkei*	E	1	1	1	1	0	0	0	1	0	0	0	0
	Hyperolius	*cf. acutus*		0	0	0	0	0	1	0	1	1	0	0	0
	Hyperolius	*viridiflavus s.l.*		0	0	0	0	0	1	1	1	1	1	0	0
	Hyperolius	*sp.*		0	0	0	0	0	1	0	0	0	0	0	0
	Paracassina	*Obscura*	E	0	0	0	0	0	1	0	1	1	0	0	0
Phrynobatrachidae	*Phrynobatrachus*	*Inexpectatus*	E	0	0	1	0	0	0	0	0	0	0	0	0
	Phrynobatrachus	*Minutus*	E	1	1	1	0	0	0	0	1	0	1	0	0
	Phrynobatrachus	*cf. Natalensis*		0	0	0	0	0	0	0	1	1	1	0	0
Ptychadenidae*	*Ptychadena*	*Erlangeri*	E												
	Ptychadena	*Mascareniensis*													
	Ptychadena	*Neumanni*													
	Ptychadena	*Schillukorum*													
Pipidae	*Xenopus*	*Clivii*		0	0	0	0	0	1	0	1	1	0	0	0

6.2 Photos

Figure 1: Tadpoles of (**a**) *Afrixalus clarkei*, (**b**) *Conraua beccarii,* (**c**) *Hyperolius sp.*, (**d**) *Leptopelis* cf. *ragazzi*, (**e**) *Leptopelis sp.* Boka, (**f**) *Phrynobatrachus* cf. *minutus*, (**g**) *Paracassina obscura*, (**h**) *Xenopus clivii*, not to scale (photos: Hendrik Müller)

Figure 2: *Leptopelis vannutelli*, Komba Forest
(photo: Hendrik Müller)

Figure 3: *Hemisus microscaphus*, Gojeb Wetland
(photo: Hendrik Müller)

Figure 4: Eggs of *Hyperolius sp.,* Alemgono Wetland
(photo: Hendrik Müller)

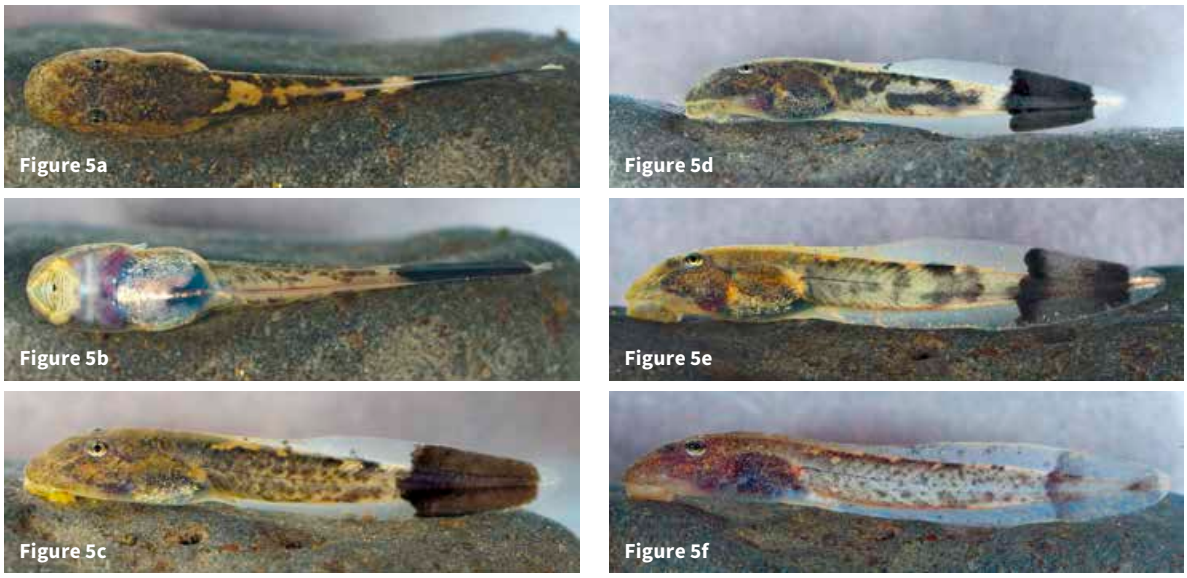

Figure 5: Tadpoles of *Conraua beccarii*, dorsal (**a**), lateral (**b**) and ventral (**c**) view of the same tadpole, (**d**) – (**f**) illustrate variation in pigment pattern, not to scale (photos: Hendrik Müller)

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Figure 6: Eggs of *Ptychadena sp.* (large eggs) and *Phrynobatrachus natalensis* (small eggs), Shorori quarry (photo: Hendrik Müller)

Figure 7: Pisaurid spider with its prey, a *Xenopus clivii* tadpole (photo: Hendrik Müller)

Figure 8: Amplexus of Hyperolius *viridiflavus* s.l. (photo: NABU/Tom Kirschey)

Figure 9: Calling male of Hyperolius *viridiflavus* s.l.
(photo: NABU/Tom Kirschey)

Figure 10: *Paracassina obscura*
(photo: NABU/Tom Kirschey)

Figure 11: *Afrixalus clarkei*
(photo: NABU/Tom Kirschey)