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Final Research Report

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Summary

We report on the results of our assessment of amphibians in the forests of southern Ghana. During two surveys in 2005 and 2007 we recorded at least 43 frog species, including one first country record (*Kassina cochranae*) and several species that had not or rarely been found after they had been described more than 30 years ago (e.g. we herein report the rediscovery of *Conraua derooi*). A high percentage of the recorded frog assemblages consisted of species endemic to the Upper Guinea forest, to Ghana or even a particular region within this country. The majority of species was closely related to forest habitats. However, in some forest areas the presence of savanna and farmbush species indicated serious habitat degradation. The fact that one third of the encountered amphibians are threatened according to the IUCN Red list highlights the importance of the forest ecosystems of southern Ghana, as well as the urgent need to protect them. One Ghanaian student and one stuff member of the Ghana Wildlife Division participated on these surveys and were trained in species identification and monitoring techniques.

Introduction

West African rain forests rank among the 25 most important biodiversity hotspots of the world (MYERS et al. 2000). At the same time they are highly threatened by logging, agriculture and increasing human population (BAKARR et al. 2001). In Ghana only 11.8-14.5% of the original forest cover is left (UICN 1996, POORTER et al. 2004). The situation of forests in the Volta Region in the East of the country, where most of the forests have been highly degraded or destroyed and subsequently transformed into agricultural areas, is especially serious (RÖDEL & AGYEI 2003). By facing the still fast ongoing deforestation in West Africa, it is one of the most urgent targets to get more knowledge about forest dependent species and to define the conservation status of those forests that still remained.

For a long period the amphibian fauna in Ghanaian forests seemed to be less diverse than the well known communities of other Upper Guinean countries, like Guinea and Côte d'Ivoire. For these countries the documented species richness in forests ranges from 40 to 56 species (RÖDEL & BRANCH 2002; RÖDEL 2003; RÖDEL & ERNST 2003), while the few investigations focusing on Ghanaian amphibians (SCHIØTZ 1964a,b, 1967, RÖDEL & AGYEI 2003 provide a summary of all surveys) revealed only 10 to 20 species per site. Only the most recent studies showed that the Ghanaian amphibian communities are not necessarily less diverse than in the neighbouring countries, but were just incompletely explored (RÖDEL & AGYEI 2003, ERNST et al. 2005, RÖDEL et al. 2005, LEACHÉ et al. 2006, KOUAMÉ et al. in press). This might be especially true for the forests in southern Ghana.

During a survey of the Togo-Volta Highlands in eastern Ghana 31 amphibian species were recorded and 41 species were estimated to live within the study area (RÖDEL & AGYEI 2003). A herpetological survey of different forests in the West of the country revealed a total richness of 47 species (RÖDEL et al. 2005). Hence, the studied areas proved to comprise much higher amphibian diversity than assumed. Furthermore, the sites so far investigated showed a unique species composition (i.e. high percentage of endemic and endangered species). Unfortunately, in most forests several invasive species, species that normally do not occur in healthy forests, were documented, thus indicating a significant alteration of the original forest habitats.

Whereas both surveys revealed a number of first country records and even new taxa, the existence of several threatened and endemic amphibians could not be confirmed in the Volta Region. It was not clear whether the respective species simply could not be recorded or if these taxa have disappeared. This especially concerns those species that are confined to flowing water in rainforest habitats (e.g. *Conraua derooi*), or larger closed forests (*Bufo togoensis*).

Based on these findings, and facing the threats to the remaining Ghanaian forests, we aimed to investigate several forested areas in southern Ghana, with a major emphasis on the search for endemic and endangered amphibian species (e.g. *Conraua derooi*, *Hyperolius torrentis, H. bobirensis, Phrynobatrachus ghanensis*). The purpose of our survey was to gain knowledge about the presence and distribution of these species, as well as to define their population status, especially for those amphibians that where never recorded again after their description (*Conraua derooi*). Based on our findings, we secondly aimed to provide conservation recommendations concerning the investigated sites.

This work was conducted in close cooperation with the monitoring group of the Ghana Wildlife Division and the Kwame NKrumah University in Kumasi. One student (CALEB OFORI BOATENG) and one stuff member from the Ghana Wildlife Division (ALEX CUDJOE AGYEI) were trained in species identification and field techniques, now being able to help with future amphibian identification and monitoring.

Study Sites and Methods

Our investigations focused on forests in southern Ghana with a main emphasis on particularly endangered amphibian species and species that are Upper Guinean or Ghanaian endemics.

To account for seasonal differences we combined the data of two field trips to Ghana. The survey times were 7 July to 16 August 2005 and 25 March to 18 April 2007.

Based on the known distribution of the endemic and threatened species within Ghana, we first of all focused on areas formerly known to comprise the species in question. These areas were around the villages of Amedzofe, Biakpa and Leklebi in the Volta Region near the Togolese border, Bobiri Forest Reserve in the Central Region, and

Ankasa National Park and Kakum National Park in south-western Ghana (see Fig. 1). At these sites we spent six (Bobiri, Ankasa, Kakum; each) to 14 days (in total for different sites in the Volta region: Amedzofe, Biakpa, Leklebi). Additionally, we included further, so far herpetologically unknown forests in the surveys, mainly representing smaller forest areas. These areas were Kalakpa National Park in south-eastern Ghana, Owabi Wildlife Sanctuary and Tano Offin Forest Reserve in the Central Region, as well as Bia National Park in western Ghana (Fig. 1). At these sites we spent one to three days of field work each.

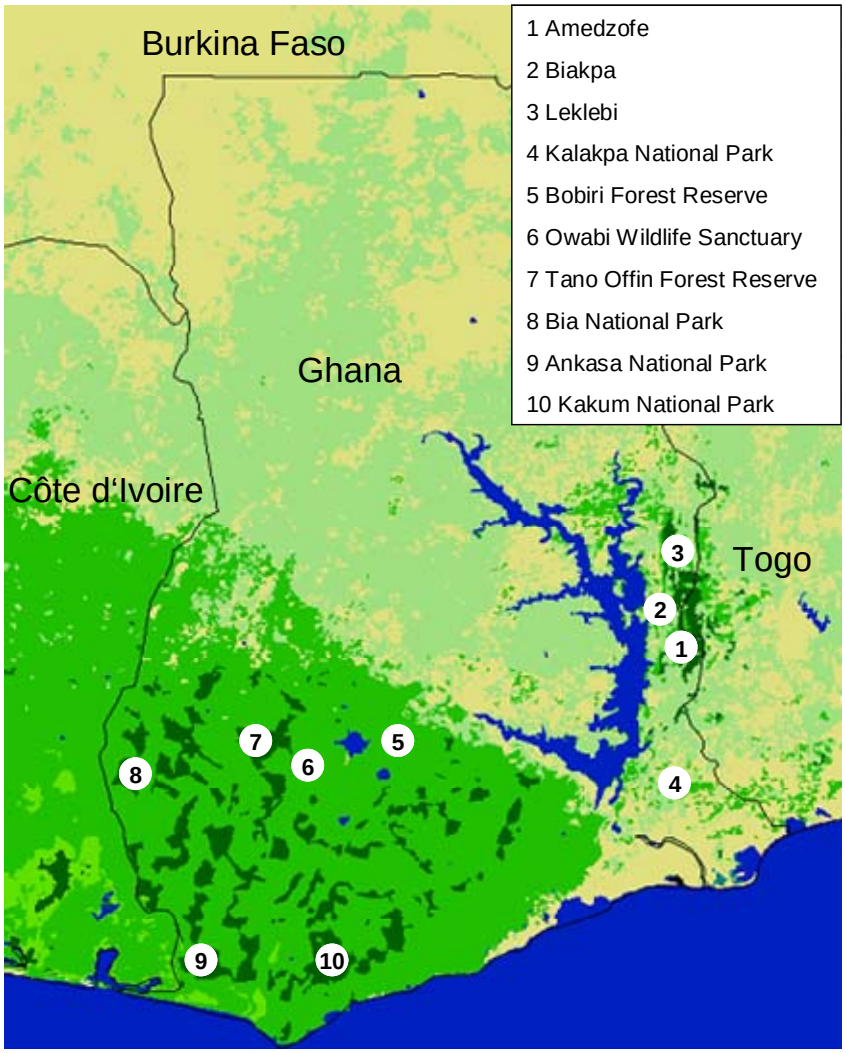

Figure 1: Location of investigated forests in southern Ghana.

While the Volta Region is characterized by a mosaic of villages, plantations and heavily degraded forests (Fig. 2), the other study sites showed a better conservation status by being Wildlife Sanctuaries, Forest Reserves or National Parks. In most of the cases there were only small gallery forests left in the Volta Region, which were all highly threatened by the needs of the growing population. In some cases, forest alteration and degradation were also visible in the other investigated forests, especially at the forest edges, which very often were directly adjacent to the villagers' plantations. However, larger tracks of primary forest could be reached and searched for frogs in most of the investigated sites.

Figure 2: Typical landscape in the Volta Region, south-eastern Ghana; plantations within logged and degraded forest.

The sites visited at Amedzofe in the Volta Region were mainly small gallery forests and small forest islands not far from the village or from plantations. There were no real pristine forests left, only single parts of the forests, that were inaccessible, seemed to be rather undisturbed. The same situation occurred around the village Biakpa, where the degradation of forest habitat around the village even appeared to be more severe. The area of Leklebi consisted of several smaller villages. The only forests that were not absolutely degraded were located in inaccessible areas close to the hills and mountains leading to the Togolese border. At all sites investigated in the Volta Region, the aquatic habitats included streams and ponds of different sizes, located next to the villages. At only very few occasions we found waterfalls and streams that were surrounded by true forest habitat.

The Kalakpa National Park sites were characterized by extended farmbush and savanna habitats with a stream surrounded by a gallery forest and a big pond next to this forest.

Bobiri Forest Reserve (also known for its Butterfly Sanctuary) is already protected since 1939. While there were several streams running through the reserve (but partly being dried out during the survey period), other aquatic habitats were reduced to smaller ponds or puddles, mainly situated in vicinity of a road traversing the reserve. Similar to the roads in Ankasa and Bia National Parks, this road provides a corridor and a habitat for invasive amphibian species, normally not present in the forest.

Owabi Wildlife Sanctuary consisted of some forest islands that are located next to a big water supply dam. There were big ponds next to the lake and the forest.

The habitats investigated at Tano Offin Forest Reserve and Bia National Park were mainly rather degraded forests, especially at the edges of the reserves. There the forests comprised secondary forest with dense vegetation in lower strata. Forest areas of a more pristine state could only be reached after longer walks (app. 4-8 km from the edges). While there were different types of aquatic habitats present in Tano Offin (stream, ponds etc.), the number of aquatic habitats in Bia National Park was very low, and mainly restricted to temporary pools in the forest or puddles along the road that cuts through the more degraded southern part of the National Park.

Ankasa National Park showed the most healthy forest habitats of all sites. Present aquatic habitats were several streams, as well as ponds of different sizes within or close to the forest. Like the two roads within Ankasa National Park, a power line that runs through the park facilitated the access for invasive, non-rainforest frogs and toads.

Kakum National Park also harbored several types of aquatic habitats, i.e. streams and ponds. Like in Ankasa and the Forest Reserves, the edges of Kakum were characterized by rather degraded forest with dense lower vegetation, while the core area of the park harbored undisturbed primary forest with a high canopy.

In Appendix 1 we provide a list of all investigated sites, including a short habitat description. Geographical positions of all sites were taken with a hand held GPS receiver (Garmin 12XL).

Amphibians were recorded during visual and acoustic encounter surveys by up to four people. The surveys were undertaken during day and night. Searching techniques included visual scanning of the terrain and investigation of potential hiding places or very specific habitats (e.g. small rivers and waterfalls; see also HEYER et al. 1994, RÖDEL & ERNST 2004). Additionally, pitfall traps were installed at different study sites (Amedzofe, Leklebi, Bobiri, Ankasa, Kakum). As this method did not add additional species to our list, the latter data will not be presented in detail within this report.

In the Volta Region we also applied interviews with villagers, using questionnaires with frog pictures, to learn if particular amphibians (e.g. *Conraua derooi*) are consumed as bush meat by the local population.

Our sampling design only provided qualitative and semi-quantitative data. We therefore calculated the estimated species richness and hence our sampling efficiency with the Jack-knife 1 and Chao 2 estimators (software: EstimateS, COLWELL 2005). These incidence based estimators were calculated based on the presence/absence data of our daily species lists (39 days) for 43 species. We accomplished 500 random runs of the daily species lists to avoid order effects.

Our nomenclature follows the taxonomy by FROST (2004). Table 1 includes the changes according to FROST et al. (2006). Vouchers are currently deposited at M.-O. RÖDEL's collection at Würzburg University and will be later on inventoried in the zoological collection of the Natural History Museum in Berlin. Tissue samples (toe tips and muscle) were preserved in 95% Ethanol. They are stored at the Institute for Biodiversity and Ecosystem Dynamics at the University of Amsterdam.

Results

Species Richness

During our surveys of the forests in southern Ghana we recorded at least 43 amphibian species. So far it is not possible to reliably differentiate *Arthroleptis* spp. based on morphological data only (RÖDEL & BANGOURA 2004). Preliminary genetic investigations suggest that our samples comprise several species (A. HILLERS, unpubl. data). A list of all recorded amphibians with site records, known habitat preference, African distribution and

IUCN Red list category is given in Table 1. A list with more specific record sites is given in Appendix 2.

The comparison of the species accumulation curve with the species numbers calculated by the two estimators showed that more than the 43 recorded amphibian species are likely to occur in the investigated forest areas (Fig. 3). The Chao 2 and the Jack-knife 1 estimator calculated 45 and 48 species, respectively. We hence would have recorded about 90-95% of the amphibian species potentially occurring in the forests of southern Ghana.

The species richness at the respective sites was: 19 species in the Volta region (Amedzofe, Biakpa and Leklebi), seven species in Kalakpa National Park, 18 species in Bobiri Forest Reserve, 12 species in Owabi Wildlife Sanctuary, 13 species in Tano-Offin Forest Reserve, 14 species in Bia National Park, 28 species in Ankasa National Park and 24 species in Kakum National Park.

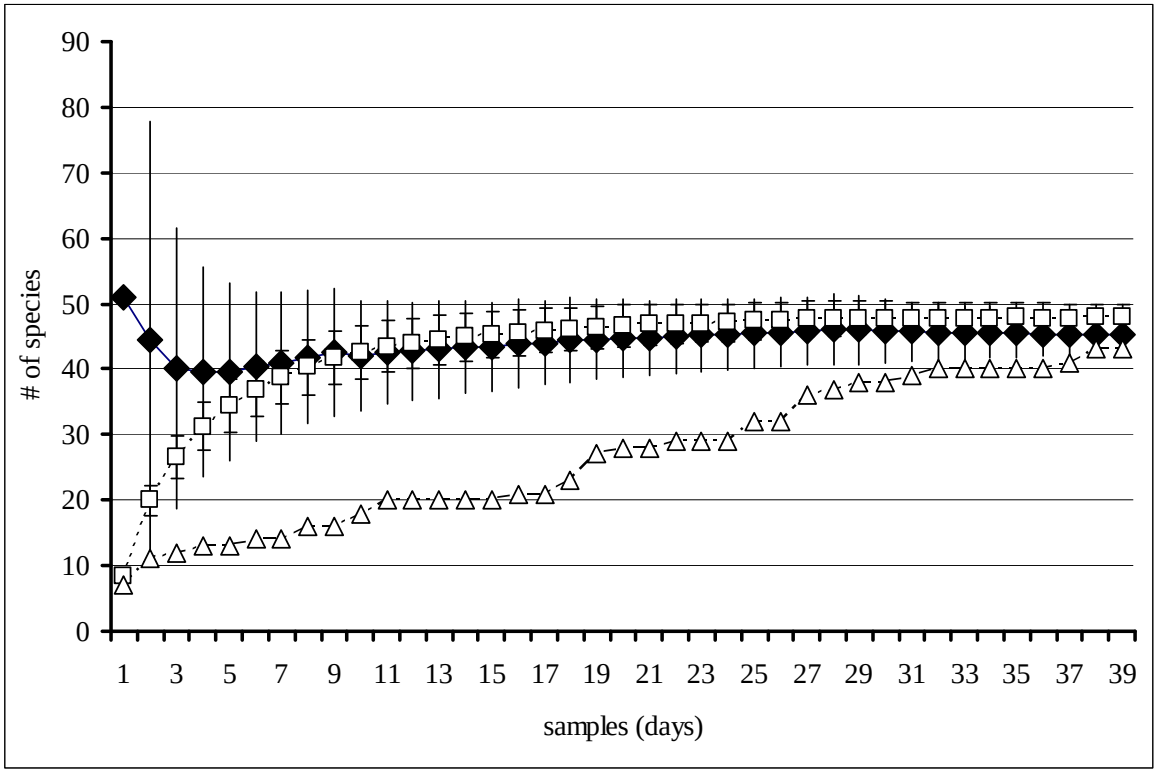

Figure 3: Estimated species richness for amphibians in the forests of southern Ghana (based on 39 days of survey work). Open squares = Jack-knife 1 estimator (47.9 ± 2.1 species)); black diamonds = Chao 2 estimator (45.3 ± 3.0 species); open triangles = species accumulation curve.

Habitat requirements

The majority of detected species was closely related to forest habitats (20 species, 46%). Eleven species (26%) were also forest species, but being tolerant to farmbush habitat. Twelve species (28%) showed a strong preference for savanna and farmbush habitats and are not normally occurring in primary forest situations.

At most survey sites the amphibian communities were generally dominated by forest related species (Tab. 1). However, we observed invasive species with preferences for farmbush and savanna habitats at all sites, indicating a certain degree of forest alteration. The presence of invasive species (e.g. *Hoplobatrachus occipitalis, Ptychadena oxyrhynchus*) was especially obvious in the Volta Region.

Species distributions

The majority of recorded species (65%) did not occur outside West Africa (Tab. 1), and was often even restricted to smaller parts of West Africa. Thirteen species (30%) only occur in the Upper Guinea forest area, while five species (12%) were endemic to the forested areas of southern Ghana. Three of the latter species are described to occur only in the Volta Region (*Conraua derooi, Hyperolius baumanni, Hyperolius torrentis*; Tab. 1).

The treefrog species *Kassina cochranae* (Fig. 4) was for the first time recorded in Ghana. Until now it was only known from areas much further West in Upper Guinea (western Côte d'Ivoire to Sierra Leone; RÖDEL et al. 2002). Also for other species our records represent range extensions, i.e. *Phlyctimantis boulengeri, Phrynobatrachus plicatus* and *Phrynobatrachus tokba* had not been found in Ghana's Central Region before. However, *P. tokba* and *P. plicatus* were observed during a survey of the Atewa Forest Reserve in the Eastern Region in 2006 (KOUAMÉ et al. in press) and *P. plicatus* had also been reported from Kyabobo National Park in the northern Volta Region (LEACHÉ et al. 2006).

Figure 4: The Near Threatened species *Kassina cochranae*, so far only known from areas much further West in the Upper Guinea Forest, was found at the border of Bia National Park in south-western Ghana.

Threatened and endemic species

Seven of the recorded species were Near Threatened according to the IUCN Red List: *Bufo togoensis, Afrixalus nigeriensis, Kassina cochranae, Leptopelis macrotis, Leptopelis occidentalis, Phrynobatrachus alleni, Phrynobatrachus liberiensis*; two are Vulnerable: *Hyperolius laurenti, Phrynobatrachus villiersi*; three are Endangered: *Hyperolius bobirensis, Hyperolius torrentis, Phrynobatrachus ghanensis*; and one species, *Conraua derooi*, is Critically Endangered (IUCN et al. 2004; Tab. 1). The number of threatened species was especially high in Ankasa and Kakum National Parks.

Five species were endemic to the forested areas of southern Ghana and Togo (*Hyperolius bobirensis, H. sylvaticus sylvaticus, H. torrentis* (but see below), *H. baumanni*, and *Conraua derooi*). The first species was only known from one single forest locality, the three latter species were only known from the Ghanaian/Togolese border region. For *Hyperolius baumanni* and *Conraua derooi* the distribution range has been recently extended more into central Ghana as they were also recorded from Atewa Forest Reserve (KOUAMÉ et al. in press). *Hyperolius torrentis* was very recently found for the first time outside of the Volta Region. It was reported to be present in northern Benin (M.-O. RÖDEL et al., unpubl. data).

Table 1: Amphibian species recorded in the forests of southern Ghana with record sites, habitat preference, African distribution of species and IUCN Red list category (IUCN et al. 2004). AM = Amedzofe, BI = Biakpa, LE = Leklebi, KAL = Kalakpa National Park, BOB = Bobiri Forest Reserve, OWS = Owabi Wildlife Sanctuary, TOF = Tano Offin Forest Reserve, BIA = Bia National Park, ANK = Ankasa National Park, KAK = Kakum National Park. S = savanna, FB = farmbush (degraded forest and farmland), F = forest, A = Africa (occurs also outside West Africa), WA = West Africa (Senegal to eastern Nigeria), UG = Upper Guinea (forest zone West of the Dahomey Gap), E = endemic to Ghana or Togo-Volta-Highlands, * = records possibly comprise several species, LC = Least concern, NT = Near threatened, VU = Vulnerable, EN = Endangered, CR = Critically endangered, [1] = first country record.

FROST et al. (2006) introduced many new names and relationships. As these are not yet generally accepted (WIENS 2007, but also see author's response) and to allow for a better orientation, we herein list the old names (FROST 2004). The new affiliations according to FROST et al (2006) are: The West African *Bufo* species are now in the genus *Amietophrynus*, the African *Amnirana* species in the genus *Hydrophylax*. *Astylosternus* and *Leptopelis* moved into the family Arthroleptidae. *Conraua* now is a member of the family Petropedetidae, *Hoplobatrachus* is in the family Dicroglossidae, *Ptychadena* forms the family Ptychadenidae and *Phrynobatrachus* forms the family Phrynobatrachidae. *Leptopelis spiritusnoctis* was previously termed *L. hyloides* (compare RÖDEL 2007). The former name for the West African *Cardioglossa occidentalis* was *C. leucomystax*. Central African populations still have to be termed *C. leucomystax* (compare BLACKBURN et al. in press).

Species	Site	S	FB	F	A	WA	UG	E	IUCN Red list category
Arthroleptidae									
Arthroleptis spp. *	AM, BI, LE, KAL, BOB, OWS, TOF, BIA, ANK, KAK		x	x			x		LC
Cardioglossa occidentalis	ANK, KAK			x			x		LC
Bufonidae									
Bufo maculatus	AM, BI, LE, BOB, OWS, ANK, KAK	x	x		x				LC
Bufo regularis	AM, BI, LE, OWS, BIA, ANK, KAK	x	x		x				LC
Bufo togoensis	ANK			x			x		NT
Hemisotidae									
Hemisus marmoratus	BOB, BIA, KAK	x	x		x				LC

Species	Site	S	FB	F	A	WA	UG	E	IUCN Red list category
Hyperoliidae									
Afrixalus dorsalis	BI, LE KAL, BOB, OWS, TOF, BIA, ANK, KAK	x	x		x				LC
Afrixalus nigeriensis	BOB, TOF, ANK			x		x			NT
Afrixalus vittiger	LE	x	x			x			LC
Hyperolius baumanni	AM, BI LE		x	x				x	LC
Hyperolius bobirensis	ANK			x				x	EN
Hyperolius concolor	AM, BI, LE, KAL, BOB, OWS, TOF, BIA, ANK, KAK	x	x			x			LC
Hyperolius fusciventris burtoni	BI, LE, KAL, OWS		x	x		x			LC
Hyperolius fusciventris lamtoensis	BIA, ANK, KAK		x	x			x		LC
Hyperolius guttulatus	BI, OWS, ANK, KAK		x		x				LC
Hyperolius laurenti	ANK			x			x		VU
Hyperolius sylvaticus sylvaticus	BOB, KAK			x				x	LC
Hyperolius torrentis	AM, BI			x				x	EN
Kassina cochranae[1]	BIA		x	x			x		NT
Leptopelis macrotis	ANK, KAK			x			x		NT
Leptopelis occidentalis	ANK, KAK			x			x		NT
Leptopelis spiritusnoctis	AM, BI, LE, KAL, BOB, TOF, BIA, ANK, KAK		x	x		x			LC
Leptopelis viridis	AM, LE	x	x		x				LC
Phlyctimantis boulengeri	BOB, ANK		x	x		x			LC

Species	Site	S	FB	F	A	WA	UG	E	IUCN Red list category
Petropedetidae									
Phrynobatrachus accraensis	LE, BOB, OWS, TOF, BIA, ANK, KAK	x	x			x			LC
Phrynobatrachus alleni	BOB, TOF, BIA, ANK, KAK			x			x		NT
*Phrynobatrachus calcaratus**	AM, BI, LE, KAL, BOB, TOF, KAK		x	x	x				LC
Phrynobatrachus ghanensis	ANK, KAK			x			x		EN
Phrynobatrachus gutturosus	KAK			x		x			LC
Phrynobatrachus liberiensis	ANK, KAK			x			x		NT
Phrynobatrachus plicatus	BOB, OWS, TOF, ANK, KAK			x		x			LC
Phrynobatrachus tokba	ANK			x			x		LC
Phrynobatrachus villiersi	BOB, BIA, KAK			x			x		VU
Pipidae									
Silurana tropicalis	AM, LE, BI, KAK		x	x	x				LC
Racophoridae									
Chiromantis rufescens	ANK		x	x	x				LC
Ranidae									
Amnirana albolabris	AM, BI, LE, KAL, OWS, TOF, ANK, KAK			x	x				LC
Aubria subsigillata	OWS, ANK			x	x				LC
Conraua derooi	AM, BI, LE			x				x	CR
Hoplobatrachus occipitalis	LE, BOB, OWS, TOF, BIA, ANK	x	x		x				LC
Ptychadena aequiplicata	BOB, TOF, KAK			x	x				LC

Species	Site	S	FB	F	A	WA	UG	E	IUCN Red list category
Ptychadena longirostris	BOB, BIA, ANK		x	x		x			LC
Ptychadena mascareniensis	ANK		x		x				LC
Ptychadena oxyrhynchus	AM, BOB, TOF	x			x				LC

Notes on selected species

Conraua derooi HULSELMANS, 1971

The Critically Endangered species *Conraua derooi* (IUCN et al. 2004; Fig. 5) was originally described from western Togo (HULSELMANS 1971) and apart from there only known from a few Ghanaian sites, close to the Togolese border (SCHIØTZ 1964a as *Conraua alleni*). Until our survey in 2005 it was never found again, although numerous suitable habitats were searched for it (RÖDEL & AGYEI 2003, LEACHÉ et al. 2006). Its preferred habitat are slightly rocky streams in forests (Fig. 6). In the Volta Region *C. derooi* is extremely threatened because of the heavy destruction and alteration of its habitat and because of being regularly consumed by humans. This is also the case at the Togolese part of the Volta Region, where *C. derooi* was found during a short survey in 2007 (A. HILLERS et al., unpubl. data). Another recent survey reported *C. derooi* from Atewa Forest Reserve (KOUAMÉ et al. in press), where it seems to hold still large and viable populations along the intact forest streams. However, first analyses revealed that although both being *C. derooi,* the populations in the Volta Region and Atewa show some genetic differences, which underlines their uniqueness in the two areas, respectively (M.-O. RÖDEL et al., unpubl. data).

Reliable statements and detailed information about the size of the Ghanaian populations of *Conraua derooi,* especially in the Volta Region, where they are restricted to small, isolated populations, would require more focused and intensive monitoring work.

Figure 5: Male of the Critically Endangered aquatic frog *Conraua derooi*.

Figure 6: Preferred habitat type of *Conraua derooi*; a partly rocky forest stream.

Hyperolius torrentis SCHIØTZ, 1967

The Endangered species *Hyperolius torrentis* (IUCN et al. 2004; Fig. 7) was so far believed to be endemic to the Volta Region in eastern Ghana and adjacent Togo (SCHIØTZ 1967, RÖDEL & AGYEI 2003). However, recently it was found in northern Benin as well (M.-O. RÖDEL et al., unpubl. data). *H. torrentis* occurred in forests along streams and at waterfalls. It seems to be abundant at the sites investigated in the Volta Region, but facing the serious destruction of forest habitats in this area, *H. torrentis* has to be regarded as threatened because of habitat loss, like in the case of *Conraua derooi*. During a short survey of the Togolese part of the Togo-Volta highlands, *H. torrentis* could not be recorded (A. HILLERS et al., unpubl. Data)

Hyperolius bobirensis SCHIØTZ, 1967

The Endangered species *Hyperolius bobirensis* (IUCN et al. 2004, Fig. 8) has its type locality in the Bobiri Forest Reserve. Since its discovery in the 1960s (SCHIØTZ 1967) it had only been found in Ankasa National Park (this survey and see also RÖDEL et al. 2005) and in Atewa Forest Reserve (KOUAMÉ et al. in press). During our survey we were not able to confirm the species for the Bobiri Forest Reserve. One reason could be the absence of a suitable habitat as it was reported to occur at "stagnant, overgrown waterholes in the dense forest" (SCHIØTZ 1967). The only waterholes and ponds that we detected in Bobiri were located next to the road running through the reserve, and not in

the true forest habitat itself. Further amphibian surveys in Bobiri should reveal if in general the suitable habitats for *H. bobirensis* disappeared and if this is a reason for the possible absence of this species. In Ankasa, we found only a single juvenile individual of *H. bobirensis* hinting on the possibility that this species might not be very abundant in this forest.

Figure 7: *Hyperolius torrentis*

Figure 8: *Hyperolius bobirensis*

Phrynobatrachus ghanensis SCHIØTZ, 1964

The Endangered species *Phrynobatrachus ghanensis* (IUCN et al. 2004) was previously only known from Kakum National Park. In the meantime it was found in Ankasa National Park (also throughout this survey), Draw River and Boi Tano Forest Reserves (RÖDEL et al. 2005), and recently also in Atewa Forest Reserve (KOUAMÉ et al. in press). Furthermore it is also present in Banco National Park in Côte d'Ivoire (ASSEMIAN et al. 2006). Therefore it can not be seen as a species endemic only to the Ghanaian forests anymore. In Ankasa National Park we were able to observe several individuals of this small leaf litter frog.

Given the fact that the distribution range of *Phrynobatrachus ghanenis* is still restricted to a rather small area within Upper Guinea, which is comparable to other Endangered species like e.g. *Phrynobatrachus annulatus* (IUCN et al. 2004), it should still be seen as Endangered according to the IUCN Red list. Further monitoring of *P. ghanensis* and its population sizes at different, also partly degraded sites would be required to decide on

keeping its status as Endangered or changing it into a lower Red list category (Vulnerable or Near Threatened).

Phrynobatrachus calcaratus PETERS, 1863

Phrynobatrachus calcaratus is widespread in West and Central Africa and typically lives in rain forest edges and in gallery forests in the savanna zone (RÖDEL 2000). First genetic analyses and morphometric examinations revealed that the species *Phrynobatrachus calcaratus* in the Volta Region is not identical with the *P. calcaratus* in the other investigated Ghanaian forests and in other Upper Guinean regions (RÖDEL & AGYEI 2003, M.-O. RÖDEL et al., unpubl. data). Further analyses will clarify the taxonomic status of the various populations and if it can be regarded as a species complex, including undescribed species.

Discussion

Recent surveys of Ghanaian amphibians revealed higher species richness than previously assumed (RÖDEL & AGYEI 2003, ERNST et al. 2005, RÖDEL et al. 2005, LEACHÉ et al. 2006, KOUAMÉ et al. in press). This might especially be true for the forests of southern Ghana where the last intensive investigations had been undertaken during the 1960s (SCHIØTZ 1964a, b, 1967). The recent studies highlighted the unique compositions of Ghanaian amphibian assemblages as they comprise a very high percentage of species that are threatened and/or endemic to the Upper Guinea forest block or to even smaller parts within Ghana. The investigated forests therefore showed a very high potential for nature conservation.

The current lack of knowledge about forest amphibians including the distribution patterns of endemic and endangered species is especially problematic facing the high deforestation rate in West Africa. Therefore we investigated the amphibian faunas in several of the remaining forests in southern Ghana, with an emphasis on endemic and endangered species, such as *Conraua derooi*, *Hyperolius bobirensis*, *Hyperolius torrentis* and *Phrynobatrachus ghanensis*.

During our survey we were able to trace all endangered and endemic target species, even those that had not or only rarely been seen since their description around 30

years ago (*Conraua derooi*, *Hyperolius bobirensis*). Except for the species *Hyperolius bobirensis*, for which we only found a single individual in Ankasa National Park, therefore not assuring a stable population in the studied forests, we found several (*Conraua derooi*, *Phrynobatrachus ghanensis*) or even many (*Hyperolius torrentis*) populations and individuals for the other species, indicating a potentially sufficiently high number of individuals and population for a long-term persistence of these species. However, while *Phrynobatrachus ghanensis* really seems to form stable populations in different forests (Ankasa, Kakum), the torrenticolous species (*Conraua derooi* and *Hyperolius torrentis*) are highly threatened by the destruction of their habitats (see below) and by human consumption (*C. derooi*). As *C. derooi* is a permanently aquatic species it is easy to track and to hunt for locals, making it especially vulnerable.

Like in other recent surveys (RÖDEL & AGYEI 2003, ERNST et al. 2005, RÖDEL et al. 2005, LEACHÉ et al. 2006, KOUAMÉ et al. in press) the recorded species richness was higher than stated in older papers. We hence could confirm the assumption that the amphibian fauna in Ghana's forests is not less diverse than in neighbouring countries, but instead was incompletely explored. It is very likely that a more thorough survey, also including more of the remaining forests, will even reveal higher species richness in southern Ghana than observed during our surveys. This is also supported by the slightly higher estimated species richness compared to the recorded number of species. Taking into account that during the works in forests in western Ghana the species richness reached 47 species (RÖDEL et al. 2005) the calculated number of up to 48 species for the forests investigated throughout this study might be an underestimation. This is also illustrated by the fact that several species that had been reported to occur in southern Ghana, some of them even in Ankasa National Park, were not observed throughout this survey, like e.g. *Acanthixalus sonjae*, *Kassina arboricola*, *Hyperolius viridigulosus*, *Amnirana occidentalis*, and *Astylosternus* sp. (RÖDEL & AGYEI 2003, ERNST et al. 2005, RÖDEL et al. 2005, LEACHÉ et al. 2006, KOUAMÉ et al. in press).

The numbers of species varied among the different study sites. On the one hand this can be explained by the big differences of survey times (e.g. in Kalakpa National Park we only stayed for one day while in other areas for six or more days). It is likely that we would have found more species in all of the investigated areas by increasing the

searching effort. For example in Ankasa, where 36 species had been recorded in former studies (RÖDEL et al. 2005), we only found 28 species, which on the other hand included the species *Bufo togoensis* that had not been found in Ankasa before.

A second reason for the differences in species richness between the different sites can be explained by factors related to the West African forest history. As it is also mentioned in previous studies (RÖDEL & AGYEI 2003, RÖDEL et al. 2005, LEACHÉ et al. 2006), we observed a difference of species richness between south-western Ghana and the other studied forest areas. More species were found in Ankasa National Park than in the other forests. This can be related to the fact that Ankasa might have been a forest refugium that existed during dry periods in earth's history in south-western Ghana and might therefore harbour a higher species diversity (e.g. UICN 1996, FALK et al. 2003, POORTER et al. 2004). In contrast, no forest refugia are assumed for the eastern part of Ghana (ROMPAEY 1993, PARREN & DEGRAAF 1995). Furthermore, the Volta Region probably has been continuously inhabited by more humans and natural habitats have been scarcer than in the western forests throughout the past millennium (RÖDEL & AGYEI 2003).

In addition to the high anuran species richness, we also could confirm the high conservation potential and urgent need for conservation of forests in southern Ghana that was already indicated in other recent studies (RÖDEL & AGYEI 2003, ERNST et al. 2005, RÖDEL et al. 2005, LEACHÉ et al. 2006, KOUAMÉ et al. in press). The amphibian communities observed during our survey in general showed a remarkable species composition with regard to regional endemicity and a high amount of threatened and rare species. However, despite the fact that forest specialists were dominating the species communities, we also recorded invasive, non-rainforest species at all sites that clearly indicated a persistent level of forest habitat disturbance. At single sites we observed a varying ratio between forest species and species related to farmbush (e.g. *Bufo maculatus, Afrixalus dorsalis, Hyperolius concolor*) or savanna (*Bufo regularis, Hoplobatrachus occipitalis, Ptychadena oxyrhynchus, Phrynobatrachus accraensis*) habitat. These invasive species were especially observed in higher numbers in the Volta Region, as well as in the different Forest Reserves compared to Ankasa and Kakum. But even in the Ankasa National Park, that was closest to primary forests, the presence of

several invasive species was recorded. RÖDEL et al. (2005) state that some of the invasive species they found in Ankasa, Draw River and Boi-Tano forests in south-western Ghana were already well established within the forests and might compete and eventually displace true forest species. This could also be the case in the forests studied throughout this survey.

It has been shown that amphibians react already very sensitive to comparatively minor forest degradation, such as selective logging, by an altered species composition, a different community structure and the loss of particular functional groups (ERNST & RÖDEL 2005, ERNST et al. 2006). This highlights the importance to maintain larger intact forest blocs. The loss of particular species, but even more importantly the loss of particular functional groups, may also result in a decrease of resistant functions of a given ecosystem to e.g. invasive species (ERNST et al. 2006, HILLERS et al., subm.).

The forest situation is especially serious in the Volta Region, where no larger tracks of natural forests seemed to be left. We were able to rediscover *Conraua derooi* throughout this survey, but its small, isolated populations are extremely threatened by being consumed by the local population and, more seriously, with further habitat destruction they are likely to disappear in the Volta Region and also on the Togolese side of the Togo-Volta highlands. The remaining populations of *C. derooi* show genetic differences compared to the individuals of *C. derooi* in Atewa (M.-O. RÖDEL et al., unpubl. data). Therefore it is even more important to urgently protect this unique species by protecting all remaining forests and forest streams and by sensitizing the population in the Volta Region for a sustainable consumption or if possible no consumption at all of *C. derooi.*

The destruction of forests also threatens all other forest stream dependent amphibians, like *Hyperolius torrentis*, as well as species requiring large forests, like e.g. *Bufo togoensis* which was not recorded in the Volta Region throughout this and other recent surveys (RÖDEL & AGYEI 2003, LEACHÉ et al. 2006).

Conservation Recommendations

Based on the findings gained throughout our survey of the endangered and endemic amphibians in the forests of southern Ghana, we recommend the following for an improved knowledge of the Ghanaian amphibian fauna and its long-term protection:

- undertake further surveys also in smaller forest areas that are located in between the forests that were investigated throughout this survey to gain a clearer picture of the distribution and abundance of threatened and endemic amphibian species;
- undertake a thorough survey on the Togolese side of the Togo-Volta highlands to search for threatened and endemic species (*Conraua derooi*, *Hyperolius torrentis*, and *Werneria preussi*), and to assess their chances to survive in the Togo-Volta highlands;
- conduct regular monitoring on the persisting populations of particular frog species, especially focusing on the threatened or rare and endemic species, i.e. *Conraua derooi*, *Hyperolius torrentis*, *Hyperolius bobirensis*, *Phrynobatrachus ghanensis*, to assess how stable the populations are at different sites. For *Conraua derooi* this monitoring should not only focus on the Volta Region, but also on Atewa Forest Reserve;
- protect remaining forests as well as forest streams in the Volta Region to avoid extinction of forest and forest stream dependent species;
- involve local communities in the management and conservation of all remaining forests and sensitize them concerning a sustainable consumption of *Conraua derooi*;
- prevent any further encroachment, illegal logging and farming activities in all remaining forests.

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Appendix 1

Locality list and short description of habitats investigated in the forested areas of southern Ghana. AM = Amedzofe, BI = Biakpa, LE = Leklebi, KAL = Kalakpa National Park, BOB = Bobiri Forest Reserve, OWS = Owabi Wildlife Sanctuary, TOF = Tano Offin Forest Reserve, BIA = Bia National Park, ANK = Ankasa National Park, KAK = Kakum National Park.

Site	Latitude (N)	Longitude (W)	Description
AM1	6°50.614'	0°26.440'	stream/around stream within gallery forest
AM2	6°50.713'	0°26.288'	stream and pond within gallery forest
AM3	6°50.757'	0°26.444'	borders of road within village, grass
AM4	6°50.643'	0°26.821'	around stream on top of waterfall
AM5	6°50.057'	0°26.306'	small stream near corn and cassava plantation and small gallery forest
AM6	6°50.109'	0°26.306'	dry forest remnant within plantations, in vicinity to gallery forest
AM7	6°50.429'	0°25.582'	stream in valley, small gallery forest, near corn, cassava and banana plantations
AM8	6°50.611'	0°26.084'	trees on edge of village
AM9	6°50.930'	0°26.240'	stream near village
BI1	6°50.730'	0°25.412'	stream near village, near cocoa plantation
BI2	6°50.652'	0°25.280'	rocky stream near village with small forest
BI3	6°50.700'	0°25.612'	stream near corn and banana plantation
BI4	6°50.567'	0°25.404'	pond near stream and banana plantation
BI5	6°50.582'	0°25.404'	pond within plantation near stream
BI6	6°50.561'	0°25.310'	canal within village
BI7	6°50.078'	0°25.081'	dry and hilly forest, partly thick undergrowth
BI8	6°51.205'	0°25.166'	waterfall within forest
LE1	6°55.920'	0°29.154'	pond near village, many shrubs around
LE2	6°56.023'	0°29.026'	pond near stream and cocoa plantation
LE3	6°56.115'	0°29.328'	trees and grassland near road/village
LE4	6°56.946'	0°29.497'	slowly flowing stream within forest, forest partly with thick undergrowth
LE5	6°56.911'	0°29.407'	cocoa plantation near stream and small forest
LE6	6°57.167'	0°29.319'	small brook, near cassava and corn plantation
LE7	6°56.942'	0°29.258'	swampy area near banana and cocoa plantation
LE8	6°57.247'	0°29.899'	at stream in cocoa plantation

Site	Latitude (N)	Longitude (W)	Description
LE9	6°57.226'	0°25.953'	cocoa plantation on small hill, near forest and stream
LE10	6°57.166'	0°29.976'	rocky stream within forest
LE11	6°57.362'	0°29.862'	swampy area near stream, village and plantation
LE12	6°55.754'	0°29.305'	small forest with stream
LE13	6°58.478'	0°30.220'	big pond with trees and grassland around
LE14	6°58.688'	0°29.743'	small forest with stream next to road
LE15	6°58.688'	0°29.692'	slightly swampy area with grass and herbaceous plants
LE16	6°58.693'	0°29.712'	stream with herbaceous plants around
LE17	6°58.395'	0°30.188'	small pond with herbaceous plants and some trees around
LE18	6°58.248'	0°30.242'	small pond with bamboo around
LE19	6°58.061'	0°30.990'	pond with plantation and some trees around
LE20	6°58.293'	0°30.931'	stream close to village
LE21	6°58.306'	0°30.916'	small pond with shrubs around
LE22	6°58.089'	0°31.280'	rocky stream close to forest and village
LE23	6°54.799'	0°29.931'	waterfall in forest
KAL1	6°27.363'	0°22.316'	gallery forest along stream, with pond
BOB1	6°41.280'	1°20.531'	puddles and borders along road within forest
BOB2	6°41.318'	1°20.581'	forest near dry stream
BOB3	6°41.669'	1°18.087'	puddles on road within forest
BOB4	6°42.383'	1°15.881'	forest near flowing stream
BOB5	6°40.849'	1°20.284'	primary forest near dry stream
BOB6	6°41.477'	1°20.195'	puddles and borders along road within forest
BOB7	6°41.312'	1°20.685'	forest near dry stream
BOB8	6°41.111'	1°21.341'	border of road within forest
BOB9	6°41.073'	1°21.493'	dry pond, swampy area near road within forest
BOB10	6°41.212'	1°20.629'	open area within forest, grass, at camp
BOB11	6°41.422'	1°19.485'	puddles and borders along road within forest
BOB12	6°41.411'	1°20.070'	pond, puddles and borders along road within forest
OWS1	6°44.476'	1°42.400'	partly dry forest
OWS2	6°44.387'	1°42.285'	big pond near lake and river
OWS3	6°44.313'	1°42.052'	border of lake in forest
OWS4	6°44.842'	1°42.194'	forest near lake and stream

Site	Latitude (N)	Longitude (W)	Description
OWS5	6°44.890'	1°42.096'	forest near river below dam
TOF1	6°46.374'	2°02.538'	dry forest
TOF2	6°46.289'	2°02.413'	cocoa plantation at forest border
TOF3	6°47.183'	2°01.451'	pond/swampy area near forest and banana and cassava plantation
TOF4	6°47.130'	2°01.633'	banana and cassava plantation near pond
TOF5	6°47.257'	2°01.511'	pond near road with shrubs and grass around
TOF6	6°46.715'	2°01.863'	forest near stream
TOF7	6°46.647'	2°01.840'	stream in forest
TOF8	6°46.347'	2°01.692'	road near forest
BIA1	6°32.091'	3°02.861'	stream next to road through forest
BIA2	6°32.033'	3°03.226'	dried stream and puddles, border of road through forest
BIA3	6°32.642'	3°02.610'	primary forest with dry stream, partly thick undergrowth
BIA4	6°32.585'	3°02.872'	dry primary forest on hill
BIA5	6°31.966'	3°03.075'	dry secondary forest, partly thick undergrowth and many lianas
BIA6	6°33.308'	3°05.770'	big puddle on open area in primary forest and surrounding forest
BIA7	6°33.382'	3°05.759'	primary forest with many tree fall gaps, partly thick undergrowth and slightly swampy areas
BIA8	6°34.132'	3°01.606'	pond next to road
BIA9	6°34.132'	3°01.950'	pond with dense vegetation, on forest edge and close to road
ANK1	5°16.642'	2°38.253'	primary forest near stream, partly swampy
ANK2	5°16.356'	2°38.698'	primary forest near stream
ANK3	5°16.706'	2°38.814'	border of road within forest
ANK4	5°16.916'	2°38.498'	camp, open area within forest
ANK5	5°17.377'	2°38.637'	stream and swampy area within primary forest
ANK6	5°17.410'	2°38.375'	pond near electricity line next to forest, puddles on road to pond
ANK7	5°17.425'	2°38.300'	pond near electricity line next to forest
ANK8	5°17.340'	2°37.238'	big pond with trees inside, near primary forest and electricity line
ANK9	5°18.188'	2°36.564'	waterfall and big stream within primary forest
ANK10	5°16.060'	2°38.800'	dry primary forest with tree fall gaps

Site	Latitude (N)	Longitude (W)	Description
ANK11	5°16.873' & 5°16.915'	2°38.366' & 2°38.417'	bamboo "cathedral" near stream
ANK12	5°17.075'	2°38.919'	pond near electricity line, with dense vegetation, next to forest
ANK13	5°15.714'	2°38.703'	primary forest with brook and swampy area, with Raffia palms
ANK14	5°13.034'	2°39.090'	forest near big stream
ANK15	5°16.485'	2°38.790'	border of road within forest
ANK16	5°16.728’	2°38.274’	dry primary forest on hill
ANK17	5°16.921’	2°38.482’	dry forest next to camp, partly thick undergrowth
KAK1	5°27.000'	1°24.983'	near stream within forest
KAK2	5°27.018'	1°24.831'	dry primary forest
KAK3	5°26.819'	1°24.873'	forest with swampy area and stream
KAK4	5°26.521'	1°24.411'	swampy area in forest
KAK5	5°21.208'	1°22.875'	near stream within primary forest
KAK6	5°21.322'	1°22.779'	stream with rocks, dense tree vegetation around
KAK7	5°20.257'	1°22.735'	pond in village near Kakum National Park
KAK8	5°21.672'	1°21.602'	near stream within forest
KAK9	5°21.604'	1°21.521'	around stream in farmbush area next to forest
KAK10	5°26.599'	1°24.934'	road near camp, open area
KAK11	5°26.916'	1°25.009'	near stream within forest

Appendix 2
Amphibian species recorded in the forests of southern Ghana with specific record sites. AM = Amedzofe, BI = Biakpa, LE = Leklebi, KAL = Kalakpa National Park, BOB = Bobiri Forest Reserve, OWS = Owabi Wildlife Sanctuary, TOF = Tano Offin Forest Reserve, BIA = Bia National Park, ANK = Ankasa National Park, KAK = Kakum National Park.

Species	Site
Arthroleptidae	
Arthroleptis spp.	AM1,3,6,7, BI1,7, LE5,7,9, KAL1, BOB10, OWS1,4, TOF1,2,6,7, BIA2,3,6,7, ANK1,2,4,5,9,10,11,13,14,16,17, KAK1,2,3,5,9,10,11
Cardioglossa occidentalis	ANK9, KAK3
Bufonidae	
Bufo maculatus	AM3, BI1,6, LE22, BOB1,5, OWS3, BIA8, ANK12, KAK7
Bufo regularis	AM3, BI6, LE1,5,8,12,13,20,22, OWS2,4, BIA8, ANK4,12, KAK10
Bufo togoensis	ANK9
Hemisotidae	
Hemisus marmoratus	BOB8, BIA 2, KAK1
Hyperoliidae	
Afrixalus dorsalis	BI5, LE1,13,15,19,20 KAL1, BOB12, OWS2,3,5, TOF5,8, BIA1,8 ANK6,7,8,12, KAK7
Afrixalus nigeriensis	BOB6,9,12, TOF8, ANK6,12
Afrixalus vittiger	LE1
Hyperolius baumanni	AM1,2, BI1,4 LE7,19,21
Hyperolius bobirensis	ANK12
Hyperolius concolor	AM1,2,9, BI1,3,5 LE1,2,13,17,19,20, KAL1, BOB12, OWS2,3,5 TOF4,5, BIA8, ANK6,7,8,12, KAK7
Hyperolius fusciventris burtoni	BI1,5, LE1,2,19,20, KAL1, OWS2,3
Hyperolius fusciventris lamtoensis	BIA8, ANK6,7,8,12, KAK7
Hyperolius guttulatus	BI5, OWS2, ANK4,6,7,8,12, KAK7
Hyperolius laurenti	ANK9,11,14
Hyperolius sylvaticus sylvaticus	BOB12, KAK6
Hyperolius torrentis	AM1,2, BI3,7,8
Kassina cochranae	BIA9
Leptopelis macrotis	ANK2,14, KAK1,4

Species	Site
Leptopelis occidentalis	ANK2, KAK1,4
Leptopelis spiritusnoctis	AM1,2,7,9, BI5, LE16,19, KAL1, BOB9,12, TOF3,5,8, BIA1,2, ANK6,9,14, KAK1,3,4,6,7
Leptopelis viridis	AM8, LE3,15,19
Phlyctimantis boulengeri	BOB12, ANK6,12
Petropedetidae	
Phrynobatrachus accraensis	LE6,7,9,11,13,17,19, BOB3,12, OWS4, TOF5,8, BIA1,6,8 ANK7, KAK11
Phrynobatrachus alleni	BOB2,4,5,7, TOF2,6, BIA7, ANK1,2,9,11,14,15,17 KAK1,2,3,5,6,11
Phrynobatrachus calcaratus	AM1,2,5,7, BI1,7, LE4,5,7,8,9,14, KAL1, BOB5, TOF2,7, KAK5,6,8
Phrynobatrachus ghanensis	ANK11,13, KAK1
Phrynobatrachus gutturosus	KAK3,6
Phrynobatrachus liberiensis	ANK1,2,11,13, KAK3,4,5
Phrynobatrachus plicatus	BOB4,11, OWS1, TOF1,7, ANK4,15, KAK1,5,11
Phrynobatrachus tokba	ANK17
Phrynobatrachus villiersi	BOB2, BIA7, KAK1,3,11
Pipidae	
Silurana tropicalis	AM2, LE20, BI6, KAK1
Racophoridae	
Chiromantis rufescens	ANK6
Ranidae	
Amnirana albolabris	AM1,2,7, BI1,7, LE2,20, KAL1, OWS3,4, TOF3,7, ANK1,2,3,5,7,11 KAK1,3,4,11
Aubria subsigillata	OWS3, ANK6,7
Conraua derooi	AM1,2, BI2, LE23
Hoplobatrachus occipitalis	LE1,2,7,13,17,18,19, BOB1,11,12, OWS2, TOF3,8, BIA1,2,8 ANK7
Ptychadena aequiplicata	BOB2,5,9, TOF7, KAK1,5,11
Ptychadena longirostris	BOB6,11,12, BIA1,2,6,8, ANK3,6,15
Ptychadena mascareniensis	ANK12
Ptychadena oxyrhynchus	AM3, BOB1, TOF8