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1 Introduction

West African rain forests are within the 25 most important biodiversity hotspots of the world (Myers et al. 2000). They are highly threatened by logging, agriculture and increasing human populations (Bakarr et al. 2001). About 80 % of the Upper Guinean forests in Côte d'Ivoire have been destroyed during the last 20 years (Rompay 1993, Chatelain et al. 1996). In Ghana even less of the original forest cover is still present.

Despite the fact that West Africa was the target of herpetological investigations for more than a 100 years (e.g. Werner 1898, Ahl 1924 a,b), our present knowledge is still rather scanty (Hughes 1988 provides an overview on the history of herpetological investigations in Ghana). For most of the described West African amphibians and reptiles biological data are still more or less anecdotal or completely lacking. However, in the 1970's it was assumed that at least the species inventory was nearly complete. Based on this assumption West Africa was looked upon as an area with a comparatively low diversity. Lamotte (1983) wrote that there is no place in West Africa where more than 40 amphibian species live in sympatry. This seemed also to be true for the Eastern part of the Upper Guinean Forest block. According to an unpublished checklist, compiled by A. Schiøtz for the Conservation Priority Setting Workshop (From the Forest to the Sea: Biodiversity Connections from Guinea to Ghana, December 6.-10.1999 in Elmina, Ghana), only 36 amphibian species have been recorded so far from this region.

However, recent investigations in Côte d'Ivoire revealed anuran communities, comprising more than 30 species, even in savanna habitats (Rödel 1998, 2000a, b, Rödel & Spieler 2000). Known forest communities comprise between 40 and 60 species (Rödel 2000b, Rödel & Ernst unpubl., compare Tab. 5 and Fig. 5). From West Africa seven new species have been described within the last eight years and more new species still await description (Perret 1994; Lamotte & Ohler 1997; Rödel 1998; Rödel & Ernst 2000, in press; Rödel et al. in press a, b). Remaining forest reserves in the Upper Guinea forest block probably comprise more than 60 sympatric amphibian species (Fig. 5). Diversity even exceeds most neotropical regions (Ernst & Rödel unpubl.). Similar species numbers are likely to occur in snakes (Hallermann & Rödel 1995, Rödel et al. 1995, 1999, Rödel & Mahsberg 2000, Ernst & Rödel in press).

From the Eastern part of the Upper Guinean forests only nine endemic amphibian species have been described so far. The last more extensive field work in this region date back to the early 1960's (Schiøtz 1964a, b, 1967). More recent investigations in Ghana were not focused on forest habitats or were not undertaken with special emphasis on amphibians

(Hoogmoed 1979, 1980 a-g; Hughes 1988). Judging from our results in Côte d'Ivoire the herpetofauna of Ghana is probably only very incompletely known. This especially concerns the almost neglected Togo highlands in the east of the country. For this reason A. Schiøtz and M.-O. Rödel defined the eastern Ghanian forests as an area with an exceptionally high priority level for rapid assessment during the Conservation Priority Setting Workshop in Ghana (Bakarr et al. 2001).

2 Study sites

All study sites were situated within the zone of humid semi-deciduous forest and dense deciduous forest of the Upper Guinean Forest Block between Lake Volta and the Togo border (Fig. 1, 4). Climatologically this area is part of the wet semi-equatorial region, geologically it belongs to the Voltaian Basin (Buem series and Togo series, Frempong 1995). A short characterization of all three regions and description of the respective habitats (habitat # in parentheses, compare Tab. 1) investigated are given below. The exact geographic positions are given in appendix A1.

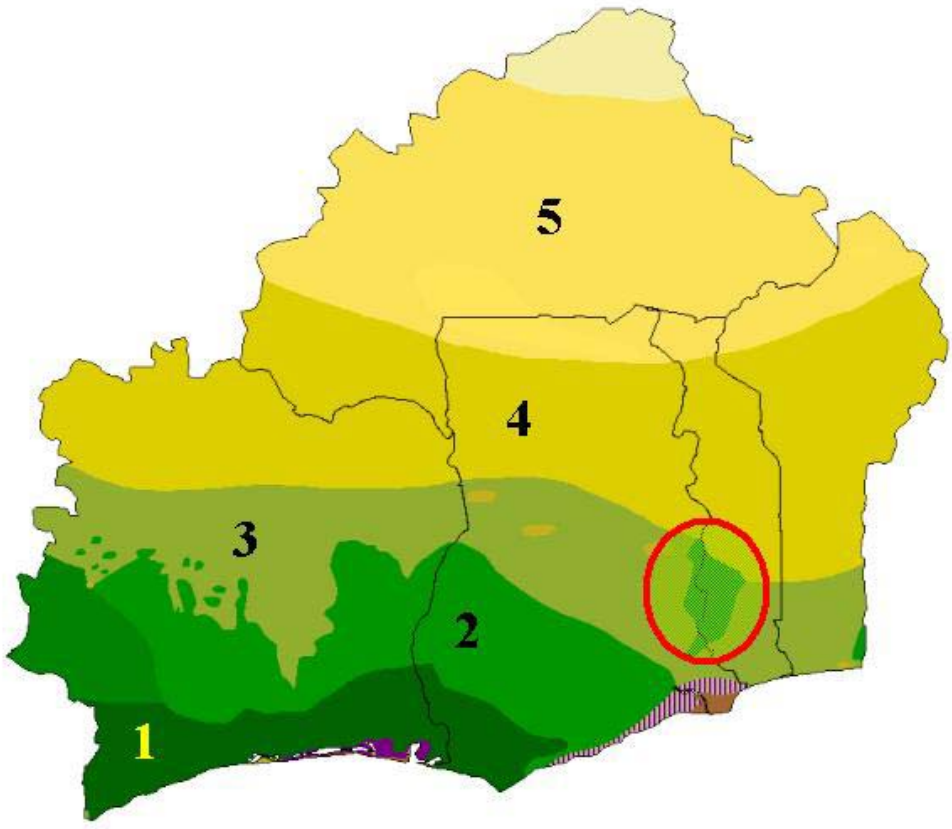

Fig. 1: Vegetation zones of West Africa, study area circled in red. 1 = rain forest, 2 = humid semi-deciduous forest, 3 = dense deciduous forest (Guinea Zone), 4 = open savanna woodland (Sudan Zone), 5 = Sahel Zone.

2.1 Wli and Liati-Wote Waterfalls Region, Southeast of Hohoe

The geological underground comprises quartzite, shale and phyllite. Mean annual precipitation is 1650 mm (Frempong 1995).

Wli Waterfall: Escarpment close to the Togo border, steep slopes with scattered forest remnants and plantations (11); fast flowing mountain creek in the valley (3); bordered by rain forest remnants (10); open areas with scattered lower trees (3); heavily vegetated swamps fully exposed to sun, forest fragments nearby, small shrubs (2, 12); shallow pond heavily vegetated, part of large flooded area, shrubs and larger herbs at pond border (5); plantations and secondary forest (9); degraded forest between the NCRC nursery and pond (6); dense under storey, open canopy, rocky mountain creek, waterfall (4); small pond in dry bed of small creek (7); way through forest remnants, dead tree with water hole (8).

Liati Wote Waterfall (=Tagbo Fall): valley with fast running rocky creek, waterfall, cacao plantations and forest remnants (35); village, artificial pond, rice fields, surrounding of village resembles humid savanna (36).

2.2 Kyabobo National Park, Shiare and Nkwanta

The underground is formed by quartzite, shale and phyllite. Mean annual precipitation is 1400 mm (Frempong 1995).

Nkwanta: road ditches, garden (13); rice fields East of Nkwanta, puddles on dirt road (14), rice fields north of Nkwanta, small ponds (15).

Kyabobo NP: way into park, hilly landscape, character of tree savanna, on the slopes dense but low forest, in the valley corn, cassava and banana plantations (16); in the NP fast flowing rocky creek, very hilly landscape, forest with single larger trees (up to 40 m) on steep slopes, primary forest on bottom of valley, on hill tops forest changes into savanna (17, 18).

Shiare: dirt road with shallow puddles (33); plantations, fast flowing creek (water polluted with sewage run-off from village), partly deep water, rocks, rapids, forest remnants with dense under storey (32); small rocky creek, bank with dense vegetation, gallery forest, partly high forest, bordered by plantations, (cassava, bananas), on hill-top savanna forest (34).

2.3 Apesokubi area and Northern Lake Volta

The Upper Precambrian underground comprises shale sandstone, arhose and lava. Mean annual precipitation is 1524 mm (Frempong 1995).

Apesokubi: West of town, dried up pond, bank with herbs and shrubs, degraded forest remnant (19, 20); puddles on dirt road, bordered by dense shrubs and degraded forest and cacao plantations (21, 25, 26); rice fields (22, 24); shallow, slow running muddy creek, secondary forest, single emergent trees, few puddles in a rice field (23); South of town, large pond, partly heavily vegetated, floating herbs, secondary forest, plantations (27); small pond, bank vegetated with herbs and shrubs (28); two shallow ponds between dirt road and secondary forest (29).

Katanka and bank of Lake Volta: small puddle without vegetation, surrounded by savanna (30); Volta bank without vegetation, *Borassus* palm savanna (31).

Tab. 1: Investigated regions, the respective habitat numbers and time spent (m/h) looking for amphibians in every region.

Region	habitat #	m/h
Wli and Liati Wote Waterfalls	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 35, 36	94,25
Kyabobo NP, Shiare, Nkwanta	13, 14, 15, 16, 17, 18, 32, 33, 34	75,75
Apesokubi, Volta	19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31	37,5

3 Sampling methods and sampling effort

The sampling method for amphibians in all areas investigated was the same and consisted of opportunistic visual and acoustical monitoring of all present habitat types (Heyer et al. 1993). Sampling was done during day and night time, preferably after rainfall when possible. With this kind of sampling design, only qualitative and semi quantitative data can be obtained. For exact quantitative data mark-recapture experiments along standardized transects or on definite plots would have been necessary. Since this survey allowed only three to five days for every region investigated, time was not sufficient to employ these methods. To evaluate our sampling efficiency we measured the time, in men hours (m/h) looking for amphibians at a certain place. More time for investigation was spent in complex and larger habitats, than in small and uniform ones. Tab. 1 and 2 summarize sampling time and date for all habitats investigated. Reptiles were recorded opportunistically while monitoring amphibians. A few voucher specimens, from both amphibians and reptiles, were collected. All vouchers were anesthetized and killed in a chlorbunatol solution and thereafter preserved in 70 % ethanol. Vouchers will be deposited in the collection of the Staatliches Museum für Naturkunde Stuttgart.

Tab. 2: Habitats and sampling effort (m/h), geographic position of habitats is given in appendix A1, for habitat description see study sites.

habitat #	man/hours	date	habitat #	man/hours	date
1	14	10.-13.8.2001	19	3	25.08.2001
2	11	10.-12.08.2001	20	10	25.-28.08.2001
3	3	10.08.2001	21	2	26.08.2001
4	16	11.08.2001	22	2	26.08.2001
5	12	12.08.2001	23	3	26.08.2001
6	3	12.08.2001	24	0.5	26.08.2001
7	0.3	12.08.2001	25	0.5	26.08.2001
8	9	11.-14.08.2001	26	1.5	26.08.2001
9	8	12.08.2001	27	7	27.08.2001
10	4	13.08.2001	28	3	27.08.2001
11	5	13.08.2001	29	3.5	27.08.2001
12	5	13.-14.08.2001	30	0.5	28.08.2001
13	7.5	15.-20.08.2001	31	2	28.08.2001
14	0.25	20.08.2001	32	13	22.08.2001
15	3	20.08.2001	33	14	21.-24.08.2001
16	2	16.08.2001	34	20	21.-23.08.2001
17	5	16.-18.08.2001	35	3.5	29.08.2001
18	11	16.-18.08.2001	36	0.5	29.08.2001

4 Sampling efficiency

During the whole investigation 32-34 amphibian species were recorded (DNA analyzes to clarify the taxonomic position of two doubtful "species" are in progress). A species accumulation curve, shows how many new species were added each day (Fig. 2). The continued increase of the curve's slope indicates that, during the survey period, we most likely did not record all amphibian species living within the Volta region.

Based on the assumption that sampling effort was the same for every habitat we calculated the approximate total number of amphibian species living in the Volta region. Because we had no quantitative data available, we used the Jack-knife 1 estimator, based on presence/absence data for all habitats (program: BiodivPro from the Natural History Museum London). This procedures indicated that approximately 46 amphibian species live within the Volta region (Fig. 3). We thus recorded about 74 % of the regional amphibian fauna.

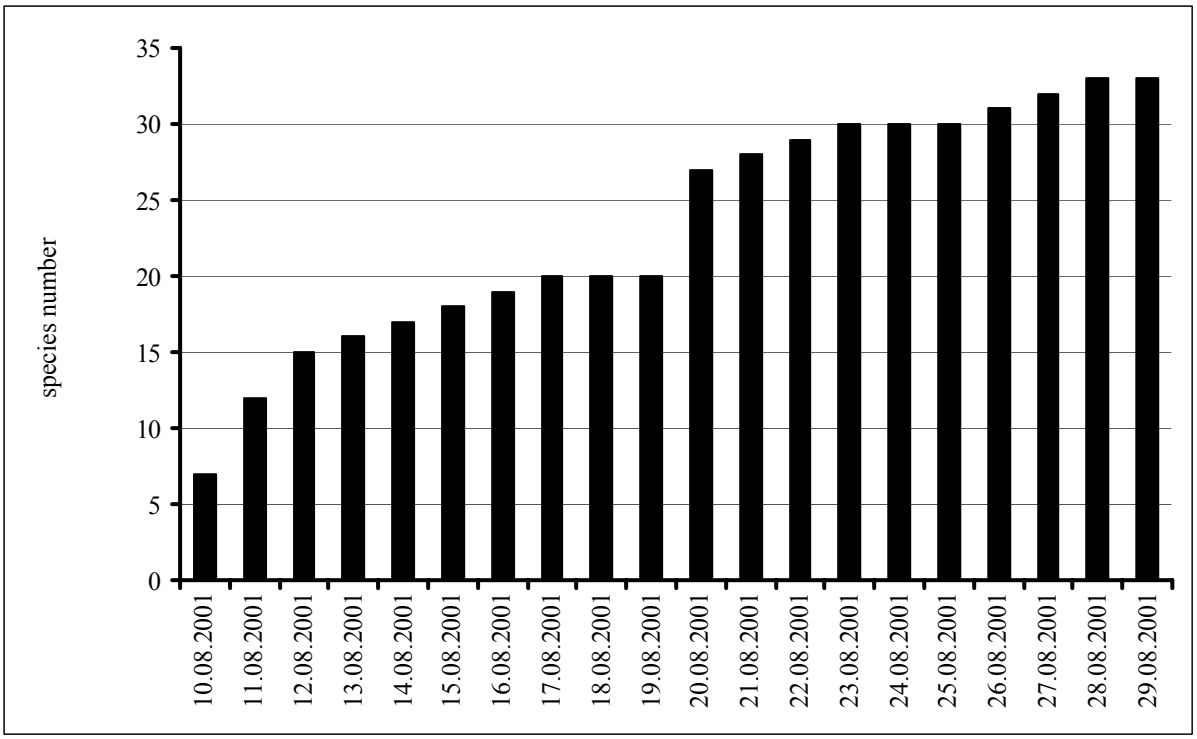

Fig. 2: Species accumulation curve of amphibians registered in the Volta region from 10-29 August 2001.

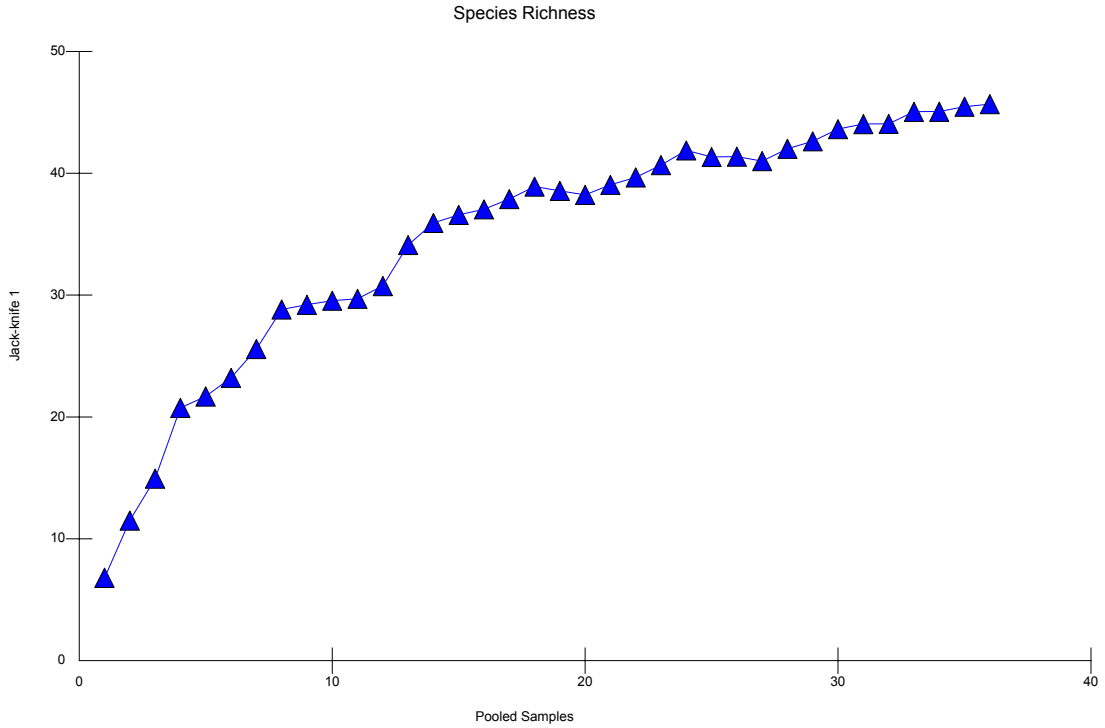

Fig. 3: Estimation of amphibian species number in the Volta region. Approximately 46 amphibian species may be living in that area.

5 Species account: amphibians

Below we give a short description of the distribution and habitat preferences of the recorded amphibian species, including possible conservation status. More detailed descriptions are provided by Schiøtz (1967) and Rödel (2000a). Nomenclature follows Schiøtz (1967), Rödel (2000a) and Frost (2001, http://research.amnh.org/herpetology/amphibia/index.html). Species names are followed by a quotation of those habitats were the respective species was recorded (compare study sites and Tab. A2).

Family Pipidae

Silurana tropicalis GRAY, 1864 (5): A widespread aquatic, West African forest frog that takes advantage of spreading from gallery forests into the savanna zone. Not threatened.

Family Bufonidae

Bufo maculatus HALLOWELL, 1885 "1854"(5, 9, 10, 13, 20, 32, 33, 36): Very common and widespread African toad, that inhabits all habitat types from degraded forests to moist savannas. Only very dry savannas and primary rain forest are avoided. Not threatened.

Bufo regularis REUSS, 1833 (1, 4, 6, 9, 10, 13, 20, 31, 33, 36): Very common West and Central African toad that is especially abundant around human settlements. Not threatened.

Family Hemisotidae

Hemisus sp. (1, 5): Burrowing frog and therefore rarely encountered. The collected specimens occurred close to forest remnants but are clearly different from forest dwelling *Hemisus guineensis*. As they also show some differences to the savanna dwelling *Hemisus marmoratus* the taxonomic status of these frogs remains doubtful. DNA analyses are in progress (Rödel & Kosuch in prep.). Status uncertain.

Family Ranidae

Hoplobatrachus occipitalis GÜNTHER, 1859 (4, 5, 10, 12, 15, 20, 26, 29, 30, 33, 35): Extremely common, aquatic savanna species that penetrates the forest zone in disturbed areas. Not threatened in most areas, possibly threatened in others by human consumption.

Amnirana albolabris (HALLOWELL, 1856) (3, 7, 23, 25, 27, 32): Common West- and Central African forest frog that inhabits primary and degraded forests close to rivers. Not threatened.

Amnirana galamensis (DUMÉRIL & BIBRON, 1844)(15): Common, but not abundant West African savanna species. Status uncertain.

Ptychadena aequiplicata (WERNER, 1898)(12): Widespread but never abundant West and Central African forest frog. With few exceptions inhabits only primary forest. Possibly vulnerable due to habitat destruction.

Ptychadena bibroni (HALLOWELL, 1845)(1, 5, 15, 33): Very common West African inhabitant of degraded forests and moist savannas. Not threatened.

Ptychadena mascareniensis (DUMÉRIL & BIBRON, 1841)(24, 28): A taxonomically difficult species complex that occurs in almost all habitats throughout Africa and Madagascar. Taxonomy is not sufficiently settled to estimate possible threats, but West African forest species might be restricted to comparatively small areas.

Ptychadena oxyrhynchus (SMITH, 1849)(33, 34): Widespread and common African savanna frog. Not threatened.

Ptychadena pumilio (BOULENGER, 1920)(15, 20, 31): Widespread and very common African frog that inhabits degraded forests and moist savannas all over Africa south of the Sahara. Might comprise several species. Not threatened.

Ptychadena schubotzi (STERNFELD, 1917)(29, 30, 36): Common West and Central African savanna species. Not threatened.

Phrynobatrachus accraensis AHL, 1923 (3, 4, 5, 8, 12, 13, 15, 21, 23, 27, 29, 33): Extremely common and widespread West African savanna species that inhabits also degraded forest areas. New DNA analyses proved this species to be conspecific with *Phrynobatrachus latifrons,* and therewith also with the Volta "endemic" *Phrynobatrachus latifrons togoensis* Ahl, 1924 (Rödel & Kosuch unpubl.). Not threatened.

Phrynobatrachus calcaratus (PETERS, 1863)(17, 10, 18, 33): Widespread West and central African forest frog. Not threatened.

Phrynobatrachus aff. *calcaratus* (8): Very similar to typical *Phrynobatrachus calcaratus*, however differs by smaller size and different coloration. We have collected these frogs in a water filled tree hole where they also reproduced. This kind of breeding behavior is either unknown for the species or might speak in favor of specific distinctiveness of our voucher specimens to *Phrynobatrachus calcaratus*. DNA analyses will clarify the taxonomic status of these frogs. If this proves to be an undescribed species, it might be threatened due to a very small range.

Phrynobatrachus francisci BOULENGER, 1912 (31): Widespread and common West African savanna frog. Not threatened.

Phrynobatrachus natalensis (SMITH, 1849)(15, 20, 33, 34): Widespread African savanna frog. Not threatened.

Phrynobatrachus plicatus (GÜNTHER, 1859 "1858")(12): Widespread West African forest frog. Not threatened.

Family Arthroleptidae

Arthroleptis sp. (1, 4, 6, 11, 16, 17, 18, 20, 23, 26, 33, 34, 35): Very common frog in degraded forest throughout the Volta region. Taxonomic status uncertain. Obviously different from species from the Western part of the Upper Guinean Forest Block because it has a completely different advertisement call. Coloration and morphology are identical to *Arthroleptis variabilis, A. crusculum* and *A. poecilonotus*. Frogs from the Volta region seem to be smaller. It might be either *A. breviceps*, originally described by Ahl (1924) from a locality in nearby Togo (Misahöhe) and never recorded since its first description in 1923, or *Schoutedenella zimmeri*, described by Ahl (1925) from Accra. However, as frogs of the genera *Arthroleptis* and *Schoutendenella* (it is unclear whether both of these genera are valid or *Schoutedenella* is simply a subgenus of *Arthroleptis*) comprise the taxonomically most difficult African frogs and morphological comparison with museum vouchers is insufficient for determination, the taxonomic status of our vouchers remain unclear. Status uncertain, but based on its habitat preference most probably not threatened.

Family Hyperoliidae

Leptopelis viridis (GÜNTHER, 1868)(13, 15): Widespread West African savanna frog. Not threatened.

Leptopelis hyloides (BOULENGER, 1906)(1, 5, 10, 12, 20, 23, 32, 33, 35): Widespread West African forest species. Inhabits primary and degraded forests. At all sites very common. Not threatened.

Hyperolius baumanni AHL, 1931 (2, 5, 12, 20, 22, 23, 25, 27, 28, 29): Endemic frog of Eastern Ghana and the Togo highlands. Inhabits degraded forests and forest edges.

Hyperolius cf. *viridigulosus* SCHIØTZ, 1967 (34): Status of vouchers uncertain (DNA analyses in prep.). Most probably *H. viridigulosus* that is a forest species endemic to Côte d'Ivoire and Western Ghana. Our records therefore are either a first record for Eastern Ghana or speak in favor of an undescribed species. Possibly vulnerable due to deforestation.

Hyperolius cf. *picturatus* PETERS, 1875 (18): Not previously recorded from Eastern Ghana. Either new record or new taxa (DNA analyses in prep.). Habitat preference exactly the same as Ivorian *H. picturatus* from Taï and Mont Sangbé National Parks (Rödel unpubl.). Status uncertain.

Hyperolius cf. *torrentis* SCHIØTZ, 1967 (32): Status of vouchers uncertain (DNA analyses in prep.). Most probably *H. torrentis* that is a forest species endemic to Eastern Ghana and adjacent Togo. Possibly vulnerable due to forest destruction.

Hyperolius concolor RAPP, 1842 (2, 3, 5, 6, 12, 15, 19, 20, 22, 23, 26, 27, 28, 29): Widespread West and Central African frog that lives in degraded forest habitats as well as in very moist savanna areas. Not threatened.

Hyperolius fusciventris burtoni SCHIØTZ, 1967 (5, 12, 27, 28): Widespread West African forest frog. The subspecies *H. f. burtoni* is endemic to the Eastern part of the Upper Guinean Forest Block. Not threatened.

Hyperolius nasutus GÜNTHER, 1864 (15): Widespread frog that lives mostly in drier savanna areas all over Africa South of the Sahara. Not threatened.

Hyperolius nitidulus PETERS, 1875 (14, 15): Very common and widespread West African savanna frog. Not threatened.

Hyperolius sp. (5): Taxonomic status uncertain. If it is an undescribed species, possibly threatened due to very small range.

Afrixalus dorsalis (PETERS, 1875)(2, 4, 5, 12, 19, 27, 28): Widespread and common West and Central African forest frog that inhabits degraded forests in the forest zone and gallery forests in the savanna zone. Not threatened.

Afrixalus vittiger (PETERS, 1876)(14, 15): Widespread West African savanna species. Not threatened.

Kassina senegalensis (DUMÉRIL & BIBRON, 1841)(14): Widespread African savanna frog. Not threatened.

6 Anuran community composition in different study sites in the Volta region

Table 3 provides an overview of all amphibian species recorded by us in the Volta region, with respect to the three areas investigated. The table also provides information on which principal habitat types were mainly selected by a certain species. Forest species are those that need more or less closed forest, both degraded and primary forest. The definition of farmbush species is based on Schiøtz (1967). It comprises all amphibian species that live within the former forest zone, but are not dependent on closed forest canopy and are not able to survive within true savanna habitats. Normally these species can be found at forest edges, in highly degraded forests, in agricultural areas within the forest zone that still provide small forest remnants and in forests within the savanna zone (gallery forests and island forests). As savanna species I define those amphibians that survive in moist and/or dry savanna types. Sometimes these species can penetrate the forest zone in areas were forest cover is highly destroyed.

The Wli/Liati Wote area provided habitats to the highest percentage of forest specialists (40 %), compared to the two other areas. In Apesokubi farmbush species were

predominant (56.3 %). In the northernmost area (Kyabobo/Nkwanta) we found the highest percentage of savanna species within the regional amphibian community (45.5 %, Tab. 4). Composition of different habitat specialists was not statistically different between the three regions (Kruskal Wallis test, $p = 0.3$).

Tab. 3: Amphibian species recorded in the three areas of the Volta region, investigated, and their preferred macrohabitat type.

genus	species	Wli	Kyabobo	Apesokubi	forest	farmbush	savanna
Silurana	*tropicalis*	1	0	0	X		
Bufo	*maculatus*	1	1	1		X	
Bufo	*regularis*	1	1	1			X
Hemisus	sp.	1	0	0		X	
Hoplobatrachus	*occipitalis*	1	1	1			X
Amnirana	*albolabris*	1	1	1	X		
Amnirana	*galamensis*	0	1	0			X
Ptychadena	*aequiplicata*	1	0	0	X		
Ptychadena	*bibroni*	1	1	0		X	
Ptychadena	*mascareniensis*	0	0	1		X	
Ptychadena	*oxyrhynchus*	0	1	0			X
Ptychadena	*pumilio*	0	1	1		X	
Ptychadena	*schubotzi*	1	0	1			X
Phrynobatrachus	*accraensis*	1	1	1		X	
Phrynobatrachus	aff. *calcaratus*	1	0	0	X		
Phrynobatrachus	*calcaratus*	1	1	0	X		
Phrynobatrachus	*francisci*	0	0	1			X
Phrynobatrachus	*natalensis*	0	1	1			X
Phrynobatrachus	*plicatus*	1	0	0	X		
Arthroleptis	sp.	1	1	1		X	
Leptopelis	*viridis*	0	1	0			X
Leptopelis	*hyloides*	1	1	1	X		
Hyperolius	*baumanni*	1	0	1		X	
Hyperolius	cf. *viridigulosus*	0	1	0	X		
Hyperolius	cf. *picturatus*	0	1	0		X	
Hyperolius	cf. *torrentis*	0	1	0	X		
Hyperolius	*concolor*	1	1	1		X	
Hyperolius	*fusciventris burtoni*	1	0	1		X	
Hyperolius	*nasutus*	0	1	0			X
Hyperolius	*nitidulus*	0	1	0			X
Hyperolius	sp.	1	0	0	X		
Afrixalus	*dorsalis*	1	0	1		X	
Afrixalus	*vittiger*	0	1	0			X
Kassina	*senegalensis*	0	1	0			X

genus	species	Wli	Kyabobo	Apesokubi	forest	farmbush	savanna
	species #	20	22	16	10	12	12

Tab. 4: Number of amphibian ecotypes per region.

	forest	farmbush	savanna	total #
Wli & Liati-Wote Waterfalls	8	9	3	20
Kyabobo & Nkwanta	5	7	10	22
Apesokubi & Lake Volta	2	9	5	16

7 Comparison of the amphibian fauna from the Volta region with other West- and Central African regions

Despite the fact that biological inventories in West Africa started already in the 19th century very few areas are really well known. It was not until the 1960's that the first nearly complete West African amphibian inventories were presented by Lamotte and co- workers (Lamto,

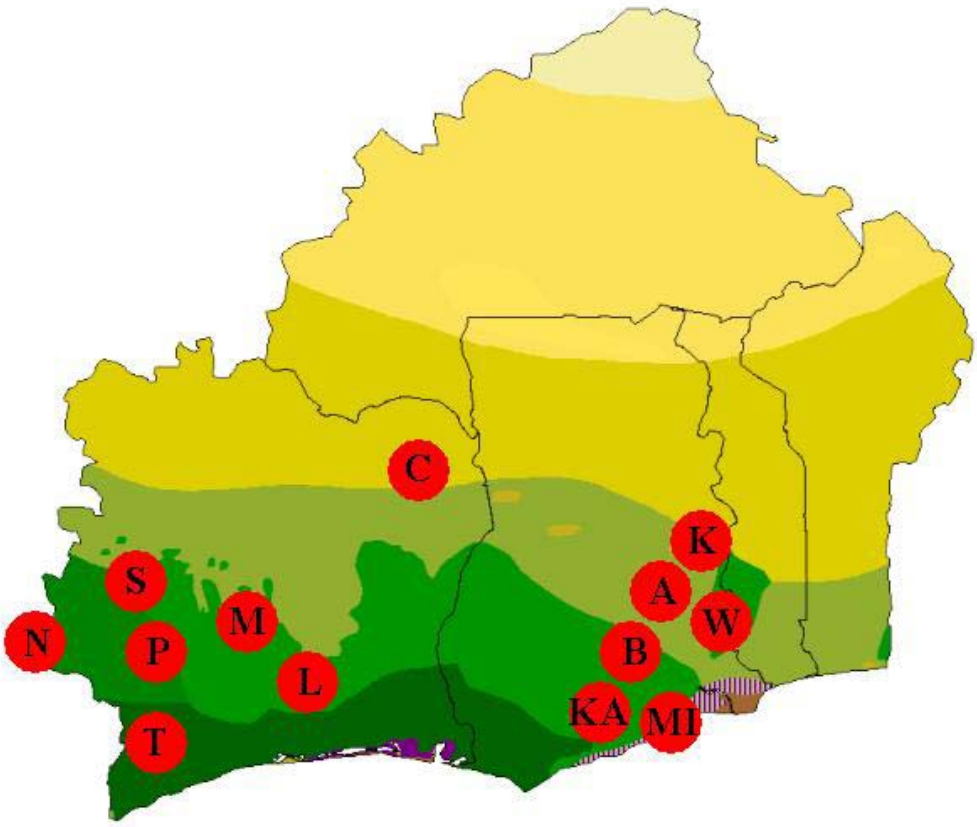

Fig. 4: Ivorian and Ghanian areas were extensive amphibian inventories are available are marked with red dots. A = Apesokubi, B = Bobiri Forest, C = Comoé NP, K = Kyabobo NP, KA = Kakum NP, L = Lamto, M = Marahoué NP, MI = Muni Lagoon, N = Mt. Nimba, P = Mt. Péko, S = Mt. Sangbé NP, T = Taï NP, W = Wli & Liati-Wote Waterfalls.

Mt. Nimba, Mts. Loma) and Schiøtz (several West African localities, however with the main emphasis on tree frogs). In the 1990's one of us (MOR) started to investigate most National Parks of Côte d'Ivoire. All together (including the present study) no more than 13 areas in Côte d'Ivoire and Ghana can be regarded as more or less well known with respect to their amphibian fauna (Fig. 4).

In Tab. 5 we have summarized all West African amphibian inventories in which at least 10 species have been recorded. Generally areas that naturally comprise different habitat types (e.g. mountain savannas, different forest types, different savanna types) showed highest species richness. This became also obvious for relatively dry areas, e.g. Comoé National Park, were different vegetation zones meet (Guinea and Sudan savanna, as well as gallery and island forests). However, normally diversity was higher in the more humid forest zone than in the savanna area. The Western part of the Upper Guinean forest block harbors more species than its Eastern part. This is also shown by comparing species numbers of Côte d'Ivoire (99 species; Rödel unpubl.) and Ghana (70 species, including several that have not yet been recorded but are believed to exist in the country; Hughes 1988).

These differences might have historical reasons. During very dry periods some 10.000-40.000 years ago the West African forest has been split up into relatively small forest remnants. These areas may have been larger in Western Côte d'Ivoire and Liberia, possibly allowing more species to survive and to evolve into new species, than in the Ghana-Togo area. Within the Volta region, there were no Pleistocene forest refugia at all (Rompay 1993, Parren & DeGraaf 1995). Additionally the Ghana-Togo area probably was always inhabited by more humans and natural habitats have been scarcer than in the Western forests throughout some 1.000 years.

In Fig. 5 we analyze the similarity of amphibian communities between 18 West and Central African study sites. We included only those areas were more than 10 species have been recorded and where the species list indicated that the amphibian fauna was comparatively well investigated (leaf litter frogs and tree frogs are best recorded with different methods. Inventories either show predominantly leaf litter or tree frogs thus most likely do not represent a balanced view of the whole fauna).

Tab. 5: West and Central African amphibian inventories. Only those West African areas are included where at least 10 species have been recorded.

country	locality	main habitat	species #	source
Senegal	Nikola-Koba	savanna	24	Lamotte 1969, Joger & Lambert in press
Sierra Leone	Mts. Loma	mountain, forest	38	Schiøtz 1967, Lamotte 1971
Sierra Leone	Freetown	farmbush, forest	11	Schiøtz 1967
Sierra Leone	Kamakwie	savanna	10	Schiøtz 1967
Sierra Leone	Gola	forest	15	Schiøtz 1967
Sierra Leone	Kassewe	forest, farmbush	18	Schiøtz 1967
Sierra Leone	Kenema	forest, farmbush	15	Schiøtz 1967
Guinea	Ziama	forest, farmbush	27	Böhme 1994 a/b
Liberia, Guinea, Côte d'Ivoire	Mt. Nimba	mountain, forest	57	Guibé & Lamotte 1958, 1963; Schiøtz 1967
Côte d'Ivoire	Mt. Sangbé	forest, mountain, savanna	42	own data
Côte d'Ivoire	Mt. Péko	forest, farmbush	35	own data
Côte d'Ivoire	Tai	forest	56	own data
Côte d'Ivoire	Marahoué	forest, savanna	31	own data
Côte d'Ivoire	Lamto	forest savanna	39	Lamotte 1967
Côte d'Ivoire	Comoé	savanna	34	own data
Ghana	Kakum	forest	11	Schiøtz 1967
Ghana	Kumasi	forest	10	Schiøtz 1967
Ghana	Muni	lagoon	13	Raxworthy & Attuquayefia 2000
Ghana	Bobiri	forest	20	Schiøtz 1967
Ghana	Achimota	savanna	11	Schiøtz 1967
Ghana	Biakpa	farmbush	12	Schiøtz 1967
Ghana	Wli	forest, farmbush	20	own data
Ghana	Apesokubi	farmbush, savanna	16	own data
Ghana	Kyabobo	forest, savanna	22	own data
Ghana	Bolgatanga	savanna	10	Schiøtz 1967
Ghana	Walewale	savanna	12	Schiøtz 1967
Nigeria	Ibadan	forest, savanna	23	Schiøtz 1967
Nigeria	Oyo	savanna	13	Schiøtz 1967
Nigeria	Iperin	forest, farmbush	18	Schiøtz 1967
Nigeria	Osomba	forest, farmbush	30	Schiøtz 1967
Nigeria	Obudu	mountain, forest	12	Schiøtz 1967
Cameroon	Korup	mountain, forest, farmbush	88	Lawson 1993
Cameroon	Mt. Kupe	mountain, forest, farmbush	31	Euskirchen et al. 1999; Hofer et al. 1999, 2000; Schmitz et al. 1999
Congo	Kouilou	forest, farmbush	37	Largen & Dowsett-Lemaire 1991
Equatorial Guinea	Mt. Alen	forest, farmbush	48	Riva 1994

Amphibian species probably endemic to the Volta region

Hyperolius cf. *viridigulosus*

Hyperolius cf. *torrentis*

Hyperolius fusciventris burtoni

Hyperolius baumanni

Arthroleptis sp.

Phrynobatrachus cf. *calcaratus*

Hemisus sp.

Amphibian species not endemic to the Volta region


Leptopelis hyloides


Afrixalus dorsalis


Hyperolius concolor


Hoplobatrachus occipitalis


Phrynobatrachus calcaratus


Bufo regularis


Phrynobatrachus accraensis

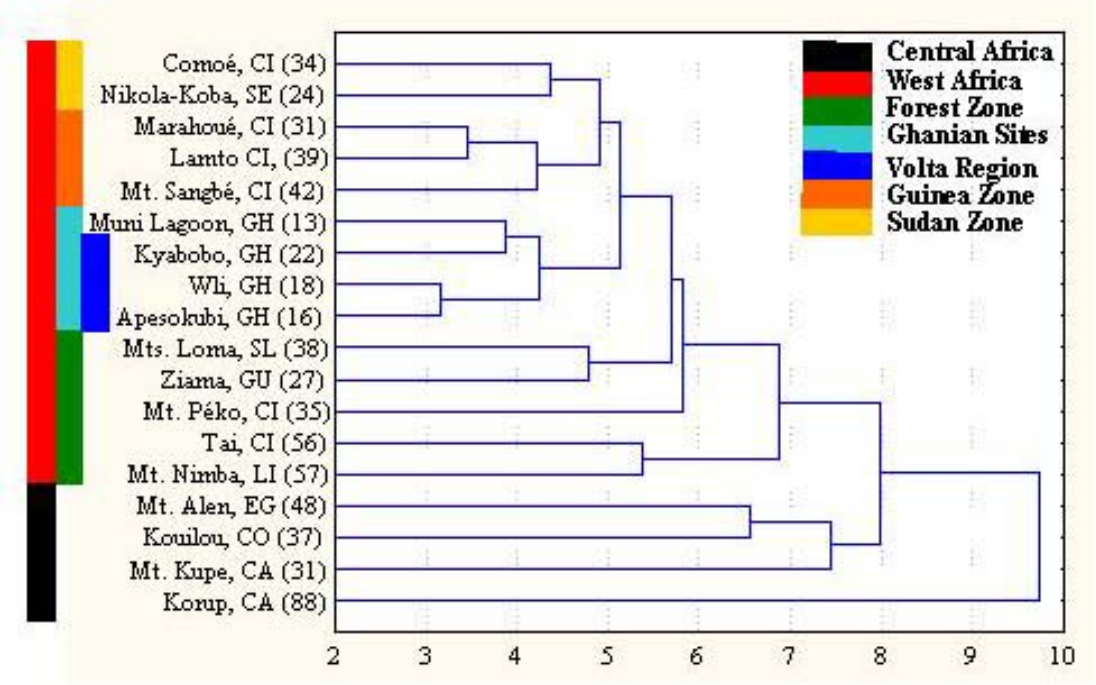

Fig. 5: Similarity of West- and Central African amphibian communities. Compared were only presence-absence data (unweighted pair group average, euclidian distances), species numbers are given in parenthesis; CA = Cameroon, CI = Côte d'Ivoire, CO = Democratic Republic of Congo, GH = Ghana, EG = Equatorial Guinea, GU = Guinea, LI = Liberia, SE = Senegal; own data: Comoé, Marahoué, Mt. Sangbé, Mt. Péko, Taï; Kyabobo, Wli, Apesokubi; literature data: Nikola-Koba (Joger et al. in press); Muni Lagoon (Raxworthy & Attuquayefio 2000); Lamto (Lamotte 1967); Mts. Loma (Lamotte 1971); Ziama (Böhme 1994a,b); Mt. Nimba (Guibé & Lamotte 1958, 1963, Schiøtz 1967); Monte Alen (De la Riva 1994); Kouilou (Largen & Dowsett-Lemaire 1991); Mt. Kupe (Schmitz et al. 1999, Euskirchen et al. 1999, Hofer et al. 2000); Korup (Lawson 1993).

West and Central African amphibian communities were clearly separated by species composition. Within West Africa, savanna areas showed closest similarity, separating the drier Sudan from the more humid Guinea savanna. Within forest areas species similarity was lower. Interestingly, all Ghanian localities grouped together. One reason for this might be that all these areas are at least partly degraded and therefore harbor typical and widespread farmbush species, making them nowadays appear more similar than they were formerly. Within the Upper Guinean forest block the Guinean Ziama forest and the Monts Loma in Sierra Leone on the one side and Taï National Park and Mont Nimba Reserve on the other side showed closest similarities.

8 Status of amphibians endemic to the Togo Highlands / Volta region and conservation status of the amphibian fauna of that region

While the farmbush inhabiting *Arthroleptis* sp. (taxonomic status uncertain, compare species account) and *Hyperolius baumanni* seemed to be very common frogs in the Volta region, other typical forest frogs were only very rarely encountered. Most of our records of forest tree

frogs have been gained in the Kyabobo/Shiare area. At these localities none of the species (*Hyperolius* cf. *torrentis*, *H*. cf. *viridigulosus*, *H*. cf. *picturatus*) was common. *H*. cf. *virdigulosus* and *H*. cf. *picturatus* might either represent undescribed taxa or are at least new records for the Volta region. Two forest toads that are known from the Togo/Volta region couldn't be found during our survey. While *Bufo togoensis*, described by Ahl (1924) from Bismarckburg in Togo, seems to be widespread and abundant also in the Western part of the Upper Guinean forests (Rödel unpubl.), *Werneria preussi* is a more Central African species, not recorded in West Africa during recent investigations (*Atelopus africanus* described by Werner in 1898 from Bismarkburg is a synonym of *Werneria preussi*). Because larger virgin forest areas seemed to be almost gone along the Togo/Ghana border the remaining forest remnants should be urgently protected, to avoid extinction of these species.

In 1972 an aquatic frog, *Conraua derooi* was described by Hulselmans from Misahöhe, Togo. Like other species from that genus it was said to live in fast running creeks. Other West African species that share this habitat niche are *Astylosternus occidentalis, Petropedetes natator* and *Conraua alleni*. The latter species has been recorded by Schiøtz (1967) from Biakpa and Amedzofe, that are close to our Wli/Liati-Wote area. It is not known, but very probable, that Schiøtz's records were *C. derooi*, as this species is reported to be very similar to *C. alleni*, and other Togo Highland endemics (e.g. *H. baumanni*) are very common also on the Ghanian side. Hughes (1988) cites *C. derooi* for Ghana, however without providing locality data. Despite extensive search along fast running creeks and rivers in Wli, Liati-Wote, Shiare and Kyabobo National Park, we failed to find one of these three frog species. Instead at all these sites we recorded large *Hoplobatrachus occipitalis* and catfish (*Clarias* sp., *Heterobranchus* sp.). *H. occipitalis* normally does not live in this habitat type. Both, *H. occipitalis* and catfish are known to prey on frogs. Additionally *H. occipitalis* has carnivorous tadpoles that feed on other tadpoles (Rödel 2000a). To our opinion it is very likely that the typical torrenticol frog species (species that are specialized on fast flowing waters) were definitely not present, at least at those sites that we have investigated. It should be urgently examined if these species are generally declining in Eastern Ghana. Known populations in Côte d'Ivoire were still numerous and active (Rödel unpubl., recorded only two weeks after the Ghana survey). We are currently investigating if Chydrit fungus, responsible for amphibian decline in many areas around the world, is present in West African amphibian populations (Spear, Kosuch & Rödel in prep.).

9 Reptiles recorded in the Volta region

All reptile records were obtained by opportunistic search while looking for amphibians. The list is thus far from being complete. Snakes were determined using Villiers (1975), Meirte (1992) and Chippaux (2001). Lizards have been determined with Hoogmoed (1974) and Rödel et al. (1997). Numbers in parentheses refer to habitat numbers (compare chapter 2 and Tab. 1). Hughes (1988) provides a checklist to all reptiles know to occur in Ghana.

Sauria

Scincidae

Mabuya affinis (10, 33): a widespread forest species that also inhabits gallery and island forests in the savanna area.

Mabuya buettneri (34): a common farmbush skink.

Mabuya perrotetii (19): a common savanna species.

Geckonidae

Hemidactylus fasciatus (17, 19):a nocturnal forest species that can be regularly observed close to human settlings or on houses within in the forest zone.

Hemidactylus brooki (19): a common and widespread savanna species, that lives also in gallery forests.

Agamidae

Agama agama: an extremely common agamid lizard that lives in almost all kinds of habitats with the exception of closed primary rain forests. Even in Accra very abundant.

Chamaeleonidae

Chamaeleo senegalensis (13): a common West African savanna chameleon, probably more abundant in humid savannas, possibly threatened by bush fires and collecting for local medical use.

Serpentes

Colubridae

Afronatrix anoscopus (3, 17): a widespread West African water snake, the site 17 might be the northernmost known locality in Ghana. Not threatened.

Dispholidus typus (29): the Boomslang is a rear-fanged snake that is highly venomous, confined to forested areas either forest edges or savanna forests. Not threatened.

Atractaspidae

Polemon acanthias (17): a rare burrowing viper, our record is possibly the northernmost known locality in Ghana, lives exclusively in forest habitats close to water. Status uncertain, possibly vulnerable due to forest destruction.

10 Summary, conclusions and conservation implications

During the present survey we were able to record about 34 amphibian species for the whole Volta region. Two species might be new to science, but details still need to be clarified by genetic and morphometric examinations (Rödel in prep.). Based on our sampling effort and statistical and comparative extrapolation, we estimate that about 46 amphibian species live within the study area. So the Volta-Togo Highlands are clearly more diverse than previously assumed. We failed to record those species that are highly adopted to fast flowing water (*Conraua derooi, Petropedetes natator, Astylosternus occidentalis, Aubria* sp.), or larger closed forests (*Bufo togoensis, Werneria preussi*).

Because most creeks and rivers appear to be in good condition, but intensive investigations revealed no records of certain rare species, we believe that these species might be declining due to causes others than habitat destruction. Anurans that are specialized on running water were also the first to disappear in other regions of the world (e.g. the toad genus *Atelopus* in South America).

We also could not find larger tracts of closed forests in the Volta region. This explains the lack of several primary forest specialists in our records. In fact most of the "forest" species we found prefer forest edges, natural disturbances within forests (e.g. tree fall gaps), or so called farmbush habitats (compare section 6). The high percentage of farmbush species in our list is a clear hint that the natural forest cover has been largely destroyed in many areas, probably for quite some time. However, since we could still find some true forest specialists (especially around Wli and Shiare) there seem to be some relict populations in those areas where at least smaller, well protected forest remnants are present. Those forests are not necessarily part of officially protected areas such as the new Kyabobo National Park. It seems that communally protected forests, including so called sacred groves (Decher 1997, Decher & Bahian 1999, Decher et al. 2000), might play at least an equal role in the maintenance of natural diversity within the Togo/Volta region.

Future conservation efforts should encourage all local activities that are likely to preserve these forests. Additionally all larger remaining forest areas in the Volta region should be given highest conservation priority and efforts should be considered to link or buffer smaller forest remnants through reforestation efforts. Given that based on our assessment amphibian diversity in the eastern part of Ghana might have suffered considerably by recent forest destruction, it seems pressing to investigate other forests and water catchment areas in Western and Central Ghana for their remaining amphibian diversity.

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12 Literature

AHL, E. (1924a): Über einige afrikanische Frösche. - Zool. Anz., **59/60**: 269-273.

AHL, E. (1924b): Neue Reptilien und Batrachier aus dem zoologischen Museum Berlin. - Arch. Naturgesch., **1924**, A: 246-254.

BAKARR, M., B. BAILEY, D. BYLER, R. HAM, S. OLIVIERI & M. OMLAND (2001, Eds.): From the forest to the sea: Biodiversity connections from Guinea to Togo, Conservation Priority-Setting Workshop, December 1999, Conservation International, Washington D.C.

BÖHME, W. (1994a): Frösche und Skinke aus dem Regenwaldgebiet Südost–Guineas, Westafrika. I. Einleitung; Pipidae, Arthroleptidae, Bufonidae.– herpetofauna, **16** (92): 11–19.

BÖHME, W. (1994b): Frösche und Skinke aus dem Regenwaldgebiet Südost-Guineas, Westafrika. II. Ranidae, Hyperoliidae, Scincidae; faunistisch-ökologische Bewertung.– herpetofauna, **16** (93): 6–16.

CHATELAIN, C., L. GAUTIER & R. SPICHIGER (1996): A recent history of forest fragmentation in southwestern Ivory Coast. - Biodiv. Conserv., **5**: 37-53.

CHIPPAUX, J.-P. (2001): Les serpents d'Afrique occidentale et centrale. - Éditions de l'IRD, Paris, 292 pp.

DECHER, J. (1997): Conservation, small mammals, and the future of sacred groves in West Africa. - Biodiv. Conserv., **6**: 1007-1026.

DECHER, J. & L.K. BAHIAN (1999): Diversity and structure of terrestrial small mammal communities in different vegetation types on the Accra plains of Ghana. - J. Zool., London, **247**: 395-408.

DECHER, F., C.W. KILPATRICK & K.L. BAHIAN (2000): Small mammal zoogeography and diversity in West African forest remnants: Progress report to the National Geographic Society committee for research and Exploration and the Ghana Wildlife Division, 21 pp.

ERNST, R. & M.-O. RÖDEL (in press): A new *Atheris* species from Taï National Park, Ivory Coast. – Herpetol. J.

EUSKIRCHEN, O., A. SCHMITZ & W. BÖHME (1999): Zur Herpetofauna einer montanen Regenwaldregion in SW-Kamerun (Mt. Kupe und Bakossi-Bergland), II. Arthroleptidae, Ranidae und Phrynobatrachidea. – herpetofauna, **21** (122): 25-34.

FREMPONG, E. (1995): Limnological research and training in Ghana: The past, present and perspectives for future development. – In: GOPAL, B. & R.G. WETZEL (Eds.): Limnology in developing countries: 1-39.

GUIBE, J. & M. LAMOTTE (1958): La réserve naturelle intégrale du Mont Nimba. XII. Batraciens (sauf *Arthroleptis, Phrynobatrachus* et *Hyperolius*).– Mem. Inst. fond. Afr. noire, **53**: 241–273.

GUIBE, J. & M. LAMOTTE (1963): La réserve naturelle intégrale du Mont Nimba. XXVIII. Batraciens du genre *Phrynobatrachus*.– Mem. Inst. fond. Afr. noire, **66**: 601–627.

HEYER, W.R., M.A. DONNELLY, R.W. MCDIARMID, L.-A.C. HAYEK & M.S. FOSTER (1993): Measuring and monitoring biological diversity, standard methods for amphibians. - Smithsonían Institution Press, Washington D.C., 364 pp.

HOFER, U., L.-F. BERSIER & D. BORCARD (1999): Spatial organization of a herpetofauna on an elevational gradient revealed by null model tests. – Ecology, **80**: 976-988.

HOFER, U., L.-F. BERSIER & D. BORCARD (2000): Ecotones and gradients as determinants of herpetofaunal community structure in the primary forest of Mount Kupe, Cameroon. – J. Trop. Ecol., **16**: 517-533.

HOOGMOED, M.S. (1974): Ghanese lizards of the genus *Mabuya* (Scincidae, Sauria, Reptilia). - Zool. Verhand., No. **138**: 3-61 + 6 plates.

HOOGMOED, M.S. (1979): Herpetologische waarnemingen in Ghana.– Lacerta, **37**: 164–168.

HOOGMOED, M.S. (1980a): Herpetologische waarnemingen in Ghana II.– Lacerta, **38**: 10–20.

HOOGMOED, M.S. (1980b): Herpetologische waarnemingen in Ghana III.– Lacerta, **38**: 42-48.

HOOGMOED, M.S. (1980c): Herpetologische waarnemingen in Ghana IV.– Lacerta, **38**: 50-53.

HOOGMOED, M.S. (1980d): Herpetologische waarnemingen in Ghana V.– Lacerta, **38**: 62-65.

HOOGMOED, M.S. (1980e): Herpetologische waarnemingen in Ghana VI.– Lacerta, **38**: 76-80.

HOOGMOED, M.S. (1980f): Herpetologische waarnemingen in Ghana VII.– Lacerta, **38**: 88-95.

HOOGMOED, M.S. (1980g): Herpetologische waarnemingen in Ghana VIII.– Lacerta, **38**: 112-116.

HUGHES, B. (1988): Herpetology in Ghana (West Africa).- Brit. Herp. Soc. Bull., **25**: 29-38.

JAHN, S., M. HÜLS & M. SARNTHEIN (1998): Vegetation and climate history of west equatorial Africa based on a marine pollen record off Liberia (site GIK 16776) covering the last 400,000 years. – Rev. Palaeobot. Palynology, **102**: 277-288

JOGER, U. & M.R.K. LAMBERT (in press): Inventory of amphibians and reptiles in SE Sénégal, including the Niokola-Koba National Park, with observations on factors influencing diversity.

LAMOTTE, M. (1966): Types de répartition géographique de quelques batraciens dans l'Ouest Africain.– Bull. Inst. fond. Afr. noire, Sér. A, **28**: 1140–1148.

LAMOTTE, M. (1967): Les batraciens de la région de Gpakobo (Côte d'Ivoire).– Bull. Inst. fond. Afr. noire, Sér. A, **29**: 218–294.

LAMOTTE, M. (1969): Le parc national du Niokolo–Koba, Fasciule III; XXX. Amphibiens (deuxième note).– Mem. Inst. fond. Afr. noire, **84**: 420–426.

LAMOTTE, M. (1971): Le Massif des Monts Loma (Sierra Leone), Fasciule I; XIX. Amphibiens.– Mem. Inst. fond. Afr. noire, **86**: 397-407.

LAMOTTE, M. (1983): Amphibians in savanna ecosystems.– In: BOURLIÈRE, F. (Ed.): Ecosystems of the World 13, Tropical savannas, Elsevier Scientific Publishing Company, Amsterdam: 313–323.

LAMOTTE, M. & A. OHLER (1997): Redécouverte de syntypes de *Rana bibroni* HALLOWELL, 1845, désignation d'un lectotype et description d'une espèce nouvelle de *Ptychadena* (Amphibia, Anura).- Zoosystema, **19**: 531-543.

LARGEN, M.J. & F. DOWSETT-LEMAIRE (1991): Amphibians (Anura) from the Kouilou River basin, République du Congo.– Tauraco Research Report, **4**: 145–168.

LAWSON, D.P. (1993): The reptiles and amphibians of the Korup National Park project, Cameroon. – Herpetol. Nat. Hist., **1**: 27-90.

MEIRTE, D. (1992): Clés de détermination des serpents d'Afrique. - Musée Royal de l'Afrique Centrale, Tervuren, Annales Sciences Zoologiques, Vol. 267, 152 pp.

MOREAU, R.E. (1963): Vicissitudes of the African biomes in the late Pleistocene. – Proc. Zool. Soc. London, **141**: 395-421.

MOREAU, R.E. (1969): Climatic changes and the distribution of forest vertebrates in West Africa.- J. Zool., London, **158**: 39-61.

MYERS, N., R.A. MITTERMEIER, C.G. MITTERMEIER, G.A.B. DA FONSECA & J. KENT (2000): Biodiversity hotspots for conservation priorities.- Nature, **403**: 853-845.

PARKER, H.W. (1936): Amphibians from Liberia and the Gold Coast.– Zool. Mededel., **19**: 87–102

PARREN, M.P.E. & N.R. DE GRAAF (1995): The quest for natural forest management in Ghan, côte d'Ivoire and Liberia. - Tropenbos Series 13, Wageningen, 199 pp.

PERRET, J.-L. (1991): Le statut *d'Arthroleptis bivittatus* F. MÜLLER (Anura, Arthroleptidae).– Bull. Soc. neuchât. Sci. Nat., **114**: 71–76.

PERRET, J.-L. (1994): Revision of the genus *Aubria* BOULENGER 1917 (Amphibia Ranidae) with the description of a new species.– Trop. Zool., **7**: 255–269.

RAXWORTHY, C.J. & D.K. ATTUQUAYEFIO (2000): Herpetofaunal communities at Muni Lagoon in Ghana. – Biodiv. Conserv., **9**: 501-510.

RIVA, DE LA, I. (1994): Anfibios anuros del Parque Nacional de Monte Alén, Río Muni, Guinea Ecuatorial. – Rev. Esp. Herp., **8**: 123-139.

RÖDEL, M.-O. (1998): Kaulquappengesellschaften ephemerer Savannengewässer in Westafrika. - Edition Chimaira, Frankfurt/M., 195 pp.

RÖDEL, M.-O. (2000a): Herpetofauna of West Africa, Vol. I: Amphibians of the West African savanna. - Edition Chimaira, Frankfurt/M., 335 pp.

RÖDEL, M.-O. (2000b): Les communautés d'Amphibiens dans le Parc National de Taï, Côte d'Ivoire. Les Anoures comme bio-indicateurs de l'état des habitats. – Sempervira, Rapport de Centre Suisse de la Recherche Scientifique, Abidjan, **9**: 108-113..

RÖDEL, M.-O. & R. ERNST (2000): *Bufo taiensis* n. sp., eine neue Kröte aus dem Taï-Nationalpark, Elfenbeinküste. – herpetofauna, **22** (125): 9-16.

RÖDEL, M.-O. R. ERNST (in press): A new *Phrynobatrachus* species from the Upper Guinean rain forest, West Africa, including a description of a new reproductive mode for the genus. – J. Herpetol.

RÖDEL, M.-O., K. GRABOW, C. BÖCKHELER & D. MAHSBERG (1995): Die Schlangen des Comoé-Nationalparks, Elfenbeinküste (Reptilia: Squamata: Serpentes). - Stutt. Beitr. Naturk., Ser. A, Nr. **528**: 1-18.

RÖDEL, M.-O., K. GRABOW, J. HALLERMANN & C. BÖCKHELER (1997): Die Echsen des Comoé-Nationalparks, Elfenbeinküste.- Salamandra, **33**: 225-240.

RÖDEL, M.-O., U.T. GRAFE, V.H.W. RUDOLF & R. ERNST (in press a): Review of West African spotted *Kassina*, including a description of *Kassina schioetzi* sp. nov. (Amphibia: Anura: Hyperoliidae). – Copeia.

RÖDEL, M.-O., J. KOSUCH, M. VEITH & R. ERNST (in press b): First record of the genus *Acanthixalus* LAURENT, 1944 from the Upper Guinean rain forest, West Africa, including the description of a new species. – J. Herpetol.

RÖDEL, M.-O., K. KOUADIO & D. MAHSBERG (1999): Die Schlangenfauna des Comoé-Nationalparks, Elfenbeinküste: Ergänzungen und Ausblick. - Salamandra, **35**: 165-180.

RÖDEL, M.-O. & D. MAHSBERG (2000): Vorläufige Liste der Schlangen des Tai-Nationalparks / Elfenbeinküste und angrenzender Gebiete. - Salamandra, **36**: 25-38.

RÖDEL, M.-O., M. SPIELER, K. GRABOW & C. BÖCKHELER (1995): *Hemisus marmoratus* (PETERS, 1854) (Anura: Hemisotidae), Fortpflanzungsstrategien eines Savannenfrosches.– Bonn. zool. Beitr., **45**: 191–207.

RÖDEL, M.-O. & M. SPIELER (2000): Trilingual keys to the savannah-anurans of the Comoé National Park, Côte d'Ivoire. - Stutt. Beitr. Naturk., Ser. A, Nr. **620**: 1-31.

ROMPAEY, van R.S.A.R. (1993): Forest gradients in West Africa. A spatial gradient analysis. – PhD Thesis, Wageningen, 142 pp.

SCHIØTZ, A. (1964a): A preliminary list of amphibians collected in Ghana. – Vidensk. Meddr. dansk naturh. Foren., **127**: 1–17.

SCHIØTZ, A. (1964b): The voices of some West African amphibians. – Vidensk. Meddr. dansk naturh. Foren., **127**: 35–83.

SCHIØTZ, A. (1967): The treefrogs (Rhacophoridae) of West Africa. – Spolia zool. Mus. haun., **25**: 1–346.

SCHMITZ, A., O. EUSKIRCHEN & W. BÖHME (1999): Zur Herpetofauna einer montanen Regenwaldregion in SW-Kamerun (Mt. Kupe und Bakossi-Bergland), I. Einleitung, Bufonidae und Hyperoliidae. – herpetofauna, **21** (121): 5-17.

VILLIERS, A. (1975): Les serpents de l'Ouest Africain. - Initiations et études africaines, No II, 3é édition, Dakar, 195 pp.

WERNER, F. (1898): Ueber Reptilien und Batrachier aus Togoland, Kamerun und Tunis aus dem kgl. Museum für Naturkunde in Berlin. – Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft in Wien, **XLVIII**: 191-230 + 1 plate.

13 Appendix

Tab. A1: Gazetter, UTM coordinates of habitats investigated.

habitat #	right	high	habitat #	right	high
21, 22, 23	2.126.193.287	8.397.661.234	18	2.342.524.873	9.218.567.623
24, 25	2.125.712.145	8.401.380.378	35, 36	2.286.141.645	7.768.006.099
26	2.121.376.372	8.415.173.269	15	2.246.141.589	9.166.435.369
27, 28	2.129.249.673	8.364.012.685	13, 14	2.260.844.887	9.154.714.188
28, 29	2.127.013.079	8.363.462.091	32, 33, 34	2.362.515.874	9.177.981.966
19, 20	2.132.214.833	8.376.449.688	1, 2, 3, 10, 11, 12	2.345.590.589	7.870.054.578
30, 31	2.052.704.337	8.483.675.992	5, 6, 9	2.339.687.613	7.871.610.711
16	2.319.227.052	9.219.737.428	4, 7, 8	2.357.555.773	7.861.035.995
17	2.328.117.744	9.218.620.221			

Tab. A2: Sites and amphibian species recorded in the Volta region, compare Tab. 1.

genus	species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
Silurana	*tropicalis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bufo	*maculatus*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	8
Bufo	*regularis*	1	0	0	1	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	10
Hemisus	sp.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hoplobatrachus	*occipitalis*	0	0	0	1	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	1	0	1	0	11
Hylarana	*albolabris*	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	6
Hylarana	*galamensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptychadena	*aequiplicata*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ptychadena	*bibroni*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4
Ptychadena	*mascareniensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2
Ptychadena	*oxyrhynchus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
Ptychadena	*pumilio*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
Ptychadena	*schubotzi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	3
Phrynobatrachus	*accraensis*	0	0	1	1	1	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	12
Phrynobatrachus	aff. *calcaratus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Phrynobatrachus	*calcaratus*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4
Phrynobatrachus	*francisci*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Phrynobatrachus	*natalensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	4
Phrynobatrachus	*plicatus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Arthroleptis	sp.	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	0	13
Leptopelis	*viridis*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Leptopelis	*hyloides*	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	9
Hyperolius	*baumanni*	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	10
Hyperolius	*viridigulosus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Hyperolius	cf. *picturatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hyperolius	*torrentis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Hyperolius	*concolor*	0	1	1	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	14
Hyperolius	*fusciventris*	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	4
Hyperolius	*nasutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hyperolius	*nitidulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hyperolius	sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Afrixalus	*dorsalis*	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	7
Afrixalus	*vittiger*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Kassina	*senegalensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		6	5	6	9	17	9	8	10	11	15	12	21	17	17	26	17	19	21	21	29	22	24	29	25	27	29	33	33	34	32	34	36	43	38	38	39	