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The amphibians of Marahoué and Mont Péko National Parks, Ivory Coast

Die Amphibien der Marahoué und Mont Péko Nationalparks, Elfenbeinküste

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KURZFASSUNG

Wir berichten über die Amphibien des Marahoué Nationalparks (MNP) und des Mont Péko Nationalparks (PNP), Elfenbeinküste. Beide Parks liegen in der Übergangszone zwischen Regenwald und Savanne. Der MNP umfaßt feuchte Savannenhabitate und halbimmergrüne Wälder. Der PNP besteht vorwiegend aus halbimmergrünen Wäldern, die größtenteils degradiert sind, sowie Savannenhabitaten auf Berggipfeln. Wir stellten in jedem der beiden Parks das Vorkommen von 33 Anurenarten (insgesamt 47 Arten) fest und schätzen die Anzahl der zu erwartenden Arten auf 38 (MNP) bzw. 42 (PNP). Die Anurengemeinschaft des MNP ist der von Lamto, einem anderen Gebiet in der Guinea Savanne der Elfenbeinküste, sehr ähnlich, während die Anurengemeinschaft des PNP am ehesten der gestörter Wälder in der weiter südlich gelegenen Regenwaldzone entspricht Wir fassen alle nachgewiesenen Arten und die untersuchten Lebensräume zusammen und machen Angaben zur Taxonomie und Biologie von fünf Arten: *Hemisus* cf. *guineensis*, *Phrynobatrachus* sp., *Ptychadena* cf. *schillukorum*, *Astylosternus* sp. und *Hyperolius lamottei.*

ABSTRACT

We report on the amphibian fauna of Marahoué National Park (MNP) and Mont Péko National Park (PNP), Ivory Coast. Both parks are situated in the transition zone between evergreen rain forest and savanna. MNP comprises humid savanna and semi-deciduous forest, while main habitats of PNP are semi-deciduous forest (mostly secondary) and savanna habitats on mountain tops. We recorded 33 anuran species in each park (47 species in total) and estimated the number of species expected to occur to be 38 (MNP) and 42 (PNP), respectively. The anuran assemblage of MNP is most similar to that of another site in the Ivorian Guinea savanna: Lamto, while the assemblage of PNP shows closest affinities to that of degraded forests further south in Ivory Coast. We summarize the records and habitats and comment on the taxonomy and biology of five species: *Hemisus* cf. *guineensis*, *Phrynobatrachus* sp., *Ptychadena* cf. *schillukorum, Astylosternus* sp., and *Hyperolius lamottei.*

KEY WORDS

Amphibia: Anura: *Hemisus guineensis*, *Phrynobatrachus* sp., *Ptychadena schillukorum*, *Astylosternus* sp., *Hyperolius lamottei*, Marahoué National Park, Mont Péko National Park, Ivory Coast, checklist, savanna, forest, distribution, habitat selection, taxonomy

INTRODUCTION

West African forests are highly threatened by logging, agriculture and the increasing human population (BAKARR et al. 2001). About 80% of the Upper Guinea forests in Ivory Coast have been destroyed during the last 20 years (ROMPAY 1993; PARREN & DEGRAAF 1995; CHATELAIN et al. 1996). Conservation programs therefore are urgently needed to preserve the remaining pristine areas that probably harbor most of the high West African bio-diversity. However, even the most basic data inevitable for such efforts, as e.g. simple species lists, are mostly lacking.

Although herpetological investigations in West Africa started in the 19th century (compare RÖDEL & AGYEI in press), very few areas are well known. All together (including the present study) the amphibian fauna of no more than nine areas in Ivory Coast can be regarded as more or less well studied (GUIBÉ & LAMOTTE 1958, 1963; SCHIØTZ 1967; LAMOTTE 1967; RÖDEL 2000a, 2000b; RÖDEL & SPIELER 2000; RÖDEL in press; RÖDEL & BRANCH 2002). Generally, increased species richness is found in areas that naturally comprise diverse habitat types (compare RÖDEL & AGYEI in press).

Ivory Coast is characterized by a steep precipitation gradient, showing a dramatic decrease in annual precipitation from the South-West (2,300 mm) to the North-East (900 mm) of the country. Along this gradient, vegetation cover changes from rain forest in the South to dry savanna in the North. Three Ivorian national parks are situated in the transition zone between rain forest and savanna: the Mont Sangbé, the Marahoué and the Mont Péko National Parks. During recent surveys in Mont Sangbé National Park, we were able to show that its geographic position between two major ecoregions resulted in a very high amphibian diversity (RÖDEL in press). It therefore seemed to be promising to study Marahoué and Mont Péko National Parks as well. Both have never been investigated herpetologically before. This paper presents results of surveys undertaken by the authors in both reserves in the years 2000 and 2001.

STUDY SITES AND SAMPLING METHODS

Marahoué National Park (MNP): SCHULENBERG et al. (1999) provide a summary of the geography, flora and fauna of MNP which is situated in central Ivory Coast, about 30 km west of the town of Bouaflé, in the transition zone between semi-deciduous forest and humid savanna. Its surface area of about 1,010 km² is covered with forest (two thirds) and savanna. Four main habitat types occur: open canopy forest (the majority of forest habitats), gallery forests, forest-savanna edge and savanna. One of the most characteristic savanna trees is the Borassus palm, *Borassus aethiopum* (fig. 1). Two dry periods can be distinguished, stretching from November to February and from July to August. Mean annual precipitation varies between 1,100 and 1,800 mm. We searched for amphibians on 18.-19.V. 2000, 25.-27.VIII.2000, and 26.-27.V.2001. Main threats to the park are illegal farming (illegal farms cover huge areas in the former forest zone) and poaching. Geographic position and short habitat descriptions of all MNP sites investigated are summarized in appendix 1.

Mont Péko National Park (PNP): The available general data on PNP are summarized in an unpublished management plan for the park (BELIGNÉ 2000). PNP is 295 km² in size, situated in western central Ivory Coast approximately 40 km north of the town of Duékoué and forms the south-easternmost part of the Upper Guinea highlands, stretching westwards into Guinea and Sierra Leone. The landscape of the northern part of the park is characterized by granite inselbergs. The highest are Mont Péko (1,002 m a.s.l.), Mont Guéi (1,096 m a.s.l.), and Mont Kahoué (967 m a.s.l.). The park is located in the equatorial transition zone. Its climate is subequatorial with higher amounts of precipitation from May to October. Within this period, most rain falls in May-June and September-October. The core dry season stretches from February to March. Weather in the dry season is mainly influenced by the Harmattan, a dry wind coming from the Sahara desert. Some decades ago (1965) mean annual rainfall reached 1,550 mm. During the last 30 years, annual precipitation dropped to 1,400 mm. Mean annual temperature is 24.5°C (1961-1975). Temperatures range from 19-34°C (BELIGNÉ 2000). With the exception of the granite inselbergs, the vegetation consists of the humid semi-deciduous forest type (PARREN & DEGRAAF 1995). The tops of the inselbergs harbor a very specialized, savanna-like flora. It comprises very dry, as well as extremely moist habitats (fig. 2, compare POREMBSKI & BARTHLOTT 2000 for review of this habitat type). According to official sources, 83% of the park is forested (where forested means forest coverage over 90%). However, selective logging took place already in most parts of the national park. Large areas in the South have even been transformed into plantations. We found undisturbed forest only on the slopes of Mont Péko. Other areas in the central and north-western parts of the park, reported to us as being primary, were inaccessible during the present survey. However, as the same informants reported pristine forests to exist in places where at best secondary growth could be confirmed, we have some doubt if there is any primary forest left

Fig. 1: Typical savanna habitat with *Borassus* palms in Marahoué Nationalpark.
Abb. 1: Typischer Savannenlebensraum mit Rhônier Palmen im Marahoué Nationalpark.

Fig. 2: Very humid short grass landscape on rocky ground on Mont Péko.
Abb. 2: Sehr feuchte Kurzgraslandschaft auf felsigem Grund auf dem Mont Péko.

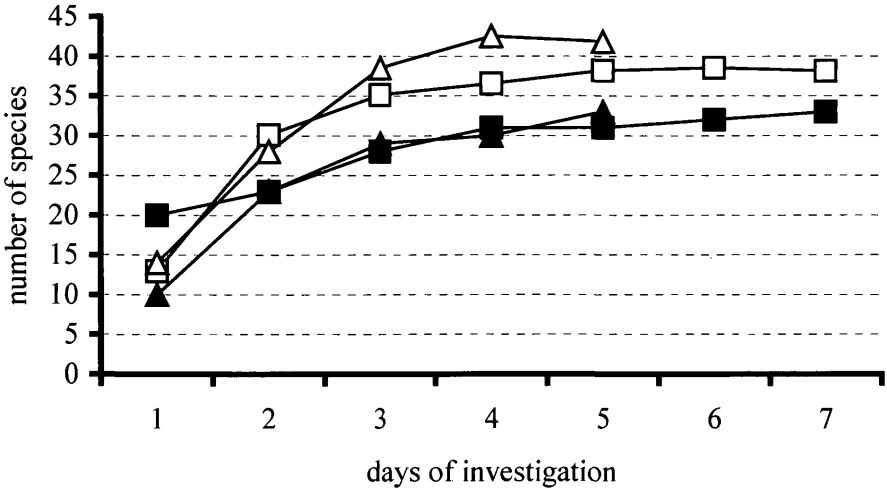

Fig. 3: Daily species accumulation curves (black symbols) and estimated species richness (white symbols, Jack-knife 1 estimator) for the amphibians of Marahoué (squares) and Mont Péko (triangles) National Parks, Ivory Coast.

Abb. 3: Tägliche Artenakkumulationskurven (schwarze Symbole) und geschätzter Artenreichtum (weiße Symbole, Jack-knife 1 Schätzstatistik) für die Amphibien des Marahoué (Quadrate) und Mont Péko (Dreiecke) Nationalparks, Elfenbeinküste. Y-Achse: Artenzahlen; X-Achse: Untersuchungstage.

in PNP. Amphibians were searched for on 21.-22. V., and 7.-9. IX. 2000. Geographic position and short habitat descriptions of all PNP sites investigated are summarized in appendix 2.

For the geographic position of the two national parks in Ivory Coast see maps published in RÖDEL (in press) and RÖDEL & BRANCH (2002).

Specimens were mainly located opportunistically. Surveys were undertaken during the day and during the evening. Search techniques included visual scanning of the terrain and refuge examination (e.g., lifting rocks and logs, scraping through leaf litter). We also applied acoustic monitoring of all available habitat types (HEYER et al. 1993). Additionally, we checked all available water courses for tadpoles by dip-netting. Time spent for searching was relatively longer in complex than in uniform habitats. Sampling took place through seven days in MNP and five days in PNP. Sampling effort summed up to about 210 man-hours in MNP (two persons searching), and to about 225 man-hours in PNP (three persons searching).

Below we give a short description for only a few remarkable amphibian species we encountered during this survey. All species records, their habitats in MNP and PNP, their African distributions, general habitat preferences, and kind of records (observation, call, voucher, tissue) are summarized in appendices 3 - 4. If not stated otherwise, nomenclature follows SCHIØTZ (1967), RÖDEL (2000a) and FROST (2002). Measures are given in mm and have been taken with dial-calipers.

Voucher specimens were collected, anesthetized and killed in a chlorbutanol solution and thereafter preserved in 70% ethanol. Vouchers are deposited in the Staatliches Museum für Naturkunde Stuttgart, Germany (SMNS) or in the senior author's possession (MOR). Tissue samples (indicated with G) of recorded species were preserved in 95% ethanol. These samples are stored in the Institute of Zoology at the University of Mainz, Germany. Geographic positions were taken with a hand-held GPS receiver (Garmin 12KL). For position readings we applied the WGS84 standard.

RESULTS AND DISCUSSION

Sampling efficiency

Assuming that sampling effort was the same for each habitat, we calculated the approximate total number of amphibian species expected to live in each park using the Jack-knife 1 estimator, based on presence/absence data for all habitats (program: BioDiversity Pro® from the Natural History Museum, London). The Jack-knife 1 estimator is an incidence-based estimator. We thus used presence-absence data only. Calculation was based on the daily species lists, including all amphibian species of a particular park. For a brief introduction to the method and the respective mathematic formula see (COLWELL 1994-2000).

We recorded 33 species in each national park. The estimate of the number of species to be expected was 38 for MNP, and 42 for PNP. According to these calculations, we recorded about 87% of the estimated species in MNP and 79% in PNP (fig. 3).

Species account

Hemisus cf. *guineensis* COPE, 1865. In PNP we found an exceptional female *Hemisus* (fig. 4) at the base of Mont Péko within leaf litter in a cacao plantation after ~~a~~ heavy rain. So far two *Hemisus* species have been recorded from West Africa (LAURENT 1972): *H. marmoratus sudanensis* (STEINDACHNER, 1863) and *H. guineensis guineensis* COPE, 1865. While, in West Africa, *H. marmoratus* lives in the savanna region, *H. guineensis* occurs in the forest or near forest zone (RÖDEL et al. 1995; RÖDEL 2000a). On the basis of the characters summarized below, we tentatively assign our record to *H. guineensis*. (compare LAURENT 1972; LARGEN 1997; RÖDEL 2000a; CHANNING & BROADLEY 2002). Our female measured 39.3 mm (SVL), thus being within the range of both, *H. marmoratus* (30 - 47 mm) and *H. guineensis* (35 - 53 mm; LAURENT 1972; LARGEN 1997; RÖDEL 2000a). Other measures were: head broarder (13.6 mm) than long (11.3 mm); snout 1.5 times longer than the eye (1.75 - 2.4; in parentheses: LAURENT's 1972 measures for *H. guineensis guineensis*); distance between eye and nostrils 3.3 times longer than distance nostril to snout (2.25 - 4); interorbital space 1.9 times the internarial space (1.6 - 2.5) and 2.6 times the width of upper eyelid (2.4 - 4); tibia length 56.8% of foot length (including longest toe); SVL 2.8 times the tibia length (2.2 - 3.25); inner metatarsal tubercle 3.4 mm, thus, being 2.1 times longer than free part of shortest toe (up to 2.2). None of the *Hemisus* so far recorded by us from the West African forest zone looked like frogs figured under the name *H. guineensis* by AMIET (1991; compare fig. 4 in RÖDEL & AGYEI in press). A reinvestigation of the *H. marmoratus* / *H. guineensis* taxa in West Africa based on genetic and acoustic data is planned.

Ptychadena cf. *schillukorum* (WERNER, 1908) According to PERRET (1987) and CHANNING (1993) *P. schillukorum* comprises several other *Ptychadena* species described: *P. floweri* (BOULENGER, 1917), *P. barbouri* (LOVERIDGE, 1925), *P. cotti* (PARKER, 1931), and *P. frontalis* LAURENT, 1954. *Ptychadena schillukorum* and *P. floweri* have been described from Sudan, *P. barbouri* from Tanzania, *P. frontalis* from eastern Democratic Republic of Congo, and *P. cotti* from Mozambique (FROST 1002). RÖDEL (2000a) summarized published habitat descriptions of frogs of that species group. In PNP we found frogs of that group that did not exactly match any of the above mentioned "species". We observed these frogs frequently in the very dense short-grass savanna on Mont Péko (fig. 2), however, managed only to catch one female (MOR PNP1, SVL 36.4 mm, fig. 5) and a juvenile (MOR PNP2, SVL 15.9 mm). Possible breeding sites might have been the vegetationless rocky creeks on the mountain top. The head of the female was longer (13.0 mm) than broad (10.6 mm). Distance between eye and nostril (3.4 mm) longer than distance nostril to snout (2.3 mm); eye diameter (4.8 mm) larger than internarial distance (3.5 mm) or tympanum diameter (2.9 mm). Dorsal and lateral ridges broken into wart-like structures, the lateral ones being white, the dorsal ones black. The female had a clear vertebral line. The thigh (17.7 mm) showed five, the lower leg (19.4 mm) four black bars. The outer parts of the thighs had two broken, yel-

Fig. 4: Adult female of *Hemisus* cf. *guineensis* from base of Mont Péko.
Abb 4: Adultes Weibchen von *Hemisus* cf. *guineensis*, gefangen am Fuße des Mont Péko.

Fig. 5: Adult female *Ptychadena* cf. *schillukorum* from top of Mont Péko.
Abb. 5: Auf dem Mont Péko gefangenes Weibchen von *Ptychadena* cf. *schillukorum*.

low, longitudinal lines. The skin of the flanks was warty. The venter, including the foot (29.0 mm incl. longest toe) was white, the webbing dark gray. The webbing formula (compare RÖDEL 2000a) was: 1 (1), 2 i/e (1 - 0.5), 3 i/e (2 - 0.5), 4 i/e (2), 5 (0.25). Length of inner metatarsal tubercle (1.5 mm) 39.5 % the length of shortest toe (3.8 mm). The juvenile shared the morphological characters of the female.

Phrynobatrachus sp., MOR M23, M23G. In MNP we found an adult female *Phrynobatrachus* (fig. 6) not assignable with certainty to any West African *Phrynobatrachus* species described so far. The frog (SVL 23.5 mm) was caught in a forest. It resembled most *P. natalensis* (SMITH, 1849) and *P. francisci* BOULENGER, 1912. It differed from both species by the presence of black spots on the belly and yellowish underparts of thighs, the sides of the latter were speckled with black spots. The webbing was within the range of both other species. It was larger than known *P. francisci* females (19 - 22 mm) and smaller than females of *P. natalensis* (26 - 39 mm, for review see RÖDEL 2000a). Both *P. francisci* and *P. natalensis* are savanna species (RÖDEL 2000a). However, without having male specimens and advertisement calls available it can not be decided if this frog represents an undescribed species or only an aberrant representative of one of the above mentioned species.

Astylosternus sp. SMNS 09615-16. We recorded this *Astylosternus* along a very small and shallow creek, running through a small forest remnant on the top of Mont Péko. There males called well concealed under stones in very dense vegetation, close to the water. We managed to catch two males with snout-vent-lengths of 67.6 (fig. 7) and 55.6 mm, respectively. Tadpoles that probably belonged to this species were caught in the shallow creek, as well as in the flooded grassland outside the forest remnant, providing water heights of less than 1 cm. All tadpoles were very small (25-30 mm, GOSNER 1960 stages 26-35) but exhibited all characters typical for *Astylosternus* tadpoles. Normally, in *Astylosternus* habitats, the typical, very large tadpoles (up to 80 mm at GOSNER 1960 stages 26-35; LAMOTTE & ZUBER-VOGELI 1954; M. O. RÖDEL unpublished data) are the most obvious hint on the presence of these frogs (RÖDEL in press; RÖDEL & BRANCH 2002). Our PNP vouchers differed in several morphological features from specimens found in lowland forests of Ivory Coast (RÖDEL 2000b; RÖDEL in press; RÖDEL & BRANCH in press, unpubl. data) and Guinea (BÖHME 1994). Additionally, the PNP males called differently to males from Taï National Park (TNP; RÖDEL & ERNST unpubl.). While the TNP males uttered buzzing sounds, the PNP frogs called very similar to the cackle calls of *Ptychadena*. However, SCHIØTZ (1964) recorded *Astylosternus* in Sierra Leone that produced two types of calls that resemble the above mentioned two calls. According to him the buzzing call could be uttered alone, whereas the other call was always proceeded by the buzzing one. The PNP frogs were never heard producing a buzzing call.

Two West African *Astylosternus* species have been described so far: *Astylosternus occidentalis* PARKER, 1931 from Sandaru, east Sierra Leone, and *Hylambates yalense* ANGEL, 1944 from the Guinean region of Mont Nimba (village of Yale, in secondary forest). The latter was later on put into the synonymy of *Astylosternus diadematus* WERNER, 1898 by GUIBÉ (FROST 2002), and after it had become clear that *A. diadematus* is a Central African species, into the synonymy of *A. occidentalis* PARKER, 1931 by LAMOTTE (in SCHIØTZ 1967, compare FROST 2002). The species identity of our PNP specimens remains unresolved unless the above mentioned types have been investigated (RÖDEL & ERNST in prep.).

Hyperolius lamottei LAURENT, 1958, MOR PNP3-6, MOR BWü3-4G. *Hyperolius lamottei* was described from a locality between Zouguépo and Sérenbara in Liberia. It was reported to occur in savanna habitats from the Mont Nimba region, eastward into Sierra Leone. Only one more western locality, Lamto in Ivory Coast, was known (SCHIØTZ 1967, 1999). Our findings therefore would represent the second record for Ivory Coast. However, very recently, based on acoustics, CHANNING et al. (2002) put *H. lamottei* into synonymy with *H. acuticeps* AHL, 1931, originally described from Tanzania, together with frogs that have been formerly assigned to *H. nasutus* GÜNTHER,

Fig. 6: Adult female of *Phrynobatrachus* sp. from Marahoué National Park.
Abb. 6: Adultes Weibchen von *Phrynobatrachus* sp. aus dem Marahoué Nationalpark.

Fig. 7: Adult male *Astylosternus* sp. from top of Mont Péko.
Abb 7: Auf dem Mont Péko gefangenes Männchen von *Astylosternus* sp.

Fig. 8: Adult female *Hyperolius lamottei* LAURENT, 1958 from top of Mont Péko.
Abb. 8: Auf dem Mont Péko gefangenes Weibchen von *Hyperolius lamottei* LAURENT, 1958 .

1864 (e.g., frogs from Comoé National Park, RÖDEL 2000; RÖDEL & SPIELER 2000). *Hyperolius nasutus* so far was thought to be widespread throughout almost all savanna habitats south of the Sahara (see map in SCHIØTZ 1999). CHANNING et al. (2002) further recognized "real" *H. nasutus* from West Africa, that however should live in forests. To our experience there are no forest dwelling *H. nasutus* in West Africa. We could not detect any differences between *H. nasutus*, e.g., recorded in the Ghanian Volta region (RÖDEL & AGYEI in press), the Comoé National Park (RÖDEL 2000a; RÖDEL & SPIELER 2000), the Mont Sangbé National Park (RÖDEL in press) and MNP (this paper). To our experience *H. nasutus* from Comoé and MNP, and *H. lamottei* from PNP are two clearly discernible species, although the voices are indeed very similar. In central Ivory Coast SCHIØTZ (1967, 1999) recorded both species almost in sympatry, without finding any transitional forms. Both species exclusively inhabit savannas, however they seem to have differing reproductive sites within this main habitat type. While *H. nasutus* calls close to ponds (e.g., RÖDEL 2000a), *H. lamottei* apparently prefers inundate short-grass savanna (ARNOULT & LAMOTTE 1958; LAMOTTE 1967; SCHIØTZ 1967, 1999). This fits well with our data. In PNP *H. lamottei* was calling from grasses on the overflown rocks (fig. 2). Larger stagnant waters were lacking at these sites. *Hyperolius lamottei* often inhabits mountainous habitats (ARNOULT & LAMOTTE 1958; this paper), whereas *H. nasutus* is absent in these habitats in West Africa (compare however LARGEN 1998, 1999 for Ethiopian localities). We therefore continue using the names *H. nasutus* for green and *H. lamottei* for brown West African sharp-nosed reed frogs (fig. 8), an opinion that corresponds with the experience of A. SCHIØTZ (in litt.). However, we share the opinion of CHANNING et al. (2002) that *H. nasutus* (sensu SCHIØTZ 1967, 1999) comprises several, cryptic species. Based on acoustic and genetic data, we plan to reinvestigate the taxonomic situation of West African sharp-nosed reed frogs.

Table 1: Habitat selection and African distribution of the amphibian species of Marahoué (MNP) and Mont Péko (PNP) National Parks. F - forest, FB - farmbush (sensu SCHIØTZ 1967, degraded forest and altered land in the former forest zone), S - savanna.

Tab. 1: Lebensräume und afrikanische Verbreitung der Amphibienarten des Marahoué (MNP) und Mont Péko (PNP) Nationalparks. F - Wald, FB - Buschwald (im Sinne von SCHIØTZ 1967, degradierter Wald und umgewandeltes Land in der ehemaligen Regenwaldzone), S - Savanne.

	F		F/FB		FB/S		S	
	MNP	PNP	MNP	PNP	MNP	PNP	MNP	PNP
OWA	1	1	5	7	7	6	10	2
WA	1	2	3	4	1	1	3	0
UG	1	3	1	6	0	0	0	1

Anuran assemblages

About half of the amphibian species of MNP were widespread African savanna and farmbush species (table 1; appendix 4). Twelve species could be regarded as dependant on forest habitats and only two (*Phrynobatrachus* sp. and *Kassina schioetzi* RÖDEL, GRAFE, RUDOLF & ERNST, 2002) were endemic to the Upper Guinea forest zone. Generally, the anuran fauna of MNP was representative for the humid southern Guinea savanna, comprising savanna frogs that prefer humid savannas or farmbush habitats, enriched by some forest species (SCHIØTZ 1967; RÖDEL 2000a). Thereby, the anuran fauna of MNP was very similar to the only other place of that zone so far investigated: the Lamto scientific station (LAMOTTE 1967). Both areas had 83% of their amphibian fauna in common (Sørensen coefficient; species list of Lamto adapted to recent taxonomic changes). Savanna species that prefer drier habitats, e.g., *Hildebrandtia ornata* (PETERS, 1878), *Kassina cassinoides* (BOULENGER, 1903), and are present in the northern parts of the savanna zone of Ivory Coast (RÖDEL 2000a; RÖDEL & SPIELER 2000) were absent, as were most true forest species. However, the estimated number of species exceeds the number of 33 anuran species recorded. Additional species can be especially expected in the less investigated forest areas of south-western MNP.

The situation was different in PNP (table 1, appendix 4). Here, two thirds of the anuran fauna was made up by forest and farmbush species. Only three species could be regarded as savanna specialists and they all occurred on the rocky mountain top of Mont Péko (*Ptychadena* cf. *schillukorum*, *Leptopelis viridis* GÜNTHER, 1859 "1858", *Hyperolius lamottei*). There we also found two other widespread savanna and farmbush inhabitants: *Bufo maculatus* HALLOWELL, 1854 and *Hoplobatrachus occipitalis* (GÜNTHER, 1858). In PNP nearly one third of the species was endemic to the Upper Guinea zone and another seven species were at least endemic to West Africa (table 1). Compared to other Ivorian amphibian faunas, the anuran assemblage of PNP clustered with forest communities (RÖDEL in press). It had closest species similarities with two forests in south-western Ivory Coast classified as disturbed (RÖDEL & BRANCH 2002), a fact that is most probably caused by the high amount of altered forest habitats in these three areas and the consequent invasion of farmbush species into former closed canopy forests. The unique species composition of PNP resulted from the inselbergs as extrazonal habitats, providing savanna environments in the forest zone (POREMBSKI & BARTHLOTT 2000). If pristine forest areas proof to be still existent in more inaccessible areas of the park, additional forest frogs, already recorded from the even more northern Mont Sangbé National Park (RÖDEL in press), are likely to occur, e.g., *Conraua alleni* (BARBOUR & LOVERIDGE, 1927), *Petropedetes natator* BOULENGER, 1905, *Hyperolius chlorosteus* (BOULENGER, 1915), *H. sylvaticus* SCHIØTZ, 1967.

Conclusions and conservation implications

West African rain forests are among the 25 most important biodiversity hotspots of the world (MYERS et al. 2000). They are highly threatened by logging, agriculture

and an increasing human population (BAKARR et al. 2001; ROMPAY 1993; PARREN & DEGRAAF 1995; CHATELAIN et al. 1996). In recent decades deforestation rate in Ivory Coast was one of the highest continent-wide (BARNES 1990; MARTIN 1991). MNP and PNP are both situated in the transition zone between these rain forests and the adjacent savanna formations. This is reflected by their unique anuran assemblages, and the high diversity of this group. In MNP and PNP we recorded 11 species endemic to Upper Guinea (23.4% of the recorded 47 species). Nine of the eleven endemic species (81.8%) are adapted to forest habitats. Four species, *Hemisus* cf. *guineensis*, *Ptychadena* cf. *schillukorum*, *Phrynobatrachus* sp. and *Astylosternus* sp., might represent undescribed species. We assume that in both parks additional forest species occur. Unlike West African savanna species, most forest amphibians are endemic to West Africa or even the Upper Guinea forests. Thus, the percentage of endemic species is likely to be underestimated in this study. Protection of forest sites in both national parks therefore should be given highest priority.

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Appendix 1

Geographic position and short habitat characterization of sites in Marahoué National Park (Ivory Coast)
Geographische Lage und kurze Lebensraumbeschreibung der Fundorte im Marahoué Nationalpark (Elfenbeinküste)

Code	N	W	Habitat
1	07°00'27.0"	005°57'38.5"	tributary of Marahoué river; shallow pond at forest edge, few submerse plants, many sedges, open tree savanna / Zufluß des Marahoué; flacher Tümpel am Waldrand mit wenigen sub mersen Pflanzen, viele Seggen, offene Baumsavanne
2	07°01'01.7"	005°57'41.1"	large and deep pond in open savanna, large areas without vegetation in water, others with water lilies, many sedges on bank, small creek flowing into pond; creek flowing through small, swampy gallery forest / großer, tiefer Tümpel in offener Savanne, große offene Wasserflächen,

Code	N	W	Habitat
			Areale mit Seerosen, viele Seggen am Ufer, kleiner Bach als Zufluss der durch einen kleinen, sumpfigen Galeriewald fließt
3	07°02'59.5"	005°56'51.1"	large savanna pond with water lilies (Mare au buffles); dried up creek with small gallery forest, small pond in creek bed / großer Savannentümpel mit Seerosen bewachsen; Galeriewald mit aus getrocknetem Bach und kleinem Resttümpel
4	07°04.885'	005°57.096'	stagnant pools in river bed in forest, open canopy, dense under-storey / Resttümpel in Flussbett, Galeriewald mit offenem Kronendach und dichtem Unterwuchs
5	07°04.980'	005°57.236'	transition between tree savanna and forest / Übergang zwischen Baumsavanne und Wald
6	07°04'58.8"	005°57'14.1"	small pond at forest edge / kleiner Tümpel am Waldrand
7	07°05.294'	005°57.124'	road ditch in savanna / Wagenspur in der Savanne
8	07°05.429'	005°56.462'	small tributary of Marhoué river, gallery forest / kleiner Zufluss des Marahoué, Galeriewald
9	07°05'13.2"	005°56'36.5"	forest, two small, shallow ponds without vegetation; shallow savanna pond, bordered on one side with shrubs, other banks with open Borassus-palm savanna, water nearly without vegetation; small creek (Marigot des elephants) with stagnant pools, water ferns, low gallery forest / zwei kleine, flache, vegetationslose Tümpel im Wald; flacher, nahezu vegetationsloser Savannentümpel, an einer Seite mit Büschen bewachsen, an der anderen offene Rhônier Palmen Savanne; kleiner Bach mit Resttümpeln, Wasserfarne, niedriger Galeriewald
10	07°05'17.9"	005°57'07.4"	open forest / offener Wald
11	07°06.432'	005°58.407'	small savanna ponds, one pond with crocodile hole / kleine Savannentümpel, einer mit Krokodilloch
12	07°06.606'	005°55.746'	small gallery forest in savanna area, two puddles without vegetation / kleiner Galeriewald in der Savannenzone, zwei Pfützen ohne Vegetation
13	07°06'34.7"	005°55'44.2"	shallow savanna pond / flacher Savannentümpel
14	07°06'54.4"	005°55'36.8"	large savanna pond without vegetation in water and on bank, shallow road ditch / großer Savannentümpel, weder im Wasser noch am Ufer bewachsen, flache Wagenspur
15	07°07'34.1"	005°53'38.0"	deep pond with water lilies in savanna, bank densely vegetated / tiefer Seerosentümpel in der Savanne, Ufer dicht bewachsen
16	07°07'45.0"	005°54'28.3"	small forest pond without vegetation; deep forest pond surrounded by closed canopy forest; large swampy area with grasses in close vicinity to forest, large densely vegetated savanna pond / kleiner, vegetationsloser Waldtümpel; große Sumpffläche mit Gräsern in waldnähe, großer, bewachsener Savannentümpel
17	07°07'52.9"	005°55'17.8"	heavily vegetated puddles in savanna; dried up pond in dense forest / dicht bewachsene Pfützen in der Savanne; ausgetrockneter Tümpel in dichtem Wald
18	07°08.108'	005°56.334'	shallow forest ponds in open low forest; road ditches on dirt road bor dered by forest; puddles in savanna, swampy savanna area / flache Waldtümpel in offenem, niedrigem Wald, Wagenspuren auf Piste, von Wald eingerahmt; Pfützen in der Savanne, sumpfiges Savannengebiet
19	07°08.209'	005°56.306'	dried up creek with small swampy area in gallery forest / ausgetrockneter Bach und kleiner Sumpf im Galeriewald
20	07°08.251'	005°56.094'	two savanna ponds / zwei Savannentümpel
21	07°08'01.8"	005°55'52.4"	shallow savanna pond with dense vegetation, partly shadowed by shrub; partly dried up pond surrounded by a few shrubs in savanna; large, deep, heavily vegetated pond in closed canopy forest / flacher Savannentümpel mit dichter Vegetation, teilweise im Schatten e ines Busches; teilweise ausgetrockneter Savannentümpel, eingerahmt von Büschen; großer, dicht bewachsener Tümpel in Wald mit geschlossenem Kronendach
22	07°08'08.9"	005°56'20.9"	forest with water filled buffalo and elephant tracks; swampy areas; large road ditch with open canopy but bordered with forest / Wald mit wassergefüllten Spuren von Elefanten und Büffeln; Sumpfgebiete; große Wagenspur, darüber offenes Kronendach, von Wald eingerahmt
23	07°08'16.8"	005°56'12.6"	small puddle covered by shrubs and tress in dried up river bed close to Marahoué river / kleine Pfütze in ausgetrocknetem Bachbett in der Nähe des Marahoué Flusses, von Büschen und Bäumen überdacht
24	Bouaflé	no GPS data	surroundings of town, puddles, swampy area, highly polluted environment / Umgebung der Stadt, Pfützen, Supfgebiet, stark verschmutztes Gebiet

Appendix 2

Geographic position and short habitat characterization of sites in Mont Péko National Park (Ivory Coast)

Geographische Lage und kurze Lebensraumbeschreibung der Fundorte im Mont Péko Nationalpark (Elfenbeinküste)

Code	N	W	Habitat
1	06°57.090'	007°19.906'	dirt road with puddles of various sizes, some with dense vegetation, degraded forest, cacao plantations, very dense herb and shrub storey / Piste mit Pfützen unterschiedlicher Größe, degradierter Wald, Kakaoplantagen, sehr dichte Kraut- und Buschschicht
2	06°57.956'	007°20.650'	dirt road bordered by plantations and degraded forest, large puddles, dense under-storey, fast flowing creek at park border / Piste von degradiertem Wald und Plantagen gerahmt, schnell fließender Bach am Parkrand
3	06°58'21.1"	007°10'19.5"	fast flowing creek; floated forest with sparse under-storey; large pond with shallow parts, those densely vegetated, bordered by degraded forest and cacao plantation, bank grown with large herbs and shrubs; small pond, densely vegetated, high vegetation on bank, forest with spare under-storey and nearly closed canopy / schnell fließender Bach; überschwemmter Wald mit spärlichem Unterwuchs; großer Tümpel mit flachen Bereichen, diese dicht bewachsen, von degradiertem Wald und Plantagen umgeben; kleiner Tümpel, dicht bewachsen, hohe Vegetation am Ufer, Wald mit lichtem Unterwuchs und fast geschlossenem Kronendach
4	06°59'16.4"	007°10'00.5"	south-west corner of the park, river Bihi, secondary forest and planta tions, gallery forest of Bihi with open under-storey, otherwise very dense forest with open canopy; swampy pond, muddy buffalo pool; stagnant ponds in river bed, mostly without vegetation, clear water on sandy soil / Südwestecke des Parks, Fluss Bihi, Sekundärwald und Plantagen, sonst sehr dichter Wald mit offenem Kronendach; sumpfiger Tümpel, schlam miger Büffeltümpel, klares Wasser und sandiger Untergrund
5	06°59'19.9"	007°10'03.4"	dried up pond, bordered by Raphia palms / ausgetrockneter Tümpel von Raphia-Palmen umgeben
6	07°04.499'	007°11.092'	1 km south of Guezon, puddles on dirt road; creek and swampy area in secondary forest / 1 km südlich von Guezon, Pfützen auf Piste; Bach und Sumpfgebiet in Sekundärwald
6	07°04.499'	007°11.092'	base of Mont Péko, creek, puddle with swampy area, open forest and cacao plantation / Fuß des Mont Péko, Bach, Pfützen in Sumpfgebiet, offener Wald und Kakaoplantage
7	07°05'06.4"	007°12'10.7"	rocky plateau on Mont Péko, very humid grassland / felsiges Plateau auf dem Mont Péko, sehr feuchtes Grassland
8	07°05'13.6"	007°12'11.4"	fast flowing river on eastern side of Mont Péko, rocky ground, jammed to little ponds on rock terraces, ponds mostly without any vegetation, humid grassland / schnell fließender Bach auf der Ostseite des Mont Péko, auf felsigem Grund an Terrassen zu kleinen Tümpeln gestaut, diese meist völlig vegetationslos, feuchtes Grasland
9	07°05'20.5"	007°11'38.2"	fast flowing rocky creek at base of Mont Péko, bordered by secondary forest and plantations / schnell fließender Bach am Fuss des Mont Péko, von Sekundärwald und Plantagen gerahmt
10	07°05'26.0"	007°12'13.8"	small creek on mountain, bordered with low but dense forest; open grass land, partly high grasses, partly very low grass and moor / kleiner Bach auf dem Berg, von niedrigem aber dichtem Wald gerahmt, offenes Grassland, teilweise sehr niedrige Grass- und Moorvegetation

Appendix 3

Amphibian species recorded in the Marahoué and Mont Péko National Parks and code numbers of locations/habitats where the species have been recorded (compare appendices 1 & 2). Q - tadpole records not determinable to species level.

Die im Marahoué und Mont Péko Nationalpark nachgewiesenen Amphibienarten und die Nummern der Fundorte/Lebensräume, wo sie nachgewiesen wurden (siehe Anhänge 1 & 2). Q - Nachweise, die auf nicht bis zur Art bestimmbaren Kaulquappen basieren.

Species / Art	Marahoué National Park Code	Péko National Park Code
Pipidae		
Silurana tropicalis	16, 19, 23	1
Bufonidae		
Bufo maculatus	2, 8, 9, 15, 18	1, 3, 4, 6, 7, 9, 10
B. regularis	24	
B. sp. Q	3	
Hemisotidae		
Hemisus marmoratus	13, 16, 18, 22, 23	
H. cf. *guineensis*		9
Ranidae		
Hoplobatrachus occipitalis	3, 3, 9, 14, 15, 17, 18, 21, 23	1, 3, 5, 6, 8, 10
Amnirana albolabris	2, 8	3, 6
A. galamensis	2, 3, 15	
Ptychadena aequiplicata	17, 19, 22	5
P. bibroni	1, 2, 3, 7, 9, 13, 14, 18, 21, 23	1, 3, 8, 9
P. longirostris	19	1, 9
P. oxyrhynchus	3	
P. cf. *schillukorum*		10
P. tellinii	1, 13, 14, 21, 24	
P. sp. Q	2	8, 10
Phrynobatrachus accraensis	1, 2, 3, 4, 8, 9, 11, 12, 13, 14, 15,16, 17, 18, 19, 21, 23, 24	2, 3, 4, 5, 6
P. alleni		2, 4, 5
P. calcaratus	1, 2, 4, 6, 9, 17, 23	
P. francisci	1, 3, 7, 8, 9, 14	
P. gutturosus	1, 2, 4, 6, 8, 9, 14, 15, 18, 19	2, 3, 5
P. liberiensis		4, 6
P. natalensis	2	
P. phyllophilus		5
P. plicatus	2, 4, 6, 9, 17, 22	5, 6
P. sp.	3	
P. sp. Q	3, 6, 9, 10, 14, 18	
Arthroleptidae		
Arthroleptis poecilonotus	2, 18, 21	10
A. sp.	3, 5, 9, 10, 16	6
A. sp. 1		1, 3, 6
A. sp. 2		3, 4
Astylosternidae		
Astylosternus sp.		10
Hyperoliidae		
Afrixalus dorsalis	2, 3, 9, 14, 18, 21, 22	1, 3
A. vittiger	2, 3, 13, 15, 20, 21, 24	
A. weidholzi	3, 13, 14, 21	
A. sp. Q	1, 3, 9, 18	
Hyperolius chlorosteus		3
H. concolor	1, 2, 3, 5, 9, 13, 15, 18, 20, 21, 22	1, 3
H. fusciventris		1, 3
H. guttulatus	2, 3, 9, 15, 18	3
H. lamottei		10
H. nasutus	1, 2, 3, 15	
H. nitidulus	1, 2, 3, 14, 15, 16, 20, 24	
H. picturatus		1, 2
H. sp. Q	3	

Species / Art	Marahoué National Park Code	Péko National Park Code
Kassina arboricola		1, 3
K. schioetzi	2, 3, 5, 13, 14, 16	1, 2, 3
K. senegalensis	2, 3, 5, 13, 14, 15, 18, 21, 24	
K. sp. Q	1, 2, 3, 13, 14, 21	
Leptopelis hyloides	21, 22	1, 3, 10
L. viridis	2, 3, 7, 9, 13, 14, 20, 21, 24	10
Phlyctimantis boulengeri		1
Rhacophoridae		
Chiromantis rufescens	21	1
Microhylidae		
Phrynomantis microps	1, 3, 14, 21, 24	

Appendix 4

Amphibians of Marahoué (MNP) and Mont Péko (PNP) National Parks, including type of record (O - visual observation, C - call, V - voucher specimen(s), T - tissue sample) and preferred habitat and African distribution. F - forest, FB - farmbush (sensu SCHIØTZ 1967, degraded forest and altered land in the former forest zone), S - savanna, OWA - occurs also outside West Africa, WA - West Africa (defined as stretching from Senegal to eastern Nigeria), UG - Upper Guinea (forested area West of the Dahomey Gap).
1 - compare text, 2 - West African *Arthroleptis* species can not be assigned to available names right now (compare RÖDEL & AGYEI in press; RÖDEL & BRANCH 2002), 3 - described subspecies of *H. fusciventris* probably deserve species rank (RÖDEL unpubl.), 4 - might be an undescribed cryptic species (RÖDEL unpubl.).

Amphibien der Marahoué (MNP) und Mont Péko (PNP) Nationalparks unter Angabe der Art des Nachweises (O - Sichtbeobachtung, C - Rufnachweis, V-= Belegexemplar(e), T - Gewebeprobe), des bevorzugten Lebensraums und der afrikanischen Verbreitung. F - Wald, FB - Buschwald (im Sinne von SCHIØTZ 1967, degradierter Wald und umgewandeltes Land in der ehemaligen Regenwaldzone), S - Savanne, OWA - auch außerhalb Westafrikas verbreitet, WA - Westafrika (definiert als vom Senegal bis ins östliche Nigeria sich erstreckend), UG - Oberguinea (bewaldetes Gebiet westlich der Dahomey Lücke).
1 - vergleiche Text, 2 - westafrikanische *Arthroleptis* Arten können verfügbaren Namen derzeit nicht zugeordnet werden (vergleiche RÖDEL & AGYEI im Druck; RÖDEL & BRANCH 2002), 3 - die beschrieben Unterarten von *H. fusciventris* verdienen vermutlich Artrang (RÖDEL unpubl.), 4 - möglicherweise unbeschriebene, kryptische Art.

Species / Art	MNP	PNP	F	FB	S	OWA	WA	UG
Silurana tropicalis	O, T	O	+	+		+		
Bufo maculatus	O, C	O, C, V		+	+	+		
B. regularis	O				+	+		
Hemisus marmoratus	O, V, T			+	+	+		
H. cf. *guineenis* [1]		O, V	+	+		+		
Hoplobatrachus occipitalis	O, C	O, C		+	+	+		
Amnirana albolabris	O, T	O	+	+		+		
A. galamensis	O, C				+	+		
Ptychadena aequiplicata [4]	O, V, T	O	+			+		
P. bibroni	O, C	O, C, V		+	+	+		
P. longirostris	O, T	O	+				+	
P. oxyrhynchus	O, C				+	+		
P. cf. *schillukorum* [1]		O, V, T			+	+		
P. tellinii	O, C				+	+		
Phrynobatrachus accraensis	O, C, V, T	O, C, V, T		+	+		+	
P. alleni		O, V, T	+				+	
P. calcaratus	O, V, T		+	+		+		

Species / Art	MNP	PNP	F	FB	S	OWA	WA	UG
Phrynobatrachus francisci	O, V, T				+		+	
P. gutturosus	O, C, V, T	O, V, T	+	+			+	
P. liberiensis		O, V	+					+
P. natalensis	C				+	+		
P. phyllophilus		O, V, T	+					+
P. plicatus	O, V, T	O, V, T	+	+			+	
P. sp. [1]	O, V, T		+					+
Arthroleptis poecilonotus [2]	O, C, V, T	O, C, V		+	+	+		
A. sp. [1] [2]		O, C, V, T	+	+				+
A. sp. [2] [2]		C	+	+				+
Astylosternus sp. [1]		O, C, V		+[1]				+
Afrixalus dorsalis	O, C	O, C, V	+	+		+		
A. vittiger	O, C				+		+	
A. weidholzi	O, C				+	+		
Hyperolius chlorosteus		C	+					+
H. concolor	O, C, T	O, C, V		+	+	+		
H. fusciventris sensu lato [3]		O, C, V	+	+			+	
H. guttulatus	O, C	O, C		+	+	+		
H. lamottei		O, C, V, T			+			+
H. nasutus [1]	O, C, T				+	+		
H. nitidulus	O, C				+		+	
H. picturatus		O, C, V	+	+				+
Kassina arboricola		O, C, V	+	+				+
K. schioetzi	O, C	O, C, V	+	+				+
K. senegalensis	O, C				+	+		
Leptopelis hyloides	C	O, C	+	+			+	
L. viridis	O, C	O, C, V			+	+		
Phlyctimantis boulengeri [4]		O, C	+	+		+		
Chiromantis rufescens	E	O, E	+	+		+		
Phrynomantis microps	C				+	+		

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