

## The anurans of the Banco National Park, Côte d'Ivoire, a threatened West African rainforest

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**Abstract.** We studied the anuran fauna of the Banco National Park (BNP) in south-eastern Côte d'Ivoire from July 2003 to February 2004. During this period we recorded 28 anuran species. Important faunistic records were: a new hyperoliid treefrog that represents a new genus, a new species of *Astylosternus*, and the first country record for *Phrynobatrachus ghanensis*. On the basis of our standardized monitoring data we estimated that 34 to 38 amphibian species live in BNP. The presence of e.g. *Phrynobatrachus phyllophilus*, *P. ghanensis* and *Ptychadena aequiplicata*, that are typical primary forests species, shows that BNP still comprises primary forest. However, the occurrence of several other species such as *Phrynobatrachus accraensis*, *Hoplobatrachus occipitalis*, *Ptychadena pumilio*, *P. mascareniensis*, *Bufo regularis* and *B. maculatus* which normally inhabit secondary forest, farmbush or even savannah, indicates that BNP forests are already altered by human activities. Overall species richness of BNP was unexpectedly low compared to other known Upper Guinea forest areas, as was the proportion of species that are endemic to West Africa and the Upper Guinea forest block. The lack of numerous otherwise widespread forest frogs might be a hint that BNP already is too small (3000 ha) to assure long-term survival of particular amphibian species and thus is a pressing sign to put more emphasis on forest protection actions in south-eastern Côte d'Ivoire.

Key words. Amphibia: Anura: Côte d'Ivoire, diversity, conservation, rainforest, taxonomy, West Africa.

**Résumé.** L'étude de la faune des anoures du Parc National du Banco (PNB), situé dans le Sud-est de la Côte d'Ivoire, a été menée de juillet 2003 à février 2004. Durant cette période, 28 espèces d'amphibiens ont été échantillonnées. Une grenouille arboricole de la famille des Hyperoliidae, l'espèce du genre *Astylosternus* et l'espèce *Phrynobatrachus ghanensis* sont tous trois de nouveaux taxons pour la Côte d'Ivoire, les deux premiers cités le sont pour le monde entier. Sur la base des échantillonnages standardisés, on estime que 34 à 38 espèces d'amphibiens vivent dans le PNB. La présence des espèces *Phrynobatrachus phyllophilus*, *P. ghanensis* et *Ptychadena aequiplicata*, caractéristiques des forêts primaires, indique que le PNB renferme encore des reliques de forêts vierges. En revanche, l'occurrence de plusieurs autres espèces telles que *Phrynobatrachus accraensis*, *Hoplobatrachus occipitalis*, *Ptychadena pumilio*, *P. mascareniensis*, *Bufo regularis* et *B. maculatus*, habitant les forêts secondaires, les formations herbacées et les savanes, traduit une forte pression de l'homme dans le milieu. La richesse spécifique globale du PNB reste toutefois inférieure à celle rencontrée dans diverses autres régions du bloc forestier de la Haute Guinée. Il en est de même des proportions des espèces endémiques à cette région et à toute l'Afrique de l'Ouest. L'absence constatée des taxons présumés répandus dans ce type de forêt pourrait être due aux dimensions réduites du PNB (3000 ha) qui ne favoriseraient pas la survie à long terme de telles espèces ou encore la forte pression anthropique qui s'y exerce.

Mots-clés. Amphibiens, anoures, Côte d'Ivoire, diversité, conservation, forêt humide, taxonomie, Afrique de l'Ouest.

### Introduction

The amphibian fauna of Côte d'Ivoire has been intensively investigated in several sa-

vannah habitats (LAMOTTE 1967, RÖDEL & SPIELER 2000, RÖDEL 2003) and a few forest and mountainous regions in the western part of the country (GUIBÉ & LAMOTTE 1958, 1963;

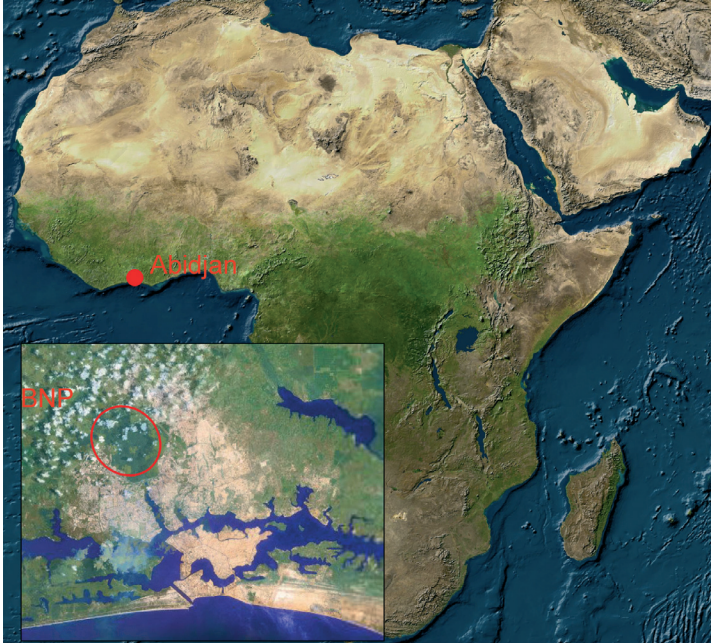


Fig. 1. Geographical position of Abidjan. The Banco National Park (BNP) and its position in midst of Abidjan is shown in the inlet figure. The Park, visible in dark green and encircled in red, is situated between the densely populated quarters of Adjamé and Yopougon. Inlet picture modified after Google Earth, 2005.

LAURENT 1958; RÖDEL & BRANCH 2002; RÖDEL & ERNST 2003, 2004). Other regions, in particular those of the south-eastern part of Côte d'Ivoire, still remain to be explored, i.e. special publications on the forests amphibians of this region are restricted to two papers describing a new frog species each (PERRET 1985, 1994). Both descriptions comprise vouchers that have been collected in the Banco National Park, the first Ivorian national park (founded at 31 October 1953). This park is situated in the middle of Abidjan, the economic capital of the country (Fig. 1). Surprisingly, the unsustainable use of timber, that e.g. during the last 20 years destroyed about 80% of primary forests in western Côte d'Ivoire (CHATELAIN et al. 1996) did not much affect the Banco National Park. Hence, there are still primary relicts of evergreen forest left (HALL & SWAINE 1981, PARREN & DE GRAAF 1995). However, Abidjan is still attracting national and international immi-

gration and is continuously expanding. In the face of increasing socio-economic constraints and conflicting land use options, a rapid assessment of the Banco National Park's amphibian fauna seemed to be a pressing necessity. The results of our investigations form the topic of this paper.

### Material and methods

Study site: The Banco National Park (BNP, 5°21'-5°25' N; 4°01'-4°05' W) is a 3000 ha rain forest remnant located in midst of Abidjan (AKÉ ASSI 1960, DAGET & LITIS 1965). The mean annual temperature in BNP is 26.4 °C. The mean annual precipitation sums to about 2000 mm. A longer great dry season lasts from December to March, and is followed by the period with highest precipitation in March to July. A minor rainy season lasts from October to November. The River Banco



Fig. 2. Swampy part of the Banco National Park (Tarnsect 6).

crosses the entire reserve over approximately 9 km. It has its source close to the northern edge of BNP and flows into the Ebrié lagoon. BNP mainly consists of moist, almost primary forest on predominantly sandy soils.

The flora on sandy-sandstone soils, hence the dryer parts of the forest, is dominated by the trees *Turraeanthus africanus* (Meliaceae) and *Heisteria parvifolia* (Olacaceae). Other tree species such as *Uapca guineensis* (Euphorbiaceae), *Hallea ciliata* (Rubiaceae) and *Cynometra ananta* (Leguminosae) dominate swampy areas (Fig. 2). Besides undisturbed areas, BNP also comprises altered forest areas, e.g. a large clearing in the middle of the park harbours artificial ponds for *Tilapia* breeding and buildings of a forestry school. Forest structure at the edges of BNP is heavily altered by illegal timber harvesting, plantations and pollution. Within these areas no primary forest remained.

**Sampling:** After randomized survey walks in different habitats (HEYER et al. 1994), we selected areas for sixteen rectangular transects (Table 1 and Appendix 1), each 600 m in length. Habitat parameters and amphibian data were collected in a standardized way along these transects from July 2003 to February 2004 (for exact transect and sampling design see RÖDEL & ERNST 2004). Political unrest made impossible regular data collection after that period. The geographical po-

sition of our study sites was recorded with a handheld GPS-receiver (SP12X). These transects were assumed to represent all major habitat types of BNP. Additionally we continued performing randomized survey walks in four other habitat types of BNP, not represented on the transects (see Table 1 and Appendix 1). Sampling was done during day and night time.

Assuming that sampling effort was comparable throughout all transect walks (always three people involved in searching), we estimated the total number of amphibian species living in BNP. Calculation bases were the frogs recorded during the 75 transect walks. We used the Jackknife1 and Chao2 estimators, based on presence/absence data and the Jackknife2 and Chao1 estimators, based on abundance data (COLWELL 1994-2000). For a brief introduction to these methods and the respective mathematical formulae see <http://viceroy.eeb.uconn.edu/Estimates6> and literature cited therein. To prevent order effects, all calculations have been based on 500 randomized runs of the transect walks species lists.

During the transect walks frogs were captured, determined, sexed and measured, before releasing them at the same point. Measures were taken with dial-callipers (precision:  $\pm 1$  mm). Representatives of each species were collected, anesthetized and killed in a chlorobutanol solution and thereafter preserved in 70% ethanol. Unnumbered, but labelled, vouchers of all species were deposited in the collections of the Laboratoire d'Environnement et de Biologie Aquatique of UFR-SGE at the University of Abobo-Adjamé, Côte d'Ivoire. Further vouchers are housed in the Staatliches Museum für Naturkunde Stuttgart (SMNS) and the research collection of M.-O. RÖDEL (MOR, Appendix 2). The latter vouchers will be deposited later on in collections of various natural history museums. Tissue samples (toe tips) of recorded species were preserved in 95% ethanol. These samples are stored in the Institute of Zoology at Mainz University, Germany.

Species	1	2	3	4	5a	5b	6	7	8	9	10	11	12	13	14	15	US	FF	SB	HDS	
<b>Pipidae</b>																					
<i>Silurana tropicalis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
<b>Bufo</b>																					
<i>Bufo maculatus</i>	1	1	1	1	1	-	1	1	1	1	1	1	1	1	1	-	1	1	-	-	
<i>B. regularis</i>	-	-	-	1	1	-	-	1	-	1	1	-	-	-	1	1	1	1	1	1	
<b>Ranidae</b>																					
<i>Hoplobatrachus occipitalis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	
<i>Amnirana albolabris</i>	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	1	1	1	-	
<i>Aubria subsigillata</i>	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	
<i>Ptychadena aequiplicata</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>P. bibroni</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	
<i>P. aff. mascareniensis</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	
<i>P. cf. pumilio</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	
<i>P. longirostris</i>	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	1	1	-	-	1	
<b>Petropedetidae</b>																					
<i>Phrynobatrachus accraensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	
<i>P. ghanensis</i>	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	
<i>P. liberiensis</i>	-	-	-	1	1	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-	
<i>P. phyllophilus</i>	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	
<i>P. tokba</i>	-	-	-	1	-	1	1	1	-	-	1	1	1	-	-	-	1	-	-	-	
<b>Astylosternidae</b>																					
<i>Astylosternus</i> sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	
<b>Arthroleptidae</b>																					
<i>Arthroleptis</i> sp. 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	-	-	-	
<i>A.</i> sp. 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	-	-	-	
<b>Hyperoliidae</b>																					
<i>Leptopelis hyloides</i>	-	-	-	-	1	-	1	1	1	-	-	-	-	-	-	-	1	1	1	-	
<i>L. macrotis</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	
<i>Hyperolius concolor</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
<i>H. fusciventris</i>	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	1	1	1	
<i>H. guttulatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	
<i>H. picturatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
<i>Afrixalus dorsalis</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	1	1	
<i>A. fulvovittatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
undescribed treefrog	-	-	-	1	1	1	1	1	-	-	-	-	-	-	-	-	1	1	-	-	
<b>total number of species</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>10</b>	<b>14</b>	<b>7</b>	<b>15</b>	<b>10</b>	<b>6</b>	<b>7</b>	<b>6</b>	<b>4</b>	<b>4</b>	<b>3</b>	<b>5</b>	<b>6</b>	<b>20</b>	<b>16</b>	<b>11</b>	<b>7</b>	

Tab. 1. Presence (1) and absence (-) of 28 anuran species on 16 transects and four additional areas in the Banco National Park, Côte d'Ivoire. No. 1 to 15 = transects; for short site descriptions and abbreviations compare Appendix 1.

### Results and discussion

Sampling intensity and efficiency: In total we performed 26 transect walks during the night and 49 walks during the day (total of 348 man hours of sampling activity). During these surveys we recorded 1725 individuals of 28 anuran species; 753 frogs were re-

corded visually, 972 frogs were recorded acoustically.

Based on the 75 transect walk lists we evaluated our sample efficiency. With the presence / absence data we calculated that 34-37 species should occur in BNP (mean ± sd: Jackknife1 = 33.9 ± 2.2 species; Chao2 = 37.3 ± 17.1). We achieved an almost identi-

cal result by using the abundance data for all transect walks (mean  $\pm$  sd: Jackknife2 = 37.8  $\pm$  0 species; Chao1 = 34.3  $\pm$  11.7). We hence estimated having recorded between 73.7-82.4 % of the amphibian fauna of BNP. Whereas we assume that this figure is correct for the BNP as a whole, sampling effort was too small to calculate species numbers for particular transects. For this purpose at least 20 independent transect walks per transect would have been necessary (compare VEITH et al. 2004).

List of selected species: A list of all recorded species is provided in Tab. 1. Below, we only comment on a few selected species of particular interest.

The status of frogs of the genus *Aubria* was recently summarized by RÖDEL et al. (2005). Following the arguments of the latter publication, the frogs of the genus *Aubria* from Banco are *Aubria subsigillata* (DUMÉRIL, 1856). *A. occidentalis* PERRET, 1995, described from BNP, is a synonym of this species. In BNP we found *A. subsigillata* mainly in very swampy parts of the forest (Fig. 2). As long as the central clearing (FF, compare Appendix 1) was densely covered by higher herbs and the ponds were still heavily vegetated, we found this species also on this site. After most vegetation was removed and the ponds were deepened, *A. subsigillata* disappeared from the clearing. In BNP most specimens showed a very conspicuous reddish back. The femoral glands were often colored bright red. Males measured up to 73 mm SVL, females up to 78 mm SVL. Juvenile frogs (SVL 16-21 mm) were found exclusively in swampy forest with closed canopy.

As shown by VENCES et al. (2004) *Ptychadena mascareniensis* (DUMÉRIL & BIBRON, 1841) comprises several cryptic species. In West Africa frogs of this complex seem to have a very patchy distribution (RÖDEL & BRANCH 2002). In BNP these frogs were extremely abundant in open areas like FF and SB (compare Appendix 1). Males reached 40-54 mm SVL, females 42-59 mm SVL (Fig. 3). This species, all congeners and *Hoplobatrachus occipitalis* are regularly collected

and sold for human consumption in BNP (B. TOHÉ unpubl. data).

In BNP a smaller *Ptychadena* occurs that is not clearly assignable to a described West African species of this genus. It best fits *Ptychadena pumilio* (BOULENGER, 1920), however, seems to occur in two different morphs or comprises two sibling species. These morphs differ in the position of the vocal sac opening in male frogs and the size and position of presumed pectoral glands. Both forms occur in syntopy. Calls could not be recorded so far. Males reached 36-48 mm SVL, females 30-54 mm, clearly exceeding the known size of *P. pumilio* (compare RÖDEL 2000).

*Phrynobatrachus ghanensis* SCHIÖTZ, 1964 was described from the Bobiri and Kakum reserves in Ghana and was only recently rediscovered in various other forests of south-eastern Ghana (SCHIÖTZ 1964, RÖDEL et al. 2005). Herein we report *P. ghanensis* for the first time from Côte d'Ivoire, thus affirming PERRET (1988) who already predicted a more widespread distribution. This species resembles very much *P. phyllophilus* RÖDEL & ERNST, 2002. It differs from the latter species by a conspicuous wart on the eyelid (not an eyelid cornicle!), a back that seems to be more warty and a distinctive ventral pattern, consisting of black spots (Fig. 4, compare RÖDEL & ERNST 2002). In BNP, it prefers bamboo forest in swampy areas of the primary forests. Males reached 18 mm SVL, females 20 mm.

BNP is the easternmost known site of the recently described *Phrynobatrachus phyllophilus*. In our study area we caught it in syntopy with *P. ghanensis*, often in closed forest under bamboo and on moist leaf litter. The call of both species is similar but can be differentiated by an experienced observer. Unfortunately no recording of the *P. ghanensis* call was sufficiently good for analyses.

As already reported in RÖDEL et al. (2005) an undescribed *Astylosternus* species lives in western Ghanaian and eastern Ivorian forests. This species was also recorded from BNP and will be dealt with in more detail in a separate



Fig. 3. *Ptychadena* aff. *mascareniensis* from the fish farm within Banco National Park.



Fig. 4. *Phrynobatrachus ghanensis*, a species confined to primary swamp forest.

publication. Frogs of this species were caught close to the River Banco and in closed canopy forest at about 1 km from the source of this river in leaf litter. Recorded specimens measured between 30-64 mm SVL.

*Arthroleptis* spp. were common in almost all parts of BNP. According to genetic analysis (A. HILLERS et al. unpubl. data) and voice recordings, BNP harbours two species, neither conspecific with those from western Ivory Coast (e.g. RÖDEL & BRANCH 2002) nor with those from Ghana (RÖDEL & AGYEI 2003, RÖDEL et al. 2005). For a short review of the taxonomic situation in West African *Arthroleptis* spp. see RÖDEL & BANGOURA (2004).

Both BNP species were common in primary and secondary forest. Species 1 was recorded in swampy areas, leaf litter of drier



Fig. 5. *Hyperolius fusciventris lamtoensis* male with female colouration.

parts of the forests and even on dirt roads. Only very open forest parts were not inhabited by this species. After rain, males called also during daytime. The metallic advertisement call was emitted by specimens with and without a black hourglass pattern on the back. Males measured up to 21 mm SVL, females up to 28 mm. The call of the second species sounds similar but is lower in frequency. None of the specimens recorded as species 2 with known calls exhibited a hour-glass pattern on the back. SVL of males was within the range of species 1.

*Hyperolius fusciventris lamtoensis* SCHIØTZ, 1967 was common on all larger stagnant water bodies in open forest or farmbrush situations. Most specimens well fitted SCHIØTZ's (1967) original description. On 4 September 2003 we collected a male (MOR B 03.17, 22.4 mm SVL) at a pond close to the fish farm clearing. It uttered advertisement calls typical for the subspecies, but exhibited a colour



Fig. 6. A new hyperoliid frog from Banco National Park; female (top, photo: D. MAHSBERG) and ventral aspect of male (bottom).

pattern normally typical for females of this subspecies (Fig. 5, compare SCHIØTZ 1967, 1999; RÖDEL 1998).

Our investigations revealed the occurrence of an undescribed treefrog species, representing a new genus, in BNP. This species was first discovered about 30 years ago by J.-J. MORÈRE (J.-L. PERRET in lit.), but never described scientifically. Males are brown to beige with black spots on the back and a small gular gland (Fig. 6). Females are orange to red and have grayish to bright blue eyes (Fig. 6). The iris of males varied from porcelain white to greyish or yellowish brown. Male's advertisement call was very faint and was not audible from more than 3 m away. A separate paper will deal with the description of this species, its phylogenetic relationships and its natural history. We collected 38 specimens at night on trees and on grass or reed



Fig. 7. Forest edge with water filled ditch in the Banco National Park. The right part of the picture shows part of the central clearing with the fish farm. The new hyperoliid species was often encountered in the lower shrub stratum at the forest edge.

at 0.5-1.5 m high. This frog called in swampy forest areas, at heavily vegetated ponds or on dense bushes along small creeks and puddles (Fig. 7).

Status of the anurans of Banco National Park: Half of all recorded species (14) have distributions beyond West Africa. The other half is restricted to West Africa, the majority of these being endemic (35.7%) to the Upper Guinea forest zone (UG). From the latter 10 species, five are restricted to the eastern part of the UG (*Phrynobatrachus ghanensis*, *Arthroleptis* spp., *Astylosternus* sp., new treefrog). In terms of conservation value these species are the most important BNP anurans. This especially concerns the new treefrog, which might be even endemic to BNP.

The BNP percentage of West African and UG endemics was very low compared to other West African forest regions. In western Ghanaian forests about 45% of the anurans are endemic to UG, and almost two thirds of the species are endemic to West Africa (RÖDEL et al. 2005). Similar percentages were observed in south-eastern Guinea were between 42-53% of the recorded species are UG endemics (RÖDEL et al. 2004).

With  $8 \pm 5$  ( $x \pm sd$ ) species per study site, overall species richness in BNP was very poor. However, it is well possible that the fauna of a particular transect was not suffi-

ciently sampled (compare above). The US and FF areas, as well as transects 5 and 6 (see Appendix 1) had highest species richness (Table 1), and were close to the range of species diversity in primary forest transects in Tai National Park (RÖDEL & ERNST 2004, VEITH et al. 2004). The overall species richness of BNP, which can be regarded as sufficiently sampled as a whole, is the lowest of all the protected Ivorian areas so far investigated. Highest species richness in BNP occurred in either swampy forest areas or sites that comprised a mixture of real forest and altered habitats, resulting in respective mixtures of species. The majority of the recorded species (21) were farmbrush and savannah species. The presence of these, in particular that of *Bufo maculatus*, *B. regularis*, *Hoplobatrachus occipitalis*, *Phrynobatrachus accraensis*, *Ptychadena bibroni*, *P. cf. pumilio*, *Afrixalus dorsalis*, and *Hyperolius concolor*, clearly indicates that the BNP is already heavily impacted and that at least parts of the forest system are no longer natural. Only 17 of the recorded BNP species can be regarded as “real” forest anurans. In a species similarity analysis (M.-O. RÖDEL & M. WEGMANN unpubl. data) BNP grouped together with an other altered Ivorian forest site: Mont Péko National Park (RÖDEL & ERNST 2003). These two sites were most similar to forests from western Ghana (RÖDEL et al. 2005).

Even more astonishing than the comparatively low species richness *per se*, is the apparent absence of many species, otherwise widely distributed in forests east and west of BNP. These normally very common species are e.g.: *Cardioglossa leucomystax*, *Phrynobatrachus alleni*, *P. plicatus*, *P. gutturosus*, *Chiromantis rufescens*, *Afrixalus nigeriensis*, *Hyperolius sylvaticus*, and *Leptopelis occidentalis*. Other less common species, which however could also have been expected for BNP are the caecilian *Geotrypetes seraphini*, and the anurans: *Bufo togoensis*, *B. superciliaris*, *Hemismus guineensis*, *Amnirana occidentalis*, *Phrynobatrachus viliersi*, *P. annulatus*, *Acanthixalus sonjae*, *Hyperolius viridigulosus*, *H. laurenti*, and

*Phlyctimantis boulegeri* (compare e.g. RÖDEL et al. 2005). We even failed to record one species that was described from BNP: *Kassina arboricola* (PERRET 1985). During the eight month of prospecting and monitoring in various habitats of BNP, no signs of these species were noted. During some times, i.e. the large rainy season, no prospecting of BNP was possible due to the recent political unrest in Côte d'Ivoire. It is thus possible that we missed to record species that are only or predominantly active during these periods. Others like the caecilian or *Hemismus* and *Acanthixalus* are normally rare or hard to find and hence may have escaped our attention because of these reasons. However, species like various *Phrynobatrachus* and hyperoliid treefrogs are normally quite easy to assess. Their absence in our data thus seems to be real.

RÖDEL & AGYEI (2003) showed that species richness generally decreased from the western towards the eastern part of the UG. However, RÖDEL et al. (2005) recently could provide herpetological evidence (high species richness and the presence of various endemic species) for a forest refugium in western Ghana / eastern Côte d'Ivoire. The depauperated anuran fauna of BNP thus requires alternative explanations. The most likely one is the comparatively small size of this reserve and / or the potentially enormous environmental impact of the surrounding mega-city Abidjan. This may have already resulted in the extinction of several amphibian species. Although these hypotheses are hard to prove, the presented results of our work in BNP underline the necessity of much more attention towards the eastern Ivorian forests and respective, sustainable conservation measures. Especially in the light of rumours that the few remaining forests in eastern Côte d'Ivoire, until recently protected by a German-Ivorian joint project, will be logged in the near future, this is more urgent than ever.

The species composition of BNP indicates that this forest still possesses a high potential in the conservation of forest am-



phibians. However, the presence of many disturbance indicators and the absence of many forest species is a pressing hint to enhance and improve conservation measures for this most valuable forest relict. Banco National Park, due to its position within Abidjan also has a huge educational potential for a better national understanding of the biodiversity and the conservation needs within Côte d'Ivoire.

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## Appendix 1

Geographic position and short description of study sites in in Banco National Park. BT = Banco transect.

No.	Geographic position	Description
BT1	05°21'49" N / 04°02'40" W	dense forest with some clearings, located at 200 m of the main entry of the park
BT2	05°21'59" N / 04°02'59" W	at 500 m of BT1, crossed by a dirt road, dense forest, no open water
BT3	05°22'59" N / 04°02'56" W	located at 600 m of BT2, habitat similar to BT1
BT4	05°22'26" N / 04°03'10" W	located at the entry of the arboretum, > 1.5 km from BT3, open forest, swampy areas covered, bamboo areas
BT5a	05°23'12" N / 04°03'09" W	swampy forest, located about 50 m of the central clearing with the fish farm, close to River Banco
BT5b	05°23'12" N / 04°03'09" W	habitat similar to BT5a, runs along Banco River, comprises swampy areas and dry forest, large plots of bamboo forest
BT6	05°23'05" N / 04°03'06" W	very swampy part of the forest, partly inundated during the wet season, the water might be flowing
BT7	05°23'15" N / 04°03'18" W	large forest gap with a hill, swampy forest borders the River Banco
BT8	05°23'38" N / 04°03'24" W	dense forest without open water, located 700 m of BT7
BT9	05°23'05" N / 04°02'57" W	closed canopy forest, undulating terrain with many small hills and deeper valleys
BT10	05°22'56" N / 04°03'30" W	forest similar to BT, no open water
BT11	05°22'41" N / 04°03'57" W	dense forest with deeper valleys, located 500 m of BT10
BT12	05°22'37" N / 04°03'59" W	in 200 m distance of the similar BT11
BT13	05°24'06" N / 04°01'21" W	similar to BT1, water filled tracks
BT14	05°24'02" N / 04°01'11" W	100 m distance to the similar BT13, fewer water filled tracks

## The anurans of the Banco National Park, Côte d'Ivoire

BT15	05°24'16" N / 04°01'31" W	heavily degraded forest with open canopy, three larger ponds that are polluted due to the nearby mechanics quarter, corn, manioc, and yam plantations
US	05°24'03" N / 04°03'51" W	dense and open forests, natural gaps, borders the River Banco, river's source in about 700 m distance, larger pond
FF	05°23'06" N / 04°03'06" W	central clearing with 16 artificial ponds, partly open, partly heavily vegetated and only with shallow water, temporary and perennial waters (the latter stocked with <i>Tilapia</i> fish), flowing creek crosses clearing and runs along forest, surrounded by swampy forest, the River Banco and bamboo plots
SB	05°21'41" N / 04°02'32" W	located at the main entry of the Park, open zone covered by grass, heavily degraded and water polluted due to the „Fanico“ launderers, people that use the river for religious rituals or car washing
HDS	05°24'21" N / 04°01'18" W	often flooded, partly populated, large water reservoir

### Appendix 2

Anuran voucher specimens from Banco National Park stored in the research collection of M.-O. RÖDEL and the Staatliches Museum für Naturkunde Stuttgart (SMNS): **Bufonidae**: *Bufo maculatus*: B 03.9; **Ranidae**: *Aubria subsigillata*: B 5, B 03.5, Ba 04.4-5; *Amnirana albolabris*: B 03.8; *Ptychadena aequiplicata*: Ba 04.18; *P. bibroni*: B04.2; *P. longirostris*: B 04.1; *P. aff. mascareniensis*: B 03.1, B 03.4, B 03.6, Ba 04.17; *P. cf. pumilio* 1: Ba

04.19; *P. cf. pumilio* 2: Ba 04.20; **Petropedetidae**: *Phrynobatrachus ghanensis*: B 2-4, B 03.14, B 03.22-25, Ba 04.9, Ba 04.12-15; *P. liberiensis*: B 1, B 03.7; *P. phyllophilus*: Ba 04.16; **Arthroleptidae**: *Arthroleptis* spp: B 1, Ba 03.13, B 04.6-8, B 03.16, Ba 04.10-11; **Astylosternidae**: *Astylosternus* sp.: Ba 04.21-26; **Hyperoliidae**: *Afrixalus dorsalis*: B 03.19; *Hyperolius concolor*: B 03.15; *H. fusciventris lamtoensis*: B 03.17, B 03.20-21; *H. guttulatus* B 03.2-3; undescribed treefrog: B 03.18-19, Ba 04.1-3, SMNS 11939-40, SMNS 82796.

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