

The taxonomic status of two West African *Leptopelis* species: *L. macrotis* Schiøtz, 1967 and *L. spiritusnoctis* Rödel, 2007 (Amphibia: Anura: Arthroleptidae)

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Abstract

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We herein examine the taxonomic status of two West African forest-dwelling *Leptopelis* species. The small *L. spiritusnoctis*, described from the Upper Guinean forests of West Africa, was recently synonymized with *L. aubryi*, described from Gabon. The large *L. macrotis*, known from Ghana to Sierra Leone, was downgraded to a subspecies of *L. millsoni*, ranging from the Niger Delta to eastern Democratic Republic of Congo. These taxonomic decisions are in contrast to the general biogeographic pattern of African forest anurans and we consequently tested if the morphologically similar taxon pairs are indeed conspecifics by applying acoustic and molecular techniques. Both techniques confirmed that populations from West Africa differ significantly from their Central African morphological equivalents. Consequently, we herein resurrect *L. spiritusnoctis* as a valid species. The acoustic data indicate that *L. aubryi* may comprise a complex of cryptic species. We further advocate using the name *L. macrotis* for West African and *L. millsoni* for Central African populations of these larger arboreal frogs. However, we had neither genetic nor acoustic data from the type locality of *L. millsoni* available and could not clarify if these frogs belong to the more western or eastern taxon or even represent a Nigerian endemic. Thus, it is possible that West African populations need to be termed *L. millsoni* in the future. For populations east of the Cross River, Nigeria, the name *L. guineensis* would be available.

Introduction

In many older and recent herpetological papers the term West Africa is used to describe a region, ranging approximately from Senegal in the northwest, along the western coast of the continent to Gabon, or even further south to northern Angola. However, recent investigations showed that the Upper and parts of the Lower Guinean forests, as defined based on plant distributions (see Udvardy 1975, White 1983), comprise very unique amphibian faunas (Penner et al. 2011). The two zoogeographic regions, West and Central Africa, are roughly separated by the Cross River in easternmost Nigeria (Schiøtz 1967, Penner et al. 2011). However, it is presumably not this river, but a tongue of the Atlantic Ocean that reached far inland from ca. 50 to 100 MA (Scotese 2001) and has acted as a zoo-

geographic barrier. The amphibian faunas east and west of this salt water barrier could thus independently evolve for at least that time span. Nowadays, this is visible in ecologically and most often also morphologically very similar but distinct forest species in almost all groups of anuran amphibians: e.g. Bufonidae (e.g. Perret and Amiet 1971, Rödel and Ernst 2000, Barej et al. 2011), Arthroleptidae (e.g. Blackburn et al. 2008, 2009, 2010, Ernst et al. 2008), Phrynobatrachidae (e.g. Lamotte and Xavier 1966, Zimkus et al. 2010), Hyperoliidae (e.g. Schiøtz 1967, 2007, Seymour et al. 2001, Rödel et al. 2003) and Ranidae (e.g., Perret 1977, Rödel and Bangoura 2004).

Biogeographic subdivisions are even found within West Africa (Schiøtz 1967, Penner et al. 2011). Only very few forest anuran species are still believed to be distributed in the Upper and Lower Guinea forest bioregion

(Rödel and Ernst 2001, Rödel et al. 2002, Schiøtz 2007). However, in most cases there is already unpublished evidence that they actually comprise complexes of cryptic species, supporting the above sketched biogeographic borders (Rödel et al. unpubl. data). This biogeographic separation of ranges also applies for all forest-dwelling species of the predominantly arboreal arthroleptid genus *Leptopelis* (compare e.g. Schiøtz 1999, 2007 although there might be an overlap in southern Nigeria, see discussion). Thus, it was very surprising that in his seminal book on the treefrogs of Cameroon, Amiet (2012) synonymized a West African forest *Leptopelis*, *L. spiritusnoctis* Rödel, 2007, type locality Taï National Park, Ivory Coast (Rödel 2007), with a species known from central African forests, *L. aubryi* (Duméril, 1856), type locality Gabon (Duméril 1856, Guibé 1950). Amiet (2012) further downgraded another West African forest-dwelling species, *L. macrotis* Schiøtz, 1967, only known from the western part of the Upper Guinean forests (Schiøtz 1999, type locality: Gola Rainforest National Park, Sierra Leone), to a subspecies of the mostly central African *L. millsoni* (Boulenger, 1895), type locality being the Niger Delta, Nigeria (Boulenger 1895). These taxonomic conclusions were based on morphological similarities and the (visual) comparisons of published call descriptions (Amiet 2012). If the mentioned taxa are indeed conspecific, they would constitute very remarkable exceptions from the above outlined general biogeographic pattern in African forest anurans.

As detailed morphological descriptions of these species show, they are morphologically very similar to each other (Perret 1962, Schiøtz 1967, 1999, Rödel 2007; Amiet 2012, Figs 1 & 2). However, frogs of this genus are often only offering few and delicate morphological differences (Schiøtz 1967, 1999, Amiet 2012, Frétey et al. 2012). We thus tested Amiet's (2012) conclusions, using molecular

techniques and detailed comparisons of call characteristics. Both methods are well established to clarify the taxonomic status of anurans when morphology alone is not very informative (Schiøtz 1973, Vieites et al. 2009).

Material and methods

Origin of specimens. Specimens of all four species have been collected by ourselves in various West African countries and Cameroon, respectively, or were obtained from the collections of the Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK) and the Museum für Naturkunde, Berlin (ZMB; see Table 1). Vouchers were euthanized in a chlorobutanol solution and thereafter preserved in 70% ethanol and deposited in the collections mentioned above. Tissue samples (toe tips, muscle or liver samples) were separately stored in pure ethanol.

Molecular data. We analyzed 454 and 522 base pairs (bp) of the mitochondrial 16S ribosomal RNA gene (Table 1). DNA was extracted using either QIAamp or DNeasy tissue extraction kits (Qiagen) or High Pure PCR Template Preparation kits (Roche). We used the primers 16SA-L and 16SB-H of Palumbi et al. (1991) to amplify the 16S rRNA gene. Standard PCR protocols were used and PCR products were purified using QIAquick purification kits (Qiagen) or High Pure PCR Product Purification kits (Roche). Purified templates were directly sequenced using an automated sequencer (ABI 377 or ABI 3100). Sequences were aligned using ClustalX (Thompson et al. 1997; default parameters) and manually checked using the original chromatograph data in the program BioEdit (Hall 1999). Uncorrected pairwise sequence divergence was calculated using PAUP* 4beta10 (Swofford 2001).

Table 1. Origin, museum collection and GenBank accession numbers of the four West and Central African *Leptopelis* species compared herein.

Species	Catalogue	GenBank #	Locality	Country
<i>L. aubryi</i>	ZFMK 73157	KF888326	Barrage de Tchimbélé	Gabon
<i>L. aubryi</i>	ZFMK 73236	KF888327	Fougamou	Gabon
<i>L. aubryi</i>	ZFMK 75456	KF888328	N'guégué	Cameroon
<i>L. aubryi</i>	ZFMK 87728	KF888329	Nkoelon	Cameroon
<i>L. aubryi</i>	ZFMK 89560	KF888330	Big Massaka	Cameroon
<i>L. aubryi</i>	ZFMK 89562	KF888331	Big Massaka	Cameroon
<i>L. spiritusnoctis</i>	ZMB 79578	KF888332	near Banambala	Guinea
<i>L. spiritusnoctis</i>	ZMB 79579	KF888333	near Gbanshue	Liberia
<i>L. spiritusnoctis</i>	ZMB 79580	KF888334	Mt. Jideh	Liberia
<i>L. spiritusnoctis</i>	ZMB 79581	KF888335	Sapo National Park	Liberia
<i>L. spiritusnoctis</i>	ZMB 79582	KF888336	Sapo National Park	Liberia
<i>L. spiritusnoctis</i>	ZMB 79583	KF888337	Sapo National Park	Liberia
<i>L. macrotis</i>	ZMB 79584	KF888338	near Gpaole	Guinea
<i>L. macrotis</i>	ZMB 79585	KF888339	near Yomou	Guinea
<i>L. macrotis</i>	ZMB 79586	KF888340	Sapo National Park	Liberia
<i>L. macrotis</i>	ZMB 79587	KF888341	Mt. Jideh	Liberia
<i>L. millsoni</i>	ZFMK 87708	KF888342	Nkoelon	Cameroon

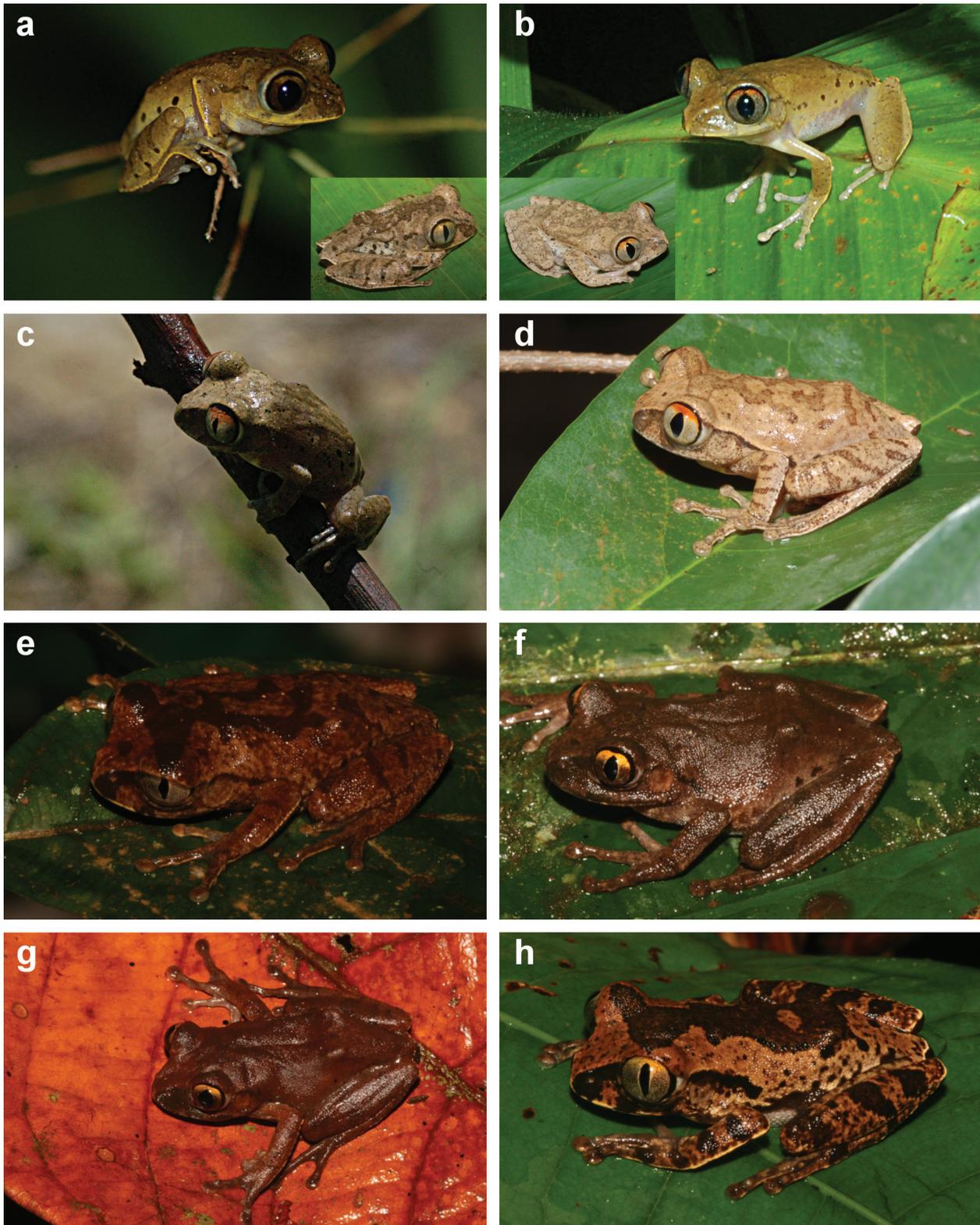


Figure 1. Life coloration and morphology in *Leptopelis aubryi* (a-c) and *L. spiritusnoctis* (d-h); a) *L. aubryi*, ZFMK 89562, call analyzed herein, and b) ZFMK 89560, call analyzed herein, both frogs from Big Massaka, Cameroon, large pictures color during night, inlet pictures color during daytime; c) *L. aubryi* (ZFMK 87728) from Nkoelon, Cameroon; d) *L. spiritusnoctis* (ZMB 79578) from Banambala, Guinea; e) *L. spiritusnoctis* (ZMB 79580) from Mt. Jideh, Liberia; f-h) *L. spiritusnoctis* (ZMB 79581-583) from Sapo National Park, Liberia.

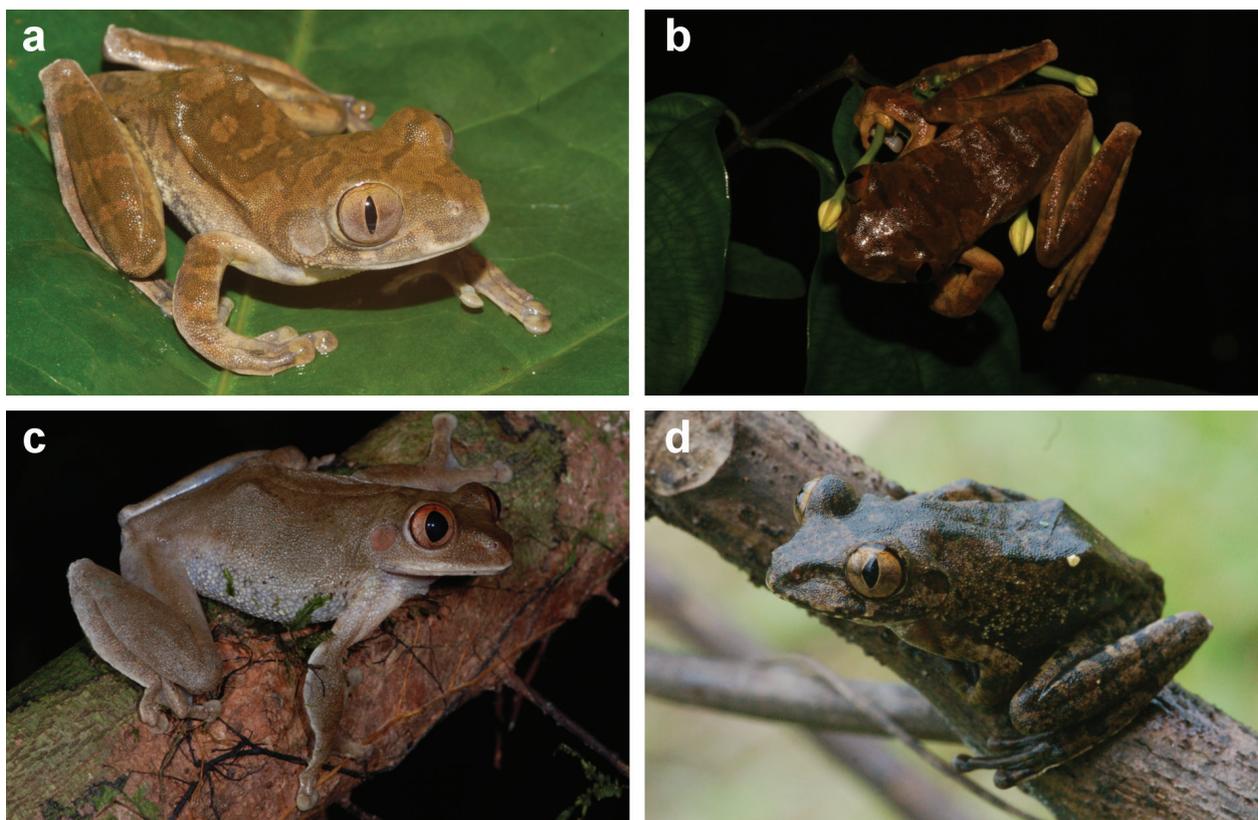


Figure 2. Life coloration and morphology in *Leptopelis macrotis* (a-c) and *L. millsoni* (d); *L. macrotis* from a) Yomou, Guinea (ZMB 79585); b) Mt. Jideh, Liberia (ZMB 79587); c) Gola Rainforest National Park, Sierra Leone (type locality, not collected); d) *L. millsoni* from Nkoelon, Cameroon (ZFMK 87708).

Acoustic data. Calls were either recorded by ourselves (various different recorders) and analyzed (44.1 kHz sample ratio, 16 bits resolution, FFT length = 256) with the software Soundruler 0.9.6 (Gridi-Papp 2007), extracted from the original call collection of A. Schiøtz (analyzed like our own recordings) or data have been gathered from literature (Schiøtz 1967, 1999, Amiet and Schiøtz 1974, Bosch et al. 2000). Values are presented as mean \pm standard deviation; figures were prepared using the Soundruler 0.9.6 (Gridi-Papp 2007). The majority of collected call characteristics are mainly used by females to discriminate between conspecific and heterospecific calls (Duellman and Trueb 1986, Gerhardt 1991, Littlejohn 2001, Ryan and Rand 2001). Thirteen call characteristics were measured: call duration, minimum frequency, maximum frequency, overall frequency range, dominant frequency, fundamental frequency, start value of dominant frequency, end value of dominant frequency, change in dominant frequency, number of pulses per call, pulse duration, interval of pulses and pulses per second.

Results

Molecular data. We analyzed 454 bp of the mitochondrial 16S ribosomal RNA gene for the *L. macrotis* / *L. millsoni* comparison and 522 bp for the *L. spiritusnoctis* / *L. aubryi* comparison. The uncorrected pairwise sequence

divergence between *L. aubryi* (N = 6) and *L. spiritusnoctis* (N = 6) ranged from 5.74–6.56% ($6.23 \pm 0.22\%$; N = 36). The intraspecific variation in *L. aubryi* ranged from 0–2.12% ($0.86 \pm 0.94\%$; N = 15). The intraspecific variation in *L. spiritusnoctis* ranged from 0–0.62% ($0.27 \pm 0.23\%$; N = 15). The uncorrected pairwise sequence divergence between *L. macrotis* (N = 4) and *L. millsoni* (N = 1) ranged from 11.07–11.30% (mean \pm sd: $11.24 \pm 0.12\%$; N = 4). The intraspecific variation in *L. macrotis* ranged from 0–0.22% ($0.11 \pm 0.12\%$; N = 6).

Acoustic data. For *L. aubryi* and *L. spiritusnoctis* we could analyze the “chuck” (Fig. 3) and “buzz” (Fig. 4) calls (compare Amiet and Schiøtz 1974 and Grafe et al. 2000 for intraspecific call variability in *Leptopelis*). Both call types showed distinct differences in a variety of different call characteristics between populations of different origin (Table 2). At first sight the “chuck” call of *L. aubryi* (N = 22) and *L. spiritusnoctis* (N = 13) looked similar (Schiøtz 1967). Both calls are short single notes. However, the call of *L. spiritusnoctis* (Ivory Coast) was almost twice as long (18.8 ± 4.2 ms) compared to the chuck of *L. aubryi* (10.0 ± 2.0 ms) from Cameroon (Fig. 3). Likewise the dominant frequency differed between these populations (Table 2). The “buzz” call of these two species also showed differences. The “buzz” of *L. spiritusnoctis* (N = 22) was longer (334.5 ± 122.5 ms) than in *L. aubryi* (duration 51–105 ms; N = 3) and comprised more pulses (Fig.

Table 2. Comparison of call characteristics of *Leptopelis spiritusnoctis* and calls assigned to *L. aubryi* (compare text). “Chucks” are interpreted as advertisement calls whereas “buzz” are regarded as territorial calls (compare Grafe et al. 2000). We summarize the mean \pm standard deviation values (range if only two values available) of call duration (CD); minimum frequency (minF); maximum frequency (maxF); frequency range (FR); dominant frequency (DF); fundamental frequency (FF); start value of the dominant frequency (sDF); end of the dominant frequency (eDF); change in frequency (CF); number of pulses per call (PC); pulse duration (PD); pulse interval (PI) and pulses per second (Pps). All call duration values are provided in [ms], and frequency values in [Hz], N= sample size (number of calls analyzed). We further provide the country where the calls have been recorded, as well as the data source. A. Schiøtz’s call data were analyzed based on his original recordings. Not all values were available for all recordings.

Species and call type	CD	minF	maxF	FR	DF	FF	sDF	eDF	CF	PC	PD	PI	Pps	Country	source
<i>spiritusnoctis</i> (chuck; N= 13)	18.8 \pm 4.2	2307.7 \pm 46.3	3143.4 \pm 80.5	835.5 \pm 62.5	2726.4 \pm 156.7	2726.4 \pm 156.7	2786.1 \pm 126.0	2660.2 \pm 215.4	(-)125.9 \pm 119.8					Ivory Coast	this paper
<i>aubryi</i> (chuck; N= 4)	43.0 \pm 8.0	1353.0	2019.0	1540.0 \pm 321.0	2049.0 \pm 461.0				162.0 \pm 225.0	13.0 \pm 2.0			281.0 \pm 31.0	Equatorial Guinea	Bosch et al. (2000)
<i>aubryi</i> (chuck; N= 22)	10.0 \pm 2.0	1512.3 \pm 238.4	3771.2 \pm 292.3	2259.1 \pm 440.8	2984.6 \pm 238.0	2984.6 \pm 238.0	3004.2 \pm 249.3	3009.8 \pm 217.2	5.6 \pm 159.8					Cameroon	this paper
<i>aubryi</i> (chuck; N= 1)	35.0	2547.0	3394.0	847.0	2842.0		2842.0	3015.0	173.0					eastern Nigeria	A. Schiøtz
<i>spiritusnoctis</i> (buzz; N= 22)	334.5 \pm 122.5	2525.0 \pm 114.0	3297.9 \pm 86.5	773.0 \pm 122.0	2996.9 \pm 26.2	2996.9 \pm 26.2	2799.5 \pm 43.5	2998.9 \pm 27.5	199.4 \pm 50.6	15.2 \pm 5.5	11.40 \pm 3.43	12.69 \pm 3.49	45.4 \pm 1.1	Ivory Coast	this paper
<i>aubryi</i> (buzz; N= 3)	51.0 – 105.0	2191.0	3562.0	1370.7	2906.3	2906.3	2719.0	2906.0	187.0	2.33 \pm 0.58	3.97 \pm 1.38	46.24 \pm 2.22	0.03 \pm 0.01	Cameroon	this paper

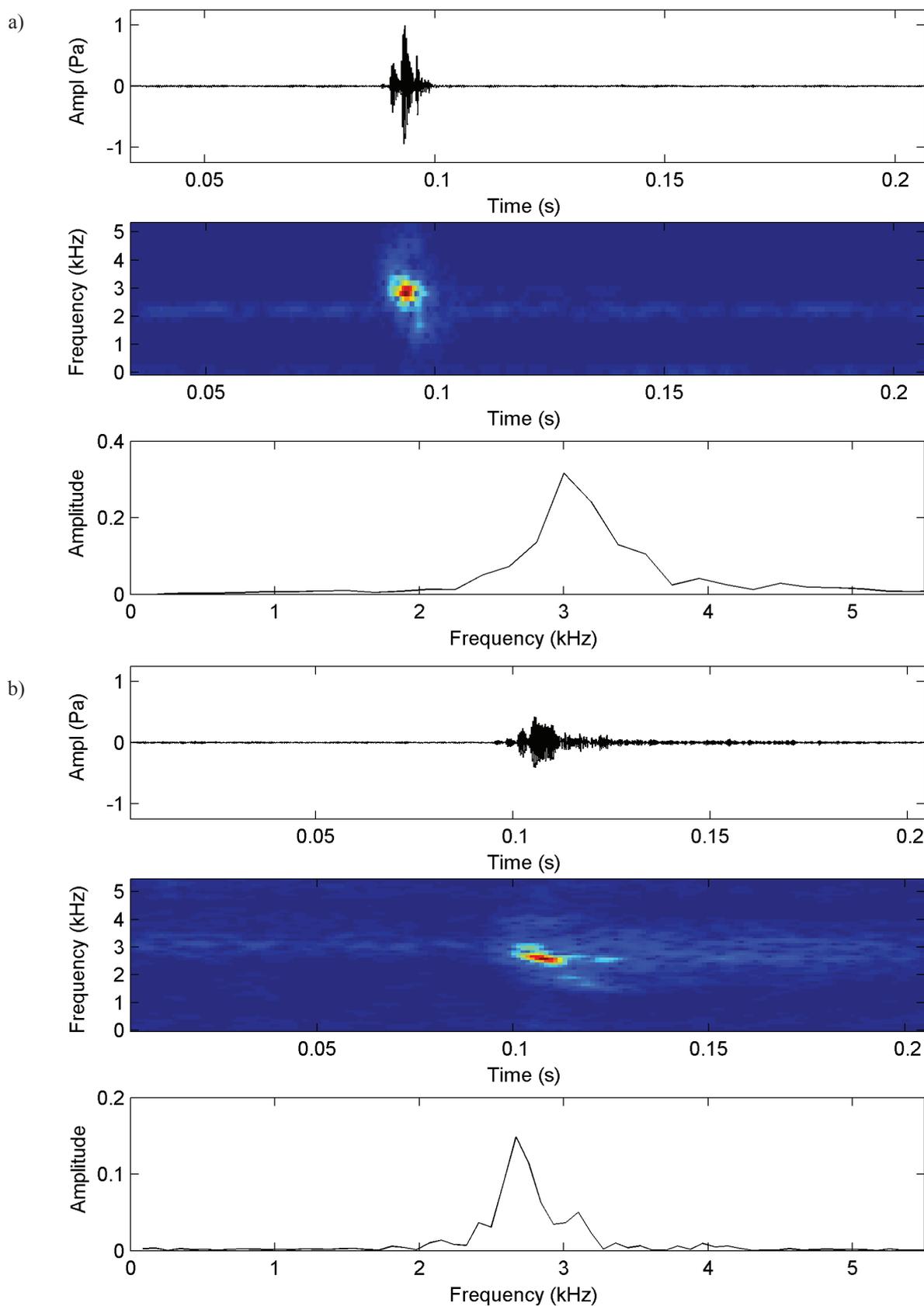


Figure 3. Oscillograms, audio spectrograms and power spectrograms of the “chuck” call of *Leptopelis aubryi* (ZFMK 89560) from Big Massaka, Cameroon (a) and *Leptopelis spiritusnoctis* from Taï National Park, Ivory Coast (b). This audio files are also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following links: a) http://www.tierstimmenarchiv.de/recordings/Leptopelis_aubryi_DIG0174_01_short.mp3 (Suppl. material 2), b) http://www.tierstimmenarchiv.de/recordings/Leptopelis_spiritusnoctis_DIG0174_02_short.mp3 (Suppl. material 5).

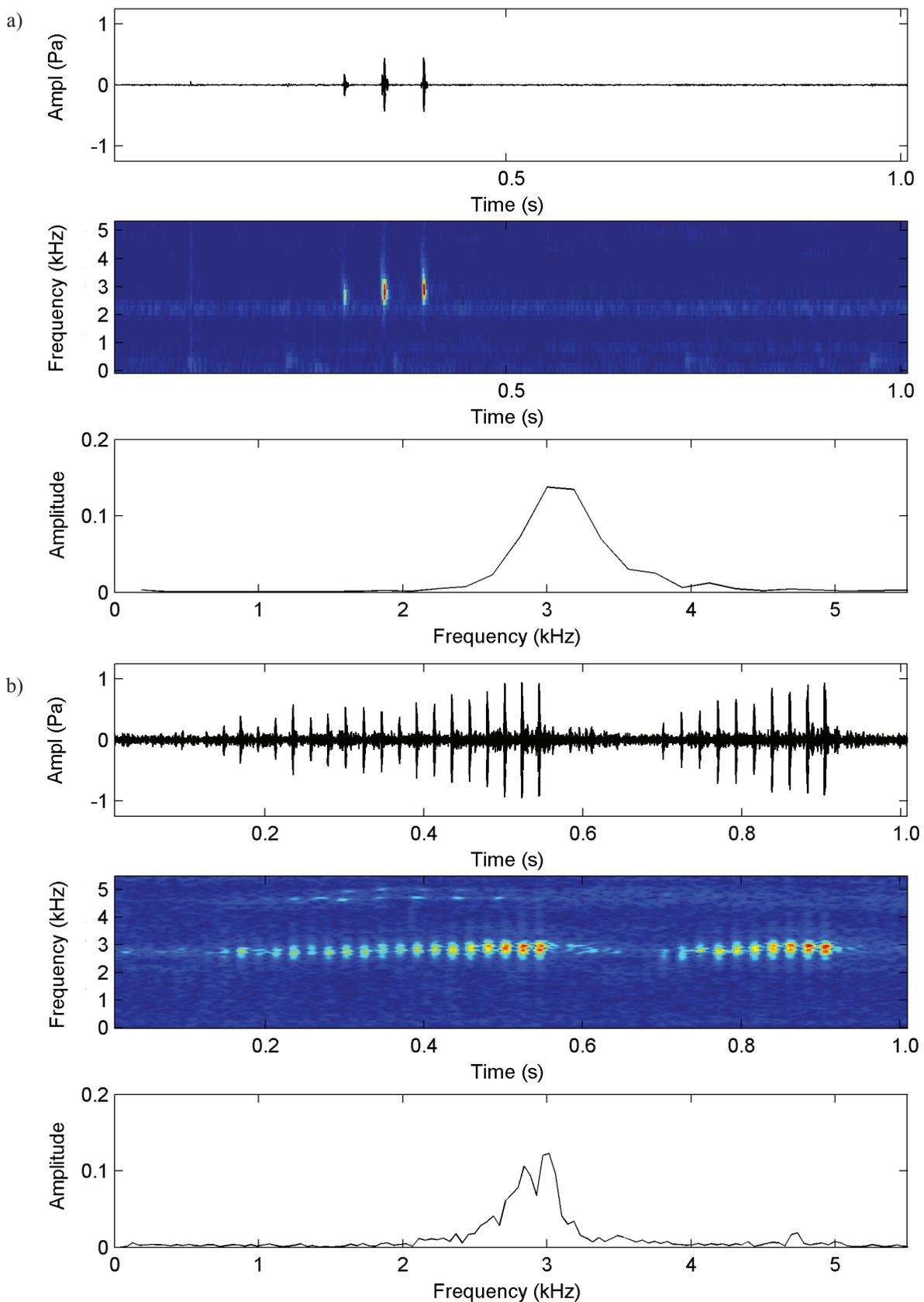


Figure 4. Oscillograms, audio spectrograms and power spectrograms of the buzz calls of *Leptopelis aubryi* (ZFMK 89560) from Big Massaka, Cameroon (a) and of *Leptopelis spiritusnoctis* (two calls) from Tai National Park, Ivory Coast (b). This audio files are also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following links: a) http://www.tierstimmenarchiv.de/recordings/Leptopelis_aubryi_DIG0174_03_short.mp3 (Suppl. material 1), b) http://www.tierstimmenarchiv.de/recordings/Leptopelis_spiritusnoctis_DIG0174_04_short.mp3 (Suppl. material 4).

4; Table 2). However, the “chuck” calls of “*L. aubryi*” from different localities were extremely variable (Table 2). In contrast to our *L. aubryi* records from Cameroon “chucks” from eastern Nigeria and Equatorial Guinea (recordings A. Schiøtz and Bosch et al. 2000, respectively) were three to four times longer than in Cameroon (Table 2) and also differed in the dominant frequencies (Table 2). Some parameters of a particular *L. aubryi* population had similar values compared to *L. spiritusnoctis* calls. However, each “*aubryi*” population showed distinct differences to the *L. spiritusnoctis* calls, which exhibit only very little variation (Table 2; MOR, JP, MFB own experiences of calls heard throughout West Africa).

From *L. macrotis* we only know of one call type (Fig. 5). Our *L. macrotis* calls (N = 3; recorded in Cavally Forest Reserve, Ivory Coast) had the following call characteristics (always: mean \pm sd): call duration 388.0 \pm 19.0 ms; note duration 92.0 \pm 10.0 ms; duration of interval between notes 204.0 \pm 15.0 ms; minimum frequency 1300.3 \pm 18.5 Hz; maximum frequency 2432.0 \pm 19.1 Hz; frequency range 1132.0 \pm 19.1 Hz; dominant frequency and fundamental frequency 1729.8 \pm 22.2 Hz; the dominant frequency starts at 1715.5 \pm 22.2 Hz and ends with 1744.2 \pm 27.2 Hz.

From *L. millsoni* we had no own recording available. The call of *L. millsoni* is described as a nasal “himp”,

consisting of a single tonal long note (approximately 170 ms) with a high frequency range (Amiet and Schiøtz 1974). *L. macrotis* calls, sounding like the meowing of a suffering cat to the human ear (“mmau”), consists of two (instead of one in *L. millsoni*) short, tonal notes with a smaller frequency range. In comparison to the spectra of *L. millsoni* the dominant frequency in *L. macrotis* (approximately 1500 Hz) seems to be similar, but *L. millsoni* may have a much lower fundamental frequency (approximately 250 Hz).

Discussion

The overall morphological and presumed acoustic similarity between *Leptopelis aubryi* with *L. spiritusnoctis* and that of *L. millsoni* with *L. macrotis* (Figs 1 & 2) led Amiet (2012) to consider the West African taxa to be a synonym or subspecies, respectively, of the similar Central African taxon. In fact, this judgment is not new and in particular *L. spiritusnoctis* (termed *L. hyloides* prior to Rödel 2007, see Rödel 2007 for discussion of the taxonomic history of this taxon) was treated as a synonym of *L. aubryi* (e.g. Lamotte and Perret 1961, Schiøtz 1963, Perret 1966). Likewise, West African populations (e.g. from south-eastern Guinea) of the large forest *Leptopelis*

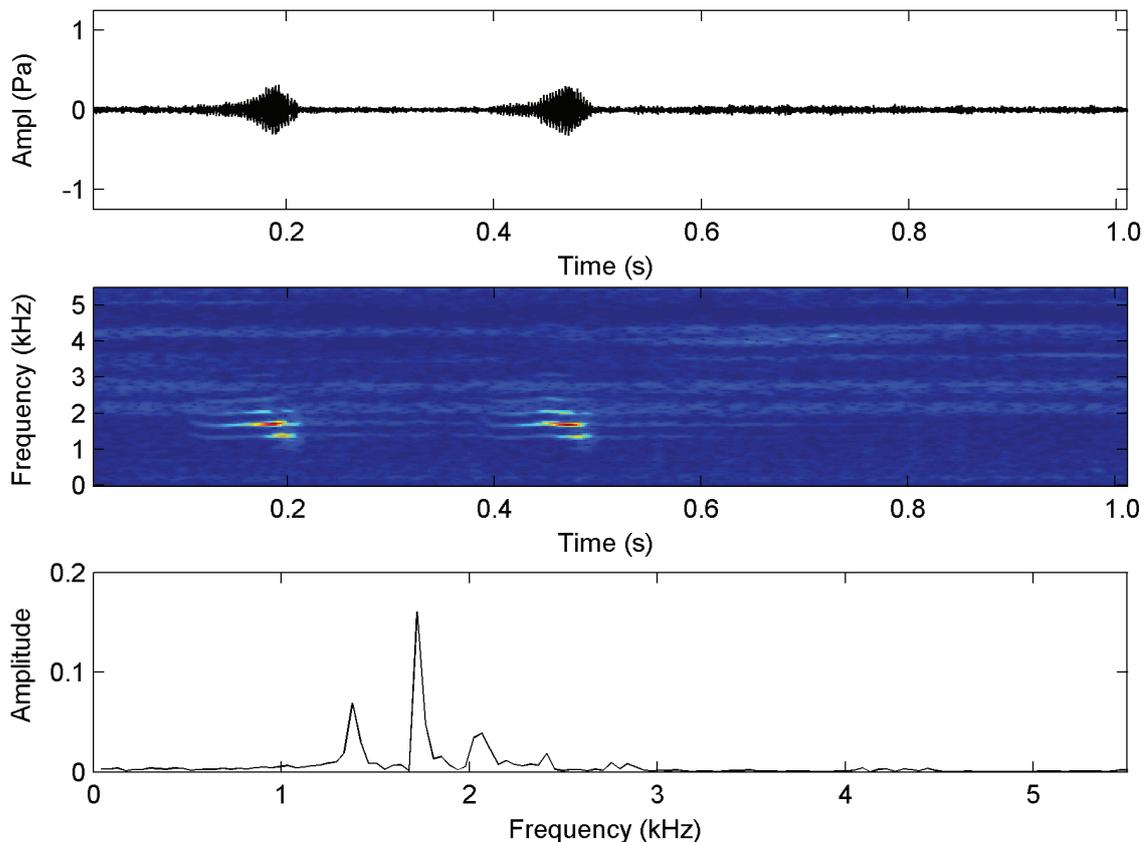


Figure 5. Oscillograms, audiospectrograms and power spectrograms of the advertisement call (“mmau”) of *Leptopelis macrotis* from Cavally Forest Reserve, Ivory Coast. This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link http://www.tierstimmenarchiv.de/recordings/Leptopelis_macrotis_DIG0174_05_short.mp3 (Suppl. material 3).

have been assigned to *L. millsoni*, until Schiøtz (1967) described them as a distinct species. Thus, we can see the reasoning for the doubts on the validity of these two species. In contrast, as already outlined in the introduction, the distribution of the forest anurans, *L. millsoni* and *L. aubryi*, far into West Africa would be a remarkable exception from the almost general biogeographic pattern of western African anuran species (compare Schiøtz 1967, 2007, Penner et al. 2011).

Nevertheless, the Cross River in eastern Nigeria is not an all-or-nothing barrier, and a few Central African forest anurans indeed managed to occur further West reaching the Niger Delta or even beyond (e.g. *Hymenochirus boettgeri*, *Amietophrynus camerunensis*, *Nectophryne afra*, *Conraua crassipes*, *Acanthixalus spinosus*, *Afrixalus paradorsalis*; Akani et al. 2004, Onadeko and Rödel 2009). Also a few species of the Upper Guinean forests managed to cross the Dahomey Gap (a natural forest gap at the Gulf of Guinea coast roughly aligned with the countries Togo and Bénin; see Schiøtz 1967, Penner et al. 2011) to the east and reach the Niger River (e.g. *Leptopelis* cf. *occidentalis*, *Phrynobatrachus* cf. *plicatus*; Onadeko and Rödel 2009) or even Cameroon (e.g. *Hyperolius concolor*, *H. guttulatus*, *H. fusciventris*, *Phlyctimantis boulengeri*; Schiøtz 1967, 1999). The latter are farmland species (species tolerating forest degradation and commonly are most abundant in the forest-savanna ecotone; Schiøtz 1967, 1999, Rödel 2000, Rödel and Ernst 2001) and thus not strictly bound to forest vegetation and respective barriers (compare Schiøtz 2007), although different subspecies of the *Hyperolius* species are accepted to occur in West and Central Africa (e.g. Schiøtz 1967, 2007). The four *Leptopelis* species treated in this paper are strictly forest-dwelling.

Our molecular and acoustic data presented herein, clearly support the view that West and Central Africa comprise distinct anuran faunas, including the *Leptopelis* populations in question. The genetic distances between *L. aubryi* and *L. spiritusnoctis* in the studied 16S gene fragment (5.74–6.56%) and *L. millsoni* and *L. macrotis* (11.07–11.30%), respectively, by far exceed the values which are commonly assumed to indicate distinct species (3–5% in 16S; see Vieites et al. 2009 for general statement and e.g. Blackburn et al. 2008, Zimkus 2009, Rödel et al. 2012a, Zimkus and Gvodzík 2013 for values between distinct western African anuran species). Furthermore, our detailed call analyses revealed distinct differences between these taxa in almost all examined call parameters, in particular in parameters with low intraspecific variability (i.e. fundamental frequency, dominant frequency, call duration; Gerhardt 1991, Ryan and Rand 2001). That *L. spiritusnoctis* and *L. aubryi* have very different calls was already mentioned by Schiøtz (1967, 1999) and Amiet and Schiøtz (1974). In contrast Amiet and Schiøtz (1974) regarded the calls of *L. millsoni* and *L. macrotis* as almost identical. This could not be confirmed herein.

Taxonomic conclusions. Based on the molecular and acoustic data presented we conclude that synonymizing *L. spiri-*

tusnoctis with *L. aubryi* was not justified and thus resurrect *L. spiritusnoctis* for the small forest-dwelling *Leptopelis* species in the Upper Guinean forest zone (see Rödel 2007 for the distribution). Although our genetic samples of *L. aubryi* from Gabon and Cameroon were relatively similar (maximum difference in the 16S sequence being 2.12%), the large variation of call characteristics in *L. aubryi* might be an indication that this name currently covers a complex of cryptic species, indicating the needs for further taxonomic studies. Various names currently regarded as synonyms of *L. aubryi*, are available (see Frost 2013).

The downgrading of *L. macrotis* as a subspecies of *L. millsoni*, as currently understood, was likewise erroneous. However, the situation is more complex. West and Central African populations clearly represent distinct species. Currently, we cannot decide to which species the name *L. millsoni* (type locality is the Niger delta, geographically a part of the western species assemblage) should be applied. Unfortunately, so far we do not have genetic samples from Nigeria. Thus, we do not know which species occurs in Nigeria and we cannot even exclude that southern Nigeria harbors taxa which are morphologically similar, but distinct on the basis of genetics and acoustics from those adjacent to the east and west (compare e.g. Rödel et al. 2012b). To resolve this problem new material, tissue samples and call recordings, from the *L. millsoni* type locality are needed. If *L. millsoni* would be the valid name for the West African species, the name *L. guineensis* Ahl, 1929 (type: ZMB 20047; type locality: Makomo, Equatorial Guinea) would be available for the Central African species (Ahl 1929, Perret 1962). With respect to taxonomic stability we suggest to continue using the name *L. macrotis* and *L. millsoni* as defined by Schiøtz (1967, 1999) until new material becomes available.

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Supplementary material 1

Buzz call of *Leptopelis aubryi* (ZFMK 89560) from Big Massaka Cameroon

Authors: Mark-Oliver Rödel, Mike Emmrich, Johannes Penner, Andreas Schmitz, Michael F. Barej

Data type: multimedia

Explanation note: This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link: http://www.tierstimmenarchiv.de/recordings/Leptopelis_aubryi_DIG0174_03_short.mp3.

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Link: <http://id.pensoft.net/suppl/efaa4ed0-b67d-11e3-b3d7-677993a45e50>

Supplementary material 2

Chuck call of *Leptopelis aubryi* (ZFMK 89560) from Big Massaka, Cameroon

Authors: Mark-Oliver Rödel, Mike Emmrich, Johannes Penner, Andreas Schmitz, Michael F. Barej

Data type: multimedia

Explanation note: This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link: http://www.tierstimmenarchiv.de/recordings/Leptopelis_aubryi_DIG0174_01_short.mp3.

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Supplementary material 3

Advertisement call of *Leptopelis macrotis* from Cavally Forest Reserve, Ivory Coast

Authors: Mark-Oliver Rödel, Mike Emmrich, Johannes Penner, Andreas Schmitz, Michael F. Barej

Data type: multimedia

Explanation note: This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link: http://www.tierstimmenarchiv.de/recordings/Leptopelis_macrotis_DIG0174_05_short.mp3.

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Supplementary material 4

Two buzz calls of *Leptopelis spiritusnoctis* from Tai National Park, Ivory Coast

Authors: Mark-Oliver Rödel, Mike Emmrich, Johannes Penner, Andreas Schmitz, Michael F. Barej

Data type: multimedia

Explanation note: This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link: http://www.tierstimmenarchiv.de/recordings/Leptopelis_spiritusnoctis_DIG0174_04_short.mp3.

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Supplementary material 5

Chuck call of *Leptopelis spiritusnoctis* from Tai National Park, Ivory Coast

Authors: Mark-Oliver Rödel, Mike Emmrich, Johannes Penner, Andreas Schmitz, Michael F. Barej

Data type: multimedia

Explanation note: This audio file is also available from the Tierstimmenarchiv at the Museum für Naturkunde, Berlin, through the following link: http://www.tierstimmenarchiv.de/recordings/Leptopelis_spiritusnoctis_DIG0174_02_short.mp3.

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