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A new slippery frog (Amphibia, Conrauidae, *Conraua* Nieden, 1908) from the Fouta Djallon Highlands, west-central Guinea

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Abstract

We describe a new species of the genus *Conraua* from the Fouta Djallon Highlands in Guinea. The species is recognised as distinct from nominotypical *C. alleni*, based on morphological evidence and is supported by a recent species delimitation analysis, based on DNA sequence data. The new species is distinguished from its congeners by the unique combination of the following characters: medium body size, robust limbs, only one instead of two palmar tubercles, the first finger webbed to below the first subarticular tubercle, presence of a lateral line system, indistinct tympanum, two subarticular tubercles on fingers III and IV, venter in adults white with dark brown spots or dark brown with grey or whitish spots. The new species differs from all congeners by more than 6% in the DNA sequence of mitochondrial ribosomal 16S. We discuss isolation in Pliocene and Pleistocene forest refugia as a potential driver of speciation in the *C. alleni* complex. We also emphasise the importance of conserving the remaining forest fragments in the Fouta Djallon Region for the preservation of both its unique biodiversity and its valuable water sources for local people.

Resumé

Nous décrivons une nouvelle espèce du genre *Conraua* des hauts plateaux du Fouta Djallon en Guinée. L'espèce est reconnue comme distincte du *C. alleni* nominotypique, sur la base de preuves morphologiques et est soutenue par une analyse récente de délimitation des espèces, basée sur des données de séquence d'ADN. La nouvelle espèce se distingue de ses congénères par la combinaison unique des caractères suivants: taille moyenne du corps, membres robustes, un seul tubercule palmaire au lieu de deux, premier doigt palmaire jusqu'en dessous du premier tubercule subarticulaire, présence d'un système de lignes latérales, tympan indistinct, deux tubercules subarticulaires sur les doigts III et IV, ventre blanc avec des taches brun foncé ou brun foncé avec des taches gris ou blanchâtre chez les adultes. La nouvelle espèce diffère de ses congénères avec plus de 6% de sa séquence d'ADN du ribosome mitochondrial 16S. Nous discutons de l'isolement dans les refuges forestiers du Pliocène et du Pléistocène comme facteur potentiel de spéciation dans le complexe *C. alleni*. Nous soulignons également l'importance de conserver les fragments de forêt restants dans la région du Fouta Djallon pour préserver à la fois sa biodiversité unique et ses sources d'eau précieuses pour les populations locales.

Key Words

Anura, conservation, forest refugia, Upper Guinea forest zone, West Africa

Introduction

The Fouta Djallon is a poorly studied mountainous region in west-central Guinea (Rödel et al. 2021). It is characterised by plateaus with irregular profiles, permanent rivers in deep valleys, steep slopes with waterfalls and an elevational gradient of 1000–1600 m a.s.l. (Young and Young 1992). The proximity to the Atlantic Ocean and south-westerly winds generate higher levels of precipitation than in other parts of West Africa (Kamara et al. 2002; Descroix et al. 2020). Together, the topographic and climatic complexity of Fouta Djallon creates a unique ecoregion with patches of tropical and subtropical moist broadleaf forests in valleys, surrounded by tropical and subtropical grasslands, savannahs and shrublands (ecoregions, *sensu* Dinerstein et al. 2017).

For decades, it has been stated that the Fouta Djallon harbours a large and unique floral diversity and that its conservation should be a priority (Hepper 1968; Schnell 1968). However, the habitats of this area have experienced severe degradation due to agricultural expansion and cattle ranching (Couch et al. 2019, 2020). Several plant species, endemic to the Fouta Djallon, have not been seen in over 60 years and are likely to be extinct (Couch et al. 2019). In contrast to botanical inventories, the fauna of the Fouta Djallon has been largely neglected though there has been some recent progress. For instance, two candidate species of barb fishes, genus *Enteromius*, have been recognised in different basins of the Fouta Djallon (Schmidt et al. 2019). To date, 94 amphibian species are known from Guinea (Channing and Rödel 2019), with 25 species recorded from the Fouta Djallon (Hillers et al. 2008). However, Hillers et al. (2008) suggested this diversity might be higher and this is supported by the subsequent discovery and description of a new *Arthroleptis* (Rödel et al. 2011) and two *Odontobatrachus* species (Barej et al. 2015b). Hillers et al. (2008) also briefly mentioned and figured an enigmatic, likely undescribed species of *Conraua*. This taxon was subsequently listed as a distinct taxon in Channing and Rödel (2019), but it has not yet been formally described.

Seven species of *Conraua* are currently recognised as valid (Neira-Salamea et al. 2021). They are distributed in East (*C. beccarii*), Central (*C. goliath*, *C. crassipes*, *C. robusta*) and West Africa (*C. alleni*, *C. derooi*, *C. sagyimase*). A recent phylogenetic analysis of the genus *Conraua* indicated that the frogs, known as *C. alleni*, actually comprise a species complex, including lineages from the Fouta Djallon (Blackburn et al. 2020). Here, we take a step forward in disentangling the taxonomy of this species complex. Through a combination of comparative morphology and the recent molecular phylogenetic analyses of Blackburn et al. (2020), we describe a new species of *Conraua* that is known from Konkouré Fetto, Hörè Binti and Chute de Ditinn in the Fouta Djallon Highlands, central Guinea.

Materials and methods

We examined four *Conraua* specimens from Konkouré Fetto, five specimens from Hörè Binti and five specimens from Chute de Ditinn, all of which are from the Fouta Djallon Region in Guinea and all are deposited in the collection of the Museum für Naturkunde Berlin, Germany (ZMB). The holotype and two paratypes of the new species were included in the study by Blackburn et al. (2020). All individuals were preserved in 75% ethanol.

For comparison, we examined specimens of all other species of *Conraua*, including 19 specimens of *C. alleni*, three *C. beccarii*, four *C. goliath*, four *C. robusta*, nine *C. crassipes*, 34 *C. derooi* and eight C. *sagyimase.* The comparative material included the holotype of *C. alleni* from the Museum of Comparative Zoology (Harvard University, Cambridge, USA; MCZ), four paratypes of *C. derooi* from the Royal Museum for Central Africa (Tervuren, Belgium; MRAC) and the Muséum national d'Histoire naturelle (Paris, France; MNHN), the holotypes of *C. crassipes*, *C. sagyimase* and *C. robusta* from the ZMB and the holotype of *Rana Griaulei* Angel, 1934 (a synonym of *C. beccarii*) from the MNHN. All comparative material is listed in Appendices 1 & 2. MOR measured the *C. alleni* holotype, the four *C. derooi* paratypes and the *R. Griaulei* holotype. All other data were collected by KNS. To account for potential individual differences when measuring museum specimens, we included only the data collected by KNS in statistical comparisons.

We measured the following morphometric variables: snout–vent length (SVL, from tip of snout to posterior end of vent), head length (HL, from tip of snout to posterior end of head protuberance), head width (HW at corners of the mouth), snout length (SL, from anterior edge of orbit to tip of snout), eye diameter (ED, maximum horizontal diameter), interorbital distance (IOD, shortest distance between upper eyelids), upper eyelid width (UEW, maximum width of upper eyelid), eye to nostril distance (EN, from anterior edge of eye to centre of nostril), eye to snout distance (ES, from anterior edge of eye to tip of snout), internarial distance (IND, between centre of nostrils), tympanum diameter (TD, maximum horizontal diameter), eye to tympanum distance (ETD, from posterior edge of eye to anterior edge of tympanum), crus (tibiofibula) length (TL, from the bent knee to heel), foot length (FL, from the proximal end of tarsus to tip of fourth toe), toe IV length (T4), hand length (HAL, from the proximal edge of the palm to the tip of the finger III), finger III length (F3) and forearm length (FLL). All measurements were taken with a digital calliper (± 0.1 mm) and/or a dissecting microscope and are given in millimetres (mm). Measurements of the type series are presented in Table 1, summarised measurements for the populations of Hörè Binti and Chute de Ditinn are given Table 2.

Sex and maturity were assessed by examination of gonads through an incision in the lateral body wall. Additional qualitative morphological characters that we examined include: tympanum detectability (distinct/indistinct), webbing condition (complete/incomplete), head shape in lateral view (round/pointed/truncated),

Table 1. Measurements [mm] of the type series of *Conraua kamancamarai* sp. nov. (holotype in bold); m = male, f = female, s = sub-adult; SVL = snout–vent length, HW = head width, HL = head length, SL = snout length, ED = horizontal eye diameter, EN = eye to nostril distance, ES = eye to snout distance, IND = internarial distance, IOD = interorbital distance, UEW = upper eyelid width, TD = tympanum diameter, ETD = eye to tympanum distance, TL = crus length, FL = foot length including toe IV, T4 = toe IV length, HAL = hand length, F3 = finger III length, FLL = forearm length; ZMB = Museum für Naturkunde, Berlin.

Voucher ZMB	Sex	SVL	HW	HL	SL	ED	EN	ES	IND	IOD	UEW	TD	ETD	TL	FL	T4	HAL	F3	FLL
78432	**f**	**71.7**	**23.7**	**23.5**	**7.0**	**6.5**	**4.3**	**8.2**	**4.0**	**5.2**	**3.8**	**4.3**	**4.0**	**33.3**	**44.8**	**29.3**	**16.8**	**9.8**	**12.4**
78429	m	56.8	20.3	19.1	5.9	5.8	3.5	6.7	4.6	4.5	3.2	-	-	25.2	35.0	21.1	14.2	8.2	10.4
78430	s	48.6	16.6	17.3	5.4	5.0	3.0	6.3	3.9	4.1	3.1	-	-	21.6	29.1	20.9	12.4	6.4	8.4
78431	s	49.4	19.4	16.8	6.1	5.0	3.7	7.5	4.1	5.0	3.0	-	-	22.3	30.6	22.6	12.6	7.5	8.9

Table 2. Summary measures [mm] of *Conraua kamancamarai* sp. nov. from Hörè Binti and Chute de Ditinn (referred material; total of four males and females, respectively). SVL = snout–vent length, HW = head width, HL = head length, SL = snout length, ED = horizontal eye diameter, EN = eye to nostril distance, ES = eye to snout distance, IND = internarial distance, IOD = interorbital distance, UEW = upper eyelid width, TD = tympanum diameter, ETD = eye to tympanum distance, TL = crus length, FL = foot length including toe IV, T4 = toe IV length, HAL = hand length, F3 = finger III length, FLL = forearm length.

	Sex	SVL	HW	HL	SL	ED	EN	ES	IND	IOD	UEW	TD	ETD	TL	FL	T4	HAL	F3	FLL
mean	f	81.7	28.3	25.1	8.0	7.5	5.4	10.3	6.5	5.8	4.5	5.1	4.9	35.1	52.9	32.2	19.1	11.0	14.6
sd	f	5.6	2.4	3.3	0.6	1.0	0.5	0.9	0.9	1.0	0.9	0.4	2.5	2.7	7.1	6.4	1.6	0.8	0.6
max	f	86.6	31.5	27.6	8.7	8.8	6.1	11.4	7.4	6.7	5.5	5.3	6.7	38.5	62.2	38.3	21.3	12.1	15.2
min	f	74.3	25.9	20.3	7.2	6.5	5.0	9.2	5.3	4.4	3.3	4.8	3.1	32.1	46.5	24.3	17.6	10.2	13.8
mean	m	78.8	26.9	26.2	8.2	7.5	5.3	9.9	6.1	5.9	5.0	4.3	6.3	34.2	42.9	31.7	21.6	13.3	13.4
sd	m	9.7	3.5	2.3	0.6	1.0	0.4	1.3	1.1	0.7	0.7	0.3	3.3	1.5	7.5	8.7	4.0	3.4	2.0
max	m	88.6	30.3	28.3	9.0	8.4	5.7	11.2	7.6	6.9	6.0	4.5	8.6	35.7	49.4	44.0	26.9	18.1	16.4
min	m	70.1	23.2	23.4	7.5	6.6	4.7	8.6	5.0	5.3	4.5	4.1	4.0	32.8	32.2	24.4	17.5	10.1	12.0

relative length of fingers (i.e. comparative lengths were assessed by pressing fingers together and fingers were numbered from pre-axial to postaxial I to IV), presence of an interorbital stripe, colour and shape (curved/straight/slightly-curved) of the supra-tympanic ridge, presence or absence of subarticular tubercles, undivided or divided palmar tubercles, belly and throat colouration in alcohol and presence of a lateral line system (see Lamotte and Perret 1968; Fritzsch et al. 1987). Concerning the nomenclature of these lines (infra-orbital line, supra-orbital line, upper lateral line, lower lateral line, median lateral line, caudal lateral line and jugular line, anterior lower lateral line, posterior lower lateral line and mandibular lateral line), we followed Escher (1925) and Shelton (1970). Colouration of the back in preservation was only specified as being comparatively light or dark. The variation of qualitative morphological characters amongst all *Conraua* species is summarised in Table 3.

For statistical comparisons of morphological characters with the new taxa, we focused on populations of the *C. alleni* complex that were included in the recent phylogeny of the genus (see Blackburn et al. 2020). Our analyses included thirteen individuals of *C. alleni sensu lato* (Table 4, Appendix 2), three individuals from Soyah, Fouta Djallon (Appendix 2) and 10 from Konkouré Fetto, Hörè Binti and Chute de Ditinn, Fouta Djallon. We performed a principal component analysis (PCA) to reduce morphometric variables and explore intraspecific differences of morphometric measurements amongst individuals (Neff and Marcus 1980). A subsequent discriminant function analysis (linear

Table 3. Comparison of qualitative morphological characters of all currently recognised *Conraua* species. All species have completely webbed feet.

Characters	*C. kamancamarai* sp. nov.	*C. alleni*	*C. sagyimase*	*C. derooi*	*C. goliath*	*C. beccarii*	*C. crassipes*	*C. robusta*
Webbing hands	finger I webbed	absent	absent	absent	absent	absent	absent	absent
Palmar tubercle	single	double	double	double	single	single	single	absent
Belly colouration	white with brown spots	white or white with brown mottling	white or white with brown mottling	white or white with brown mottling	mostly yellow	uniform white or grey	uniform white or grey	white or white with brown mottling
Throat colouration	white with brown spots or brown with white or grey spots	white	white with brown mottling	white with brown mottling	white or white with brown mottling	white or white with brown mottling	white or white with brown mottling	white or white with brown mottling
Relative length of fingers	III>IV>II>I	III>IV>II>I	III>IV>II≈I	III>IV>II>I	III>IV>II>I	III>IV>II>I	III>IV>II>I	III>IV>II>I
Snout shape	rounded	rounded	rounded	rounded	pointed	rounded	rounded	rounded
Interorbital stripe	mostly present	mostly present	mostly present	mostly absent	mostly absent	mostly present	mostly present	mostly absent
Supratympanic fold	slightly curved	straight or slightly curved	slightly curved	curved	curved	curved	curved	curved
Lateral line system	present	present	present	present	absent	present	absent	absent
Tympanum visibility	indistinct	indistinct	indistinct	indistinct	distinct	distinct	distinct	distinct

Table 4. Summary measures (in mm) of adult *Conraua alleni*; m = male, f = female, N = sample size; SVL = snout–vent length, HW = head width, HL = head length, SL = snout length, ED = horizontal eye diameter, EN = eye to nostril distance, ES = eye to snout distance, IND = internarial distance, IOD = interorbital distance, UEW = upper eyelid width, TD = tympanum diameter, ETD = eye to tympanum distance, TL = crus length; FL = foot length including toe IV, T4 = toe IV length, HAL = hand length, F3 = finger III length, FLL = forearm length.

	Sex	*N*	*SVL*	*HW*	*HL*	*SL*	*ED*	*EN*	*ES*	*IND*	*IOD*	*UEW*	*TD*	*ETD*	*TL*	*THL*	*FL*	*T4*	*HAL*	*F3*	*FLL*
mean	f	5	58.4	22.3	20.7	5.6	6.5	3.7	7.3	5.0	4.9	3.7	4.0	2.9	28.0	27.6	38.4	24.0	14.9	8.6	10.0
sd	f	5	25.1	9.6	8.8	2.3	2.8	1.7	3.2	2.1	2.1	1.6	1.9	1.5	12.1	11.7	16.6	10.1	6.4	3.7	4.3
max	f	5	68.4	26.4	24.1	6.4	7.5	5.0	9.0	6.0	6.3	4.4	4.4	4.0	33.4	31.9	46.9	28.5	17.8	10.1	12.3
min	f	5	50.9	19.5	18.2	5.0	5.2	3.0	6.3	4.2	4.4	3.4	3.4	2.4	23.6	24.3	32.4	21.8	12.8	7.2	8.0
mean	m	8	55.5	21.5	20.1	5.9	5.9	3.7	7.3	4.5	4.9	3.6	3.5	2.8	26.6	27.3	36.4	23.3	13.5	7.9	10.3
sd	m	8	7.7	2.8	2.9	0.9	0.8	0.5	1.2	0.7	0.7	0.2	0.4	0.5	3.6	3.7	6.7	3.8	2.0	1.1	1.6
max	m	8	71.6	27.3	26.1	7.0	7.4	4.5	9.5	5.7	6.2	4.0	4.1	3.5	34.0	34.0	47.3	30.8	16.5	9.8	14.0
min	m	8	48.3	18.9	16.9	4.7	5.0	3.2	6.2	3.6	4.0	3.3	3.0	2.4	23.4	23.7	28.9	18.6	11.4	6.5	8.8

discriminant analysis, LDA) was used to calculate the reliability of morphological quantitative traits in assigning individuals to the species groups, identified by Blackburn et al. (2020). To visualise morphometric variation independent of SVL, PCA was run on residuals of linear regressions of the measured variables. LDA was applied on raw morphometric measurements including SVL, because the aim of the LDA was to determine the use of all morphometric measurements to distinguish the different lineages (Funk et al. 2012). Both analyses were performed on log-transformed data. In some analyses, we investigated both sexes together because sex is difficult to determine, based on external morphology for most *Conraua* species (see Neira-Salamea et al. 2021). Tympanum diameter (TD) and eye to tympanic distance (ETD) were excluded from the analysis, as the tympanum was not visible in most specimens. Statistical analyses were performed in R version 3.5.1 (R Core Team 2018) using the *prcomp* function for PCA (with values scaled and centered) and *lda* function for LDA from the MASS package (v.7.3-51.3; Venables and Ripley 2002) and for PCA visualisation, we used the function *autoplot* of the ggplot2 package (Wickham 2016).

Results

Based on the multi-locus phylogeny, published by Blackburn et al. (2020), the *Conraua* populations from Fouta Djallon are distinct from *C. alleni*, *C. derooi* and *C. sagyimase*, all of which form a large clade. Uncorrected p-distances of the mitochondrial 16S rRNA fragment (569 bp) revealed high genetic divergence between the populations from Fouta Djallon and all other *Conraua* species. Uncorrected p-distances between the undescribed species from Fouta Djallon and other species is as follows: *C. derooi*, 6%; *C. sagyimase*, 7%; *C. alleni*, 7%; *C. goliath*, 9%; *C. robusta*, 9%; *C. beccarii*, 11%; and *C. crassipes*, 12%. These values are higher than the 3% threshold, usually applied for recognising anuran candidate species (Fouquet et al. 2007; Vieites et al. 2009). Barcoded specimens within the type series (ZMB 78432, 78429, 78430) of the undescribed species had uniform 16S sequences. The genetic distance between these frogs and a population from Soyah (ZMB 90175, 90176), a site well situated within the Fouta Djallon, was about 3% (mean ± sd: 0.0295 ± 0.008, range: 0.028–0.030). Therefore, we excluded the Soyah population from the description of the new species and suggest further bioacoustics analysis to confirm if it belongs to the species described below. The frogs of the type series further showed genetic differences to other populations from the Fouta Djallon. For instance, a specimen from Hörè Binti (ZMB 90177) differed from the type series by 0.9% (this specimen differed from the Soyah population by 0.029% ± 0.0008, 0.028–0.030%). Although we believe that specimens from Hörè Binti and Chute de Ditinn represent the new species, we list and describe material from these locations only as additional referred material.

We analysed morphological characters (Tables 1, 2 and 4) of all lineages of the *C. alleni* complex included in the genus phylogeny (for details, see 'Material and Methods' and Blackburn et al. 2020; for morphological comparisons with other *Conraua* species, see 'Diagnosis' below). Five principal components with eigenvalues > 1.0 (PC1–PC5) accounted for 72.8% of the total character variation (Fig. 1; Table 5). PC1 accounted for 29.3% of the variation and loaded most strongly for eye to snout distance (ES) and crus (tibiofibula) length (TL). PC2 accounted for 14.8% of the variation and loaded negatively most strongly for finger III length (FE) and eye to nostril distance (EN). PC3 was mainly impacted by upper eyelid width (UEW), eye diameter (ED) (both negatively). PC4 was dominated by hand length (HAL, negatively) and interorbital distance (IOD). PC5 loaded most strongly for head length (HL, negatively) and internarial distance (IND). A plot of PC1 versus PC2 showed both large variation amongst individuals, as well as a large amount of overlap between the four genetic lineages included (Fig. 1). However, a subsequent linear discriminant analyses (LDA) of the morphological raw data correctly assigned all individuals to their respective genetic lineage. The characters contributing most to the species assignment were SVL, HL and TL. Coefficients of linear discriminant analysis (LDA) are provided in Table 6.

An unexpected diagnostic character was the number of palmar tubercles. Whereas *C. derooi*, *C. sagyimase* and *C. alleni* have a divided, double palmar tubercle (an outer and a middle one), all *Conraua* populations from the Fouta Djallon exhibit only an undivided palmar tubercle

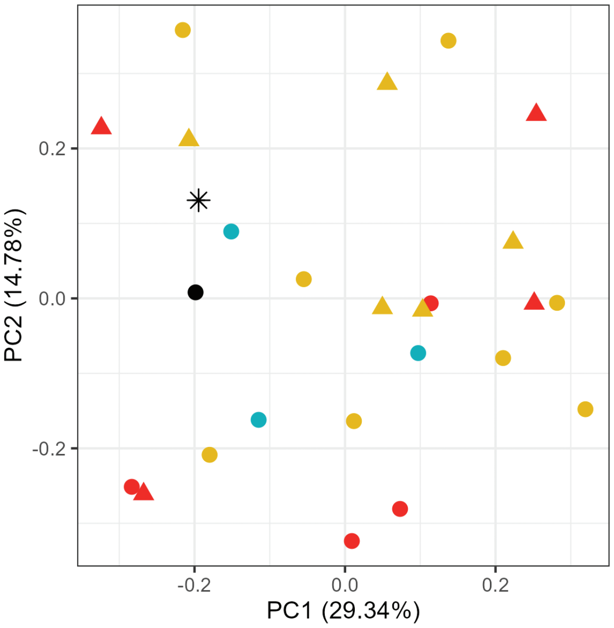

Figure 1. Axes I and II from the Principal Component Analyses (PCA), based on 15 size-corrected morphometric variables of four *Conraua* lineages from West Africa; only adult frogs included. Black = *Conraua kamancamarai* sp. nov. types from Konkouré Fetto (asterisk = female holotype), red = *Conraua kamancamarai* sp. nov. populations from Hörè Binti and Chute de Ditinn, blue = *Conraua* populations from Soyah, Fouta Djallon, yellow = *C. alleni*; triangle = females, circle = males; compare Table 5.

Table 5. Principal component analysis on morphometric measurements for *Conraua kamancamarai* sp. nov., *C. alleni* and *Conraua* populations from Soyah. Character loading, percentage (%) and cumulative percentage of explained variance for principal components with eigenvalues > 1.0, (PC) I–V; variables with the highest loadings are given in bold; compare Fig. 1; for abbreviations of morphological measures, see 'Materials and Methods' section or Tables 1, 2 and 4.

Variable	*PC1*	*PC2*	*PC3*	*PC4*	*PC5*
HW	0.33	0.08	-0.03	0.16	-0.07
HL	0.26	0.06	-0.19	0.15	***-0.62***
SL	0.23	-0.31	-0.04	0.13	0.31
ED	0.10	0.30	***-0.44***	0.10	-0.13
EN	0.13	***-0.45***	0.19	0.34	0.15
ES	***0.37***	-0.07	0.04	0.25	0.10
IND	0.26	0.05	-0.35	0.11	***0.45***
IOD	0.30	-0.04	0.10	***0.40***	-0.22
UEW	-0.20	-0.29	***-0.49***	0.06	-0.09
TL	***0.35***	0.08	-0.04	-0.33	-0.17
FL	0.31	0.20	0.19	-0.39	0.24
T4	0.30	0.32	0.19	0.02	0.09
HAL	0.26	-0.25	-0.33	***-0.45***	0.01
F3	0.17	***-0.49***	-0.04	-0.28	-0.13
FLL	0.07	-0.23	0.41	-0.16	-0.31
Eigenvalue	4.40	2.22	1.75	1.35	1.20
%	29.34	14.78	11.64	8.98	8.02
Cumulative %	29.34	44.12	55.75	64.74	72.75

Table 6. Coefficients of linear discriminant analysis (LDA) based on the 16 morphometric variables of three *Conraua* populations from West Africa: *Conraua kamancamarai* sp. nov., *Conraua* populations from Soyah, Fouta Djallon and *C. alleni*; those characters that contribute most are given in bold; for abbreviations of morphological measures, see 'Materials and Methods' section or Tables 1, 2 and 4.

	LD1	*LD2*
SVL	***-33.06***	-6.11
HW	5.43	6.73
HL	0.67	***31.97***
SL	-13.74	-9.47
ED	4.93	-9.75
EN	-5.73	15.57
ES	19.41	-0.79
IND	1.26	3.27
IOD	10.45	-18.10
UEW	3.23	-2.18
TL	***23.24***	-14.45
FL	8.12	-2.75
T4	-12.27	6.19
HAL	-8.53	5.04
F3	-5.55	-2.96
FLL	-1.84	-9.82

(Fig. 2). In *C. derooi*, the divided palmar tubercles are nearly connected and the thenar tubercle is clearly separated from the middle palmar tubercle. In *C. alleni*, the divided palmar tubercles (outer and middle) are very close to each other, but not connected and the thenar tubercle is separated from the middle palmar tubercle. In *C. sagyimase*, the divided palmar tubercles (outer and middle) are close but separated and the middle palmar and the thenar tubercle are distinctly separated (Fig. 2).

The most conspicuous morphological character of diagnostic value is the ventral pattern. Whereas most West African *Conraua* species have a predominantly white or light grey venter, often with dark mottling, but never with distinct spots or blotches, the new species exhibits a white ventral colour with well-defined dark brown spots and blotches (or dark colour with scattered grey or whitish spots) (Figs 3, 5 and 6). This ventral colour patterning is most distinct in adults, but already developed in some subadults.

Based on the genetic differences and the above diagnostic characters, we describe the *Conraua* populations from Konkouré Fetto, Hörè Binti and Chute de Ditinn as a species new to science. Due to their genetic divergence from other Fouta Djallon populations, we exclude the population from Soyah until larger sample size and call recordings are available (e.g. compare Neira-Salamea et al. 2021). This population might represent another cryptic species that would be described separately.

Description of the new species

Conraua kamancamarai sp. nov.

http://zoobank.org/625E8A78-5BB3-4EB1-8405-159C93135699
Figs 2–6

Holotype. ZMB 78432 (field and tissue #: GN11-140; GenBank # for 16S: MT669400) adult female, Guinea, Fouta Djallon Region, Konkouré Fetto, 10°20'28.21"N,

Figure 2. Ventral view of hands of four *Conraua* species showing palmar tubercles differences. Whereas three species possess a divided (outer and middle) palmar and a thenar tubercle, *Conraua kamancamarai* sp. nov. has an undivided palmar and a thenar tubercle. **a.** *Conraua kamancamarai* sp. nov. holotype (ZMB 78432); **b.** *C. derooi* (MNHN-RA 1993 4087); **c.** *C. sagyimase* (UWBM Herp 05841, paratype); **d.** *C. alleni* (ZMB 90390); Scale bars: 5 mm.

12°10'16.82"W, 650 m a.s.l., 20 June 2011, collected by Laura Sandberger-Loua & Joseph Doumbia.

Paratypes. ZMB 78429 (field and tissue #: GN11-130; GenBank # for 16S: MT669399) adult male; ZMB 78430, ZMB 78433 (field and tissue #: GN11-133, GN11-136; GenBank # for 16S: KF693389) subadults, all other data as holotype.

Additional referred material. For the description of the new species, we restrict the type series to the population from Konkouré Fetto. We do so because there may be additional undescribed diversity within the group identified as "*C. alleni* 1b" by Blackburn et al. (2020). The vouchers from Hörè Binti, Pita and Chute de Ditinn, Dalaba (all from Fouta Djallon, Guinea) are, therefore, listed as additional referred material (see Table 2).

Hörè Binti, Pita. ZMB 90301, ZMB 90304 (field and tissue #: CB2010-055, CB2010-061), adult females; ZMB 90302 (field and tissue #: CB2010-056), adult male; ZMB 90177 (field and tissue #: CB2010-057; GenBank # for 16S: MT669401), subadult; ZMB 90303 (field and tissue #: CB2010-059), subadult, 10°51'04.8"N, 12°31'14.1"W, 657 m a.s.l.; 22 July 2010, collected by Christian Brede & Joseph Doumbia.

Chute de Ditinn, Dalaba. ZMB 90305, ZMB 90307, ZMB 90309 (field and tissue #: CB2010 082, CB2010 089, CB2010 091), adult males; ZMB 90306, ZMB 90308 (field and tissue #: CB2010 088, CB2010 090), adult females, 10°49'13.1"N, 12°11'30.7"W, 760 m a.s.l.; 24 July 2010, collected by Christian Brede & Joseph Doumbia.

Diagnosis. The new species resembles other members of the genus *Conraua* Nieden, 1908. *Conraua kamancamarai* sp. nov. is an aquatic frog with the following traits: smooth dorsal skin, covered with scattered small, rounded warts on back and longitudinal ridges on dorsal part of hind legs; venter skin smooth; three odontoid projections on lower jaw, one at symphysis and one to each side on dentary; vocal sacs absent; fully webbed feet, i.e. to end of last phalanx of toe. *Conraua kamancamarai* sp. nov. is closely related to a clade including *C. alleni sensu stricto*, *C. derooi* and *C. sagyimase* (see Blackburn et al. 2020). Genetic distances between the new species and all other

Figure 3. *Conraua kamancamarai* sp. nov., female holotype (ZMB 78432) in lateral, dorsal and ventral view. Scale bar: 20 mm.

Figure 4. *Conraua kamancamarai* sp. nov., female holotype (ZMB 78432) lateral view of head and ventral view of left foot. Scale bar: 10 mm.

Conraua species were higher than 6% in the examined part of the 16S gene.

Conraua kamancamarai sp. nov. can be distinguished from *C. goliath* by a rounded snout (pointed in *C. goliath*), the absence of short dorsal skin ridges, a white venter with dark brown botches (yellow venter in *C. goliath*), the presence of a lateral line system, an indistinct tympanum, a wide tarsal fold and by having more than one subarticular tubercle on fingers (one in *C. goliath*). *Conraua kamancamarai* sp. nov. differs from *C. crassipes* by a white venter with dark brown blotches (uniform white or cream in *C. crassipes*), an indistinct tympanum, the presence of a lateral line system, by a conspicuous outer metatarsal tubercle (less conspicuous in *C. crassipes*) and by lacking a dermal fold near the elbow. *Conraua kamancamarai* sp. nov. differs from *C. beccarii* by the absence of a transverse fold behind the eyes and across the interorbital region, by lacking a swollen post-occipital and suprascapular region in adult males, by a white-coloured venter with dark brown blotches (no spots in *C. beccarii*) and by having a head that is as wide as long (wider than long in *C. beccarii*). *Conraua kamancamarai*

Figure 5. *Conraua kamancamarai* sp. nov., female holotype (ZMB 78432) in life.

sp. nov. differs from *C. robusta* by having a head that is as wide as long (wider than long in *C. robusta*), by having a U-shaped notched tongue-tip (tip of tongue rounded in *C. robusta*), by a white venter with dark brown blotches (uniformly white or with dark mottling in *C. robusta*) and the presence of a lateral line system. *Conraua kamancamarai* sp. nov. differs from *C. alleni sensu stricto* by having an undivided palmar tubercle, by having a white-coloured

Figure 6. Dorsal and ventral views of paratypes of *Conraua kamancamarai* sp. nov., male (ZMB 78429), subadults (ZMB 78430, ZMB 78431). Scale bars: 20 mm.

venter with dark brown blotches (uniform light or light with dark mottling in *C. alleni*), by a larger inner metatarsal tubercle, a wider tarsal fold and by the presence of webbing between fingers I and II. *Conraua kamancamarai* sp. nov. differs from *C. derooi* by having a more slender body and limbs, a slightly curved supratympanic fold (distinctly curved in *C. derooi*), two subarticular tubercles on finger III (one in *C. derooi*), by lacking a swollen postoccipital and suprascapular region in adult males, by the absence of a divided palmar tubercle, by a white venter with dark brown blotches (uniform whitish or with dark mottling in *C. derooi*) and by the presence of webbing between fingers I and II. *Conraua kamancamarai* sp. nov. differs from *C. sagyimase* by having narrower fingertips, a wider tarsal fold, by the absence of a divided palmar tubercle, by a white venter with dark brown blotches (uniform pale or with dark mottling in *C. sagyimase*) and by the presence of webbing between fingers I and II.

Description of the holotype (Figs 2–5; measurements in mm). Adult female; slightly dorsoventrally flattened, short and rounded body; snout rounded in dorsal and lateral view, with upper lip slightly projecting forward; SVL 71.7; head width 23.7, approximately equal to head length 23.5; head length 33% of SVL; snout length 7.0, 30% of head length; eye–nostril distance 4.25; eye–snout distance 8.1; internarial distance 4.0, slightly larger than interorbital distance 5.2; nostrils protuberant, directed dorsolaterally, visible in lateral and dorsal view; large eyes, projecting laterally beyond margins of head in dorsal view; eyes projecting slightly above dorsal margin of head in lateral view; eye diameter 6.5, horizontal diameter of tympanum 4.3; upper eyelid width 3.8, 73% of interorbital distance; eye–tympanum distance 3.9; tympanum indistinct; canthus rostralis distinct and rounded; loreal region concave; slightly curved supratympanic fold extending from posterior edge of eye to shoulder, joining the lateral fold; upper lip slightly protruding; premaxillary and maxillary teeth slender and pointed, three odontoid projections on lower jaw, one on at symphysis and one to each side on dentary; vomerine teeth pointed; about half of anterior tongue attached to floor of mouth, tongue-tip with U-shaped notch.

Forelimbs robust; forearm length 12.4, 74% of hand length 16.8; thenar and palmar tubercle oval and protruding, palmar tubercle larger than thenar tubercle; shape of fingers conical, wider at bases and narrower towards tips; finger tips rounded, non-expanded; one subarticular tubercle on fingers I and II; two subarticular tubercles on fingers III and IV; subarticular tubercles absent on base of fingers; relative length of fingers: III > IV > II ≈ I, length of finger III 9.8; fingers I and II webbed to first subarticular tubercle.

Hind limbs moderately robust; crus length 33.3, 46% of the SVL; foot including longest toe 44.8, 62% of SVL; elongated, prominent oval inner metatarsal tubercle, more than twice as long (4.4) as wide (1.7); outer metatarsal tubercle absent; supernumerary plantar tubercles absent; subarticular basal tubercles absent; one subarticular tubercle on toes I and II; two subarticular tubercles on toes III and V, three subarticular tubercles on toe IV; toe tips rounded, forming small discs, as broad as subarticular tubercles; relative lengths of toes: VI > III > V > II > I; length of toe IV 29.3; webbing complete, i.e. to end of last phalanx of toe; dermal fringing on outer surfaces of toes I and V, forming lateral skin folds; wide tarsal fold.

Skin texture on dorsal parts of head, body, flanks and limbs smooth with scattered, small, rounded warts; upper eyelid skin with many warts; inner surface of upper arm smooth; dorsal surface of crus with 12 rows of longitudinal ridges; ventral skin smooth, throat with longitudinal folds; a post-gular (thoracic) fold extending to level of forelimbs insertion; lateral line system with jugular line, upper lateral line, lower lateral line, median lateral line, caudal lateral line, infra-orbital line, supra-orbital line, mandibular lateral line and anterior lower lateral line (see Shelton 1970).

Colouration in preservative (after 10 years in 75% ethanol; Figs 2–4). Dorsum brown with scattered small cream warts, warts more abundant on posterior surface; light interorbital stripe; upper eyelids brown with abundant lighter spots; lips brown or brown with lighter mottling; supratympanic fold brown; lateral fold light; upper arm fold light; dorsal surface of flanks brown; ventral surface of flanks white or light grey with brown spots; dorsal surface of legs brown with dark scattered spots; dorsal surface of toes I, II, III and IV with brown mottling; dorsal surface of toe V brown; dorsal surface of arms brown with scattered light brown warts; dorsal surface of fingers I and II light brown with dark mottling, fingers III and IV brown; ventral surface of throat and belly whitish with dark brown blotches; ventral surface of crus and feet light brown with dark mottling; ventral surface of hands brown.

Colouration in life (Fig. 5). Dorsum dark brown with scattered lighter dots and dark spots; lips same colour as dorsum, paler on lateral surfaces; flanks dark; iris gold; ventral surfaces white with dark brown spots; ventral surface of hands dark, tubercles lighter; ventral surfaces of legs with scattered reddish dots; lateral fold light brown.

Variation (Figs 6–7; Tables 2 and 3). Overall, the paratypes are similar to the holotype in external appearance and colouration. Dorsal colouration ranges from uniform dark brown (ZMB 78432) to predominantly brown with dark mottling (ZMB 78430, ZMB 78431) or predominantly brown with dark spots. In the male paratype (ZMB 78429), the jugular lateral line is more conspicuous than in the holotype and the upper lip is light brown. Ventral colour pattern of all specimens similar: whitish with distinct brown blotches, however, these blotches are lighter in the subadult paratypes (ZMB 78430, ZMB 78431).

***Referred specimens from Hörè Binti*:** Dorsal colouration varies from similar to the type series (ZMB 90177, ZMB 90303) to darker (ZMB 90301, ZMB 90302, ZMB 90304) or a dark dorsum with light brown spots (ZMB 90302). Ventral colouration of some individuals deviates from that of the type series by a greyish belly with dark mottling and a dark throat with lighter spots (ZMB 90304, ZMB 90301). Ventral colouration of ZMB 90302 is difficult to define due to its preservation condition. Ventral colouration of juveniles is showing fewer dark spots than in adults (ZMB 90177, ZMB 90303). Lateral line system in ZMB 90304 is more conspicuous than in the type series.

***Referred specimens from Chute de Ditinn*:** Dorsal colouration of all individuals darker than that of type series, some individuals with light brown spots (ZMB 90307, ZMB 90308) that are absent in the type series. Some individuals present a different colouration pattern than type series on the throat with a dark base colour and lighter spots (ZMB 90306, ZMB 90307, ZMB 90308). Belly of ZMB 90305 greyish with dark mottling, different to the colour pattern of the type series, probably due to preservation. The lateral line system in all individuals is more conspicuous than in the type series. A posterior lower lateral line (see Shelton 1970) is present in ZMB 90307 and ZMB 90309. This part of the lateral line system was not detected in the type series.

For variation in life colouration of *Conraua* specimens from various localities in the Fouta Djallon Region, see Figure 7.

Distribution (Fig. 8). So far, the known range of *Conraua kamancamarai* sp. nov. is restricted to the type locality at Konkouré Fetto and to two other sites, Hörè Binti and

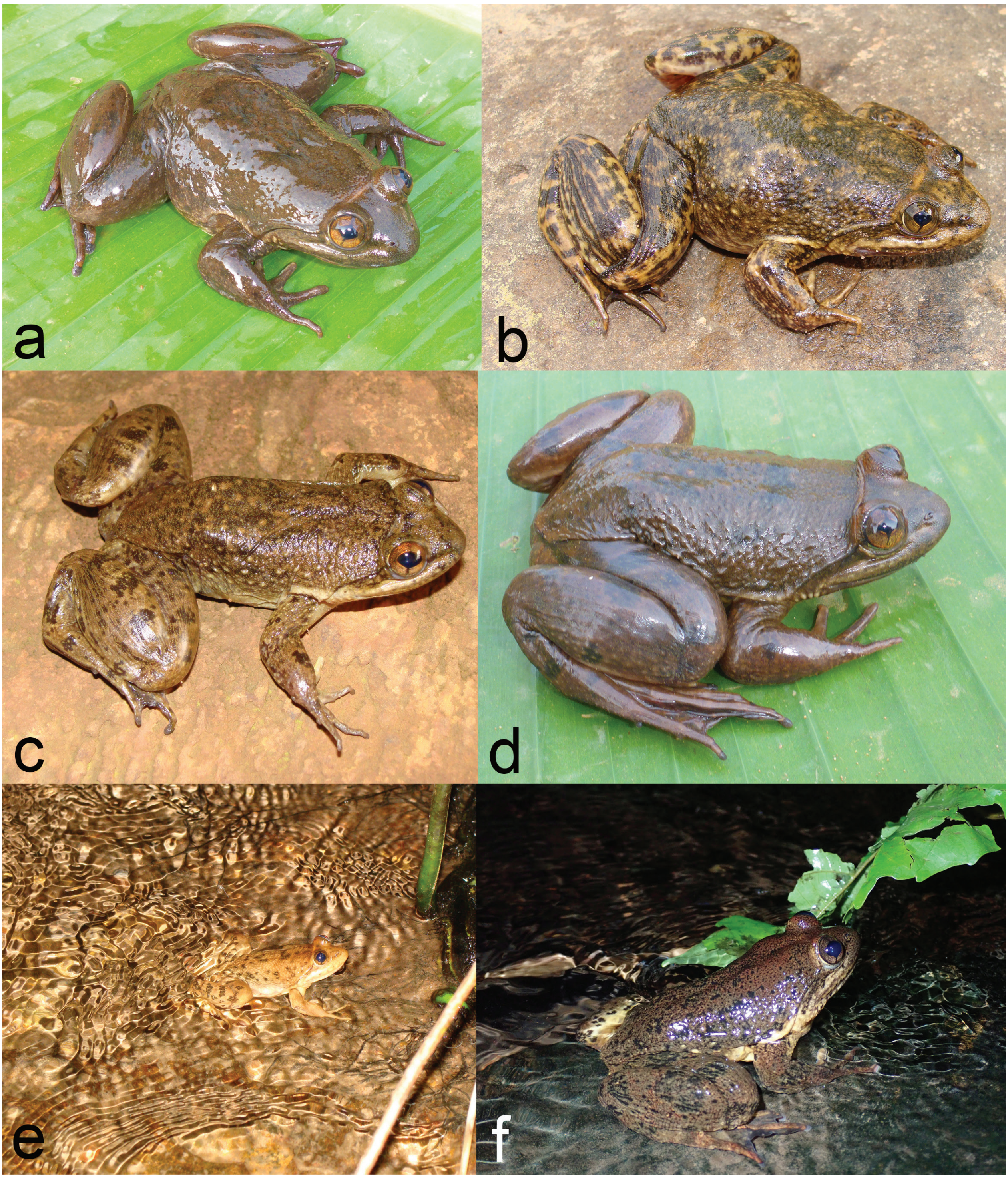

Figure 7. Colouration of life *Conraua kamancamarai* sp. nov. from the Fouta Djallon and surrounding region, Guinea, illustrating variation in colour pattern and skin texture. **a.** From Dubreka, River Bindinbandan (10°22'21.9"N, 13°9'16.8"W, 199 m a.s.l.); **b.** From Dalaba, Chute de Ditinn; **c.** From Hörè Binti; **d.** From Dubreka, River Bindinbandan (10°22'21.9"N, 13°9'16.8"W, 199 m a.s.l.); **e.** From Dalaba, Chute de Ditinn; **f.** From Télimélé, locality Kourakoto, river Didounpouriguè (10°55'30.4"N, 13°47'39.4"W, 238 m a.s.l.); frogs in lower row in typical calling position, sitting in shallow water; specimens either not collected or not assignable to a voucher specimen, whereas the frogs from Hörè Binti and Chute de Ditinn can be assigned to *Conraua kamancamarai* sp. nov. without doubt; the other frogs may represent an undescribed *Conraua*.

Chute de Ditinn. Although the species probably occurs in a few more rivers that have not yet been surveyed, the entire range almost certainly will not extend beyond the Fouta Djallon, where it is very likely patchily distributed.

Biology and habitat (Figs 9 and 10). The new species occupies fast-flowing rocky streams with waterfalls within riverine forest in mountainous areas in the Fouta Djallon, Guinea (Figs 9 and 10). Like other frogs of the genus, they

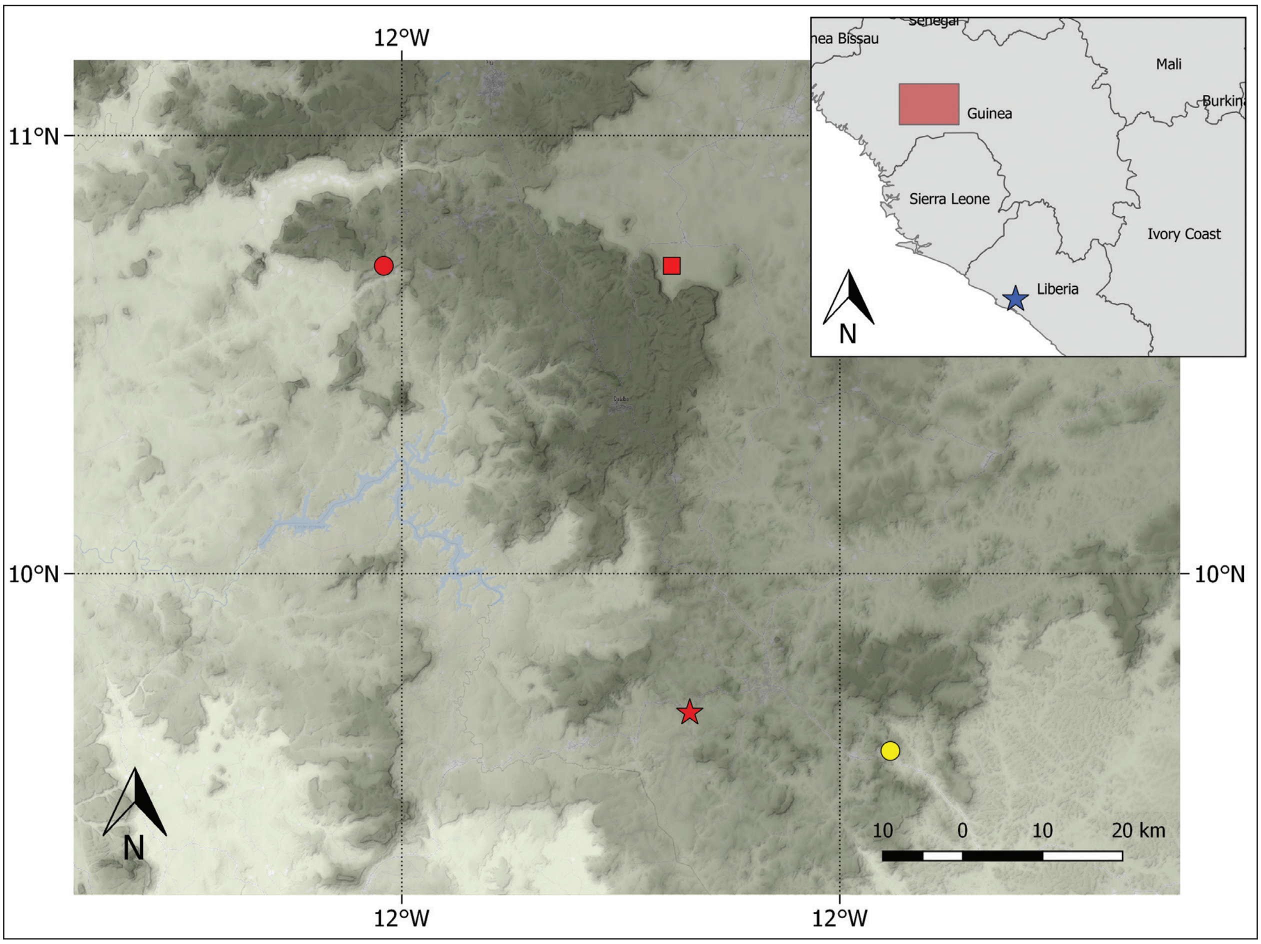

Figure 8. Map of known localities of *Conraua kamancamarai* sp. nov. in the Fouta Djallon Highlands, Guinea. Inset (upper right) shows a map of West Africa indicating in red, the area of occurrence of the new species in the Fouta Djallon and in blue, the assumed type locality of *C. alleni*. Known localities of *Conraua kamancamarai* sp. nov. are shown in red (Konkouré Fetto, type locality: star; Hörè Binti: circle; Chute de Ditinn: square), the population from Soyah, potentially representing another undescribed *Conraua*, is given in yellow. Altitudinal range is indicated with light shading from lowlands (112 m a.s.l.) to dark shading highlands (1089 m a.s.l.). Sources: OpenStreetMap (2020), U.S. Geological Survey (2020).

are predominately nocturnal and aquatic. Despite their occurrence in fast flowing streams, adults show a preference for calmer river sections, where turbulent water is absent. Usually, frogs are encountered at least partly submerged in shallow water, facing the riverbanks. When outside of the water, they remain within jumping distance to water. Disturbed frogs seek shelter on the ground of pools, sometimes trying to burrow deeper into them and cover themselves with gravel or substrate (Fig. 11). This behaviour is similar to what Knoepffler (1985) described for *Conraua crassipes*. They call (whistle) with an open mouth, sitting in shallow water (Fig. 7; compare Amiet 1990). Mating has never been observed by the authors; however, single observations of clutches and jelly remnants of spawn indicate that oviposition sites are small puddles or depressions on the riverbanks near the spray water zone of cascades and waterfalls. *Conraua* tadpoles usually were observed in silted calm ponds where up to 50 tadpoles of about the same size have been encountered. If this and other species of the genus show breeding behaviour comparable to *Conraua goliath* (compare Schäfer et al. 2019), remains to be researched.

The surroundings of the forest fragments where the species occurs are generally degraded by anthropogenic disturbance, particularly peanut and rice crops and cattle grazing. The type locality (Fig. 10) is located between Konkouré and the largest city within the Fouta Djallon, Mamou, within a relatively short distance to the connection road and was surveyed on 20 June 2011. Along the national route one (N1), one of the largest roads connecting the East with the West of Guinea, houses are numerous, but already within a relatively short distance to the road, human presence may be considerably scarcer. Slopes are either covered by an open, short, dry forest with signs of cattle grazing and used for charcoal production (Fig. 10) or comparatively large fields for peanuts or rice crops. Only steep slopes surrounding rivers had sometimes larger trees and denser vegetation with higher humidity levels than the surroundings. The type locality is at a river within denser forest, with large boulders and some cascades, allowing for a diverse river site with fast and slow flowing parts and comparatively clear water (Fig. 10). These forests are not protected and were in the past burned by the population as protest against government decisions in Conakry.

Figure 9. The Fouta Djallon, Guinea and habitats of *Conraua kamancamarai* sp. nov. Hörè Binti landscape (upper photo) and typical river habitats.

The classified forest (partly protected areas allowing forestry) of Hörè Binti is located within a mountainous area containing several freshwater sources. It was surveyed from 22–23 July 2010. Many fast-flowing streams with cascades have its source on the mountain. The habitat degradation due to anthropogenic alterations was dramatic and only very small forest fragments remained. The anthropogenic pressure consisted of cultivations/fields (mainly peanut and rice) and grazing cattle. Only streams were surrounded by some remaining larger trees. The Ditinn / Dalaba site was within a small fragment of gallery forest with a stream, next to the waterfall of Ditinn. It was surveyed from 24–25 July 2010. Although there is a small village next to the forest, only minor anthropogenic alterations were detectable.

Threat status. *Conraua kamancamarai* sp. nov. should be considered Data Deficient (DD) because more information is required to make an adequate assessment of the species' extinction risk. However, if the species range is

Figure 10. The type locality of *Conraua kamancamarai* sp. nov. near Konkouré Fetto, Fouta Djallon, Guinea (10°20'28.21"N, 12°10'16.82"W, 650 m a.s.l.). The frogs live in clear, fast flowing streams, with riverine forest. The surroundings are heavily degraded by agriculture, cattle grazing and charcoal production (inset figure).

indeed restricted to the sites of Konkouré Fetto, Hörè Binti and Chute de Ditinn, the species should be categorised as Endangered (EN) following the IUCN (2012) criteria B2bi (continuing decline, observed, inferred or projected in extent of occurrence) and B2biii (continuing decline, observed, inferred or projected, in area, extent and/or quality of habitat).

Etymology. This species is dedicated to Kaman Camara (Fig. 12), our long-term field assistant and friend, who started working with MOR in 2002 on a survey to the Simandou Range that was organised by Conservation International (Rödel and Bangoura 2004). From 2007 until his recent death, Kaman was a member of our Guinean team, investigating the amphibians of the Nimba Mountains and other Guinean areas. Kaman had outstanding skills in detecting and catching frogs, and, more importantly, an unswerving positive attitude. A day could be completely exhausting and frustrating, but with a simple joke from Kaman all was good again! Kaman was born and lived in a remote village at the western foothills of

Figure 11. *Conraua alleni* hiding on river bottom, the new species shows an identical behaviour when trying to escape.

Figure 12. Kaman Camara in June 2007 on Mount Nimba, Guinea. Inset figure taken on a Rapid Assessment to south-eastern Guinea, organised by Conservation International and Kaman's first experience with frog work, from left to right: Mark-Oliver Rödel, Mohamed Alhassane Bangoura and Kaman Camara.

the Simandou Range. He never received any formal education. Still, he repeatedly rejected other better paying job offers from mining companies, preferring instead to work with his frog team whenever it was possible. Kaman died in June 2020 after a short severe disease. These frogs shall be a permanent memory to an outstanding person! We suggest 'Kaman Camara's Slippery Frog' as the English common name, 'la grenouille glissante de Kaman Camara' in French and in the local language Poular: 'Tôti bhowroundi de Kaman Camara'.

Discussion

Surveys in West Africa over the past 20 years have revealed previously unknown populations of the genus *Conraua* and prompted the need for re-evaluating the taxonomy of this genus, including exploring the potential for undescribed and morphologically-cryptic species (Rödel and Branch 2002; Rödel and Bangoura 2004; Hillers et al. 2009; Leaché et al. 2020). Based on comparative morphology and molecular phylogenetic data, we describe a new species, *Conraua kamancamarai* from three sites in the Fouta Djallon, Guinea, thus confirming the existence of an Unconfirmed Candidate Species (UCS) (*sensu* Vieites et al. 2009), as suggested by Blackburn et al. (2020).

The uncorrected p-distances of mitochondrial 16S between the new species and all other *Conraua* species was greater than 6% and, thus, well above the usual threshold (~ 3%) for potential anuran candidate species (Fouquet et al. 2007; Vieites et al. 2009). Although we had no bio-acoustic data available and individuals overlap in their body shape with those of *C. alleni*, these populations are diagnosable as a distinct species by various characters, including the absence of a divided palmar tubercle, having a first finger webbed to below the first subarticular tubercle and the unique ventral colour pattern in adults.

Conraua kamancamarai is the most westerly distributed *Conraua* species. Its closest congeners are found to the east, including the *C. alleni* complex from Guinea (east of the Fouta Djallon to lowland forests in western Ghana, west of the Atewa Forest Range), *C. sagyimase* in the Atewa Range Forest in Central Ghana and *C. derooi* along the escarpment of the montane border in western Ghana and eastern Togo. Similar patterns of distribution are also found in other pairs or groups of closely related vertebrates; for instance, toothed frogs (*Odontobatrachus*; Barej et al. 2015b), reed frogs (*Hyperolius*; Rödel et al. 2010; Channing and Rödel 2019), horseshoe bats (*Rhinolophus*; Fahr et al. 2002) and suckermouth catfishes (*Chiloganis*; Schmidt et al. 2017).

Although the fauna of the Fouta Djallon has been poorly studied compared to other forests in West Africa (Rödel et al. 2021), studies of its flora have identified the region as a centre of endemism and species richness (Porembski et al. 1994; Poorter et al. 2004). These two metrics are commonly used to recognise areas that may have been forest refugia (Hillers 2008; Tchouto et al. 2009), i.e. forests that persisted during cold and dry climatic periods (Haffer 1969; Couvreur et al. 2021). By investigating the phylogeography of several puddle frog species, *Phrynobatrachus*, Hillers (2008) confirmed the presence of macro- and micro-forest refugia in the highlands of Fouta Djallon during the Pleistocene. This finding, together with the results of Blackburn et al. (2020), which found the divergence of *C. alleni* into various lineages during the Pliocene and Pleistocene, suggests allopatric speciation, associated with isolation in Pleistocene forest refugia, led to the evolution of one or more endemic *Conraua* species in the Fouta Djallon. Pliocene–Pleistocene speciation events are well documented for other African forest taxa (e.g. rodents: Nicolas et al. 2010; Bohoussou et al. 2015; legumes: Duminil et al. 2013; bats: Hassanin et al. 2015).

Today the ecosystems of the Fouta Djallon are heavily degraded (Wilson 1992; Couch et al. 2019), threatening the area's unique biodiversity (Schmidt 2014; Barej et al. 2015a) including this newly-described *Conraua* species. A preliminary assessment of the conservation status of vascular plants identified Guinea as amongst the top countries in tropical Africa with the highest proportion of threatened species (Stévart et al. 2019). In Fouta Djallon, there are still patches of forest (Wilson 1992) that seem sufficient to facilitate the survival of endemic frog species, such as the new *Conraua* or the endemic *Odontobatrachus* species (Barej et al. 2015b; this study). The conservation of preserved small areas can be key to the survival of regional biodiversity and these isolated forests that served as refugia in the past may also be more resistant to future climatic changes (Hillers 2008). *Conraua kamancamarai* occurs in classified forests (Konkouré Fetto and Binti classified forests), i.e. areas designated for sustainable management of forest resources (Brugiere and Kormos 2008). However, these forests have historically been given low priority, have been illegally degraded (Brugiere and Kormos 2008), being ineffective in mitigating the effects of anthropogenic intervention on vegetation change (Liu et al. 2017). A more rigorous protection of these forests and potentially upgrading of the conservation status of these forests would be important steps towards the preservation of the region's biodiversity, as well as for the long-term maintenance of this important water source for local people. The Fouta Djallon is known as the "Water Tower" of West Africa, being the principal water supply for several countries in the region. For instance, Mauritania and Niger rely on this source for 96% and 70% of their water, respectively (Descroix et al. 2020).

With the description of *Conraua kamancamarai*, we continue to refine the taxonomy of the West African slippery frogs. However, there still remains work to be done. Further data and analyses are required to re-evaluate the larger *C. alleni* complex and to identify whether other populations in the Fouta Djallon, such as at Soyah (subclade 1a; see Blackburn et al. 2020), might represent additional undescribed species.

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Appendix 1

Additional *Conraua* specimens examined for qualitative comparisons. MCZ = Museum of Comparative Zoology at Harvard University, Cambridge; MNHN = Muséum national d'Histoire naturelle, Paris; MRAC = Musée Royal de l'Afrique Centrale, Tervuren, Belgium; UWBM = Burke Museum of Natural History and Culture, Seattle; ZFMK = Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, ZMB = Museum für Naturkunde, Berlin.

Conraua alleni (*sensu lato* = all *Conraua* from the western Upper Guinea forest zone, morphologically assignable to *C. alleni*). MCZ A-11991, subadult, holotype, Liberia, Firestone Plantation No. 3, Du River, Liberia; ZMB 90351, adult male, Guinea, Mont Béro Classified Forest, 08°08'30.9"N, 08°34'09.6"W; ZMB 90443, adult female, Sierra Leone, Tingi Hills, 08°53.4'N, 10°47.4'W; ZMB 90426, adult female, Sierra Leone, Loma Mountains Forest Reserve, 9°12.752'N, 11°08.623'W; ZMB 90178, adult female, Sierra Leone, Nimini Forest Reserve, 8°30.035'N, 11°08.800'W; ZMB 90388, ZMB 90389, adult males; ZMB 90179, adult female, Liberia, Putu Range, 05°39'44.6"N, 08°09'39.2"W, 306 m a.s.l.; ZMB 90304, adult male, Guinea, Fouta Djallon, 10°49'13.1"N, 12°11'30.7"W, 513 m a.s.l.; ZMB 90357, adult male and ZMB 90358, adult female, Ivory Coast, Haute Dodo, 04°59'14"N, 07°19'39"W; ZMB 90310, ZMB 90313, adult females, ZMB 90311, ZMB 90312, adult males, Guinea, Forêt Classée de Ziama, 8°21'02.7"N, 9°25'01.8"W, 467 m a.s.l.; ZMB 90325, adult female, ZMB 90326, adult male, Guinea, Nimba Range, 07°38'56.3"N, 8°25'25.56"W, 680 m a.s.l.; ZMB 90388, ZMB 90389, adult males, Liberia, Slabbert´s Ville, 05°39'44.6"N, 8°09'39.2"W, 316 m a.s.l.; ZMB 90342, adult male, Liberia, Gola National Forest, 07°27'17"N, 10°41'52"W, 299 m a.s.l.

Conraua beccarii. ZFMK 15749–15750, Ethiopia, Illubator; MNHN 1933. 21, adult male, holotype of *Rana Griaulei* Angel, 1934, Ethiopia, Gondar, 2,200 m a.s.l.

Conraua crassipes. ZMB 8360, holotype, "Abo", north of Douala, Cameroon; ZFMK 73216, Gabon, Barrage de Kinguélé, Tchimbélé; ZFMK 69351, 69353, 69354, Cameroon, Mt. Nlonako, Nguengue, Campsite; ZMB 90400–90403, Gabon, Moukalaba-Doudou National Park.

Conraua derooi. MRAC 112077–112078, paratypes, Togo, Missahohe; MRAC 112079–112080, paratypes, Togo, Missahohe; ZMB 71293, adult male and ZMB 71294, adult female, Ghana, Biakpa, 06°50.652'N, 00°25.280'E; ZMB 71298–71300, ZMB 71302 adult males and ZMB 71301, adult female, Togo, Missahohe, 6°57.094'N, 0°33.878'E; UWBM:Herp 09599–09603, adult females and UWBM:Herp 09604, adult male, Ghana, Volta Region, Adaklu-Anyigbe; MNHN 1978.2027, 1978.2029, adult males and MNHN 1978.2030, 1978.2031, adult females and MNHN 1978.2028, adult with unknown sex, Togo, Dangi Atiba; MNHN 1993.2627, 1993.2629, adult males and MNHN 1993.2630, 1993.2631, adult females and MNHN 1993.2628 adult with unknown sex, Togo, Kloto; MNHN 1993.4084–1993.4087, Togo, Missahohe; MNHN 1995.5726, 1995.5727, Togo, Kluto; MNHN 1987.2026, Togo, Dangi Atigba.

Conraua goliath. ZFMK 77927, 77928, 77930, 77932, Cameroon, Mt. Nlonako, Ekomtolo, 500 m a.s.l.

Conraua robusta. ZMB 20085, holotype, Cameroon; ZMB 78427, Cameroon; ZMB 90174, Cameroon, Manengouba Village, Mt. Manengouba; ZFMK 67288, Cameroon, Bakossi Mts., Kodmin.

Conraua sagyimase. UWBM:Herp 5839, holotype, adult male, Ghana, Eastern Region, Atewa Range Forest Reserve, 06°13'57.79"N, 0°33'07.08"W, 633 m a.s.l.; ZMB 91136, paratype, adult female, Ghana, Asiakwa South, 06°15'44.3"N, 0°33'18.8"W, 783 m a.s.l.; ZMB 91137–91138, paratypes, adult females, Asiakwa North, 06°16'16.1"N, 0°33'52.7"W, 814 m a.s.l.; UWBM:Herp 5840–5843, paratypes, adult male and female and two subadults, Ghana, Eastern Region, Atewa Range Forest Reserve, 06°13'57.79"N, 0°33'07.08"W, 633 m a.s.l.

Appendix 2

***Conraua* specimens examined for quantitative comparisons.** ZMB = Museum für Naturkunde, Berlin.

***Conraua* sp. from Soya, Fouta Djallon.** ZMB 90341, ZMB 90175, ZMB 90176, adult males, Guinea, Soya, 10°17'50.9"N, 11°56'32.4"W, 515 m a.s.l.

Conraua alleni. ZMB 90310, ZMB 90313, adult females, ZMB 90311, ZMB 90312, adult males, Guinea, Forêt Classée de Ziama, 8°21'02.7"N, 9°25'01.8"W, 467 m a.s.l.; ZMB 90325, adult female, ZMB 90326, adult male, Guinea, Nimba Range, 07°38'56.3"N, 8°25'25.56"W, 680 m a.s.l.; ZMB 90388, ZMB 90389, adult males, ZMB 90390, adult female, Liberia, Slabbert´s Ville, 05°39'44.6"N, 8°09'39.2"W, 316 m a.s.l.; ZMB 90427, ZMB 90428, adult males, Guinea, Nimba Range, 07°42'82"N, 8°21'70"W, 848 m a.s.l.; ZMB 90342; adult male, Liberia, Gola National Forest, 07°27'17"N, 10°41'52"W, 299 m a.s.l.; ZMB 90350, adult female, Guinea, Mont Béro Classified Forest, 08°08'30.9"N, 08°34'09.6"W, 622 m a.s.l.

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