SALAMANDRA **59**(1): 42–50
15 February 2023 | ISSN 0036–3375

SALAMANDRA
German Journal of Herpetology

New records and advertisement calls of *Ptychadena* species from Rwanda

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Manuscript received: 21 July 2022
Accepted: 29 November 2022 by Stefan Lötters

Abstract. Species of African Grass Frogs (*Ptychadena*) are notoriously difficult to distinguish based on external morphological characters. Therefore, the geographic range of several species and the number of local species at a given locality are often unclear. However, previous studies have shown that species of *Ptychadena* possess many external morphological characteristics that allow unequivocal distinction. Furthermore, species of *Ptychadena* are readily distinguished by their distinct advertisement calls. We herein present the results of our investigation of the diversity of *Ptychadena* in Rwanda. We report on the presence of a total of seven species, two of which were previously not known to occur in the country, and describe the hitherto unreported advertisement calls of four species. We provide keys to species based both on external morphological characters and on parameters of the advertisement call for all species from Rwanda.

Key words. Amphibia, Anura, *Ptychadena chrysogaster*, *P. guibei*, *P. oxyrhynchus*, *P. uzungwensis*, bioacoustics, Africa.

Introduction

Presently, the genus *Ptychadena* Boulenger, 1917 contains 58 species that are distributed in sub-Saharan Africa, northwards along the Nile to the Mediterranean Sea, and on some islands in the Indian Ocean (Frost 2022). Usually, two or more species occur sympatrically at the same locality, and most species resemble each other in the general habitus, having a long, sharp snout and long legs, and their colouration and pattern can show a high degree of variation. As a consequence, many species were confused with each other in the past, leading to an overestimation of variation within certain taxa and to incorrect species accounts and unusable keys to species in the literature (Laurent 1954, Poynton 1970, Dehling & Sinsch 2013a, 2013b, Goutte et al. 2021). Most species of *Ptychadena*, however, have a high number of external morphological characteristics, and the specific combination of these allows unequivocal distinction between species (Bwong et al. 2009, Dehling & Sinsch 2013a, 2013b). Furthermore, species of *Ptychadena* are readily distinguished by their distinct advertisement calls (Passmore 1977, Perret 1979, Bwong et al. 2009, Dehling & Sinsch 2013a, Goutte et al. 2021).

Five species of *Ptychadena* have been recorded from Rwanda (Dehling & Sinsch 2013b), i.e., *P. anchietae* (Bocage, 1868), *P. chrysogaster* Laurent, 1954, *P. nilotica* (Seetzen, 1855), *P. porosissima* (Steindachner, 1867), and *P. uzungwensis* (Loveridge, 1932). The advertisement calls of *P. anchietae*, *P. nilotica*, and *P. porosissima* were described by Dehling & Sinsch (2013a). Two further species, *P. grandisonae* Laurent, 1954 and *P. oxyrhynchus* (Smith, 1849), had been reported from Rwanda. The presence of *P. grandisonae* was rejected by Dehling & Sinsch (2013b) for being solely based on a confusion of the location ("Bitare", Burundi) in the literature (Laurent 1964 and several subsequent authors). Several specimens reported from Rwanda as "*P. oxyrhynchus*" were re-identified as *P. anchietae* and consequently, the occurrence of *P. oxyrhynchus* in Rwanda was doubted (Dehling & Sinsch 2013b).

During our ongoing assessment of the diversity of anurans in Rwanda, we collected an additional species of *Ptychadena*, confirmed the occurrence of *P. oxyrhynchus*, and recorded the advertisement calls of all species now known from the country. We herein report these records and give an overview of the species of *Ptychadena* in Rwanda and their advertisement calls.

Material and methods

We investigated the distribution of species of the genus *Ptychadena* at the following sites in Rwanda (Fig. 1): [1] Rukarara River (2.45208° S, 29.45824° E, 2006 m asl), [2] Mwogo River I (2.46883° S, 29.68242° E, 1580 m asl), [3] Mwogo

River II (2.25787° S, 29.59536° E, 1518 m asl), [4] Nyabarongo River I (1.72216° S, 29.63664° E, 1457 m asl), [5] Nyabarongo River II/Kigali (1.96364° S, 30.00163° E, 1357 m asl), [6] Nyabarongo River III/Mugesera (2.20525° S, 30.27109° E, 1324 m asl), [7] Akagera River (2.22441° S, 30.82755° E, 1292 m asl), [8] wetlands near Butare (2.59937° S, 29.75639° E, 1643 m asl), [9] wetlands near Gitarama (2.10053° S, 29.75739° E, 1785 m asl), [10] Bugarama plain (2.67977° S, 29.01115° E, 962 m asl), [11] wetlands near Cyangugu (2.49074° S, 28.90536° E, 1574 m asl), [12] wetland outside Cyamudongo Forest (2.53798° S, 28.99471° E, 1839 m asl), [13] Rugezi Swamp (1.48557° S, 29.88928° E, 2055 m asl), [14] wetland near Kitabi (2.52841° S, 29.42046° E, 2269 m asl), and several locations in Akagera National Park, i.e., [15] Muyumbu Hill (1.85101° S, 30.72006° E, 1642 m asl), [16] Lake Birengero (1.80369° S, 30.74211° E, 1290 m asl), [17] pond at Bweya (1.69726° S, 30.69982° E, 1326 m asl), and [18] Kilala Plains (1.41878° S, 30.57959° E, 1292 m asl).

Specimens were examined and the character states evaluated following Dehling & Sinsch (2013b). The webbing formulae are given as proposed by Dehling (2015). Terminology for dermal dorsal ridges and orientation of external vocal sac aperture follows Perret (1979).

For the quantitative analysis of advertisement call features we recorded series of advertisement calls (number of calls analysed: 485) given by 52 individuals that called without acoustic interference of other individuals, using a Sony PCM–D50 Linear PCM Recorder with stereo microphones, Sony Deutschland GmbH, Cologne. Air temperature (to the nearest 0.1°C) was registered at the calling sites (usually at 0.5–1.0 m height within vegetation) immediately after recording using a TinyTag temperature logger, Gemini Data Loggers Ltd., UK.

For quantitative call descriptions, we analysed the spectral features and the temporal structure of vocalisations using ADOBE Audition 1.0. Stereo recordings were converted to mono using a sampling rate of 44.1 kHz and resolution of 16 bits. Sonagrams and frequency analyses were prepared applying Blackman–Harris Fast Fourier transformation with a FFT size of 1,024 Hz. Each advertisement call was characterized by twelve variables, following Dehling & Sinsch (2013a): (1) call duration [ms]; (2) intercall interval [ms]; (3) call repetition rate [N/min]; (4) number of pulse groups per call [N]; (5) pulse-group duration [ms], only measured in calls with more than one pulse group; (6) interpulse-group interval [ms], only measured in calls with more than one pulse group; (7) number of pulses per call [N]; (8) pulse duration [ms]; (9) interpulse interval [ms]; (10) pulse rate [N/s]; (11) fundamental frequency of complete call [Hz]; (12) dominant frequency of complete call [Hz].

Call variables were compared among the seven *Ptychadena* species using an ANCOVA with species as fixed factor and ambient temperature as continuous co-variable. Data

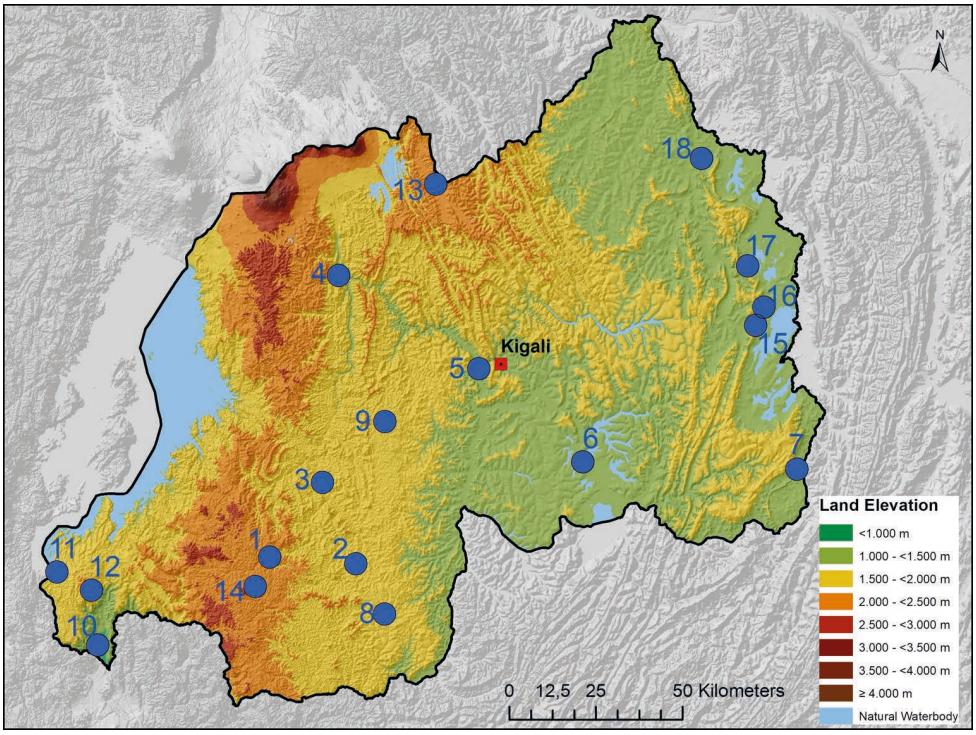

Figure 1. Sampling sites in Rwanda studied: [1] Rukarara River, [2] Mwogo River I, [3] Mwogo River II, [4] Nyabarongo River I, [5] Nyabarongo River II/Kigali, [6] Nyabarongo River III/Mugesera, [7] Akagera River, [8] wetlands near Butare, [9] wetlands near Gitarama, [10] Bugarama plain, [11] wetlands near Cyangugu, [12] wetland outside Cyamudongo Forest, [13] Rugezi Swamp, [14] wetland near Kitabi, [15] Muyumbu Hill, [16] Lake Birengero, [17] Bweya, [18] Kilala Plains. For details see Materials and methods.

are given as least square means and the range of variations among calls per species. For multiple group comparisons we used a multiple range test with Bonferroni correction. Significance level was set to alpha = 0.05. All calculations were performed using the statistical package Statgraphics Centurion, version XVIII (Statpoint Inc., 2018).

Results

Diversity of *Ptychadena* in Rwanda and morphological diagnoses

We collected a total of 86 adult specimens of *Ptychadena,* which we referred to the seven different species. These included the five species already reported by Dehling & Sinsch (2013b), but also a confirmation of the presence of *P. oxyrhynchus* and a new country record for *P. guibei* Laurent, 1954. The species are unequivocally distinguished from each other based on the following morphological diagnoses. A key to the species based on morphological characters is in the Appendix 1.

Ptychadena anchietae (Fig. 2A): 20 specimens, recorded from [1], [2], [3], [4], [5], [6], [8], [9], [11], [12], [14], [15], [16], [17], [18] (Fig. 1). SVL 38.0–42.4 mm in adult males, 46.7–51.3 mm in adult females. Vocal sac aperture in males inferior, at ventral edge of arm insertion; spiny tubercles on venter absent; median dorsal ridge on snout absent; inner metatarsal tubercle about half the length of metatarsus I; toe webbing I0.5/2II0.5/2III0.5,1/2IV2-/0.5V; head white, trunk yellow ventrally; dark brown stripe on preaxial side of tibia absent; light tibial line absent; light medial dorsal band absent; light, prominent dorsolateral fold usually absent; postaxial side of femur with irregularly delimited, reticulated, longitudinal bands, alternately yellow and dark brown coloured.

Ptychadena chrysogaster (Fig. 2B): 4 specimens, recorded from [13], [14] (Fig. 1). SVL 37.8–49.7 mm in adult males, 48.0–57.7 mm in adult females. Vocal sac aperture in males inferior, at ventral edge of arm insertion; spiny tubercles on venter present in males, very small; median dorsal ridge on snout absent; inner metatarsal tubercle less than half the length of metatarsus I; toe webbing I2/2.5II1.5,1.75/3III2,2-/3.25,3+IV3/1.5,2V; head and trunk yellow ventrally; dark brown stripe on preaxial side of tibia present, continuous or almost continuous; light tibial line usually present, rarely absent; light medial dorsal band usually present, rarely absent; light, prominent dorsolateral fold present; postaxial side of femur with irregularly delimited, reticulated, longitudinal dark bands on greenish-yellow background.

Ptychadena guibei (Fig. 2C): 3 specimens, recorded from [10] (Fig. 1). SVL 35.5–37.5 mm in adult males, 43.6–49.0 mm in adult females. Vocal sac aperture in males inferior, at ventral edge of arm insertion; spiny tubercles on venter present in males, very small; median dorsal ridge on snout absent; inner metatarsal tubercle less than half the length of metatarsus I; toe webbing I2/2.5II1.5,1.75/2.75,3,3.25III2,-2-/3IV3/1.5,1.75V; head and trunk yellow ventrally; series of dark brown blotches on preaxial side of tibia present; light tibial line usually present; light medial dorsal band present; light, prominent dorsolateral fold present; postaxial side of femur with three sharply delimited

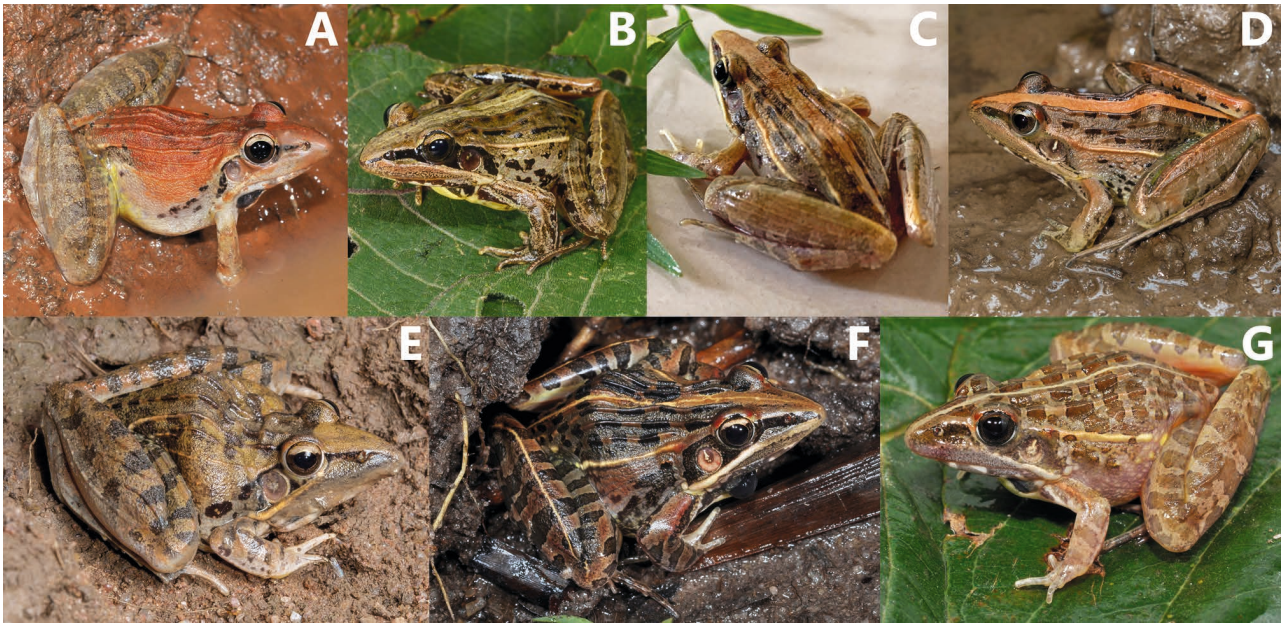

Figure 2. *Ptychadena* species recorded from Rwanda: (A) *P. anchietae* (Mwogo River II, photo: JMD), (B) *P. chrysogaster* (Rugezi Swamp, photo: JMD), (C) *P. guibei* (Bugarama Plain, photo: MM), (D) *P. nilotica* (Mugesera, photo: JMD), (E) *P. oxyrhynchus* (Bweya, Akagera National Park, photo: JMD), (F) *P. porosissima* (Butare, photo: JMD), (G) *P. uzungwensis* (Butare, photo: JMD).

longitudinal, bright greenish yellow stripes on dark brown to blackish background.

Ptychadena nilotica (Fig. 2D): 36 specimens, recorded from [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [16], [17], [18] (Fig. 1). SVL 37.2–45.2 mm adult in males, 45.6–53.1 mm in adult females. Vocal sac aperture in males superior, above dorsal edge of arm insertion; spiny tubercles on venter absent; median dorsal ridge on snout absent; inner metatarsal tubercle less than half the length of metatarsus I; toe webbing I1.5,1.75/2,2.25II1.5/2.75,3III1.75,2/3 IV2.75/1,1.5V; head white, mottled with grey, trunk yellow ventrally; dark brown stripe on preaxial side of tibia absent in most specimens, few with dark mottling, not forming continuous stripe; light tibial line present or absent; light medial dorsal band present or absent; light, prominent dorsolateral fold present; postaxial side of femur with relatively sharply delimited longitudinal bands, alternately yellow and black coloured.

Ptychadena oxyrhynchus (Fig. 2E): 4 specimens, recorded from [15], [17] (Fig. 1). SVL 49.2–52.7 mm in adult males, 58.0 mm in adult females. Vocal sac aperture in males inferior, at ventral edge of arm insertion; spiny tubercles on venter absent; median dorsal ridge on snout absent; inner metatarsal tubercle about half the length of metatarsus I; toe webbing I0.5,1/1.75,2-II0.5/2+,2.25III0.5/2.25IV2-, 2/0,0.5V; head white and trunk yellow ventrally; dark brown stripe on preaxial side of tibia absent; light tibial line absent; light medial dorsal band absent; light, prominent dorsolateral fold absent, but postpalpebral fold white and prominent in its posterior fourth; postaxial side of femur with irregularly reticulated mottling.

Ptychadena porosissima (Fig. 2F): 13 specimens, recorded from [2], [3], [4], [5], [6], [7], [8], [9] (Fig. 1). SVL 37.3–44.5 mm in adult males, 39.0–52.1 mm in adult females. Vocal sac aperture in males inferior, at ventral edge of arm insertion; spiny tubercles on venter present in males, comparatively large; median dorsal ridge on snout absent; inner metatarsal tubercle more than half the length of metatarsus I; toe webbing I1.75,2/2.25II1.5/3III1.75/3,3.25IV3/ 1,1.5V; head and trunk yellow ventrally; dark brown stripe on preaxial side of tibia absent; light tibial line present; light medial dorsal band present or absent; light, prominent dorsolateral fold present; postaxial side of femur with yellow spots diffusely arranged in longitudinal rows on dark brown background.

Ptychadena uzungwensis (Fig. 2G): 6 specimens, recorded from [8] (Fig. 1). SVL 33.3–35.7 mm in adult males, 43.3 mm in adult females. Vocal sac aperture in males semi-inferior, at level of centre of arm insertion; spiny tubercles on venter present in males, very small; median dorsal ridge on snout present; inner metatarsal tubercle about half the length of metatarsus I; toe webbing I2/2.25,2.5II1.5/3-III1.75,2-/3IV3/1+,1.25V; head and abdomen yellow, breast yellowish white ventrally; dark brown stripe on preaxial side of tibia absent; light tibial line absent; light medial dorsal band present; light, prominent dorsolateral fold present; postaxial side of femur with two faint, longitudinal yellow bands, widened to irregularly delimited yellow blotches distally, on greyish dark brown background.

Bioacoustics of *Ptychadena* spp. from Rwanda

Advertisement call variation among the analysed series corroborated the morphological assignment of individuals to seven species. Temporal structure and spectral properties allowed for the unequivocal identification of each species based on single calls (Figs. 3, 4; Table 1). As we have provided quantitative analyses of the calls of *P. anchietae*, *P. nilotica*, and *P. porosissima* in earlier papers (Sinsch et al. 2012, Dehling & Sinsch 2013a), we herein only show oscillograms and sonagrams of the call of these species for comparison (Fig. 3) and restrict the description of advertisement calls to *P. chrysogaster*, *P. guibei*, *P. oxyrhynchus*, and *P. uzungwensis*. The advertisement call of *P. chrysogaster* has been hitherto undescribed. A key to all species based on features of the advertisement calls is in the Appendix 2.

Ptychadena chrysogaster. This is the first record and quantitative analysis of the advertisement call of this species. The advertisement call is a short, quacking trill. The only series recorded had four calls, each consisting of three pulse groups, i.e., the same basic structure as in *P. guibei*. The call repetition rate was as low as in *P. oxyrhynchus*, but pulse rate was significantly higher than in the latter (Table 1). Unlike the advertisement call of *P. guibei*, each pulse group had about the same amplitude and was rather homogenous with five pulses each (Fig. 4A, B). There was little amplitude modulation within a pulse group. The dominant frequency was the first harmonic of the fundamental frequency with slightly higher sound pressure. For further details on the temporal and spectral structure see Table 1.

Ptychadena guibei. The advertisement call, a scraping, cricket-like short trill, was given in series comprising 2 to 28 calls. Series started usually with a call including 1–2 pulse groups and continued with another 2–3 calls with two pulse groups. Amplitude of these calls was low but increasing, reaching its maximum at the fourth call that was composed of three pulse groups. The amplitude remained at the maximum level until the end of the call series. Within a three-pulse group of a fully developed advertisement call, the amplitude increased from the first to the third pulse group, as did their duration (Fig. 4C, D, Table 1). This feature distinguished *P. guibei* calls from those of *P. chrysogaster*, the only other *Ptychadena* species in Rwanda with an advertisement call composed of three pulse groups. Another distinctive feature was the spectral composition of the *P. guibei* call, with a fundamental and dominant frequency almost double of that of *P. chrysogaster* (Table 1). The pulse rate of 213 pulses/s on average was the highest of

all *Ptychadena* in Rwanda. For further details on the temporal and spectral structure see Table 1.

Ptychadena oxyrhynchus. The advertisement call, a moderately low-pitched trill, consisting of a single pulse group, was given in series comprising 10 to 19 calls. Series usually started with a call containing 5–6 pulses, with a slightly lower amplitude than the following calls. At the end of a series, calls reached up to 10 pulses (Table 1). Call amplitude increased from the first pulse to reach its maximum in the central pulses and decreased again at the last two pulses (Fig. 4E, F). Correspondingly, the dominant frequency increased from the first pulse to the central pulses and slightly decreased at the last pulses. A unique feature of the calls was that the fundamental frequency was the dominant frequency, whereas in all other *Ptychadena* species in Rwanda the first harmonic was the dominant frequency.

Ptychadena uzungwensis. The vocalizations of this species are complex. We identified a call with 1–3 short introductory pulse groups (trills) followed by a long pulse group that was given at the beginning of a call series (Fig. 4G, H). A call series consisted typically of up to 40 long, rapidly repeated pulse groups. As the long pulse group was the only vocalization that was repeated regularly in long series, we consider it the advertisement call of *P. uzungwensis* (Table 1). The moderately high-pitched call sounds to the human ear like stuttered baaing. Advertisement calls given in a chorus were sometimes interrupted by much louder single- or double-pulse calls that were probably related to aggressive male-male interactions. Therefore, we provide details on the temporal and spectral fine structure of both the introductory pulse groups (trills) and the long pulse group (advertisement call) in Table 2. The advertisement call always had an irregular amplitude modulation with single loud pulses interrupted by 3–6 considerably lower pulses.

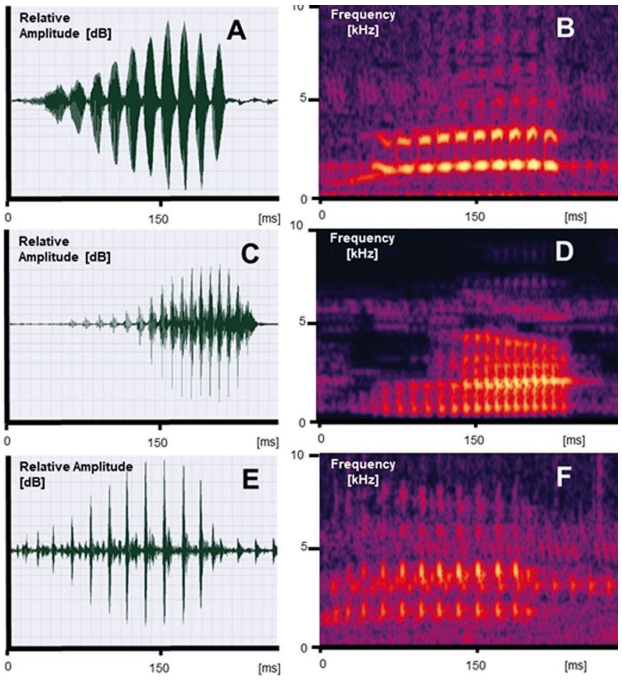

Figure 3. Advertisement calls of three common *Ptychadena* species of Rwanda (left: oscillograms, right: sonagrams): (A, B) *P. anchietae*; (C, D) *P. nilotica*; (E, F) *P. porosissima*.

Discussion

The new records raise the number of *Ptychadena* species in Rwanda to seven. Previously, five species have been known to occur in the country (Dehling & Sinsch 2013b), of which three species (*P. anchietae*, *P. nilotica*, *P. porosissima*) are widespread and occur in most parts of the country, including farmland (Sinsch et al. 2012, Dehling & Sinsch 2013a, Mindje et al. 2020, Tumushimire et al. 2020, Dehling & Dehling 2021). *Ptychadena uzungwensis* is known from only few localities in southern Rwanda, whereas *P. chrysogaster* is restricted to natu-

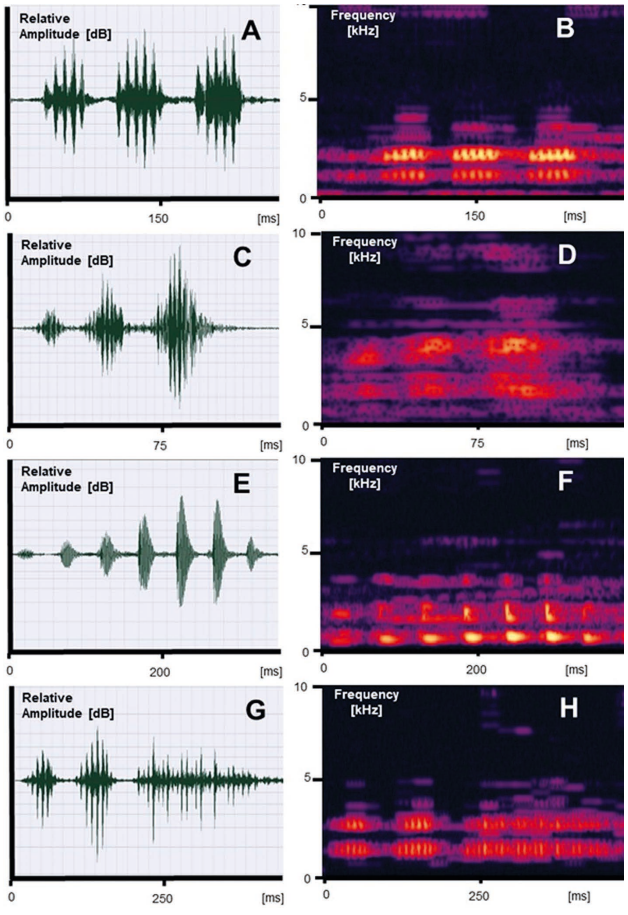

Figure 4: Advertisement calls of four *Ptychadena* species recorded in Rwanda (left: oscillograms, right: sonagrams): (A, B) *P. chrysogaster*; (C, D) *P. guibei*; (E, F) *P. oxyrhynchus*; (G, H) *P. uzungwensis* (shown are two trills and the advertisement call).

Table 1. Features of the advertisement calls of seven *Ptychadena* species recorded in Rwanda. Data are given as temperature-adjusted least square means and corresponding 95 % confidence interval. The range of data measured in single calls is given in parentheses. Hyphenated letters indicate significant differences among advertisement call features (P < 0.05, multiple range test with Bonferroni correction). ind. = individuals.

Call parameter	*P. anchietae* N=19 ind. (n=187 calls)	*P. chrysogaster* N=1 ind. (n=4 calls)	*P. guibei* N=3 ind. (n=37 calls)	*P. nilotica* N=5 ind. (n=36 calls)	*P. oxyrhynchus* N=2 ind. (n=20 calls)	*P. porosissima* N=21 ind. (n=194 calls)	*P. uzungwensis* N=6 ind.	
							Trill (n=19 calls)	Advertisement (n=44 calls)
Call duration [ms]	203 [e] (110–278)	189 [d] (164–177)	124 [b] (52–128)	163 [c] (72–281)	406 [f] (238–445)	188 [d] (100–262)	55 (41–76)	310 [f] (154–585)
Intercall interval [ms]	929 [b] (274–3072)	1717 [c] (796–2558)	581 [a] (399–1027)	479 [a] (95–2504)	1472 [c] (602–1801)	471 [a] (116–996)	152 (39–71)	633 [a] (32–6042)
Call repetition rate [N/min]	63 [a] (51–72)	33 [a] (22–62)	93 [b] (80–156)	125 [c] (67–110)	32 [a] (27–60)	101 [b] (90–111)	582 (517–652)	163 [d] (94–190)
Pulse groups per call [N]	1	3	3 (1–3)	1	1	1	1	1
Pulse group duration [ms]								
1		36.8	22.6					
2		37.5	26.6					
3		36.3	35.8					
Pulse group interval [ms]								
1-2		28.5	11.0					
2-3		34.0	12.6					
Pulses per call [N]	11 [a] (7–14)	15 [b] (13–15)	23 [c] (4–37)	16 [b] (8–26)	8 [a] (5–9)	10 [a] (5–13)	6 (5–9)	38 [d] (17–79)
Pulse duration [ms]	10.6 [c] (8–13)	4.5 [b] (4–5)	2.5 [a] (2–5)	4.8 [b] (3–7)	32.1 [d] (28–38)	6.3 [b] (3–12)	5.1 (4–7)	4.2 [b] (2–6)
Interpulse interval [ms]	5.5 [b] (3–8)	2.6 [b] (2–3)	0 [a] (0)	4.3 [b] (2–6)	19.8 [d] (12–23)	13.2 [c] (7–20)	4.2 (3–6)	5.1 [b] (2–9)
Pulse rate [N/s]	54 [b] (36–64)	82 [c] (79–86)	213 [d] (68–305)	96 [c] (74–111)	18 [a] (17–23)	53 [b] (41–84)	116 (105–125)	128 [d] (97–162)
Fundamental frequency [Hz]	1,571 [c] (1,480–1,691)	1,190 [b] (1,136–1,195)	2,070 [e] (1,828–2,296)	617 [a] (599–754)	1,045 [b] (965–1,107)	1,952 [d] (1,808–2,067)	1,505 (1,167–1,851)	1,578 [c] (1,231–1,779)
Dominant frequency [Hz]	3,243 [d] (2,971–3,724)	2,378 [b] (2,368–2,411)	4,559 [f] (4,284–4,970)	2,660 [b] (1,722–2,712)	1,045 [a] (965–1,107)	3,961 [e] (3,617–4,306)	2,941 (2,627–3,156)	2,890 [d] (2,679–3,156)

ral or near-natural wetlands at higher altitudes and was once widespread and common in Rwanda but has undergone a massive population decline and is now restricted to few scattered localities (Laurent 1954, Dehling & Sinsch 2013b, Dehling & Dehling 2021). Our records of *P. oxyrhynchus* from eastern Rwanda were not surprising, given the species' occurrence in the northwesternmost parts of Tanzania (Nieden 1913). Whereas a previous record of the species from northwestern Rwanda ("Kisenyi" = Gisenyi/Rubavu; Loveridge 1942) was based on misidentified *P. anchietae* (Dehling & Sinsch 2013b, see also Schmidt & Inger 1959, Guibé & Lamotte 1960), we confirmed the identity of a specimen collected by Louis Burgeon in October 1932 at Gabiro (deposited at the Royal Museum for Central Africa [RMCA] in Tervuren, Belgium, RMCA 36857; de Witte 1933) in eastern Rwanda as an adult male (SVL 49.2 mm) of *P. oxyrhynchus*, thus representing the first and only other record of *P. oxyrhynchus* from Rwanda. Our specimens of *P. guibei* closely match the description of the species and the type we examined (Laurent 1954, Schmidt & Inger 1959, Channing 2001, du Preez & Carruthers 2017). The advertisement call of Rwandan specimens closely matches the advertisement call of *P. guibei* described as a sonagram in du Preez & Carruthers (2017) who also provided a sound recording. The geographical origin of the recording was not explicitly stated but is probably in Botswana. Therefore, we assign the Rwandan population to *P. guibei*. The species has been known from south-eastern Democratic Republic of the Congo and north-eastern Zambia (Schmidt & Inger 1959, Channing 2001). Our record of the species from Bugarama in Rwanda extends the geographical range of the species more than 600 km to the north. We expect the species to be found also in adjacent Burundi, western Tanzania and the South Kivu Province of the DRC.

The advertisement call of *P. chrysogaster* has hitherto been unknown. Its three-note structure resembles that of *P. guibei,* but it differs in dominant frequency and amplitude modulation. Still, these similarities suggest a close relationship between the two species in addition to the morphological resemblance (Laurent 1954). The advertisement call of *P. oxyrhynchus* from West Africa (Sierra Leone) has been depicted as a sonagram in Schiøtz

(1964), from Central Africa (Cameroon, DRC) in Amiet (1974) and Inger (1968), from southern Africa (Zululand, northern South Africa) in Passmore (1977; also shown in du Preez & Carruthers 2017), and from East Africa (Kenya) in Bwong et al. (2009). The temporal and spectral structure of the calls recorded in Sierra Leone, Cameroun, DR Congo, and Kenya closely match those from Rwanda (Table 1), whereas calls recorded in South Africa are composed of considerably more pulses (14–16). The features reported for calls in southern Africa by Channing (2001) and in East Africa by Channing & Howell (2006) resemble those of South African specimens, but the geographical origin of the call recordings is not stated.

Channing & Howell (2006) describe the advertisement call of *P. uzungwensis* from Tanzania as a short trill consisting of seven pulses, which agrees with the features of the introductory pulse groups preceding the advertisement call series in our recordings from Rwanda. The geographical origin of the call series published as a sonagram in du Preez & Carruthers (2017) is not explicitly stated, but might be Tanzania, as the call was recorded by Channing. The temporal and spectral features likewise agree with those of the introductory pulse groups. Yet, the number of consecutive trills never exceeded three in Rwanda, and they were always associated with the long pulse group. The cause of this apparent discrepancy and the resulting disagreement upon the identity of the advertisement call remain unknown.

Acknowledgements

Permission for field studies, handling and exportation of specimens was kindly issued by the Rwanda Development Board – Tourism & Conservation (RDB; officer in charge: Antoine Mudakikwa). African Parks (Jes Gruner) kindly supported our fieldwork in Akagera National Park. We would like to thank Siegmar Seidel (Rwanda Center and Office for Africa Cooperations, University of Koblenz), Sarah Müller and Bonny Dumbo (Cyamudongo Project, University of Koblenz), Katja Rembold (Butare Field Station, University of Koblenz), and Eberhard Fischer (Department of Biology, University of Koblenz) for various support in Rwanda. Siegmar Seidel also kindly produced the map of Rwanda. Danny Meirte and G. Cael (RMCA), and Dennis Rödder and Wolfgang Böhme (ZFMK) provided working space and facilitated examination of material under their care. JMD's visit to the RMCA was funded by the Synthesys Project (http://www.synthesys.info) which is financed by European Community Research Infrastructure Action under the FP6 "Structuring the European Research Area" programme (BETAF-2107).

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Appendix 1
Key to *Ptychadena* species from Rwanda based on external morphological characters

1 Median dorsal ridge reaching onto snout . *P. uzungwensis*

1´ Median dorsal ridge not reaching beyond level of eyes . 2

2 Toe webbing reaching to distal subarticular tubercle or beyond on fourth toe and to distal phalanx on first and fifth toes; light, prominent dorsolateral fold usually absent 3

2´ Toe webbing reaching only to penultimate subarticular tubercle or slightly beyond on fourth toe, not reaching to distal phalanx on first and fifth toes; light, prominent dorsolateral fold usually present 4

3 Large, SVL of adult males 49.2–52.7 mm, of adult females 58.0 mm; snout very long, internarial distance less than distance from nostril to tip of snout; postaxial side of thigh with yellow mottling .... *P. oxyrhynchus*

3´ Smaller, SVL of adult males 38.0–42.4 mm, of adult females 46.7–51.3 mm; snout shorter, internarial distance equal to distance from nostril to tip of snout; postaxial side of thigh with irregularly delimited, reticulated longitudinal yellow bands ..... *P. anchietae*

4 Postaxial side of thighs with yellow spots; inner metatarsal tubercle large, more than half the length of metatarsus of first toe ..... *P. porosissima*

4´ Postaxial side of thighs with bright longitudinal bands; inner metatarsal tubercle small, less than half the length of metatarsus of first toe 5

5 Ventral side of head white, sometimes with grey mottling; webbing reaching beyond distal subarticular tubercle on first toe and on postaxial side of fourth toe; vocal sac aperture in males superior ..... *P. nilotica*

5´ Ventral side of head yellow; webbing not reaching beyond distal subarticular tubercle on first toe and on postaxial side of fourth toe; vocal sac aperture in males inferior 6

6 Large, SVL of adult males 37.8–49.7 mm, of adult females 48.0–57.7 mm, of females to 57.7 mm; postaxial side of thighs with irregularly shaped bright bands; dark pattern on preaxial side of tibia usually forming continuous line ..... *P. chrysogaster*

6´ Small, SVL of adult males to 35.5–37.5 mm, of adult females to 43.6–49.0 mm; postaxial side of thighs with sharply defined stripes; dark pattern on preaxial side of tibia usually consisting of separated blotches ..... *P. guibei*

Appendix 2
Key to *Ptychadena* species from Rwanda based on features of the advertisement calls

1 Call with three pulse groups 2

1′ Call with a single pulse group 3

2 Amplitude of pulse groups increases from the first to the third, dominant frequency > 4,000 Hz ..... *P. guibei*

2′ Amplitude of pulse groups remains at the same level, dominant frequency < 2,500 Hz ..... *P. chrysogaster*

3 Pulse repetition rate < 25 ..... *P. oxyrhynchus*

3′ Pulse repetition rate > 36 4

4 Fundamental frequency < 800 Hz ..... *P. nilotica*

4’ Fundamental frequency > 1,100 Hz 5

5 Call without marked frequency modulation, repeated at high rate (> 150/m) in long series, pulse repetition rate > 95/s ..... *P. uzungwensis*

5′ Call with marked dominant-frequency modulation, cricket-like, repeated at lower rate (< 120/m), pulse repetition rate < 85/s 6

6 Pulses widely separated, interpulse interval 13.2 [7–20] ms, fundamental frequency > 1800 Hz, dominant frequency usually < 3600 [2,971–3,724] Hz .. *P. anchietae*

6′ Pulses not widely separated, interpulse interval 5.5 [3–8] ms, fundamental frequency < 1700 Hz, dominant frequency usually > 3,700 [3,617–4,306] Hz .... *P. porosissima*