

# Three new species of the microhylid frog genus *Choerophryne* (Amphibia, Anura, Microhylidae) from Papua New Guinea

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## Abstract

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We describe three new species of the microhylid frog genus *Choerophryne* from the mountains and foothills of southern and northeastern Papua New Guinea. All three species lack elongated snouts and all are arboreal, calling from elevated perch sites between ~1 and 10 m above the forest floor. Advertisement calls and habitat preferences are described for each species. Descriptions of these three frogs brings the total number of *Choerophryne* recognized to 34 but numerous additional species undoubtedly remain to be discovered in poorly-surveyed mountainous regions of New Guinea.

## Key Words

New Guinea

taxonomy

frogs

Gulf Province

Southern Highlands Province

Huon Peninsula

## Introduction

The microhylid genus *Choerophryne* Kampen, 1914 currently contains 31 species of small (SUL < 30 mm), terrestrial or arboreal frogs (Iannella et al. 2014, 2015; Frost 2016). The taxonomy and relationships of *Choerophryne* remain poorly understood. Until recently the genus contained species with moderately to extremely elongated snouts (Kraus and Allison 2001, Günther 2008), and morphological characters associated with snout elongation were used to distinguish it from the similar short-snouted Papuan microhylid genus *Albericus* Burton & Zweifel, 1995. However Kraus (2013) suggested that features associated with snout elongation are of limited diagnostic value, and described a new species (*C. bryonopsis*) with morphological characters intermediate between the two genera. Subsequently Peloso et al. (2016) provided molecular evidence that the genus *Albericus* is paraphyletic with respect to *Choerophryne* and synonymised *Albericus* with the older name *Choerophryne*.

Here we describe three new species of *Choerophryne* lacking elongated snouts, two from the southern slopes of Papua New Guinea's central cordillera and one from the mountains of the Huon Peninsula in northern Papua New Guinea. There is no doubt that many species of this moderately diverse genus remain to be discovered and described from the large areas of mountainous terrain in New Guinea that remain incompletely surveyed.

## Material and methods

Male frogs were collected at night after they were located by their advertisement calls. Representative specimens were photographed in life, and all specimens were anaesthetised in an aqueous chlorobutanol solution next day and subsequently fixed in 5% formalin. Liver samples were taken from some specimens before fixation, and stored in 95% ethanol to enable later DNA sequencing. All specimens were transferred to 70% ethanol within two days of fixation.

The following measurements were taken with a digital caliper ( $> 10$  mm) or with a binocular dissecting microscope fitted with an ocular micrometer ( $< 10$  mm) to the nearest 0.1 mm from preserved specimens only:

SUL	snout-urostyle length from tip of snout to distal tip of urostyle bone; SUL is generally slightly shorter than snout-vent length (SVL). As the measurement error is higher in the latter, we prefer to use the former. Both measurements are sufficiently similar (unpublished data) that, where relevant, we compare our SUL measurements with SVL's presented for members of the genus in some papers;
TL	tibia length: external distance between knee and ankle;
TaL	length of tarsus: external distance between tibio-tarsal and heel joints held at right angles;
T4L	length of 4th toe: from tip of toe to proximal end of inner metatarsal tubercle;
T4D	transversal diameter of disc of 4th toe;
T1D	transversal diameter of disc of first toe;
F3L	length of 3rd finger;
F3D	transversal diameter of disc of 3rd finger;
F1D	transversal diameter of disc of first finger;
HL	head length, from tip of snout to posterior margin of tympanum;
HW	head width, taken in the region of the tympana;
SL	snout length, from an imaginary line connecting the centres of the eyes to tip of the snout;
END	distance from anterior corner of orbital opening to centre of naris;
IND	internarial distance between centres of nares;
ED	eye diameter, from anterior to posterior corner of orbital opening;
TyD	horizontal diameter of tympanum.

Advertisement calls were recorded under natural conditions with a Sony Pro-Walkman or a Sony TCM 5000EV tape recorder and a Sennheiser ME66 Microphone with K6 power module, and analysed with Avisoft-SAS Lab Pro software. Air temperatures adjacent to calling males were recorded using a rapid-reading digital thermometer.

Type material of *Choerophryne* species examined for this study, including species previously included in *Albericus*, is listed in Günther and Richards (2011) and in Iannella et al (2014; 2015). Additional comparisons with other “short-nosed” *Choerophryne* relied on the papers by Kraus and Allison (2005a, 2005b, 2009) and Kraus (2010).

#### Abbreviations of collections:

PNGNM	Papua New Guinea National Museum and Art Gallery;
MNHNP	Muséum national d'Histoire naturelle, Paris, France;
SAMA	South Australian Museum, Adelaide, Australia;
ZMB	Museum für Naturkunde Berlin (formerly Zoologisches Museum Berlin).

## Systematics

### *Choerophryne crucifer* sp. n.

<http://zoobank.org/31112467-259E-401A-ACB6-59E0B0960FEA>

**Holotype.** SAMA R69448 (Field number: FN SJR 8623), adult male, Iagifu Ridge near Moro, Southern Highlands Province, Papua New Guinea (06°22.099'S, 143°13.374'E; 900 m asl) collected on 21-11-2004 by S.J. Richards.

**Paratypes.** ZMB 84336 (FN SJR 8622), same data as holotype; SAMA R69440–69442 (FN SJR 3147–3148, 3151), Darai Plateau, Gulf Province, Papua New Guinea (07°07.771'S, 143°36.806'E; 400 m asl) collected on 23-07-2003 by S.J. Richards.

**Diagnosis.** A species of the genus *Choerophryne* lacking an elongated snout. Snout-urostyle length in males ( $n=5$ ) from 13.4–17.3 mm (mean  $14.7 \pm 1.58$  mm). No webs between fingers or toes; fifth toe longer than third; finger discs wider than toe discs (ratio T4D/F3D 0.78–0.88); shanks short (TL/SUL 0.38–0.44). Eyes medium sized (ED/SUL 0.110–0.127), eye-naris distance greater than internarial distance (END/IND 1.00–1.25). Dorsum with a brown hour-glass mark that has an approximately median constriction; and a pale cross with a definite posterior ‘extension’ on head. Dorsal surfaces covered with tubercles in life, lower surface smooth and brown with numerous whitish dots, inguinal region yellowish. Advertisement call a series of musical clicks sounding like ‘tink-tink-tink...’ lasting 1.01–4.75 s and containing 5–22 clicks (notes) per call at a repetition rate of 4.39–5.18 notes/s. Dominant frequency is at 5.5 kHz.

**Description of the holotype.** Adult male with a SUL of 14.9 mm. Additional measurements and ratios are listed in Table 1. Head broader than long (HL/HW 0.73); tip of snout rounded in dorsal view and truncate in lateral view; nostrils near tip of snout, directed laterally and not visible from above, distance between nares less than distance between eye and naris (END/IND 1.25); canthus rostralis in dorsal view straight and rounded; loreal region slightly sloped; tongue oval, narrower anteriorly than posteriorly, posterior margin without indentation; anterior prepharyngeal ridge well developed and smooth, posterior “ridge” a plaque with many longitudinal furrows; fairly long vocal slits on both sides of mouth floor; tympanum small (about one-third of eye diameter) and hardly visible; no supratympanic fold. Shanks of medium length (TL/SUL 0.44). Fingers unwebbed with broad, grooved terminal discs, their relative lengths  $3 > 4 > 2 > 1$  (Fig. 1a, b); disc of third finger slightly more than twice width of penultimate phalanx, no prominent metacarpal or subarticular tubercles. All toes with wide, grooved terminal discs, those of fourth toe slightly narrower than those of third finger; no webs between toes, no metatarsal tubercles, subarticular tubercles weakly developed; relative lengths of toes  $4 > 5 > 3 > 2 > 1$  (Fig. 1a, b). Skin smooth with small



**Figure 1a.** Preserved holotype of *Choerophryne crucifer* sp. n. in dorsal view.



**Figure 1b.** Preserved holotype of *Choerophryne crucifer* sp. n. in ventral view.

but distinct tubercles dorsally in life, less conspicuous in preservative. No distinct tubercles on ventral surfaces in preservative.

**Colour of the holotype in preservative** (Fig. 1a, b). Colour of holotype in life unknown. In preservative ground colour of dorsal surfaces of head, body and hind limbs light-grey, that of fore limbs yellowish; a dun hour-glass shaped patch from eyes to inguinal region, this patch constricted at mid-dorsum and “split” anteriorly by posterior arm of pale cross on head; some diffuse smaller brownish spots on head and dorsal surfaces of extremities. Inguinal region with conspicuous dark brown areas bordered anteriorly by yellow flecks; dark brown inguinal spots merge ventrally into brown colour of abdomen. Underside of thighs, chest and throat also brown and interspersed with small whitish spots. An irregularly shaped dark brown band across anal region.

**Colour in life.** Based on paratype SAMA R69440, mid-dorsum covered by a large brown patch, dorsolaterally bordered by an irregular off-white longitudinal stripe. Flanks reddish-brown with a dark grey reticulum, inguinal region with a yellowish area, dorsal surfaces of extremities grey-yellowish with irregular dark grey, brownish and reddish spots; ventral surfaces grey with whitish mottles (Fig. 2).

**Morphological variation.** Measurements and body ratios of the type specimens are presented in Table 1. While four males had a SUL between 13.8 and 14.9 mm, one male

measured 17.3 mm. This difference of 3.5 mm between adult males is fairly large for frogs of this small size. All five specimens exhibit a dark brown mid-dorsal patch with a pair of anterior and a pair of posterior “wings”, the posterior ones in almost all cases more strongly expanded than the anterior ones. This patch is bordered dorso-laterally by an irregular whitish stripe in four specimens and by a light brown stripe in one specimen. A complete cross-shaped figure on the head is evident in four specimens; it is incomplete in ZMB 84336 where only the posterior section is pronounced. All specimens exhibit the large, pale semicircular patch on the posterior end of the body and pale spots or bands proximally on posterior thighs and distally on dorsal shanks. Throat, chest, abdomen and inferior surface of thighs are brown and more or less densely speckled with whitish spots in all specimens. Ventral surfaces of extremities are off-white and mottled with brownish and/or whitish spots.

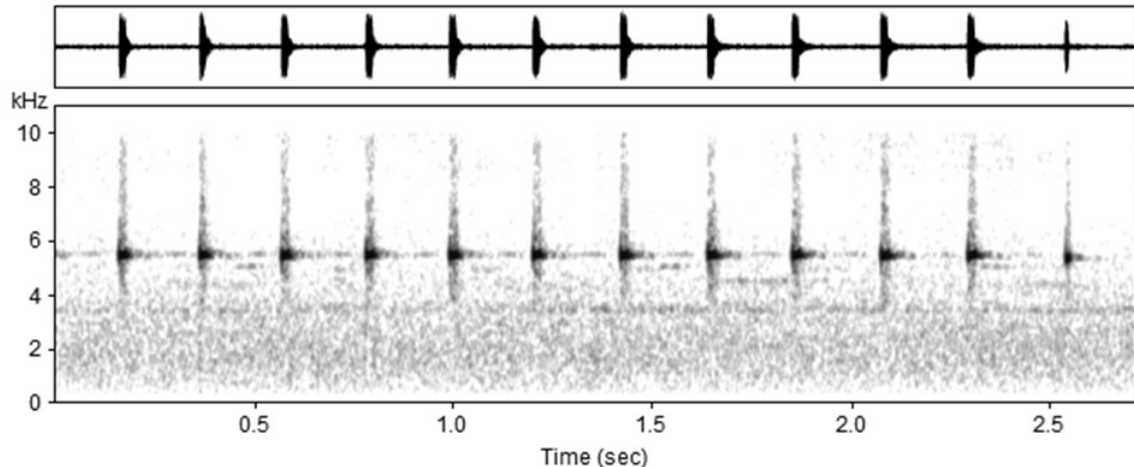
**Distribution and ecological notes.** All records of *Choerophryne crucifer* are from lowland and foothill forest in south-central Papua New Guinea, at altitudes ranging from ~100 m in the lowlands and foothills of Gulf Province to nearly 1,000 m asl on Iagifu Ridge in Southern Highlands Province. Males called at night from the upper surfaces of leaves, generally between 2–10 m above the forest floor.

**Vocalisation.** The advertisement call of the new species, recorded at air temperatures of 23.2–24.0 °C, consists of a series, or ‘train’ of rather musical clicks (Fig. 3). Calls





**Figure 2.** Paratype SAMA R69440 of *Choerophryne crucifer* sp. n. in life.



**Figure 3.** Wave form (above) and spectrogram (below) of an advertisement call from *Choerophryne crucifer* with 12 notes.

follow one another at variable intervals (a few seconds to half a minute and more). Eleven calls were analysed from ZMB 84336 and 16 from SAMA R69442. Because characteristics of both call trains are similar, they are treated together here. 27 calls had a mean duration of  $2.75 \pm 0.82$  s, range 1.01–4.75 s. Mean number of clicks (notes) per call  $13.2 \pm 3.81$ , range 5–22. Notes had a mean duration of  $20.6 \pm 2.91$  ms, range 13–25 ms,  $n=93$ . Inter-note intervals lasted  $200.6 \pm 13.4$  ms, range 176–238 ms,  $n=92$ . Mean note repetition rate  $4.82 \pm 0.21$ , range 4.39–5.18 notes/s,

$n=27$ . Frequencies scatter mostly between 5 and 6 kHz; the dominant frequency is at 5.5 kHz (Fig. 4). Notes start at maximum sound amplitude and, after a short time at this level, amplitude drops quickly. All notes have a similar maximum amplitude.

**Etymology.** The specific epithet *crucifer* is a Latin substantive in apposition and means carrier (porter) of a cross. It refers to the conspicuous yellowish cross on the head of most specimens.

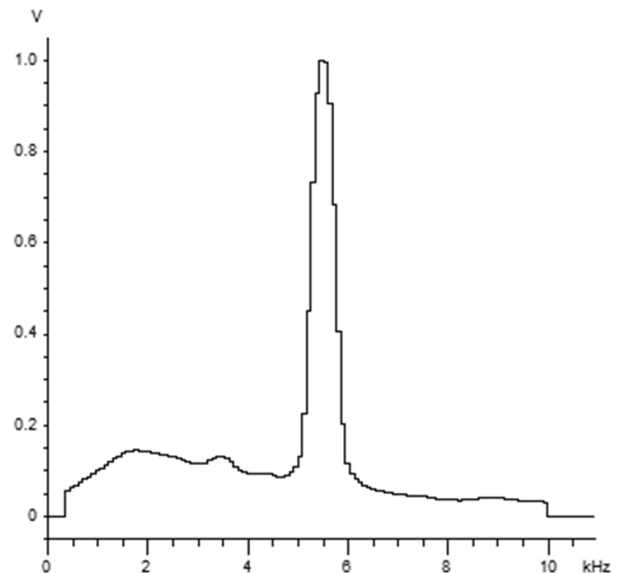
**Table 1.** Body measurements and body ratios of the type series of *Choerophryne crucifer* sp. n. SAMA R69448 is the holotype, all five types are adult males; all measurements in mm. Reg.-No = Registration number; SD = standard deviation; for explanations of abbreviations for measurements see “Material and methods”.

Reg.-No.	SAMA R69440	SAMA R69441	SAMA R69442	ZMB 84336	SAMA R69448	Mean±SD
SUL	13.4	13.8	13.9	17.3	14.9	14.7±1.580
TL	5.3	5.7	6.1	7.0	6.5	
TaL	3.7	3.5	3.9	4.7	4.5	
T4L	4.9	4.8	5.4	5.6	5.5	
T4D	0.7	0.7	0.7	0.9	0.7	
T1D	0.6	0.6	0.6	0.9	0.5	
F3L	3.6	3.9	4.2	4.0	4.2	
F3D	0.8	0.8	0.9	1.1	0.8	
F1D	0.5	0.5	0.5	0.7	0.5	
HL	4.0	3.7	3.6	5.5	3.7	
HW	4.5	4.6	4.9	5.8	5.1	
END	1.1	1.1	1.2	1.5	1.5	
IND	1.0	1.1	1.0	1.3	1.2	
SL	2.1	2.0	2.3	2.8	2.5	
ED	1.7	1.6	1.6	1.9	1.8	
TyD	0.5	0.5	0.4	0.7	0.6	
TL/SUL	0.40	0.41	0.44	0.38	0.44	0.41±0.026
TaL/SUL	0.28	0.25	0.28	0.27	0.30	0.28±0.018
T4L/SUL	0.37	0.35	0.39	0.32	0.37	0.36±0.026
T4D/SUL	0.052	0.051	0.050	0.052	0.047	0.050±0.002
F3L/SUL	0.27	0.28	0.30	0.23	0.28	0.27±0.026
F3D/SUL	0.060	0.058	0.065	0.064	0.054	0.060±0.004
T4D/F3D	0.88	0.88	0.78	0.82	0.88	0.85±0.046
T1D/F1D	1.20	1.20	1.20	1.29	1.00	1.18±0.107
HL/SUL	0.30	0.27	0.26	0.32	0.25	0.28±0.029
HW/SUL	0.34	0.33	0.35	0.34	0.34	0.34±0.007
HL/HW	0.89	0.80	0.73	0.95	0.73	0.82±0.098
END/IND	1.10	1.00	1.20	1.15	1.25	1.14±0.096
ED/SUL	0.127	0.116	0.115	0.110	0.121	0.118±0.006
TyD/SUL	0.037	0.036	0.029	0.040	0.040	0.036±0.005
TyD/ED	0.29	0.31	0.25	0.37	0.33	0.31±0.045
SL/SUL	0.157	0.145	0.165	0.162	0.168	0.159±0.009

**Comparisons with other species.** With its short snout *Choerophryne crucifer* differs from all twelve *Choerophryne* with an elongated snout and would have been placed in the genus *Albericus* in the former sense. According to Frost (2016) 18 species of short-snouted *Choerophryne* are recognized at present. The advertisement call of most short-snouted species is described as a buzz. Apart from *C. crucifer*, calls consisting of clicking notes are produced only by *C. gudrunae*, *C. gunnari*, *C. sanguinopicta* and *C. valkuriarum*.

*Choerophryne gudrunae* has longer legs (TL/SVL 0.44–0.46 vs. 0.38–0.44) and a higher ratio of END/IND (1.20–1.50 vs. 1.00–1.25) than *C. crucifer*. The advertisement calls of the former consist of about 10 clicks, those of *C. crucifer* of 13 on average. Dominant frequency of *gudrunae*-calls is at 3.5 kHz, of *crucifer*-calls at 5.5 kHz.

*Choerophryne gunnari* has longer legs (TL/SVL 0.44–0.51), a higher ratio END/IND (1.25–1.45) and conspicu-



**Figure 4.** Power spectrum of an advertisement call of *Choerophryne crucifer* sp. n.

ous blue pigmentation on the belly and hind limbs (absent in *C. crucifer*). Note repetition rate of the advertisement call of *C. gunnari* is, according to the spectrograms published by Menzies (1999, 2006), about two clicks/s (erroneously reported as about 4 clicks/s in the 1999 paper) vs. 4.4–5.2 clicks/s in *C. crucifer*. Figure 17 in Menzies (1999) shows a dominant frequency of about 3.3 kHz for this species, which is much lower than in calls from *C. crucifer* (5.5 kHz). Menzies (1999) also reports that the clicks uttered by *C. gunnari* have ‘no musical quality’ whereas those produced by *C. crucifer* are distinctly musical, sounding to the ear like ‘tink..tink..tink’.

*Choerophryne sanguinopicta* occurs at elevations of >1,400 m asl (vs. lowlands and foothills <1000 m asl) and exhibits an extraordinary polychromatic colouration (absent in *C. crucifer*). Moreover its advertisement calls are very long series (several minutes) of clicks with a note (= call) repetition rate of less than three calls/s and a dominant frequency of around 4.0 kHz (vs. shorter series of clicks, each series lasting less than 4 seconds and with a repetition rate of more than 4.4 per second and a higher dominant frequency (at 5.5 kHz) in *C. crucifer*).

*Choerophryne valkuriarum* generally occurs at elevations over 2000 m asl (vs. <1000 m asl in *C. crucifer*). According to Kraus and Allison (2005a) HW/SVL in *C. valkuriarum* is 0.37–0.43 and F3D/SVL is 0.067–0.088, we found values of 0.33–0.35 and 0.054–0.064 in *C. crucifer*. There are also differences in the advertisement calls. Menzies (1999) notes a maximum repetition rate for *C. valkuriarum* of two notes/s and reports that notes are uttered “once or in irregular series”. In *C. crucifer* clicks are uttered at regular intervals and at a rate of 4.4–5.2 per s.

*Choerophryne variegata* is known from a single specimen, and its advertisement call is unknown. According to measurements by Menzies (1999) the holotype of this

species differs from the new species described here by the ratios TL/SVL (0.47 vs. 0.38–0.44), F3D/SVL (0.071 vs. 0.054–0.065), END/IND (1.38 vs. 1.00–1.25) and ED/SVL (0.133 vs. 0.110–0.127). Moreover, toes 4 and 5 are connected by webbing in *C. variegata* and not so in *C. crucifer*.

### *Choerophryne multisyllaba* sp. n.

<http://zoobank.org/7496397F-B370-4034-AFA4-B7189236E5A7>

**Holotype.** SAMA R70322 (FN SJR 2322), adult male, Iagifu Ridge near Moro, Southern Highlands Province, Papua New Guinea (06°26.4864'S, 143°13.1040'E; 1,413 m asl) collected on 21-10-2001 by S.J. Richards.

**Paratypes.** SAMA R70323–70325 (FN SJR 2070, 2286, 2325), PNGNM unregistered (FN SJR 2137), ZMB 84337–84338 (FN SJR 2323 & 2324), all details same as holotype except PNGNM collected on 28-05-2002 and SAMA R70324 collected on 19-10-2001 by S.J. Richards.

**Diagnosis.** A species of the genus *Choerophryne* lacking an elongated snout. Snout-urostyle length in males (n=7) from 14.0–15.2 mm (mean 14.4±0.45 mm). No webs between fingers or toes; fifth toe longer than third; finger discs wider than toe discs (ratio T4D/F3D 0.67–0.89); shanks medium-length (TL/SUL 0.43–0.47). Eyes fairly large (ED/SUL 0.126–0.143), eye-naris distance greater than internarial distance (END/IND 1.00–1.17). Almost all specimens with a yellowish (whitish in preservative) interocular stripe, an irregular longitudinal mark of the same colour in the scapular region and a narrow streak between corner of the mouth and tympanum. No brown hour-glass mark on dorsum and no light cross on head. Best diagnostic character is the advertisement call: a rattle of 0.7–1.0 s duration with a dominant frequency of 3.5 kHz.

**Description of the holotype.** Adult male with a SUL of 14.9 mm. Additional measurements and ratios are listed in Table 2. Head broader than long (HL/HW 0.86); tip of snout subelliptical with a small median protuberance in dorsal view and slightly protruding in lateral view; nostrils near tip of snout, directed laterally and not visible from above, distance between nares less than distance between eye and naris (END/IND 1.15); canthus rostralis rounded, loreal region slightly sloped and with some elongate pits; tongue strongly widened posteriorly, with a weak indentation and its posterior part nearly half free; one prepharyngeal ridge without denticles; fairly long vocal slits on both sides of mouth floor. Tympanum medium-sized (TyD/ED 0.42) and well visible, no supratympanic fold. Shanks medium sized (TL/SUL 0.44). Fingers unwebbed and with semi-circular or truncate, grooved terminal discs, their relative lengths 3>4>2>1 (Fig. 5a, b); disc of third finger substantially more than twice width of penultimate phalanx, metacarpal and subarticular tubercles absent. All

toes with wide and grooved terminal discs, those of fourth toe clearly narrower than those of third finger; no webs between toes, no metatarsal tubercles, subarticular tubercles weakly developed; relative lengths of toes 4>5>3>2>1 (Fig. 5a, b). A group of distinct tubercles dorsolateral of the tympanum and some tubercles also on flanks; throat and chest with small tubercles, abdomen and ventral surfaces of extremities smooth.

**Colour of the holotype in preservative.** Colour of holotype in life unknown. In preservative ground colour of dorsal surfaces of head, body, upper arm, forearm, thigh and shank light-grey, that of hands and feet yellowish. All dorsal surfaces more or less densely dotted with tiny dark brown dots: less so on hands, feet, between eyes, on tibio-tarsal joint and on sacral region continued on to thighs; more so on all other dorsal surfaces. A scarcely visible pale interocular stripe and a pale, irregular stripe(s) in the scapular region; a similarly inconspicuous pale, irregular stripe along the upper flanks and a pale lumbar “eye-spots” (Fig. 5a). Ground colour of all ventral surfaces yellowish and covered with more or less dense brown punctations. Underside of hands and feet with least punctations (Fig. 5b).

**Morphological variation in the paratypes.** Measurements and body ratios of the type specimens are presented in Table 2.

Colour in preservative of the type series: The pale inter-ocular stripe is more strongly expressed in the paratypes than in the holotype. The pale and irregularly shaped longitudinal line in the scapular region is also more strongly developed in most paratypes, and in some specimens it reaches the inguinal region. Ground colour of the dorsal surfaces in all specimens is off-white. Tiny, clearly demarcated brown dots are distributed on all dorsal surfaces. These dots form clusters of small circles on various body parts. In addition there are light or dark brown spots of different shape on various parts of the dorsal and lateral surfaces. Paler areas occur mostly on the snout, extremities, sacral region and upper flanks. Ground colour of ventral surfaces is also off-white and covered by many tiny brown dots. Their distribution ventrally is more homogenous than on dorsal surfaces, and larger spots are rare. Small and inconspicuous white spots occur on ventral surfaces of all specimens.

Tubercles are generally few and inconspicuous on dorsal surfaces but more conspicuous on flanks. Striking in all specimens studied is a tubercle directly behind the angle of the jaw and several tubercles in the postocular region.

Colour in life of two paratypes (PNGNM unreg. and SAMA R70324): Dorsal surfaces of the former (Fig. 6) and of the latter (Fig. 7) exhibit a mixture of different colours and spots. Brownish colours with yellow marks dominate in the former, and reddish areas in the latter. One additional, unvouchered specimen for which an image in life is available has a more uniform grey-brown dorsal colouration.





**Figure 5a.** Preserved holotype of *Choerophryne multisyllaba* sp. n. in dorsal view.



**Figure 5b.** Preserved holotype of *Choerophryne multisyllaba* sp. n. in ventral view.

**Table 2.** Body measurements and body ratios of the type series of *Choerophryne multisyllaba* sp. n. SAMA R70322 is the holotype, all types are adult males, all measurements in mm; for explanation of abbreviations see Table 1.

Reg.-No	SAMA R70323	PNGNM unreg.	SAMA R70324	SAMA R70322	ZMB 8433	ZMB 84338	SAMA R70325	Mean±SD
SUL	14.2	14.3	14.1	14.9	15.2	14.3	14.0	14.4±0.45
TL	6.2	6.3	6.0	6.5	7.0	6.7	6.1	
TaL	4.3	4.4	4.3	4.5	4.8	4.5	4.4	
T4L	5.7	5.5	5.8	5.5	6.2	5.4	5.2	
T4D	0.8	0.9	0.7	0.8	1.0	0.7	0.8	
T1D	0.7	0.7	0.6	0.7	0.9	0.7	0.7	
F3L	4.3	4.5	4.4	4.5	4.6	4.2	4.0	
F3D	1.2	1.1	0.9	1.2	1.3	1.0	0.9	
F1D	0.6	0.7	0.6	0.7	0.9	0.7	0.7	
HL	4.4	4.3	4.4	5.0	4.5	4.5	4.2	
HW	5.7	5.4	5.3	5.8	5.7	5.5	5.6	
END	1.4	1.4	1.4	1.5	1.4	1.4	1.3	
IND	1.4	1.3	1.2	1.3	1.3	1.2	1.3	
SL	2.4	2.3	2.5	2.5	2.7	2.3	2.2	
ED	2.0	1.8	2.0	1.9	2.0	2.0	2.0	
TyD	0.8	0.7	0.8	0.8	0.6	0.6	0.7	
TL/SUL	0.44	0.44	0.43	0.44	0.46	0.47	0.44	0.45±0.013
TaL/SUL	0.30	0.31	0.30	0.30	0.32	0.31	0.31	0.31±0.007
T4L/SUL	0.40	0.38	0.41	0.37	0.41	0.38	0.37	0.39±0.018
T4D/SUL	0.056	0.063	0.050	0.054	0.066	0.049	0.057	0.056±0.006
F3L/SUL	0.30	0.31	0.31	0.30	0.30	0.29	0.29	0.30±0.008
F3D/SUL	0.085	0.077	0.064	0.081	0.086	0.070	0.064	0.075±0.009
T4D/F3D	0.67	0.82	0.88	0.67	0.77	0.70	0.89	0.77±0.095
T1D/F1D	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.02±0.064
HL/SUL	0.31	0.30	0.31	0.34	0.30	0.31	0.30	0.31±0.014
HW/SUL	0.40	0.38	0.38	0.39	0.38	0.38	0.40	0.39±0.009
HL/HW	0.77	0.80	0.83	0.86	0.79	0.82	0.75	0.80±0.037
END/IND	1.00	1.08	1.17	1.15	1.08	1.17	1.00	1.09±0.074
ED/SUL	0.141	0.126	0.142	0.128	0.132	0.140	0.143	0.136±0.007
TyD/SUL	0.056	0.049	0.057	0.054	0.039	0.042	0.050	0.050±0.007
TyD/ED	0.40	0.39	0.40	0.42	0.30	0.30	0.35	0.37±0.050
SL/SUL	0.169	0.161	0.177	0.168	0.178	0.161	0.157	0.167±0.008



**Figure 6.** Paratype PNGNM unreg. (=FN SJR2137) of *Choerophryne multisyllaba* sp. n. in life.

**Distribution and ecological notes.** *Choerophryne multisyllaba* is currently known from two locations: the vicinity of the type locality at elevations between about 1,300–1,400 m asl on Iagifu Ridge in the Agogo Range, Southern Highlands Province, and at 1,600 m asl at Sawetau Camp in the Muller Range, Western Province (05°39.397'S, 142°18.277'E; Richards and Dahl (2011)), both in the central mountains of Papua New Guinea. Males call from hidden positions, often within curled leaves, between 1–3 m above the ground in extremely wet, mossy forest.

**Vocalisation.** Forty-six calls from the male holotype (SAMA R70322), recorded at an air temperature of 21.5 °C, were analysed. The advertisement call sounds like a quick rattle comparable to the rattling calls of various *Oreophryne*-species. These calls follow one another at short intervals of about two seconds (Fig. 8). Mean call length is  $0.85 \pm 0.07$  s, range 0.71–0.96 s. The calls contain 18–23 notes, mean  $20.1 \pm 1.30$  notes/call. Mean interval length between calls  $2.11 \pm 0.67$  s, range 1.48–4.75 s,  $n=42$ . Call notes are unpulsed and without frequency modulation (Fig. 9). Mean note length  $5.6 \pm 1.31$  ms, range 2–9 ms,  $n=174$ ; mean internote length  $34.6 \pm 9.8$  ms, range 6–63 ms,  $n=162$ . Mean note repetition rate  $23.8 \pm 2.02$ , range 21.3–31.1 notes/s,  $n=46$ . Frequencies scatter mostly between 2.5 and 4.5 kHz. The dominant frequency is at 3.75 kHz (Fig. 10).

**Etymology.** The specific epithet *multisyllaba* is a Latin feminine adjective meaning polysyllabic and refers to the polysyllabic advertisement call.

**Comparisons with other species.** With its short snout *Choerophryne multisyllaba* differs from all twelve *Choerophryne* with an elongated snout. Most short-snouted *Choerophryne* utter buzzing, squeaking or clicking advertisement calls. *Choerophryne multisyllaba* is the first whose call sounds like a rattle (similar to the rattle calls of various *Oreophryne*-species).



**Figure 7.** Paratype SAMA R70324 of *Choerophryne multisyllaba* sp. n. in life.

*Choerophryne crucifer* differs significantly from *C. multisyllaba* in the following body ratios: HW/SUL ( $p=0.005$ ), ED/SUL ( $p=0.009$ ), TyD/SUL ( $p=0.015$ ), T1D/F1D ( $p=0.018$ ) and F3D/SUL ( $p=0.022$ ). Moreover, note repetition rate ranges from 4.4 to 5.2/s in the former and from 21 to 31 notes/s in the latter.

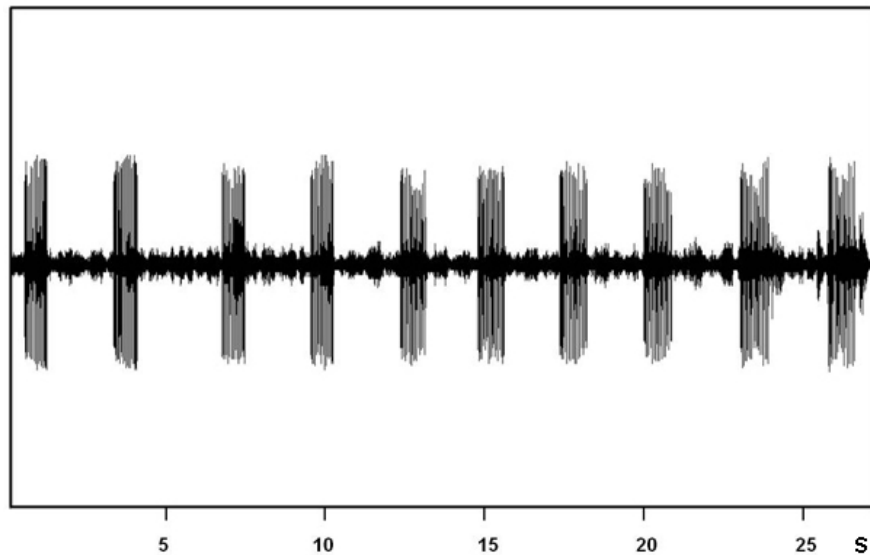
*Choerophryne gudrunae* has a higher ratio END/IND than *C. multisyllaba* (1.20–1.50 vs. 1.00–1.17). The advertisement call of the former consists of about 10 clicks, those of the new species of 18–23. Note repetition rate in *C. gudrunae* is about 5 notes/s and in *C. multisyllaba* of more than 20 notes/s.

*Choerophryne gunnari* has a higher ratio END/IND (1.25–1.45 vs. 1.00–1.17) and conspicuous blue pigmentation on the belly and hind limbs, which is absent in *C. multisyllaba*. Note repetition rate of the advertisement call of *C. gunnari* is, according to the spectrograms published by Menzies (1999, 2006), not more than 4 clicks per second vs. 20–30 clicks per second in *C. multisyllaba*.

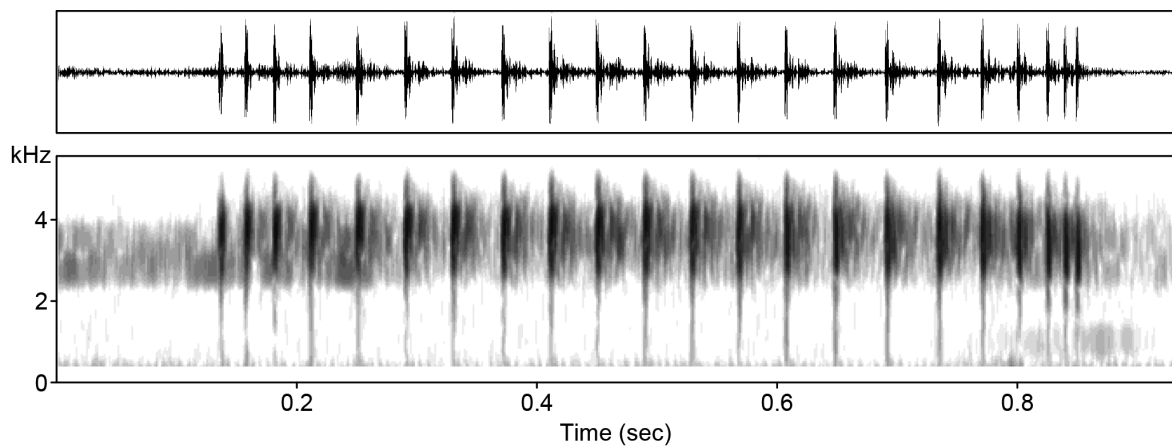
*Choerophryne sanguinopicta* is larger than *C. multisyllaba* (SVL 15.4–17.4 mm vs. SUL 14.0–15.2 mm); its dorsum has a pale blue or green ground colour (off-white in *C. multisyllaba*) and its advertisement call is a very long series (several minutes) of clicks with a note (=call) repetition rate of less than three calls/s and a dominant frequency of around 4.0 kHz vs. much shorter series of clicks (each series lasting less than one second) with a repetition rate of more than 20 notes per second and a lower dominant frequency (at 3.5 kHz) in *C. multisyllaba*.

*Choerophryne valkuriarum* has shorter shanks (TL/SVL 0.37–0.44 vs. 0.43–0.47 in *C. multisyllaba*) and strongly different advertisement calls. Menzies (1999) mentioned the fastest rate as two clicks (=notes) per s uttered in irregular series. *C. multisyllaba* call series are fairly regular and clicks are uttered at a rate of 20–30 per second.

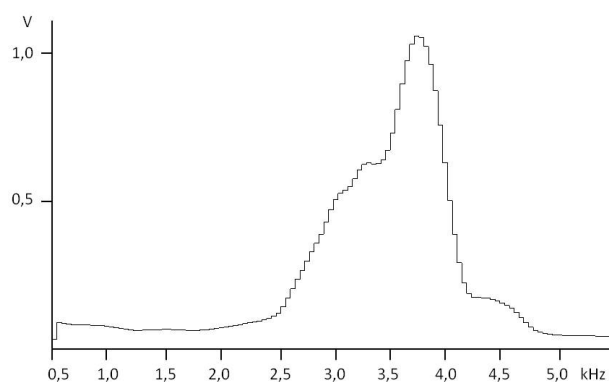




**Figure 8.** Wave form of a series of ten calls from *Choerophryne multisyllaba* sp. n.



**Figure 9.** Wave form (above) and spectrogram (below) of an advertisement call from *Choerophryne multisyllaba* sp. n. consisting of 22 notes.



**Figure 10.** Power spectrum of an advertisement call from *Choerophryne multisyllaba* sp. n.

*Choerophryne variegata* is known from a single specimen and its advertisement call is unknown. According to measurements by Menzies (1999) the holotype of this species differs from the new one by the ratios TL/SVL

(0.47 vs. 0.43–0.47) and END/IND (1.38 vs. 1.00–1.17) as well as by the presence of webbing between toes 4 and 5 vs. no webbing at all in *C. multisyllaba*.

This new species differs by its polysyllabic calls clearly from the next new species which utters disyllabic calls.

#### *Choerophryne bisyllaba* sp. n.

<http://zoobank.org/7496397F-B370-4034-AFA4-B7189236E5A7>

**Holotype.** SAMA R70326 (FN SJR 2178), adult male, Dendawang Camp, Finisterre Range, Huon Peninsula, Morobe Province, Papua New Guinea (6°04.899'S, 146°34.335'E; 2,400 m asl) collected on 1-10-2001 by S.J. Richards.

**Paratypes.** SAMA R70327 (FN SJR 2179), PNGNM unreg. (FN SJR 2186, 2187), ZMB 84339–84340 (FN SJR 2188, 2190), same data as holotype; SAMA R70328–70330 (FN SJR 5992–4), same data as holotype but

collected 28-09-2001; SAMA R70331–70332 (FN SJR 5990–5991), adjacent Teptep Village, Finisterre Range, Huon Peninsula, Morobe Province, Papua New Guinea (5°57.00'S, 146°33.60'E; 2,200 m asl) collected on 27-09-2001 by S.J. Richards.

**Diagnosis.** A species of the genus *Choerophryne* lacking an elongated snout. Snout-urostyle length in males ( $n=10$ ) from 14.2–17.4 mm (mean  $15.4\pm0.94$  mm). No webs between fingers or toes; fifth toe longer than third; finger discs wider than toe discs (ratio T4D/F3D 0.70–0.89); shanks short (TL/SUL 0.36–0.42). Eyes medium sized (ED/SUL 0.115–0.141), eye-naris distance about same as internarial distance (END/IND 0.86–1.25). A brown hour-glass mark present on dorsum, with anterior part of mark much smaller than posterior part. Dorsal surfaces covered with scattered tubercles in life but these become inconspicuous or are absent in preservative. Lower surfaces smooth with a mixture of small brown dots and larger brown spots on a yellow-grey background, throat more strongly pigmented than remaining ventral surfaces. Advertisement calls consist generally of two short but

clearly pulsed notes produced in long series, a call structure that is unique for short-snouted species in the genus *Choerophryne*. Dominant frequency is at 3.5 kHz.

**Description of the holotype.** Adult male with a SUL of 14.4 mm. Additional measurements and ratios are listed in Table 3. Head broader than long (HL/HW 0.82); tip of snout truncate with a small median protuberance in dorsal view and truncate in lateral view; nostrils near tip of snout, directed laterally and not visible from above, distance between nares greater than distance between eye and naris (END/IND 0.92); canthus rostralis in dorsal view rounded and slightly bent; loreal region nearly vertical; tongue strongly widened posteriorly with distinct indentation, posterior half and sides free; prepharyngeal ridge without denticles, fairly long vocal slits on both sides of mouth floor; tympanum half size of eye, its upper margin covered by tympanic fold. Shanks short (TL/SUL 0.40). Fingers unwebbed and with broad and grooved terminal discs, their relative lengths  $3>4>2>1$  (Fig. 11a, b); disc of third finger twice as wide as penultimate phalanx, no prominent metacarpal or subarticular tubercles. All toes with wide and grooved terminal

**Table 3.** Body measurements and body ratios of the type series of *Choerophryne bisyllaba* sp. n. SAMA R70326 is the holotype, all types are adult males, except SAMA R70332 which is a subadult (?) female; all measurements in mm.

Reg.-No	SAMA R70326	SAMA R70327	PNGNM unreg.	PNGNM unreg.	ZMB 84339	ZMB 84340	SAMA R70331	SAMA R70332	SAMA R70328	SAMA R70329	SAMA R70330	Mean $\pm$ SD
SUL	14.4	15.1	15.2	16.0	15.7	14.5	17.4	15.2	14.2	15.4	15.7	15.4 $\pm$ 0.94
TL	5.7	6.2	5.9	6.4	5.8	5.2	6.4	6.4	5.6	6.4	6.0	
TaL	3.6	4.1	4.0	4.5	3.8	4.0	4.4	4.4	4.7	5.2	5.5	
T4L	5.0	5.2	4.9	5.5	5.1	4.8	5.7	5.4	4.7	5.2	5.5	
T4D	0.8	0.8	0.7	0.8	0.7	0.7	0.8	0.8	0.7	0.8	0.9	
T1D	0.6	0.6	0.5	0.5	0.5	0.4	0.7	0.6	0.5	0.6	0.7	
F3L	3.6	3.5	3.5	4.5	3.7	3.6	4.3	4.1	3.4	3.9	4.4	
F3D	0.9	0.9	0.8	1.0	1.0	0.8	1.0	0.9	0.9	1.0	1.0	
F1D	0.5	0.6	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.6	0.5	
HL	4.7	5.1	4.7	5.4	5.2	4.9	5.4	4.8	4.5	5.1	5.0	
HW	5.7	6.0	5.7	6.1	5.8	5.5	6.3	5.5	5.3	6.2	5.7	
END	1.2	1.4	1.5	1.7	1.4	1.3	1.5	1.4	1.2	1.4	1.2	
IND	1.3	1.4	1.2	1.6	1.2	1.4	1.4	1.3	1.3	1.4	1.4	
SL	2.5	2.3	2.3	2.7	2.4	2.2	2.5	2.3	2.2	2.5	2.5	
ED	1.9	2.1	2.0	2.1	2.0	1.8	2.0	1.9	2.0	2.0	2.0	
TyD	0.8	0.9	0.8	1.0	0.8	0.7	0.8	0.7	0.8	1.0	0.8	
TL/SUL	0.40	0.41	0.39	0.40	0.37	0.36	0.37	0.42	0.39	0.42	0.38	0.39 $\pm$ 0.020
TaL/SUL	0.25	0.27	0.26	0.28	0.24	0.28	0.25	0.29	0.28	0.27	0.27	0.27 $\pm$ 0.016
T4L/SUL	0.35	0.34	0.32	0.34	0.32	0.33	0.33	0.36	0.33	0.34	0.35	0.34 $\pm$ 0.013
T4D/F3D	0.056	0.053	0.046	0.050	0.045	0.048	0.046	0.053	0.049	0.052	0.057	0.050 $\pm$ 0.004
F3L/SUL	0.25	0.23	0.23	0.28	0.24	0.25	0.25	0.27	0.24	0.25	0.28	0.25 $\pm$ 0.018
F3D/SUL	0.063	0.060	0.053	0.063	0.064	0.055	0.057	0.059	0.063	0.065	0.064	0.061 $\pm$ 0.004
T4D/F3D	0.89	0.89	0.88	0.80	0.70	0.88	0.80	0.89	0.78	0.80	0.70	0.82 $\pm$ 0.073
T1D/F1D	1.20	1.00	1.00	1.00	0.83	0.80	1.17	1.20	1.00	1.00	1.40	1.05 $\pm$ 0.170
HL/SUL	0.33	0.34	0.31	0.34	0.33	0.34	0.31	0.32	0.32	0.33	0.32	0.33 $\pm$ 0.011
HW/SUL	0.40	0.40	0.38	0.38	0.37	0.38	0.36	0.36	0.37	0.40	0.36	0.38 $\pm$ 0.016
HL/HW	0.82	0.85	0.82	0.88	0.90	0.89	0.86	0.87	0.85	0.82	0.88	0.86 $\pm$ 0.029
END/IND	0.92	1.00	1.25	1.06	1.17	0.93	1.07	1.08	0.92	1.00	0.86	1.02 $\pm$ 0.120
ED/SUL	0.132	0.139	0.132	0.131	0.127	0.124	0.115	0.125	0.141	0.130	0.127	0.129 $\pm$ 0.007
TyD/SUL	0.056	0.060	0.053	0.063	0.051	0.048	0.046	0.046	0.056	0.065	0.051	0.054 $\pm$ 0.007
TyD/ED	0.42	0.43	0.40	0.48	0.48	0.39	0.40	0.37	0.40	0.50	0.40	0.42 $\pm$ 0.043
SL/SUL	0.174	0.152	0.151	0.169	0.153	0.152	0.144	0.151	0.155	0.162	0.159	0.157 $\pm$ 0.009



**Figure 11a.** Preserved holotype of *Choerophryne bisyllaba* sp. n. in dorsal view.



**Figure 11b.** Preserved holotype of *Choerophryne bisyllaba* sp. n. in ventral view.

discs, discs of fourth toe narrower than disc of third finger (T4D/F3D 0.89), no webs between toes, no metatarsal tubercles or subarticular tubercles; relative lengths of toes  $4 > 5 > 3 > 2 > 1$  (Fig. 11a, b). All dorsal surfaces in preservative smooth with only a few low tubercles, flanks with more tubercles; conspicuous are tubercles on distal tarsi and behind angle of jaw; ventral surfaces smooth except for throat and anterior chest that are coarsely textured.

**Colour of the holotype in preservative** (Fig. 11a, b): Colour of holotype in life not known. In preservative ground colour of dorsal surfaces of head, body and extremities light-grey or light brown; some dark brown flecks on head, in the scapular region and on extremities, one dark brown fleck bordered anteriorly by a yellowish fleck in the lumbar region, discs of fingers and toes yellowish and markedly less pigmented than most other dorsal surfaces. Conspicuous is an off-white interocular stripe continuing on eye lids and extending dorsolaterally to the lumbar fleck. This off-white stripe broadening irregularly in the scapular region and in combination with the dark brown mid-dorsum giving the impression of an hour-glass mark with anterior part clearly shorter than its posterior one. A distinct short whitish stripe between eye and angle of jaws. Ground colour of ventral surfaces yellowish. Extremities, throat and anterior chest fairly uniform dark brown, the paler abdomen mottled with some small brown spots. Margin of lower lip unpigmented; anal region spotted with dark brown.

**Morphological variation in the preserved type specimens.** Measurements and body ratios of the type specimens are presented in Table 3. Ten adult males have a SUL

between 14.2 and 17.4 mm (mean  $15.4 \pm 0.94$  mm) and one subadult (?) female (SAMA R70332) with very small eggs in its ovaries measured 15.2 mm. All specimens exhibit a lighter or darker brown mid-dorsal patch that shows a clear constriction in the scapular region. There is a tendency for the anterior part of this patch to be more strongly pigmented than the posterior one. This patch is bordered dorsolaterally by an irregularly shaped light grey stripe in all specimens. A light interocular stripe is present in all but one specimen. A large, pale semi-circular patch in the coccygeal region is present in a few specimens. Throat brown with small whitish spots in most specimens; abdomen in most specimens light grey or yellowish with brown spots, and inferior surfaces of legs brown with whitish spots. Nine of the types have a whitish longitudinal hairline in middle of abdomen; in some specimens this line continues on the throat or forms a cross in the pectoral region.

**Colour in life.** Colour images taken in life are available for three individuals from the type series, but we are unable to assign them to specific vouchers specimens. Two of these individuals are shown in Figs 12 and 13. In the first specimen the snout, dorsolateral stripe, lumbar spots, distal tarsi and heel region are light grey; anterior part of dorsal hourglass mark is blackish, its posterior (much larger) part more brownish; all dorsal surfaces with a few reddish sections even on basal parts of finger and toe discs; stripe between eye and angle of jaws striking white; iris silvery with blackish venation, its inner margin an orange oval; all dorsal surfaces and throat with small white dots (Fig 12). The second specimen has grey lateral surfaces, the anterior part of the hourglass mark on dorsum is blackish, its posterior part a mixture of dark brown and





Figure 12. Paratype of *Choerophryne bisyllaba* sp. n. in life.



Figure 13. Paratype of *Choerophryne bisyllaba* sp. n. in life.

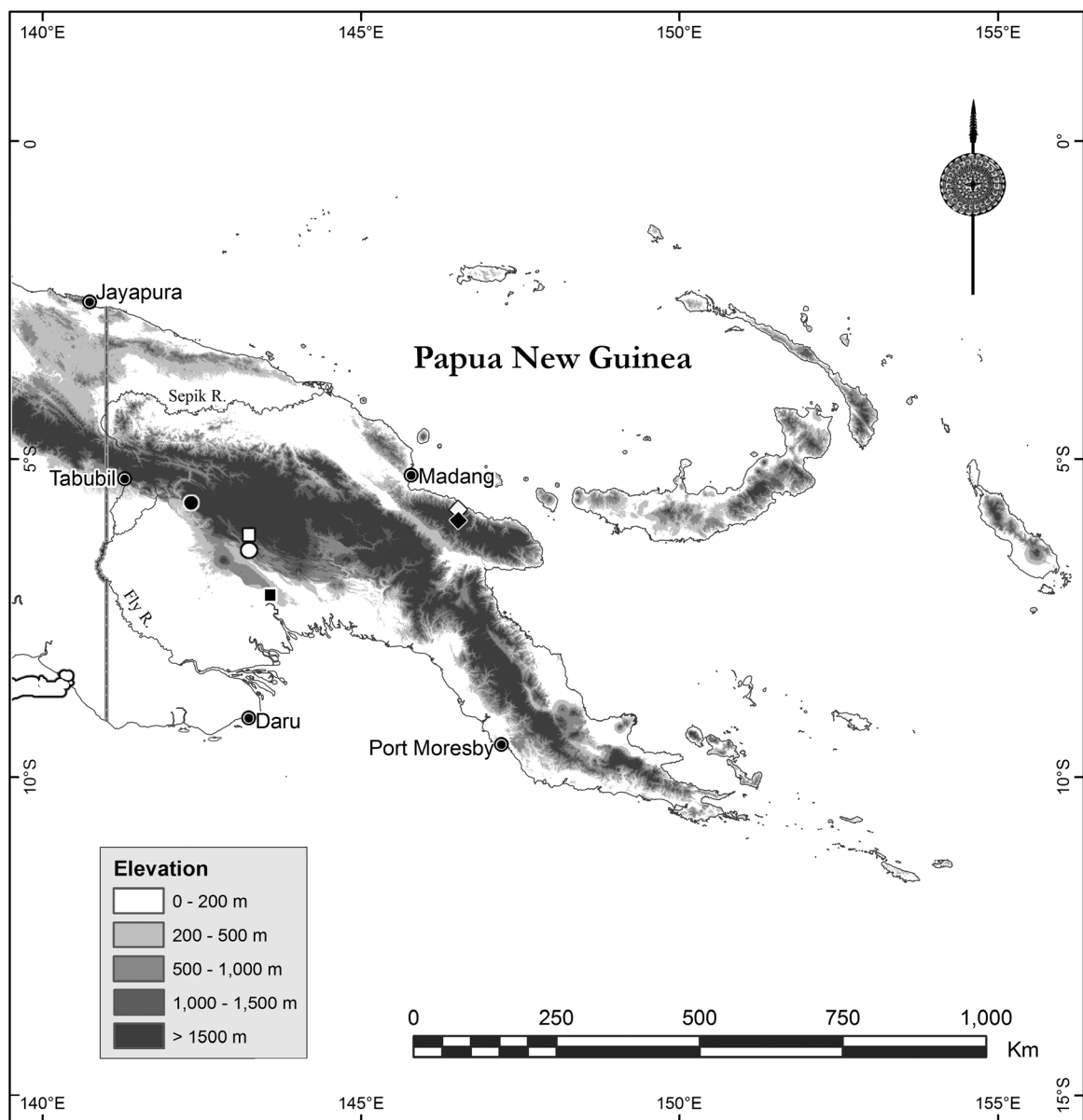
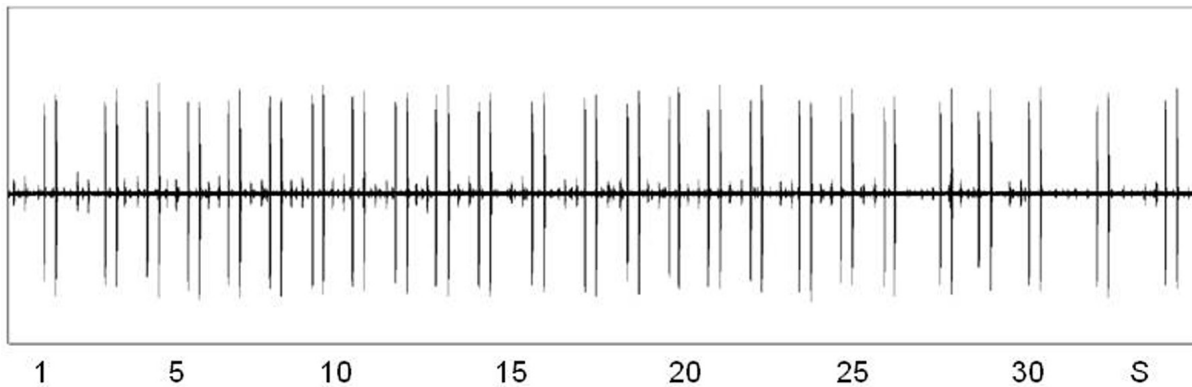
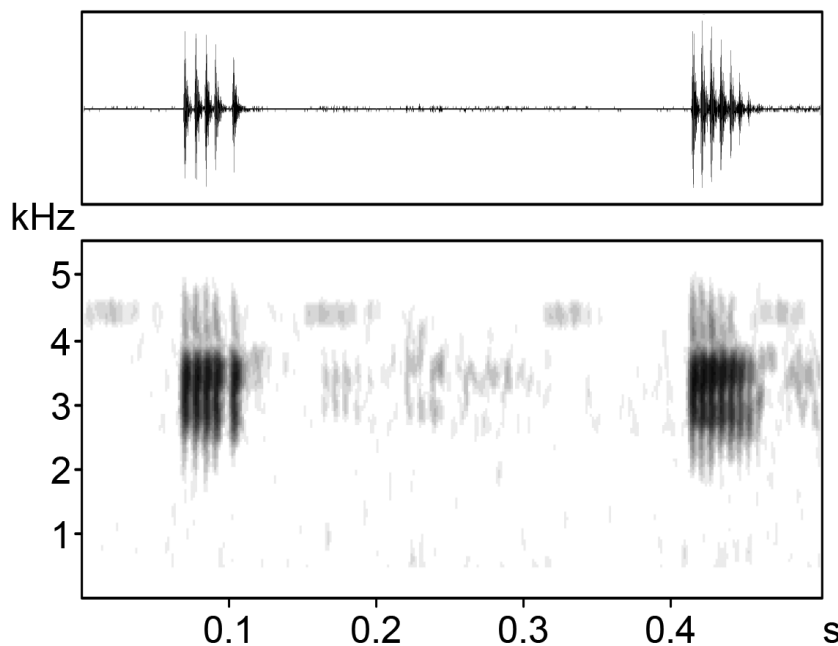


Figure 14. Map showing collection localities of three new *Choerophryne* species. Symbols in white are type localities, those in black represent additional collection localities. Squares = *C. crucifer*; circles = *C. multisyllaba*; diamonds = *C. bisyllaba*. Elevation data are based on 30 m LiDAR Digital Elevation Model (DEM) data from ASTER GDEM v2 (product of METI and NASA).



**Figure 15.** Wave form of a series of 25 calls from *Choerophryne bisyllaba* sp. n.

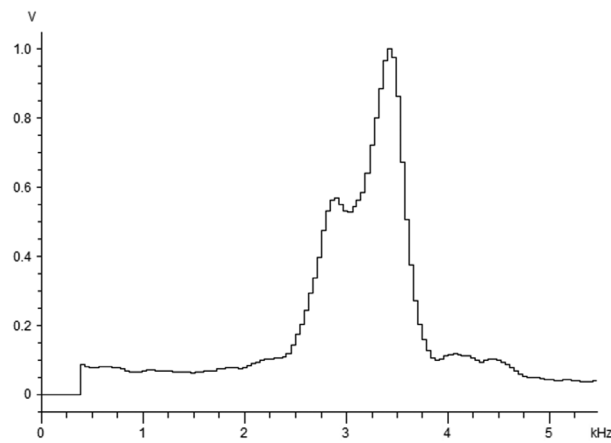


**Figure 16.** Wave form (above) and spectrogram (below) of an advertisement call from *Choerophryne bisyllaba* sp. n. consisting of two pulsed notes.

reddish spots; reddish spots also occur around the elbows and heels, in the inter-ocular and the dorsolateral stripe; throat, lateral sides of head and lower flanks grey with dark grey and white dots (Fig. 13). The third specimen is coloured much as is illustrated in Fig. 13 with most of its dorsal surfaces dark brown or blackish, but conspicuous is a dark red diagonal stripe above insertion of forearm and a large dark red fleck on the coccygeal region.

**Distribution and ecological notes.** *Choerophryne bisyllaba* is currently known only from two locations at elevations between 2,200 and 2,400 m asl in the mountains of the Huon Peninsula, Morobe Province, north-eastern Papua New Guinea (Fig. 14). Males called from semi-concealed or exposed positions on low foliage, normally between 1–2.5 m above the forest floor at night. At Teptep males were calling from leaves in remnant and severely disturbed forest patches, while at Dendawang the species was common in undisturbed, wet mossy forest.

**Vocalisation.** The advertisement call of *C. bisyllaba* normally consists of two notes that are uttered in long series lasting up to several minutes (Fig. 15). A few calls were recorded that consist of only one note, and these were normally (but not always) early in a sequence. Those calls were not considered further. Two-note calls recorded at air temperatures of 14.8 °C to 16.4 °C were analysed from SAMA R70327 (n=50), SAMA R70329 (n=13) and SAMA R70329 (n=32). Because characteristics of all two-note calls are similar, they were combined for analysis here. Mean call duration was  $0.39 \pm 0.034$  s, range 0.25–0.52 s, n=95. Mean duration of intervals between successive calls  $1.01 \pm 0.20$  s, range 0.78–2.03 s, n=94. Mean duration of the first note  $34.2 \pm 7.21$  ms, range 25–52 ms, n=46. Notes are clearly pulsed and most notes start with pulses of maximum sound amplitude that drops relatively quickly; this amplitude decrease is more pronounced in the second note than in the first (Fig. 16). Mean number of pulses in the first note  $4.6 \pm 0.99$ , range



**Figure 17.** Power spectrum of an advertisement call from *Choerophryne bisyllaba* sp. n.

2–8,  $n=46$ . Mean duration of the second note with  $47.7 \pm 3.79$  ms is longer than that of the first note, range 39–54 ms,  $n=46$ . Mean number of pulses in the second note  $7.35 \pm 0.77$ , range 6–8,  $n=46$ . Mean duration of intervals between both notes  $0.30 \pm 0.039$  s, range 0.15–0.35 s,  $n=46$ . Mean note repetition rate is  $5.18 \pm 0.57$  notes/s, range 4.65–8.33 notes/s,  $n=95$ . Frequencies scatter mostly between 2.50 and 3.75 kHz; the dominant frequency is at 3.50 kHz (Fig. 17), a second (lower), peak is pronounced at 2.9 kHz.

**Etymology.** The specific epithet *bisyllaba* is a feminine Latin adjective (in accordance with the feminine genus name) and means disyllabic. It refers to the advertisement call of the species which consists predominantly of two notes (or syllables).

**Comparisons with other species.** With its short snout *Choerophryne bisyllaba* differs from all *Choerophryne* with an elongated snout. According to Frost (2016) 18 species of short-snouted *Choerophryne* are recognized at present. All of these have buzzing, squeaking, clicking or bell-like (‘peeping’) advertisement calls except *C. multisyllaba* with rattling calls. *Choerophryne bisyllaba* is the only species in the genus known so far which utters disyllabic calls with discretely pulsed notes. Menzies (1999) mentioned, but did not formally describe, a population of *Choerophryne* (then *Albericus*) from Teptep with a ‘double-note’ call. However he described that species’ call as ‘bell-like’ with notes lasting <10 ms, and these clearly differ from calls of *C. bisyllaba* which are distinctly pulsed and notes last >25 ms. Resolution of the taxonomic status of the *Choerophryne* population from Teptep reported by Menzies (1999) is not possible with the information currently available.

*Choerophryne variegata* is known from a single specimen, and its advertisement call is unknown. According to measurements by Menzies (1999) the holotype of this species differs from *C. bisyllaba* by the ratios TL/SVL

(0.47 vs. 0.36–0.42), F3D/SVL (0.071 vs. 0.053–0.065) and END/IND (1.38 vs. 0.86–1.25). Moreover, toes 4 and 5 are connected by webbing in *C. variegata* and not so in *C. bisyllaba*.

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