

Three new species of *Callulops* (Anura: Microhylidae) from western New Guinea

RAINER GÜNTHER*, BJÖRN STELBRINK & THOMAS VON RINTELEN

Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt-University, Invalidenstr. 43, 10115 Berlin, Germany.

* corresponding author.
rainer.guenther(at)mfn-berlin.de

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> Abstract

Various works in recent years have shown that the microhylid genus *Callulops* is not a monophyletic group, and that the „central species“ *Callulops robustus* is not, as previously assumed, distributed over the entire island of New Guinea. Further, *Callulops robustus* apparently does not occur in the northwestern part of the island. This species is there replaced by a number of other species, and at present no sympatric occurrence of species in the *C. robustus*-group are known. On the basis of our own collections in the Wondiwoi Mountains at the base of the Wandammen Peninsula as well as on the islands of Yapen and Biak (Cenderawasih Bay) in the years 1998 to 2003, we here describe three new species in the *Callulops robustus*-group.

> Kurzfassung

Verschiedene Arbeiten in den letzten Jahren haben gezeigt, dass die Microhylidengattung *Callulops* keine monophyletische Gruppe ist und die „zentrale Art“ *Callulops robustus* nicht, wie bisher angenommen, über die gesamte Insel Neuguinea verbreitet ist. Auch im Nordwestteil der Insel kommt *Callulops robustus* offenbar nicht vor. Diese Art wird hier durch eine Reihe anderer Spezies ersetzt, wobei bisher keine sympatrischen Vorkommen von Arten der *C. robustus*-Gruppe bekannt wurden. Auf der Basis eigener Aufsammlungen in den Wondiwoi Bergen an der Basis der Wandammenhalbinsel sowie auf den Inseln Yapen und Biak (Cenderawasih Bay) in den Jahren 1998 bis 2003 werden hier drei neue Arten der *Callulops robustus*-Gruppe beschrieben.

> Key words

Amphibia, Anura, Microhylidae, *Callulops*, new species, New Guinea.

Introduction

About three-quarters of the Papuan batrachofauna belongs to the family Microhylidae and all Papuan microhylids are members of the subfamily Asteroophryinae (FROST *et al.* 2006, KÖHLER & GÜNTHER 2008). The most speciose Papuan asteroophryine genus is *Oreophryne*, with presently about 50 species, followed by *Cophixalus* with 35 species. The genus *Xenorhina* contains 29 species, *Austrochaperina* 25, *Callulops* 18, and *Albericus* 15 species. The remaining 16 genera contain fewer than 10 species each (MENZIES 2006, FROST 2011). The genus *Callulops* was revised

by ZWEIFEL (1972) under the name *Phrynomantis*, but this name had to be changed to *Callulops* for name priority reasons (DUBOIS 1988). The genus was considered monophyletic by BURTON (1986), but KÖHLER & GÜNTHER (2008) doubted this view. With the description of the new genera *Metamagnusia* and *Pseudocallulops*, GÜNTHER (2009) split the former *Callulops* into three supposedly monophyletic groups. Other recent publications on the genus *Callulops* are descriptions of new species (KRAUS & ALLISON 2003, 2009; OLIVER, RICHARDS & TJATURADI 2012) and a re-

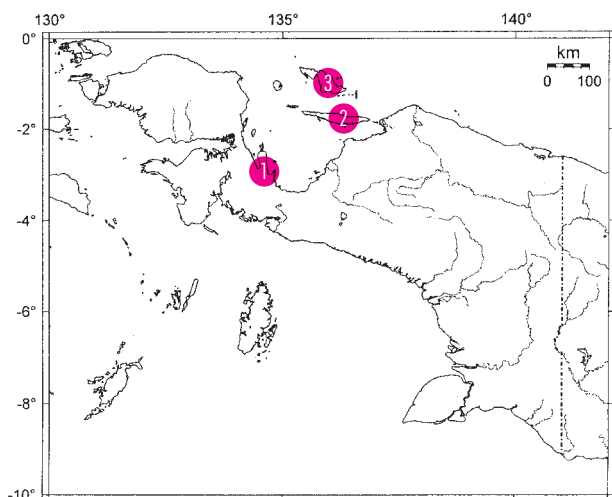


Fig. 1. Map of the Papua Province of Indonesia with type localities of the new taxa from the Wondiwoi Mountains at the base of the Wandammen Peninsula (1), Yapen Island (2), and Biak Island (3).

diagnosis of the type species *Callulops robustus* connected with a resurrection of *Mantophryne microtis* WERNER, 1901 by KRAUS (2012).

The senior author collected *Callulops* frogs in the Wondiwoi Mountains (Wandammen Peninsula), on Yapen Island, on Biak Island, and on the Fakfak Peninsula in the 1990's and in the first decade of this century. All localities are in the Papua Province of Indonesia, in the far western part of the island of New Guinea. Although all these frogs are morphologically similar to *Callulops robustus* (BOULENGER, 1898), there remained serious doubts about their proper allocation. Because of these doubts they were preliminary classified as *Callulops cf. robustus*, for example by KÖHLER & GÜNTHER (2008). Closer examination of this material, including comparisons of their mtDNA, have shown that they belong to four different species, three of them new to science. Here these new species, from the Wondiwoi Mountains, Biak Island, and Yapen Island (Fig. 1), are formally described.

Material and methods

Most frogs were collected after locating them by their advertisement calls, at night, on the ground, and at the entrances to their burrows; others were found moving on the ground surface. Some specimens were photographed in life the next day. Tissue probes were taken from thigh muscles were taken from some specimens and stored in 75 % ethanol for later DNA sequencing. All specimens were preserved in 2 % formalin in the

field and were later transferred to 75 % ethanol in the collection of the Museum für Naturkunde. Two specimens from the Wondiwoi Mountains population (ZMB 70530 and ZMB 70531) were cleared and stained as osteological preparations according to a method modified from DINGERKUS & UHLER (1977).

Measurements were made only on preserved specimens with a sliding calliper (< 10 mm) or with a binocular dissecting microscope fitted with an ocular micrometer (< 10 mm) to the nearest 0.1 mm, as follows:

- SUL** snout-urostyle length from tip of snout to distal tip of urostyle bone; SUL differs only slightly from snout-vent length (SVL), but is more accurately measured. Both measures will be treated as synonymous in the following text;
- TL** tibia length: external distance between knee and ankle;
- TaL** length of tarsus: external distance, tarsal and ankle joints held at right angles;
- T4L** length of fourth toe: from tip of toe to proximal end of inner metatarsal tubercle;
- T4D** transverse diameter of disc of fourth toe;
- T1D** transverse diameter of disc of first toe;
- F3L** length of third finger;
- F3D** transverse diameter of disc of third finger;
- F1D** transverse 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;
- 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;
- EST** distance from anterior corner of eye to tip of snout;
- SL** snout length, from an imaginary line connecting the centres of the eyes to the tip of snout.

Advertisement calls were recorded under natural conditions with a Sony Digital Audio Tape (DAT) Walkman TCD-D 100 and a Sennheiser microphone MKE 300 and analysed with Avisoft-SAS Lab software. All specimens are currently stored in the Museum für Naturkunde Berlin (ZMB) and given registration numbers of this institution. Part of the material will be transferred to the Museum Zoologicum Bogoriense (MZB) at Cibinong after completion of our studies.

Comparisons of the new species with congeners are mostly based on data published in the respective original descriptions or comparative studies (ZWEIFEL 1972, BURTON 1986, MENZIES 2006).

Genomic DNA isolation and mitochondrial fragment amplification (12S and 16S rRNA) was performed according to KÖHLER & GÜNTHER (2008). Forward and reverse strands were aligned using CodonCode

Aligner v. 3.5.7 (CodonCode Corporation, Dedham, MA, USA) and corrected by eye. The sequences were aligned using MAFFT (KATO & TOH 2008); substitution models were obtained from jModeltest v. 0.1.1 ((POSADA 2008); AIC and BIC; 12S rRNA: GTR+G, 16S rRNA: GTR+G).

Phylogenetic analyses of the combined dataset (12S + 16S) were performed using maximum parsimony (MP) as implemented in PAUP* v. 4.0b10 (Swofford 2002), maximum likelihood (ML) using RAxML Blackbox (STAMATAKIS *et al.* 2008) and Bayesian inference (BI) using MrBayes v. 3.1.2 (RONQUIST & HUELSENBECK 2003). MP parameters: heuristic search with 10 random additions (maximum number of saved trees), tree bisection and reconstruction (TBR) branch swapping, number of bootstrap replicates = 100. ML parameters: bootstrap replicates = 100; BI parameters: 1,000,000 generations, sample frequency = 20, number of chains = 4, burnin value = 35,001.

Types of *Callulops microtis* and *C. fuscus* were examined by the authors; other values were taken from the original descriptions and comparative treatments. Fig. 24 is by B. STELBRINK, all others are by the senior author.

Callulops wondiwoiensis sp. nov.

Figs. 2–7, Table 1

Holotype. ZMB 58676 (field number = FN 6761), adult male, Wondiwoi Mountains at the base of the Wandammen Peninsula (Cenderawasih Bay), 650 m a.s.l. (above sea level), 2°56'S and 134°36'E, Papua Province of Indonesia, collected by R. GÜNTHER and G. MAREKU on 29 July 1998.

Paratypes. ZMB 58675 (FN 6738), ZMB 70530 (FN 6601, now an osteological preparation), ZMB 70531 (no FN, now an osteological preparation), collected at the end of July 1998; ZMB 62035 (FN 6917), ZMB 62036 (FN 7031), ZMB 62037 (FN 7032), ZMB 63874 (FN 6949), ZMB 63875–77 (no FN), collected from 22–26 August 1999; ZMB 62568 (FN 7299), collected on 10 May 2000; ZMB 70315 (FN 7705) and ZMB 70316 (FN 7706), collected on 25 June 2003. All paratypes were found on the eastern flank of the Wondiwoi Mountains at elevations of from 500 m to 750 m a.s.l. Collectors were R. GÜNTHER and G. Mareku.

Diagnosis. A medium-sized *Callulops* (snout-urostyle lengths of five adult males 49.5–57.2 mm, mean 53.4 mm, of four adult females 56.0–61.5 mm, mean 59.0 mm, and of one presumed subadult female 51.9 mm) with short legs (TL/SUL 0.38–0.42), moderately expanded terminal discs on fingers and toes, those of toes slightly wider than those of fingers (F3D/T4D 0.75–0.93). All finger and toe discs with terminal grooves. Head broader than long (HL/HW 0.84–0.93), truncate in dorsal view. Eye medium-sized (ED/SUL



Fig. 2. Dorsolateral view of the paratype ZMB 63874 of *Callulops wondiwoiensis* sp. nov. in life.



Fig. 3. Ventral view of the paratype ZMB 63874 of *Callulops wondiwoiensis* sp. nov. in life.

in adults 0.107–0.125) and internarial distance clearly wider than distance eye-naris (END/IND 0.64–0.88). Dorsal surfaces grey-brown to reddish-brown with diminutive white dots predominantly on flanks; ventral surfaces light grey-brown, throat and especially chin darker than belly. Iris bronze with strong blackish pigmentation. Mainly located in burrows. Advertisement call consists of a series of 6–9 loud croaking notes and is very similar to the calls of female mallard duck, *Anas platyrhynchos* LINNAEUS, 1758. Mean note length 147 ms, mean note repetition rate 2.18 notes/s, and dominant frequency around 1.75 kHz.

Description of the holotype. The body appears chunky and is wider than the head. Head is shorter than

Table 1. Body ratios of five adult males, four adult females, and one subadult female of the type series of *Callulops wondiwoiensis* sp. nov. Abbreviations are explained in the section “Material and methods”.

Ratio	Mean	SD	Range
TL/SUL	0.40	0.012	0.38–0.42
TaL/SUL	0.26	0.005	0.25–0.27
T4D/SUL	0.031	0.0012	0.029–0.032
T4D/T1D	1.33	0.116	1.20–1.60
F3D/SUL	0.026	0.0018	0.23–0.28
F3D/F1D	1.16	0.031	1.08–1.18
T4D/F3D	1.19	0.075	1.07–1.29
HL/SUL	0.33	0.011	0.31–0.35
HW/SUL	0.37	0.008	0.36–0.39
HL/HW	0.88	0.029	0.84–0.93
END/IND	0.73	0.082	0.64–0.88
ED/SUL	0.117	0.0057	0.107–0.125
TyD/ED	0.48	0.037	0.44–0.57

broad (HL/HW 0.90). Head is truncate viewed from above and rounded in profile, nostrils elevated, laterally directed, and near tip of snout. Canthus rostralis rounded, loreal region slightly concave. Eye moderately large (ED/SUL 0.107), its horizontal diameter slightly longer than distance from eye to snout tip (EST/ED 0.95), supratympanal fold strongly developed and reaching from eye to fore arm. Tympanum, except its margins, clearly visible and half the size of eye (TyD/ED 0.49). Internarial distance clearly wider than distance eye-naris (END/IND 0.75). The forelegs are moderately long and heavily built, fingers end as small discs, all with terminal grooves. Relative length of fingers $3 > 2 = 4 > 1$, metacarpal tubercles and subarticular tubercles poorly developed. Hind legs fairly short and of heavy build, toe discs larger than finger discs, all discs with terminal grooves. Inner metatarsal tubercle and subarticular tubercles weakly developed, no outer metatarsal tubercle. Relative length of toes $4 > 3 > 5 > 2 > 1$. No webs between fingers or toes. All dorsal and ventral surfaces smooth, except for some tubercles on posterior dorsum. Dorsal surfaces uniformly dark brown, abdomen and inferior thighs light grey-brown, chest and throat darker brown than abdomen but lighter than dorsum. Measurements (in mm) of the holotype: SUL 57.2, TL 22.7, TaL 14.9, T4L 13.5, T4D 1.9, T1D 1.5, F3L 13.5, F3D 1.5, F1D 1.3, HL 19.2, HW 21.4, END 3.6, IND 4.8, ED 6.1, TyD 3.0, EST 5.8, SL 8.7.

Morphological variation in the type series. There are five adult males, four adult and one presumed sub-

adult (ZMB 62568) females, and three juveniles in the type series. The SUL of the males is 49.5–57.2 mm, mean 53.4 (SD 3.07) and that of the four adult females is 56.0–61.5 mm, mean 58.9 mm (SD 2.32). Various body ratios of adult specimens are shown in Tab. 1. Their colouration is very similar to that of the holotype and the paratype shown in Fig. 2 and Fig. 3. Some specimens exhibited in life scattered small yellow spots in the region behind the eyes and/or anterior back, which spots disappeared in preservation fluid. Snout-urostyle lengths of three juveniles was 22.0–28.5 mm. Juveniles differ significantly from adults. They have a clearly larger eye (ED/SUL 0.132–0.140 vs. 0.107–0.125) and smaller tympanum (TyD/SUL 0.045–0.053 vs. 0.052–0.065). Moreover, basic colour of dorsal surfaces is black with numerous white spots and irregular white flecks, and with orange or yellow patches on the central and anterior dorsum (Fig. 4a). Ventral surfaces were also blackish with numerous white spots in life (Fig. 4b). Black colour changed to grey in preserved specimens.

Distribution and ecological notes. We collected *C. wondiwoiensis* at from 500 m to 700 m a.s.l. and heard them calling in primary rain forest between 300 m and 750 m a.s.l. on the eastern slopes and valleys of the Wondiwoi Mountains at the base of the Wandammen Peninsula. Most adult males, some females, and one of the juvenile specimens were found at the entrances to burrows in humus or stony loam soil. One specimen was excavated at the end of a burrow of one meter length and at a depth of 25 cm. No specimen was found under leaf litter or on vegetation. The new species was fairly common but distances between calling males were pronounced (at minimal distances of about 20 m). While adult specimens did not show an apparent preference for bodies of water, all juveniles were found proximate to a waterfall (Fig. 5). Calling specimens were heard in all months when the senior author visited the Wondiwoi Mountains, i.e. in April, May, June, July, August, and September.

The ovaries of a ripe female (ZMB 70531), collected at the end of July 1998, contained 16 eggs, with a maximum diameter of 4.0 mm.

Vocalisation. Males called predominantly during late dusk and in the first few hours after dusk; few calls were heard during early dusk and in later night hours. Calls consisted of a series of very loud croaking notes and were emitted at long intervals, i.e. intervals between calls lasted several minutes and longer. They sounded very much like calls of the female mallard duck, *Anas platyrhynchos*. No calls were noted during the day. Males called mostly from the entrance to their burrows, sometimes also from within the burrow, or from a few meters away. In some cases antiphony



Fig. 4a. Dorsolateral view of a juvenile specimen of *Callulops wondiwoiensis* (ZMB 62035) sp. nov. in life.



Fig. 4b. Ventral view of a juvenile specimen of *Callulops wondiwoiensis* sp. nov. in life.



Fig. 5. Waterfall and surroundings of the mountain stream "Sungai Maja" at 550 m a.s.l., habitat of *Callulops wondiwoiensis* sp. nov. and more than 20 other anuran species.

of neighbouring males occurred. Advertisement calls of three different males were analysed. The first note was nearly always the shortest, followed in length by the second and the third notes. Notes are clearly pulsed, with interpulse intervals longer in the first half of a note. First and last internote intervals are mostly longer than the other intervals (Figs. 5, 6). Mean call length of 12 calls was 3.49 s, minimum 2.43 and maximum 5.47 s. Calls contained 6-9 notes, mean 7.4 notes per call. Note length of 94 notes was 147 ms on average, min. 59 ms, max. 214 ms. Mean internote length of 71 intervals was 371 ms, min. 255 ms, max. 909

ms. The note repetition rate varied from between 1.65 and 2.59 notes per second, mean 2.17 notes/s ($n = 12$). The pulse repetition rate varied from 119 to 239 per second, mean 189 pulses/s ($n = 74$). Frequency spectrum reaches from 0.5 to about 6 kHz, with dominant frequency at 1.75 kHz (Fig. 7). Calls were recorded at air temperatures of from 21 to 23 °C.

Comparisons with other species. *Callulops wondiwoiensis* sp. nov. differs from the recently described species of *Metamagnusia* and *Pseudocallulops* (GÜNTHER 2009), among others, by its more chunky body,

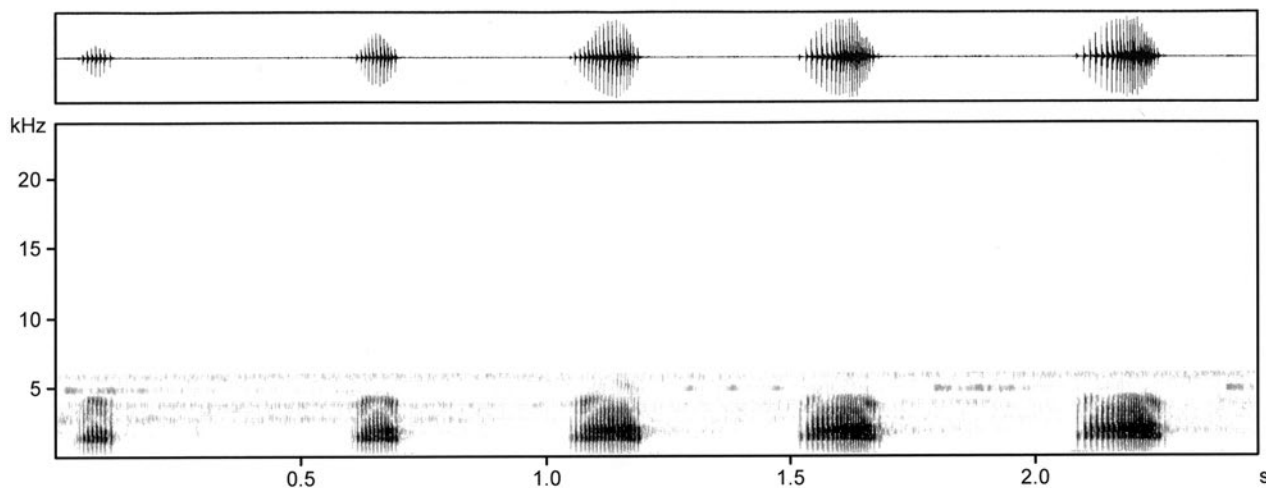


Fig. 6. Wave form (above) and spectrogram (below) of first five notes of an advertisement call of *Callulops wondiwoiensis* sp. nov. consisting of seven notes.

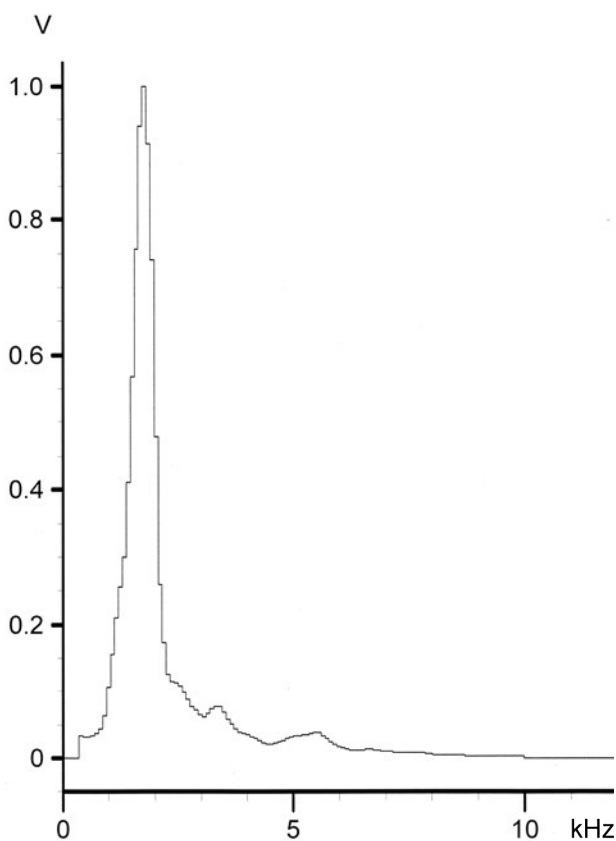


Fig. 7. Power spectrum of an advertisement call note of *Callulops wondiwoiensis* sp. nov.

shorter legs, less expanded finger and toe tips, and discs of toes broader than those of fingers (vice versa in the latter two genera).

Callulops glandulosus (ZWEIFEL, 1972), *C. sagittatus* RICHARDS, BURTON, CUNNINGHAM & DENNIS, 1995, *C. stictogaster* (ZWEIFEL, 1972), and *C. wilhelmanus* (LOVE-RIDGE, 1948), completely lack expanded digital tips

with grooves; the new species has slightly expanded digital tips, all with terminal grooves.

Callulops boettgeri (MÉHELY, 1901) and *C. dubius* (BOETTGER, 1895) from the island of Halmahera, *C. eremnosphax* KRAUS & ALLISON, 2009 from the Gulf Province of Papua New Guinea, *C. kopsteini* (MERTENS, 1930) from the Sula Islands, and *C. mediodiscus* OLIVER, RICHARDS & TJATURADI, 2012 from the Southern Highlands Province of Papua New Guinea, all with snout-vent lengths of under 50 mm, are clearly smaller than *C. wondiwoiensis*.

Callulops comptus (ZWEIFEL, 1972) has shorter hind legs (TL/SVL 0.30–0.39 versus 0.38–0.42), an orange or pink postocular patch, and a boldly mottled ventral surface.

Callulops doriae BOULENGER, 1888 has a larger body (SVL up to 100 mm) and a verrucous dorsal surface showing numerous blackish spots, each with a central white cap.

Callulops fojaensis OLIVER, RICHARDS & TJATURADI, 2012 has shorter hind legs (TL/SVL 0.34), longer call notes (mean 225 ms versus 147 ms in *C. wondiwoiensis*), and a lower dominant frequency (1.3 kHz versus 1.75 kHz).

Callulops fuscus (PETERS, 1867) utters advertisement calls with three notes per second and seems to be restricted to Ambon, Seram, and Batanta Islands (MENZIES 2006).

Callulops humicola (ZWEIFEL, 1972) has a bright yellow or flesh coloured mottled ventrum, is smaller (SVL up to 50 mm) than *C. wondiwoiensis*, and lives at higher elevations (1500–2000 m a.s.l.).

Callulops marmoratus KRAUS & ALLISON, 2003 has longer hind legs (TL/SVL 0.45–0.49) and a mottled dorsal surface.

Callulops omnistriatus KRAUS & ALLISON, 2009 has longer legs (TL/SVL 0.41–0.47, mean 0.44 vs. 0.38–0.42 mean 0.40 in *C. wondiwoiensis*), larger eyes (ED/SVL 1.20–1.40 vs. 1.07–0.125), and larger toe discs (T4D/SVL 0.033–0.044 vs. 0.029–0.033).

Callulops personatus (ZWEIFEL, 1972) has, except on the loreal region, a black head, its dorsal surfaces not uniformly coloured as in *C. wondiwoiensis*, but with a pattern of grey (blackish in life) flecks and blotches, and its belly is pale orange vs. light grey in the new species.

Callulops robustus was redefined recently by KRAUS (2012). Males have a snout-vent length of from 60 to 65 mm and females of from 60 to 78 mm, and thus are larger than *C. wondiwoiensis*. Moreover, *C. robustus* occurs, according to KRAUS (2012), only locality on Misima Island in the Louisiade Archipelago.

Callulops microtis (WERNER, 1901) was recently resurrected from synonymy with *C. robustus* by KRAUS (2012). According to his data and our study of the holotype (ZMB 16499), this species differs from *C. wondiwoiensis* mainly by its skin structure and colouration: flanks and the dorsum (less intensive) are tubercular in the former species but smooth in the latter, and the dorsal surfaces have a uniformly grey-brown or red-brown colour in *C. wondiwoiensis*, but are dark-grey with white flecking in *C. microtis*.

Considering the fact that *Callulops robustus* was restricted to Misima Island, *Liophryne kampeni* BOULENGER, 1914 from the Mimika River region in the southern Papua Province of Indonesia, and *Pomatops valvifera* BARBOUR, 1910 from the Fakfak Mountains, throat of the Vogelkop Peninsula (both now obviously belong in the genus *Callulops*), can no longer be treated as synonyms of *Callulops robustus*. *Callulops kampeni* has broader toe tips (according to measurements by ZWEIFEL 1972, the ratio T4D/F3D is 1.33 in the holotype, which is the only hitherto known specimen of *C. kampeni*, but is 1.07–1.29 in *C. wondiwoiensis*) and a smaller tympanum (TyD/SVL 0.049 vs. 0.052–0.065, and TyD/ED 0.43 vs. 0.44–0.57). Moreover, the dorsal outline of the snout of *C. kampeni* (see Fig. 2B in Kraus & Allison 2009) differs clearly from that of *C. wondiwoiensis*, and odontoids on the vomer are weakly developed in the latter species but are strongly developed in the former (BOULENGER 1914).

The senior author in 2008 collected some *Callulops* frogs in the Fakfak Mountains and in the near future

intends to resurrect the name of the species *Pomatops valvifera* from synonymy with *C. robustus* on the base of this material. Differences between *P. valvifera* and *C. wondiwoiensis* will be outlined in the planned paper.

Etymology. Named after the collection site of the type series, the Wondiwoi Mountains on the Wandammen Peninsula, Cenderawasih Bay, north-western New Guinea.

Callulops yapenensis sp. nov.

Figs. 8–13

Holotype. ZMB 62566 (FN 7350), adult male, collected on 17 May 2000 on Waira Mountain about 7 km NEN of the village of Kontiunae (Konti), about 12 km direct line NE of Serui, 620 m a.s.l., 1°47'S and 136°20'E, Yapen Island, Papua Province of Indonesia, collector R. Günther.

No paratypes.

Diagnosis. With 48.2 mm SUL, a medium-sized species of the genus. Eye large (ED/SUL 0.135), hind leg medium-sized (TL/SUL 0.43). Finger tips and toe tips dilated to small discs, all with terminal grooves. Toe tips insignificantly wider than finger tips (T4D/F3D 1.07). Dorsal and lateral surfaces light grey-brown with a dense pattern of middle- and dark-brown smaller and larger flecks which are connected with one another in many cases. Conspicuous are two irregular pale patches above insertion of fore legs, and large lumbar “ocelli” of a similar colour. Abdomen uniformly light grey, chest and throat brownish with whitish spots. Body sides with many light pustules. Advertisement call consists of 4–11 loud croaking notes, note length 60–163 (mean 139) ms, note repetition rate 2.4–2.8 (mean 2.55) notes/s, and dominant frequency 2.2 kHz.

Description of the holotype (Figs. 8 and 9). Head moderately broad, wider than long (HL/HW 0.88), snout truncate in dorsal view and rounded in profile, canthus rostralis rounded and loreal region slightly concave, nostrils lateral at the snout tip. Supratympanic fold from posterior eye corner to insertion of upper arm well pronounced, tympanum scarcely visible.

All fingers with broadened tips, terminal grooves well developed, no webs. Except inner metacarpal tubercle, all other palmar and subarticular tubercles scarcely visible. Relative length of fingers $3 > 4 > 2 > 1$, first finger almost as long as second, no webs. All toes with broadened tips, that of fourth toe a little wider than that of third finger. Subarticular tubercles and es-



Fig. 8. Dorsolateral view of the holotype of *Callulops yapenensis* sp. nov. in life.



Fig. 9. Ventral view of the holotype of *Callulops yapenensis* sp. nov. in life.

pecially inner metatarsal tubercle more conspicuous than tubercles on fingers and hands. No webs on toes. Relative length of toes $4 > 3 > 5 > 2 > 1$.

Skin on dorsum with some tubercles, tubercles most numerous on dorso-lateral trunk, lower surfaces smooth. Ground colour of the preserved specimen light grey. Dorsal surfaces with a more or less dense brown reticulum. Brown areas most pronounced on anterior back, on dorsal snout, on upper eyelids, and on dorsal forelimbs. Light areas are most expressed on the posterior half of the back, on dorsal hind limbs, and as a row of four patches across the anterior back between the insertion of the fore limbs. Flanks show a reticulum of light grey and brown, abdomen immaculate light grey, in life with whitish spots on its margin, and chest and throat brownish with white spots. A row of whitish spots on dark brown ground along the chin. Lumbar “ocelli” conspicuous.

Measurements (in mm) and ratios of the holotype: SVL 48.2, TL 20.6, TaL 13.3, T4L 22.0, T4D 1.5, T1D 1.1, F3L 12.1, F3D 1.4, F1D 1.1, HL 16.7, HW 18.9, SL 5.5, END 3.2, IND 4.3, ED 6.5, TyD 3.6, EST 4.5, SL 5.5; TL/SUL 0.43, TaL/SUL 0.28, T4D/SUL 0.031, T4D/T1D 1.36, F3D/SUL 0.029, F3D/F1D 1.27, T4D/F3D 1.07; HL/SUL 0.35, HW/SUL 0.39, HL/HW 0.88, END/IND 0.74, ED/SUL 0.117, and TyD/ED 0.55.

Distribution and ecological notes. The holotype was found on an eastern slope of Waira Mountain, about 7 km NEN of the village of Kontinuae (Konti), at 620 m a.s.l. This slope was covered by patches of primary and secondary rain forest. Selective logging was then in progress. The forest substrate was mainly clay, loam, and humus, and covered by some leaf litter and dry wood. Ferns and shrubs were abundant in places and sparsely distributed in others. The animal was encountered in front of a burrow and calling from time to time. A few other calling *Callulops yapenensis* sp. nov. were heard at between 300 and 700 m a.s.l. on



Fig. 10. Surroundings of the Waira Mountain north of the village of Konti, where *Callulops yapenensis* sp. nov. males were heard calling.

Waira Mountain and on adjacent mountains (Fig. 10).

Vocalisation. Calling behaviour is much the same as in *Callulops wondiwoiensis*. The advertisement calls of two males were analysed (Fig. 11). Mean call length of seven calls was 3.73 s (SD 1.24), range 1.43–4.52 s. Calls contained 4–11 notes, mean 8.4 (SD 2.76) notes per call. Mean note length of 59 notes was 139 ms (SD 21.9), range 60–163 ms. Mean internote interval length of 52 intervals was 294 ms (SD 37.5), range 247–431 ms. The note repetition rate in seven calls varied from 2.4–2.8, mean 2.55 notes/s. The

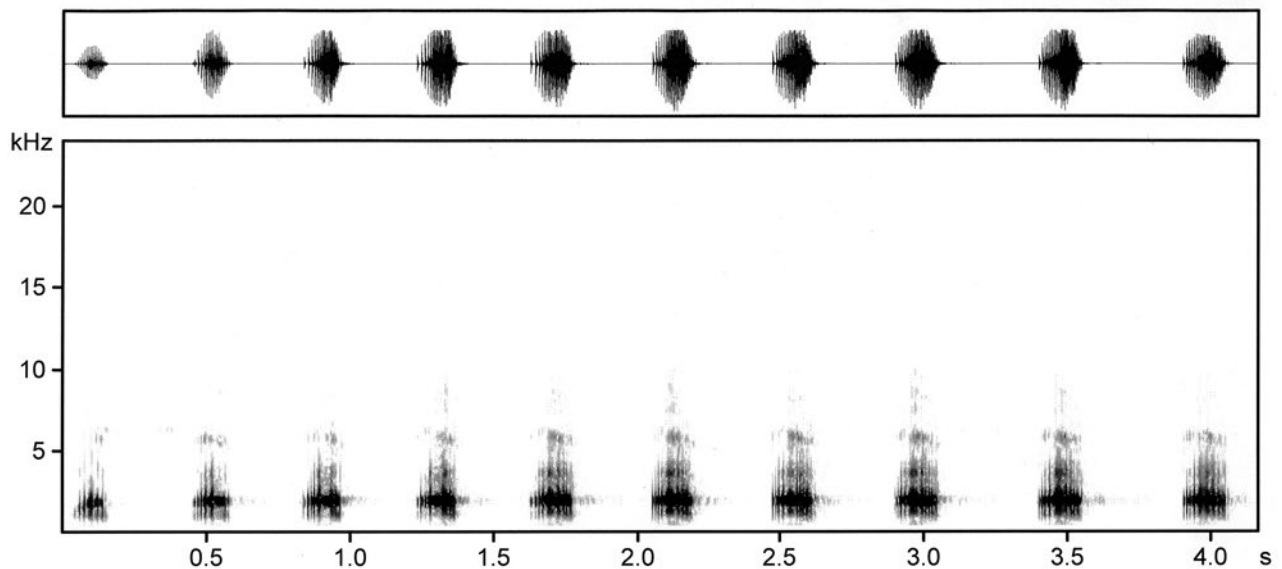


Fig. 11. Wave form (above) and spectrogram (below) of an advertisement call of *Callulops yapenensis* sp. nov. consisting of 10 notes.

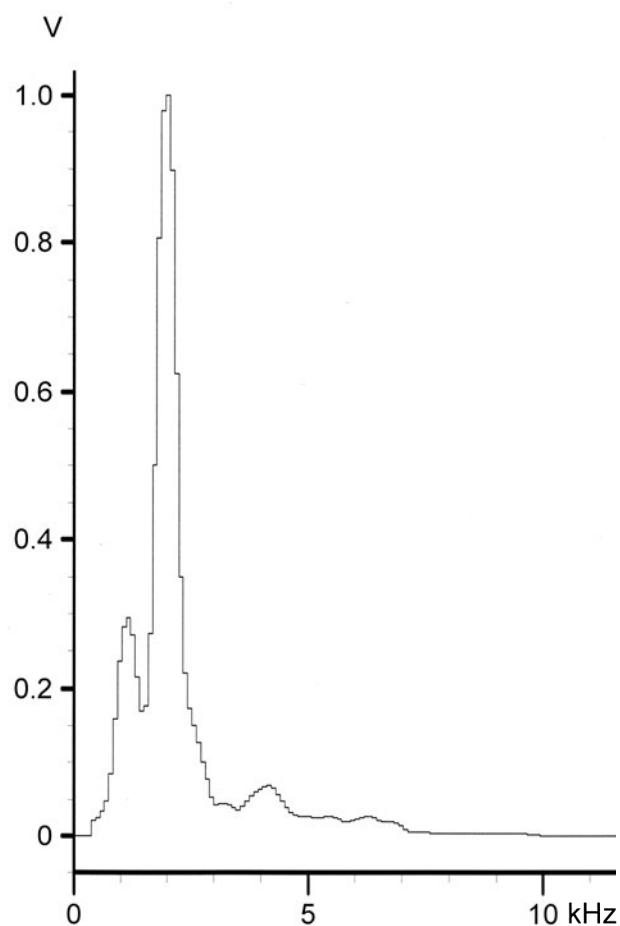


Fig. 12. Power spectrum of an advertisement call note of *Callulops yapenensis* sp. nov.

pulse repetition rate in 58 notes varied from 110–211, mean 168, pulses/s. The frequency spectrum extends from 0.4 to about 7 kHz with dominant frequency at 2.2 kHz (Fig. 12). There is a second frequency peak at

1.2 kHz. This second peak seems not to be obligatory because it was not expressed in the calls of the second specimen. Calls were recorded at an air temperature of 22 °C.

Advertisement call is much like that of *C. wondiwoiensis* and structure of calls and notes are very similar in both species. Differences of single parameters are given in the next paragraph.

Comparisons with other species. *Callulops yapenensis* sp. nov. differs from the recently described species of *Metamagnusia* and *Pseudocallulops* (GÜNTHER 2009), among others, by its more chunky body with shorter legs, less expanded finger and toe tips, and discs of toes broader than those of fingers (vice versa in the latter two genera).

Callulops glandulosus, *C. sagittatus*, *C. stictogaster*, and *C. wilhelmanus* completely lack expanded digital tips with grooves, while the new species has slightly expanded digital tips, all with terminal grooves.

Callulops boettgeri, *C. dubius*, *C. eremnosphax*, and *C. kopsteini* are clearly smaller than *C. yapenensis*.

Callulops comptus has shorter hind legs (TL/SVL 0.30–0.39 versus 0.43), an orange or pink postocular patch, and a boldly mottled ventral surface.

Callulops doriae has a larger body (SVL up to 100 mm), and a verrucous dorsal surface showing numerous blackish spots, each with a central white cap.

Callulops fojaensis has shorter hind legs (TL/SVL 0.34), longer call notes (mean 225 ms versus 139 ms in *C. yapenensis*), and a lower dominant frequency (1.3 kHz versus 2.2 kHz).

Callulops fuscus has a dark brown dorsum without pattern (*C. yapenensis* has a grey dorsum mottled with dark brown), an advertisement call with three notes per second, and seems to be restricted to Ambon, Seram, and Batanta Islands (MENZIES 2006).

Callulops humicola has a dark brown dorsum without pattern and a bright yellow or flesh coloured mottled ventrum and lives at higher elevations (1500–2000 m a.s.l.).

Callulops marmoratus has longer hind legs (TL/SVL 0.45–0.49 vs. 0.43 in *C. yapenensis*) and a different advertisement call (significantly longer notes, fewer notes per second, and a lower dominant frequency).

Callulops mediodiscus has a uniformly brown dorsum, longer hind legs (TL/SVL 0.46–0.48), and a different advertisement call.

Callulops microtis with SVL of males of 51.6–58.8 mm is larger than the new species, has a shorter hind leg (TL/SUL 0.35–0.43 vs. 0.43 in the new species), smaller eye (ED/SUL 0.100 vs. 0.135 and ED/EST 1.00–1.30 vs. 1.44), less pronounced terminal grooves on fingers and toes, and its dorsal surfaces are more pustulose than those in *C. yapenensis*.

Callulops omnistriatus is larger (males 55–59.6 mm SVL vs. 48.2 mm in the new species), and its dorsum is uniformly grey-brown versus mottled in *C. yapenensis*.

Callulops personatus has, except on loreal region, a black head, and its belly is pale orange vs. light grey in the new species.

Callulops robustus males have a snout-vent length from 60 to 65 mm and females from 60 to 78 mm and with this are evidently larger than *C. yapenensis*. Moreover, this species has a uniformly coloured dorsum and is restricted to Misima Island.

Callulops wondiwoiensis has a larger body (SUL 49.5–57.2 mm vs. 48.4 mm), shorter hind leg (TL/SUL 0.38–0.43 vs. 0.43), smaller eye (ED/SUL 0.107–0.125 vs. 0.135), and a uniformly coloured dorsum vs. a mottled dorsum in *C. yapenensis*. Moreover, there are statistically confident differences in internote interval duration ($t = 6.05$ and $p = 0.00$) (Fig. 13), in note repetition rate ($t = 3.22$ and $p = 0.005$), and in pulse rate per second ($t = 4.66$ and $p = 0.000$). Dominant frequency is 1.75 kHz in *C. wondiwoiensis* and 2.2 kHz in *C. yapenensis*.

The senior author in 2008 collected some *Callulops* frogs in the Fakfak Mountains which obviously be-

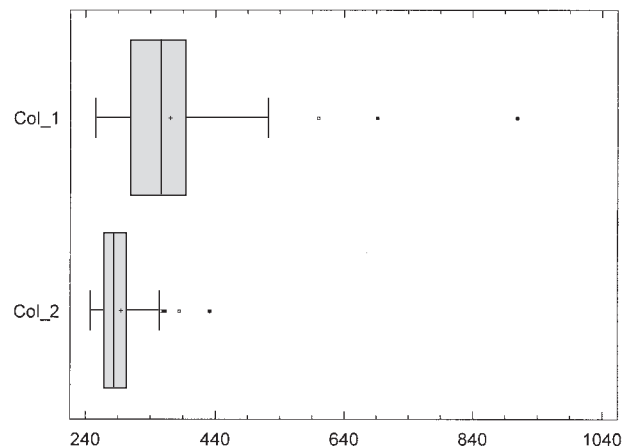


Fig. 13. Box-Whisker-Plot of 71 internote-intervals from *Callulops wondiwoiensis* sp. nov. (Col_1) and 52 internote-intervals from *C. yapenensis* sp. nov. (Col_2). Values on abscissa in milliseconds (ms).

long to *Pomatops valvifera* described by BARBOUR 1910 and treated as a synonym of *Phrynomantis* (now *Callulops*) *robustus* by ZWEIFEL (1972). The senior author intends to resurrect the name *Pomatops valvifera* from synonymy with *C. robustus* on the basis of this material in the near future.

Callulops kampeni, which is currently treated as a synonym of *C. robustus* (ZWEIFEL 1972, and FROST 2011) and the taxonomic status of which is to be re-determined, differs from *C. yapenensis* by its uniform brown dorsal colour, larger size, smaller eye (ED/SUL 0.115 vs. 0.135) and different snout shape (see Fig. 2B in KRAUS & ALLISON 2009).

Etymology. Named after the collection site of the type series, Yapen Island, Cenderawasih Bay, north-western New Guinea.

Callulops biakensis sp. nov.

Figs. 14–23, Table 2

Holotype. ZMB 64107 (FN 7535), adult male, northern surroundings of Biak Town, Island of Biak, Cenderawasih Bay, 80 m a.s.l., 1°10'S and 136°03'E, Papua Province of Indonesia, collector Marthinus Kapisa, 15 February 2001.

Paratypes. ZMB 64108 (FN 7536), same data as for holotype except collection date, which was 25 February 2001. ZMB 64109 (FN 7369) and ZMB 64110 (FN 7370) both were collected near the village of Arwe, about six km south-west of Korem (Korim), northern Biak Island, collectors were R. GÜNTHER and M. KAPISA, and collection date was 21 March 2002.

Diagnosis. With males up to 67.8 mm SUL, a large-sized *Callulops*. Snout not completely truncate as in

Table 2. Biometrical values of the holotype (ZMB 64107) and three paratypes of *Callulops biakensis* sp. nov. ZMB 64109 is a female, all others are males. All measurements in mm. Abbreviations are explained in the section “Material and methods”.

ZMB-No.	64107	64108	64109	64110	Mean	SD
SVL	66.2	67.8	61.0	53.6		
TL	28.2	29.1	26.9	25.2		
TaL	19.2	18.5	17.5	15.4		
T4L	28.1	28.6	27.0	25.0		
T4D	2.3	2.2	2.0	1.7		
T1D	1.8	1.7	1.8	1.2		
F3L	16.5	17.3	16.2	13.8		
F3D	2.0	1.9	1.8	1.4		
F1D	1.6	1.6	1.5	1.2		
HL	20.4	19.6	17.6	17.1		
HW	24.1	23.5	22.5	20.3		
END	3.7	4.0	3.5	3.5		
IND	5.5	5.6	4.9	5.0		
ED	6.1	6.4	5.5	5.2		
TyD	3.7	4.0	3.4	3.0		
EST	5.9	6.2	5.2	5.0		
SL	8.3	8.2	6.9	6.0		
TL/SUL	0.43	0.43	0.44	0.47	0.44	0.019
TaL/SUL	0.29	0.27	0.29	0.29	0.29	0.010
T4D/SUL	0.035	0.032	0.033	0.032	0.034	0.0021
T4D/T1D	1.28	1.29	1.11	1.42	1.28	0.127
F3D/SUL	0.030	0.028	0.030	0.026	0.029	0.0019
F3D/F1D	1.25	1.19	1.20	1.17	1.20	0.034
T4D/F3D	1.15	1.16	1.11	1.21	1.16	0.041
HL/SUL	0.31	0.29	0.29	0.32	0.30	0.015
HW/SUL	0.36	0.35	0.37	0.38	0.37	0.013
HL/HW	0.85	0.83	0.78	0.84	0.83	0.031
END/IND	0.67	0.71	0.71	0.70	0.70	0.019
ED/SUL	0.092	0.094	0.090	0.097	0.093	0.0029
TyD/ED	0.61	0.63	0.62	0.58	0.61	0.022

many other *Callulops*, but snout tip slightly rounded. Leg fairly long for the genus (TL/SUL 0.43–0.47). Eye small (ED/SUL 0.90–0.94). All fingers and toes with medium-sized discs. Dorsal surfaces with inconspicuous tubercles and uniformly dark brown colour. Advertisement call lasts about two seconds, mean note length 117 ms, mean internote interval length 217 ms, and note repetition rate 3.06–3.48 notes per s.

Description of the holotype. Head in the region of tympana only slightly more narrow than body, broader than long (HL/HW 0.85). Snout truncate with slightly rounded tip, canthus rostralis rounded and curved outward superior of the nostril, loreal region slightly sloped and slightly concave. Nostrils situated laterally almost at tip of snout, scarcely visible from above. Supratympanic fold clearly expressed and reaches

from posterior corner of eye to a short distance behind tympanum. Except for this fold, a very fine middorsal fold, and a few minor tubercles on flanks, all dorsal and ventral surfaces smooth. Subarticular tubercles more developed on feet than on hands, three poorly defined metacarpal tubercles and a well expressed inner metatarsal tubercle. Relative length of fingers $3 > 4 > 2 > 1$ and relative length of toes $4 > 3 > 5 > 2 > 1$. All fingers and toes with well developed grooved terminal discs, those on fingers narrower than those on toes (T4D/F3D 1.15). Fingers and toes without webbing.

All dorsal and lateral surfaces uniformly brown, some tiny tubercles on posterior flanks are darker and with a whitish tip, and tympana are noticeably lighter brown than their surroundings. Ventral surfaces show a mixture of grey and brown, the brownish fractions



Fig. 14. Dorsolateral view of a paratype of the female, ZMB 64109, *Callulops biakensis* sp. nov. in life.



Fig. 15. Ventral view of the paratype of *Callulops biakensis* sp. nov. shown on fig. 14.



Fig. 16. Habitat of *Callulops biakensis* sp. nov. near the village of Arwe on central northern Biak

predominant on chest and throat. For measurements of the holotype see Table 2. Iris black with minute silvery speckles and a golden inner margin.

Morphological variation in the type series. For measurements and ratios of the type series see Table 2. Both specimens (two males) from near Biak Town have a greater SUL than male and female from Arwe. Interestingly, the largest specimen is a male of 67.8 mm SUL. The only female paratype (Figs. 14 and 15) is gravid, its largest eggs measure 3.8 mm in diameter. Colouration is much the same in all paratypes, except ZMB 64108 which has some very irregular whitish flecks on the dorsum.

Distribution and ecological notes. *Callulops biakensis* is fairly common on Biak Island. We collected specimens near Biak Town on the south coast, and near the village of Korem on the north coast (Fig. 16). Moreover, we heard males calling on eastern Supiori, at various sites along the north coast between Supiori and Korem, and across the island between Korem and Biak Town. All were at elevations of from 30 m to 400 m a.s.l. All specimens were encountered in secondary forest (in partly primary forest on Supiori) where trees and bushes grew more or less densely.

One specimen was in front of a burrow, another, surprisingly, was at about one meter height on a tree trunk, and a couple showed mating behaviour on a

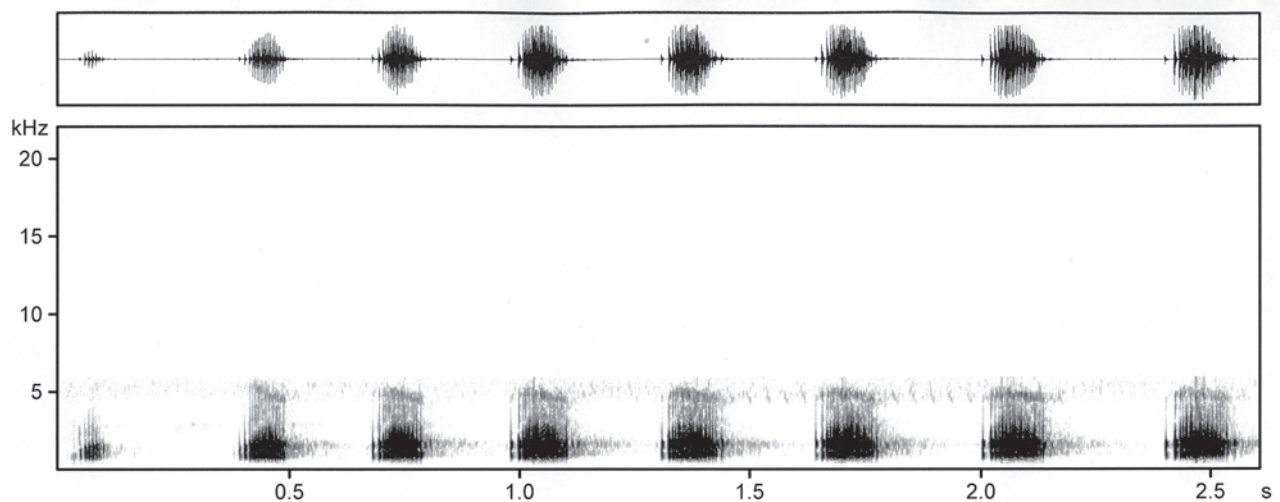


Fig. 17. Wave form (above) and spectrogram (below) of an advertisement call of *Callulops biakensis* sp. nov. consisting of eight notes.

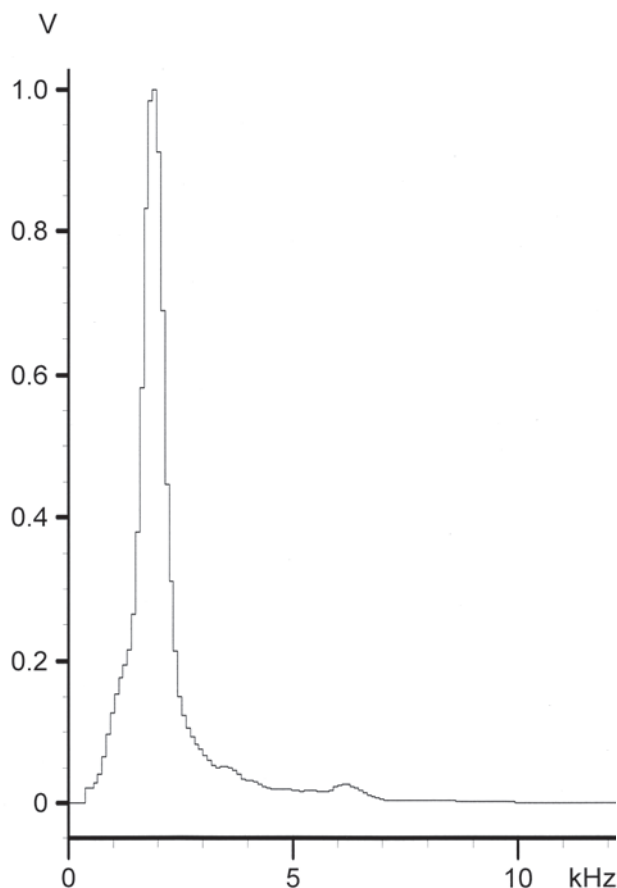


Fig. 18. Power spectrum of an advertisement call note of *Callulops biakensis* sp. nov.

fallen and rotting log. During the last, the male tried several times to crawl **under** its mate. It could be supposed that the male tried to stimulate its mate that way to later amplexus. Unfortunately, this mating behaviour finished unsuccessfully. Calling was more common during and after rainfall and in the first hours of evening. No calling was heard during the day.

Vocalisation. As in both former new species, the advertisement call consists of a series of loud croaking notes. Fifteen calls from one male were analysed. Eleven calls belonged to a series which lasted a total of eleven minutes, i.e. this male uttered one call per minute. Shortest time between two successive calls was 40 s. Mean number of notes per call was 7.0 (SD 0.38), range 6–8. Mean call length was 2.12 s (SD 0.15), range 1.78–2.52 s. The first note was clearly shorter than all others, and the last note was mostly the longest in all calls. First and last internote interval were longest in all calls (Fig. 17). Typically, the pulse repetition rate was slower at the beginning and at the end of a note, and faster in the middle of a note. Mean note length of 105 notes was 117 ms (SD 26.7), range 37–152 ms. Mean internote interval length of 90 intervals was 217 ms (SD 28.6), range 169–320. Note repetition rate varied between 3.06–3.48, mean 3.3, notes/s (SD 0.11) in 15 calls. Pulse repetition rate varied from 132–235, mean 196 pulses/s in 105 notes. Frequency band reaches from 0.5 to 7 kHz, dominant frequency at 2.2 kHz (Fig. 18). Calls were recorded at an air temperature of 24 °C.

Comparison with other species. In contrast to *Callulops biakensis* sp. nov., *C. glandulosus*, *C. sagittatus*, *C. stictogaster*, and *C. wilhelmanus* do not have dilated terminal discs on fingers and toes.

Callulops boettgeri, *C. dubius*, *C. eremnosphax*, and *C. kopsteini*, with SUL less than 50 mm, are clearly smaller than the new species.

Callulops comptus has, among others, a shorter hind leg (TL/SVL 0.30–0.39) than *C. biakensis* (TL/SUL 0.43–0.47).

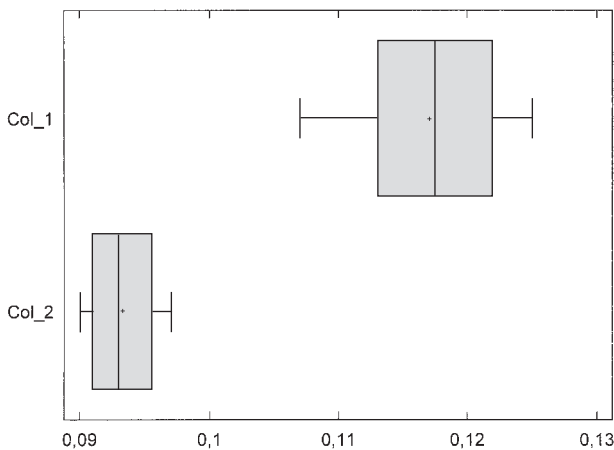


Fig. 19. Box-Whisker-Plot of the ratio eye diameter/snout-urostyle length of *Callulops wondiwoiensis* sp. nov. (Col_1) and *C. biakensis* sp. nov. (Col_2).

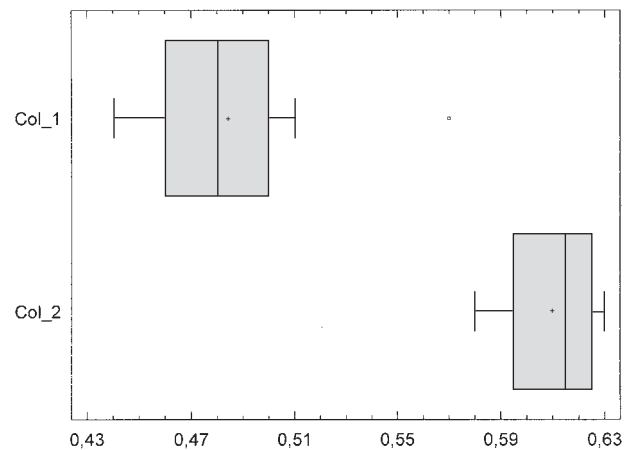


Fig. 20. Box-Whisker-Plot of the ratio tympanum diameter/eye diameter of *Callulops wondiwoiensis* sp. nov. (Col_1) and *C. biakensis* sp. nov. (Col_2).

Callulops doriae has a larger body and numerous striking blackish spots on dorsal surfaces vs. no spots in *C. biakensis*.

Callulops fojaensis has a shorter hind leg (TL/SVL (TL/SVL 0.34) and longer call notes (mean 225 ms vs. 117 ms in *C. biakensis*).

Callulops fuscus seems to be restricted to Ambon, Seram, and Batanta Islands in the west of the Vogelkop Peninsula.

Callulops humicola has a reddish ear patch and a strongly mottled ventrum, with no such ear patch and a uniformly coloured ventrum in *C. biakensis*.

Callulops marmoratus has a mottled dorsum, and it is uniform in *C. biakensis*.

Callulops mediodiscus is clearly smaller (SVL 42–49 mm) than *C. biakensis* and has a different advertisement call (mean note length 210 ms, note repetition rate 1.4–1.6 notes/s vs. 117 ms and 3.1–3.5 notes/s).

Callulops microtis has a shorter hind leg (TL/SVL 0.35–0.43 vs. 0.43–0.47), less developed discs on fingers and toes, and mottled vs. uniformly coloured dorsal and ventral surfaces.

Callulops omnistriatus has a larger eye (ED/SVL 0.120–0.140) than *C. biakensis* (ED/SVL 0.90–0.94) and differs clearly in DNA-sequences (following paragraph).

Callulops personatus has a black head and its belly is pale orange vs. grey-brown in *C. biakensis*.

Callulops robustus is restricted to Misima Island, at the easternmost extremity of the geographic range of the genus *Callulops*.

Callulops wondiwoiensis and *C. biakensis* differ statistically in the following parameters:

— Morphological parameters. ED/SUL 0.107–0.125 in the former vs. 0.090–0.097 in the latter ($t = 7.49$, $p = 0.000$) (Fig. 19); TyD/ED 0.44–0.57 vs. 0.58–0.63 ($t = 5.97$, $p = 0.000$) (Fig. 20); TaL/SUL 0.25–0.27 vs. 0.27–0.29 ($t = 5.43$, $p = 0.000$); TL/SUL 0.38–0.43 vs. 0.43–0.47 ($t = 4.04$, $p = 0.002$) (Fig. 21); HL/SUL 0.31–0.35 vs. 0.29–0.32 ($t = 3.76$, $p = 0.003$); F3D/F1D 1.08–1.18 vs. 1.17–1.27 ($t = 3.13$, $p = 0.009$); HL/HW 0.84–0.93 vs. 0.78–0.85 ($t = 3.11$, $p = 0.009$)

— Bioacoustic parameters. Note repetition rate is 1.65–2.59 notes/s (mean 2.18) in *C. wondiwoiensis* and 3.06–3.48 notes/s (mean 3.31) in *C. biakensis* ($t = 13.33$, $p = 0.000$) (Fig. 22); Duration of internote intervals is 255–909 ms (mean 371 ms) in *C. wondiwoiensis* and 169–320 ms (mean 216 ms) in *C. biakensis* ($t = 12.89$, $p = 0.000$); Note length is 59–214 ms (mean 147 ms) in *C. wondiwoiensis* and 37–152 ms (mean 116 ms) in *C. biakensis* ($t = 6.36$, $p = 0.000$).

Because we have only a single specimen of *Callulops yapenensis*, statistics of metrical parameters is not possible. The following metrical characters of *C. yapenensis* are not in the range of variation of *C. biakensis* and could be confirmed as real differences if more material becomes available: T4D/SUL 0.031 in *C. yapenensis* vs. 0.032–0.035 in *C. biakensis*; F3D/F1D 1.27 vs. 1.17–1.25; T4D/F3D 1.07 vs. 1.11–1.21; HL/SUL 0.35 vs. 0.29–0.32; HW/SUL 0.39 vs. 0.35–0.38; HL/HW 0.88 vs. 0.78–0.85; END/IND 0.74 vs. 0.67–0.71; TyD/ED 0.55 vs. 0.58–0.63; ED/SUL 0.135 vs. 0.090–0.097; especially this last dif-

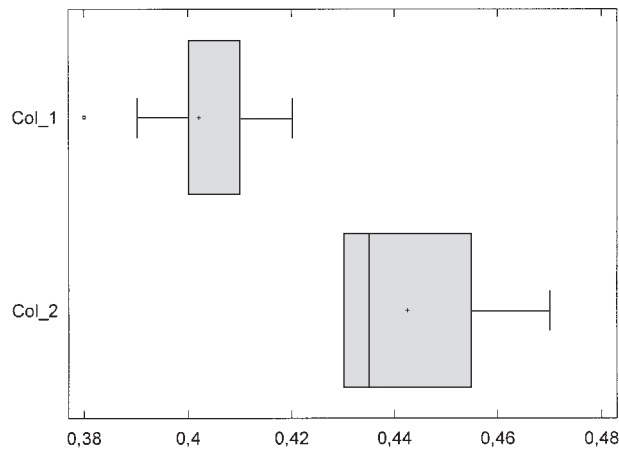


Fig. 21. Box-Whisker-Plot of the ratio tibia length/snout-urostyle length of *Callulops wondiwoiensis* sp. nov. (Col_1) and *C. biakensis* sp. nov. (Col_2).

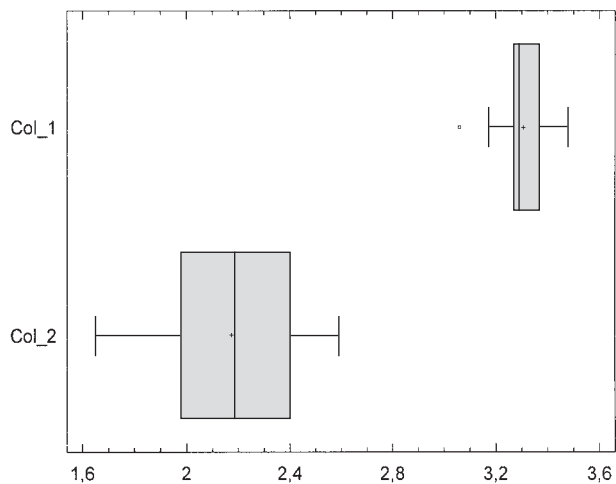


Fig. 22. Box-Whisker-Plot of notes/s from 12 calls of *Callulops wondiwoiensis* sp. nov. (Col_1) and 15 calls from *C. biakensis* sp. nov. (Col_2).

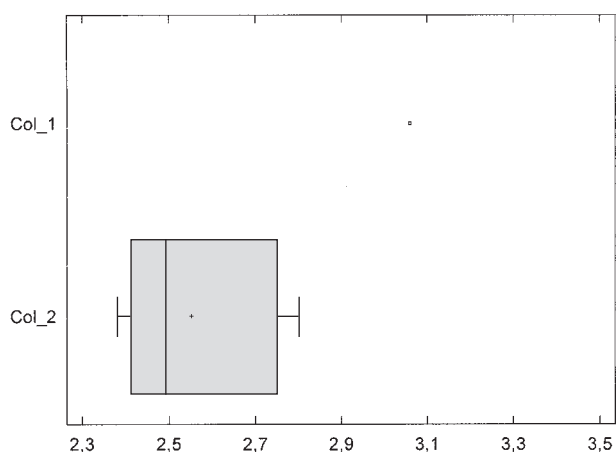


Fig. 23. Box-Whisker-Plot of notes/s from seven calls of *Callulops yapenensis* sp. nov. (Col_1) and 15 calls from *C. biakensis* sp. nov. (Col_2).

Table 3. Uncorrected interspecific genetic p-distance range (%) for 12S and 16S markers studied in some species of *Callulops*.

Species pair	12S	16S
<i>C. yapenensis</i> — <i>C. biakensis</i>	2.3	4.5–5.0
<i>C. yapenensis</i> — <i>C. wondiwoiensis</i>	3.0–4.4	7.1–7.6
<i>C. yapenensis</i> — <i>C. cf. robustus</i> (Fakfak)	3.0–3.2	6.9–7.1
<i>C. biakensis</i> — <i>C. wondiwoiensis</i>	2.1–4.3	6.2–6.9
<i>C. biakensis</i> — <i>C. cf. robustus</i> (Fakfak)	2.8–3.0	7.6–7.8
<i>C. wondiwoiensis</i> — <i>C. cf. robustus</i> (Fakfak)	2.8–3.9	7.1–7.6
<i>C. yapenensis</i> — <i>C. omnistriatus</i>	3.6	5.5
<i>C. biakensis</i> — <i>C. omnistriatus</i>	3.4	6.2–6.7
<i>C. cf. robustus</i> (Fakfak) — <i>C. omnistriatus</i>	0.4–0.5	1.9
<i>C. wondiwoiensis</i> — <i>C. omnistriatus</i>	3.2–3.9	6.2–6.4

ference and other head proportions seem to be “good” diagnostic characters.

Besides these metric features, both species differ clearly in colouration: *C. yapenensis* has mottled dorsal and lateral surfaces with large “ocelli” in the lumbar region, *C. biakensis* has a uniformly coloured dorsum and flanks and no lumbar “ocelli”. Statistically relevant are the following bioacoustic parameters:

— Internote interval duration ($n = 52$ for *C. yapenensis* and $n = 90$ for *C. biakensis*) was on average 294 ms (SD 37.6), range 247–431 ms in *C. yapenensis*, and 216 ms (SD 28.7), range 169–320 ms in *C. biakensis* ($t = 12.9$, $p = 0.000$).

— Note repetition rate (seven calls from *C. yapenensis* and 15 calls from *C. biakensis* were analysed) was on average 2.55 notes/s (SD 0.17), range 2.38–2.80 notes/s in *C. yapenensis*, and 3.30 (SD 0.11), range 3.06–3.48 notes/s in *C. biakensis* ($t = 12.74$, $p = 0.000$) (Fig. 23).

— Pulse repetition rate (58 notes from *C. yapenensis* and 105 notes from *C. biakensis*) was on average 168 pulses/s (SD 23.6), range 110–211 in *C. yapenensis*, and 196 pulses/s (SD 22.6), range 132–235 pulses/s in *C. biakensis* ($t = 7.4$, $p = 0.000$).

— Note length (59 notes from *C. yapenensis* and 105 from *C. biakensis*) was on average 139 ms (SD 21.9), range 60–163 ms in *C. yapenensis*, and 117 ms (SD 26.7), range 37–152 ms in *C. biakensis* ($t = 5.5$, $p = 0.000$).

Etymology. The new species is named after its type locality and, to date, the only known site of its occurrence.

Molecular evidence. *Callulops omnistriatus* from eastern New Guinea has a very similar morphology compared to some species from western New Guinea and was therefore included in our phylogenetic analysis.

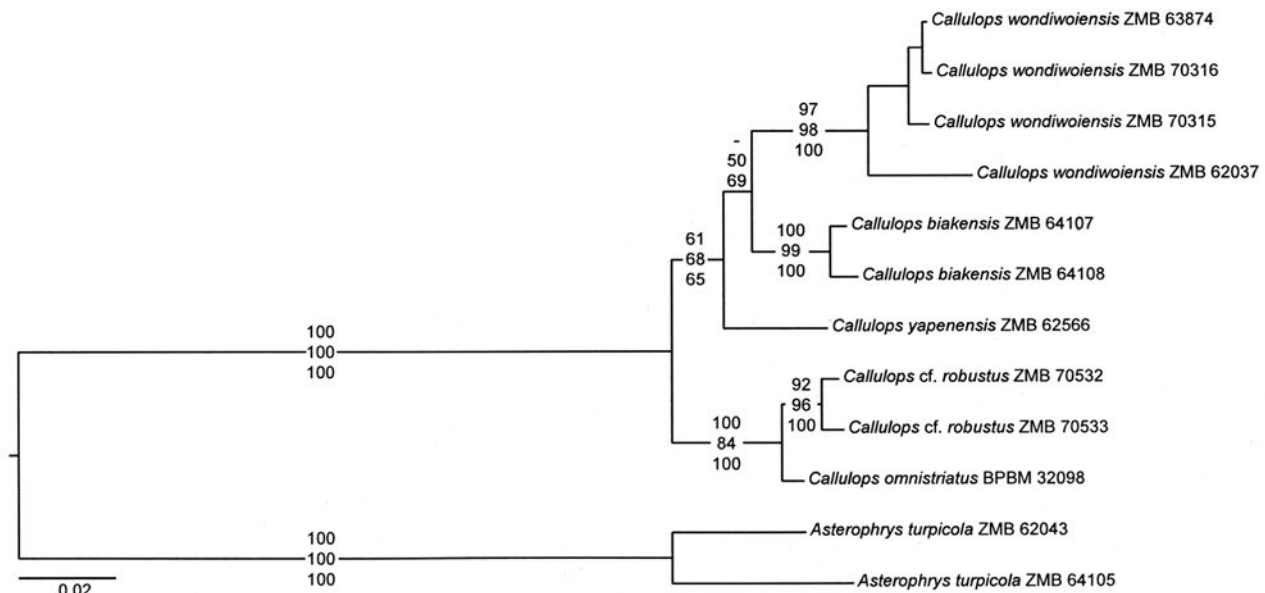


Fig. 24. Bayesian phylogram of the concatenated data set (12S rRNA and 16S rRNA). The numbers on branches are maximum parsimony bootstrap values, maximum likelihood bootstrap values, and posterior probabilities of Bayesian inference (from top to bottom).

The phylogenetic tree (Fig. 24) shows a highly supported *Callulops* clade with *C. cf. robustus* from the Fakfak Mountains + *C. omnistriatus* as sister group to a clade comprising the three new species. While each of the new species is well supported (with the exception of *C. yapenensis*, where only one sequence was available), their relationships are poorly supported. This might possibly be explained by short intervals between divergence events in that clade. However, the considerable morphological and bioacoustic differences between these species are also reflected by genetic p-distance values ranging from 2.1–4.4 % in 12S and 4.5–7.8 % in 16S, respectively (Table 3). This range of genetic distances is usually considered indicative of distinct species status in frogs (e.g. FOUQUET *et al.* 2007).

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