

## Five new microhylid frog species from Enga Province, Papua New Guinea, and remarks on *Albericus alpestris* (Anura, Microhylidae)

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### > Abstract

Five new species of microhylid frogs in the genera *Albericus*, *Cophixalus* and *Oreophryne* are described from high altitudes in the Kaijende Highlands of Enga Province, central Papua New Guinea. A population of short-legged, terrestrial *Albericus* discovered in grasslands on the Kaijende Highlands seems to be very close to the recently described *A. alpestris*. Because the systematic status of our new frogs is not yet clear, they are referred to as *Albericus* cf. *alpestris* in our paper. Information about the advertisement call of this population, its colour in life, and its habitat is presented for the first time and enables possible inferences about *Albericus alpestris* sensu stricto.

### > Kurzfassung

Auf der Basis von Aufsammlungen im August/September 2005 werden fünf neue microhylide Froscharten der Gattungen *Albericus*, *Cophixalus* und *Oreophryne* aus der alpinen Zone der Kaijende Highlands, Enga Province, zentrales Papua Neuguinea, beschrieben. Im gleichen Gebiet wurde eine Population kurzbeiniger und terrestrisch lebender Frösche der Gattung *Albericus* entdeckt, die der kürzlich nur anhand von wenigen Museumsexemplaren beschriebenen Art *Albericus alpestris* stark ähneln. Informationen zum Paarungsruf, zur Lebendfärbung und zum Habitat dieser Frösche werden erstmalig gegeben. Da ihre endgültige systematische Stellung noch zu klären ist, werden sie hier als *Albericus* cf. *alpestris* bezeichnet.

### > Key words

Amphibia, Anura, Microhylidae, *Albericus*, *Cophixalus*, *Oreophryne*, new species, Papua New Guinea.

## Introduction

The high-altitude frog fauna of New Guinea is dominated by members of the family Microhylidae, with the highest known record of a frog from the island being for an *Oxydactyla stenodactyla* that was collected at 4,000 m above sea level on Mount Wilhelm (ZWEIFEL, 2000). Although relatively few species inhabit New Guinea's alpine environments, the faunas there are phylogenetically diverse, with representatives from various genera, including *Aphantophryne*,

*Oreophryne*, and *Oxydactyla*, successfully inhabiting habitats above 3,000 m (e.g. ZWEIFEL, 2000; ZWEIFEL, COGGER & RICHARDS, 2005). Many of these species exhibit adaptations to a terrestrial life in montane meadows, having short limbs and reduced finger and toe discs in comparison to their lower-elevation forest-dwelling congeners.

In August-September 2005 the Conservation International Rapid Assessment Program (RAP) con-

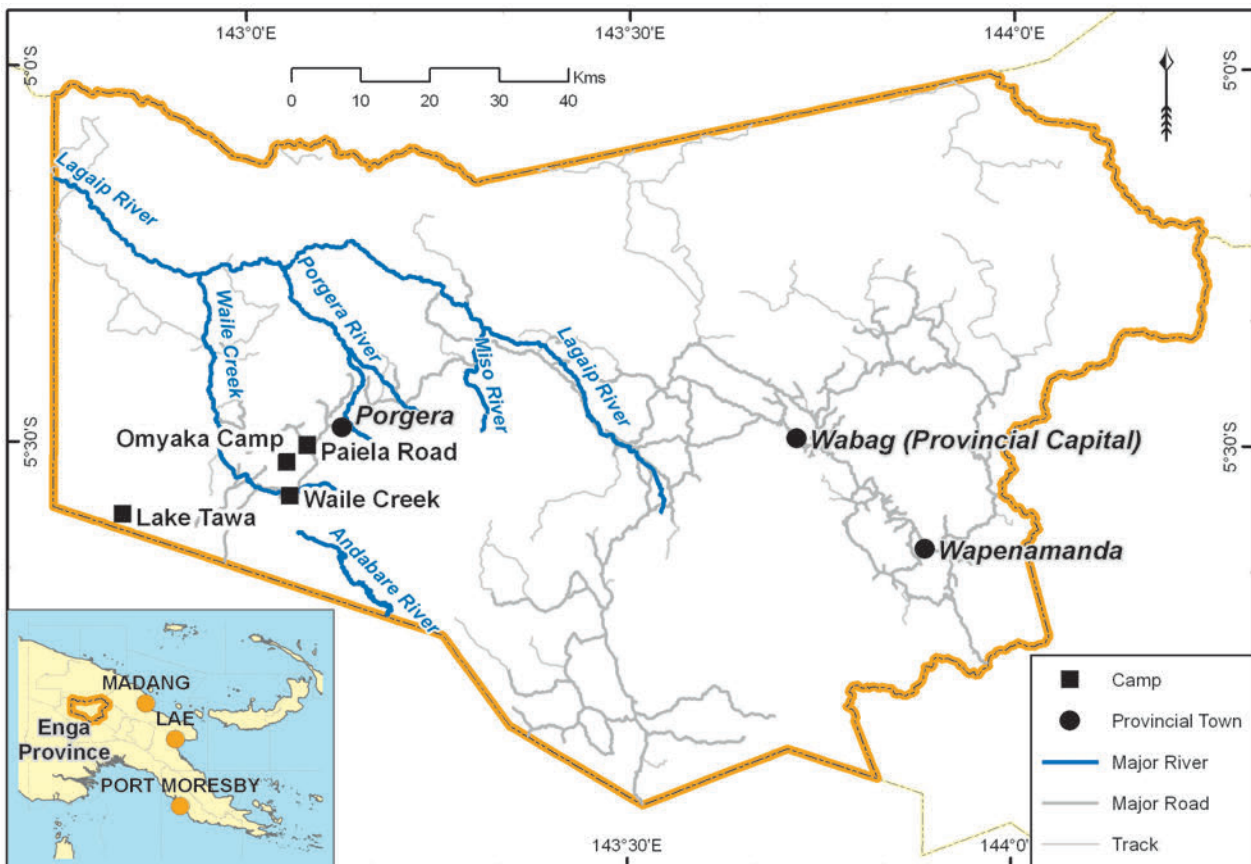


Fig. 1. Maps of Papua New Guinea and of Enga Province, PNG, showing the locations of collection sites mentioned in the text.

ducted a biological inventory of alpine environments in the Kaijende Highlands near Porgera in Enga Province, Papua New Guinea (RICHARDS, 2007) (Fig. 1). During that survey a number of new species of amphibians were discovered, including at least seven frogs in the family Microhylidae. Two of those species, *Oreophryne anamiatoi* KRAUS & ALLISON, 2009 and *Albericus alpestris* KRAUS, 2010 have subsequently been described from nearby mountain ranges and here we present descriptions of another five species.

## Material and methods

Most frogs were detected at night by tracking their advertisement calls. Some females were also encountered with the aid of head-torches, and a small number of individuals were collected from beneath stones and logs on the forest floor. Frogs were anaesthetized with chlorobutanol and most were fixed in 10 % formalin in the field for 1–2 days and transferred

to 75 % ethanol for permanent storage. Samples of liver tissue were extracted from up to five specimens of each species and stored in 95 % ethanol to permit future DNA analysis. Clearing and double staining of one specimen of each new species as an osteological preparation according to a modified method of DINGERKUS and UHLER (1977) was carried out in order to identify their generic allocation.

Measurements of SUL, TaL, and TL to the nearest 0.1 mm were made with a digital calliper, all others were made with an ocular micrometer in a dissecting microscope:

- SUL** snout-urostyle length, from tip of snout to distal tip of urostyle bone (SUL and snout-vent length differ insignificantly, but SUL is more accurately measured);
- TL** tibia length, external distance between knee and heel (calliper gently pressed);
- TaL** length of tarsus, external distance, tarsal and heel joints held at right angles;
- L4T** length of fourth toe, from tip of toe to proximal end of inner metatarsal tubercle;
- L3F** length of third finger;
- F3D** transverse diameter of third finger disc;
- F1D** transverse diameter of first finger disc;
- T4D** transverse diameter of fourth toe disc;

- T1D** transverse diameter of first toe disc;  
**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;  
**SL** snout length, from an imaginary line connecting the centres of the eyes to tip of snout;  
**EST** distance from eye corner to tip of snout.

Calls were recorded in the field with a Sony TCM-5000 Tape Recorder and a Sennheiser ME66 microphone and analysed with Avisoft-SAS Lab Pro software. Specimens are housed in the herpetological collections of the Natural Sciences Resource Collection of the University of Papua New Guinea (UPNG), the South Australian Museum, Adelaide (SAMA), and in the Museum für Naturkunde, Berlin (ZMB) and bear registration numbers of these institutions.

## Material compared

We examined the type series of *Albericus laurini* and *A. tuberculatus* and the following additional *Albericus* type specimens: *A. alpestris* (paratypes BPBM 5626–5627); *A. brunhildae* (holotype UPNG 7192, paratypes UPNG 7188–7191, 7193–7196); *A. darlingtoni* (eight paratypes MCZ 25931–25939); *A. exclamitans* (paratypes PNGM A23997–24002); *A. fafniri* (holotype UPNG 5562, paratypes UPNG 5563–5566); *A. gudrunae* (holotype UPNG 8124, paratypes UPNG 8123, 8125); *A. gunnari* (holotype UPNG 5240, paratypes UPNG 4153–4154); *A. rhenaureum* (holotype UPNG 4417, paratype UPNG 4418); *A. siegfriedi* (holotype UPNG 3480, paratypes UPNG 3481, 3483–85, 3487–93); *A. swanhildae* (holotype UPNG 5572, paratypes UPNG 5573–5576, 5591–5592); *A. valkuriaurum* (holotype UPNG 9454, and about 80 paratypes); *A. variegatus* (holotype ZMA 5706). We also referred to the paper by KRAUS & ALLISON (2005) who present measurements of all *Albericus* species described to that date.

Material of the genus *Cophixalus* examined by us is listed in the papers by RICHARDS, JOHNSTON & BURTON (1992), GÜNTHER (2003a, 2006a) and RICHARDS & OLIVER (2007, 2010).

Specimens of the genus *Oreophryne* studied by us are listed in the papers by RICHARDS & ISKANDAR (2000); GÜNTHER, RICHARDS & ISKANDAR (2001); GÜNTHER (2003b and 2003c); ZWEIFEL, COGGER & RICHARDS (2005); and GÜNTHER *et al.* (2009).

## Abbreviations of collections

- BPBM Bernice P. Bishop Museum, Honolulu;  
 MCZ Museum of Comparative Zoology, Harvard University, Cambridge;

- PNGM National Museum and Art Gallery, Port Moresby;  
 SAMA South Australian Museum, Adelaide;  
 UPNG University of Papua New Guinea, Port Moresby;  
 ZMA Zoologisch Museum, Universiteit van Amsterdam;  
 ZMB Museum für Naturkunde Berlin (formerly Zoologisches Museum Berlin).

## *Albericus pandanicolus* sp. nov.

Plate I, Figs. 2–4 and Table 1

**Holotype.** SAMA R66102 (Field number=FN SJR 9712), adult male, Paiela Road (05°30.183'S, 143°04.866'E; 2,900 m asl), near Porgera Town, Enga Province, Papua New Guinea, collected by S. Richards on 5 September 2005.

**Paratypes.** SAMA R66101 (FN SJR 9697), ZMB 76958 (FN SJR 9696) and ZMB 76959 (FN SJR 9713). Same details as holotype but SAMA R66101 and ZMB 76958 collected on 4 September 2005. All three paratypes are males; ZMB 76959 is now an osteological preparation.

**Diagnosis.** A relatively large (SUL of males 18.0–19.6 mm) species of *Albericus* with short legs (TL/SUL 0.34–0.38), rather narrow head (HW/SUL 0.35–0.41), medium-sized finger and toe discs, finger discs somewhat wider than toe discs (T4D/F3D 0.86–0.92) and eye-naris distance the same as internarial distance (END/IND 0.88–1.06). Colour of dorsal surfaces off-white to brown with dark brown and a few light spots and a whitish interocular bar. Advertisement calls are uttered in series with irregular distances between calls. The call itself is a buzz of 229–275 ms duration with 188–243 pulses per second and a dominant frequency of 3.3 kHz.

**Description of the holotype.** For morphological characters see Plate I and for body measurements and body ratios see Table 1. Head width (in the region of tympana) greater than head length (HL/HW 0.91); neck region clearly constricted; snout in dorsal view rounded with a small tip and truncate in profile; loreal region oblique, no canthus rostralis; nostrils anterolaterally directed and near tip of snout, visible from above but not from below; internarial distance slightly greater than distance between eye and naris; pupil horizontally oval. Tongue broad, scarcely notched and its posterior and lateral parts free; no clearly serrated prepharyngeal ridge, long vocal slits on both sides of the tongue. Tympanum barely visible, especially upper margin which is covered by skin, its horizontal diameter about half of eye diameter; supratympanic fold interspersed with big tubercles. Fingers long with discs clearly wider than penultimate phalanges,



**Plate I.** Holotype of *Albericus pandanicolus* sp. nov. (a) dorsal view, (b) ventral view, (c) lateral view of head, (d) ventral view of left hand, (e) ventral view of left foot.

their relative length  $3 > 4 > 2 > 1$ ; no webs; all discs with circummarginal grooves; no subarticular tubercles, weakly expressed inner metacarpal tubercle, no outer metacarpal tubercle. Hind limbs short (TL/SUL 0.38); terminal discs roughly as wide as those on fingers; relative length of toes  $4 > 5 > 3 > 2 > 1$ ; no webbing between toes; no clearly expressed subarticular, plantar, or metatarsal tubercles. Moderately large tubercles on all dorsal surfaces, rare in middle of dorsum, head, and on fore limbs, and most frequent on body sides, hind limbs, and around tympanum; a ring of characteristic tubercles around tympanum; all ventral surfaces smooth.

Ground colour of all dorsal and ventral surfaces greyish-yellow, dark brown blotches in the scapular region, some diffuse blotches on head, behind tympanum, and on extremities. Besides these blotches,



**Fig. 2.** Adult male paratype of *Albericus pandanicolus* (SAMA R66101) sp. nov. in life.

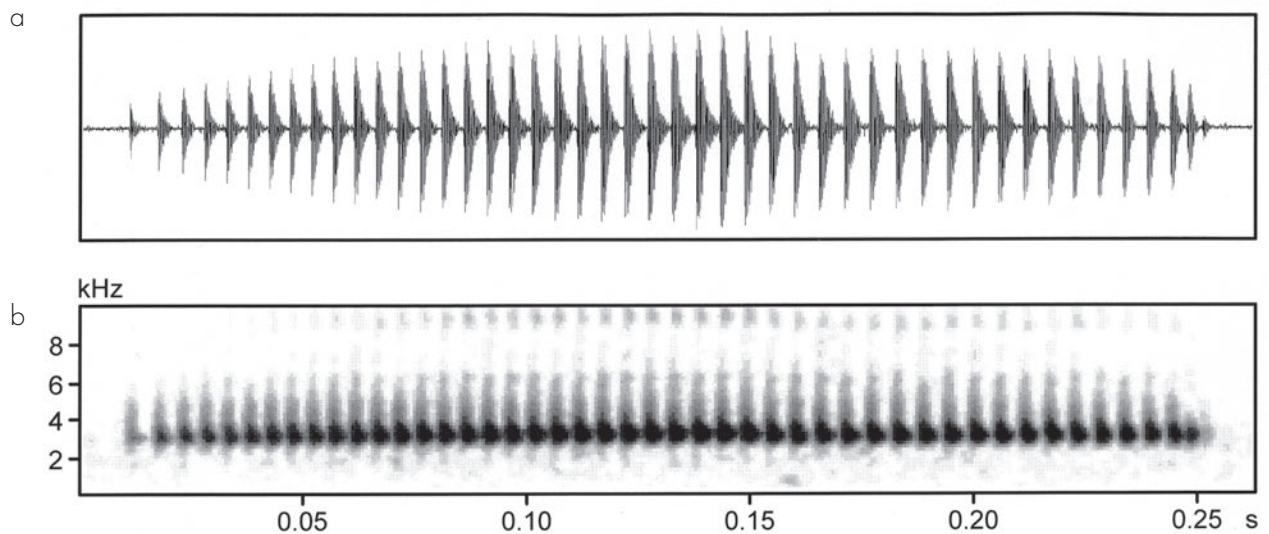


Fig. 3. Wave form (a) and audiospectrogram (b) of an advertisement call of *Albericus pandanicolus* sp. nov. (ZMB 76958).

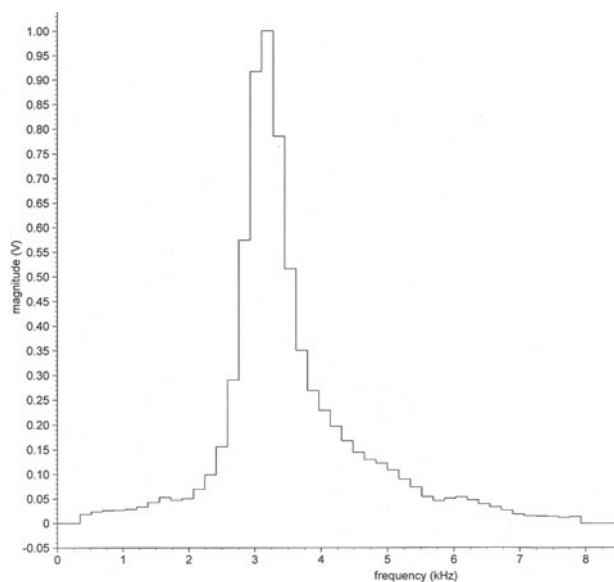


Fig. 4. Power spectrum of an advertisement call of *Albericus pandanicolus* sp. nov. (ZMB 76958).

numerous dark brown dots present on all dorsal and ventral surfaces except central dorsum and areas around elbow; conspicuous are a transverse whitish band between eyes, a whitish spot in front of the tympanum, and a patch of dark pigmentation along the supratympanic fold.

**Morphological characters of the paratypes.** There are three male paratypes, one slightly smaller and two slightly larger than the holotype. All of their body dimensions are similar to those of the holotype (Table 1). Skin structure, distribution of tubercles, and basic colour are also similar in all types. ZMB 76958 and SAMA R66101 exhibit a much more pronounced

dark brown pigmentation than the holotype. Their dorsal and lateral head surfaces are completely dark brown, and, compared to the holotype, there are more blotches on most of the other dorsal surfaces, and the ventral surfaces are also more densely dotted. Conspicuous in all types are a fine whitish band between the eyes, an irregular whitish spot in front of the tympanum, a diagonal white stripe and some white tubercles in the scapular region, a dark brown patch or streak from eye corner to shoulder, and a pigmentless patch below the elbow. The following remarks on colouration in life are based on a photograph of the paratype SAMA R66101 (Fig. 2): ground colour of head and dorsum darker than that of lateral surface of torso and limbs; head and nape predominantly dark brown; upper eyelids, lower loreal region and area behind eyes light grey; dorsum grey brown; flanks uniform grey; dorsal surfaces of limbs grey with some diffuse red-brown flecks especially around tubercles; further anterior markings consist of small white spots in the tympanic region and a short diagonal white stripe above the arm insertion. We did not note the colour characters of ZMB 76959, now an osteological preparation.

**Distribution and ecological notes.** This species is known only from the type locality (Fig. 7) in mossy montane forest on the Paiela Road near Porgera, Enga Province, where the males were calling from heights of ~2–3 m in *Pandanus* trees at night. This species was not heard calling in areas of the forest without *Pandanus* trees.

**Vocalisation.** Following the terminology of MENZIES (1999), the calls are buzzes (Figs. 3a and 3b). Twenty-five calls from two males (ZMB 76958 and SAMA

**Table 1.** Body measurements and body ratios of the type series of *Albericus pandanicolus* sp. nov. SAMA R66102 is the holotype, ZMB 76959 is now an osteological preparation. All types are adult males. All measurements are in mm; abbreviations are explained in “Material and methods”.

Inventory number	SAMA R66101	SAMA R66102	ZMB 76958	ZMB 76959	Mean ± SD
SUL	19.6	18.4	18.0	19.3	18.8 ± 0.75
TL	7.0	7.0	6.8	6.6	
TaL	5.3	5.1	5.1	5.0	
T4L	7.4	7.0	6.9	7.3	
T4D	1.2	1.1	1.1	1.2	
T1D	1.2	1.0	1.1	1.0	
F3L	5.4	5.6	5.1	5.3	
F3D	1.4	1.2	1.2	1.3	
F1D	1.0	0.8	0.8	0.9	
HL	6.2	6.0	5.9	6.0	
HW	8.0	6.6	6.7	6.7	
END	1.9	1.7	1.7	1.5	
IND	1.9	1.6	1.9	1.7	
SL	2.6	2.3	2.6	2.5	
EST	2.4	2.4	2.5	2.1	
ED	2.5	2.1	2.5	2.4	
TyD	1.1	1.0	1.0	1.1	
TL/SUL	0.36	0.38	0.38	0.34	0.37 ± 0.019
TaL/SUL	0.27	0.28	0.28	0.26	0.27 ± 0.009
T4L/SUL	0.38	0.38	0.38	0.38	0.38 ± 0.00
T4D/SUL	0.061	0.060	0.061	0.062	0.061 ± 0.0008
T4D/F3D	0.86	0.92	0.92	0.92	0.91 ± 0.03
F3L/SUL	0.28	0.30	0.28	0.27	0.28 ± 0.013
HL/SUL	0.32	0.33	0.33	0.31	0.32 ± 0.009
HW/SUL	0.41	0.36	0.37	0.35	0.37 ± 0.026
HL/HW	0.78	0.91	0.88	0.90	0.87 ± 0.060
END/IND	1.00	1.06	0.89	0.88	0.96 ± 0.087
ED/SUL	0.128	0.114	0.128	0.124	0.124 ± 0.006
TyD/ED	0.44	0.48	0.43	0.46	0.45 ± 0.022

R66101) were analysed. Air temperature during recording was 17 °C. Calls were uttered at irregular intervals, and the shortest interval between two calls was 4.5 s. Call duration is from 229 ms to 275 ms, mean 247 ± 9.4 ms. Number of pulses per call varies from 46–63, mean 53, and pulse repetition rate varies from 188 to 243 pulses per s, mean is 215 pulses per s. Frequencies scatter in a broad range between 2.5 kHz and 7 kHz, with dominant frequencies at 3.3 kHz (Fig. 4). Wave forms of the calls show a spindle-like shape, with the weakest pulses at the beginning and towards the end of the calls.

**Comparison with other species.** *Albericus pandanicolus* sp. nov. belongs to the species having a “buzz-call”. The other species with such calls are *A. alpestris* KRAUS, 2010; *A. brunhildae* MENZIES, 1999; *A. darlingtoni* (LOVERIDGE, 1948); *A. fafnieri* MENZIES, 1999; *A. laurini* GÜNTHER, 2000; *A. rhenaurum* MENZIES,

1999; *A. siegfriedi* MENZIES, 1999; and *A. tuberculatus* (RICHARDS, JOHNSTON & BURTON, 1992). *Albericus alpestris* has, among others (see last chapter of this paper), a larger body size (one male has a SVL of 22.5 mm, and two females have a SVL of 26.4 and 29 mm) than *A. pandanicolus* (male SUL 18.0–19.6 mm), shorter hind legs (TL/SVL 0.29–0.33), and a different advertisement call. *Albericus brunhildae* is of the same size but has clearly longer tibiae (TL/SVL 0.38–0.47) than *A. pandanicolus* (TL/SUL 0.34–0.38). Its call lasts 435–570 ms, with a pulse repetition rate of 545 pulses per s. Calls of *A. pandanicolus* last for 229–275 ms, with a mean pulse repetition rate of 215 pulses per s.

*Albericus darlingtoni* has a similar call length and pulse repetition rate as *A. pandanicolus* but differs in dominant frequency (2.5 kHz in *A. darlingtoni* according to illustrations in Menzies, 1999 and 2006, versus 3.3 kHz in *A. pandanicolus*). The two

species also differ morphologically; the third toe is slightly shorter than the fifth in *A. darlingtoni* but distinctly shorter in *A. pandanicolus*; *Albericus darlingtoni* is larger (mean SUL of six male paratopotypes of *A. darlingtoni*  $23.0 \pm 1.55$  mm (range 21.2–24.5 mm) and range of three female paratopotypes 23.5–25.9 mm) than *A. pandanicolus* (mean SUL of four males  $18.8 \pm 0.75$  mm (range 18.0–19.6 mm); and the following ratios also show no overlap (values for nine paratopotypes of *A. darlingtoni* given first and four types of *A. pandanicolus* second): T4L/SUL (0.33–0.36 vs. 0.38), T4D/SUL (0.047–0.059 vs. 0.060–0.062), F1D/F3D (0.36–0.62 vs. 0.67–0.71), and F1D/SUL (0.028–0.041 vs. 0.043–0.051).

*Albericus fafnieri* is larger (21–23 mm SVL), has longer tibiae (0.38–0.43), and has different advertisement calls: the mean call duration is 650 ms and the pulse repetition rate is 70–170 pulses per s. *Albericus laurini* has longer hind legs (TL/SUL 0.39–0.43), different head ratios (among others END/IND in *A. pandanicolus* is 0.88–1.06 and in *A. laurini* is 1.24–1.50), and a different call (call duration is 157–204 ms in *A. laurini* and 229–275 ms in *A. pandanicolus*). *Albericus rhenaurum* is smaller (14.9–15.8 mm SVL), has longer hind legs (TL/SVL 0.42–0.45), and a different call: the call duration is 470–510 ms and the note (pulse) repetition rate is 40–50 pulses per s. *Albericus siegfriedi* is slightly larger (SVL 18.2–21.3 mm SVL), has longer hind legs (TL/SVL 0.41–0.45), and a pulse repetition rate of 500–600 pulses per s. *Albericus tuberculus* has more pronounced tubercles on body and limbs, longer hind legs (TL/SVL 0.40–0.46), a different END/IND ratio (1.0–1.67), and a different call (less than 200 pulses per s). Data for comparisons were taken from the original descriptions of the species (see above).

**Etymology.** Specimens were found on plants of the genus *Pandanus*. The specific epithet *pandanicolus* is in accordance with the gender of the genus, a composite masculine substantive in apposition and means “inhabitant of *Pandanus* plants”.

### *Albericus brevicrus* sp. nov.

Plate II, Figs. 5–9 and Table 2

**Holotype.** SAMA R66100 (FN SJR 9710), adult male, collected at Paiela Road (05°30.183'S, 143°04.866'E; 2,900 m asl) near Porgera Town, Enga Province, Papua New Guinea on 5 September 2005, by S. Richards.

**Paratypes.** UPNG 10061 (FN SJR 9711) same data as holotype; SAMA R66097 (FN SJR 9648), R66098 (FN SJR 9651), R 66099 (FN SJR 9656) and ZMB 76742 (FN SJR 9655) collected adjacent to Lake Tawa, Enga Province, Papua New

Guinea (05°35.716'S, 142°50.433'E; 2,117 m asl) on 1 September 2005, by S. Richards; ZMB 76744 (FN SJR 9618) and ZMB 76743 (FN SJR 9617) same data (Lake Tawa) but collected on 28 August 2005; ZMB 76745 (FN SJR 9628), Lake Tawa but collected on 29 August 2005; and UPNG 10060 (FN SJR 9647) Lake Tawa but collected on 31 August 2005.

**Diagnosis:** Belongs to the smaller (SUL of males 14.3–18.2 mm, one female 17.7 mm) species of the genus and has extremely short hind legs (TL/SUL 0.30–0.35). Finger discs and toe discs, especially in the smaller animals, insignificantly wider than the penultimate phalanges (T4D/SUL 0.030–0.044). A whitish inter-ocular bar and dark ventral surfaces are also characteristic. Advertisement calls are uttered in series in which the single calls follow one another at short and regular intervals. Each call is a buzz of 489–641 ms duration, with a pulse repetition rate of 146–197 pulses per s. Its dominant frequency is at 3.5 kHz.

**Description of the holotype.** For morphological characters see Plate II and for body measurements and body ratios see Table 2. Head in the region of tympana clearly broader than long (HL/HW 0.75); neck region constricted; snout from above mucronate, round in profile; canthus rostralis clearly expressed and curved; eyes large and protruding, pupil horizontally oval; loreal region oblique, nostrils anterolaterally directed, neither visible from above nor from below, nearer to tip of snout than to eyes; internarial distance wider than distance from eye to naris (END/IND 0.85); only lower part of tympanum visible, its horizontal diameter less than half of eye diameter (TyD/ED 0.41), supratympanic fold consists of large tubercles; tongue longitudinally oval, posteriad somewhat broadened and without posterior notch, its lateral and posterior regions free, prepharyngeal ridge of strong and irregularly shaped protuberances, vocal slits fairly long. Fingers of medium size, all with terminal discs and circum-marginal grooves, disc of first finger conspicuously smaller than all others (F1D/F3D 0.45), relative length of fingers  $3 > 4 = 2 > 1$ , no webs between fingers, weak inner metacarpal tubercle, no outer one, no other palmar or subarticular tubercles. Hind limbs very short (TL/SUL 0.31), all toes flattened and with terminal discs of a similar size, circum-marginal grooves present on all discs, discs of toes somewhat narrower than those of fingers, no conspicuous plantar or subarticular tubercles, no webbing, relative lengths of toes  $4 > 5 > 3 > 2 > 1$ .

All dorsal surfaces with tubercles, those around tympanum and on hind legs especially conspicuous. Ventral surfaces smooth. Ground colour light grey, with almost unpigmented blotches on dorsum of snout, on central dorsum, along upper flanks, on the anterior elbow region, on sacrum, along posteri-



**Plate II.** Holotype of *Albericus brevicrus* sp. nov. (a) dorsal view, (b) ventral view, (c) lateral view of head, (d) ventral view of left hand, (e) ventral view of right foot.

or thighs, and on distal shanks. Blackish and brown spots on dorsal extremities, encircling light blotches on dorsum, and around anal opening. All ventral surfaces, except those of toe discs, finger discs, and proximal fore arm, strongly pigmented with brown, only venter shows some light ground colour between dark brown areas.

Based on photographs in life of the holotype (SAMA R66100), body and limbs generally brown with extensive areas of darker brown pigmentation, focused as follows: in a broad band extending from a line mid-way between the orbits to the posterior edge of the arm insertion; in a broad canthal stripe from the tip of the snout to the eye and extending posterior of eye along the curved glandular supratympanic fold to the axilla; along the edge of the upper and lower jaws; and in a series of small patches and bars asso-

ciated with tubercles and narrow glandular folds. A broad patch of paler pigment extends from posterior corner of eye, below the darker supratympanic band, to a point immediately anterior of the arm insertion. Scattered pale flecks are concentrated laterally and ventro-laterally with several flecks behind the eye and along the jaw, and on the dorsal surfaces of the thighs. Iris copper with brown flecks.

**Morphological characters of the paratypes.** For measurements of all types see Table 2. Including the holotype, there are eight adult males with SUL from 14.3–18.2 mm, one adult female of 17.7 mm SUL, and one probably subadult male of 13.4 mm in which no vocal slits could be seen. Vocal slits were also not seen in the male ZMB 76743 of 14.4 mm SUL. Ovarian eggs of the one female were unpigmented



**Table 2.** Body measurements and body ratios of the type series of *Albericus brevicrus* sp. nov. SAMA R66100 is the holotype; ZMB 76745 is now an osteological preparation; ZMB 76744 is a female, all others are males. UPNG 10060 is a subadult with small testes and without vocal slits.

Inv.No	ZMB 76743	ZMB 76744	ZMB 76745	UPNG 10060	SAMAR 66097	SAMA R66098	ZMB 76742	SAMA R66099	SAMA R66100	UPNG 10061	Mean ± SD
SUL	14.4	17.7	15.1	13.4	14.5	14.8	15.0	14.3	17.8	18.2	
TL	5.1	5.3	5.2	4.7	4.8	5.0	5.0	4.9	5.6	5.9	
TaL	3.9	4.0	3.8	3.5	3.6	3.8	3.8	3.7	3.9	3.9	
T4L	5.3	5.4	4.8	5.0	4.8	5.1	4.9	5.1	5.7	5.5	
T4D	0.50	0.60	0.45	0.45	0.50	0.65	0.60	0.60	0.80	0.8	
T1D	0.50	0.50	0.45	0.40	0.45	0.50	0.55	0.45	0.60	0.6	
F3L	3.7	3.7	3.6	3.4	3.3	3.7	3.5	3.4	4.0	4.1	
F3D	0.80	0.60	0.65	0.55	0.65	0.65	0.70	0.60	1.00	0.75	
F1D	0.45	0.35	0.35	0.30	0.30	0.40	0.45	0.35	0.45	0.45	
HL	5.0	5.2	5.1	4.5	4.6	5.0	4.9	4.5	5.4	5.7	
HW	6.1	6.2	6.5	5.8	6.0	6.3	6.4	6.1	7.2	6.9	
END	1.4	1.3	1.4	1.1	1.2	1.25	1.2	1.15	1.35	1.5	
IND	1.4	1.4	1.4	1.2	1.2	1.5	1.5	1.35	1.6	1.7	
SL	2.0	2.2	2.1	1.9	1.75	2.3	2.0	1.9	2.1	2.5	
EST	1.8	2.0	2.2	1.6	1.7	2.0	1.8	1.7	2.2	2.2	
ED	2.0	2.2	1.8	1.7	1.8	1.8	1.9	1.8	2.2	2.1	
TyD	0.6	0.9	0.9	0.7	0.8	0.8	0.9	0.7	0.9	1.2	
TL/SUL	0.35	0.30	0.34	0.35	0.33	0.34	0.33	0.34	0.31	0.32	0.33±0.017
TaL/SUL	0.27	0.23	0.25	0.26	0.25	0.26	0.25	0.26	0.22	0.21	0.25±0.019
T4L/SUL	0.37	0.31	0.32	0.37	0.33	0.34	0.33	0.36	0.32	0.30	0.34±0.025
T4D/SUL	0.035	0.034	0.030	0.034	0.034	0.044	0.040	0.042	0.045	0.044	0.038±0.005
T4D/F3D	0.63	1.00	0.69	0.82	0.77	1.00	0.86	1.00	0.80	1.07	0.86±0.14
F3L/SUL	0.26	0.21	0.24	0.25	0.23	0.25	0.23	0.24	0.22	0.23	0.24±0.015
HL/SUL	0.35	0.29	0.34	0.39	0.32	0.34	0.33	0.31	0.30	0.31	0.33±0.029
HW/SUL	0.42	0.35	0.43	0.43	0.41	0.43	0.43	0.43	0.40	0.38	0.41±0.027
HL/HW	0.82	0.84	0.78	0.78	0.77	0.79	0.77	0.74	0.75	0.83	0.79±0.033
END/IND	1.00	0.93	1.00	0.92	1.00	0.83	0.80	0.85	0.84	0.88	0.91±0.076
ED/SUL	0.139	0.124	0.119	0.127	0.124	0.122	0.127	0.126	0.124	0.115	0.125±0.006
TyD/ED	0.30	0.41	0.50	0.41	0.44	0.44	0.47	0.39	0.41	0.57	0.43±0.071

and measured about one mm in diameter. Four specimens (UPNG 10060, SAMA R66097, R66098, and R66099) exhibit a similar basic colour and a similar mottling as the holotype, colouration of pigmented areas varied from brown to black. One paratype (ZMB 76742) has completely blackish dorsal and lateral surfaces, except a whitish coloured snout dorsum, a light interocular bar, two curved stripes in the scapular region, some whitish spots around elbow and tibio-tarsal articulation, one white spot right of the urostyle, and a transverse bar on the posterior thighs. All dorsal surfaces of paratype ZMB 76743 are darker or lighter brown with irregular blackish spots and stripes. The one female (ZMB 76744) and UPNG 10061 show a reticulate pattern of brown, blackish and greyish spots on all dorsal surfaces except for light yellowish areas between eyes, on fore and hind legs, and a

transverse stripe above the vent. Their ventral surfaces exhibit a dense pattern of brown spots on a yellowish ground colour. Conspicuous is a fine longitudinal line of whitish colour in the middle of the abdomen which crosses the vent opening and extends on the dorsum up to the snout tip. A similar line extends across the chest. Abdomen and ventral surfaces of legs of most paratypes are dark brown with yellowish spots; throat and chest are uniformly brown and without such yellowish spots. Abdomen of paratype ZMB 76743 exhibits more lighter than darker (brown) areas, and its throat and chest are spotted. ZMB 76745 is brown with pale brown snout and pale on dorsum and dorsolaterally; darker brown band between eyes, behind eye to axilla, in patch below eye and on limbs, pale cream stripe on distal edge of hind limbs. UPNG 10060 mottled dark and lighter brown with extensive



**Fig. 5.** Adult male paratype of *Albericus brevicrus* (SAMA R66099) sp. nov. in life.



**Fig. 6.** Montane forest at Lake Tawa (2,200 m asl), habitat of, and only second known location for, *Albericus brevicrus* sp. nov.

grey stippling concentrated predominantly over the paler brown blotches. All three previous specimens with pale cream patch that covers region of the axilla and extends ventrally to angle of the jaws.

In life colour pattern extremely variable. SAMA R66099 (Fig. 5) golden brown on snout anterior of eyes, with additional large golden-brown patches on mid-dorsum, dorso-laterally, postero-dorsally, and in a broad band along distal edge of thigh and around tip of heels. A broad, dark brown band extends from orbits posteriorly above supratympanic fold laterally to a point above arm insertion. Remaining lateral areas translucent pale grey with stippled dark brown pigment and pale cream, russet and golden-brown pigments, and patches of darker brown mottling. Iris golden-cream with narrow reticulations and a vertical, dark brown triangular notch.

**Distribution and ecological notes.** *Albericus brevicrus* is known from wet, mossy mid-montane rainforest adjacent to Lake Tawa (2,200 m asl) and along the Paiela Road (~ 2,900 m asl) in Enga Province, Papua New Guinea (Figs. 6 and 7) where males called from low perches on leaves ~ 20–30 cm above the ground at night.

**Vocalisation.** Forty-six calls from three males (SAMA R66097, R66098, and ZMB 76742) were analysed. Air temperature during all recordings was 14 °C. Calls are buzzes (Figs. 8a and 8b) and are uttered in series with well-defined short intervals between calls. Forty-one inter-call intervals have a mean duration of  $3.1 \pm 0.72$  s, range 2.30–4.99 s; intervals longer than five seconds within one series rarely occur. Mean call duration is  $561 \pm 49$  ms, range 489–641 ms; mean number of pulses per call is  $92 \pm 9.5$ , range 76–105; mean pulse repetition rate is  $165 \pm 15.5$  pulses per s, range 146–197 pulses per second. Frequencies scat-

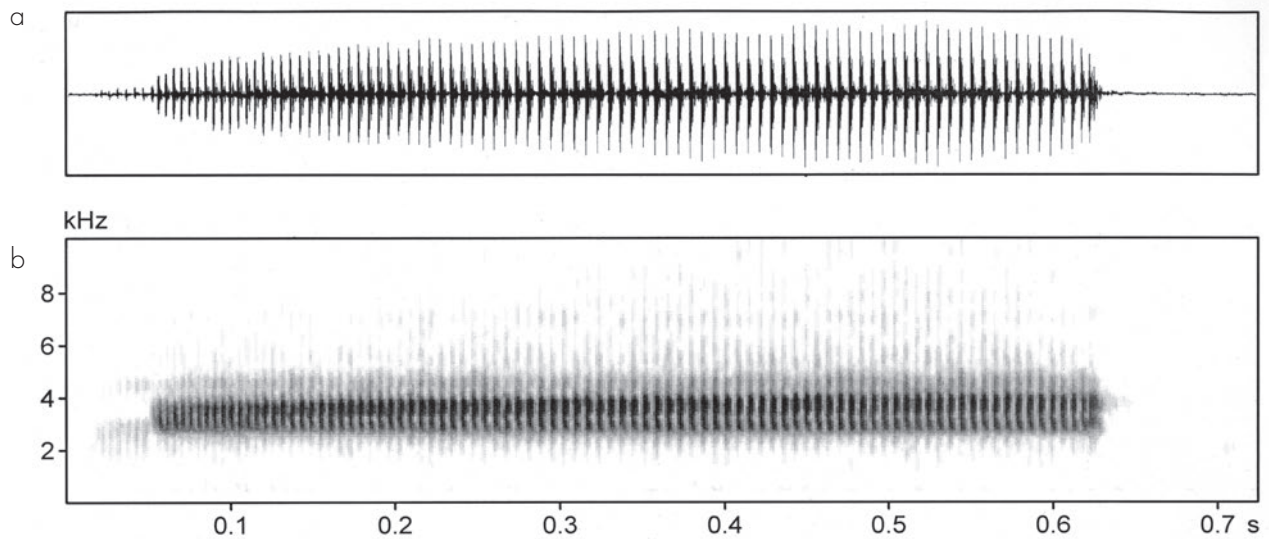


**Fig. 7.** Montane forest (2,900 m) at the base of Mt. Kumbepara along the Paiela Road, type locality of *Albericus pandanicolus* sp. nov., *Albericus brevicrus* sp. nov., and *Oreophryne streiffeleri* sp. nov.

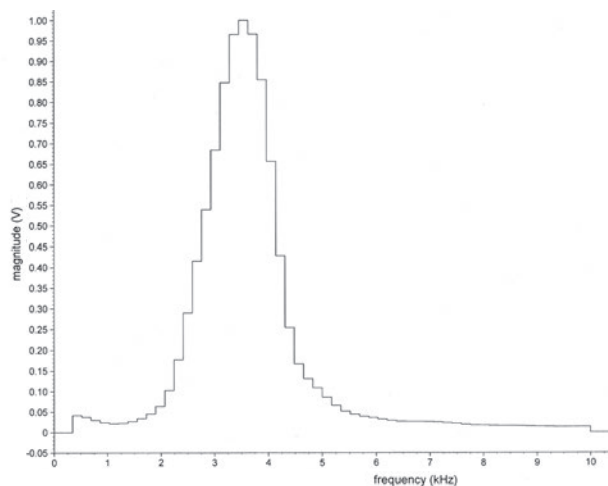
ter in a broad range mainly between 2 kHz and 5 kHz, dominant frequency is at 3.5 kHz (Fig. 9). Most calls start with up to 10 very weak pulses and end with one double pulse.

**Comparison with other species.** *Albericus brevicrus* belongs to the group of species with a buzz-call (MENZIES 1999). Its extremely short hind legs (TL/SUL 0.30–0.35, mean 0.33) delineate it from all other species of the genus except *A. alpestris*. This latter species has even shorter legs (TL/SUL 0.26–0.33) but a larger body: SUL more than 19 mm versus a maximum SUL of 18 mm in *A. brevicrus* (for further details see last section below).

**Etymology.** The specific epithet is a composite adjective, derived from the Latin word *brévis* (-is, -e) for short or small and the Latin *crus* (crúris) for shank. It refers to the extremely short hind legs of the new species.



**Fig. 8.** Wave form (a) and audiospectrogram (b) of an advertisement call of *Albericus brevicrus* sp. nov. (ZMB 76742).



**Fig. 9.** Power spectrum of an advertisement call of *Albericus brevicrus* sp. nov. (ZMB 76742).

### *Cophixalus tenuidactylus* sp. nov.

Plate III, Figs. 10–13 and Table 3

**Holotype.** SAMA R66105 (FN SJR 9546), adult male, collected at Omyaka Camp near Porgera Town, Enga Province, Papua New Guinea (05°31.533'S, 143°03.266'E; 3,200 m asl) on 21 August 2005, by S. Richards.

**Paratypes.** SAMA R66103 (FN SJR 9538), SAMA R66104 (FN SJR 9543), same data as for holotype; ZMB 76746 (FN SJR 9580) cleared and stained, same data as holotype but collected on 22 August 2005; ZMB 76747 (FN SJR 9670), ZMB 76748 (FN SJR 9671), SAMA R66106 (FN SJR 9672), and UPNG 10062 (FN SJR 9700), Paiela Road near Porgera Town, Enga Province, Papua New Guinea (05°30.183'S, 143° 04.866'E; 2,875 m asl) collected on 4 September 2005, by S. Richards.

**Diagnosis.** A small- to medium-sized (SUL of adult males 18.4–20.3 mm, of adult females 20.9–23.5

mm) *Cophixalus* with very short hind legs (TL/SUL 0.31–0.38) and narrow finger tips and toe tips (T4D/SUL 0.022–0.038); finger tips narrower than toe tips or of the same width; fifth toe much shorter than third. Advertisement calls resemble cricket-songs: each trill lasts from 3.5–4.3 seconds with a note repetition rate of 15.6–19.1 notes per s.

**Description of the holotype.** For morphological characters see Plate III and Fig. 10 and for body measurements and body ratios see Table 3. Head wider than long (HL/HW 0.80), no constriction at neck region, snout rounded in dorsal view and truncate in profile, canthus rostralis clearly expressed, curved outwards above nostrils and continued on tip of snout; loreal region oblique, eyes relatively small (ED/SUL 0.118) with pupils small and almost round; nostrils nearer to tip of snout than to eyes, internarial distance considerably greater than distance between eye and naris (END/IND 0.75); tongue long and narrow without posterior indentation, prepharyngeal ridge weakly expressed and not denticulate, vocal slits present on floor of mouth; tympanum barely visible, its diameter less than half eye diameter (TyD/ED 0.38), supratympanic fold pronounced. Forelegs well developed, fingers narrow without broadened tips, terminal grooves present on fingers 2–4 but difficult to identify on finger 1; relative lengths of fingers  $3 > 4 > 2 > 1$ , finger 1 less than half length of finger 2; no clearly expressed subarticular, carpal, or metacarpal tubercles. Hind limbs well developed but with very short thighs and shanks (TL/SUL 0.33); toe tips not broadened, those of toes 2, 3 and 4 with clearly recognizable grooves, grooves on fingers 1 and 5 poorly developed; no webbing between toes, relative lengths



**Plate III.** Holotype of *Cophixalus tenuidactylus* sp. nov. (a) dorsal view, (b) ventral view, (c) lateral view of head, (d) ventral view of left hand, (e) ventral view of left foot.

of toes  $4 > 3 > 5 > 2 > 1$ , toe 1 rudimentary. Posterior dorsum, dorsal surfaces of tibiae, of tarsi, and of lateral body covered with tubercles; head, anterior back, thighs, and forelegs smooth; undulating dorsolateral folds from eyes to lumbar region conspicuous; ventral surfaces smooth. There is an abdominal incision on the right side of body.

Ground colour of dorsum, flanks, and extremities reddish brown with diffuse blackish spots and reticulations, dorsal surface of snout (back to level between eyes) distinctly lighter than other dorsal surfaces; two light lumbar spots and one triangular light spot above posterior urostyle, some small white spots on lower flanks; abdomen and ventral surfaces of extremities with a mixture of irregular brownish, blackish, and off-white spots, with conspicuous numerous white

dots; throat medium-brown with fine white and larger brown spots. Upper lips brown, loreal region blackish, a blackish stripe inferior to lateral glandular ridges, and with a conspicuous white fleck which continues onto parts of the tympanum and is bordered by blackish areas behind the eyes.

Based on photographs in life of the holotype, body and limbs generally brown with extensive areas of darker brown pigmentation, focused as follows: in a broad band that extends from a line mid-way between the orbits to the posterior edge of the arm insertion; in a broad canthal stripe from the tip of the snout to the eye and back from eye along the curved glandular supratympanic fold to the axilla; along the edge of the upper and lower jaws; and in a series of small patches and bars associated with tubercles and narrow

**Table 3.** Body measurements and body ratios of the type series of *Cophixalus tenuidactylus* sp. nov. SAMA R66105 is the holotype, ZMB 76746 is now an osteological preparation. SAMA R66103, SAMA R66105, and ZMB 76746 are adult males, SAMA R66104 and ZMB 76747 are adult females, and ZMB 76748, SAMA R66106, and UPNG 10062 are probably subadult specimens.

Inv.No.	SAMA R66103	SAMA R66104	SAMA R66105	ZMB 76746	ZMB 76747	ZMB 76748	SAMA R66106	UPNG 10062	Mean ± SD
SUL	20.3	23.5	20.3	18.4	20.9	17.8	16.8	16.5	
TL	6.3	7.6	6.7	6.6	7.1	6.3	6.3	6.2	
TaL	4.4	5.3	4.9	4.4	4.8	4.4	4.7	3.8	
T4L	7.9	8.6	8.2	7.5	8.4	7.8	7.5	6.9	
T4D	0.50	0.55	0.45	0.45	0.60	0.50	0.50	0.40	
T1D	0.40	0.35	0.30	0.30	0.30	0.30	0.25	0.25	
F3L	4.5	5.2	4.6	4.4	4.3	4.4	4.5	4.1	
F3D	0.50	0.45	0.40	0.35	0.50	0.50	0.50	0.35	
F1D	0.35	0.35	0.30	0.30	0.40	0.30	0.25	0.20	
HL	6.1	7.1	6.0	5.7	6.0	5.9	6.0	5.2	
HW	8.5	9.0	7.5	7.7	7.5	7.2	7.0	6.5	
END	1.3	1.7	1.5	1.4	1.6	1.5	1.25	1.2	
IND	2.0	2.2	2.0	2.0	1.9	1.8	1.6	1.65	
SL	2.4	2.9	2.5	2.3	2.4	2.1	2.3	2.4	
EST	2.1	2.5	2.2	2.5	2.5	2.4	2.1	2.0	
ED	2.1	2.6	2.4	2.15	2.2	2.0	2.0	2.0	
TyD	0.8	1.0	0.9	0.9	1.1	1.0	0.9	0.9	
TL/SUL	0.31	0.32	0.33	0.36	0.34	0.35	0.38	0.38	0.35±0.026
TaL/SUL	0.22	0.23	0.24	0.24	0.23	0.25	0.28	0.23	0.24±0.018
T4L/SUL	0.39	0.37	0.40	0.41	0.40	0.44	0.45	0.42	0.41±0.026
T4D/SUL	0.025	0.023	0.022	0.024	0.029	0.028	0.030	0.024	0.026±0.003
T4D/F3D	1.00	1.22	1.13	1.29	1.20	1.00	1.10	1.14	1.14±0.10
F3L/SUL	0.22	0.22	0.23	0.24	0.21	0.25	0.27	0.25	0.24±0.02
HL/SUL	0.30	0.30	0.30	0.31	0.29	0.33	0.36	0.32	0.31±0.023
HW/SUL	0.42	0.38	0.37	0.42	0.36	0.40	0.42	0.39	0.40±0.024
HL/HW	0.72	0.79	0.80	0.74	0.80	0.82	0.86	0.80	0.79±0.043
END/IND	0.65	0.77	0.75	0.70	0.84	0.83	0.78	0.73	0.76±0.064
ED/SUL	0.103	0.111	0.118	0.117	0.105	0.112	0.119	0.121	0.113±0.006
TyD/ED	0.38	0.38	0.38	0.42	0.50	0.50	0.45	0.45	0.43±0.051

glandular folds. A broad patch of paler pigment extends from posterior corner of eye, below the darker supratympanic band, to a point immediately anterior of the arm insertion. Scattered pale flecks are concentrated laterally and ventro-laterally with several flecks behind the eye and along the jaw, and on the dorsal surfaces of the thighs. Iris copper with brown flecks.

**Morphological characters of the paratypes.** For measurements and body ratios of all types see Table 3. The paratypes include two adult males (SAMA R66103, and ZMB 76746) with SUL of from 18.4 to 23.5 mm, two adult females (SAMA R66104, and ZMB 76747) with SUL of 20.9 and 23.5 mm, and three subadult specimens, probably females (ZMB 76748, SAMA R66106, and UPNG 10062) with SUL

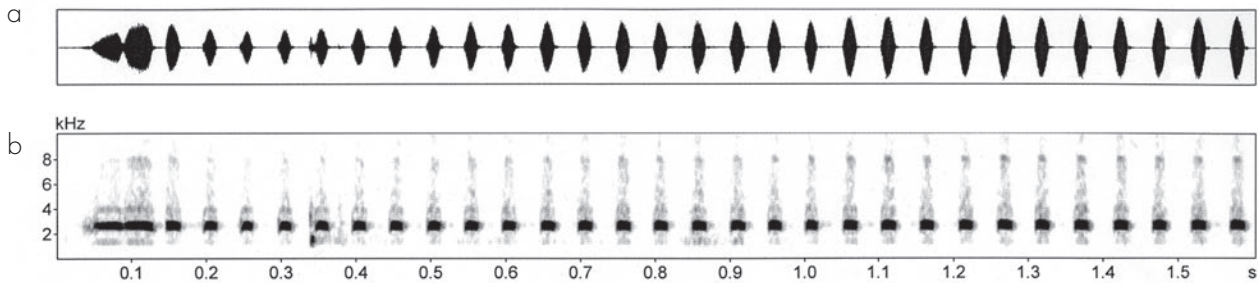
of 16.5–17.8 mm. Ovarian eggs of the two adult females are entirely whitish and are 1.5 to 2.0 mm in diameter. Five specimens have a similar ground colour as the holotype and two specimens have a greyish-brown ground colour. Three of the eight frogs show fairly uniform dorsal colouration, the others exhibit more or less numerous irregularly-shaped blackish spots on the dorsum. Characteristic of all specimens are a light snout dorsum, light spots in lumbar region, blackish longitudinal stripes that border the dorsolateral glandular ridges inferiorly, blackish upper half of loreal region, and an elongate whitish spot behind the eye which is superiorly and inferiorly bordered by blackish areas. Occasional tubercles are on the flanks, shanks, and in the lumbar region; ventral surfaces are commonly light yellow with medium- or



**Fig. 10.** Adult male holotype of *Cophixalus tenuidactylus* sp. nov. in life, guarding a clump of eggs.



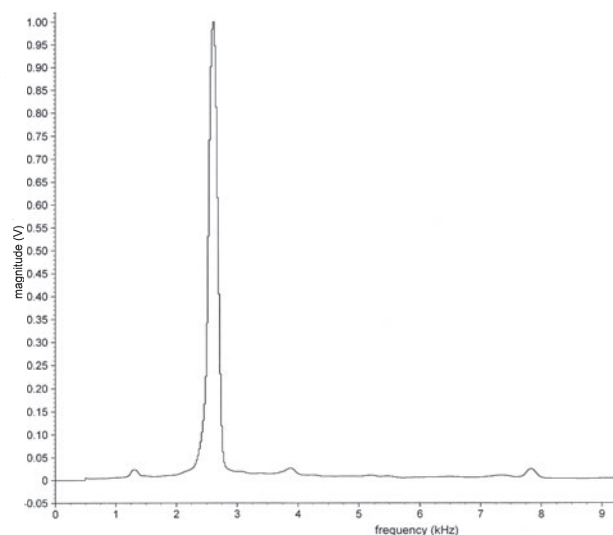
**Fig. 11.** Montane grassland at Omyaka Camp, habitat of *Cophixalus tenuidactylus* sp. nov. and *Albericus* cf. *alpestris*.



**Fig. 12.** Wave form (a) and audiospectrogram (b) of the first thirty notes of an advertisement call of *Cophixalus tenuidactylus* sp. nov.

dark-brown spots, and in a few individuals the ventral surfaces are completely brown. Numerous whitish dots on the ventral surfaces are characteristic of all specimens. The holotype is the darkest individual and one paratype is more golden brown with a greenish tinge (ZMB 76746) and another is almost olive coloured (un-numbered individual) in life.

**Distribution and ecological notes.** *Cophixalus tenuidactylus* was found in alpine grassland around Omyaka Camp at elevations between 3,100–3,300 m (Fig. 11) and at the edge of montane mossy forest along the Paiela Road at about 2,900 m asl, both locations on the Kaijende Highlands. Males called from within soil and humus below grass and fern mats in the alpine grasslands, and from within raised mossy clumps surrounding small patches of stunted forest within these grasslands. At Paiela Road, specimens were collected from beneath logs and mats of grass at the edge of the forest during the day. No specimens were seen or heard within the forest, and no specimens were found in elevated or in exposed positions. Two calling males traced by their calls deep inside mossy clumps in the grassland were guarding five and eight large, unpigmented eggs in small hollows within the moss clump (Fig. 10). However, calling males were extremely difficult to find because indi-



**Fig. 13.** Power spectrum of one advertisement call note of *Cophixalus tenuidactylus* sp. nov.

viduals called only infrequently, and they hid in thick mossy humus under clumps of grass. As a result, few individuals were found despite intensive searching during the survey period. Egg guarding seems to be common among New Guinean microhylids (e.g. GÜNTHER, 2006b).

**Vocalisation.** Males called throughout the day, particularly when overcast and rainy. However, all calling activity ceased soon after nightfall. Advertisement calls are long and conspicuous trills that are similar to cricket-songs (Figs. 12a and 12b) and their melodious trills were a conspicuous feature of the acoustic landscape during the day in the alpine meadows of the Kaijende Highlands. Six calls from three males (ZMB 76746, and two specimens not found) were analysed. Air temperature during recording was 10–13 °C. Call duration was from 3.6 to 4.3 s, mean  $4.08 \pm 0.27$  s. A total of 319 notes and 315 inter-note intervals from five calls were measured. Mean note length varies from 20.8 to 22.8 ms, mean of means  $21.4 \pm 0.84$  ms. A few double notes with length of 90–100 ms occurred but were not considered in the calculations. Mean inter-note interval length varies from 33.5 to 41.9 ms, mean of means  $36.0 \pm 3.4$  ms. Total range of note length is 17–26 ms with a total range of inter-note intervals of 30–53 ms. Note repetition rate varies in six calls from 15.6 to 19.1 notes per second, mean rate 18.0 notes per second. Except for the introductory note, all wave forms of the notes exhibit the shape of a cross section of a discus. Most introductory notes are double notes. Both parts of the introductory notes are longer than the remaining notes. The wave form of the first part of these double notes looks like an asymmetric spindle and has a lower volume than all remaining notes. The second part is spindle-like and has the same volume as the following notes. Fundamental frequency of the calls is around 1.3 kHz and dominant frequency is concentrated in a small range around 2.6 kHz (the dominant frequency band is synonymic with the first harmonic band). Further harmonics are at 3.9 kHz, 5.2 kHz, 6.5 kHz (scarcely expressed) and 7.8 kHz (Fig. 13).

**Comparison with other species.** Nearly all species in the genus *Cophixalus* possess dilated finger and toe tips. Exceptions in New Guinea are *C. sphagnicola* ZWEIFEL & ALLISON, 1982 and *C. verecundus* ZWEIFEL & PARKER, 1989. The third case is the new species *C. tenuidactylus*. These three species are morphologically similar but they differ conspicuously in their advertisement calls. *Cophixalus sphagnicola* utters long, high-pitched, and finely tuned peeps. Mean note length is 260–320 ms with a dominant frequency above 3.2 kHz and a note repetition rate of about 1.5 notes per s. *Cophixalus verecundus* utters a “rapid train of click-like pulses giving the aural effect of a soft buzz” (ZWEIFEL & PARKER, 1989). Notes (= pulses) are not finely tuned but show a wide spectrum of frequencies with energy peaks at about 2.5 and 3.3 kHz. Inter-note intervals are very short, and from this results a note (pulse) repetition rate of 50–60 per s. Notes (pulses) and inter-note intervals are considera-

bly longer and notes are finely tuned in *C. tenuidactylus*, and this results in a note repetition rate of 15–19 per s.

**Etymology.** The specific name is derived from the Latin adjective *tenuis* (-is, -e) for narrow or slender, and the Latin substantive *dáctylus* (-i) (Greek *ho dáctylos*) for digit. It refers to the unusually narrow (for the genus *Cophixalus*) finger and toe tips of the new species.

### *Oreophryne streiffeleri* sp. nov.

Plate IV, Figs. 14–16, and Table 4

**Holotype.** SAMA R66120 (FN SJR 9715), adult female, Paiela Road near Porgera Town, Enga Province, Papua New Guinea (05°30.183'S, 143°04.866'E; 2,900 m asl) collected on 5 September 2005, by S. Richards.

**Paratypes.** SAMA R66117 (FN SJR 9666), SAMA R66118 (FN SJR 9667), SAMA R66119 (FN SJR 9695), ZMB 76749 (FN SJR 9661), ZMB 76750 (FN SJR 9664), ZMB 76751 (FN SJR 9665), ZMB 76752 (FN SJR 9694, now cleared and stained), UPNG 10065 (FN SJR 9662), UPNG 10066 (FN SJR 9663), and UPNG 10067 (FN SJR 9702), all same data as holotype but collected on 4 September 2005.

**Diagnosis.** A medium-sized *Oreophryne* (SUL of males 20.2–22.4 mm, that of females 22.5–25.1 mm) with moderately short legs (TL/SUL 0.40–0.46), large finger and toe discs (T4D/SUL more than 0.060), and finger discs slightly wider than toe discs. The eye-naris distance is marginally shorter than the internarial distance (END/IND 0.86–0.95). No webs between toes. A combination of the following characters is further diagnostic: a whitish inverted U-shaped mark present on loreal region; a light W-shaped mark in scapular region; whitish lumbar spots; an elongate brown spot on underarm; a blackish spot encircling vent opening; and an elongate blackish spot above tympanum. Connection between procoracoid and scapula is cartilaginous. Advertisement call is a chain of melodious peeps or whistles. Calls last from 6.3 to 7.7 seconds with a note repetition rate of between 2.4 and 2.6 notes per second. The dominant frequency is at 2.6 kHz.

**Description of the holotype.** For morphological characters see Plate IV and for body measurements and body ratios see Table 4. There is a longitudinal cut in the left side of the posterior abdomen. Head clearly broader than long (HL/HW 0.74), weak constriction at neck region, snout blunt in dorsal view and truncate in profile, canthus rostralis slightly bent, loreal region oblique and slightly concave, nostrils lateral and near tip of snout; eyes medium-sized (ED/



**Plate IV.** Holotype of *Oreophryne streiffeleri* sp. nov. (a) dorsal view, (b) ventral view, (c) lateral view of head, (d) ventral view of left hand, (e) ventral view of right foot.

SUL 0.123), eye-naris distance smaller than inter-narial distance; tongue very broad with a posterior transverse furrow, no posterior notch; two prepharyngeal ridges, both with some indentations; tympanum nearly half the size of eye (TyD/ED 0.45), its superior margin covered by skin, supratympanic fold weakly expressed. Forelegs long and slender, fingers long, their relative length  $3 > 4 \approx 2 > 1$ , tips of fingers slightly rounded and very wide (more than twice the width of penultimate phalanges), all with terminal grooves; elongate inner and rounded outer metacarpal tubercles feebly developed, no clearly demarcated subarticular tubercles. Hind limbs also slender and with long toes, their relative length  $4 > 5 > 3 > 2 > 1$ , no webs between toes, toe tips somewhat narrower than finger tips (T4D/F3D 0.86), all with terminal grooves; and tip of first toe of the right hind leg missing. With the exception of an inner metatarsal tubercle, no other

plantar or subarticular tubercles present. Shanks moderately short (TL/SUL 0.40); some small tubercles around tympana, on body sides, and on dorsal surfaces of extremities; all ventral surfaces smooth.

Ground colour of dorsal surfaces pale straw yellow; except on snout dorsum, all dorsal surfaces covered by many dark brown spots of irregular size. Obvious are lumbar “eye spots”, a W-shaped mark in scapular region, some elongate whitish dashes bordered by blackish spots, a dark spot posterior of eye, a blackish spot surrounding vent, and an inverted whitish U in loreal region; all ventral surfaces of pale straw colour with many blackish dots.

**Morphological characters of the paratypes.** For mensural variation of the type series see Table 4. Paratypes include seven adult males with SUL of 20.2–22.4 mm, three adult females with SUL of



**Table 4.** Body measurements and body ratios of the type series of *Oreophryne streiffeleri* sp. nov. SAMA R66120 is the holotype, ZMB 76752 is now an osteological preparation. ZMB 76749, UPNG 10065, ZMB 76750, SAMA R66117, SAMA R66118, ZMB 76752, and SAMA R66119 are adult males; UPNG 10066, ZMB 76751, and SAMA R66120 are adult females, and UPNG 10067 is an immature specimen.

Inv.No	ZMB 76749	UPNG 10065	UPNG 10066	ZMB 76750	ZMB 76751	SAMA R66117	SAMA R66118	ZMB 76752	SAMA R66119	UPNG 10067	SAMA R66120	Mean ± SD
SUL	22.4	21.6	22.5	21.2	24.6	21.7	22.4	20.7	20.2	14.9	25.1	
TL	9.3	9.9	9.7	9.3	10.2	9.5	9.3	9.2	8.8	6.2	10.1	
TaL	7.2	6.9	7.0	6.7	7.4	7.1	7.0	6.8	6.5	4.8	7.4	
T4L	9.5	10.1	10.2	9.9	11.2	10.4	11.1	9.8	9.0	6.2	10.6	
T4D	1.4	1.5	1.4	1.4	1.8	1.4	1.5	1.3	1.3	0.6	1.8	
T1D	1.0	1.2	1.0	0.8	1.2	0.8	0.9	0.7	0.6	0.4	1.2	
F3L	6.4	6.8	6.7	6.6	7.6	6.8	6.5	6.5	6.0	4.1	7.7	
F3D	1.4	1.6	1.5	1.3	2.0	1.5	1.7	1.4	1.4	0.7	2.1	
F1D	1.1	1.2	1.0	0.9	1.6	1.1	1.1	0.9	0.9	0.4	1.4	
HL	7.0	6.6	6.8	6.7	7.1	7.0	6.8	6.5	6.5	4.7	7.0	
HW	8.4	8.7	8.5	8.4	9.1	8.9	8.7	8.0	7.9	5.9	9.5	
END	2.0	1.9	1.7	1.9	2.0	1.9	1.8	1.9	1.7	1.3	1.8	
IND	2.1	2.1	2.0	2.2	2.3	2.0	2.1	2.1	1.9	1.5	2.1	
SL	3.0	2.7	2.4	2.9	3.0	2.8	2.6	2.8	2.5	2.1	2.7	
EST	2.7	2.8	2.6	2.6	2.9	3.0	2.5	2.5	2.6	2.0	2.5	
ED	2.7	2.6	2.8	2.5	3.0	2.5	2.5	2.5	2.6	1.9	3.1	
TyD	0.9	0.9	1.0	0.8	1.1	0.8	1.0	1.0	0.8	0.6	1.4	
TL/SUL	0.42	0.46	0.43	0.44	0.41	0.44	0.42	0.44	0.44	0.42	0.40	0.43 ± 0.017
TaL/SUL	0.32	0.32	0.31	0.32	0.30	0.33	0.31	0.33	0.32	0.32	0.29	0.32 ± 0.012
T4L/SUL	0.42	0.47	0.45	0.47	0.46	0.48	0.50	0.47	0.45	0.42	0.42	0.46 ± 0.027
T4D/SUL	0.063	0.069	0.062	0.066	0.073	0.065	0.067	0.063	0.064	0.040	0.072	0.064±0.009
T4D/F3D	1.00	0.94	0.94	1.08	0.90	0.93	0.88	0.93	0.93	0.86	0.86	0.93 ± 0.064
F3L/SUL	0.29	0.31	0.30	0.31	0.31	0.31	0.29	0.31	0.30	0.28	0.31	0.30 ± 0.011
HL/SUL	0.31	0.31	0.30	0.32	0.29	0.32	0.30	0.31	0.32	0.32	0.28	0.31 ± 0.013
HW/SUL	0.38	0.40	0.38	0.40	0.37	0.41	0.39	0.39	0.39	0.40	0.38	0.39 ± 0.012
HL/HW	0.83	0.76	0.80	0.80	0.78	0.79	0.78	0.81	0.82	0.80	0.74	0.79 ± 0.026
END/IND	0.95	0.90	0.85	0.86	0.87	0.95	0.86	0.90	0.89	0.87	0.86	0.89 ± 0.035
ED/SUL	0.121	0.120	0.124	0.118	0.122	0.115	0.112	0.120	0.128	0.128	0.123	0.121±0.005
TyD/ED	0.33	0.35	0.36	0.32	0.37	0.32	0.40	0.40	0.31	0.32	0.45	0.36 ± 0.044

22.5–25.1 mm, and one subadult specimen with SUL of 14.9 mm. All paratypes with an off-white dorsal ground colour, this ground colour interspersed with numerous fine dark brown dots. These dots can be isolated but can occur in more or less dense groups and thus form more or less densely pigmented spots. Form and arrangements of dots varies between individuals. According to number and dimensions of spots, dorsal surfaces of paratypes appear lighter or darker. One specimen (UPNG 10066) is completely dark brown except on the snout dorsum, a W-shaped mark in the scapular region, and on lumbar spots. Characteristic features of all paratypes are a light snout dorsum, a light W-shaped mark in the scapular region, whitish lumbar spots, an elongate brown spot beneath arm, a blackish spot around vent, an elongate blackish spot above tympanum, and an inverted U-shaped mark of white colour in loreal region. Five

specimens have a uniform light ventral surface, and in all other frogs the ventral surfaces are more or less densely covered by dark brown dots; consequently, those frogs exhibit ventral surfaces from light brown to dark brown. Inferior tarsi are dark brown or blackish in most specimens. Distribution of tubercles in paratypes is much the same as in the holotype.

In life dorsally mottled with darker and lighter brown. ZMB 76749 (Fig. 14) infused with yellowish-orange particularly on posterior and lateral surfaces; ventro-lateral surfaces with translucent, creamy patches with brown stippling and pale, creamy orange mottling; a pale cream inverted 'U' on upper lip, dorsal surfaces of snout also cream but with yellowish tinge and pale yellow and small brown spots; a pale bar from posterior corner of eye to posterior edge of jaw and a narrow brown stripe from tip of snout along canthus to eye and extending, slightly narrower, pos-



**Fig. 14.** Adult male paratype of *Oreophryne streiffeleri* sp. nov. (ZMB 76749) in life.

terior of eye across top of tympanum and half-way to axilla; posterior of thighs reddish orange; a thin, pale mid-dorsal stripe may be present. Eye golden with copper flecks. SAMA R66117 similar but less translucent, and with more extensive yellow laterally, on fingers and toes, and on venter. SAMA R66118 has a similar general pattern but a much darker brown dorsum colour.

**Distribution and ecological notes.** This species is known only from mossy montane forest along the Paiela Road near Porgera Town, Enga Province (Fig. 7). Males called from the ground, or from low foliage (< 2m above the ground) during and after heavy rain. The female holotype was collected from a leaf in dense foliage during rain.

**Vocalisation.** Advertisement calls are a series of peeps (Figs. 15a and 15b). Four calls of two males (SAMA R66118, and R66119) were analysed. Air temperature during recording was 17 °C. Call length is 6.4–7.7 s, mean 6.84 s, and note repetition rate is 2.47–2.58 notes per s (mean 2.53 notes per s). Notes start explosively, show a slight sound modulation in the course of the note, and cease slowly. There is a very weak frequency modulation from lower to higher in the course of each note. Mean note length varies from 148 to 161 ms (mean of means 155 ms) and mean inter-note interval length varies from 241 to 278 ms (mean of means 258 ms). Total range of note length 142–183 ms (except first note which is often much shorter, less than 100 ms), total range of inter-note interval length 223–495 ms. Total number of analysed notes is 270 and total number of inter-note intervals is 266. Fundamental frequency is at 1.3 kHz

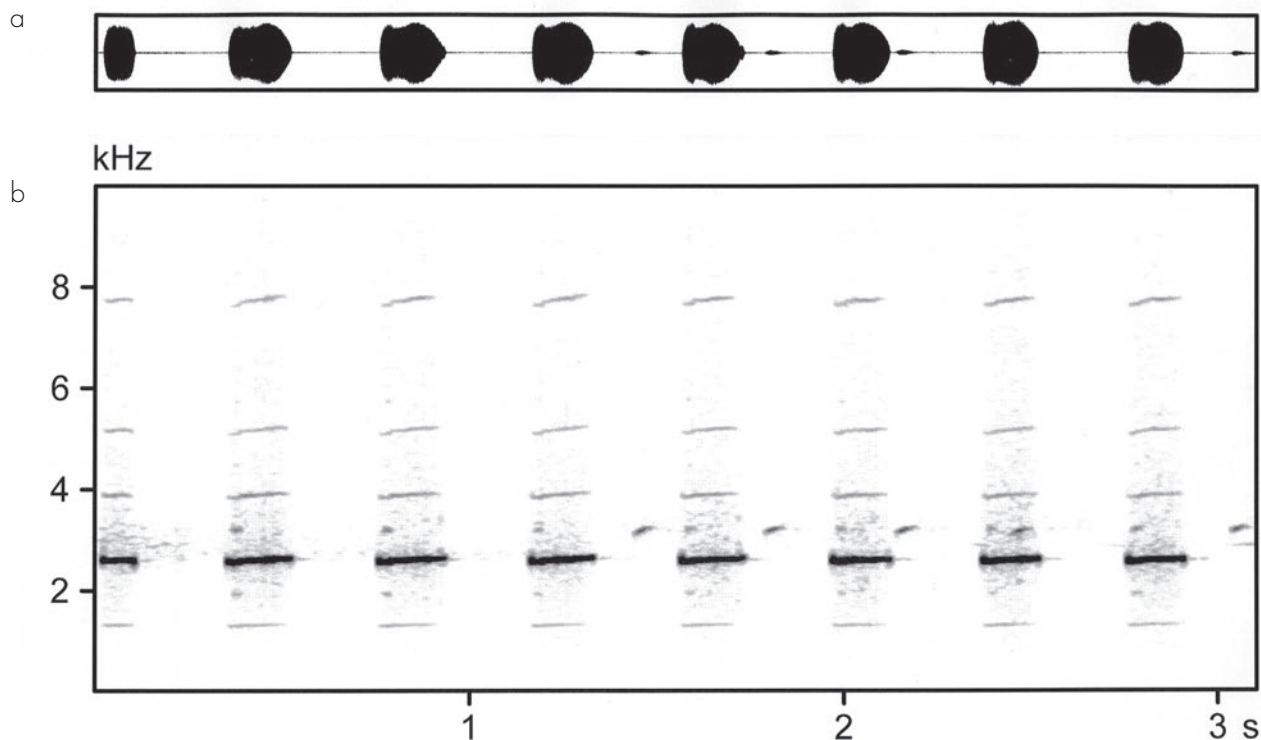
and dominant frequency at 2.6 kHz. There are five upper harmonics above the dominant band, and most pronounced of these are the first at 3.9 kHz and the fourth at 7.8 kHz (Fig. 16).

One call with 21 notes (call number 047 of SAMA R66118) differs clearly from the other two calls of this male. Mean note length is 132 ms, mean inter-note length is 208 ms, note repetition rate is 3.0, and dominant frequency 2.9 kHz. It is impossible to determine whether this call is an aberration, a “normal” variation, or whether it stems from a male of another species. A similar situation concerns a call probably by SAMA R66119 (call 145): this call lasts 4.8 s and has 18 notes. Mean note duration is 103 ms and mean inter-note interval duration is 174; consequently, this results in a note repetition rate of 3.75 notes per s.

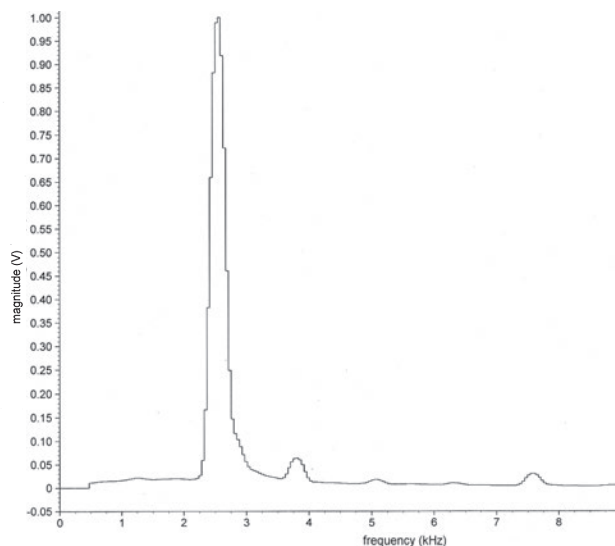
**Comparison with other species.** The procoracoid of *O. streiffeleri* is connected to the scapula by a cartilaginous bridge. All species without such a cartilaginous bridge will not be considered further here, but we will consider those species where it is not known whether the procoracoid is connected to the scapula by a ligament or by a cartilaginous bridge. *Oreophryne streiffeleri* has unpulsed peeping advertisement call notes. The call notes of the following species are, to the contrary, pulsed: *O. alticola* ZWEIFEL, COGGER & RICHARDS, 2005; *O. anamiatoi* KRAUS & ALLISON, 2009; *O. brevicrus* ZWEIFEL, 1956; *O. clamata* GÜNTHER, 2003; *O. geminus* ZWEIFEL, COGGER & RICHARDS, 2005; *O. terrestris* ZWEIFEL, COGGER & RICHARDS, 2005; and *O. waira* GÜNTHER, 2003.

*Oreophryne asplenicola* GÜNTHER, 2003 resembles *O. streiffeleri* in having a similar white-coloured inverted U- or an O-mark on the loreal region and both species are also similar in other morphological details. However, these species differ significantly in SUL (five males of *O. asplenicola* measure 19.3–21.2 mm and six males of *O. streiffeleri* measure 20.2–22.4 mm, the Mann-Whitney W-Test revealed a p-value of 0.028); in T4D/SUL (0.036–0.052 in *O. asplenicola* and 0.063–0.069 in *O. streiffeleri*; p = 0.0078); in T4D/F3D (0.64–0.85 in *O. asplenicola* and 0.86–1.08 in *O. streiffeleri*; p = 0.0031); in END/IND (0.95–1.00 in *O. asplenicola* and 0.85–0.95 in *O. streiffeleri*); in ED/SUL (0.128–0.139 in *O. asplenicola* and 0.112–0.128 in *O. streiffeleri*); and in length of call notes (mean note length in *O. asplenicola* 67–85 ms and 132–157 ms in *O. streiffeleri*).

*Oreophryne brevirostris* ZWEIFEL, COGGER & RICHARDS, 2005 is an alpine species (found at 3400–3500 m asl) with very short legs (TL/SUL less than 0.35) and no whitish mark on lores. A syntype (ZMA 5819) of *O. crucifer* (VAN KAMPEN, 1913) has webs



**Fig. 15.** Wave form (a) and audiospectrogram (b) of eight notes of an advertisement call of *Oreophryne streiffeleri* sp. nov. (SAMA R66119).



**Fig. 16.** Power spectrum of one advertisement call note of *Oreophryne streiffeleri* sp. nov.

on toes, no inverted U-mark on lores, T4D/F3D 0.84 (in *O. streiffeleri* 0.86–1.08), END/IND 1.25 (in *O. streiffeleri* 0.85–0.95). *Oreophryne flava* PARKER, 1934 has basal webs on toes, no white mark on lores, T4D/F3D 0.61–0.69,  $n = 6$  (in *O. streiffeleri* 0.86–1.08,  $n = 10$ ), ED/SUL 0.130–0.144 (in *O. streiffeleri* 0.112–0.128). *Oreophryne habbemensis* ZWEIFEL, COGGER & RICHARDS, 2005 lives at

high elevations between 3000 and 3500 m asl and has (among other differences) shorter legs than *O. streiffeleri* (TL/SUL 0.33–0.38 versus 0.40–0.46). With a SUL of up to 45 mm, *O. idenburgensis* is larger than *O. streiffeleri*. *Oreophryne kampeni* PARKER, 1934 differs from the new species by the presence of distinct digital webs, no white loreal mark, shorter legs (TL/SUL of the holotype of *O. kampeni* 0.42), distinct T4D/SUL (0.043 versus 0.62–0.73), distinct T4D/F3D (0.66 versus 0.86–1.08) and distinct ED/SUL (0.152 versus 0.112–0.128). The structure of the shoulder girdle of *O. loriae* (BOULENGER, 1898) is not clear. According to MENZIES (1975, 2006) the latter species utters “6 to 12 short, rather nasal, buzzes” with a buzz length of between 200 and 300 ms. *Oreophryne streiffeleri* utters peeping notes, with note length varying between 100 and 200 ms.

*Oreophryne notata* ZWEIFEL, 2003 has a smaller body (largest female of 20.8 mm SVL) than *O. streiffeleri* (largest female of 25.1 mm SUL), longer legs (TL/SVL 0.47–0.51 versus 0.40–0.46), larger eyes (ED/SUL 0.137–0.161 versus 0.115–0.128), smaller finger discs and toe discs (T4D/SVL 0.048–0.060 versus 0.062–0.073), and a different advertisement call. Note repetition rate in *O. notata* is about 4.0 per s, whereas in *O. streiffeleri* it is around 2.5 per s; the dominant frequency of the *notata*-calls is 3.5–3.6 kHz, that of *O. streiffeleri* is 2.6 kHz. *Oreophryne pseudasplenicola* GÜNTHER, 2003 has smaller fin-

ger discs and toe discs (T4D/SUL 0.36–0.48 versus 0.62–0.73 in *O. streiffeleri*), a significantly lower ratio T4D/F3D (0.71–0.91 versus 0.86–1.08 in the new species,  $p=0.024$ ), a significant higher ratio END/IND (0.90–1.00 versus 0.85–0.95 in the new species,  $p=0.005$ ), and larger eyes (ED/SUL 0.135–0.152 versus 0.115–0.128). Moreover, the note repetition rate in *O. pseudasplenicola* is 1.3 to 1.4 notes per s, while this rate in the new species is about 2.5 notes per s; dominant frequency in *O. pseudasplenicola* is 3.4 kHz versus 2.5 kHz in *O. streiffeleri*. The character of the shoulder girdle of *O. wolterstorffi* (WERNER, 1901) is unclear, but this species differs from the new one, among other characters, by conspicuous webs on the toes.

The presence of a white inverted U-mark or an O-mark on the loreal region and further common morphological and anatomical features as well as similarities in the advertisement calls lead to our conclusion that *O. notata*, *O. asplenicola*, *O. pseudasplenicola*, and *O. streiffeleri* belong to the same phylogenetic branch.

Comparative morphological and behavioural details in this paragraph were taken from studies of the authors and from the original descriptions of the species whose authors are mentioned when a species name was first mentioned.

**Etymology.** The specific name is in memory of one of the oldest friends of the senior author, HEINZ STREIFFELER (Berlin), who unfortunately died on 21 May, 2011 as this paper was nearing completion.

### *Oreophryne graminis* sp. nov.

Plate V, Figs. 17–20, and Table 5

**Holotype.** SAMA R66123 (FN SJR 9726), adult male, Waile Creek adjacent to Porgera Reservoir, Enga Province, Papua New Guinea (05°34.216'S, 143°03.526'E; 3,122 m asl) collected on 7 September 2005, by S. Richards.

**Paratypes.** SAMA R66121 (FN SJR 9723), R66122 (FN SJR 9724), ZMB 76753 (FN SJR 9725) same data as holotype; SAMA R66124 (FN SJR 9730), ZMB 76754 (FN SJR 9731) same data as holotype but collected on 8 September 2005, SAMA R66125 (FN SJR 9732), ZMB 76755 (FN SJR 9733), ZMB 76756 (FN SJR 9734), UPNG 10068 (FN SJR 9735), UPNG 10069 (FN SJR 9736), UPNG 10070 (FN SJR 9781) same data as holotype but collected on 9 September 2005.

**Diagnosis.** Measuring 15.7 to 18.5 mm SUL in 11 males and 22.1 mm in one female, this new species is among the smaller members of the genus. Thighs and shanks unusually short for an *Oreophryne* (TL/SUL 0.34–0.39), discs of fingers and toes rather narrow (T4D/SUL 0.040–0.058), finger discs somewhat

wider or of equal size to those of toes. No webs between toes. Internarial span clearly greater than eye-naris distance (END/IND 0.67–0.88). Dorsum of most specimens not, or only inconspicuously, spotted. No inverted U-mark or O-mark on lores. Connection between procoracoid and scapula is cartilaginous. Advertisement call consists of a train of melodious peeps. Duration of the calls 7.2–10.4 seconds, note repetition rate 2.4–2.7 notes per s, and dominant frequency at 3.6 kHz.

**Description of the holotype.** For morphological characters see Plate V and for body measurements and body ratios see Table 5. There is a longitudinal incision in the upper flank of the right body side. Head shorter than wide (HL/HW 0.77); neck region slightly constricted; snout tip weakly rounded in dorsal view and truncate in profile; canthus rostralis nearly straight, loreal region oblique; nostrils lateral and nearer to tip of snout than to eye; eyes medium sized (ED/SUL 0.120), pupil horizontally oval, iris blackish with numerous silvery spots; superior half of tympanum covered by skin, its diameter less than half that of eye (TyD/ED 0.37); eye-naris distance less than internarial distance; tongue moderately broad and posteriorly more than half free, no notch in its posterior margin; prepharyngeal ridge scarcely developed. Forelegs long and slender, fingers medium sized, their relative lengths  $3 > 4 > 2 > 1$ , all fingers with broadened tips not wider than one and a half width of penultimate phalanges, tip of first finger clearly narrower than that of other fingers, all tips with terminal grooves; no clearly developed tubercles on fingers or hands. Hind legs more robust and with long toes, toe tips rounded and discs slightly wider than width of penultimate phalanges, toe discs approximately as wide as finger discs, all discs with terminal grooves, no clearly expressed subarticular or plantar tubercles and no webs; relative length of toes  $4 > 5 > 3 > 2 > 1$ . A fairly large and angular tubercle present between insertion of foreleg and tympanum, tympanic fold inconspicuous, no other conspicuous tubercles or skin ridges.

Ground colour of dorsal surfaces light yellowish-grey and covered by a diffuse network of middle-brown to dark brown spots, these spots tending to be lighter on head posterior to eyes, dorsum, and dorsal surfaces of extremities, and darker on flanks, on anterior and posterior surfaces of extremities, and on dorsal surface of hand. Dorsal surface of snout especially light, whitish also are “eye-spots” in lumbar region; loreal and subocular region dark brown with some light dashes and spots; conspicuous is the contrast between the dark brown loreal region and the light dorsum of snout. Ground colour of throat, chest, and inferior thighs pale yellow, that of abdomen whitish; all ventral surfaces covered by numerous blackish dots.



**Plate V.** Holotype of *Oreophryne graminis* sp. nov. (a) dorsal view, (b) ventral view, (c) lateral view of head, (d) ventral view of left hand, (e) ventral view of left foot.

**Morphological characters of the paratypes.** For mensural variation of the paratypes see Table 5. Snout-urostyle length of 11 males, including the holotype, vary from 15.5 to 18.5 mm (mean 17.0 mm, SD 0.91); the only female measures 22.1 mm SUL. The latter has obviously ripe or nearly ripe ova in its ovaries. It differs from all males by its much larger tympana. Mean ratio TyD/ED of the males is 0.38, that of the female is 0.64. It is impossible to decide here whether the large tympanum of the female is an aberration or expression of a real sexual dimorphism. Its other body ratios are within those of the males. Dorsal surfaces of the female are uniformly grey-brown with only a few darker spots on extremities, above tympanum, and on eye lids; the dorsum of her snout is paler than the remaining dorsum. Dorsal surfaces of males vary from uniformly greyish to heavily spotted with irregular dark spots on certain regions, predominantly on flanks, head sides, and forelimbs. Dorsal surface

of snout is lighter than remaining dorsal surfaces and clearly demarcated from a darker region between eyes in all specimens. Only four specimens have light lumbar spots. Some frogs exhibit shorter or longer white stripes in the loreal region, but none has an inverted U-shaped mark there. Ground colour of ventral surfaces off-white. Throat in all specimens covered with fine dark brown dots and is lighter than other ventral surfaces. Venter and extremities may be finely dotted (similar to on throat) or covered by a more or less dense network of brownish spots.

Based on photographs of two specimens (SAMA R66124; and ZMB 76754, Fig. 17) in life, grey dorsally and laterally with uneven coppery tinge, or more rusty brown; indistinct brown bar between the eyes with well-defined anterior edge but poorly defined posteriorly and grading into mottled darker brown patches. Other brown pigmentation variable but may be concentrated in a poorly defined canthal stripe

**Table 5.** Body measurements and body ratios of the type series of *Oreophryne graminis* sp. nov. SAMA R66123 is the holotype, ZMB 76754 is now an osteological preparation, ZMB 76755 is a female, and all others are males.

Inv. No	SAMA R66121	SAMA R66122	ZMB 76753	SAMA R66123	SAMA R66124	ZMB 76754	SAMA R66125	ZMB 76755	ZMB 76756	UPNG 10068	UPNG 10069	UPNG 10070	Mean ± SD
SUL	16.5	17.2	17.4	18.3	16.8	15.7	17.3	22.1	18.5	17.4	16.3	15.8	
TL	6.0	6.1	6.2	6.4	6.1	5.9	5.9	7.8	6.4	6.1	6.4	5.9	
TaL	4.7	4.7	4.6	4.5	4.6	4.2	4.2	5.9	5.1	4.5	4.5	4.4	
T4L	7.1	7.2	6.7	7.3	7.2	6.8	7.0	9.1	7.2	7.3	7.2	7.0	
T4D	0.75	1.0	1.0	0.95	0.9	0.65	0.85	1.2	1.0	0.7	0.8	0.75	
T1D	0.6	0.5	0.5	0.5	0.45	0.45	0.5	0.65	0.5	0.4	0.6	0.4	
F3L	4.1	4.1	4.1	4.8	4.5	4.2	4.5	6.0	4.8	4.4	4.5	4.1	
F3D	0.9	1.0	1.0	1.0	0.8	0.75	0.8	1.3	1.0	0.75	0.8	0.75	
F1D	0.5	0.6	0.45	0.65	0.5	0.5	0.55	0.75	0.45	0.4	0.6	0.5	
HL	5.5	5.5	5.7	5.3	5.0	5.1	5.1	6.1	5.8	5.5	5.4	5.0	
HW	6.8	6.7	6.7	6.9	6.5	6.0	6.4	8.0	6.4	7.0	6.5	6.1	
END	1.2	1.4	1.3	1.5	1.25	1.2	1.3	1.6	1.2	1.5	1.35	1.1	
IND	1.6	1.8	1.9	1.8	1.6	1.55	1.6	2.2	1.8	1.7	1.8	1.5	
SL	2.2	2.1	2.4	2.2	2.2	2.3	2.1	2.3	2.5	2.4	2.1	1.9	
EST	2.1	2.0	2.3	2.1	2.0	2.2	1.9	2.4	2.1	2.1	2.0	1.9	
ED	2.0	2.0	2.2	2.2	1.9	1.9	2.0	2.5	2.3	2.1	2.0	2.0	
TyD	0.8	0.8	0.9	0.9	0.7	0.75	0.7	1.6	0.9	0.8	0.8	0.75	
TL/SUL	0.36	0.35	0.36	0.35	0.36	0.38	0.34	0.35	0.35	0.35	0.39	0.37	0.36 ± 0.014
TaL/SUL	0.28	0.27	0.26	0.25	0.27	0.27	0.24	0.27	0.28	0.26	0.28	0.28	0.27 ± 0.013
T4L/SUL	0.43	0.42	0.39	0.40	0.43	0.43	0.40	0.41	0.39	0.42	0.44	0.44	0.42 ± 0.018
T4D/SUL	0.045	0.058	0.057	0.052	0.054	0.041	0.049	0.054	0.054	0.040	0.049	0.047	0.050 ± 0.006
T4D/F3D	0.83	1.0	1.0	0.95	1.13	0.87	1.06	0.92	1.0	0.93	1.0	1.0	0.97 ± 0.081
F3L/SUL	0.25	0.24	0.24	0.26	0.27	0.27	0.26	0.27	0.26	0.25	0.28	0.26	0.26 ± 0.012
HL/SUL	0.33	0.32	0.33	0.29	0.30	0.32	0.29	0.28	0.31	0.32	0.33	0.32	0.31 ± 0.017
HW/SUL	0.41	0.39	0.39	0.38	0.39	0.38	0.37	0.36	0.35	0.40	0.40	0.39	0.38 ± 0.017
HL/HW	0.81	0.82	0.85	0.77	0.77	0.85	0.80	0.76	0.91	0.79	0.83	0.82	0.81 ± 0.043
END/IND	0.75	0.78	0.68	0.83	0.78	0.77	0.81	0.73	0.67	0.88	0.75	0.73	0.76 ± 0.060
ED/SUL	0.121	0.116	0.126	0.120	0.113	0.121	0.116	0.113	0.124	0.121	0.123	0.127	0.120 ± 0.005
TyD/ED	0.40	0.40	0.41	0.37	0.37	0.39	0.35	0.64	0.39	0.38	0.40	0.38	0.41 ± 0.075

that is narrowly interrupted behind the eye but then continues to a point above the axilla; in a broad, irregular band of mottled blotches along the upper jaw; in a broken line of patches along the mid-lateral surfaces extending to the inguinal region; in a narrower line ventrolaterally from the axilla to the inguinal re-

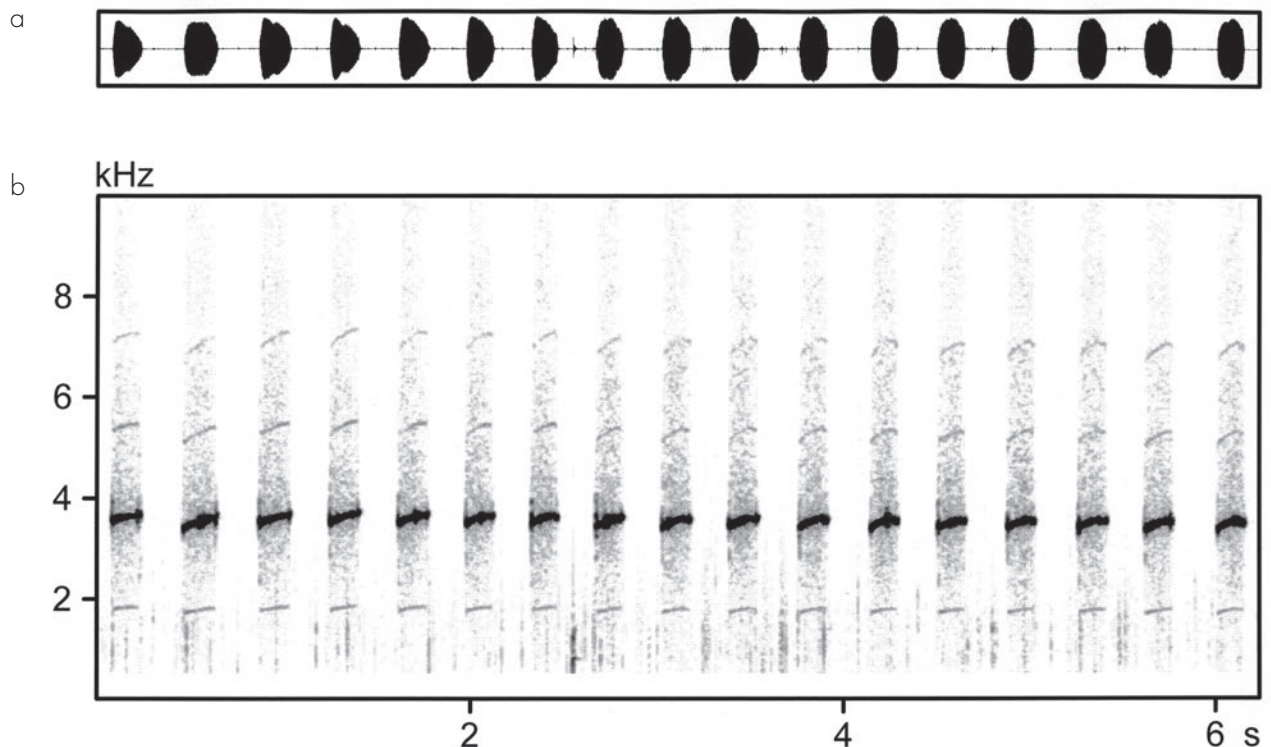
gion; and in other scattered patches on the dorsum. Ventrally translucent creamy pink on throat with pale brown stippling and splotches of opaque white, abdomen darker than throat, with scattered pale blotches. Hidden surfaces of thighs translucent with brown stippling and rusty blotches.



**Fig. 17.** Adult male paratype of *Oreophryne graminis* sp. nov. (ZMB 76754) in life.



**Fig. 18.** Alpine grassland with *Cyathea* tree ferns at Waile Creek (3,100 m asl), type locality of *Oreophryne graminis* sp. nov.

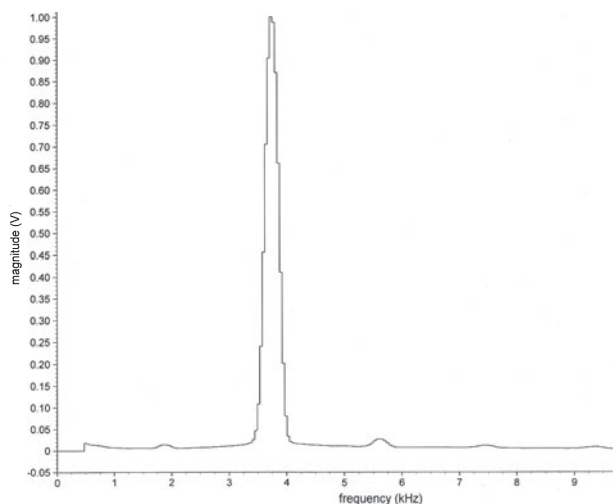


**Fig. 19.** Wave form (a) and audiospectrogram (b) of seventeen notes of an advertisement call of *Oreophryne graminis* sp. nov.

**Distribution and ecological notes.** This species was found only in the montane grasslands that dominate much of the highest altitudes of the Kaijende Highlands (Fig. 18). Males called at night, particularly after rain, from perches up to 30 cm high in *Deschampsia* grass clumps. The species' local distribution appears to be patchy because this species was not seen or heard around the nearby Omyaka Camp.

**Vocalisation.** Advertisement calls are series of peeps (Figs. 19a and 19b). Four calls by SAMA R66121

and eight calls by SAMA R66125 were analysed. Air temperature during recording was 11°C. Because characteristics of the calls of both males are similar, they are treated together. Call length varies from 7.2 s to 10.4 s, mean  $9.0 \pm 0.95$  s. Note repetition rate varies from 2.4 to 2.7 notes per s, mean  $2.54 \pm 0.12$  notes per s. Sound volume of the notes rises rapidly at the beginning of the notes, volume can remain stable in the course of the notes or may more or less vary, and it drops at the end of the note more or less quickly. Mean of means of note length varies from 148 ms to



**Fig. 20.** Power spectrum of one advertisement call note of *Oreophryne graminis* sp. nov. (SAMA R66125).

168 ms, mean  $156 \pm 6.24$  ms and mean of means of inter-note interval length varies from 231 ms to 271 ms, mean  $251 \pm 16.2$  ms. Absolutely shortest notes are about 50 ms in the case of starting notes and 135 ms in the course of a series, and the absolutely longest note is 185 ms. Absolutely shortest inter-note interval is 197 ms and absolutely longest interval, which was mostly the last interval in a call, is 542 ms. Fundamental frequency is at 1.9 kHz and the dominant frequency is at 3.8 kHz (Fig. 20). There are five upper harmonic bands (including dominant band), the highest and still well pronounced is at 11.4 kHz. All notes exhibit a weak increase of frequency.

**Comparison with other species.** There is no other *Oreophryne* species that matches a combination of the features given under the paragraph “Diagnosis”.

**Etymology.** Gramen is a Latin substantive of neuter gender and means grass. Graminis is the genitive of gramen and means “of the grass”, and refers to the preferred habitation of the new species.

### Remarks on *Albericus alpestris*

*Albericus alpestris* was recently described on the basis of four specimens that were collected in January 1973 and stored since that time in the collection of the Bishop Museum in Honolulu (KRAUS, 2010). This species exhibits most anatomical characters of the genus *Albericus* but, unlike all other known members of the genus, it does not live as an arboreal or scan-sorial forest dweller, but occupies alpine grasslands.



**Fig. 21.** Male of *Albericus* cf. *alpestris* from near Omyaka Camp in life.

Obviously connected with this life mode are very short legs and reduced digital discs (KRAUS 2010).

The junior author collected 12 specimens of an *Albericus* species at Omyaka Camp in alpine grassland at 3,200 m asl on the Kaijende Highlands (Fig. 11) of Enga Province, Papua New Guinea ( $05^{\circ}31.533'S$ ,  $143^{\circ}03.266'E$ ; 3,200 m asl) in August 2005. Their morphology and ecology suggest a close relationship with *A. alpestris*, and in the absence of information about advertisement calls and colour in life of *A. alpestris*, we have taken a conservative approach and tentatively assign the Kaijende material to that species as *Albericus* cf. *alpestris*. However, we recognise that future collections of *A. alpestris* from the type locality with associated call data and information about colours in life may reveal species-level differences. Because knowledge of *A. alpestris* is very scanty, we here provide some information on colour, morphology (Table 6), and the advertisement call of the Kaijende population of this species. Based on photographs of several specimens in life, *A. cf. alpestris* from the Kaijende Highlands is a striking orange and yellow-mottled frog with extensive patches of dark brown pigmentation that, although highly variable in extent, is often focused in a broad band posterior to the orbits, and in large but broken patches elsewhere on the dorsum, lateral surfaces and limbs (Figs. 21, 22, 23). Some specimens have a narrow, orange-yellow mid-dorsal stripe, and creamy-grey patches laterally and on the limbs. The iris is dark golden brown. Ventral surfaces are predominantly orange with scattered pale flecks, except for the under-side of the limbs and a bar across the throat which are translucent with dark stippling (on throat) and dark brown on the posterior of the thighs. There are small patches of red-brown on exposed surfaces of the hind limbs, and pale creamy-





Fig. 22. Dorsal view of six specimens of *Albericus* cf. *alpestris* from near Omyaka Camp.



Fig. 23. Ventral view of the specimens in Fig. 22.

yellow tubercles anterior to and above the arm insertion. Comparisons of the measurements of two paratypes (BPBM 5626, adult male, and BPBM 5627,

adult female) of *A. alpestris*, taken by us, with 11 adult males (all with vocal slits) and one adult female in our series yielded only few differences: T4D/F3D in *A. al-*



Fig. 24. Two paratypes (BPBM 5626–5627) of *Albericus alpestris* in dorsal view.

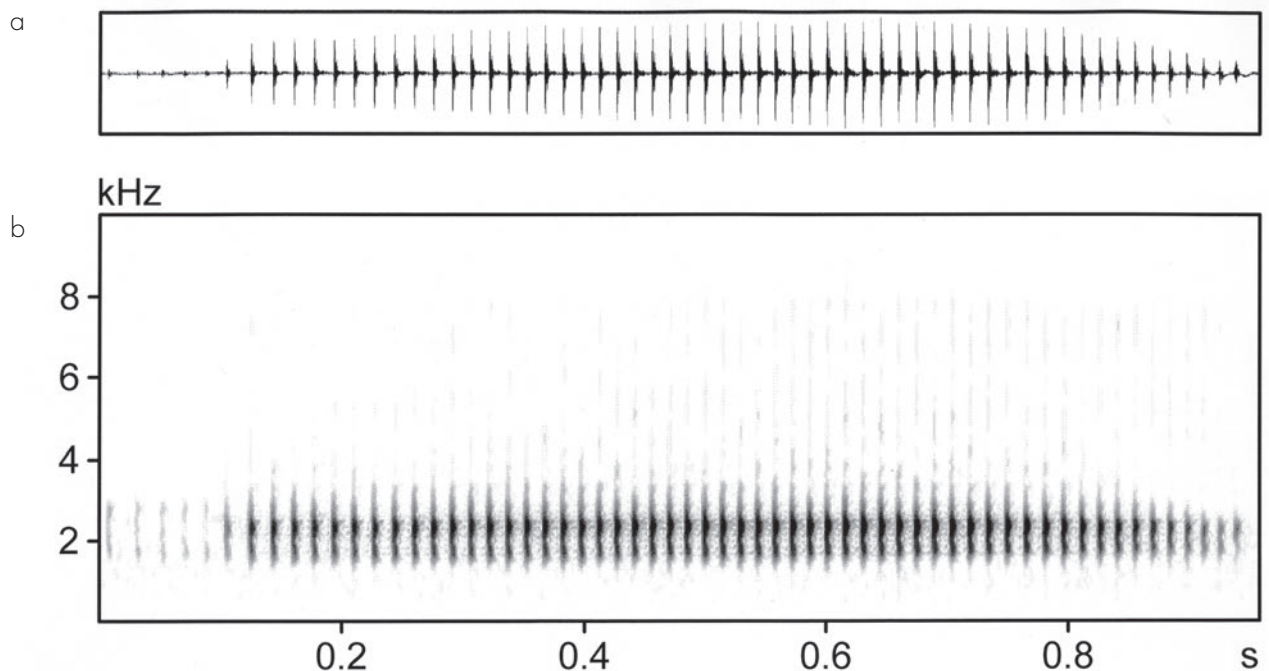


Fig. 25. Ventral view of the specimens in Fig. 24.

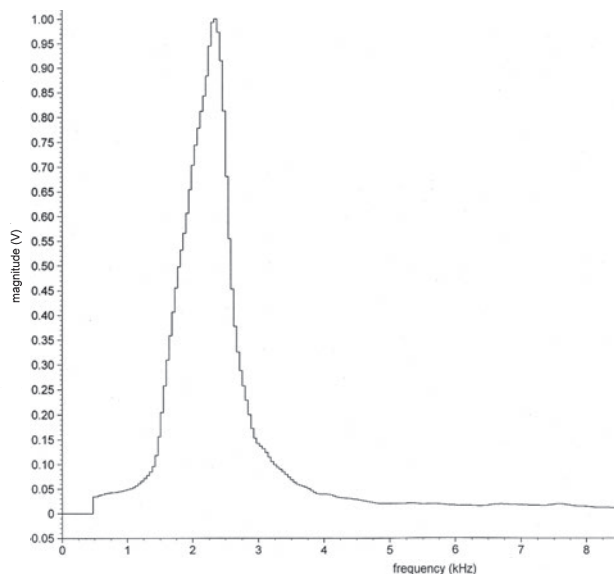
*pestris* 0.75–0.83, in *A. cf. alpestris* 0.86–1.00; and ED/SUL in *A. alpestris* 0.082–1.02, in *A. cf. alpestris* 0.095–0.120. However, there are clear differences in pigmentation: *A. cf. alpestris* from the Kaijende Highlands exhibit many more blackish spots and even blackish areas (in preservative) on all dorsal, lateral,

and ventral surfaces than the two paratypes of *A. alpestris* examined by us (Figs. 24 and 25).

*A. cf. alpestris* in the Kaijende Highlands was found only in mossy ‘fern-land’ above 3,000 m asl (Fig. 11) where males called from holes in the moss at the base of grass tussocks, or from slightly elevat-



**Fig. 26.** Wave form (a) and audiospectrogram (b) of an advertisement call (type-1) of *Albericus* cf. *alpestris* from near Omyaka Camp.



**Fig. 27.** Power spectrum of an advertisement call (type-1) of *Albericus* cf. *alpestris* from near Omyaka Camp.

of advertisement calls that differ in length and pulse repetition rate. Five type 1-calls (Figs. 26a and 26b) last 814–991 ms (mean 923 ms) and have a pulse repetition rate of 65–69 (mean 67) pulses per s; three type 2-calls last 530–537 ms and have a pulse repetition rate of 92–94 pulses per s. Dominant frequencies in both call types are at 2.2 kHz (Fig 27). *Albericus laurini* (and probably additional *Albericus* species) also utter two types of calls (GÜNTHER, 2000).

Although obvious differences in some mensural characters and in colouration between *A. alpestris* from the type locality and *A. cf. alpestris* from the Kajiende Highlands were observed, it seems premature on the data currently available to designate the specimens from the Kajiende Highlands as a separate species.

ed positions on mossy tree fern (*Cyathea*) stumps. Calling activity occurred predominantly during a short period beginning at about 5.30 pm and then ceased, or reduced to a very low level, soon after nightfall; sporadic calls were heard throughout the night. However the calling period of this species was longer than that of the sympatric *Cophixalus tenuidactylus*. The calling period of that species had ceased by around 7.30 pm. Temperatures during this time were generally 10–13 °C. There are two types

**Table 6.** Body measurements and body ratios of *Albericus cf. alpestris* from Omyaka Camp, Kajende Highlands, Enga Province, Papua New Guinea. ZMB 76759 (FN SJR 9557) is now an osteological preparation, SAMA R66108 (FN SJR 9542) is an adult female, and all others are adult males.

Inv.No	SAMA R66107	UPNG 10063	ZMB 76757	ZMB 76758	SAMA R66108	SAMA R66110	SAMA R66112	SAMA R66113	ZMB 76759	SAMA R66115	UPNG 10064	SAMA R66116	Mean ± SD
SUL	19.2	21.4	19.4	22.6	27.3	20.5	21.3	22.2	21.6	19.0	20.5	21.5	
TL	6.0	6.2	5.8	6.5	7.6	5.9	6.1	6.5	6.1	5.5	6.1	5.5	
TaL	4.5	4.4	4.0	4.7	5.8	4.6	4.6	4.8	4.6	4.1	5.1	4.5	
T4L	6.7	6.9	6.3	7.1	9.1	6.5	6.2	7.6	6.8	6.3	6.8	6.4	
T4D	0.7	0.7	0.6	0.8	1.0	0.6	0.75	0.8	0.75	0.75	0.75	0.75	
T1D	0.5	0.55	0.45	0.65	0.75	0.5	0.6	0.6	0.55	0.5	0.55	0.7	
F3L	5.0	4.9	5.0	5.5	6.8	5.0	5.1	5.6	5.1	4.6	4.8	4.8	
F3D	0.7	0.8	0.7	0.9	1.0	0.7	0.85	0.85	0.85	0.85	0.9	0.85	
F1D	0.5	0.55	0.5	0.65	0.85	0.55	0.7	0.65	0.50	0.55	0.45	0.6	
HL	6.0	6.1	5.7	6.8	7.5	6.2	6.2	6.5	6.1	5.6	6.0	5.8	
HW	8.0	8.5	8.8	9.1	11.2	8.3	8.5	8.9	8.6	8.1	8.2	8.9	
END	1.6	1.75	1.6	1.5	2.0	1.8	1.8	1.8	1.6	1.4	1.7	1.45	
IND	1.6	1.7	1.6	1.8	2.0	1.65	1.45	1.6	1.65	1.5	1.55	1.5	
SL	2.4	2.6	2.7	2.8	3.1	2.6	2.8	3.0	2.8	2.6	2.7	2.7	
EST	2.1	2.2	2.1	2.3	2.5	2.2	2.2	2.4	2.1	2.0	2.4	2.0	
ED	2.3	2.3	2.2	2.4	2.6	2.2	2.2	2.1	2.2	2.0	2.1	2.3	
TyD	1.0	1.1	0.8	1.0	1.2	0.8	1.1	0.9	1.1	1.0	0.9	1.0	
TL/SUL	0.31	0.29	0.30	0.29	0.28	0.29	0.29	0.29	0.28	0.29	0.30	0.26	0.29±0.012
TaL/SUL	0.23	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.21	0.22	0.25	0.21	0.22±0.012
T4L/SUL	0.35	0.32	0.32	0.31	0.33	0.32	0.29	0.34	0.31	0.33	0.33	0.30	0.32±0.017
T4D/SUL	0.036	0.033	0.031	0.035	0.037	0.029	0.035	0.036	0.035	0.039	0.037	0.035	0.035±0.003
T4D/F3D	1.0	0.88	0.86	0.89	1.0	0.86	0.88	0.94	0.88	0.88	0.83	0.88	0.90±0.053
F3L/SUL	0.26	0.23	0.26	0.24	0.25	0.24	0.24	0.25	0.24	0.24	0.23	0.22	0.24±0.012
HL/SUL	0.31	0.29	0.29	0.30	0.27	0.30	0.29	0.29	0.28	0.29	0.29	0.27	0.29±0.012
HW/SUL	0.42	0.40	0.45	0.40	0.41	0.40	0.40	0.40	0.40	0.43	0.40	0.41	0.41±0.016
HL/HW	0.75	0.72	0.65	0.75	0.67	0.75	0.73	0.73	0.71	0.69	0.73	0.65	0.71±0.037
END/IND	1.0	1.03	1.0	0.83	1.0	1.09	1.24	1.13	0.97	0.93	1.09	0.97	1.02±0.10
ED/SUL	0.120	0.107	0.113	0.106	0.095	0.107	0.103	0.095	0.102	0.105	0.102	0.107	0.105±0.007
TyD/ED	0.43	0.48	0.36	0.42	0.46	0.36	0.50	0.43	0.50	0.50	0.43	0.43	0.44±0.049

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