



A new large green species of *Litoria* (Anura: Hylidae) from western New Guinea

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Abstract

A new species of large green treefrog of the genus *Litoria* is described from the Mamberamo Basin of western New Guinea. It can be distinguished from all congeners by a suite of characteristics including moderately large size (male SVL 56–68 mm), moderate finger webbing, labial stripe absent or very indistinct, and lateral body surfaces and webbing with distinctive light purple colouration. Morphologically, the new species is most similar to *Litoria sanguinolenta* and, to a lesser extent, *L. infrafronata*. However, the advertisement call, a very long series of monotonously repeated, distinctly pulsed notes, differs from the calls of these two species.

Key words: Amphibia, Hylidae, *Litoria*, new species, New Guinea, Indonesia

Introduction

Large green treefrogs of the genus *Litoria* Tschudi are a distinctive component of the New Guinean herpetofauna but their taxonomy is poorly resolved due to the paucity of material available for study (Richards & Oliver 2006). For example, the large canopy-dwelling frog *L. graminea* (Boulenger) was included in the *L. aruensis* species-group by Tyler & Davies (1978), was associated with the *L. chloris* species-group by Menzies & Tyler (2004), but was treated as a species distinct from any recognised ‘complex’ by Menzies (2006). Finally, *L. graminea* as treated by all recent authors was shown to be an assemblage of at least four species without obvious affinities to other New Guinean species of *Litoria* (Richards *et al.* 2006, Richards & Oliver 2006).

Three other species of large (i.e. SVL > 50 mm) green *Litoria* are known from New Guinea. *Litoria caerulea* (White) is a robust species that is easily distinguished from *L. graminea* and all other large green *Litoria* by its short legs and distinct glandular supra-tympanic fold (Menzies 2006). The two remaining species, *L. infrafronata* (Guenther) and the poorly-known *L. sanguinolenta* (van Kampen), differ from it and from the *L. graminea* group of species (Richards & Oliver 2006) in their more slender build and reduced finger webbing. During a biodiversity survey in the southern Mamberamo Basin of Papua Province, Indonesia (Richards & Suryadi 2002), three of the authors (SR, BT and DI) found a large green undescribed species of *Litoria* that shares with *L. infrafronata* and *L. sanguinolenta* a combination of slender build and moderately-webbed fingers. However it differs from both of these species in a number of key characters including its unique advertisement call, and is herein described as a new species.

Materials and methods

Measurements (to the nearest 0.1 mm) were taken with dial calipers and a stereomicroscope fitted with an ocular micrometer, and follow Richards *et al.* (2006). They are: SVL (snout-vent length), TL (tibia length), HW (head width at tympanum), HL (head length from tip of snout to posterior edge of tympanum), EYE (horizontal eye diameter), TYM (horizontal tympanum diameter), IN (inter-narial distance), EN (distance between anterior edge of eye and posterior edge of naris), 3FD (horizontal diameter of 3rd finger disc) & 3FP (narrowest horizontal width of penultimate phalanx), 4TD (horizontal diameter of 4th toe disc) and 4TP (penultimate phalanx, as for 3rd finger). Comparative material from the following institutions was examined: British Museum of Natural History, London (BMNH); Museum Zoologicum Bogoriense, Cibinong (MZB); Naturalis - Rijksmuseum van Natuurlijke, Leiden (RMNH); South Australian Museum, Adelaide (SAMA); Queensland Museum, Brisbane (QM); and University of Papua New Guinea (UPNG). FN refers to original field numbers. A full list of material examined is presented in Appendix 1. Additional morphological data were obtained from Tyler (1968) and Tyler & Davies (1978).

Advertisement calls were recorded with a Sony TCM-5000 tape recorder and Sennheiser ME66 microphone, and analyzed on a personal computer using the AVISOFT SAS-Lab Pro sound analysis program (version 4.38). Dry-bulb air temperature adjacent to each calling frog was measured to the nearest 0.1°C with a digital thermometer. Newly reported specimens were fixed in 10% formalin for approximately 24–48 hours after collection and then they were transferred to 70% ethanol. They are deposited in the South Australian Museum (SAMA) and the Museum Zoologicum Bogoriense (MZB).

Litoria purpureolata sp. nov.

(Figs 1–5)

Litoria sp. nov. 2 nr *infrafrenata* Richards *et al.* 2002a.

Litoria sp. 2 Richards *et al.* 2002b.

Holotype. MZB Amph 12.997 (FN = JCUNQ 5783), adult male, collected at Tiri Camp (3°17'30"S, 138°34'53"E), 4.5 km SW Dabra, Mamberamo Basin, Papua Province, Indonesia, by Stephen Richards, Djoko Iskandar and Burhan Tjaturadi on 9 September 2000.

Paratypes. MZB Amph 12.998–13.000 (FN = JCUNQ 5800, JCUNQ 5803, JCUNQ 5818 respectively), SAMA R60721–23 (FN = JCUNQ 5798, JCUNQ 5799, JCUNQ 5820 respectively), all adult males from the same locality and obtained by the same collectors of the holotype, between 9 and 12 September 2000.

Diagnosis. A large species of *Litoria* characterised by: (1) SVL of males 55.7–68.2 mm, (2) dorsum entirely green, (3) dermal ridges on legs and arms white, (4) lateral surfaces and webbing in life with extensive purple pigmentation, (5) finger webbing extending no further than second metacarpal tubercle except on outer edge of digit II, (6) white labial stripe weak and not extending beyond rictus, (7) no parotoid glands, (8) no black mottling on iris, (9) large nuptial pad extending over lateral edge of thumb, with flat anterior edge, and deep triangular 'extension' on the lower posterior edge, and (10) advertisement call consisting of monotonously repeated notes produced at a rate of 1.5–1.7 notes s⁻¹ with 32–39 pulses/note at 26.8°C.

Description of holotype. Adult male with following measurements (mm): SVL 63.2, EN 5.7, HW 21.9, EYE 6.6, TL 33.8, IN 5.1, HL 2.4, TYM 4.4, 4TD 3.7, 4TP 2.7, 3FD 3.9, 3FP 2.1. Body slender; head approximately as wide as long (HW/HL 1.023), not wider than body in dorsal view; snout truncate in both dorsal and lateral aspect; labial region very marginally flared; loreal region steeply sloping and marginally concave; canthus rostralis moderately distinct, slightly curved; nares closer to tip of snout than to eyes, oriented laterally but visible in both dorsal and anterior views.



FIGURE 1. Lateral view of head of holotype of *Litoria purpureolata* sp. nov. (MZB Amph 12.997) from the Mamberamo River Basin, Papua Province, Indonesia. Scale bar = 1 cm.

Choanae large, roughly circular, separated by a distance approximately two and a half times their width; vomerine teeth in group along the posterior ridge of two prominent elevations positioned medial to choanae. Eyes moderately small (EYE/SVL 0.10), prominent in both dorsal and lateral views, pupil horizontal. Tympanum moderately large (TYM/SVL 0.07), annulus distinct and raised. Dorsal edge of tympanum obscured by supratympanic fold that extends from posterior edge of eye to above the supra-axillary junction. Dorsally skin smooth but with numerous minute pits on body and legs; ventrally skin smooth on forelimbs and lower hindlimbs, finely granular on posterior half of abdomen, less finely granular on anterior edge of abdomen and on throat and on upper hindlimbs, very coarsely granular on lateral surfaces.

Arms robust; distinct white dermal fold extends from mid-point of finger IV, along fore-arm to elbow; fingers with relative lengths of III>IV>II>I; discs prominent with supramarginal grooves, significantly wider than penultimate phalanx (3PW/3DW 0.538); subarticular tubercles indistinct and rounded, two on digits I and II, three on digits III and IV; supernumerary tubercles low, indistinct, present on proximal phalanx of digits II–IV; prominent palmar tubercle at base of digit I. Nuptial excrescence in single cluster at base of digit I, anterior edge of excrescence straight, posterior edge with elongate triangular projection extending from lower half. Nuptial excrescence (excluding triangular extension) roughly as long as wide. All digits webbed to about second subarticular tubercle, except outer edge of digit II where the webbing extends to approximately first subarticular tubercle; very slight dermal fringes on all phalanges.

Legs moderately long (TL/SVL 0.535) with prominent white dermal fold extending along tarsus from lateral edge of toe V and across heel. Relative lengths of toes IV>V>III>II>I; discs prominent and expanded with circum-marginal grooves, wider than penultimate phalanges (PW4/DW4 0.730); subarticular tubercles prominent and rounded, two on digits I and II, three on digits III and V, and four on digit IV; supernumerary tubercles faintly visible on proximal phalanx of toes II–V; prominent ovoid inner metatarsal tubercle at base of digit I. All digits webbed; webbing extends to distal end of penultimate phalanx on inner edge of digit V and outer edges of digits III, II and I, to approximately halfway up penultimate phalanx on inner edge of digits III and II, and to base of penultimate phalanx on both sides of digit IV. Slight dermal fringes on all digits.

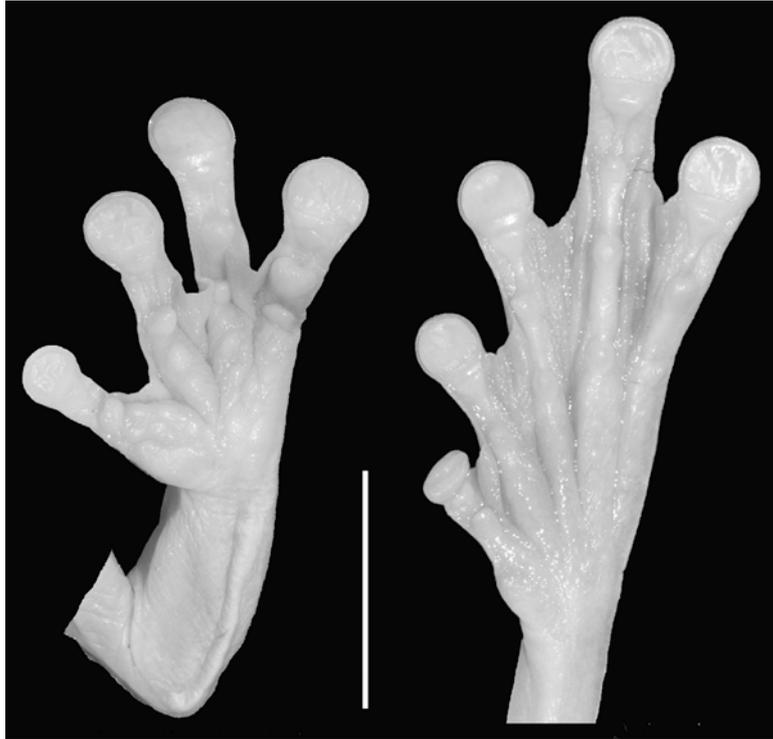


FIGURE 2. Ventral view of manus and pes of holotype of *Litoria purpureolata* **sp. nov.** holotype (MZB Amph 12.997) from the Mamberamo River Basin, Papua Province, Indonesia. Scale bar = 1 cm.

In life, dorsum entirely light green; lateral surfaces light purple with extensive cream blotching concentrated midway between the limbs; indistinct orange-brown stripe extends posteriorly from the rictal region to midway between the limbs; ventral surface of throat yellowish-cream. Brownish horseshoe shaped marking present on the tympanum; indistinct white labial stripe on the lower lip. White ring around the eye, iris orange-brown with faint grey speckling, sclera black. Dorsal surfaces of arms and legs light green; all of upper arm, and lateral surfaces of lower arm and legs purple. Prominent white dermal folds on the legs and arms, bordered ventrally by faint light brown region. Proximal dorsal surface of digits green, distal surfaces orange-brown; webbing largely purple with orange brown margins along the digits.



FIGURE 3. Adult male of *Litoria purpureolata* **sp. nov.** in life; from the Mamberamo River Basin, Papua Province, Indonesia. Photograph Stephen Richards.

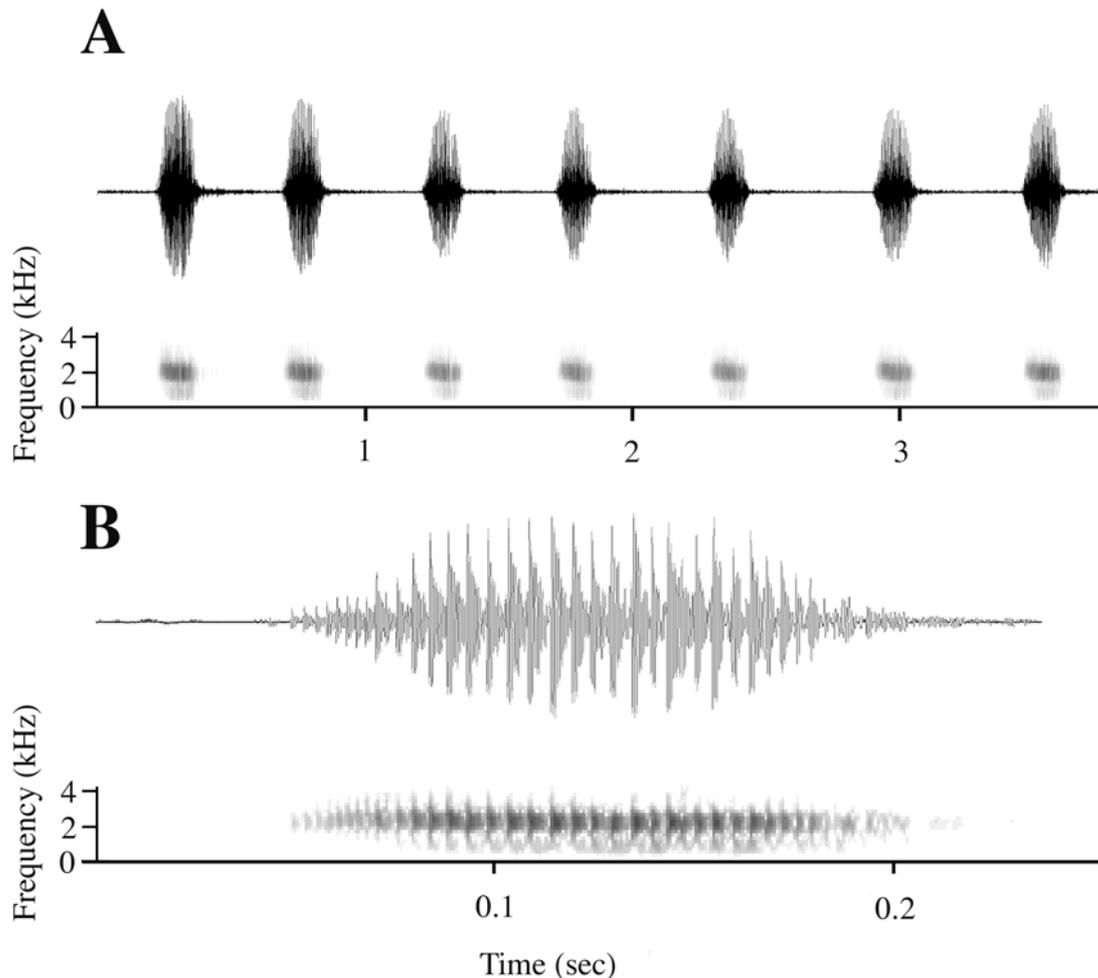


FIGURE 4. Advertisement calls of *Litoria purpureolata* sp. nov. holotype (MZB Amph 12.997) recorded at an air temperature of 26.8°C. A. Wave form (upper) and audiospectrogram (lower) of seven consecutive calls in a longer series. B. Wave form (upper) and spectrogram (lower) showing detail of pulses in a single call.

In preservative dorsal surfaces of head, body, arms and legs pale slate blue, with very small, scattered patches of darker blue. Digits and webbing off-white but tending bluish towards the proximal and posterior extremities on both the hands and feet. Ventral surfaces largely off white, with strong brownish tinge just visible on the posterior edge of the thighs and leading into strongly purplish area on the thighs; purplish tinge also apparent on webbing of hand and foot, on lateral surfaces of abdomen, and faintly over ventral surfaces of arms and legs.

Variation. In preservative dorsal colouration of all paratypes is darker than holotype, in some cases considerably so. SAMA R60723 has a few scattered very small white spots dorsally. Dark purplish colouration, of variable intensity, is visible on lateral surfaces of all specimens. Shape of nuptial pad is the same in all specimens, except the smallest specimen (MZB Amph 13.000) which possesses two distinct and relatively small (probably not fully developed) nuptial excrescences on each thumb.

Advertisement call. The advertisement call of this species is a distinctly pulsed note produced in very long series. Twenty consecutive calls of the holotype recorded at an air temperature of 26.8°C were produced at a rate of 1.76 calls s⁻¹. Duration of notes ranged from 0.11–0.17 s (mean = 0.14, SD = 0.015) and they contained 32–39 pulses (mean = 33.9, SD = 1.9) produced at a rate of 203.7–296.3 pulses s⁻¹ (mean = 246.2, SD =

24.7). The dominant frequency was 1720–1890 kHz (mean = 1814.5, SD = 50.8). Waveforms and audiospectrograms of calls are presented in Fig. 4. Calls of two additional males, SAMA R60721 (n = 36) and SAMA R60722 (n = 44) recorded at the same place and temperature were produced at a rate of 1.5 calls s⁻¹ but these calls were of insufficient quality for detailed analysis.

Distribution and ecology. *Litoria purpureolata* **sp. nov.** is known from a single locality on the Tiri River, a small tributary of the Mamberamo River in the southern Mamberamo Basin, central Papua Province, Indonesia (Fig. 5). The forest at this site has been described in detail by Richards & Suryadi (2002). Males were calling from palm leaves 4–6 metres above the water in a shallow swamp in primary lowland rainforest. Conditions during the survey were extremely dry and activity levels of frogs were generally low. Males of *L. purpureolata* **sp. nov.** called strongly despite the dry conditions and all specimens obtained had distinct nuptial excrescences. From this observation it is suggested that the breeding season of the new species may be independent of substantial rainfall.

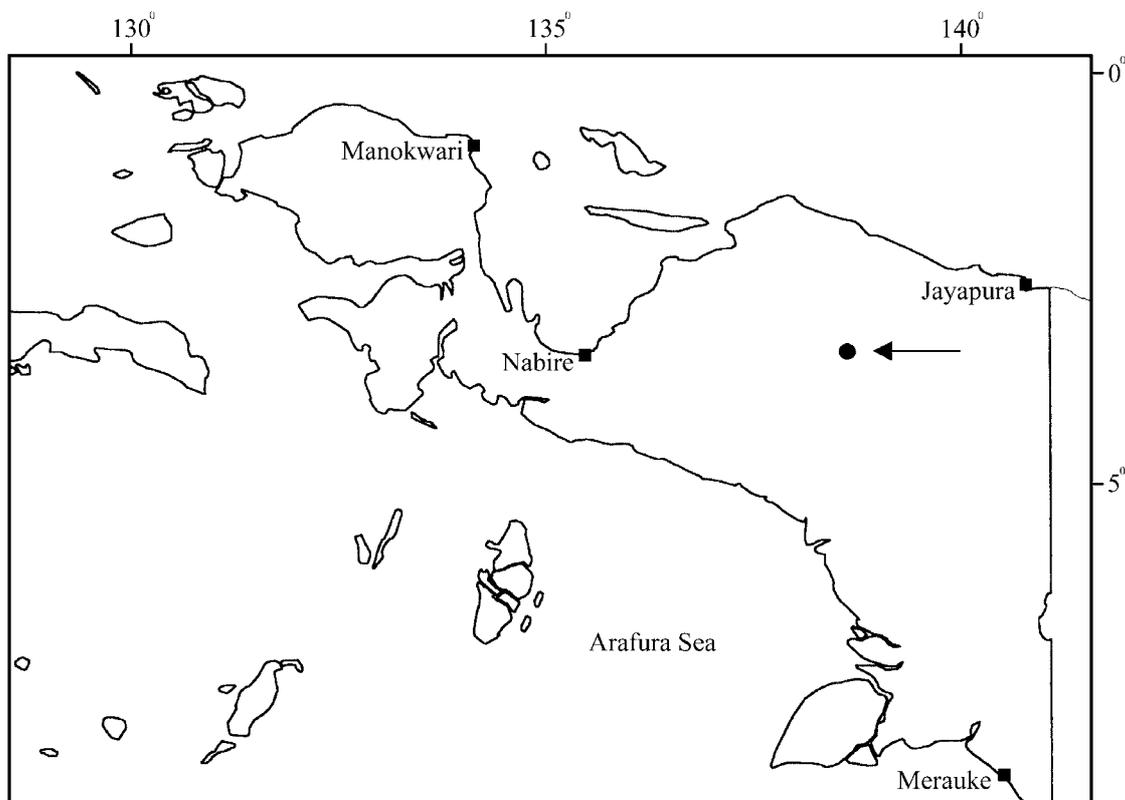


FIGURE 5. Map showing the only known locality for *Litoria purpureolata* **sp. nov.** in the Mamberamo Basin, Papua Province, Indonesia.

TABLE 1. Summary of key measurements for the type series of *Litoria purpureolata* **sp. nov.**
See ‘Materials and methods’ for explanation of abbreviations.

	MZB Amph 12.997	MZB Amph 12.998	MZB Amph 12.999	MZB Amph 13.000	SAMA R60721	SAMA R60722	SAMA R60723
SVL	63.2	63.6	61.7	55.7	60.2	67.6	68.2
EN	5.7	5.9	6.4	6.1	6.2	6.2	6.4
EYE	6.6	6.0	6.2	6.5	6.3	6.8	6.5
TL	33.8	35.4	34.2	33.2	31.6	36.3	36.8
IN	5.1	4.9	5.1	4.9	5.1	5.3	5.1
HL	21.4	21.2	21.3	19.5	19.9	22.1	22.6
EAR	4.5	5.1	4.8	4.7	4.9	4.6	5.5
HW	21.9	21.9	22.0	20.8	20.8	22.0	23.3
3FD	3.9	2.9	4.0	3.6	4.0	4.1	4.0
3FP	2.1	2.3	2.2	2.3	2.1	2.1	2.1
4TD	3.7	3.4	3.3	3.1	3.6	3.2	3.3
4TP	2.7	2.9	2.6	2.7	2.6	2.2	2.8

TABLE 2. Mean and range of key proportions for the type series (n = 7) of *Litoria purpureolata* **sp. nov.**
See ‘Materials and methods’ for explanation of abbreviations

Ratio	Mean (Range)
EN/SVL	0.10 (0.09–0.11)
HW/SVL	0.35 (0.33–0.37)
EYE/SVL	0.10 (0.09–0.12)
TL/SVL	0.55 (0.52–0.60)
IN/EN	0.83 (0.80–0.89)
HW/HL	1.03 (1.00–1.07)
EAR/SVL	0.08 (0.07–0.08)
4TP/4TD	0.79 (0.69–0.87)
4TD/SVL	0.05 (0.05–0.06)
3FP/3FD	0.58 (0.51–0.79)
3FD/SVL	0.06 (0.05–0.07)

Etymology. The species name is an adjective derived from the Latin *purpureus* (purple) and *latus* (flank) in reference to the striking purple colouration that characterises the lateral surfaces of this species in life.

Comparison with other species. The combination of large size (>55 mm SVL) and predominantly green dorsal colouration readily distinguishes *L. purpureolata* **sp. nov.** from most congeners. *Litoria caerulea*, *L. gilleni* (Spencer) and *L. splendida* Tyler can be readily distinguished from the new species by the presence of prominent glandular supra-tympanic folds, and in lacking white dermal stripes on the arms and legs. *Litoria dux* Richards and Oliver, *L. graminea*, *L. hunti* Richards, Oliver, Dahl and Tjaturadi, and *L. sauroni* Richards and Oliver, can all be distinguished by the more extensive webbing on the hands that extends distally beyond the second metacarpal tubercle on digits II and IV. *Litoria dux* can be further distinguished by its red iris and small rounded nuptial pad. *Litoria sauroni* has distinct pigment flecking over the eyelid, a red iris with black mottling and a small rounded nuptial pad. *Litoria graminea* is a more robust frog (HW/SVL 0.325–0.373 vs 0.379–0.404); and *L. hunti* is generally smaller (SVL 57.9–60.4mm), has a more distinct white labial stripe,

and a different call consisting of a long deep guttural growl uttered at much longer intervals (Richards *et al.* 2006).

Two superficially similar Australian taxa, *L. chloris* (Boulenger), and *L. xanthomera* Davies, McDonald & Adams, lack a white labial stripe and possess indistinct white dermal folds on the arms and legs. These two species also have long, drawn-out rasping calls (Davies, McDonald & Adams 1986, S. Richards pers. obs.) in contrast to the short, rapidly repeated notes of *L. purpureolata* **sp. nov.** Small individuals of the new species could be confused with members of the *Litoria gracilentata* group [as defined by Günther & Richards (2000): *L. aruensis* (Horst), *L. auae* Menzies & Tyler, *L. elkeae* Günther & Richards, *L. gracilentata* (Peters) and *L. kumae* Menzies & Tyler]; however these taxa have a distinct canthal stripe running across the eyelid, lack dermal folds and white labial or leg stripes, and have more extensively webbed hands (Tyler 1968, Günther & Richards 2000, Menzies & Tyler 2004). *Litoria multiplica* (Tyler) is also predominately green but can be immediately distinguished by having prominent white raised dermal folds around the vent, a hidden tympanum, some black ventral patterning, and smaller size (SVL of males 32.9–42.0 mm) (Tyler 1968, Richards & Oliver unpubl.).

Litoria purpureolata **sp. nov.** is morphologically most similar to *L. infrafrenata* and *L. sanguinolenta*. The former species can be differentiated by its much larger adult size (SVL up to 135 mm; Menzies 1976), bolder and far more extensive labial stripe that normally extends to at least the tympanum, and an advertisement call that is a long series of double-notes (De la Riva *et al.* 2004) unlike the uniformly pulsed call of *L. purpureolata* **sp. nov.** (Fig. 4). Richards *et al.* (2006) demonstrated that all names synonymised with *L. infrafrenata* represent that species and these synonyms are not considered further here. *Litoria sanguinolenta*, known from south of the main cordillera in Papua Province, is smaller (SVL of males < 55 mm; Tyler 1968, Richards & Tjaturadi unpubl.), is finely granular laterally (vs very coarsely granular), lacks the distinctive purple lateral colouration of *Litoria purpureolata* **sp. nov.** and has a call consisting of 6–8 pulsed notes (vs single notes with > 30 pulses) emitted in rapid succession (De la Riva *et al.* 2004).

Discussion

The description of *Litoria purpureolata* **sp. nov.** brings to four the number of large, green species of *Litoria* described from New Guinea in the past two years. Unlike *L. dux*, *L. hunti* and *L. sauroni*, *L. purpureolata* **sp. nov.** has reduced finger webbing, a feature that aligns it more with *L. infrafrenata* than with members of the *L. graminea* group (e.g. Richards & Oliver 2006, Richards *et al.* 2006), all of which exhibit extensively-webbed fingers. However the new species can be readily differentiated from *L. infrafrenata* by the absence of a white labial stripe and its significantly smaller adult size.

Based on similarity in overall morphology, notably the extent of finger webbing, we suggest that the new species is most closely related to *L. sanguinolenta*, which is known only from south of the central cordillera in western New Guinea (Tyler 1968). If, as we postulate, these two forms are sister species, then it is possible that uplift of the central mountain range (Hill & Hall 2003) has played a major role in their speciation. Genetic studies are currently under way to further examine the relationships among large green species of *Litoria* in New Guinea, and to elucidate the role (if any) of the central mountain ranges as a geographical barrier promoting speciation within the group (e.g. Richards & Oliver 2006).

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Appendix 1. Specimens examined

- Litoria auae* Menzies & Tyler, 2004. Papua New Guinea. Purari River, Gulf Province: Holotype UPNG 2490; Daru Island, Western Province: Paratypes SAMA R57262–3.
- Litoria caerulea* (White, 1790). Papua New Guinea. Balamuk, Bensbach River, Western Province: SAMA R13140; Weam, Bensbach River, Western Province: SAMA R13255A–B; Kuru, Western Province: SAMA R13256A–B, SAMA R13258A–F; Mabaduan, Western Province: SAMA R13257; Moitaka, Port Moresby, Central Province: R35358.
- Litoria chloris* (Boulenger, 1893). Australia. Warrie National Park, Springbrook, Queensland: SAMA R17612–5; Eungella National Park, Queensland: SAMA R25766.
- Litoria dux* Richards & Oliver 2006; Papua New Guinea. Yuwong Village, Morobe Province, Huon Peninsula: Holotype SAMA R60725, Paratypes SAMA R60726, UPNG 10014.
- Litoria elkeae* Günther & Richards 2000. Indonesia, Siewa, 100km N.E. Nabire, Papua Province: Paratypes QMJ 70491–2, MZB 3866, MZB 3869.
- Litoria graminea* (Boulenger, 1905); Papua New Guinea. Lakekamu, Gulf Province: SAMA R55521; ‘Northern British New Guinea’: Holotype BM 1947.2.23.31.
- Litoria hunti* Richards, Oliver, Dahl & Tjaturadi, 2006 Papua New Guinea. Utai Village, Sanduan Province: Holotype SAMA R60716, Paratypes SAMA R60714–5, UPNG 10013–14.
- Litoria infrafrenata infrafrenata* (Günther, 1867) Papua New Guinea. Lorengau, Manus Province: SAMA R5648A–D, R5801, R5999A–C; Aitape, Sanduan Province: SAMA R4164–68, R4176–93; Lega, Oro Province: SAMA R4398A–C; Lake Kutubu, Southern Highlands Province: SAMA R8766; Balimo, Western Province: SAMA R10306A–B; Kiunga, Western Province: SAMA R10307A–B; Glabi, Western Province: SAMA R11404A–B; Tengkim, Western Province: SAMA R11416; Madang: SAMA R8768–72, R8774; Epo: SAMA R4713; Tanah Merah, “upper Digoel”, Western Province SAMA R4901, R4903; Kiunga, Western Province: SAMA R10244; Emeti, Bamu River, Western Province: SAMA R13238A–B; Daru, Western Province: SAMA R10245; Maka, Lake Murray, Western Province: SAMA 10255; Mabaduan, Western Province: SAMA R13239; Balamuk, Bensbach River, Western Province: SAMA R13141; Boze, Western Province: SAMA R10246; Koaru Village, Gulf Province: SAMA R8810A–B; Uraru, Purari River, Gulf Province: SAMA 9292; Sogeri, Central Province: SAMA R9116; Moitaka Plantation, National Capital District: SAMA R9109; Waigani Swamps, National Capital District: SAMA R9121A–B; Dinawa, Owen Stanley Range: BM-1947.2.23.145, (Holotype of *Litoria spengeli*). Indonesia. Ajameroe, Vogelkop Peninsula, Papua Province: SAMA R5487.
- Litoria kumae* Menzies & Tyler 2004. Papua New Guinea. Tari, Southern Highlands Province: Holotype UPNG 3108 Paratypes SAMA R52760–61.
- Litoria multiplura* (Tyler, 1964). Papua New Guinea. Kassam Krakte Mountains, Eastern Highlands Province: SAMA R4946 Paratype; Amulua, Jimi Valley, SAMA R8923; Hindenburg Ranges: SAMA R11150; Bomai, Chimbu Province: SAMA R6303, R11833; Ialibu, Southern Highlands Province: SAMA R11834; Oferkaman: SAMA R5277, R11835; Dege, Western Highlands Province: SAMA R6169, R11832; Telefomin, Western Highlands Province: SAMA R11836–7 R11838–9; Magidobo, Southern Highlands Province: SAMA R34360.
- Litoria sanguinolenta* (Van Kampen, 1909) Indonesia. Lorentz River, Papua Province: SAMA R6318.
- Litoria sauroni* Richards & Oliver, 2006; Papua New Guinea. Dark end Lumber, Gulf Province: Paratypes SAMA R57868, SAMA R61588, UPNG 10015; Darai Plateau, Southern Highlands Province: Holotype SAMA R60727.
- Litoria xanthomera* Davies, McDonald & Adams 1986. Australia. Near Wallaman Falls, Lannercost State Forest, Queensland: Paratypes SAMA R25736–40.