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A new large green treefrog (*Litoria*: Pelodryadidae) from western New Guinea, with the description of a new diagnostic character for the *Litoria graminea* group

Rainer **Günther**[1*], Stephen J. **Richards**[2], Amir **Hamidy**[3], Wahyu **Trilaksono**[3], Taufan N. **Sulaeman**[4] & Paul M. **Oliver**[5*]

Abstract. The *Litoria graminea* group currently consists of seven nominal species of large, predominately green canopy-associated treefrogs from New Guinea and surrounding islands. Here, we first describe a character that appears to diagnose this species group from the similarly large and green *Litoria infrafrenata* group, specifically nuptial pads comprised of relatively large asperities versus more numerous and tiny asperities. We then describe a new species of this group from the Wondiwoi Mountains at the base of the Wandammen Peninsula in Indonesian New Guinea. The new species differs from other members of the *Litoria graminea* group in aspects of body proportions, extent of hand webbing, colouration, and size and shape of the male nuptial pad. Discovery of this new species emphasises the until-recently overlooked pattern of multiple co-occurring species of large, green and highly arboreal *Litoria* in lowland and foothill rainforest areas across much of New Guinea. Over 40 species of frogs were documented in the vicinity of the type locality, emphasising the high species richness of forests on the Wandammen Peninsula.

Key words. frog alpha diversity, *Litoria infrafrenata* group, Indonesia, nuptial pads

INTRODUCTION

The islands of Melanesia have the world's most diverse insular frog biota, with recent work suggesting that over 700 species may occur in the region spanning from the Moluccas to the Solomon Islands (Oliver et al., 2022). The predominantly arboreal treefrogs of the family Pelodryadidae are the second-most diverse family of frogs in this region (after Microhylidae) with over 130 recognised species. The number of species and the array of breeding strategies documented in the Pelodryadidae is increasing rapidly as new species are described (e.g., Kraus & Allison, 2004; Günther & Richards, 2005; Günther, 2008; Menzies et al., 2008; Oliver et al., 2008, 2019a, 2023; Richards et al., 2009, 2023; Richards and Oliver, 2022), and it is estimated that about 200 species may occur in Melanesia (Oliver et al., 2022).

The canopy-dwelling treefrogs of the *Litoria graminea* group occur in lowland and foothill (<1,000 m a.s.l.) habitats across a broad area of mainland New Guinea (Oliver et al., 2019b). The seven recognised species in this group (*L. dux* Richards & Oliver, 2006, *L. huntorum* Richards, Oliver, Dahl & Tjaturadi, 2006, *L. graminea* (Boulenger, 1905), *L. nullicedens* Kraus, 2018, *L. pallidofemora* Kraus, 2018, *L. pterodactyla* Oliver, Richards & Donnellan, 2019, and *L. sauroni* Richards & Oliver, 2006) share moderate to large size (adult SVL >55 mm), extensive webbing on fingers and toes and a uniform green dorsum (Oliver et al., 2021) (Fig. 1A, B). In these aspects of morphology, in addition to their canopy-dwelling lifestyle and observations of parachuting (Kraus, 2018), these frogs are in many respects convergent on very distantly related lineages from tropical Asia (e.g., some large *Rhacophorus*) (Inger et al., 2017) and the Neotropics (e.g. some *Agalychnis* and *Ecnomiohyla*) (Savage, 2002). Because they live and call high in the trees, frogs in the *L. graminea* group are also relatively rarely collected and remain poorly known, even in areas where they are frequently heard calling. The *L. graminea* group is best known from the eastern portion of New Guinea (Papua New Guinea) (Kraus, 2018), but there are also scattered records from the

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[1]Museum für Naturkunde Berlin, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstr. 43, 10115 Berlin, Germany

[2]Herpetology Department, South Australian Museum, North Terrace, Adelaide, South Australia 5000, Australia

[3]Laboratory of Herpetology, Museum Zoologicum Bogoriense, Research Center for Biosystematics and Evolution, Research Organization of Life Sciences and Environment, National Research and Innovation Agency. Jl. Raya Jakarta-Bogor Km 46, Cibinong, Bogor 16911, West Java, Indonesia

[4]Herpetological Society of Indonesia (Penggalang Herpetologi Indonesia/PHI). Bogor, West Java, Indonesia

[5]Centre for Planetary Health and Food Security, Griffith University, 170 Kessels Rd, Nathan, Queensland 4111, Australia and Biodiversity and Geosciences Program, Queensland Museum, South Brisbane, Queensland 4101, Australia; Email: p.oliver@griffith.edu.au (*corresponding author)

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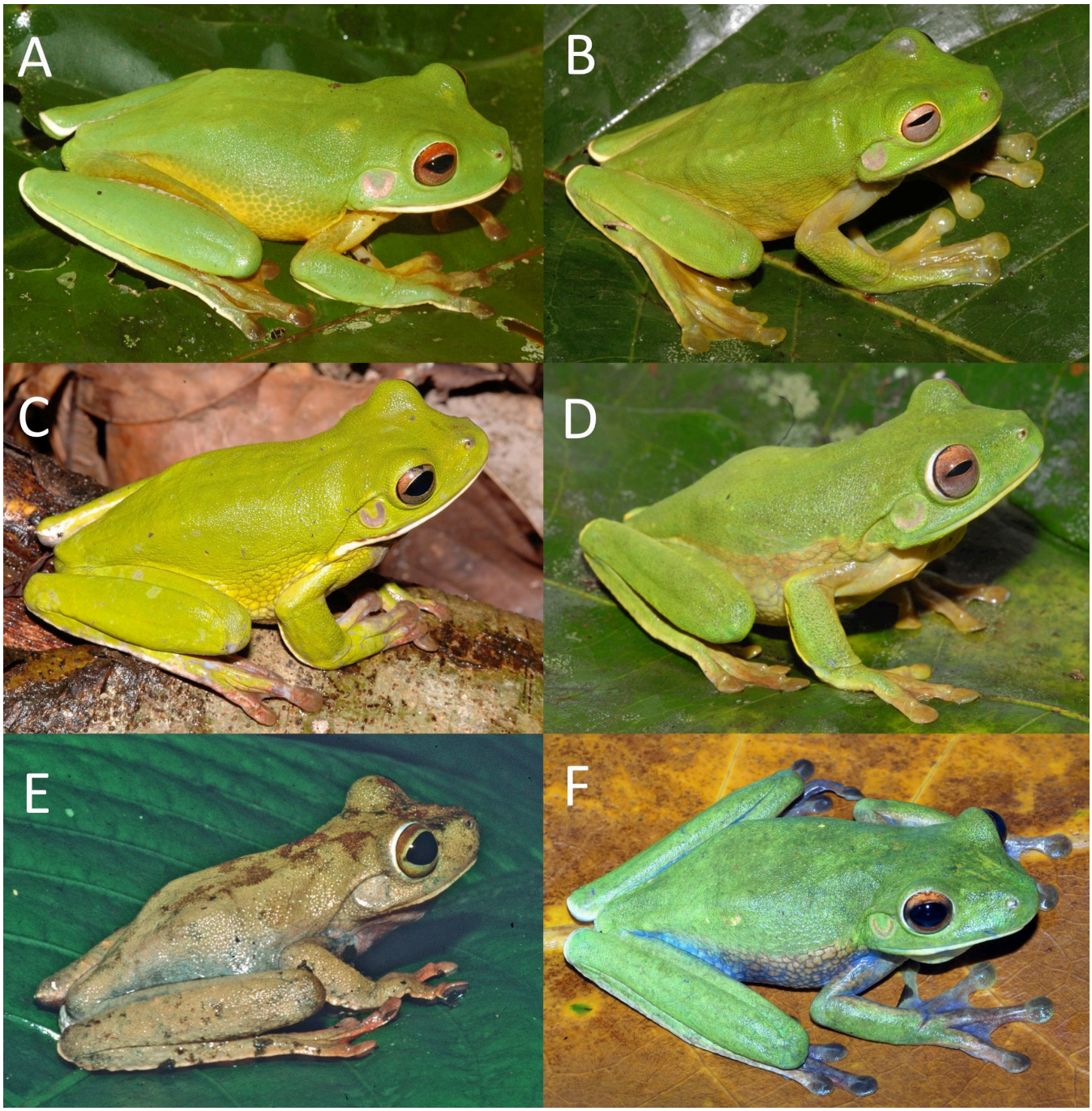

Fig 1. Selected frogs in the *Litoria graminea* (A–B) and *Litoria infrafrenata* (C–F) groups that occur in the western (Indonesian) half of New Guinea. A, *Litoria huntorum* from the foothills of the Foja Mountains, B, *L. pallidofemora* from Batanta Island, C, *Litoria infrafrenata* from Batanta Island, D, *Litoria lubisi* from Timika region, E, *Litoria multicolor* from the Wondowoi Mountains, and F, *Litoria purpureolata* from Biak Island. Note the typically less extensive webbing on the fingers and toes of species in the *Litoria infrafrenata* group. Photographs: A–D, Stephen Richards, E–F, Rainer Günther.

western (Indonesian) portion of the region (Tyler, 1968; Sulaeman et al., 2021).

Frogs in the *Litoria graminea* group are very similar in morphology to frogs in the *L. infrafrenata* group (e.g., Fig. 1C–F; *L. infrafrenata* (Günther, 1867), *L. lubisi* Oliver, Günther, Tjaturdai & Richards, 2021, *L. multicolor* Günther, 2004, *L. purpureolata* Oliver, Richards, Tjaturdai & Iskandar, 2007, *L. sanguinolenta* (Van Kampen, 1909), and *L. tenuigranulata* (Boettger, 1895)). Both species groups can be readily distinguished from all other *Litoria* by the combination of moderate to large size (adult male > 50 mm), absence of enlarged parotoid glands, having a horizontal pupil, and moderate to extensive webbing on the fingers and toes. Frogs in the *Litoria infrafrenata* group are also more frequently observed calling close to ponds and other water bodies on the ground. Currently the only morphological character to distinguish between these two species groups is the extent of finger webbing, with the *L. graminea* group having more extensive finger webbing that extends to the base of the disc on at least some fingers, while the webbing of species in the *L. infrafrenata* group does not extend to

the disc on any fingers (Oliver et al., 2021). Some molecular analyses suggest that the reciprocal monophyly of these two species groups is contentious (Sulaeman et al., 2021). Nonetheless, these phenotypic groups greatly aid diagnosis of species, and we continue to use them here.

Here we first describe a new morphological character that serves to diagnose the *L. graminea* group from the *L. infrafrenata* group (sensu Oliver et al., 2021). We then describe the eighth species in the *L. graminea* group on the basis of two specimens from the Wandammen Peninsula, Papua Barat Province, Indonesia.

MATERIAL AND METHODS

The pelodryadid species treated herein are assigned to the genus *Litoria* based on having a horizontal pupil following Kraus (2018), pending a comprehensive analysis and resolution of generic boundaries within the Pelodryadidae.

Comparative material was examined in the collections of the Museum Zoologicum Bogoriense (MZB), South Australian Museum, Adelaide (SAMA), the Natural History Museum, London (NHMUK, formerly BMNH), the University of Papua New Guinea (UPNG), and the Zoological Museum, Amsterdam (ZMA) (Appendix 1). Additional comparative data were taken from published literature (Günther, 2004; Richards et al., 2006; Richards & Oliver, 2006; Oliver et al., 2007, 2019b, 2021; Kraus, 2018). New specimens were sequentially fixed in 10% then 3% formalin, and subsequently stored in 70% ethanol. Tissues were taken and stored in ethanol.

Measurements (to the nearest 0.1 mm) were taken with dial callipers and a stereomicroscope fitted with an ocular micrometer. Morphological measurements largely follow Richards et al. (2006). They are: SVL (snout–vent length), TL (tibia length), HW (head width at tympana), HL (head length from tip of snout to posterior edge of tympanum), EYE (horizontal eye diameter), TYM (horizontal tympanum diameter), IN (inter-narial distance, distance between proximal edges of nares), EN (distance between anterior edge of eye and posterior edge of naris), 3FD (transverse diameter of 3rd finger disc) and 3FP (narrowest transverse width of penultimate phalanx), 4TD (transverse diameter of 4th toe disc) and 4TP (narrowest transverse width of penultimate phalanx).

Advertisement calls were recorded with a Sony Digital Audio Tape (DAT) Walkman TCD-D 100 and a Sennheiser microphone MKE 300 and analysed with Avisoft-SAS Lab Pro version 5.2. We calculated the audiospectrogram using a Fast-Fourier transform (FFT) of 256 points, with 87.5% overlap and frame size of 100% using FlatTop Window. The call of this species is a harsh note uttered singly or in short series separated by long periods of silence. We consider each note to represent a single call, and the multiple calls produced in series to be 'call series', following Köhler et al., (2017). Calls were recorded at an air temperature of 25°C from a distance of at least 10 m because the adults called from above that height in trees. There was also considerable environmental noise. As a result, recordings were of insufficient quality for all call parameters to be precisely measured, especially the length of calls and inter-call intervals within call series. Where this information is available it is presented as range, mean ± standard deviation. We refer five call series to the holotype because, although it was not seen calling, it was tracked down by its calls and collected in close proximity to where the call was heard.

RESULTS

A new diagnostic character for the *Litoria graminea* group

Our examination of adult males of recognised species in both the *Litoria graminea* group and *L. infrafrenata* group indicates an additional diagnostic character. In the *L. infrafrenata* group the nuptial pad asperities are finer, more numerous and much more densely arranged (Fig. 2A, B) than in the *L. graminea* group in which the pigmented asperities are distinctly larger, sometimes almost conical and more widely spaced (Fig. 2C–F). These differences are also apparent in Fig. 3 in Tyler (1968).

Based on the extent of finger webbing, the new species we describe below would be placed in the *L. infrafrenata* group as defined by Oliver et al. (2021). However, this species has relatively large asperities in the nuptial pads, suggesting affinities with the *L. graminea* group. We accordingly emphasise that with the description of the new species the main diagnostic difference between the *L. infrafrenata* and *L. graminea* groups is the differing size and density of asperities in the male nuptial pads, although the extent of finger webbing remains helpful in most taxa.

Litoria azuroscelis, new species

Azure-thighed Treefrog
Katak-pohon paha-biru
(Figs 2F, 3, 4)

Holotype. MZB Amph. 32893 (former ZMB 70521). Adult male, most likely calling when collected, Wondiwoi Mountains at the base of the Wandammen Peninsula, Papua Barat Province, Indonesia, approximately 2.9559°S, 134.6318°E, 550 m a.s.l., 23 June 2003, collected by Rainer Günther and Genus Mareku.

Paratype. ZMB 70522. Adult male, most likely calling when collected, with same locality and collector data as holotype.

Diagnosis. A treefrog that differs from other New Guinean *Litoria* in the following unique combination of characters: body large (adult male SVL to at least 66.6 mm) and robust; vomero-palatines large, prominently raised, each with ~6 small teeth; labial stripe narrow, white, not extending beyond rictus of jaw; dorsum in life predominantly or entirely dark green; enlarged parotoid glands absent; scapular region lacking deep skin creases; webbing on hands extending

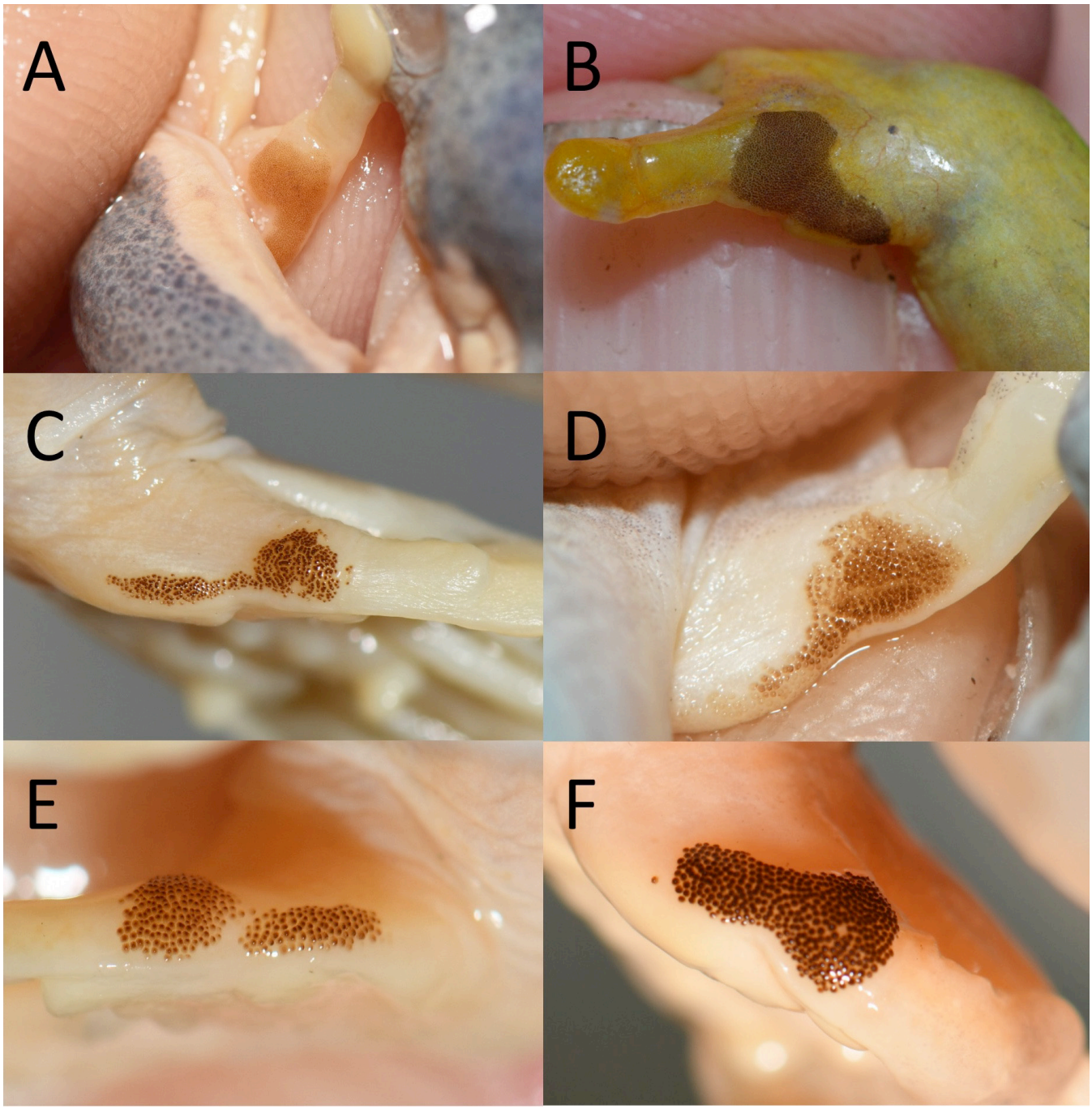

Fig. 2. Details of nuptial excrescences in frogs from the *Litoria infrafrenata* (A–B) and *Litoria graminea* groups (C–F). A, *Litoria purpureolata*, B, *Litoria lubisi*, C, *L. pallidofemora*, D, *L. pterodactyla*, E, *L. huntorum*, and F, *L. azuroscelis*, new species. Note very fine excrescences in the two species from the *Litoria infrafrenata* group (A and B).

slightly beyond distal edge of subarticular tubercles at base of penultimate phalanges on inside of Finger 4 and outside of Finger 3; webbing on feet extending to discs on all toes except Toe 4, where it reaches to midway between disc and subarticular tubercle at base of penultimate phalanx; discs very wide (3FD/SVL 0.073–0.074; 4TD/SVL 0.067–0.069); nuptial pads elongate, broader anteriorly than posteriorly, comprised of distinct almost conical asperities; hidden surfaces of limbs purplish blue in life; iris reddish brown; upper half of nictitating membrane largely clear except for dark dorsal margin; and advertisement call consisting of a harsh note (= call) produced singly or more often in series of 2–7 calls with a mean repetition rate of 2.02 calls/s.

Description of holotype. Habitus robust (Fig. 3), limbs moderately long (TL/SVL 0.55); snout broadly rounded in dorsal aspect, blunt, steeply sloping in lateral aspect. Canthus rostralis long, poorly defined, nearly straight (Fig. 4A); loreal region sloping, distinctly concave; nostrils near tip of snout, oriented laterally. Eyes moderate sized (EYE/SVL 0.110) (Fig. 4B), pigmentation on upper half of nictitating membrane restricted to narrow strip along dorsal edge. Tongue broad, covering most of mouth floor, with marginally indented posterior notch; vocal slits moderately long, lateral, extending ~4 mm anteriorly from level of angle of jaw; vocal sac single and subgular. Vomero-palatine ridges long (2 mm) prominently raised, each with six small teeth; ridges located

midway between, and abutting medial edges of, internal nares, oriented postero-medially. Tympanum moderately large (TYM/SVL 0.072), annulus distinct except postero-dorsal edge obscured by thick, curved, postocular fold that extends from posterior edge of eye to above axillary junction. Skin finely but distinctly granular dorsally; lateral surfaces with large, flat tubercles; throat and abdomen coarsely granular.

Dermal ridges along posterior edge of forearms and along shanks and ankles prominent (Fig. 3). Fingers short, terminal discs wide (3FD/SVL 0.074), with circum-marginal grooves; webbing reaches to slightly beyond distal edge of subarticular tubercles at base of penultimate phalanges on inside of Finger 4 and outside of Finger 3, to halfway between subarticular tubercles at base of penultimate and ultipenultimate phalanges on inside of Finger 3, to base of disc on outside of Finger 2, restricted to thin basal strip between Fingers 1 and 2 (Fig. 4C). Subarticular tubercles prominent, undivided. Relative lengths of fingers 3>4>2>1. Nuptial excrescences comprising dark-brown granules in an unbroken patch 3.5 and 3.7 mm long on each Finger 1, wider distally (2.0 mm) than proximally (1.1 mm) (Fig. 2F).

Toes moderately short, terminal discs wide (4TD/SVL 0.069) with circum-marginal grooves; webbing reaches discs on Toes 1–3 and 5, and to half-way between subarticular tubercle at base of penultimate tubercle and disc on Toe 4. Inner metatarsal tubercle and subarticular tubercles prominent. Relative lengths of toes 4>5>3>2>1.

In life, dorsal and upper-lateral surfaces of torso and head uniformly dark green; tympanic membrane with distinct unpigmented U-shaped region (Fig. 3A); exposed mid-lateral surfaces of torso fawn with green reticulations along skin creases; hidden surfaces of torso and inner surfaces of limbs purplish blue (Fig. 3B). Dorsal surfaces of digits and webbing fawn. Dermal ridges on posterior edges of forearm and hindlimb white. Labial stripe white, moderately distinct, extending to approximately level with posterior edge of eye. Iris reddish-brown. Skin above eye with very thin white band.

In preservative, most dorsal and upper lateral surfaces medium blue, including torso, head, outer forearms, shanks, and Toe 5 (Fig. 4D); tympanic membrane with broad U-shaped unpigmented mark; inner edge of forearm, digits and webbing buff. Lower lateral and ventral surfaces buff.

Summary meristic data. SVL 66.6; TL 36.8; HW 24.4; HL 21.7; EYE 7.0; TYM 4.8; IN 5.7; EN 6.7; 3FD 4.9; 3FP 3.4; 4TD 4.6; 4TP 3.6.

Variation. The sole paratype (ZMB70522) is an adult male with the following measurements: SVL 65.5; TL 35.1; HW 23.8; HL 21.5; EYE 7.3; TYM 4.8; IN 5.8; EN 6.6; 3FD 4.8; 3FP 3.3; 4TD 4.4; 4TP 3.7. It closely resembles the holotype in all pertinent respects, except that the vomerine teeth are in two prominent circular clumps (rather than two elongate ridges), and the tongue is narrower with a more distinct posterior notch. It is also a predominantly green frog but there are several small, irregular patches of pale cream

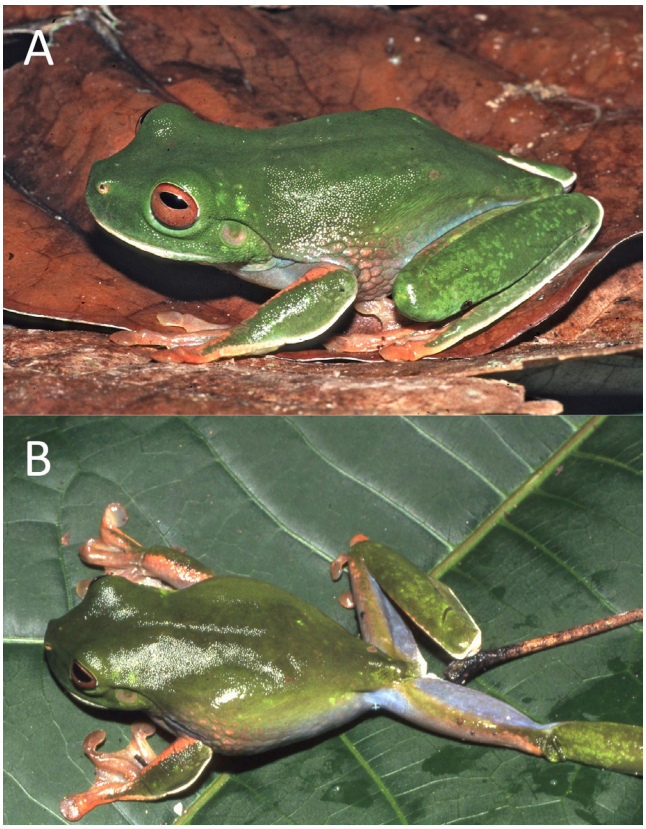

Fig 3. *Litoria azuroscelis*, new species, holotype MZB Amph. 32893 in life. A, lateral view, B, more dorsal view highlighting blue wash on groin and hidden surfaces of hindlimbs. Photographs: Rainer Günther.

(in preservative) colour on the head and anterior dorsal surfaces of the torso.

Advertisement call. The advertisement call is a loud, harsh "tonk….tonk…tonk" sound uttered from the forest canopy. Of the 51 calls recorded, two were produced singly and the remainder were produced in 16 call series each containing 2–7 calls (mean 3.19 ± 1.28). A total of 18 calls that were most likely produced by the holotype were of sufficient quality for detailed analysis. They were uttered in five short series, each containing 3–4 calls (mean = 3.6 ± 0.55) produced at a rate of 1.93–2.16 calls/s (mean = 2.02 ± 0.11 calls/s). Calls start abruptly with high sound amplitude which decreases quickly to a very low level. This low-amplitude sound component is relatively long but its terminal point is difficult to determine precisely due to loud background noise (Fig. 5). Call duration is approximately 100–150 ms and intercall intervals within a call series are around 450–550 ms. Six harmonics, all with a weak frequency modulation from higher to lower frequencies, are apparent: the basal one is the weakest with a peak at 0.45 kHz, followed by three strongly pronounced bands with peaks at 0.9 kHz, 1.35 kHz and 1.8 kHz (the latter is the dominant frequency); the last bands, with peaks at 2.25 kHz and 2.70 kHz are again weakly expressed (Fig. 5). An additional 33 calls were audible on recordings but were of insufficient quality for detailed analysis. They were uttered singly (n = 2) or in short series similar to those produced by the holotype. These series (n = 11) contained 2–7 calls (mean = 3.0 ± 1.48).

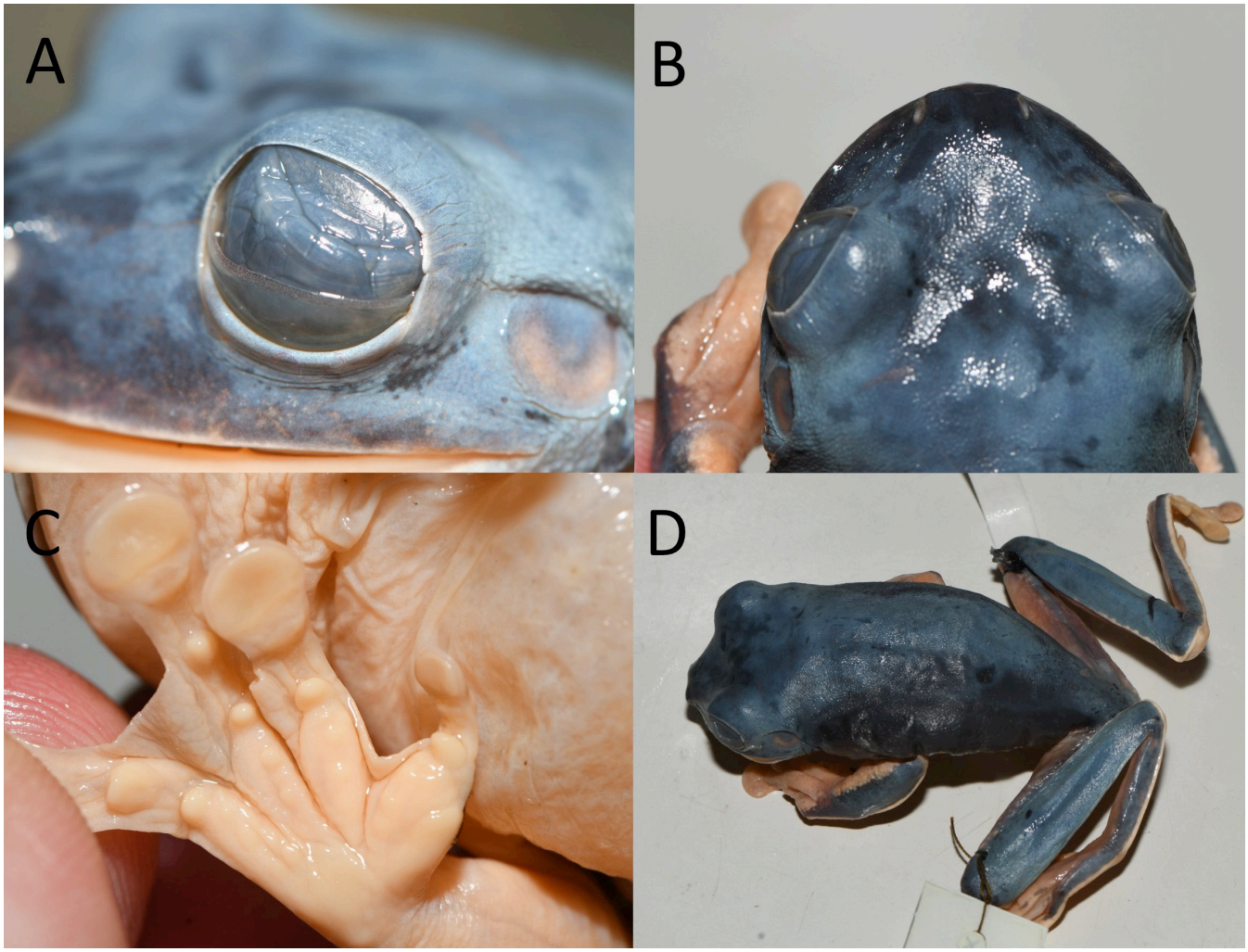

Fig. 4. Details of *Litoria azuroscelis*, new species, holotype MZB Amph. 32893 in preservative. A, Details of eye showing largely unpigmented nictitating membranes, B, dorsal view of head, C, details of hand show moderately extensive webbing, and D, whole animal showing colouration in preservative.

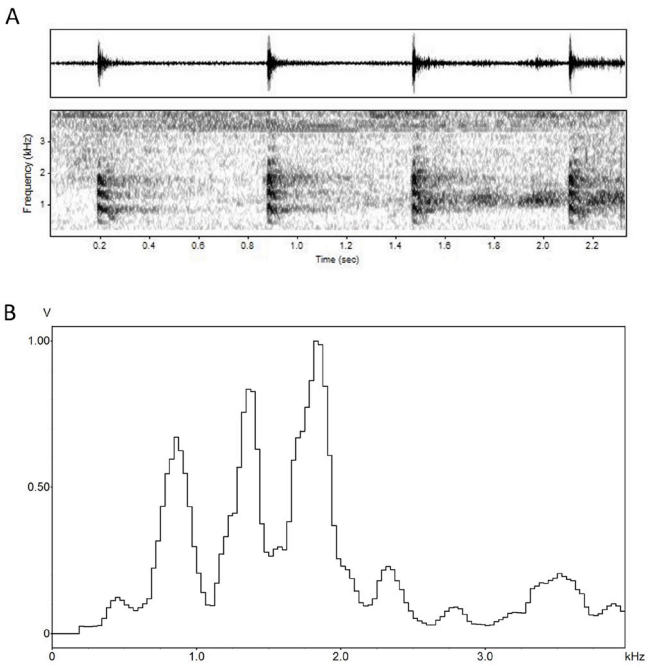

Fig. 5. A, Spectrogram of male *Litoria azuroscelis*, new species, and B, amplitude spectrum for calls in 5A. Calls recorded at 25°C.

Distribution and natural history. *Litoria azuroscelis*, new species, is only known from a single locality on the Wandammen Peninsula in the Bird's Neck region of Indonesian New Guinea (Fig. 6) The habitat where it was collected is primary hill rain forest in the Wondiwoi Mountains, near a waterfall on a mountain stream called Sungai Maja at about 550 m a.s.l (Fig. 7). The type specimens were calling from elevated positions in trees; although several additional specimens were heard in the vicinity, they were not collected. Based on repeated observations that they call from high in trees in areas where there is no obvious standing water on the ground, we speculate that this species, and other related taxa in the *L. graminea* group, breed in tree hollows. The new species is sympatric with two other large green *Litoria* species, *L. infrafrenata* (Günther) and *L. pallidofemora* Kraus. *Litoria multicolor* Günther, a similarly large arboreal *Litoria*, was collected a few kilometres from the type locality on the main ridge of the Wondiwoi Mountains at around 900 m a.s.l. (Günther, 2004).

Suggested IUCN Conservation Status. This large hill forest species is known only from a single locality, but it is probably more widespread given that large areas of similar habitat remain intact on the Wandammen Peninsula and in

Fig. 6. Map of New Guinea with the type locality of *Litoria azuroscelis*, new species, at the base of the Wandammen Peninsula indicated by a red star.

nearby areas adjacent to Cenderawasih Bay. However, at the time the specimens were collected, a logging road was being constructed at the foot of the Wondiwoi Mountains, and in the years thereafter numerous large trees in the vicinity of this road were felled (R. Günther, personal observations). If our speculation that this species breeds in tree-hollows is correct (see above), it could make these frogs particularly vulnerable to the loss of large trees. Until its distribution and potential threats are better documented, we suggest that the new species be considered Data Deficient.

Etymology. Named after the colouration on the hidden surfaces of the hindlimbs, from the combination of the Greek azur (deep blue) and scelis, latinised version of Greek skelos (leg).

Comparisons. *Litoria azuroscelis*, new species, differs from all other *Litoria* except taxa in the *L. infrafrenata* group and *L graminea* group in the following combination of characters; adult size large (> 55 mm SVL), dorsal colouration uniform green, parotoid glands not evident, and interdigital webbing extensive.

Litoria azuroscelis, new species, is similar in size and build to members of the *L. graminea* group but differs from all known species in that group by having webbing on the hands not extending beyond the penultimate tubercle on the inside of Finger 3 (versus extending beyond penultimate tubercle). *Litoria azuroscelis,* new species, further differs from *L. dux* in having nuptial pads elongate and longer than terminal disc on Finger 1 (versus rounded and half size of disc) and iris reddish brown (versus white and reddish) (Richards & Oliver, 2006); from *L. graminea* by having nuptial pads elongate, longer than disc on Finger 1 (versus rounded and half size of disc), iris reddish brown (versus "tan/pale gray

Fig. 7. Forest interior at Maja Waterfall, Papua Barat Province, Indonesia, the type locality of *Litoria azuroscelis*, new species. Photograph: Rainer Günther.

with red margin, finely stippled with black"; Kraus, 2018) and lacking deep skin creases extending to shoulder (versus usually present); from *L. huntorum* by lateral edges of venter and limbs purplish-blue (versus yellow or orange (Fig. 1A), larger size (male SVL 66 mm versus 53–60 mm; n = 5) and indistinct labial stripe ending before rictus (versus extending to below tympanum); from *L. nullicedens* by nuptial pads elongate (versus round and small), white labial stripe present (versus absent), iris predominately reddish brown (versus reticulated black and dark brown), nictitating membrane without flecking (versus present) and lateral surfaces of torso and limbs purple (versus bright orange-red; Kraus, 2018); from *L. pallidofemora* Kraus by having lateral edges of venter and limbs purplish-blue (versus yellow or orange (Fig. 1B), and iris predominately reddish-brown (versus tan or reddish with a wide black outer margin); from *L.*

Table 1. Frog species recorded during surveys at the base of the Wandammen Peninsula, Papua and Papua Barat Provinces, Indonesia. Species that have to date only been found from this area are indicated with an asterisk. The elevational range over which each species has been observed in this area is also given.

	Sea-level site (0–100 m. a.s.l.)	Maja Waterfall site (~550 m. a.s.l.)	Ridgetop sites (850–950 m. a.s.l)	Observed elevational range
Ceratobatrachidae				
Cornufer bimaculatus		×		350–900
Cornufer papuensis	×	×		0–820
Cornufer punctatus		×		450–700
Dicroglossidae				
Limnonectes grunniens	×			10
Limnodynastidae				
Platyplectrum melanopyga		×		500–900
Microhylidae				
Asterophrys turpicola		×		100–900
*Austrochaperina rudolfarndti**		×		400–650
Austrochaperina macrorhyncha		×		700–950
*Austrochaperina minutissima**			×	800–900
*Callulops wondiwoiensis**		×		450–800
Choerophryne laurini			×	750–880
*Choerophryne microps**		×		380–980
Cophixalus tridactylus		×		400–750
*Copiula major**		×		500–700
Copiula obsti		×		500–750
Hylophorbus picoides		×		350–850
Hylophorbus tetraphonus		×		380–650
*Hylophorbus wondiwoi**			×	580–980
*Metamagnusia marani**		×		550–900
Oreophryne atrigularis		×		350–750
*Oreophryne clamata**			×	750–900
Oreophryne sibilans		×		450–750
Oreophryne unicolor		×		500–950
*Pseudocallulops pullifer**		×		350–850
Sphenophryne cornuta		×		560–900
Xenorhina bouwensi		×		400–800
Xenorhina oxycephala		×		500–600
Pelodryadidae				
Litoria amboinensis		×		50–700
Litoria arfakiana		×		500–600
*Litoria azuroscelis**				550
Litoria christianbergmanni			×	550

	Sea-level site (0–100 m. a.s.l.)	Maja Waterfall site (~550 m. a.s.l.)	Ridgetop sites (850–950 m. a.s.l)	Observed elevational range
Litoria cf. *havina*		×		600
Litoria cf. *thesaurensis*	×			0–50
Litoria infrafrenata		×		0–560
*Litoria mareku**		×		200–600
*Litoria multicolor**			×	800–860
Litoria pallidofemora		×		400–700
Litoria pygmaea		×		500–600
Litoria rivicola		×		450–800
*Litoria umarensis**	×			0–50
*Litoria verae**		×		550
Ranidae				
Papurana arfaki		×		100–700
Papurana daemeli		×		0–600
Papurana volkerjane		×		250–700

pterodactyla by iris predominately reddish brown (versus light grey with light-brown vermiculations) and its more prominently expanded finger discs (3FD/SVL 0.073–0.074 versus 0.052) and toe discs (4TD/SVL 0.067–0.069 versus 0.053); and from *L. sauroni* in having iris reddish-brown (versus with red and black vermiculations), pigment flecks across lower eyelid absent (versus present) and nuptial pads elongate (versus small and round) (Richards & Oliver, 2006).

Litoria azuroscelis, new species, differs from the five species in the *L. infrafrenata* group by having nuptial pads consisting of relatively large and widely spaced conical asperities (versus numerous densely packed minute low asperities) (Fig. 2). It further differs from *L. infrafrenata* and *L. tenuigranulata* by having hidden lateral surfaces of limbs and torso purplish blue (versus plain light yellow or off white) and pale labial stripe ending before posterior edge of lower jaw (versus distinct and extending to tympanum (Fig. 1C)); from *L. lubisi* in having hidden lateral surfaces of torso and limbs purplish blue (versus largely yellow (Fig. 1D)) and a slightly narrower head (HW/SVL 0.36 versus 0.38); from *L. multicolor* in its larger size (adult male SVL 66.0 mm versus SVL of 49.1–55.4 mm, n = 14; Günther 2004), dorsal colouration uniformly green (versus green, grey, brown or yellow, and often patterned with black spots (Fig. 1E)), red spots on venter and thighs absent (versus present), webbing extending to just beyond penultimate subarticular tubercle between Fingers 3 and 4 (versus ending at subarticular tubercle on Finger 4 and before subarticular tubercle on Finger 3); from *L. purpureolata* in having discs wider (3FD/SVL 0.073–0.074 versus 0.054–0.066; n = 10); and from *L. sanguinolenta* by its larger size (male SVL 66 mm versus maximum male SVL 55 mm; n = 10) and latero-ventral regions of torso yellow with light purple reticulations (versus white).

DISCUSSION

Despite recent advances in taxonomy, the ecology and distribution of arboreal and difficult-to-find frogs in the *L. graminea* group remains poorly known. Recent fieldwork and taxonomic investigations have revealed that multiple species of large green treefrogs within both the *L. graminea* and *L. infrafrenata* groups have overlapping ranges in many areas of New Guinea, especially south of the Central Cordillera (Richards et al., 2015; Kraus, 2018, Oliver et al., 2021). With the description of *L. azuroscelis,* and the detection of *L. pallidofemora*, four species from these two groups are now known to co-occur in the Wondiwoi Mountains of the Wandammen Peninsula. No obvious differentiation in elevation or habitat use was detected between the new species and *L. pallidofemora* or *L. infrafrenata*, which were all heard calling in small numbers on tall trees at elevations below 650 m a.s.l. In contrast, *L. multicolor* was found in large numbers on shrubs and smaller trees around small water bodies on the crest of a nearby ridge at higher elevations (850–950 m. a.s.l.) (Günther, 2004). The abundance and calling sites of *L. multicolor* suggests that it may be restricted to higher elevations, and like *Litoria infrafrenata*, it may breed in ponds.

Litoria azuroscelis, new species, is currently known only from the base of the Wandammen Peninsula. At this location, in an area of approximately one square kilometre around the Maja-Waterfall, Rainer Günther and colleagues Marthinus Kapisa, Salom Marani, and Genus Mareku observed 35 species of anurans (Table 1) in 30 days of survey across multiple trips spanning 1998–2003 in the months of May, June, July and August. This diversity is noticeably higher than surveys of slightly smaller sites (0.5 km^2) in lowland areas of northern Papua New Guinea (Dahl et al., 2009), but

comparable with estimates of alpha diversity in many hill forest and montane areas of New Guinea based on IUCN range maps (Oliver et al., 2022). In the same general area, three additional species were found only at lower altitudes (< 100 m a.s.l.), while five species were only found along a ridge at higher elevations (~850–950m a.s.l.) (Table 1). In total at least 44 anuran species from five different families occur in a small area of predominantly primary rain forest at the base of the Wandammen Peninsula, 14 of which have not been documented elsewhere. An estimated five additional species were heard calling, but were not collected or identified.

The highest species diversity encountered in the Wondiwoi Mountains was at intermediate elevations around 550 m. a.s,l. (Table 1). Although survey effort was not standardised across elevations so these data do not represent a formal elevational transect, the exceptional diversity encountered in these foothill habitats is consistent with data from elsewhere in New Guinea (and elsewhere in the tropics) emphasising that hill and lower montane rainforests support rich and often highly endemic frog faunas (Brown et al., 2016; Tallowin et al., 2017; Oliver et al., 2022). The high diversity of amphibians on the Wandammen Peninsula argues for the value and ongoing protection of the Pegunungan Wondiwoi/ Wandammen Reserve.

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Appendix I. Indonesian abstract and key words.

Abstrak. Grup *Litoria graminea* merupakan kelompok katak-pohon hijau-besar yang berasosiasi dengan kanopi dari wilayah Papua, Papua New Guinea dan kepulauan sekitarnya yang saat ini terdiri dari tujuh jenis. Pada awalnya kami mendeskripsikan suatu karakter yang menjadi pembeda kelompok ini dari kelompok katak-pohon hijau-besar serupunnya, grup *Litoria infrafrenata*, khususnya pada bantalan nuptial yang sangat kasar berbanding bantalan nuptial yang kecil kecil dan tidak terlalu kasar. Selanjutnya, kami mendeskripsikan jenis tersebut sebagai satu jenis baru katak-pohon hijau-besar grup *Litoria graminea* dari Pegunungan Wondiwoi, tepatnya di Semenanjung Wandammen, Papua, Indonesia. Jenis baru ini berbeda dari jenis-jenis lain dari grup *Litoria graminea* pada karakter proporsi tubuh, lebar selaput pada tangan, warna, serta ukuran dan bentuk bantalan nuptial pada jantan. Penemuan jenis baru ini menegaskan pola yang sering diabaikan tentang kemunculan bersama jenis-jenis katak-pohon hijau-besar genus *Litoria* yang menghuni dataran rendah dan kaki-bukit daerah hutan hujan tropis sepanjang Papua dan Papua New Guinea. Dengan ditemukannya sekitar 40 jenis katak dari daerah sekitar lokasi tipe, menegaskan tingginya kekayaan jenis pada wilayah hutan di Semenanjung Wandammen.

Kata kunci. keaneragaman alfa katak, Grup *Litoria infrafrenata*, New Guinea, bantalan nuptial.

Appendix II. Specimens examined.

Litoria graminea group

Litoria dux. Papua New Guinea. Yuwong Village, Morobe Province, Huon Peninsula: Holotype SAMA R60725, Paratypes SAMA R60726, UPNG 10014.
Litoria graminea. Papua New Guinea. 'Northern British New Guinea': Holotype NHMUK 1947.2.23.31; SAMA R71328, Managalas Plateau, Oro Province.
Litoria huntorum. Papua New Guinea. Utai Village, Sandaun Province: SAMA R60716 (holotype), SAMA R60714–5, UPNG 10013–14 (paratypes). Indonesia. Marina Valen, Foja Mountains, Papua Province: FN SJR6163, 6167.
Litoria pallidofemora. Papua New Guinea. Ivimka Camp, 11 km SW Tekadu, Lakekamu basin, Gulf Province: SAMA R55521; Upper Strickland River basin, Western province, Papua New Guinea: SAMA R71201. Indonesia. Maya Waterfall, base of Wandammen Peninsula, Papua Barat Province: ZMB 62135.
Litoria pterodactyla. Papua New Guinea. Gugusu Camp, Muller Range, Western Province: SAMA R65030 (holotype).
Litoria sauroni. Papua New Guinea. Dark End Lumber, Gulf Province: SAMA R57868, SAMA R61588, UPNG 10015 (paratypes); Darai Plateau, Southern Highlands Province: SAMA R60727 (holotype).

Litoria infrafrenata group

Litoria infrafrenata. 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: NHMUK-1947.2.23.145 (holotype of *Litoria spengeli*). Indonesia. Ajamaroe, Vogelkop Peninsula, Papua Province: SAMA R5487.
Litoria lubisi. Indonesia. 10 km south of Timika town, Papua Province: MZB Amph. 13.358 (holotype).
Litoria purpureolata. Indonesia. 4.5km SW Dabra, Mamberamo Basin, Papua Province: MZB Amph.12997 (holotype), MZB Amph.12998–13000, SAMA R60721–23 (paratypes); "Wambena Camp", Cyclops Mountains, Papua Province: FN SJR 6229–6230. Papua New Guinea. Utai Village, Sandaun Province: FN SJR3727.
Litoria sanguinolenta. Indonesia. Lorentz River, Papua Province: ZMA 5674, 5676 (Lectotype), SAMA R6318; vicinity of Timika Town, Papua Province: FN SJR10063–10069. Papua New Guinea. Upper Fly River catchment, Western Province: FN SJR14804, 14813–14.
Litoria tenuigranulata. Indonesia. Ternate, Gambesi, North Moluccas Province: MZB Amph. 12696, 12706; Halmahera, Taliwang, North Moluccas Province: MZB Amph. 3381, 17262, 17263; Halmahera, East Halmahera, Maba, Soagimalaha, North Moluccas Province: MZB Amph. 12714; Halmahera, East Halmahera, Buli km 5-10, North Moluccas Province: MZB Amph. 12730, 12731; Halmahera, West Halmahera, Sahul Timur, Goal, North Moluccas Province: MZB Amph. 12740, 12741; Halmahera, North Halmahera, Ruko, North Moluccas Province: MZB Amph. 12706; Halmahera, North Halmahera, Tobelo, Ruko, North Moluccas Province: MZB Amph. 12709; Halmahera, North Halmahera, Galela Selatan, Seki, North Moluccas Province: MZB Amph. 12710; Halmahera, Central Halmahera, Weda, North Moluccas Province: MZB Amph. 12734; Halmahera, South Halmahera, Kluting Jaya SP4, North Moluccas Province: MZB Amph. 12736; Halmahera, Central Halmahera, Weda, North Moluccas Province: MZB Amph. 12734; Tidore, Oba utara, Sofifi, North Moluccas Province: MZB Amph. 12747, 12744, 12748; Halmahera, Wasile Selatan, Desa Pintatu, North Moluccas Province: MZB Amph. 12754.