

# A new species of *Micryletta* (Amphibia: Microhylidae) from southern Thailand

## DEAR EDITOR,

We report on a new species, *Micryletta dissimulans* sp. nov., from the lowland forests of southern Thailand, which is described based on molecular and morphological evidence. The new species is characterized by a combination of the following characters: small body size (20.3–22.4 mm in males, 24.4–26.7 mm in females); slender body habitus; head longer than wide; snout rounded in dorsal and lateral view; eye length equal to snout length; tibiotarsal articulation reaching to tympanum; dorsal surface slightly granulated to shagreened; supratympanic fold indistinct, ventrally edged in black with large black spot behind eye; outer metatarsal tubercle absent; dorsum reddish-brown with merging irregular-shaped brown blotches edged in beige, no black spots on dorsum; body flanks brown with large black spots edged in whitish mottling, two large black blotches in axillary and inguinal areas on each side; lateral sides of head black, with white patches on lips absent, whitish mottling on tympanum and axillary region; ventral surface pinkish to bluish-gray, translucent, laterally with dark-brown marbled pattern, medially immaculate; throat in males dark-gray with sparse white mottling laterally; iris copper-orange. The new species is divergent from all other congeners in 16S rRNA gene sequences (5.0%–7.4%). To date, *Micryletta dissimulans* sp. nov. is only known from a single locality in Saba Yoi District, Songkhla Province, Thailand, at an elevation of 120 m a.s.l., but is also expected to occur in neighboring parts of Malaysia. We suggest *Micryletta dissimulans* sp. nov. be considered as a Data Deficient (DD) species following the IUCN's Red List categories (IUCN Standards and Petitions Committee, 2019).

Paddy frogs of the genus *Micryletta* Dubois, 1987 are a little-known group of microhylid frogs found in southern China, including the Hainan and Taiwan islands in the north, through Indochina, the northeast portion of India and Myanmar to Nicobar and the Andaman Islands, and through the Malayan

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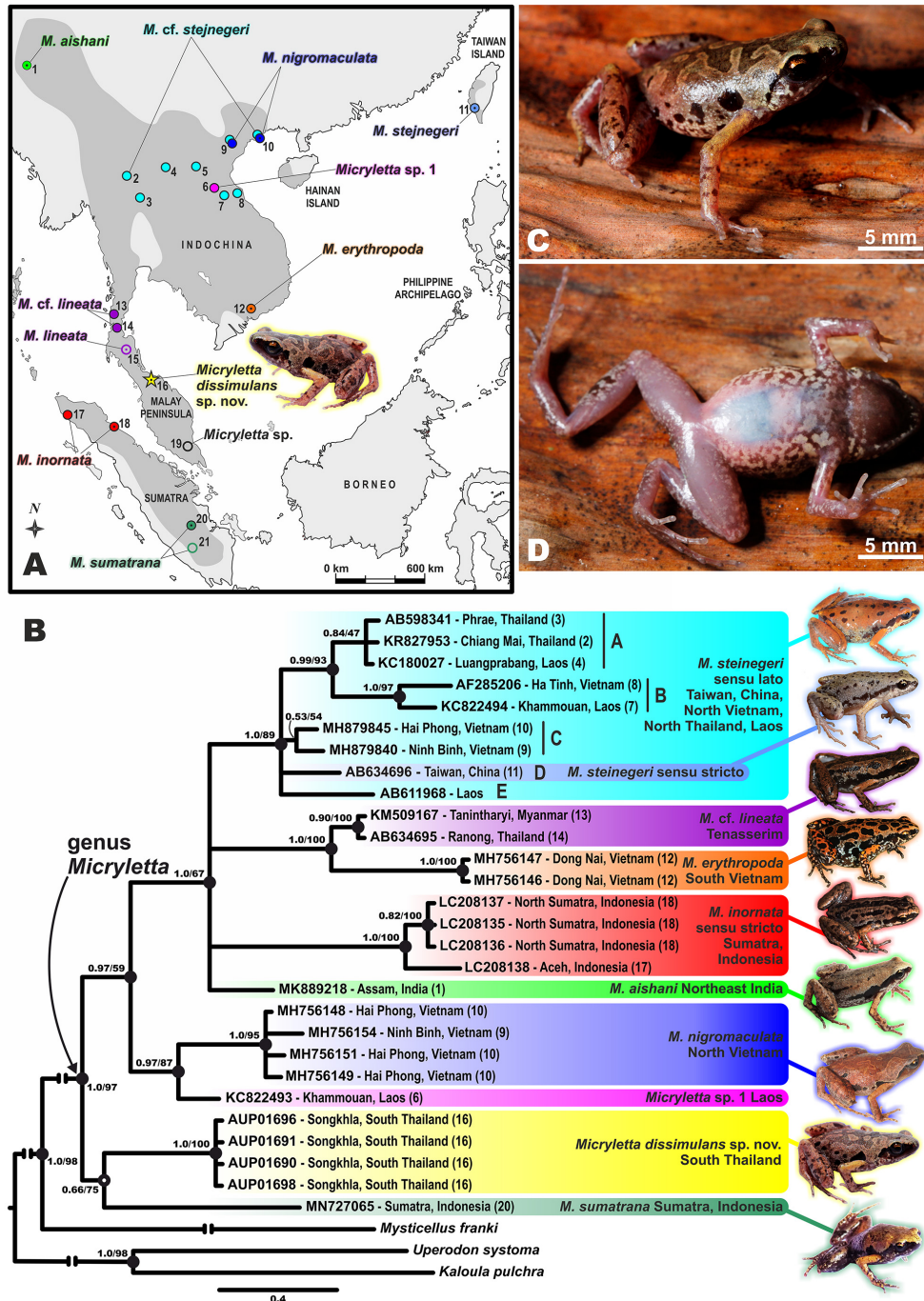
Peninsula to Sumatra in the south (Frost, 2020) (Figure 1A). To date, six species are recognized within the genus: i.e., *M. aishani* Das, Garg, Hamidy, Smith & Biju; *M. erythropoda* (Tarkhnishvili); *M. nigromaculata* Poyarkov, Nguyen, Duong, Gorin & Yang; *M. inornata* (Boulenger), *M. steinegeri* (Boulenger); and *M. sumatrana* Munir, Hamidy, Matsui, Kusriani & Nishikawa (Frost, 2020; Munir et al., 2020). The status of the subspecies *M. inornata lineata* (Taylor) remains controversial, with some studies regarding it as a full species (i.e., *M. lineata*) (e.g., Zug & Mulcahy, 2020). In addition, several preliminary phylogenies of *Micryletta* have revealed a number of deep lineages (Alhadi et al., 2019; Das et al., 2019; Munir et al., 2020; Matsui et al., 2011; Poyarkov et al., 2018), suggesting that taxonomy of the genus is far from complete.

In August 2018, during fieldwork in the lowland forests of Songkhla Province in southern Thailand (Figure 1A, locality 16), we collected a series of specimens of an unusual microhylid species, which was tentatively identified as *Micryletta* sp. Consequent phylogenetic analysis of the 16S rRNA mtDNA gene confirmed the placement of this population within *Micryletta* and the formation of a lineage deeply divergent from all other recognized species of the genus. Closer morphological examination showed that this species could be clearly distinguished from all other congeners by a combination of diagnostic morphological features. Thus, in the present paper, we describe the *Micryletta* population from Songkhla Province as a new species.

Received: 09 June 2020; Accepted: 15 July 2020; Online: 04 August 2020

Foundation items: This study was supported by the Unit of Excellence 2020 on Biodiversity and Natural Resources Management, University of Phayao (UoE63005); Thailand Research Fund (TRF: DBG6180001); and Plant Genetic Conservation Project under the Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn, University of Phayao (RD61017) to C.S.; partially supported by Chiang Mai University to S.C.; International Partnership Program of the Chinese Academy of Sciences (CAS) (152453KYSB20170033), and Southeast Asia Biodiversity Research Institute, CAS (Y4ZK111B01: 2017CASSEABRIQG002) to J.C.; and Russian Science Foundation (19-14-00050; sampling, molecular, and phylogenetic analyses) to N.A.P.

DOI: [10.24272/zj.issn.2095-8137.2020.139](https://doi.org/10.24272/zj.issn.2095-8137.2020.139)



**Figure 1** Phylogenetic relationships and distribution of the genus *Micryletta* and the holotype of *Micryletta dissimulans sp. nov.* (AUP01690) in life

A: Distribution of the genus *Micryletta* (grey shading) and location of examined populations. For locality info see Supplementary Table S1. A dot in the center of icon denotes the type locality of a species; empty circle denotes locality not included in molecular analysis; star denotes the type locality of *Micryletta dissimulans sp. nov.* in Saba Yoi District, Songkhla Province, southern Thailand. B: Phylogenetic BI tree of *Micryletta* reconstructed on the base of 569 bp of partial 16S rRNA sequences. Values on the branches correspond to BI PP/ML BS, respectively; black and white circles correspond to well-supported and moderately supported nodes, respectively. C: Holotype of *Micryletta dissimulans sp. nov.* (AUP01690), adult male, in life in dorsolateral view. D: Same specimen in ventral view. Photos by N.A. Poyarkov, P. Pawangkhanant, J.H. Yang and Eki Aprilia Resdiyanti Devung.

A total of nine specimens were collected and photographed in life before being euthanized using a 20% solution of benzocaine prior to fixation and storage in 75% ethanol. Tissue samples for genetic analysis were taken prior to preservation and stored in 95% ethanol. Specimens and tissues were subsequently deposited in the herpetological collections of the School of Agriculture and Natural Resources, University of Phayao (AUP, Phayao, Thailand) and the Zoological Museum of Lomonosov Moscow State University (ZMMU, Moscow, Russia). Measurements were taken using a digital caliper under a light dissecting microscope to the nearest 0.01 mm, subsequently rounded to 0.1 mm. The morphometrics of adults and character terminology followed Poyarkov et al. (2018) (see Supplementary Methods). Comparative data on the morphology and taxonomy of *Micryletta* were obtained from previous publications on the genus (see Supplementary Methods for details).

Total genomic DNA was extracted, and a partial fragment of the mitochondrial 16S rRNA gene was amplified and sequenced. DNA extraction, primers, and polymerase chain reaction (PCR) protocols followed Poyarkov et al. (2018) and are detailed in the Supplementary Methods. To assess the genealogical relationships among *Micryletta* species, Bayesian inference (BI) and maximum-likelihood (ML) phylogenetic trees were reconstructed based on analysis of the 16S rRNA gene fragment (for details of phylogenetic analyses see Supplementary Methods). Homologous sequences of all currently recognized *Micryletta* species and representative outgroups (*Mysticellus franki*, *Uperodon systoma*, *Kaloula pulchra*) were downloaded from GenBank (see Supplementary Table S1). We also calculated pairwise sequence divergence using uncorrected *P*-distances implemented in MEGA v6.0.6 (Tamura et al., 2013).

The topologies recovered by both BI and ML analyses were essentially identical, with relatively robust support for most terminal nodes (Figure 1B). The new microhylid species from Songkhla Province nested in the genus *Micryletta* with strong support (1.0/97; hereafter node support values are given for BI posterior probability/ML bootstrap support, respectively) and formed a distinct lineage (Figure 1B) with notable genetic divergence (*P*-distance $\geq$ 5.0%) from all other recognized species within the genus (Supplementary Table S2). Our phylogenetic tree agreed with earlier topologies of Poyarkov et al. (2018) and Das et al. (2019) but differed significantly from the topology presented in Munir et al. (2020). The Songkhla *Micryletta* sp. formed a clade (1.0/100) that was clearly distinct from all other congeners, with a possible sister species relationship shown for the recently described species *M. sumatrana* from southern Sumatra, Indonesia, although this grouping received no BI support and only weak ML support (0.66/75; Figure 1B). All remaining species of *Micryletta* formed a well-supported monophylum (0.97/79), with seven major subclades recovered within it. *Micryletta nigromaculata* from northern Vietnam grouped with *Micryletta* sp. 1 from northern Laos (0.97/87) and formed a sister clade with respect

to all other species of *Micryletta* (1.0/67). The following subclades were recovered within the latter group: *M. aishani* from northeast India; *M. inornata* from northern Sumatra, Indonesia; *M. erythropoda* from southern Vietnam; *M. cf. lineata* from Peninsular Thailand; and populations from northern Indochina and southern China, including the mainland and Taiwan. The latter group included the *M. steinegeri* sensu stricto lineage from Taiwan, China (lineage D; Figure 1B), and mainland populations formerly referred to as "*M. cf. inornata*" (lineages A–C and E; Figure 1B) (Das et al., 2019; Munir et al., 2020; Poyarkov et al., 2018). However, as the true *M. inornata* sensu stricto from Sumatra is phylogenetically distinct from the mainland populations of *Micryletta* (Alhadi et al., 2019; Das et al., 2019; Munir et al., 2020), we herein refer to the mainland lineages A–C and E of the *M. steinegeri* complex as *M. cf. steinegeri* (Figure 1A, B).

The genetic distance between the *Micryletta* sp. from Songkhla and other described species of the genus ranged from *P*=5.0% (with *M. nigromaculata*) to *P*=7.4% (with *M. erythropoda*) (Supplementary Table S2). These values of divergence in the 16S rRNA gene are notably higher than the formal *P*=3% threshold widely applied as an indicator of species-level differentiation in frogs (Vieites et al., 2009). Thus, due to congruent morphological (see below) and molecular differences from all currently recognized congeners, the newly discovered *Micryletta* population from Songkhla Province is described as a new species below.

#### Taxonomic account

***Micryletta dissimulans* sp. nov.** (Figure 1C, D; Supplementary Figures S1–4; Table 1)

**Holotype:** AUP01690, adult male from a secondary lowland bamboo forest in Saba Yoi District, Songkhla Province, southern Thailand (coordinates N6.369°, E100.873°; 120 m a.s.l.), collected on 22 August 2018 at 2200 h by P. Pawangkhanant and N.A. Poyarkov.

**Paratypes:** AUP01691–01694 and AUP01698 (five adult males), AUP01696–01697 (two adult females), and ZMMU A7262 (adult male), collected at the same time and place as the holotype.

**Diagnosis:** The new species is assigned to the genus *Micryletta* Dubois, 1987 based on the following morphological attributes: body size small; vomerine teeth absent; tympanum small, rounded, externally visible; subarticular tubercles on fingers and toes very prominent; three well-developed metacarpal tubercles; distinct supernumerary palmar and metatarsal tubercles posterior to base of digits; first finger not reduced; and webbing on fingers and toes absent (Alhadi et al., 2019; Das et al., 2019; Dubois, 1987; Munir et al., 2020; Poyarkov et al., 2018). *Micryletta dissimulans* sp. nov. is distinguished from all congeners by a combination of the following morphological characters: body size small (20.3–22.4 mm in seven males, 24.4–26.7 mm in two females); body habitus slender; head longer than wide; snout rounded in dorsal and lateral views; eye length equal to snout length; tibiotarsal articulation reaching tympanum; dorsal

**Table 1 Selected measurements (in mm) of *Micryletta dissimulans* sp. nov. type series**

Specimen ID	<b>AUP01690</b>	AUP01698	AUP01691	AUP01692	AUP01693	AUP01694	ZMMU A7262	AUP01696	AUP01697
Type status	<b>Holotype</b>	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
Sex	<b>M</b>	M	M	M	M	M	M	F	F
SVL	<b>21.2</b>	21.9	20.9	20.3	21.2	20.3	22.4	26.7	24.4
HL	<b>7.8</b>	7.6	7.2	6.9	6.9	7.1	7.4	7.4	7.3
SL	<b>2.5</b>	2.6	2.4	2.5	2.5	2.2	2.9	3.1	3.1
EL	<b>2.6</b>	2.4	2.5	2.4	2.6	2.4	2.8	3.4	3.3
N-EL	<b>1.4</b>	1.4	1.4	1.5	1.4	1.4	1.6	1.5	1.5
HW	<b>7.3</b>	7.2	7.2	6.8	7.5	7.1	8.5	10.3	8.1
IND	<b>1.9</b>	2.0	1.8	1.9	1.9	2.0	2.3	2.6	2.5
IOD	<b>2.7</b>	2.3	2.2	2.2	2.7	2.5	2.3	2.5	2.5
UEW	<b>1.9</b>	1.5	1.9	1.6	1.9	1.4	1.6	2.7	2.7
FLL	<b>12.7</b>	14.6	13.0	14.0	12.5	14.3	16.0	18.3	17.7
LAL	<b>8.3</b>	9.9	8.2	9.9	8.3	9.6	11.2	13.0	11.8
HAL	<b>5.5</b>	5.4	5.4	5.4	5.8	6.0	6.4	8.0	6.8
IPTL	<b>0.6</b>	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.5
OPTL	<b>0.9</b>	0.8	0.9	0.8	0.9	0.9	1.0	1.2	1.1
3FDD	<b>0.4</b>	0.5	0.4	0.4	0.3	0.4	0.5	0.9	0.8
HLL	<b>34.4</b>	33.0	33.4	34.6	32.8	33.7	36.9	43.9	41.3
TL	<b>10.8</b>	10.0	10.3	10.3	8.9	10.6	11.1	12.8	12.2
FL	<b>13.8</b>	13.5	13.9	14.3	14.4	13.6	15.4	18.5	17.4
IMTL	<b>0.9</b>	0.8	0.9	0.9	0.9	0.9	0.9	1.1	1.0
4TDD	<b>0.7</b>	0.7	0.7	0.6	0.6	0.6	0.7	0.8	0.8
TD	<b>1.2</b>	1.2	1.1	1.0	1.2	1.2	1.3	1.3	1.2
1FL	<b>2.2</b>	2.4	1.7	2.2	2.1	1.8	2.5	3.9	3.3
2FL	<b>3.2</b>	3.4	3.0	3.0	3.0	2.3	4.0	4.1	4.1
3FL	<b>5.1</b>	5.2	4.7	4.9	3.3	4.0	5.9	6.9	6.8
4FL	<b>3.3</b>	4.4	3.0	4.1	3.6	3.0	4.4	5.0	4.9
1TOEL	<b>2.6</b>	2.4	2.5	2.3	2.6	2.7	2.8	3.1	2.2
2TOEL	<b>4.3</b>	4.0	3.5	3.4	4.2	4.3	4.4	5.7	5.0
3TOEL	<b>6.7</b>	6.6	6.8	6.0	7.0	7.3	8.0	9.2	8.5
4TOEL	<b>10.4</b>	9.6	9.9	9.0	10.3	9.4	11.3	12.1	11.4
5TOEL	<b>6.5</b>	5.5	6.0	5.3	6.4	5.7	6.5	8.0	7.7

Holotype measurements are given in bold. For character abbreviations see Supplementary Methods section. M: Male; F: Female.

surface slightly granulated to shagreened; supratympanic fold indistinct, ventrally edged in black; large black spot behind eye; outer metatarsal tubercle absent; dorsum reddish-brown with merging irregular-shaped brown blotches edged in beige, no black spots on dorsum; body flanks brown with large black spots edged in whitish mottling, two large black blotches in axillary and inguinal areas on each side; lateral sides of head black, with white patches on lips absent, whitish mottling on tympanum and axillary region; ventral surface pinkish to bluish-gray, translucent, laterally with dark-brown marbled pattern, medially immaculate; throat in males dark-gray with sparse white mottling laterally; and iris copper-orange.

**Description of holotype:** Adult male, small-sized specimen in good state of preservation; body habitus slender, body elongated and oval-shaped (Figure 1C); head longer than wide (HL/HW 1.07); snout short (SL/SVL 0.12), rounded in dorsal view and bluntly rounded in profile, slightly projecting

beyond lower jaw (Supplementary Figure S1C); eyes comparatively large (EL/SVL 0.12), slightly protuberant in dorsal and lateral views, subequal to snout length (EL/SL 1.02) and interorbital distance (EL/IOD 0.96). Top of head flat; canthus rostralis distinct, rounded; loreal region almost vertical, concave; nostril oval, lateral, located closer to tip of snout than to eye (N-EL/SVL 0.07); interorbital distance noticeably wider than internarial distance (IND/IOD 0.70), about 1.5 times wider than upper eyelid (UEW/IOD 0.70). Pineal spot absent; tympanum small (TYD/SVL 0.06), round, poorly distinct with tympanic rim not elevated above tympanal area; supratympanic fold thin and flat, gently curving from posterior corner of eye towards axilla. Choanae elongated and oval-shaped, widely spaced; upper jaw edentate; vomerine teeth absent; tongue without papillae, roundly spatulate, lacking posterior notch and free behind for three-quarters of its length.

Forelimbs short and slender (FLL/SVL 0.60); lower arm long and slender (LAL/SVL 0.39), hand constituting less than half length of forelimb (HAL/FLL 0.43). Fingers slender, free of webbing, round in cross-section, lacking lateral skin fringes; first finger well-developed, slightly shorter than second finger (1FL/2FL 0.68); relative finger lengths: I<II<IV<III; tips of all fingers rounded, not expanded to disks; subarticular tubercles on fingers rounded and very prominent, subarticular tubercle formula: 1, 1, 2, 2; nuptial pads absent; three metacarpal tubercles: inner metacarpal tubercle distinct, rounded and flat; outer metacarpal tubercle elongated, larger than inner metacarpal tubercle (IPTL/OPTL 0.64), reniform, located on outer proximal edge of palm; medial metacarpal tubercle large, rounded and prominent, twice diameter of inner metacarpal tubercle; three prominent rounded supernumerary tubercles, each at base of fingers II–IV about same size as inner metacarpal tubercle, a small rounded supernumerary tubercle between medial metacarpal tubercle and tubercle at base of finger III, much smaller than metacarpal tubercles (Supplementary Figure S1D).

Hindlimbs slender and long (HLL/SVL 1.63), more than two times length of forelimb (FLL/HLL 0.37); tibia long and slender (TL/SVL 0.51), around one-third of hindlimb length (TL/HLL 0.31); heels meet when hindlimbs positioned at right angles to body, tibiotarsal articulation of adpressed limb reaching to tympanum; foot slightly longer than tibia (FL/TL 1.28). Relative toe lengths: I<II<V<III<IV; tarsus smooth, inner tarsal fold absent; tips of all toes rounded, weakly dilated into small disks, two times wider than those of fingers (3FDD/4TDD 0.52); toes free of webbing; subarticular tubercles on toes round and prominent, subarticular tubercle formula: 1, 1, 2, 3, 2; inner metatarsal tubercle oval-shaped, prominent, much shorter than half length of first toe (IMTL/1TOEL 0.34); outer metatarsal and supernumerary metatarsal tubercles absent (Supplementary Figure S1E).

**Skin texture and skin glands:** Dorsal surface of head and body shagreened with evenly scattered small flat granules, dorsal surfaces of forelimbs smooth, hindlimbs dorsally with small granules on shanks and thighs; flanks of body and lateral sides of head smooth; upper eyelid lacking supraciliary tubercles; supratympanic fold flat, thin; ventral surfaces of body and limbs smooth. Cloacal opening unmodified, directed posteriorly.

**Coloration:** In life, dorsum reddish-brown with large merging irregular-shaped brown blotches edged in light-beige resembling military camouflage print; no black spots on dorsum; body flanks brown with large black spots edged in whitish mottling, two large black blotches in axillary and inguinal areas on each side; lateral sides of head dark-brown, with white patches on upper lips absent, tympanum region and axillary region with whitish mottling; supratympanic fold ventrally edged in black with large black spot behind eye; dorsal surfaces of forelimbs uniform golden-yellow on upper arms, pinkish-brown with few brown spots on lower arms; dorsal surfaces of thighs and shanks golden-brown with pinkish mottling and dark-brown blotches not forming

transverse bands; fingers and toes dorsally gray with brownish dusting; ventral surfaces pinkish to bluish-gray, translucent, laterally with dark-brown marbled pattern, medially immaculate (Figure 1D); throat dark-gray with sparse white mottling laterally in lower jaw area; iris dark-brown with copper-orange sparkles in upper and lower thirds (Supplementary Figure S1C). In preservative, colors fade to gray-brown, though pattern generally remains unchanged (Supplementary Figure S2).

**Variation and sexual dimorphism:** Individuals of the type series are generally quite similar in appearance and agree well with the description of the holotype but with some variation in coloration (Supplementary Figure S3). Female paratype AUP01696 has less contrasting brown pattern on dorsum, fewer black blotches on flanks and translucent skin on belly through which the large bicolored white and black eggs are visible (Supplementary Figure S4). Variations in size and body proportions of the type series are given in Table 1. Females are distinctly larger than males: SVL 20.3–22.4 mm in males ( $n=7$ ) and 24.4–26.7 mm in females ( $n=2$ ). Females have comparatively larger bodies swollen with eggs, and comparatively shorter head length: HL/SVL mean ratio 0.34 (0.33–0.37,  $n=7$ ) in males vs. 0.29 (0.28–0.30,  $n=2$ ) in females. Males bear a single internal vocal sac. Skin texture appears to be less tuberculate in preservative than in life (Supplementary Figures S2, S3).

**Natural history notes:** *Micryletta dissimulans* sp. nov. inhabits secondary disturbed lowland tropical forests dominated by bamboo at elevations of 100–150 m a.s.l. (Supplementary Figure S5). It is an elusive frog species, with all type specimens collected at night from 1900 h to 2300 h after heavy rain and mostly recorded while hiding in bamboo leaf litter. Reproduction (pairs in amplexus) was observed in August. Advertisement calls were not recorded, and clutch size, larval morphology, diet, and predators are unknown. At the type locality, *Micryletta dissimulans* sp. nov. was found in sympatry with the following microhylid frogs: *Microhyla superciliaris* Parker, *M. heymonsi* Vogt, *M. mantheyi* Das, Yaakob & Sukumaran, *Kaloula latidisca* Chan, Grismer & Brown, and *Kalophrynus* cf. *kiewi* Matsui, Eto, Belabut & Nishikawa.

**Comparisons:** *Micryletta dissimulans* sp. nov. differs from *M. aishani* from northeast India by the following combination of characters: snout rounded in dorsal and ventral view (vs. nearly truncate); comparatively larger tympanum, TYD/EL ratio 0.42–0.49 (vs. TYD/EL 0.14–0.29); dorsum with merging irregular-shaped brown blotches edged in beige (vs. dorsum reddish-brown with faint median band); lateral dark spots scattered from tip of snout to lower abdomen on either side (vs. prominent dark-black streak); ventral surface pinkish to bluish-gray, translucent, laterally bearing dark-brown marbled pattern, medially immaculate (vs. ash-gray with purplish tinge and brown mottling towards margin); dorsum weakly granulated to shagreened (vs. minute spinules on dorsum); white spots on upper lip absent (vs. present); and tibiotarsal articulation of adpressed limb reaching to tympanum (vs. to armpit).

The new species differs from *M. erythropoda* from southern Vietnam by a combination of the following characters: smaller body size in males (SVL 20.3–22.4 mm vs. up to 30 mm); outer metatarsal tubercle absent (vs. present); dorsal surface slightly granulated to shagreened (vs. smooth); dorsum brown to reddish-brown (vs. gray or beige to saturated ochre or brick-red); dorsum pattern of merging brown blotches edged in beige (vs. extremely variable and formed by black spots on reddish background); flanks brown with dark spots edged in whitish mottling (vs. dark-brown to gray with white patches); venter pinkish to bluish-gray, laterally with dark-brown marbled pattern (vs. dark brownish-violet); and webbing between toes absent (vs. rudimentary webbing present).

*Micryletta dissimulans* **sp. nov.** differs from *M. inornata* from northern Sumatra, Indonesia, by: larger body size (20.3–22.4 mm in males, 24.4–26.7 mm in females vs. 16.8–20.5 mm in males, 19.5 mm in females); interorbital distance two times wider than upper eyelid width (vs. interorbital distance slightly wider than upper eyelid); dorsum reddish-brown (vs. dark-brown or brownish-gray with silver tinge); dorsal pattern of merging brown blotches edged in beige (vs. irregular blackish blotches); dorsum slightly granulated to shagreened (vs. smooth, covered with small tubercles or warts); sides of head dark-brown to black, with white patches along upper lip absent (vs. black with white spots along upper lip present); body flanks brown with dark spots and whitish mottling (vs. dark-brown with white patches); venter pinkish to bluish-gray laterally with brown marbled pattern (vs. light reddish-gray without mottling); and tibiotarsal articulation of adpressed limb reaching to tympanum (vs. reaching to eye).

The new species differs from *M. lineata* from Peninsular Thailand by: dorsum reddish-brown with merging brown blotches edged in beige (vs. grayish-brown with three straight continuous or broken lines); tibiotarsal articulation reaching to tympanum (vs. reaching to eye); sides of head dark-brown to black, with white patches along upper lip absent (vs. cream stripe of irregular width from snout to axilla); body flanks brown with dark spots and whitish mottling (vs. black stripe from axilla to groin with indistinct light stripe ventrally); and venter pinkish to bluish-gray laterally with brown marbled pattern (vs. immaculate).

Compared with *M. nigromaculata* from northern Vietnam, *Micryletta dissimulans* **sp. nov.** can be distinguished by: tibiotarsal articulation reaching to tympanum (vs. reaching to eye); dorsal pattern consisting of merging brown blotches (vs. generally more prominent dark hourglass-shaped markings); whitish spots present on head flanks from tympanum region to axilla (vs. immaculate dark-brown without white spots); body flanks brown with dark spots and white mottling (vs. blackish patches edged in white); pinkish to bluish-gray venter, laterally with dark-brown marbled pattern (vs. whitish with indistinct light-gray marbling).

The new species differs from *M. steinegeri* by: smaller body size in females (20.3–22.4 mm vs. 27.0–30.1 mm); dorsum brownish (vs. dark-gray to violet); dorsum pattern of merging brown blotches edged in beige with black inguinal spots (vs.

inguinal spots absent, dorsum with irregular dark blotches or speckles); head sides uniform brown, with white patches on upper lip absent (vs. gray-brown with white spots present); body flanks brown with dark spots and white mottling (vs. flanks gray brown with dark marbling); pinkish to bluish-gray venter, laterally with dark-brown marbled pattern (vs. venter pinkish to orange); and webbing between toes absent (vs. rudimentary webbing present).

*Micryletta dissimulans* **sp. nov.** differs from its putative sister species *M. sumatrana* from southern Sumatra, Indonesia, by: larger body size (20.3–22.4 mm in males, 24.4–26.7 mm in females vs. 17.4 mm in males, 22.8 mm in females); relatively longer tibia length (TL/SVL 0.42–0.51 (mean 0.49) in males, 0.48–0.50 (mean 0.49) in females vs. 0.41 in males, 0.45 in females); dorsum reddish-brown (vs. golden-brown); dorsum pattern of irregular-shaped merging brown blotches edged in beige (vs. no dark pattern on dorsum); skin on dorsum slightly granular to shagreened (vs. smooth); lateral sides of head dark-brown, with white patches on upper lip absent (vs. cream spots on lips, tympanum region, and axilla present); body flanks brown with dark spots edged in whitish mottling (vs. dark-brown with white patches); venter pinkish to bluish-gray laterally with dark-brown marbled pattern (vs. venter with dark-brown background coloration with cream mottling); tibia and tarsus with indistinct dark spots not forming cross band (vs. with dark cross bands); tibiotarsal articulation of adpressed limb reaching to tympanum (vs. reaching to eye); supratympanic fold less distinct, flat, not glandular, ventrally edged in black with large black spot behind eye (vs. supratympanic fold distinct, thick, glandular, and blackish); and iris copper-orange in upper and lower thirds (vs. golden).

**Etymology:** The specific epithet “*dissimulans*” is a Latin adjective in the nominative case, feminine gender, derived from the Latin verb “*dissimulo*” meaning “to hide” or “to conceal”, and is given in reference to the iconic “Frog Skin” camouflage pattern, resembling the characteristic mottled and disruptive dorsal pattern of the new species. The name is also given in reference to the new species being concealed for a long time until its recent discovery. We recommend “Camouflaged Paddy Frog” as the common English name and “Eung Jiew Lay Pang” (อิงจิวลายพร่าง) as the common Thai name of the new species.

**Conservation status:** To date, *Micryletta dissimulans* **sp. nov.** is known only from a single location in southern Thailand; the actual extent of distribution and population trends of the new species remain unknown. We suggest *Micryletta dissimulans* **sp. nov.** be considered as a Data Deficient (DD) species following the IUCN’s Red List categories (IUCN Standards and Petitions Committee, 2019).

**Distribution and biogeography:** To date, the new species is known only from a single locality in the lowland areas of Songkhla Province in southern Peninsular Thailand (Saba Yoi District) (see Figure 1A, locality 16), approximately 6 km from the international border with Malaysia. Biogeographically, the Songkhla Province is located southwards from the Kangar-

Pattani Line, a well-known biogeographic barrier that bisects the Thai-Malay Peninsula (Van Steenis, 1950), and thus the occurrence of the new species to the south, in Peninsular Malaysia, is highly anticipated. Similar patterns have been observed in other microhylids inhabiting this region (see Gorin et al., 2020). Munir et al. (2020) discussed that some *Micryletta* populations reported from the Malay Peninsula and Singapore superficially resemble *M. sumatrana* in coloration, but differ from the latter by fewer cream spots on the lips and tympanum and by a different arrangement of black spots on the flanks. The population from Johor (see Figure 1A, locality 19) reported by Wood et al. (2008) is indeed somewhat similar to *Micryletta dissimulans* sp. nov. in having irregular brownish spots on the dorsum and lacking white spots on the upper lip (Wood et al., 2008: Figure 3, LSUHC 7626); however, further studies are required to clarify the taxonomic status of *Micryletta* from Peninsular Malaysia and Singapore.

The present study further underlines our incomplete understanding of *Micryletta* diversity. In addition to the description of four new species of this genus in just the last two years, our study, in agreement with earlier research (Alhadi et al., 2019; Das et al., 2019; Munir et al., 2020; Poyarkov et al., 2018), identified several lineages of *Micryletta* that likely correspond to new species. The population of *Micryletta* sp. 1 from Laos (Figure 1A, locality 6), initially identified as *M. inornata* (Blackburn et al., 2013), but later suggested as *M. cf. nigromaculata* by Das et al. (2019), is geographically isolated and notably divergent from typical *M. nigromaculata* in 16S rRNA sequences ( $P=2.8\%$ ); thus, further integrative studies are needed to clarify its taxonomic status. Our study also confirms (Poyarkov et al., 2018) the close genealogical relationship between *M. erythropoda* from southern Vietnam and samples from peninsular Thailand and Myanmar (Figure 1A, localities 13–14), originally identified as *M. i. lineata* by Matsui et al. (2011) and Munir et al. (2020), or as *M. lineata* by Zug & Mulcahy (2020). However, these samples do not originate from the type locality of *M. lineata* in Nakhon Si Thammarat Province, Thailand (Figure 1A, locality 15), and are regarded as *M. cf. lineata* in our study. The geographical complexity of the Thai-Malay Peninsula compounds population estimations of *M. cf. lineata* and *M. erythropoda*, which can only be resolved using integrative taxonomic approaches and comparisons with type specimens and genetic analyses of topotypic materials. Our study further confirms that *M. inornata* sensu stricto is restricted to Sumatra (Alhadi et al., 2019), and thus application of this name for populations in northern Indochina and southern China (as in Munir et al., 2020) is misleading. We provide further evidence that a large radiation of *Micryletta* in this region is comprised of at least five divergent mtDNA lineages, including *M. steinegeri* sensu stricto from Taiwan in southern China (Figure 1B, lineage D). We herein suggest referring to this group as the *M. steinegeri* complex (Figure 1B, lineages A–E). Though the mainland lineages of this complex from Thailand and Laos (lineage A), central Vietnam and Laos (lineage B), northern Vietnam (lineage C), and Laos (lineage E) are likely

separated geographically (see Figure 1A, B), each potentially represents an undescribed species. Finally, our mtDNA-based genealogy could not provide full phylogenetic resolution for the genus *Micryletta*; the tendency for a basal position of the Sundaic clade comprised of *Micryletta dissimulans* sp. nov.+*M. sumatrana* is only poorly supported. Further multilocus phylogenies along with integrative taxonomic analyses are needed to achieve a better understanding of *Micryletta* taxonomic diversity and evolutionary history.

## NOMENCLATURE ACTS REGISTRATION

The electronic version of this article in portable document format represents a published work according to the International Commission on Zoological Nomenclature (ICZN), and hence the new names contained in the electronic version are effectively published under that Code from the electronic edition alone (see Articles 8.5–8.6 of the Code). This published work and the nomenclature acts it contains have been registered in ZooBank, the online registration system for the ICZN. The ZooBank LSIDs (Life Science Identifiers) can be resolved and the associated information can be viewed through any standard web browser by appending the LSID to the prefix <http://zoobank.org/>.

Publication LSID:

urn:lsid:zoobank.org:pub: F6ABA4F9-93E2-4BA7-8B1C-4939756C74B4

*Micryletta dissimulans* LSID:

urn:lsid:zoobank.org:act: 2C8AF677-4ED6-4588-9944-298430AED17B

## SCIENTIFIC FIELD SURVEY PERMISSION INFORMATION

Specimen collection protocols were approved by the Institutional Ethical Committee of Animal Experimentation of the University of Phayao (certificate No. UP-AE61-01-04-0022 issued to Chatmongkon Suwannapoom) and Institute of Animals for Scientific Purpose Development (IAD), Bangkok, Thailand (permit number U1-01205-2558, issued to Chatmongkon Suwannapoom).

## SUPPLEMENTARY DATA

Supplementary data to this article can be found online.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

C.S. and N.A.P. designed the study. P.P. and N.A.P. collected specimens in the field. C.S., V.A.G., and N.A.P. performed molecular experiments. C.S., T.V.N., V.A.G., and N.A.P. performed data analyses. C.S., T.V.N., and N.A.P. wrote the manuscript. T.V.N., V.A.G., C.J., S.C., and N.A.P. revised the manuscript. All authors read and approved the final version of the manuscript.

## ACKNOWLEDGEMENTS

We would like to thank the Laboratory Animal Research Center (University of Phayao), Institute of Animal for Scientific Purposes Development (IAD), and Department of National Parks, Wildlife and Plant Conservation (DNP), Thailand, for permission to do field work. The authors are grateful to Thai Van Nguyen (SVW), Andrey N. Kuznetsov (JRVTTTC), Valentina F. Orlova and Roman A. Nazarov (ZMMU) for supporting our study. We thank Watinee Juthong, Pattarawich Dawwrueng, Kanokwan Yimyo, Thiti Ruengsuwan, Kawin Jiaranaisakul, and Akkrachai Aksornneam for help, support, and encouragement during fieldwork. We also thank Jian-Huan Yang for providing photos of *Micryletta inornata* and to Eki Aprilia Resdiyanti Devung for providing photos of *M. sumatrana*. We are grateful to Mark D. Scherz, Peter Geissler, and Jian-Huan Yang for useful comments and corrections of the earlier version of the manuscript.

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