



Description of two new bird species from the Meratus Mountains of southeast Borneo, Indonesia

Mohammad Irham^{1,6} · Tri Haryoko¹ · Subir B. Shakya² · Simon L. Mitchell³ · Ryan C. Burner^{2,4} · Carlos Bocos⁵ · James A. Eaton⁵ · Frank E. Rheindt⁶ · Suparno Suparno¹ · Frederick H. Sheldon² · Dewi M. Prawiradilaga¹

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Abstract

We describe two new bird species from the Meratus Mountains of southeastern Borneo, Indonesia: a jungle-flycatcher (genus *Cyornis*) and a white-eye (genus *Zosterops*). Our descriptions are based on comparisons of plumage, mitochondrial ND2 DNA sequences, and vocalizations of the new species and their congeners. The new Meratus jungle-flycatcher is most closely related to *Cyornis montanus* but morphologically distinguished by lighter blue on the upperparts and more whitish and less reddish on the underparts. The new Meratus white-eye is most closely related to *Zosterops chloris* but distinguished by olive upperparts and darker underparts. Vocalizations and genetic divergence values also corroborate species status for both new taxa. Both new species are probably confined to the Meratus Mountains, which are currently surrounded by degraded lower elevation secondary woodland or converted agricultural landscape. They appear to have diverged from their sister species through geographic isolation in this remote mountain range compounded by altered population dynamics in a depauperate montane bird community. Although both species are relatively common in the restricted area of the Meratus Mountains, continued habitat alteration and the imminent threat of poaching may be in the process of endangering them. Therefore, we recommend the IUCN Red List status of “Vulnerable” for the new species based on criteria B1 and B2.

Keywords New species · *Cyornis* · *Zosterops* · Meratus Mountains · ND2 DNA sequences · Plumages · Vocalizations

Zusammenfassung

Beschreibung von zwei neuen Vogelarten von den Meratus-Bergen in Südost-Borneo (Indonesien)

Wir beschreiben zwei neue Vogelarten von den Meratus-Bergen in Südost-Borneo (Indonesien): einen Fliegenschnäpper (Gattung *Cyornis*) und einen Brillenvogel (Gattung *Zosterops*). Unsere Beschreibungen beruhen auf Vergleichen von Gefieder, mitochondrialen DNA-Sequenzen des ND2-Gens und Vokalisationen der zwei neuen Arten und ihrer Gattungsangehörigen. Der neue Meratus-Fliegenschnäpper ist am nächsten mit *Cyornis montanus* verwandt, unterscheidet sich jedoch morphologisch durch helleres Blau auf der Oberseite und durch mehr Weiß und weniger Rot auf der Unterseite. Der neue Meratus-Brillenvogel ist am nächsten mit *Zosterops chloris* verwandt, unterscheidet sich aber durch seine

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Mohammad Irham, Tri Haryoko, Subir B. Shakya, Simon L. Mitchell, Ryan C. Burner and Dewi M. Prawiradilaga contributed equally to this work.

✉ Dewi M. Prawiradilaga
dewi005@lipi.go.id; dewi001@brin.go.id

¹ Museum Zoologicum Bogoriense, Research Centre for Biology, Indonesian Institute of Sciences (LIPI), Jl. Raya Jakarta - Bogor Km 46, Cibinong 16911, Indonesia

² Museum of Natural Science and Department of Biological Sciences, Louisiana State University, Baton Rouge, LA, USA

³ Durrell Institute of Conservation and Ecology (DICE), School of Anthropology and Conservation, University of Kent, Canterbury, Kent, UK

⁴ Present Address: Faculty of Environmental Sciences and Nature Management, Norwegian University of Life Science, Aas, Norway

⁵ Birdtour Asia Ltd, 36 Amal an Avon, Hayle Cornwall TR274QD, UK

⁶ Department of Biological Sciences, National University of Singapore, 16 Science Drive 4, Singapore 117558, Singapore

olivfarbene Oberseite und dunklere Unterseite. Vokalisationen und genetische Divergenzwerte bestätigen ebenso den Artstatus beider neuer Taxa. Beide Arten sind wahrscheinlich auf die Meratus-Berge beschränkt, welche heutzutage von gestörtem Sekundärwald auf niedrigeren Höhen oder von in landwirtschaftliche Flächen umgewandelten Landschaften umgeben sind. Beide Arten scheinen sich von ihren Geschwisterarten durch geographische Isolation auf dieser abgelegenen Bergkette abgespalten zu haben, was durch eine veränderte Populationsdynamik in einer verarmten Bergvogelgemeinschaft verstärkt worden sein mag. Obgleich beide Arten in der beschränkten Gegend der Meratus-Berge relativ häufig sind, sind sie wahrscheinlich durch anhaltende Habitatsveränderungen und die unmittelbar bevorstehende Bedrohung durch illegalen Vogelfang in Gefahr. Wir schlagen daher vor, die neuen Arten unter den Kriterien B1 und B2 der Roten Liste der IUCN als „gefährdet“ zu führen.

Introduction

The Meratus Mountains in southeastern Borneo comprise a small range (c. 2468 km²) with a high point of 1901 m at Mt. Besar (Fig. 1). The mountains are surrounded by low elevation, heavily disturbed forest and converted lands and are separated from the main mountain range of Borneo by some 300 km. Thus, the Meratus Mountains form a well-isolated island of montane and submontane forest that is expected to contain endemic fauna and flora. Indeed, endemism has been found in taxonomic groups that have been well researched in the region, especially plants and insects (WWF and IUCN 1995; Gathorne-Hardy et al. 2002; Quek et al. 2007; Raes et al. 2009). However, other groups inhabiting the mountains have not been well documented or studied, including birds (Davison 1997). It is not surprising, therefore, that Eaton et al. (2016a) on a trip to the Meratus Mountains in July 2016 photographed and audio-recorded individuals in two bird genera—*Cyornis* and *Zosterops*—that appeared to represent distinct new species. Subsequently, in May 2017, the Museum Zoologicum Bogoriense (MZB) and the Louisiana State University Museum of Natural Science (LSU) followed up with the first-ever ornithological collecting expedition to the Meratus Mountains and obtained specimens of the new *Cyornis* and *Zosterops* (Shakya et al. 2018).

Here, using the specimens and audio-recordings from those trips, we compare the morphology, genetics, and vocalizations of the Meratus *Cyornis* and *Zosterops* populations to those of congeneric taxa in the Sundaic–Wallacean region. These comparisons verify that the Meratus populations of *Cyornis* and *Zosterops* are indeed distinct and represent previously undescribed species as defined by the multidimensional biological species concept (Mayr 1996), an extension of the classical Biological Species Concept (Mayr and Ashlock 1991; Mayr 2000). With the rapid development of technology in such fields as molecular genetics and bioacoustics, data are now available to infer the likelihood of reproductive isolation between physically isolated populations, such as those in the Meratus Mountains and on other mountains or islands of Sundaland and Wallacea (Rheindt et al. 2020).

Methods

To describe taxonomic relationships, we follow Eaton et al. (2021), which includes updates to *Cyornis* and *Zosterops* classification. Eaton et al. (2021) is the most recently published field guide to Indonesian birds and follows the most recent peer-reviewed publications in its taxonomic treatments. The Eaton et al. (2021) classification is generally in line with major global avian checklists, such as Gill et al. (2021). For example, Gill et al. (2021) elevated *Cyornis montanus* (a key taxon in our study) from subspecies to species following the first edition of Eaton et al. (2016b).

Plumage and size of the Meratus *Cyornis* and *Zosterops* specimens were compared with those of their most closely related congeners in Sundaland and Wallacea (Tables S1 and S2), as determined by Shakya et al. (2018), Gwee et al. (2019), Lim et al. (2019) and O’Connell et al. (2019). We determined plumage color and applied color nomenclature (denoted with capitalized letters in the species descriptions) and color numbers according to the color guide of Smithe (1975). Bill length was measured from the angle at the front of the skull to the tip of the bill (BSk) using a caliper. The tail (T1) was measured with a ruler from between the two innermost rectrices, where their bases emerge from the skin, to the tip of the longest feather that folded naturally (Eck et al. 2011). Wing length was measured with a 30 cm caliper in natural position from the carpal joint to the tip of the longest primary (Winker 1998). Specimens (see Table S3) were measured by MI at the MZB, except for some of the *C. montanus* specimens, which were measured by FHS at LSU. Total length and weight of the new species were determined in the field by TH.

To determine genetic relatedness, we sequenced mitochondrial ND2 genes de novo or downloaded them from GenBank, and then used them to construct phylogenetic trees following the methods of Shakya et al. (2018, 2020). Briefly, this process entailed extracting DNA and Sanger-sequencing the ND2 gene, constructing trees via maximum likelihood (ML) in RAxML 8 (Stamakis 2014), and testing branch support by bootstrapping 1000 times using the CIPRES Science Gateway (Miller et al. 2010). DNA sequences

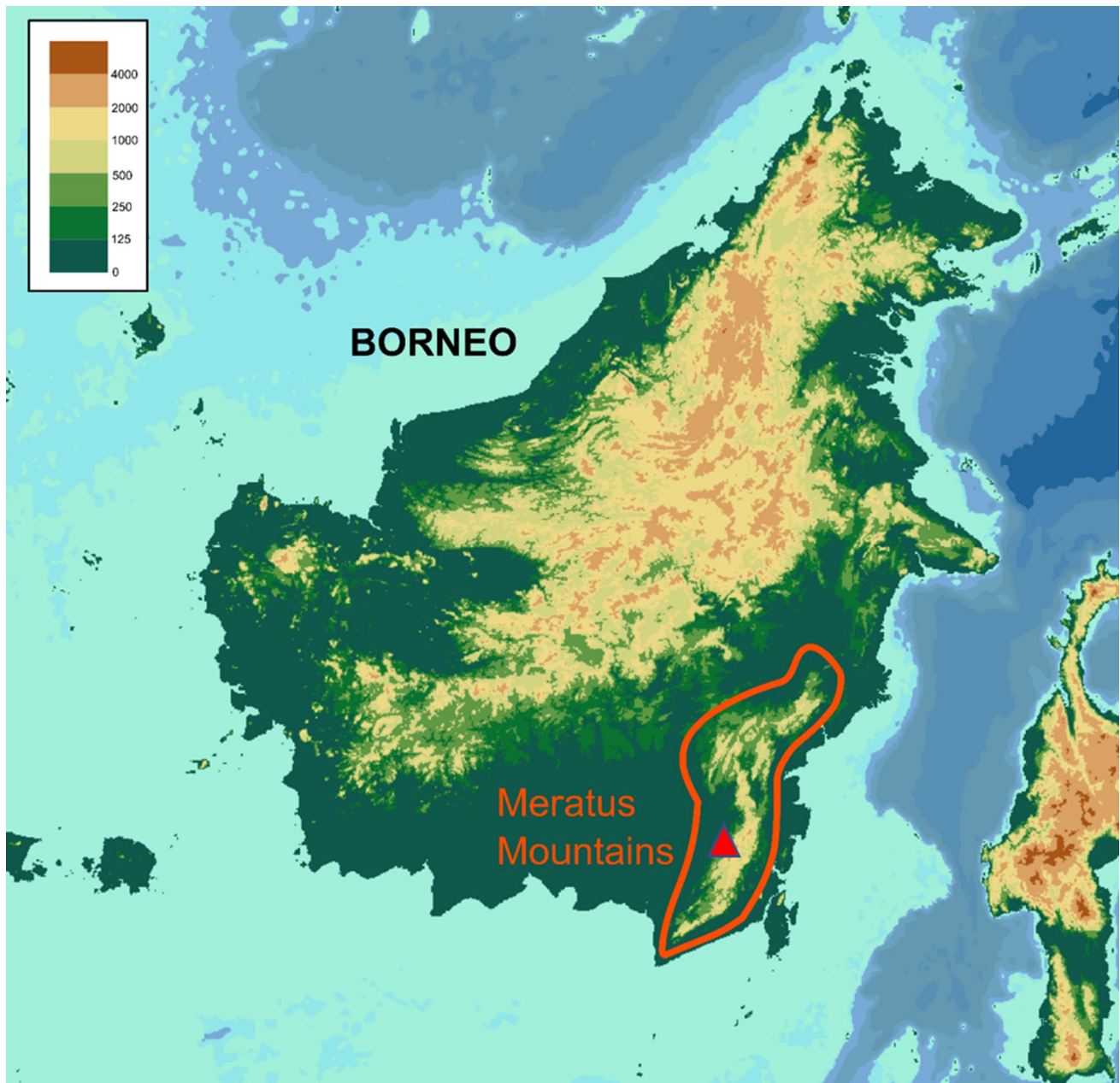


Fig. 1 Map of Borneo showing the location of the Meratus Mountains and the approximate type locality indicated by red triangle. Elevations are in meters ASL

produced for this project are deposited in GenBank under accession numbers MT936796–MT936802. Sequences of *Cyornis* and *Zosterops* individuals from the Meratus Mountains compared in earlier publications (Shakya et al. 2018, 2020) were already deposited at GenBank under accession numbers MT936796–MT936802, MG546513, and MG546514.

For comparisons of *Cyornis* vocalizations, we relied on the study of Gwee et al. (2019), which examined all pertinent taxa. For *Zosterops*, vocalizations of four individuals

from the Meratus population recorded on Mount Besar in July 2016 (at 2.7249 S, 115.5863 E) were compared with those of four individuals from the nearest populations of *Z. chloris intermedius* from Selayar, Sulawesi, made in November 2017 (at –6.2110 S, 120.5000 E; Table S4). A recording of the Meratus *Zosterops* is deposited at Xeno-Canto under catalogue number XC651666 (Vellinga and Planqué 2015). For vocal analyses, we produced spectrograms of each species and identified song phrases with the software package Raven (Center for Conservation Bioacoustics 2016). Any

song phrases with a signal to noise ratio >7 or involving simultaneous vocalizations of more than one individual were excluded from further analysis, leaving 27 discrete song phrases (Meratus population $n = 14$, *Z. c. intermedius* $n = 13$). The acoustic properties of song phrases were assessed using dynamic time warping on fundamental frequency contours following Araya-Salas and Smith-Vidaurre (2017), producing a dissimilarity matrix of all song phrases. This was then consolidated using a non-metrical dimensional scaling (NMDS) ordination ($n = 27$, dimensions = 3, stress = 11.71), with ellipses of 95% confidence intervals based on multivariate *t*-distributions added to determine clustering of song phrases by species using the R package ‘vegan’ (Oksanen et al. 2007).

Results

The *Cyornis* and *Zosterops* populations of the Meratus Mountains are adequately distinct from their congeners in plumage, genetic divergence, and vocalizations to be considered separate species. Neither has previously been named by taxonomists. Thus, we name them here and provide the pertinent details in the species descriptions.

Cyornis kadayangensis, sp. nov.

Meratus Jungle Flycatcher
Sikatan Kadayang

LSID urn:lsid:zoobank.org:act:E858FEB9-F5D2-48F7-96FC-D812365A6541.

Holotype: Study skin, Museum Zoologicum Bogoriense (MZB 35486), Bogor, Indonesia; tissue MZB 35486/LSU B79121; adult male; Indonesia, Kalimantan Selatan Province, Hulu Sungai Selatan Regency, Summit trail to Mount Besar, 2.7249 S 115.5863 E, 1150 m asl; habitat: disturbed montane forest; collected 8 May 2017; prepared by TH, original catalog number TRY 824 (Fig. 2).

Description of Holotype: Head and back to rump, lower ear coverts, cheeks, and sides of breast between Indigo Blue (73) to Blue Black (90). Forehead True Blue (168A), forming a supercilium over the eye. Lores to ear coverts and chin Jet Black (89). Throat to breast lighter Clay (123B), intergrading into greyish-clay on flanks. Breast to upper belly blended with White and continuing as clear White until undertail coverts. Scapulars True Blue (168A). Wing coverts between Indigo (73) and Blue Black (90). Wings Sepia (119) with Indigo (73) to Blue Black (90) on the outer edges. Upper tail Jet Black (89) with Indigo (73) to Blue Black (90) on the outer side of the feathers. Undertail all Sepia (119–219). Bill black. Legs Sepia (119). Iris dark brown.

Allotype: Study skin, Museum Zoologicum Bogoriense (MZB 35483), Bogor, Indonesia; tissue MZB 35483/LSU B79108; adult female; Indonesia, Kalimantan Selatan Province, Hulu Sungai Selatan Regency, Kadayang 2.7465 S 115.5555 E 500 m asl; habitat: overgrown rubber and secondary forest; collected 3 May 2017; prepared by TH, original catalog number TRY 811 (Fig. 3).

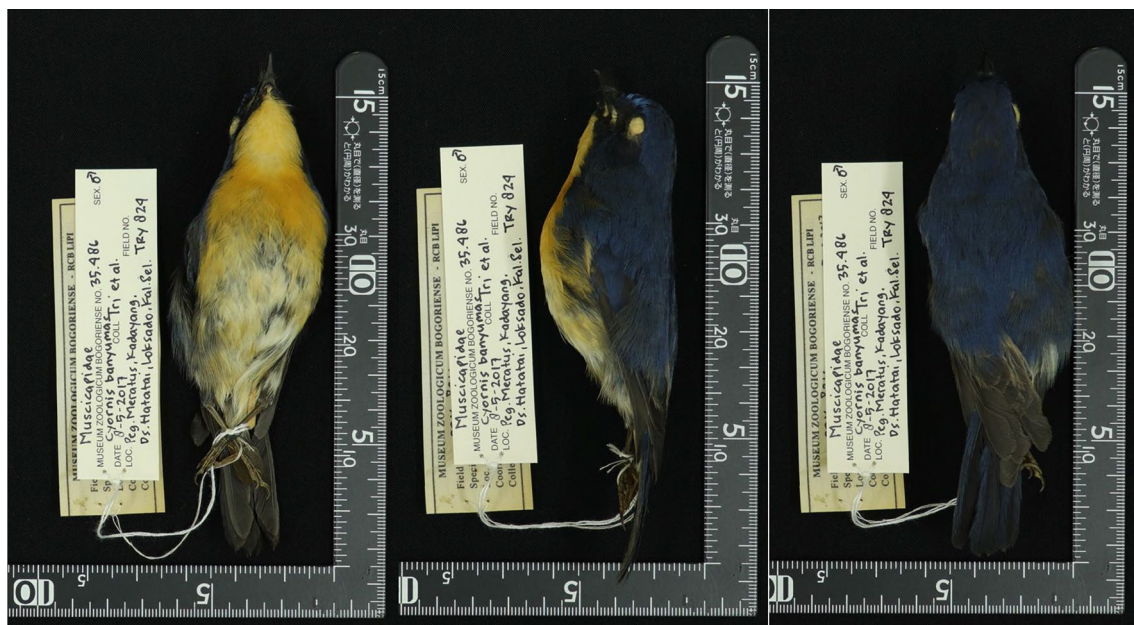


Fig. 2 The holotype of *Cyornis kadayangensis* (male, MZB35486)

Description of Allotype: Head, including ear coverts and cheeks, to rump Olive-Green (48). Base of forehead light brownish, lores whitish, and eye ring Buff-Yellow (53). Upper tail coverts Antique Brown (37). Most of the upper tail Antique Brown (37); inner side of outer rectrices blackish. Wings Dusky Brown (19) with brownish olive-green edges. Throat whitish Cream (54) with light orange-brownish bordering the lower ear coverts. Breast Clay (123B), becoming lighter on flanks. Belly white. Bill black, grey below. Legs blue grey. Iris dark brown. Description of sub-adult male (Paratype, MZB 35488): Head to nape blackish streaked Buff-Yellow, lores and eye ring Buff-Yellow. Nape towards rump blackish spotted Buff-Yellow. Wing coverts bluish with Buff-Yellow at the tip. The rest of the wings blackish with Blue Black (90) edges. Upper tail Blue Black, undertail blackish. Underparts light Clay Color from throat to belly with dark scaling. Lower belly whitish. Undertail coverts light Clay. Bill black, paler below. Legs brown-greyish (Fig. 4).

Measurements: See Table S1.

Diagnosis: Based on measurements of taxa within the *Cyornis banyumas* group (Table S1), *C. kadayangensis* tends to have a longer bill; other size parameters fall within the range of other taxa.

The male plumage of *C. kadayangensis* is most reminiscent of *C. montanus* from northern Borneo. It is distinguished from *C. montanus*, however, by having lighter upperparts and a whitish belly, whereas *C. montanus* has darker upperparts and amber underparts without any white on the belly and undertail coverts (Figs. 5 and 6).

C. kadayangensis is distinct from both *C. b. banyumas* and *C. b. ligus* from Java by having narrower and less extensive blue on the forehead; bluish cheeks and lower ear coverts as opposed to blackish in both subspecies of *C. banyumas*; and lighter blue on the upperparts from crown to tail (Fig. 5). The underparts of *C. b. banyumas* are a darker clay color than *C. kadayangensis*, which has a whiter belly and undertail coverts (Fig. 6). In *C. b. ligus*, the underparts are uniform Amber with less extensive white on the belly.

The male *C. kadayangensis* differs from *C. superbus* by having indigo blue to blue black on most of the upperparts, including the outer rectrices. Male *C. superbus* have a very bright blue band across the forehead, supercilium and nape, grading into the mantle and outer rectrices; its rump and upper tail coverts are shining blue. The cheeks and lower ear coverts are bluish in *C. kadayangensis*, whereas in *C. superbus* they are black. *C. kadayangensis* is lighter orange on its underparts than *C. superbus*.

The male *C. kadayangensis* differs from *C. caerulatus* by having indigo blue to blue black on most of the upperparts. *C. caerulatus* has brighter blue from the forehead extending into the supercilium, nape, mantle, rump, and upper tail coverts. *C. kadayangensis* has a thinner black strip on the chin, whereas *C. caerulatus* has a thicker black strip that continues to the cheeks and lower ear coverts. *C. kadayangensis* has less extensive orange on the underparts than *C. caerulatus*.

C. montanus differs distinctly in female plumage through its all-reddish underparts (down to vent) while female *C. kadayangensis* has a white belly. Similarly, female Javan *C. banyumas* seems to have more reddish

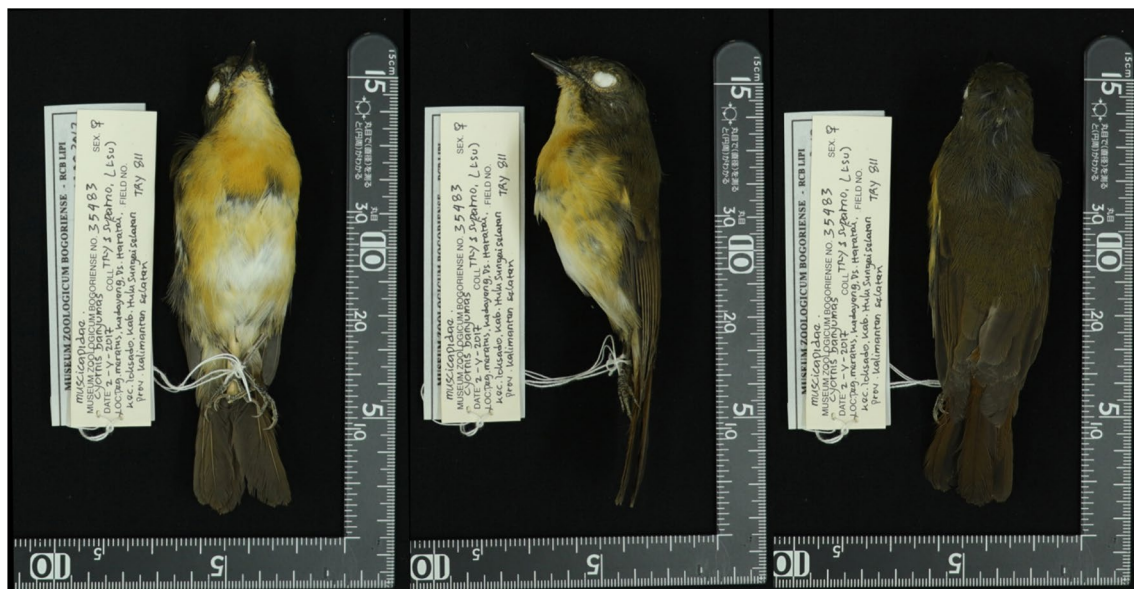


Fig. 3 The allotype of *Cyornis kadayangensis* (female, MZB35483)



Fig. 4 The paratype sub-adult male of *Cyornis kadayangensis* (MZB35488)



Fig. 5 Lateral side showing comparison of the upperparts and underparts among males of *Cyornis kadayangensis*, *C. montanus*, and *C. banyumas*. From left to right: *C. kadayangensis*; *C. montanus*; *C. banyumas ligus*; *C. banyumas banyumas*



Fig. 6 Ventral side showing comparison of the underparts among males of *Cyornis kadayangensis*, *C. montanus*, and *C. banyumas* and from left to right: *C. kadayangensis*; *C. montanus*; *C. banyumas ligus*; *C. banyumas banyumas*

underparts than female *C. kadayangensis* (Fig. 7). The female *C. kadayangensis* has olive-green upperparts (Figs. 3, 8), whereas the upperparts of female *C. superbus* are Raw Umber (23) to Antique Brown (37) from the crown to lower back and between Cinnamon-Rufous (40) and Ferruginous (41) on rump and tail. The female *C. kadayangensis* differs from female *C. caerulatus* by having a brownish instead of blue tail.

Paratypes: We designate eight paratypes: MZB 35486 male from 2.72675 S 115.58642 E at an elevation of 1126 m asl, MZB 35487 female, MZB 35488 male, both from the same locality as the allotype; LSUMZ 198285 from the type locality; and LSUMZ 198278, LSUMZ 198280, LSUMZ 198281, and LSUMZ 198283 from the same locality as the allotype.

Etymology: *Cyornis kadayangensis* is named after Kadayang, a Dayak village in the Meratus Mountains (2.7465 S 115.5555 E).

Habitat: The habitat at 1150 m is montane rain forest moderately disturbed by harvesters of forest products. The habitat at 500 m consists of highland forest partly converted into rubber plantation, partly extensively overgrown, and secondary forest resulting from shifting cultivation, wood-cutting, and gardening.

Voice: Eaton et al. (2021) described the song of the new species as a series of 3–7 glissading, prolonged, deliberate notes, occasionally with a high-pitched final note, lasting 1–2 s. Calls vary from soft, dry clicks and chirps to urgent two-syllable *chee-wheet* alarm calls, up-slurred on the first syllable (Eaton et al. 2021). Applying bioacoustic comparisons of 11 vocal parameters, Gwee et al. (2019) found that principal component analysis indicated the song of *C. kadayangensis* is distinct from all other members of the *C. banyumas* complex (sensu Gill et al. 2021) except *C. montanus*, the northern Bornean taxon. Linear discriminant analysis, however, indicated a significant difference between the vocalizations of the new species and *C. montanus* (Gwee et al. 2019).

Genetics: Shakya et al. (2018) found that the ND2 sequences of *C. kadayangensis* average 3.27% divergent from *C. montanus* of northern Borneo. The ND2 maximum likelihood tree constructed for this study (Fig. 9) indicates that *C. banyumas* of Java is sister to the clade containing *C. montanus*, *C. kadayangensis*, *C. poliogenys*, and *C. olivaceus*. The average distance between *C. kadayangensis* and *C. banyumas* is 6.5%. This branching pattern is consistent with the classification of Eaton et al. (2021).

Fig. 7 Ventral side showing comparison of the underparts among females of *Cyornis kadayangensis*, *C. banyumas ligus*, and *C. banyumas banyumas*. From left to right: *Cyornis kadayangensis*, *C. banyumas ligus*, and *C. banyumas banyumas*



Fig. 8 Dorsal side showing comparison of the upperparts among females of *Cyornis kadayangensis*, *C. banyumas ligus*, and *C. banyumas banyumas*. From left to right: *Cyornis kadayangensis*, *C. banyumas ligus*, and *C. banyumas banyumas*



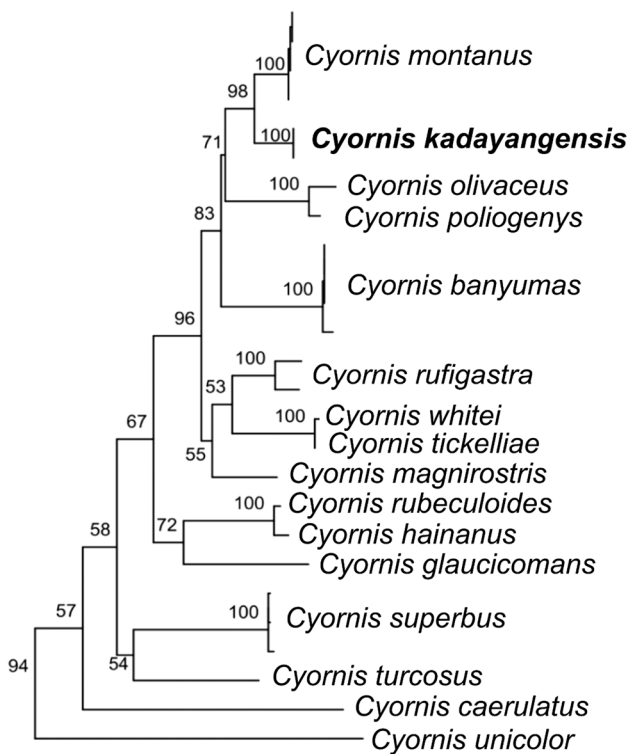


Fig. 9 Maximum-likelihood bootstrapped tree of selected *Cyornis* species constructed from mitochondrial ND2 sequences. Classification is according to Eaton et al. (2021) with outgroups according to Gill et al. (2021)

LSID urn:lsid:zoobank.org:act:7949C5BD-B8CA-4C7C-9041-0271725E6C6D.

Holotype: Study Skin, Museum Zoologicum Bogoriense (MZB 35586), Bogor, Indonesia; tissue MZB 35586/LSU B79180; adult male; Indonesia, Kalimantan Selatan Province, Hulu Sungai Selatan Regency, Summit trail to Mount Besar, 2.7228 S 115.5931 E, 1350 m asl; habitat: disturbed montane forest; collected 14 May 2017; prepared by SBS, original catalog number SBS 170 (Fig. 10).

Description of Holotype: Bill color pinkish-horn, with darker greyish-horn coloration along upper ridge of upper mandible and tip of lower mandible. Eye ring white, interrupted at front by thin black loreal line, which also runs below the eye ring. Above the loreal line, a thin streak of Olive-Yellow (52). Head, mantle, and back Yellowish Olive-Green (50), with indistinct blackish streaking on crown. Upper tail coverts between Yellowish Olive-Green (50) and Citrine (51). Flight feathers Dusky Brown (19), the edging from the outer primaries to inner secondaries grading from yellow to greenish-olive. Tail Dusky Brown (19) with paler edging. Undertail coverts Sulfur Yellow (157) with Orange Yellow (18) tinge, especially at the terminal end. The throat is Spectrum Yellow (55) with a slightly streaky appearance, becoming slightly more Olive-Yellow (52) on the breast. Belly Spectrum Yellow (Color 55) with an Orange Yellow (Color 18) tinge. Flanks including thighs between Yellowish Olive-Green (Color 50) and Olive-Yellow (Color 52). Iris dark brown. Legs greyish horn, paler at the pad.

Zosterops meratusensis sp. nov.

Meratus White-eye
Kacamata Meratus



Fig. 10 Holotype of *Zosterops meratusensis* (male, MZB35586)

Measurements: See Table S2.

Diagnosis: There is no sexual dimorphism in the species.

Since *Z. meratusensis* is most closely related to *Z. chloris* (Shakya et al. 2018), we compared it with multiple subspecies of *Z. chloris*, i.e., *Z. c. maxi*, *Z. c. mentoris*, and *Z. c. intermedius*. Morphologically, *Z. meratusensis* tends to have a shorter tail than these subspecies (Table S2). In addition, *Z. meratusensis* differs in having: Olive-Green upperparts versus a range of yellowish colors from Yellowish Olive-Green to Citrine; a thin Olive-Yellow supraloral line versus a thicker Spectrum Yellow to Orange Yellow line; and darker versus lighter underparts (Fig. 11).

Z. meratusensis is distinguished from *Z. flavissimus* by its olive-green versus bright yellow overall appearance.

We also compared the new species with *Z. flavus*, the only other all-yellow/olive Bornean white-eye, which occurs in southern coastal Borneo. *Zosterops meratusensis* differs from *Z. flavus* in having a longer bill and tail (Table S2), darker upper and underparts, and a thinner supraloral line that is more olive versus thicker and brighter yellowish (Fig. 12).

Paratypes: We designate four paratypes, all from the type locality: MZB 35585 male, MZB 35587 female, LSUMZ 198229 male, and LSUMZ 198230 female.

Etymology: *Zosterops meratusensis* is named for its type locality, the Meratus Mountains. It is likely restricted to this mountain range, which is isolated by >300 km from Borneo's main chain of high mountains.

Habitat: The habitat at 1350 m was montane rain forest moderately disturbed by harvesters of forest products.

Voice: Eaton et al. (2021) described the song of *Z. meratusensis* as a warbling series of high-pitched short notes, ending with a faster, lower-pitched jumble, lasting 1–3 s. Its call is a high-pitched, buzzy zip (Eaton et al. 2016a). Spectrogram visualization of 27 song phrases (*Z. meratusensis* $n = 14$, *Z. c. intermedius* $n = 13$) shows consistent differences, most notably a shorter duration of phrases and higher average frequency in *Z. meratusensis* (Fig. 13a, b). NMDS analysis based on time-warped fundamental frequency contours indicates that song phrases of *Z. meratusensis* and *Z. c. intermedius* form statistically discrete clusters (Fig. 13c).

Genetics: Shakya et al. (2018) found the ND2 sequence of *Z. meratusensis* averages 2.69% divergent from *Z. c. intermedius* of Sulawesi. Since publication of that study, more ND2 sequences of *Z. chloris* have become available, including those of *Z. flavissimus* (O'Connell et al. 2019), which occurs on small islands just southeast of Sulawesi's southeastern peninsula. O'Connell et al. (2019) recommended splitting *Z. c. flavissimus* from all mainland Sulawesi populations

Fig. 11 Lateral side showing the comparison of the upperparts and underparts between *Zosterops meratusensis* (right) with *Z. chloris chloris* (Mayu Is., Maluku; left)



Fig. 12 Lateral side showing the comparison of the upperparts and underparts between *Zosterops meratusensis* (right) with *Z. flavus* (West Java; left)



of *Z. chloris* based on plumage and its 2.05–2.35% ND2 divergence. Including these new sequences in a phylogenetic analysis (Fig. 14), we found that *Z. meratusensis* is relatively distant from the Sulawesi populations of *Z. chloris*, including *Z. flavissimus*.

Discussion

Both new species from the Meratus Mountains are isolated forms of widespread taxonomic groups. *Cyornis kadayangensis* is the sister of *C. montanus* (Fig. 9), which occurs in the main Bornean mountain range, and *Zosterops meratusensis* is sister to *Z. chloris* (Fig. 13), which spans the Java Sea and Wallacea. Both species have been isolated in the unique ecological circumstances of the Meratus Mountains. These mountains lie c. 300 km southeast of the central Bornean mountain chain, from which they are separated by low elevation forest, and they comprise a substantially limited subsample of Borneo's montane avifauna (Shakya et al. 2018). Several higher elevation Bornean endemics appear to be absent, such as Whitehead's Trogon *Harpactes whiteheadi*, Whitehead's Broadbill *Calyptomena whiteheadi*, Whitehead's Spiderhunter *Arachnothera juliae*, Pygmy Helea *Apalopteron squamifrons*, Mountain Black-eye *Zosterops emiliae*, and Black-capped White-eye *Z. atricapilla*. The combination of isolation and altered community

composition in the Meratus Mountains should have strongly influenced the population dynamics and, thus, evolutionary trajectory of the new species.

Cyornis kadayangensis is common to abundant in the Meratus Mountains from 500 to 1500 m. Its large elevational range and population size contrasts with *C. montanus* in the northern Bornean mountains, which has a fairly narrow submontane distribution and is nowhere abundant. The commonality of *C. kadayangensis* may be explained, in part, by a reduced number of competitors, both montane (as noted above) and lowland. Among low elevation species in the Meratus area, the only other *Cyornis* is the Bornean Jungle Flycatcher *C. superbis* (Eaton et al. 2016a), whereas in the forest surrounding the main Bornean range up to seven species may be found. In addition to *Cyornis* species, several other normally common lowland species are rare or have been extirpated from the Meratus area with the cutting and conversion of most low elevation forest to plantation (Shakya et al. 2018). Pellet-gun hunting and the pet trade have also taken a serious toll on smaller birds in the Meratus area (Eaton et al. 2015; Iqbal et al. 2018; Shakya et al. 2018).

Like *C. kadayangensis*, the invasion of the Meratus Mountains by the ancestors of *Z. meratusensis* was likely facilitated by the low number of potential competitors, including all three of the white-eye species found in the main Bornean mountain chain: *Z. atricapilla*, *Z. auriventer*, and *Z. emiliae*. The discovery of *Z. meratusensis* emphasizes the

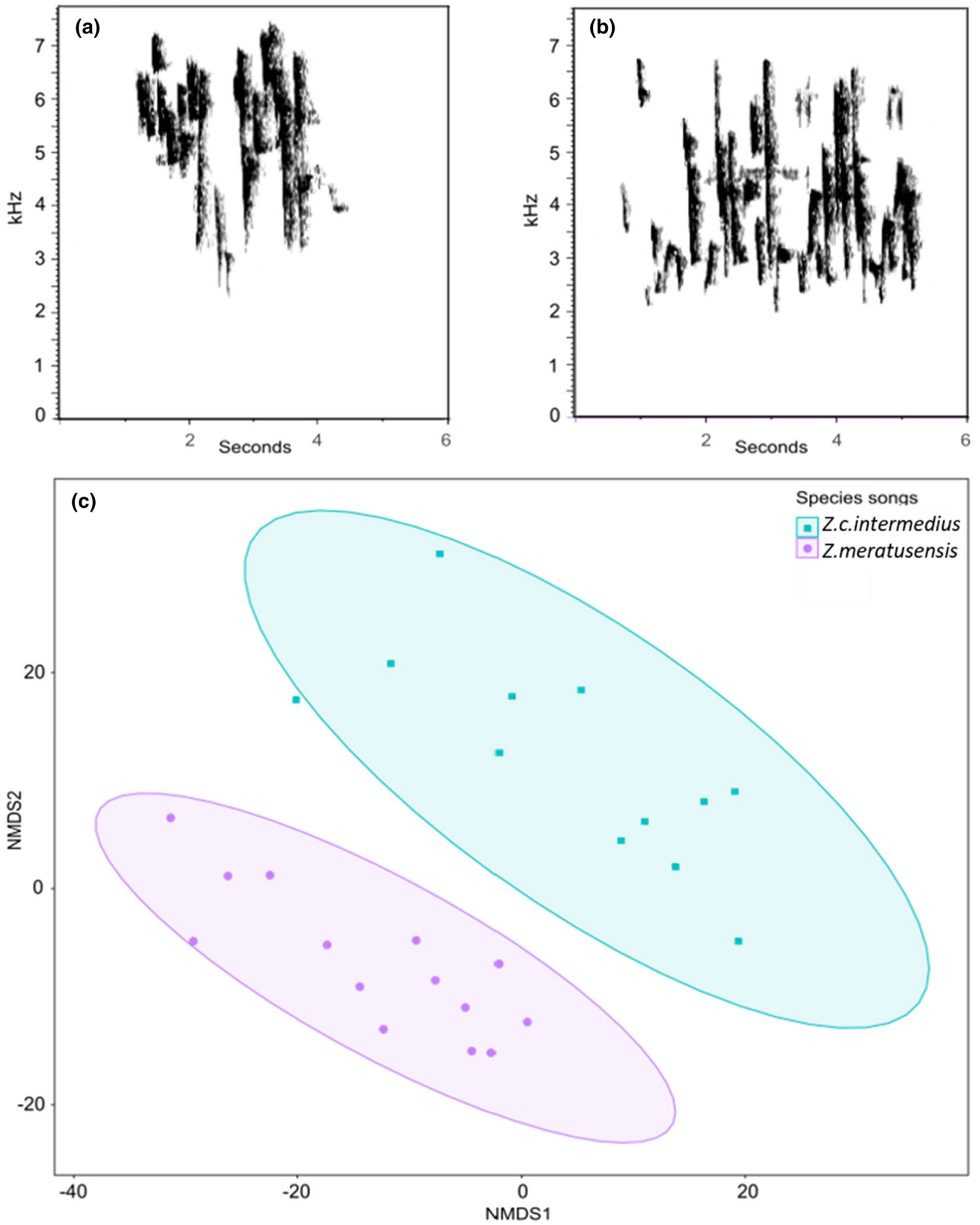


Fig. 13 Bioacoustic comparisons of *Zosterops meratusensis* and *Z. c. intermedius* including **a** a spectrogram of *Z. meratusensis*, **b** a spectrogram of *Z. chloris*, and **c** non-metric dimensional scaling of multiple song phrases of *Z. meratusensis* ($n=14$) and *Z. c. intermedius* ($n=13$), based on acoustic dissimilarity of fundamental frequency contours from multiple individuals (*Z. meratusensis* $n=4$; *Z. c. intermedius* $n=4$)

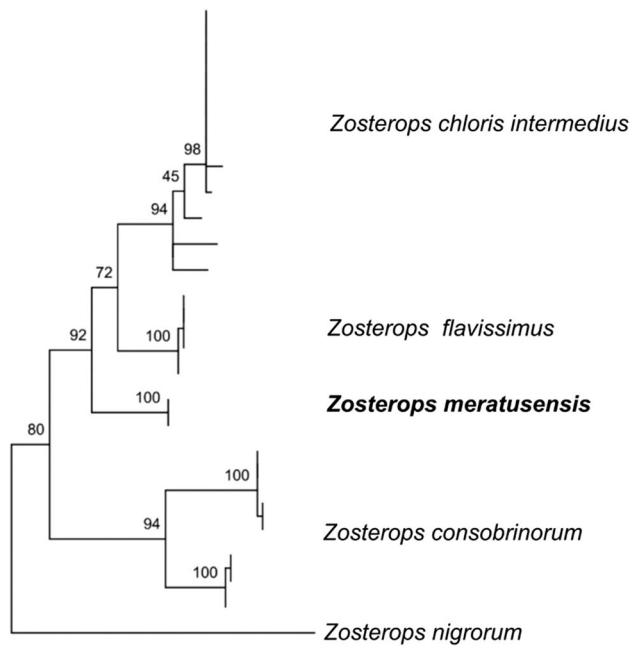


Fig. 14 Maximum-likelihood bootstrapped tree of selected *Zosterops* species constructed from mitochondrial ND2 sequences. Classification is according to Eaton et al. (2021) with the outgroup (*Z. nigrorum*) according to Gill et al. (2021)

uniqueness and importance of Borneo as a center of faunal mixing of discrete *Zosterops* lineages and, thus, diversification and radiation of the group (Gwee et al. 2020).

Conservation status

The lowland forest surrounding the Meratus Mountains has been heavily disturbed, converted to plantation, or completely removed, while the submontane and montane forest in the mountains is restricted to about 2460 km². Since the two new species occur only from 500 m asl upward, they occupy a relatively small area of the remaining intact habitat. Moreover, although Eaton et al. (2016a) and Shakya et al. (2018) noted that both species were common in the study area on Mount Besar and their populations are probably not immediately threatened, there is concern for their future as several lowland species that are popular cage birds have already been eliminated from the lower slopes of the

mountains (Shakya et al. 2018). Given the restricted range of habitat and likelihood of increasing pressure from bird poachers, we recommend the IUCN impose a Red List status of “Vulnerable” for both species, based on criteria B1 and B2, i.e., the extent of their occurrence is estimated to be less than 20,000 km² and the area of occupancy is estimated to be less than 2000 km² (IUCN 2019). In addition, we recommend protection for both species under local government decree, as this will be more effective in promoting the conservation not only of the new species but also the biodiversity of the Meratus Mountains in general. BirdLife International (2021) has taken an important first step in the process of publicizing the conservation needs of the Meratus Mountains by classifying them as an Important Bird Area (category A2 and A3).

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