



Amphibians and Reptiles Diversity in Bukit Baka Bukit Raya National Park, West Kalimantan

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Abstract

Studies related to herpetofauna diversity in the Bukit Baka Bukit Raya National Park (Tanakaya), West Kalimantan are very limited. Data related to the richness of amphibians and reptiles in this area are important for the management of the area in the future. We conducted amphibian and reptile surveys in Tanakaya in July-August 2019 using Visual Encounter Survey methods at five sites (Belaban Resort: Km 37 & 39; Resort Rantau Malam: Batu Lintang, Sungai Mangan, and Hulu Rabang). We recorded 50 amphibian species from nine families and 25 reptile species from seven different families. Twenty of these species are new records for Tanakaya. The highest diversity ($H' = 2.94$) was found in Batu Lintang, while the highest evenness ($E = 0.55$) was in Sungai Mangan, and the highest community similarity index ($IS = 0.6$) was in Batu Lintang with Km 37. Combined with previous studies, there have been 142 species (78 species of amphibians and 64 species of reptiles) recorded from Tanakaya. Further study is needed to fully understand the herpetofauna in Tanakaya, but our data highlights the importance of the national park for preserving global biodiversity.

Keywords: biodiversity, evenness, herpetofauna, richness, tanakaya

1. Introduction

Bukit Baka Bukit Raya National Park, also known as Tanakaya, is a national park administratively located in the two provinces of Central Kalimantan and West Kalimantan, Indonesia [1]. Tanakaya is one of four national parks in Kalimantan and is an important part of the forest protection program in the heart of Borneo [2]. Tanakaya has high levels of biodiversity, including amphibians and reptiles. Approximately a third of amphibian species (59 out of 180 species) and a quarter (53 reptiles out of 300 species) of reptiles in Borneo have been recorded from Tanakaya [1,3,4]. However, research and publications on amphibians and reptiles in Tanakaya are scarce compared to other taxa [1,5].

Tanakaya is home to a variety of endemic amphibians and reptiles, containing a habitat for the lungless frog (*Barbourula kalimantanensis*), which can only be found in the Tanakaya area [3]. Exploration related to amphibian and reptile groups in Tanakaya, and its buffer zone can be said to be limited, mostly studying *B. kalimantanensis* [5–9]. So far there are only four studies on the diversity of herpetofauna in the Tanakaya area and its buffer zone, including research by Kolanus et al. [10] and Mistar [11] in the PT Sari Bumi Kusuma (SBK) area, Sardi et al. [12] in Lekawai Resort (now Mentatai), and the latest research by Abduh et al. [1], which examined the biodiversity of Tanakaya (including herpetofauna).

The lack of research on herpetofauna in Tanakaya shows that the potential for new findings is still high, including new species, and new records. According to Iskandar and Erdelen [13], herpetofauna are taxa that are poorly understood in Indonesia, with a far from complete

knowledge of species numbers and distribution patterns and their evolution. The objectives of this study were to inventory herpetofauna species in two resorts (Belaban Resort and Rantau Malam Resort) at Tanakaya and compare them with previous studies.

2. Research Methodology

Surveys were carried out in two locations (Belaban Resort and Rantau Malam Resort) with five sites in the Tanakaya, two sites in Belaban Resort-Km.37 (0.60472° N, 112.244° E), and Km. 39 (0.62983° N, 112.262° E), and three sites in Rantau Malam Resort namely Batu lintang (0.51648°N, 112.601°E), Sungai Mangan (0.5527° N, 112.611° E), and Hulu Rabang (-0.6023° N, 112.650° E) (Figure 1). Data collection was conducted for 14 days, from July 22 to August 07, 2019.

The Tanakaya is a mountainous tropical rainforest ecosystem with an elevation range between 150 – 750 m asl. The forest has a dense canopy cover and a relatively sparse understory and shallow rivers with a width of 1 – 25 m. The research site has a neutral soil pH ranging from 6.7 - 7.0 and soil temperature during the day between 22° - 24°C.

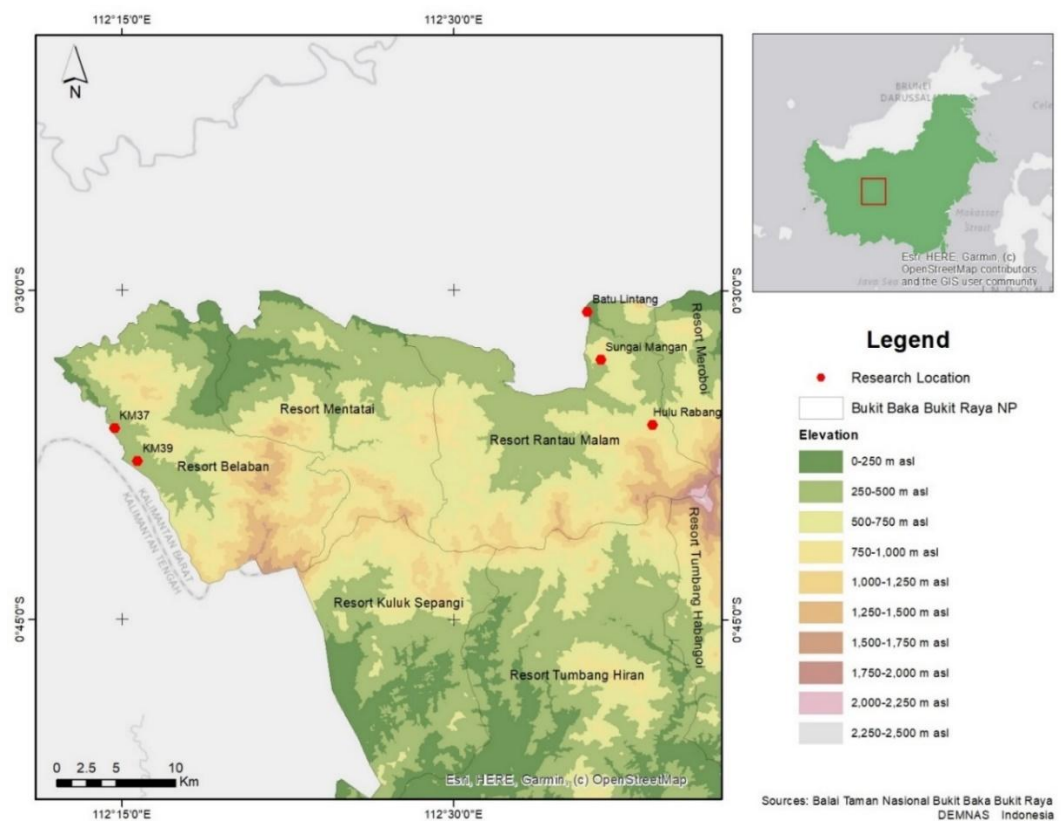


Figure 1. Amphibian and reptile survey sites in Bukit Baka Bukit Raya National Park (Tanakaya)

A Visual Encounter Survey (VES) method was used in this study. Data collection was conducted by 4 – 6 people. Active searches were conducted during the day and evening time, with transect lengths of 1 km across terrestrial and aquatic habitats. Data recorded during surveys were species ID, number of individuals of each species, the activity of the animal when found (e.g., vocalizing, resting, basking), substrate on which the animal was found on, the time of encounter, and the coordinates. Species were identified using “A Field Guide to the Frogs of Borneo” [3] and the “2018 Biodiversity Database Book of Bukit Baka Bukit Raya National Park” [1].

All amphibians and reptiles found in this study can be found on the iNaturalist.org page through the “fhadlikennedi” and “zainudin” accounts with searches in July – August 2019. One individual of each amphibian species found was euthanized with MS-222, fixed in 5%

formalin, and stored in 70% alcohol for further identification. The specimens of this study are stored at the Tanakaya Office, in Sintang, West Kalimantan.

The conservation status of the species encountered during this survey was assessed with Regulation of the Ministry of Environment of the Republic of Indonesia for protected flora and fauna (No. P.106/ MENLHK/ SETJEN/ KUM.1/ 12/ 2018), CITES Appendix, and IUCN Red List. Data were analysed quantitatively to compare communities between sites using the Shannon-Wiener Diversity Index (H') [14] and Evenness Index (E) [15]. The community similarity index was analysed using Bray-Curtis similarity index with PAST 4.03 [16,17].

3. Results and Discussion

3.1. Amphibian and reptile composition

In this study, we identified 50 amphibian species (two orders, nine families) and 25 reptile species (one order, seven families), including species that were only identified to genus level; *Ichthyophis* sp., *Leptobranchella* sp., *Leptobranchium* sp., *Philautus* sp., four *Cyrtodactylus* sp., and *Tropidophorus* sp. (Figure 2). We identified 25 amphibian species and 16 reptile species from the Belaban Resort while 46 amphibian species and 14 reptile species were found at the Rantau Malam Resort. The site with the most herpetofauna species was in Batu Lintang (Rantau Malam Resort) with 28 amphibian species and eight reptile species, while the site with the least number of species was at Km. 39 (Belaban Resort) with eight amphibian species and six reptile species. *Ansonia minuta* was the most common amphibian species found during data collection with a total of 97 individuals (Km. 37 = 61, Hulu Rabang = 20, Batu lintang = 11, and Sungai Mangan = 5) and the most common reptile species was *Tropidophorus* cf. *brookei* with a total of 22 individuals (Km. 37 = 14, Batu Lintang = 6, and Sungai Mangai = 2).

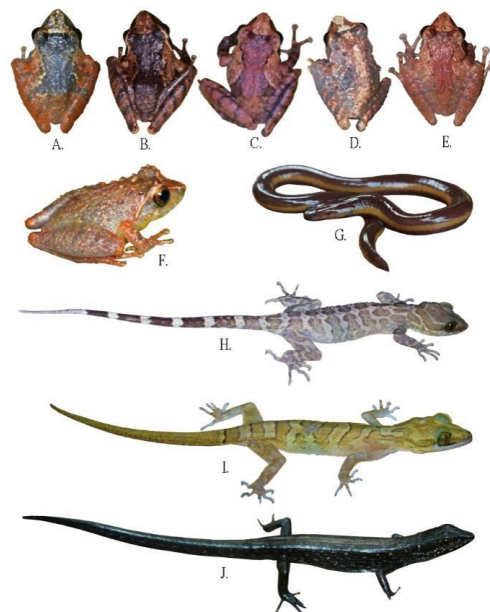


Figure 2. Individuals not identified at the species level. (a) *Philautus* sp. from Rantau Malam Resort, (b-f) color variation and dorsal pattern on specimens of *Philautus* sp. from Rantau Malam Resort, (g) limbless amphibian *Ichthyophis* sp. from Belaban Resort, (h-i) two species of curved finger lizard (*Cyrtodactylus* sp.), and (j). Water lizard (*Tropidophorus* sp.) from Rantau Malam Resort (Photograph: Zainudin).

Based on the list of herpetofauna species that have been recorded, there were no species protected by the Minister of Environment and Forestry Regulation of the Republic of Indonesia No. P.106/ MENLHK/ SETJEN/ KUM.1/ 12/ 2018. Meanwhile, based on CITES Appendix status, there are two reptile species included in Appendix II; *Python breitensteini*

and *Notochelys platynota* (Figure 3). These two species are commonly traded for either the pet trade or for consumption purposes [18–20].

Table 1. List of amphibians and reptiles identified in the Tanakaya

Species	English Name	IUCN Redlist	Appendix CITES	Endemic Borneo	Resort	
					Belaban	Rantau Malam
Amphibia						
Bombinatoridae						
<i>Barbourula kalimantanensis</i>	Bornean Flat-headed Frog	EN	-	yes	x	✓
Bufoidea						
<i>Ansonia albomaculata</i>	White-lipped Slender Toad	LC	-	yes	x	✓
<i>Ansonia leptopus</i>	Brown Slender Toad	LC	-	no	✓	✓
<i>Ansonia minuta</i>	Minute Slender Toad	LC	-	yes	✓	✓
<i>Ansonia spinulifer</i>	Spiny Slender Toad	LC	-	yes	✓	✓
<i>Ingerophrynus divergens</i>	Crested Toad	LC	-	no	x	✓
<i>Phrynoidis asper</i>	River Toad	LC	-	no	✓	✓
<i>Phrynoidis juxtasper</i>	Giant River Toad	LC	-	no	✓	✓
Ceratobatrachidae						
<i>Alcalus rajae</i>	-	NT	-	yes	✓	x
Dicroglossidae						
<i>Limnonectes asperatus</i>	-	LC	-	yes	x	✓
<i>Limnonectes ibanorum</i>	Rough-backed River Frog	LC	-	yes	✓	✓
<i>Limnonectes kuhlii</i>	Kuhl's Creek Frog	LC	-	no	✓	✓
<i>Limnonectes leporinus</i>	Giant River Frog	LC	-	no	✓	x
<i>Limnonectes palavanensis</i>	Smooth Guardian Frog	LC	-	no	x	✓
<i>Limnonectes paramacrodon</i>	Lesser Swamp Frog	NT	-	no	✓	✓
<i>Occidozyga baluensis</i>	Seep Frog	LC	-	no	✓	✓
<i>Limnonectes hikidai</i>	Rivulet Frog	-	-	yes	✓	✓
Ichthyophiidae						
<i>Ichthyophis</i> sp.	-	-	-	-	✓	x
Megophryidae						
<i>Leptobranchella fritinniensis</i>	Twittering Slender Litter Frog	DD	-	yes	x	✓
<i>Leptobranchella gracilis</i>	Sarawak Slender Litter Frog	LC	-	yes	x	✓
<i>Leptobranchium abbotti</i>	Lowland Litter Frog	LC	-	no	x	✓
<i>Pelobatrachus nasutus</i>	Long-nosed Horned Frog	LC	-	no	x	✓
<i>Leptobranchella</i> sp.	-	LC	-	-	x	✓
<i>Leptobranchella hamidi</i>	-	EN	-	yes	✓	✓
<i>Leptobranchium</i> sp.	-	LC	-	-	✓	✓
Microhylidae						
<i>Kalophrynus baluensis</i>	Kinabalu Sticky Frog	LC	-	yes	x	✓
<i>Kalophrynus meizon</i>	Bornean Sticky Frog	-	-	yes	x	✓
<i>Microhyla berdmorei</i>	Large Pygmy Frog	LC	-	no	x	✓
<i>Microhyla malang</i>	Bornean Narrow-mouthed Frog	LC	-	yes	x	✓
<i>Nanohyla perparva</i>	Labang Forest Rice Frog	LC	-	yes	x	✓
Ranidae						
<i>Chalcorana megalonesa</i>	Large White-lipped Frog	LC	-	no	x	✓
<i>Chalcorana raniceps</i>	Borneo White-lipped Frog	LC	-	no	✓	✓
<i>Indosylvirana nicobariensis</i>	Nicobarese Frog	LC	-	no	✓	x
<i>Meristogenys jerboa</i>	Western Torrent Frog	VU	-	yes	✓	✓
<i>Odontophrynus hosii</i>	Poisonous Rock Frog	LC	-	no	✓	✓

Species	English Name	IUCN Redlist	Appendix CITES	Endemic Borneo	Resort	
					Belaban	Rantau Malam
<i>Pulchrana picturata</i>	Spotted Stream Frog	LC	-	no	✓	✓
<i>Staurois guttatus</i>	Black-spotted Rock Skipper	LC	-	yes	✓	✓
<i>Staurois latopalmaris</i>	Sabah Splash Frog	LC	-	yes	✓	✓
<i>Staurois tuberilinguis</i>	Green-spotted Foot-flagging Frog	LC	-	yes	✓	✓
<i>Meristogenys cf. orphnocnemis</i>	Northern Torrent Frog	LC	-	yes	x	✓
Rhacophoridae						
<i>Feihyla kajau</i>	Charming Tree Frog	LC	-	yes	x	✓
<i>Leptomantis malkmusi</i>	Malkmus' Tree Frog	LC	-	yes	x	✓
<i>Nyctixalus pictus</i>	Peter's Tree Frog	NT	-	no	✓	✓
<i>Philautus hosii</i>	Hose's Bush Frog	LC	-	yes	x	✓
<i>Philautus macroscelis</i>	Mossy Bush Frog	LC	-	yes	x	✓
<i>Polypedates colletti</i>	Collett's Tree Frog	LC	-	no	x	✓
<i>Polypedates macrotis</i>	Dark-eared Tree Frog	LC	-	no	✓	✓
<i>Polypedates otitophus</i>	File-eared Tree Frog	LC	-	yes	x	✓
<i>Rhacophorus pardalis</i>	Harlequin Tree Frog	LC	-	no	x	✓
<i>Philautus sp.</i>	-	LC	-	-	x	✓
Reptilia						
Agamidae						
<i>Aphaniotis ornata</i>	Ornate Earless Agama	LC	-	Yes	x	✓
<i>Draco sumatranus</i>	Sumatran Flying Dragon	LC	-	no	✓	x
<i>Gonocephalus grandis</i>	Malayan Crested Lizard	LC	-	no	✓	✓
<i>Gonocephalus liogaster</i>	Blue-eyed Anglehead Lizard	LC	-	no	x	✓
<i>Pelturagonia nigrilabris</i>	Blacklipped Eyebrow Lizard	-	-	no	x	✓
Colubridae						
<i>Ahaetulla prasine</i>	Oriental Whipsnake	LC	-	no	✓	✓
<i>Aplopeltura boa</i>	Blunthead Slug Snake	LC	-	no	x	✓
<i>Boiga jaspidea</i>	Jasper Cat Snake	LC	-	no	✓	x
<i>Hebius flavifrons</i>	Sabah Keelback	LC	-	yes	✓	✓
<i>Liopeltis tricolor</i>	Malayan Ringneck	LC	-	no	✓	x
<i>Rhabdophis chrysargos</i>	Specklebelly Keelback	LC	-	no	✓	x
<i>Rhabdophis rhodomelas</i>	Blue-necked Keelback	LC	-	no	x	✓
Elapidae						
<i>Calliophis bivirgatus tetrataeniatus</i>	Blue Malaysian Coralsnake	LC	-	no	✓	x
Gekkonidae						
<i>Aeluroscalabotes felinus</i>	Cat Gecko	LC	-	no	x	✓
<i>Cyrtodactylus sp.1</i>	-	-	-	-	✓	x
<i>Cyrtodactylus sp.2</i>	-	-	-	-	✓	x
<i>Cyrtodactylus sp.3</i>	-	-	-	-	x	✓
<i>Cyrtodactylus sp.4</i>	-	-	-	-	x	✓
Geoemydidae						
<i>Notochelys platynota</i>	Malayan Flat-shelled Turtle	VU	II	no	✓	✓
Pythonidae						
<i>Python breitensteini</i>	Bornean Short Python	LC	II	yes	✓	x
Scincidae						

Species	English Name	IUCN Redlist	Appendix CITES	Endemic Borneo	Resort	
					Belaban	Rantau Malam
<i>Dasia olivacea</i>	Olive Dasia	LC	-	no	✓	x
<i>Eutropis multifasciata</i>	Common Sun Skink	LC	-	no	✓	x
<i>Eutropis rudis</i>	Rough Mabuya	LC	-	no	✓	x
<i>Tropidophorus sp.</i>	-	-	-	-	x	✓
<i>Tropidophorus cf. brookei</i>	Brook's Keeled Skink	LC	-	yes	✓	✓

Notes: DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, ✓ = Presence, X = Absence.

Based on the IUCN Red List, one amphibian species, the lungless frog (*Barbourula kalimantanensis*) categorized as Endangered (EN), was recorded at Rantau Malam Resort (Figure 3). During the data collection, only one of this species was found in Batu Lintang, trapped in a local fishing net. Based on the explanation of the people of Rantau Malam Village, *B. kalimantanensis* was often found trapped in fishing nets and was also consumed by local people. This frog is an endemic species with a limited distribution, only found in West Kalimantan and Central Kalimantan, especially in Tanakaya [3,7,9]. Based on reports from Maisyara *et al.* [5], *B. kalimantanensis* inhabits wide rivers with rocky sand substrates and fast currents of 100 m/min, light intensity of 125.5 Cd, 3.6 Mg/L TDS (Total Dissolved Solids), 9 Mg/L TSS (Total Suspended Solids), and 7.10 ppm DO (Dissolved Oxygen). In addition to *B. kalimantanensis*, 25 amphibian species and four reptile species are endemic to Kalimantan (see Table 1).



Figure 3. *Notochelys platynota* (top left) and *Python breitensteini* (top right) and *Barbourula kalimantanensis* (bottom) were collected at Rantau Malam Resort (Photograph: Umar F. Kennedy)

3.2. Amphibian and Reptile Diversity

The highest Shannon-Wiener Diversity Index for amphibians was found in Batu Lintang, Rantau Malam Resort with 2.79, while the lowest at 1.45 was found in Km. 39, Belaban Resort (Table 2). The Evenness Index of amphibians for each site was ranged from 0.42 - 0.52 with the highest found in Sungai Mangan, Rantau Malam Resort and the lowest was in Km. 39 (Belaban Resort) (Table 2). The diversity index at Batu Lintang was likely to be the highest due to the site's good canopy cover and the presence of a variety of water courses (25 m wide rivers and small rivers <10 m). The lowest diversity index at Km. 39 was probably

because this site had relatively open canopy cover compared to other sites with no smaller water courses (25 m).

The Shannon-Wiener Diversity Index for reptiles was relatively low, ranging from 1.09 - 1.91, with the highest value at Km. 37 and the lowest value at Hulu Rabang (Rantau Malam Resort) (Table 2). Km. 37 and Km. 39 in Belaban Resort were the sites with the highest diversity index scores and were in forests with relatively closed canopy cover with an elevation of around 300 m asl. Hulu Rabang (Rantau Malam Resort) likely had the lowest value because this site was at a higher elevation (ca. 750 m asl). The Evenness Index varied from 0.83 (Km. 39) to 0.47 (Hulu Rabang). The high Evenness Index scores indicated that reptile species were evenly distributed, and no species dominated [14].

Table 2. Shannon-Wiener Diversity Index (H') and Evenness Indices (E) for amphibians and reptiles in Belaban and Rantau Malam Resorts.

Resort	Sites	Amphibian		Reptile	
		H'	E	H'	E
Belaban	Km. 37	2.35	0.45	1.91	0.53
	Km. 39	1.45	0.42	1.73	0.83
	Batu Lintang	2.79	0.50	1.65	0.58
Rantau Malam	Sungai Mangan	2.58	0.52	1.74	0.79
	Hulu Rabang	2.34	0.51	1.09	0.47

3.1. Similarity of communities

Based on the distribution of amphibian communities, two sites having a similar level based on the Bray-Curtis Similarity Index were Km. 37 (Belaban Resort) and Batu Lintang (Rantau Malam Resort) (Table 3) with a value of 0.71. These two sites had similar characteristics with elevations of 200 – 300 m asl, with a wide, rocky river (>25 m width), dense forest canopy and little understory. The Bray-Curtis Similarity Index for reptiles formed two clusters, the highest Hulu Rabang and Sungai Mangan (Rantau Malam Resort) (0.50), followed by Km. 37 (Belaban Resort) and Batu Lintang (Rantau Malam Resort) (0.42) (Table 3). Hulu Rabang and Sungai Mangan shared similar habitat characteristics, including an elevation of 700 – 750 m asl, many small rivers (<10 m width), and a dense forest canopy.

Table 3. Bray-Curtis Similarity Index

Sites	Amphibian					Reptile				
	BL**	HR**	KM37*	KM39*	SM**	BL**	HR**	KM37*	KM39*	SM**
BL**	1.00					1.00				
HR**	0.38	1.00				0.29	1.00			
KM37*	0.71	0.43	1.00			0.42	0.24	1.00		
KM39*	0.28	0.15	0.39	1.00		0.00	0.00	0.12	1.00	
SM**	0.50	0.51	0.55	0.06	1.00	0.43	0.50	0.35	0.00	1.00

Notes: BL = Batu Lintang, HR = Hulu Rabang, SM = Sungai Mangan. * = Belaban Resort, ** = Rantau Malam Resort.

The species composition based on site elevation revealed interesting patterns. In the Ranidae family, the abundance of individuals found became smaller as the elevation of the location increased (Figure 4). At the lowest elevation at Batu Lintang (174 m asl), 168 individuals of Ranidae were found, while only 62 individuals were found at Km. 37 (300 m asl) and at the highest location (750 m asl), only 29 individuals were found. In contrast, in the Rhacophoridae family, the number of species increased as the elevation of the location increased. There were three species of the Rhacophoridae family in Batu Lintang while seven species were found in Mangan River (700 m asl).

The composition of reptiles based on the number of species and abundance in the Geoemydidae and Scincidae decreased as the elevation of the location increased. Geoemydidae were not found below 300 m asl (Km. 37) and Scincidae were not also found below 700 m asl (Sungai Mangan). This is in line with the opinion of Malkmus *et al.* [21], that the number of amphibian and reptile species will decrease with increasing elevation. This is likely due to reduced ecological niches and food availability (especially invertebrates).

However, it is still not possible to make a definitive statement based on the data obtained from this study. This is due to the limited location of data collection, which was restricted an elevation of 150 – 750 m asl and the maximum elevation in Tanakaya reached 2,278 m asl. However, this data can provide an overview and potential for future research on amphibian and reptile in Tanakaya.

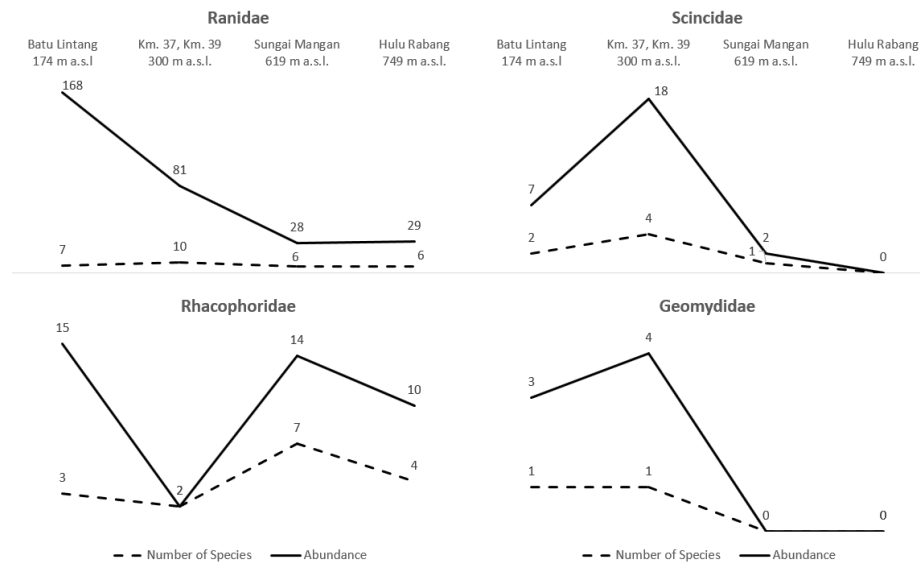


Figure 4. Species and abundance trend based on elevation.

3.2. Comparison with previous research

There were two studies of amphibian and reptile species from PT. SBK (Sari Bumi Kusuma) area, which was bordered by the west and north of the Belaban Resort. The first report recorded 47 species of amphibians and 32 species of reptiles based on a survey conducted in Km. 54, Km. 96C, Km. 69, Duwai River, Makar River and Seruyan River [11]. Another report recorded 29 amphibian species f based on survey conducted in Km. 35, Km. 37, Km. 39, and Km. 54 [10]. Inside the Tanakaya area, study of amphibians and reptiles was conducted at Lengkwai Resort (now Mentatai Resort) and recorded 24 amphibian species and 11 reptile species [12]. The latest publication of herpetofauna can be found in the “2018 Biodiversity Database Book of Bukit Baka Bukit Raya National Park”, which recorded 59 amphibian species (nine families) and 53 reptile species (five families) [1].

Compared to previous studies, there were 23 amphibian species and 52 reptile species that were absent in this study, while there were 14 amphibian species and six reptile species that had not been recorded before (Appendix 1). The distribution of the observed species was categorized as common (widely distributed in many habitat/location), uncommon (distributed in limited/some habitat/area), and rare (endemic species with single locality and limited encountered) based on data from reptile-database.org, amphibiansoftheworld.amnh.org and observation record in Borneo by Inaturalist.org [4,22], we categorized the distribution. There were eight amphibian species and 17 reptile species, categorized as common, 10 amphibian species and 22 reptile species categorized as uncommon, and nine species amphibian and six reptile species as rare (Table 4). Fewer species were found in this study compared to other studies due to a shorter time, and research area that did not cover different kind of habitat and the Tanakaya area.

Several species listed in the “2018 Biodiversity Database Book of Bukit Baka Bukit Raya National Park”, did not actually exist in Tanakaya, and had been incorrectly assigned taxonomic status, e.g. *Kurixalus appendiculatus* should be *Kurixalus chaseni* [23]; *Gonocephalus bellii* is synonymous with *Gonocephalus borneensis* [21]; *Rana chalconota* in Kalimantan was split into *Chalcorana megalonesa* and *Chalcorana raniceps* [24] but it is unsure which occurs in Tankaya; *Leptobrachium nigrops* records in Borneo had been divided into *L. ingeri* and *L. kanowitense* [22]; misidentification of the colubrid snake *Dendrelaphis*

cyanochloris, in which Uetz *et al.* [4] mentions that this species did not occur in Borneo (the species recorded in Tanakaya is possibly *D. formosus*). *Malayemis subtrijuga* is a non-native species (possibly misidentified in Abduh *et al.* [1]) with a natural distribution in the Mekong river- South Vietnam, Cambodia, East Thailand and Laos [25].

Rare species are representative of having limited geographic range and observations. We recorded three amphibian species (*Alcalus sariba*, *Leptobranchella mjobergi*, *Leptobranchium nigrops*) and three reptile species (*Anomochilus leonardi*, *Cyrtodactylus baluensis*, *Homalophis doriae*) that are potentially new records for Indonesia.

Table 4. List of amphibian and reptile species from previous studies [1,10–12] but absent in this survey.

Common	Uncommon	Rare
<i>Amphibian</i>		
<i>Duttaphrynus melanostictus</i>	<i>Ansonia longidigita</i>	<i>Pelophryne rhopophilia</i>
<i>Fejervarya limnocharis</i>	<i>Rentapia hosii</i>	<i>Alcalus baluensis</i>
<i>Limnonectes malesianus</i>	<i>Chaperina fusca</i>	<i>Alcalus sariba</i>
<i>Occidozyga sumatrana</i>	<i>Metaphrynella sundana</i>	<i>Occidozyga rhacoda</i>
<i>Kalophrynus pleurostigma</i>	<i>Abavorana luctuosa</i>	<i>Leptobranchella mjobergi</i>
<i>Hylarana erythraea</i>	<i>Huia cavitympanum</i>	<i>Leptobranchium nigrops</i> (possibly misidentified)
<i>Pulchrana baramica</i>	<i>Meristogenys phaeomerus</i>	<i>Leptolalax dringi</i>
<i>Polypedates leucomystax</i>	<i>Meristogenys poecilus</i>	<i>Leptolalax hamidi</i>
	<i>Kurixalus chaseni</i>	<i>Rhacophorus dulitensis</i>
	<i>Leptomantis gauni</i>	
<i>Reptile</i>		
<i>Bronchocela cristatella</i>	<i>Gonocephalus bornensis</i>	<i>Anomochilus leonardi</i>
<i>Draco cornutus</i>	<i>Gonocephalus doriae</i>	<i>Pseudorabdion albonuchalis</i>
<i>Draco melanopogon</i>	<i>Pelturagonia borneensis</i>	<i>Cyrtodactylus baluensis</i>
<i>Draco quinquefasciatus</i>	<i>Ahaetulla fasciolata</i>	<i>Orlitia borneensis</i>
<i>Boiga dendrophila</i>	<i>Boiga drapiezii</i>	<i>Homalophis doriae</i>
<i>Dendrelaphis caudolineatus</i>	<i>Dendrelaphis formosus</i>	<i>Tropidophorus micropus</i>
<i>Gonyosoma oxycephalum</i>	<i>Dendrelaphis striatus</i>	
<i>Psammodynastes pictus</i>	<i>Gongylosoma longicauda</i>	
<i>Bungarus fasciatus</i>	<i>Oligodon signatus</i>	
<i>Naja sumatrana</i>	<i>Pseudorabdion longiceps</i>	
<i>Ophiophagus Hannah</i>	<i>Stegonotus borneensis</i>	
<i>Heosemys spinosa</i>	<i>Cyrtodactylus consobrinus</i>	
<i>malayopython reticulatus</i>	<i>Cyrtodactylus malayanus</i>	
<i>Dasia vittata</i>	<i>Cyrtodactylus yoshii</i>	
<i>Takydromus sexlineatus</i>	<i>Malayemis subtrijuga</i>	
<i>Amyda cartilaginea</i>	<i>Rhabdophis conspicillatus</i>	
<i>Varanus salvator</i>	<i>Xenochrophis maculatus</i>	
	<i>Asthenodipsas malaccanus</i>	
	<i>Tropidophorus brookei</i>	
	<i>Manouria emys</i>	
	<i>Varanus rudicollis</i>	
	<i>Trimeresurus sumatranus</i>	

Based on this study, we found at least 20 new species for Kalimantan (14 amphibian species and six reptile species): *Ansonia albomaculata*, *Limnonectes hikidai*, *Occidozyga baluensis*, *Leptolalax fritinniensis*, *Kalophrynus heterochirus*, *Kalophrynus meizon*, *Microhyla berdmorei*, *Hylarana megalonesa*, *Meristogenys perissenensis*, *Staurois tuberilinguis*, *Nyctixalus pictus*, *Philautus amoenus*, *Philautus hosii*, *Philautus macroscelis*, *Draco sumatranus*, *Aplopeltura boa*, *Boiga jaspidae*, *Liopeltis tricolor*, *Python breitensteini*, and *Dasia olivacea* (Figure 5, Appendix 1). Overall, combined with previous studies, Tanakaya herpetofauna diversity

consisted of 142 species with 78 species of amphibians (nine families) and 64 species of reptiles (16 families).



Figure 5. *Staurois tuberilinguis* (top left), *Ansonia albomaculata* (top right), *Boiga jaspidae* (bottom left) and *Liopeltis tricolor* (bottom right). (Photograph: Umar F. Kennedy and Zainudin)

8. Conclusion

This report presents the discovery of 75 species of herpetofauna (50 species of amphibian and 25 species of reptile) in two different resorts in Tanakaya, with 20 being new national park records. Batu Lintang (Rantau Malam Resort) had highest species diversity for amphibians, while Km 37 of Belaban Resort had the highest reptile diversity. Habitat type seemed to determine the diversity of amphibian and reptile species more than geographic location. Following this study, there have been 142 species (78 species of amphibians and 64 species of reptiles) recorded from Tanakaya. Further research is needed, especially in areas where similar surveys have not been conducted, to better understand the diversity of herpetofauna.

Author Contributions

UFK: Conceptualization, Methodology, Investigation, Formal Analysis, Writing – original draft; **Z:** Conceptualization, Methodology, Investigation, Writing – original draft; **SP:** Funding acquisition, Investigation, Project administration; **MJ:** Methodology, Investigation, Writing – original draft; **MDK:** Supervision, Project administration, Writing - Review & Editing; **OJP:** Investigation; **AVY:** Investigation; **STM:** Funding acquisition, Supervision, Writing - Review & Editing.

Conflicts of interest

There are no conflicts to declare.

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References

1. Abduh, M.; Priyandono, H.; S. Harikurniawan, A. *Buku Database Keanekaragaman Hayati Balai Taman Nasional Bukit Baka Bukit Raya Tahun 2018*; Abduh, M., Priyandono, H., Eds.; Balai Taman Nasional Bukit Baka Bukit Raya: Sintang, 2018; ISBN 978-602-604-972-8.
2. Firmansyah, R.P.; Purnomo, E.P.; Kasiwi, A.N.; Sadayi, D.P. Program Heart Of Borneo WWF dalam Pelestarian Hutan di Kalimantan. *Jurnal Hutan Tropika* **2021**, *9*, 94, doi:10.20527/jht.v9i1.10477.
3. Inger, R.F.; Stuebing, R.B.; Grafe, T.U.; Dehling, M.J. *A Field Guide to the Frogs of Borneo*; 3rd ed.; Natural History Publications (Borneo): Kota Kinabalu, Sabah, Malaysia, 2017; ISBN 978 983 812 176 7.
4. Uetz, P.; Freed, P.; Aguilar, R.; Reyes, F.; Kudera, J.; Hošek, J. The Reptile Database Available online: <http://www.reptile-database.org> (accessed on 28 April 2023).
5. Maisyara, S. Mikrohabitat Katak Tanpa Paru-Paru (*Barbourula kalimantanensis* Iskandar, 1978) di Kawasan Taman Nasional Bukit Baka Bukit Raya Kabupaten Melawi Kalimantan Barat. *Jurnal Hutan Lestari* **2019**, *7*, doi:10.26418/jhl.v7i2.33866.
6. Iskandar, D.T. A New Species of *Barbourula*: First Record of a Discoglossid Anuran in Borneo. *Copeia* **1978**, *1978*, 564, doi:10.2307/1443681.
7. Santoso, E.; Shonleben, S.; Sapari, I.; Sadikin, L.A. *Barbourula kalimantanensis* Iskandar, 1978 – a New Record for Central Kalimantan, Indonesian Borneo (Amphibia: Anura: Discoglossidae). *Herpetol. Bull.* **2006**, *98*, 7–9.
8. Bickford, D.; Iskandar, D.; Barlian, A. A Lungless Frog Discovered on Borneo. *Curr. Biol.* **2008**, *18*, R374–R375, doi:10.1016/j.cub.2008.03.010.
9. Rachmayuningtyas, B.A.; Bickford, D.P.; Kamsi, M.; Kutty, S.N.; Meier, R.; Arifin, U.; Rachmansah, A.; Iskandar, D.T. Conservation Status of the Only Lungless Frog *Barbourula kalimantanensis* Iskandar, 1978 (Amphibia: Anura: Bombinatoridae). *J. Threat. Taxa* **2011**, *3*, 1981–1989, doi:10.11609/JoTT.o2560.1981-9.
10. Kolanus, F.; Yunanti, B.D.; Kaban, A. Keanekaragaman Amfibi di Kawasan Penyangga Taman Nasional Bukit Baka Bukit Raya (Studi Kasus PT. Sari Bumi Kusuma, Kalimantan Barat), Institut Pertanian Bogor: Bogor, Indonesia, 2008.
11. Kamsi, M. *Warta Herpetofauna*. 2008, pp. 12–14.
12. Sardi, M.; Siahaan, S. Keanekaragaman Herpetofauna di Resort Lekawai Kawasan Taman Nasional Bukit Baka Bukit Raya Kabupaten Sintang Kalimantan Barat. *Jurnal Hutan Lestari* **2014**, *2*, doi:<http://dx.doi.org/10.26418/jhl.v2i1.5504>.
13. Iskandar, J.I.; Erdelen, W. Conservation of Amphibians and Reptiles in Indonesia: Issues and Problems. *Amphib. Reptile Conserv.* **2006**, *4*, 60–87, doi:10.1514/journal. arc. 0040016.
14. Krebs, C.J. *Ecological Methodology*; Harper & Row Publishers, New York: New York, 1989; ISBN 0-06-043784-7.
15. Brower, J.E.; Zar, J.H.; Von Ende, C.N. *Field and Laboratory Methods for General Ecology*; 4rd ed.; McGraw-Hill: Boston, MA, 1998; ISBN 0-697-24358-3.
16. Hammer, O.; Harper, D.A.T.; Ryan, P.D. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontol. Electron.* **2001**, *4*, preprint 4: 9pp.
17. Bray, J.R.; Curtis, J.T. An Ordination of the Upland Forest Communities of Southern Wisconsin. *Ecol. Monogr.* **1957**, *27*, 325–349, doi:10.2307/1942268.
18. Kusrini, M.; Palesa, S.P.; Masy'ud, B. Snake Pet Ownership in the City: A Case Study in Greater Jakarta, Indonesia. *Biodiversitas J. Biol. Divers.* **2021**, *22*, doi:10.13057/biodiv/d220424.
19. Luiselli, L.; Bonnet, X.; Rocco, M.; Amori, G. Conservation Implications of Rapid Shifts in the Trade of Wild African and Asian Pythons. *Biotropica* **2012**, *44*, 569–573, doi:10.1111/j.1744-7429.2011.00842.x.

20. Mardiasuti, A.; Masy'ud, B.; Ginoga, L.N.; Sastranegara, H.; Sutopo Traditional Uses of Herpetofauna Practiced by Local People in the Island of Sumatra, Indonesia: Implications for Conservation. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *762*, 012003, doi:10.1088/1755-1315/762/1/012003.
21. *Amphibians & Reptiles of Mount Kinabalu (North Borneo)*; Malkmus, R., Ed.; Gantner: Ruggell, 2002; ISBN 978-3-904144-83-4.
22. Frost, Darrel R. 2023. Amphibian Species of the World: an Online Reference. Version 6.2 (accessed on 31 January 2023). Electronic Database accessible at <https://amphibiansoftheworld.amnh.org/index.php>. American Museum of Natural History, New York, USA. doi.org/10.5531/db.vz.0001.
23. Matsui, M.; Kawahara, Y.; Eto, K.; Nishikawa, K.; Hamidy, A.; Ahmad, N.; Hossman, M.Y. Distinct Species Status of *Kurixalus Chaseni* (Rhacophoridae, Anura) as Revealed by Mitochondrial Phylogeny. *Alytes* **2018**, *36*, 170–177.
24. Inger, R.F.; Stuart, B.L.; Iskandar, D.T. Systematics of a Widespread Southeast Asian Frog, *Rana Chalconota* (Amphibia: Anura: Ranidae). *Zool. J. Linn. Soc.* **2009**, *155*, 123–147, doi:10.1111/j.1096-3642.2008.00440.x.
25. Brophy, T.R. Geographic Distribution of the Southeast Asian Turtles in the Genus *Malayemys* (Testudines: Bataguridae). *Bull. Chic. Herpetol. Soc.* **2005**, *40*, 21–23.