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Amphibian diversity and species composition in a lowland tropical rainforest of Ulu Gombak, Selangor, Peninsular Malaysia

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Abstract : Surveys on amphibians were conducted from Aug–Sept 2017 in Ulu Gombak Forest Reserve to identify species composition and microhabitat affinity. A total of 316 individuals representing 20 species in six families was recorded. The updated checklist from the area now includes 35 species. The rank-abundance curve shows a steep slope from the first rank to the second due to the dominance of *Amolops larutensis*, represented by 125 individuals. The geometric series distribution pattern produced is typically associated with a disturbed habitat characterised by the recent paved roads near the sampling sites. The rarefaction curve reflects an insufficient survey effort compared to the Chao-1 index, which estimated 23 species. All the alpha diversity indices against the observed richness values show a moderate species diversity and richness (Shannon, H=2.03; Simpson Index D=0.21 or 1-D=0.79; Brillouin index=1.93 and Berger Parker=0.40). The amphibian diversity found in the lowland forest of the Ulu Gombak FR was average due to the secondary forest habitat that supports lesser biodiversity than that of the primary forest, among others. There was species overlap among different microhabitats, indicating species that share a similar niche.

Keywords: Amphibians, toads, tropical forest, microhabitat

INTRODUCTION

Amphibians achieve the highest diversity in tropical forests and are a primary component in the vertebrate fauna (IUCN 2019; IUCN *et al.* 2008). Unfortunately, they are also the most threatened vertebrate class on earth since worldwide populations are currently under threat from climate change, land-use changes and the spread of the deadly chytrid fungus (IUCN *et al.* 2008). As much as 41% of the total number of amphibian species is under threat of extinction (IUCN 2019), especially in Southeast Asia, where the rate of deforestation is among the highest in the world (Sodhi *et al.* 2010; Mietten *et al.* 2011, FAO and UNEP 2020). The tropical forests of Malaysia support a diverse array of amphibian species. There are 267 species listed to date (Norhayati 2017), but there is also much cause for concern due to increasing pressures to develop the country.

Amphibians are considered good bioindicators because they are sensitive to environmental changes (Quaranta *et al*., 2009; Saber *et al*., 2016) and require special like habitat and microhabitat to survive, especially during the breeding season (Stebbins and Cohen 1995; Nurulhuda *et al.* 2015). They are exposed to terrestrial and aquatic habitats at different stages of their life cycles and they are more sensitive to environmental toxins or changes in temperature or rainfall patterns than other terrestrial vertebrates (Alford and Richards 1999; Saber *et al.* 2016). Many studies have shown that local precipitation and humidity regimes play essential roles in the regional distribution of the amphibian community (Duellman and Trueb 1986; Nurulhuda *et al.* 2015).

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Additionally, Enge (1997) and Lim *et al.* (2010) accorded that surveying amphibian communities in an area is confounded by several variables, including species' habits and the effect of season and weather on activity patterns. Anthropogenic activities may also shape current amphibian assemblages (Das *et al.* 2007), and amphibians have been proven as a suitable model for the study of human impact on the environment in complex biological systems (Ernst and Rodel 2005). Thus, the understanding ecological diversity of amphibian fauna requires long term and consistent monitoring due to spatial and temporal changes in environmental and habitat parameters of an area (Nurulhuda *et al.* 2015).

One of the areas that have been studied by many scientists since 1965 is Ulu Gombak Forest Reserve because of the proximity of Ulu Gombak Biodiversity Centre, University of Malaya that can facilitate researchers. The centre is located on 120-hectare secondary and primary tropical rainforests. Amphibian record of Ulu Gombak was first revealed by Inger *et al.* (1974), Inger (1980a, 1980b), Berry (1975), Feng and Naris (1991), Kuramoto and Yong (1992), Jehle and Arak (1998), Narins *et al.* (1998) and Basyar (2016). These works are mainly on ecology, taxonomy, inventories, calling behaviour and genetics. Therefore, the objectives of this study are to investigate species richness, quantify terrestrial microhabitat characteristics, and update the species diversity profile of anuran assemblages in Ulu Gombak Forest Reserve to facilitate management authority of the area and enhance the conservation efforts.

MATERIALS AND METHODS

Fieldwork was conducted from Aug to September 2017. The study site is located at the Ulu Gombak Biodiversity Centre (UGBC), University of Malaya (3°19'N, 101°45'E), at the western edge of Ulu Gombak Forest Reserve (UGFR) (Figure1). UGFR is a 40-years selectively logged forest with very little seasonal variation in temperature (Sing *et al.* 2013) and significant rainfall throughout the year. Sampling sites cover all the existing forest trails of UGBC and suitable microhabitats, including streams, creeks, marshes, potholes and forest trails (Figure 2).

Frogs were actively surveyed at night using the visual encounter survey method from 1900h to 2200h. The total number of sampling days was 15 during the inter-and wet season from August to September 2017. We surveyed frogs at suitable microhabitats, such as along streams, forest trails, and riverbanks of Sungai Gombak. All frogs sighted and heard within 20 m on either side of the 1.5 km-long transect were captured by hand. Microhabitat data, based on the parameters in Table 1 were recorded in a data record sheet. All specimens were measured to the nearest 0.1 mm with Mitutoyo digital calipers. The parameters examined are the snout-vent length (SVL), measured from the tip of the snout to the tip of the vent and tibia length (TL). Determination of the male sex was made by examining the vocal slits in adult frogs or the presence of a nuptial pad on each of the first finger of the front limbs. At most, two voucher specimens were euthanized with Tricaine (Ethyl 3-aminobenzoate methane sulfonate salt), fixed in 10% formalin and transferred to 70% alcohol for storage. Colour photographs were taken, and liver tissue was extracted and stored in 95% ethanol before preservation. Taxonomic nomenclature follows Frost *et al.* (2021). All specimens were deposited at the Institute for Biodiversity, Lanchang, Pahang.

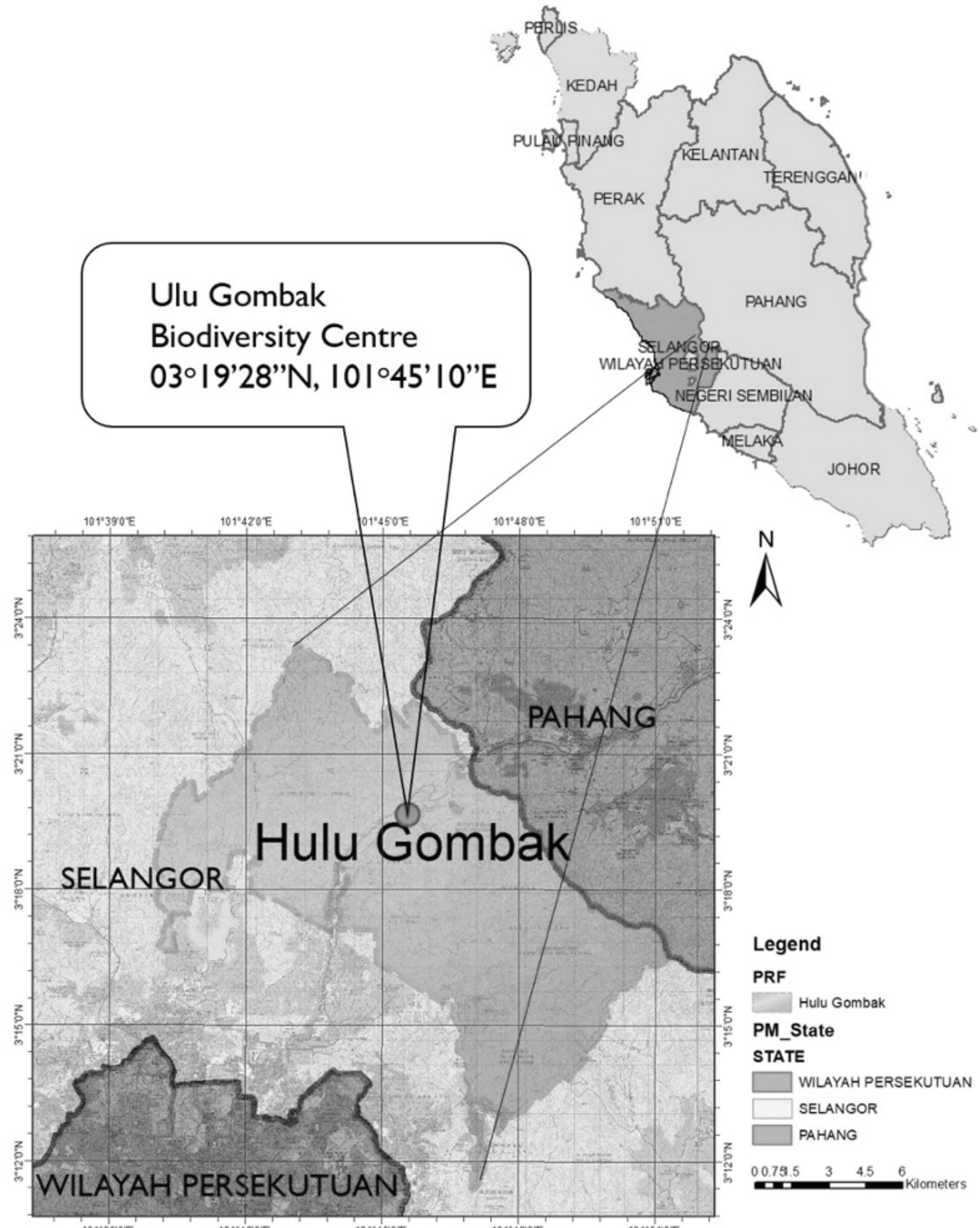

Figure 1. Location of the study area at Ulu Gombak Biodiversity Centre, Ulu Gombak Forest Reserve, Selangor.

Figure 2. Various macro-habitats are represented at the study sites in Ulu Gombak Forest Reserve, Selangor.

Diversity measures were calculated using the PAST software (version 3.06). The indices used in this study were the Dominance index (*D*), Shannon diversity index (*H'*), and the Evenness index (*E*). Species accumulation curves were generated using the software EstimateS (version 9.1.0). Non-metric multidimensional scaling (NMDS) (Hout *et al.* 2013) was used to interpret patterns of the composition of the anuran assemblage in UGFR, using the Chord Similarity Index with 2D dimensionality, where the NMDS microhabitat ordination was based on three categories of microhabitat parameters: 1) horizontal position, 2) vertical position, and 3) substrate (Table 1). NMDS optimizes the goodness of fit to a non-metric hypothesis (Kruskal 1964; Kenkel and Orlóci 1986).

Table 1. Microhabitat parameters selected for this study.

No.	Parameters	Note
1.	Vegetation type	Primary Dipterocarp forest (MDF)
2.		Peat forest
3.		Heath Forest
4.		Agriculture
5.		Edge of MDF
6.	Horizontal position	Permanent stream
7.		Intermittent stream
8.		Permanent pond
9.		Intermittent pond
10.		Swamp
11.	Distance from water body	≤ 1m from water body
12.		> 1m from water body
13.	Vertical Position	Under soil surface
14.		On top of or under leaf litter
15.		Under rock
16.		On rock
17.		Under log
18.		On log
19.		In log
20.		On exposed soil surface
21.		On leaf surface
22.		On seedling or herbaceous plant
23.		On shrub or treelet
24.		On tree or woody climber
25.		On tree stump
26.		On dead tree
27.		On leaf blade
28.		In grass
29.	Substrate	Leaf of tree
30.		On stem of herbaceous plant
31.		On branch of woody tree
32.		On stem of shrub
33.		On epiphyte
34.		Under log, fallen tree, fallen branch
35.		Muddy bank/ soil/ rock

RESULTS AND DISCUSSION

A total of 316 individuals of amphibians from 20 species was recorded from the study site (Table 2) comprising six families: Bufonidae (n=51, 2 species), Dicroglossidae (n=36, 6 species), Megophryidae (n=2, 2 species), Microhylidae (n=3, 2 species), Ranidae (n=203, 4 species) and Rhacophoridae (n=21, 4 species). The most dominant species is *Amolops larutensis* (Ranidae). The conservation status of most species is least concern, but *Limnonectes blythii* and *Nyctixalus pictus* are listed as near threatened, while *L. nitidus* is endangered (IUCN 2019).

Table 2. Species abundance of amphibians recorded in the study sites at Ulu Gombak Forest Reserve (m=male, f=female). SVL = snout-vent-length; TB = tibia length; Wt = weight

No.	Family/Species Name	No. Indiv.	Rel. Abund. %	SVL (mm)	TB (mm)	Wt (g)	IUCN Status
	Bufonidae						
1	*Ingerophrynus parvus* (Boulenger, 1887)	21	6.6	m 36.4 ± 2.2 f 37.7 ± 2.7	m 14.6 ± 1.3 f 16.5 ± 1.6	m 2.8 ± 0.7 f 4.8 ± 1.6	LC
2	*Phrynoidis asper* (Gravenhorst, 1829)	30	9.5	m 67.5 ± 6.8 f 89.5 ± 2.5	m 31.6 ± 4.4 f 44.0 ± 2.1	m 69.9 ± 12.0 f 55.7 ± 3.4.	LC
	Dicroglossidae						
3	*Fejervarya limnocharis* (Gravenhorst, 1829)	1	0.3	m 46.0	m 21.5	m 5.7	LC
4	*Limnonectes blythii* (Boulenger, 1920)	8	2.5	m 81.5 ± 3.3 f 84.9 ± 3.4	m 48.0 ± 2.0 f 52.3 ± 11.2	m 19.2 ± 4.4 f 55.1 ± 4.3	NT
5	*Limnonectes deinodon* (Dehling, 2014)	11	3.5	m 35.8 ± 3.6 f 29.5 ± 1.7	m 18.8 ± 2.6 f 13.50 ± 2.0	m 5.3 ± 2.2 f 2.6 ± 0.8	LC
6	*Limnonectes nitidus* (Smedley, 1932)	3	0.9	m 29.5 ± 2.9	m 18.0 ± 2.1	m 3.17 ± 1.5	EN
7	*Limnonectes plicatellus* (Stoliczka, 1873)	3	0.9	m 36.5 f 27.0 ±2.7	m 21.0 f 16.3 ± 2.0	m 5.1 f 2.2 ± 1.2	LC
8	*Occidozyga sumatrana* (Peters, 1877)	10	3.2	m 25.1 ± 1.8 f 36.5 ± 2.6	m 12.3 ± 1.7 f 16.7 ± 1.8	m 1.7 ± 1.0 f 5.2 ± 1.5	LC
	Megophryidae						
9	*Leptobracium hendricksoni* (Taylor, 1962)	1	0.3	m 49.0	m 19.0	m 7.09	LC
10	*Pelobatrachus nasutus* (Schlegel, 1858)	1	0.3	Detection based on its loud and distinct audio cues			LC
	Microhylidae						
11	*Kalophrynus kiewi* Tschudi, 1838	1	0.3	m 40.0	m 17.0	m 7.95	LC
12	*Microhyla heymonsi* Vogt, 1911	2	0.6	m 20.0 f 20.0	m 10.5 f 12.0	m 0.62 f 0.86	LC
	Ranidae						
13	*Amolops larutensis* (Boulenger, 1899)	125	39.6	m 34.9 ± 1.9 f 39.8 ± 9.5	m 23.8 ± 2.1 f 22.91 ± 2.2	m 3.3 ± 1.0 f 5.4 ± 2.1	LC
14	*Hylarana labialis* (Boulenger, 1887)	61	19.3	m 36.8 ± 2.8 f 47.1 ± 3.7	m 20.7 ± 1.8 f 29.1 ± 3.0	m 2.5 ± 1.1 f 8.8 ± 3.6	LC
15	*Hylarana erythraea* (Schlegel, 1837)	3	0.9	f 68.0	f 34.0	f 17.4	LC
16	*Odorrana hosii* (Boulenger, 1891)	14	4.4	m 50.6 ± 2.0 f 88.0	m 29.5 ± 2.2 f 59.5	m 8.0 ± 1.3 f 40.0	LC

	Rhacophoridae						
17	*Nyctixalus pictus* (Peters, 1871)	7	2.2	m 25.0 ± 2.5 f 29.9 ± 1.9	m 11.7 ± 1.9 f 18.0 ± 1.3	m 1.0 ± 0.7 f 1.6 ± 0.8	NT
18	*Polypedates discantus* Rujirawan, Stuart and Aowphol, 2013	1	0.3	m 46.0	24.5	m 4.7	
19	*Polypedates leucomystax* (Gravenhorst, 1829)	11	3.5	m 47.8 ± 2.0 f 46.5 ± 1.5	m 23.7 ± 2.5 f 25.5 ± 0.9	m 5.1 ± 0.9 f 3.1 ± 1.6	LC
20	*Zhangixalus prominanus* (Smith, 1924)	2	0.6	m 64.0 f 60.0	m 32.0 f 30.0	m 7.9 f 8.8	LC
	Total	**316**	**100**				

IUCN Red List of Threatened Species: NE = Not Evaluated, DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered, EW = Extinct in the Wild, EX = Extinct

Figure 3 shows the rank-abundance curve of amphibians with a steep slope from the first rank to the second due to the dominance of *Amolops larutensis* (125 individuals) (Table 2). From the graph, only three species have more than 30 individuals each, while the other 17 species trail off until five species have a minimum of one individual. The Chi-square value and p-value for the curve are 113.9 and 9.933E-19, respectively, indicating that the RAC approaches the Geometric series model. According to Tokeshi (1993), an assemblage's geometric series distribution pattern is typically associated with a disturbed habitat, which indicates the effects of the main road near the sampling sites that causes fragmentation of the forest, easy access by humans and domestic animals, such as dogs, and pollution.

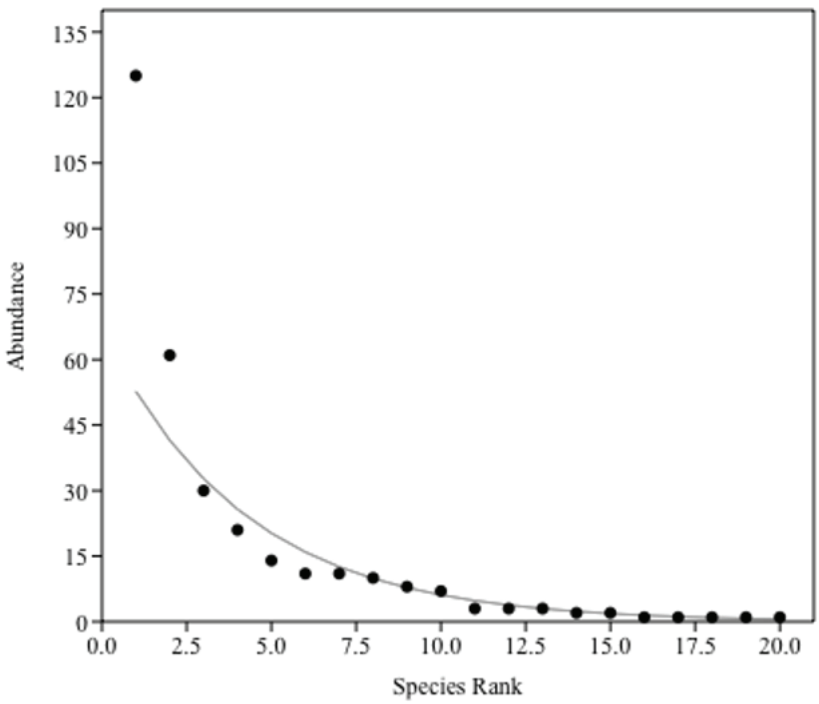

Figure 3. Species Rank abundance curve of at the study sites, Ulu Gombak Forest Reserve.

The species accumulation curve (Figure 4) rises sharply with a steep gradient but does not level off at the end of the sampling period producing 316 individuals in 20 species. This reflects an insufficient sampling effort. Nevertheless, the Chao-1 index estimated a total of 23 species against the observed species richness (S_{obs}) of 20.

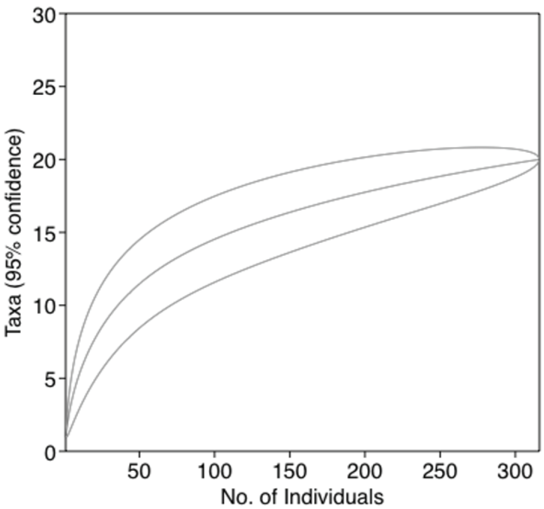

Figure 4. Species accumulation curve of amphibians at the study sites, Ulu Gombak Forest Reserve.

All the alpha diversity indices against the observed richness values show a moderate species diversity and richness (Shannon, *H*=2.03; Simpson Index *D*=0.21 or 1-*D*=0.79; Brillouin index=1.93 and Berger Parker=0.40; Table 3). The amphibian biodiversity in the lowland forest of the Ulu Gombak Forest Reserve indicates an average value due to the secondary habitat forest that supports less than that of a primary forest. Similarly, the findings of Jongsma *et al.* (2014) show that amphibian diversity and richness were lower in secondary than they were in primary tropical forest, suggesting that amphibian assemblages in interior forest habitat were more vulnerable to habitat alterations.

Table 3. Alpha diversity indices of amphibians in the study sites at Ulu Gombak Forest Reserve.

Indices	A	Lower	Upper
Taxa_S	20	20	20
Individuals	316	316	316
Dominance_D	0.21	0.18	0.27
Simpson_1-D	0.79	0.75	0.82
Shannon_H	2.03	1.93	2.17
Evenness_e^H/	0.38	0.34	0.44
Brillouin	1.93	1.83	2.07
Menhinick	1.13	1.13	1.13
Margalef	3.30	3.30	3.30
Equitability_J	0.68	0.64	0.73
Fisher_alpha	4.75	4.75	4.75
Berger_Parker	0.40	0.34	0.44
Chao-1	23.33	20.00	30.50

Figure 5 shows the NMDS microhabitat ordinance for the horizontal position of anurans, which consists of four clusters: 1) streams, 2) pond, 3) intermittent stream-marsh or marsh, and 4) terrestrial or forest trails. The ordination implies preferences for habitats in a transition from the permanent river and intermittent stream-swamp to terrestrial trails. The majority are clustered in the intermittent streams and swampy areas, and they are identified as semi-aquatic frogs.

There are two overlapping species occurring in three clusters (stream/intermittent stream-swamp/pond): *Hylarana labialis* and *Odorrana hosii*. *Limnonectes blythii*, *Phrynoidis asper* and *Amolops larutensis* are clustered more closely in the stream group than other species within the cluster. These three species are stream-dwellers with unrestricted access to water, especially during breeding time, either directly by submersion (*L. blythii* and *P. asper*) or indirectly through water sprays from fast-flowing streams (*A. larutensis*). Limnonectes blythii adult males are known to build nests in the water of shallow streams where the substrate is composed of coarse sand and pebbles (Nurulhuda *et al.* 2015). *Phrynoidis asper* is a large toad that is often found along large fast-flowing rivers (Nurulhuda *et al.* 2015), while *A. larutensis* is usually found on large boulders near splash zone or riverbank slopes (Chan *et al.* 2018). *Odorrana hosii* and *H. labialis* usually occupy permanent pond, marshy and riparian areas, whereas *H. erythraea* is associated with permanent stagnant water of water bodies, such as lakes and dams but it can also be found in a wide-ranging habitat, such as gardens, paddy fields and plantations (Malkmus *et al.* 2002).

The group, comprising *Zhangixalus prominanus*, *Pelobatrachus nasutus* and *Polypedates leucomystax* was often found near the forest trails. Species that only breed in temporary water bodies should be able to find refuge or retreat sites that will allow them to last long without access to water for rehydration (Nurulhuda *et al.* 2015). For these species, suitable retreat sites may often be remotely away from water bodies and microhabitats within the terrestrial habitat may play an essential role in influencing their distribution.

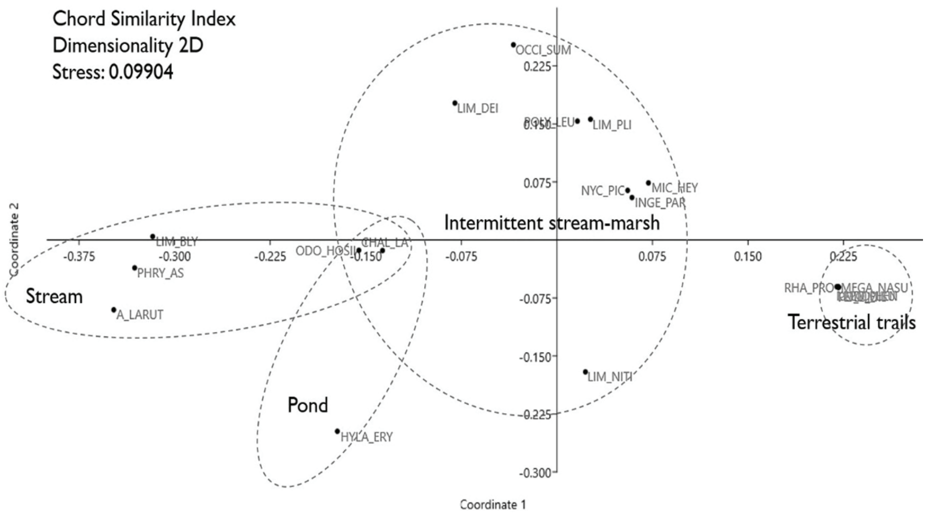

Figure 5. NMDS ordination for horizontal positions of microhabitat of anurans at UGFR.

The NMDS microhabitat ordinance for the vertical position of anurans illustrates five major positions (Figure 6): 1) on a rock, 2) on dead twigs, 3) on the bamboo, 4) shrubs below 1 m from the ground, 5) hide in the grass, forest, or marsh litter. The distance between clusters is far away, except Cluster 1, which partially overlaps Cluster 4. Clusters 2 and 3 consist of a single species each. Even though the stress value (0.1931) is high, it is still under the acceptable value (< 0.3). Phrynoidis asper is the only species that shares two vertical positions, namely on a rock or under a fallen log along Sungai Gombak. *Kalophrynus kiewi* and *Zhangixalus* *prominanus*, the single taxon recorded respectively in Cluster 2 and 3, are isolated far from the others. A pair of *Z. prominanus* was recorded on dead twigs near the old Lord Medway's field house once recided by Lord Cranbrook.

Cluster 3 is the largest, consisting of eight species and three families: Dicroglossidae (5 species), Bufonidae (2 species) and Microhylidae (1 species). Most of the species in this cluster, such as *Limnonectes plicatellus*, *L. nitidus*, *Occidozyga sumatrana*, *Ingerophrynus parvus* and *Microhyla heymonsi*, are small, and, thus, tend to have a higher ratio of mass to surface value (mass per volume, m/v) tends to lose body moisture compared to large frogs. Therefore, hiding in the grass, forest or marsh litter is the adaptation strategy of small-sized anurans to maintain or keep their body moisture.

Five species share the same vertical position, and they are grouped in Cluster 5, *Nyctixalus pictus*, *Hylarana erythraea*, *Odorrana hosii*, *Hylarana labialis* and *Polypedates leucomystax*. These species have similar morphological characteristics: the fingertips and toe tips end in disks to facilitate climbing (Berry 1975).

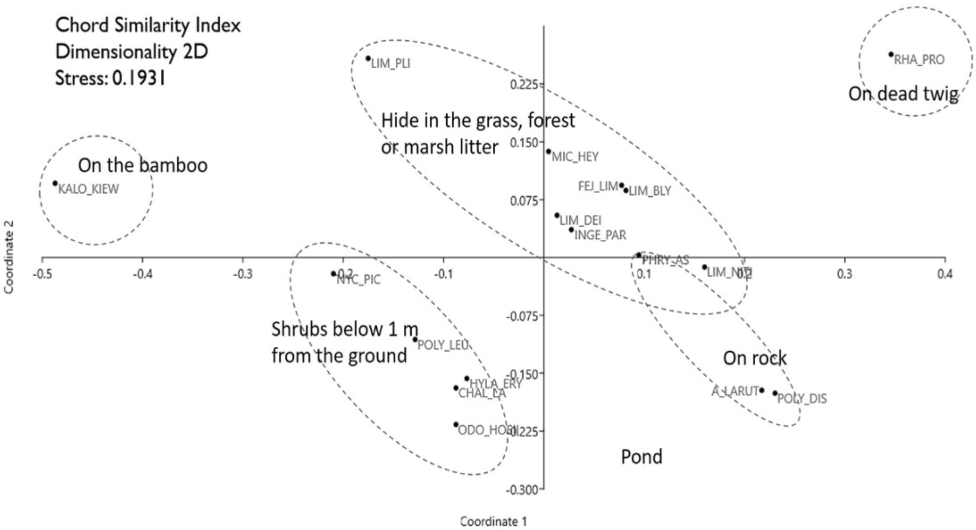

Figure 6. NMDS ordination for vertical position of microhabitat of anurans at UGFR.

Figure 7 illustrates the NMDS ordination for the different substrates that occupied by anurans in UGFR. It is clustered into three major types of substrates: 1) the bank of mud, sand, granite, or rock, 2) on leaf or stem of herbaceous plant or shrub, and 3) on bamboo. Most of the anuran species did not share the microhabitat of the substrates. The significant narrow microhabitat preference indicates that anurans at UGFR live in a narrow range of microhabitats and are sensitive to the change of their substrate environment. Any occurrences of stochastic events, such as hydrological manipulation of riverbank at Sungai Gombak or pollution at the sandy bank along the intermittent stream within the UGFR forest area, will most probably affect the majority species population.

Cluster 1 is the most important microhabitat to the anurans at UGFR as 80% of them (16 species) was recorded. *Kalophrynus kiewi* is the single taxon within Cluster 3 isolated from others due to its significant distinguish microhabitat characteristics. According to Shoemaker and Nagy (1977), soil moisture is a significant water source for some amphibian species, causing these species to stay near the substrate for long periods. Thus, the properties of soil may influence where frogs choose to rest on or burrow. Small-sized frogs that have a larger surface to volume ratio lose more water per unit of surface than larger frogs (Seymour and Lee 1974). Therefore, small frogs may be more likely to limit their movements to areas that can protect them from desiccation (i.e., moist substrates and shaded areas) than larger frogs. These small frogs are *Microhyla heymonsi*, *Limnonectes nitidus*, *L. plicatellus*, *L. deinodon* and *Occidozyga sumatrana*.

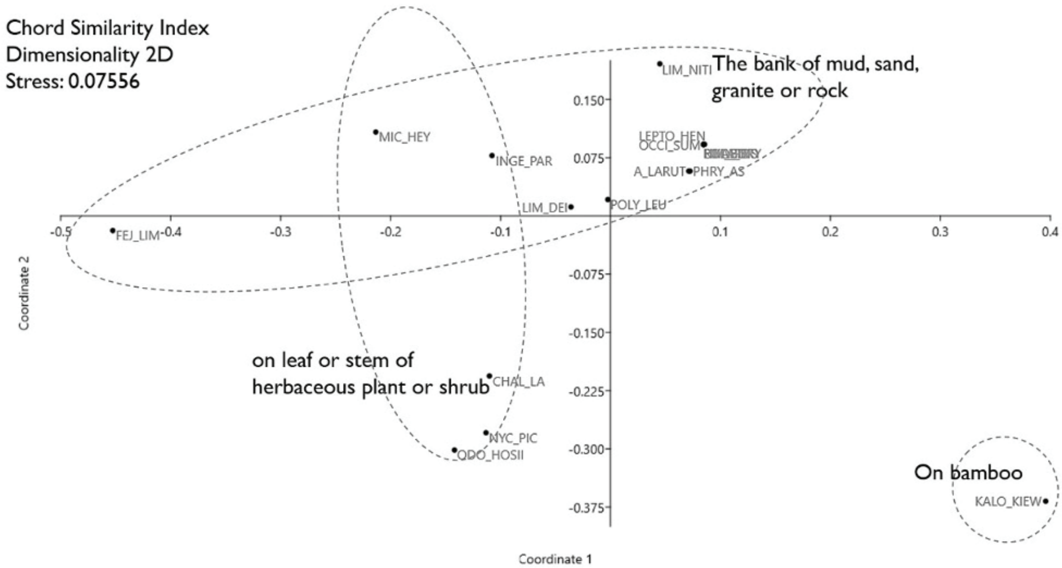

Figure 7. NMDS ordination for different microhabitat (substrates) of anurans at UGFR.

The Jaccard's Coefficient Index was chosen to estimate the similarity of the anuran communities (Figure 8). The similarity indices are within the range of 0.07 to 0.73. Groups of intermittent stream-marsh (B-E) shows the highest similarity among the assemblages with 90.9% (Table 4), in which *L. deinodon*, *Odorrana hosii* and *Hylarana labialis* were the common species found in areas that have slow-flowing and shallow water. *Ingerophrynus parvus*, *H. labialis* and *Polypedates leucomystax* were recorded within the marsh and terrestrial trails, indicating that these species have wider habitat adaptation compared to others.

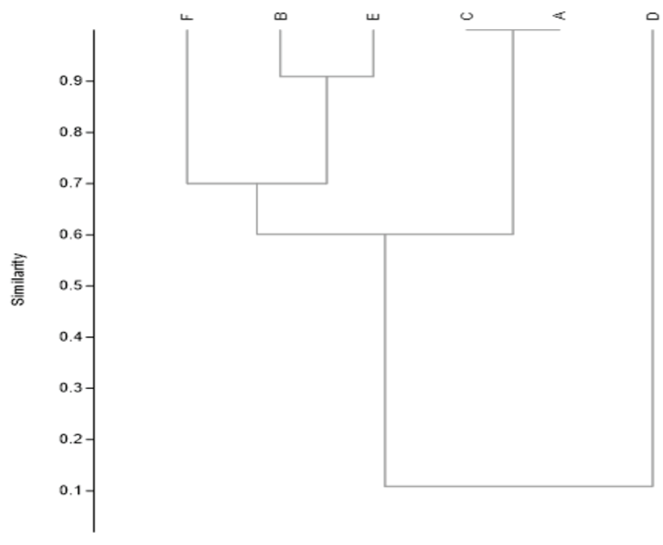

Figure 8. Cluster analysis using the Jaccard Coefficient.

Table 4. Similarity matrix for amphibian community at six habitat horizontal positions.

Habitat horizontal positions	A	B	C	D	E	F
A=	1.00	0.70	1.00	0.14	0.64	0.47
B=	0.70	1.00	0.70	0.10	0.90	0.67
C=	1.00	0.70	1.00	0.14	0.64	0.47
D=	0.14	0.10	0.14	1.00	0.09	0.07
E=	0.64	0.91	0.64	0.09	1.00	0.73
F=	0.47	0.67	0.47	0.07	0.73	1.00

A=permanent stream, B=intermittent stream, C=permanent pond, D=temporary pond, E=marsh, F=terrestrial trails

Figure 9 shows the combo graph, which consists of the average humidity recorded (2000h–2200h) on the primary axis. In contrast, the average temperature, precipitation (2000h–2200h), and species richness and abundance are shown on the secondary axis. The number of individuals increases, although the amount of rainfall decreases significantly towards the end of sampling. Air temperature does not seem to affect species number or abundance of amphibians. The humidity seems to have a positive impact on the number of individuals and species.

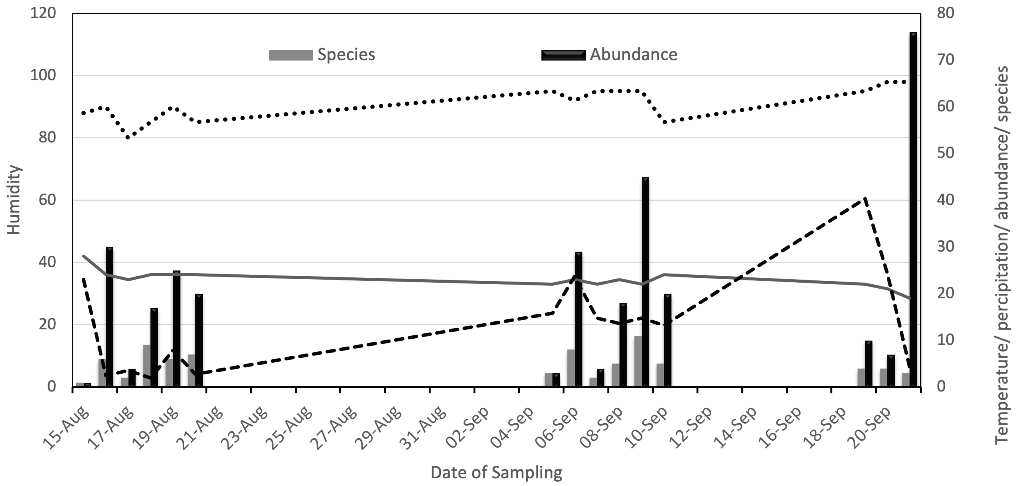

Figure 9. Microclimates with species richness and species abundance of anurans community in UGFR (dash line=precipitation (mm), dotted line=humidity (%), solid line=air temperature (2000h–2200h)

The updated checklist of anurans at Ulu Gombak Forest Reserve is 33 species in six families (Table 5). The profile of the amphibians in the study sites of Ulu Gombak Forest Reserve shows that the assemblage is abundant during high humidity levels. *Limnonectes nitidus* is still a common species as it was recorded in three studies conducted between 1975–2017. The current study shows that species composition is different compared to that of Basyar (2016) because the recent sampling was conducted during inter- and wet season (Aug–Sep 2017) compared to the previous study, which was conducted in the dry season (Mar–Apr 2016). The results suggest that species diversity and distribution might be affected by variation in temporal and humidity patterns. In short, the amphibians exhibited proximal dependence on water sources, especially during the wet season when it can provide them with crucial breeding habitat.

Table 5. Species abundance of anurans recorded in the study sites at UGFR.

No.	Family/Species Name	Present study	Basyar (2016)	Berry (1975)	IUCN Status
	Bufonidae				
1	*Ingerophrynus parvus* (Boulenger, 1887)	X	X		LC
2	*Leptophryne borbonica* Tschudi 1838			X	LC
3	*Phrynoidis asper* (Gravenhorst, 1829)	X	X		LC
	Dicroglossidae				
4	*Fejervarya limnocharis* (Gravenhorst, 1829)	X			LC
5	*Limnonectes blythii* (Boulenger, 1920)	X	X		NT
6	*Limnonectes deinodon* (Dehling, 2014)	X	X	X	LC
7	*Limnonectes selatan* (Tschudi 1838)			X	LC
8	*Limnonectes macrodon* (Tschudi 1838)			X	VU
9	*Limnonectes nitidus* (Smedley, 1932)	X	X	X	EN
10	*Limnonectes plicatellus* (Stoliczka, 1873)	X	X		LC
11	*Occidozyga sumatrana* (Peters, 1877)	X	X		LC
	Megophryidae				
12	*Leptobracium hendricksoni* (Taylor, 1962)	X			LC
13	*Pelobatrachus nasutus* (Schlegel, 1858)	X	X		LC
	Microhylidae				
14	*Chaperina fusca* Mocquard 1892			X	LC
15	*Kalophrynus kiewi* Matsui, Eto, Belabut, and Nishikawa, 2017	X	X	X	LC
16	*Microhyla berdmorei* Blyth 1856		X	X	LC
17	*Microhyla heymonsi* Vogt, 1911	X			LC
	Ranidae				
18	*Abavorana luctuosa* (Peters 1871)		X	X	LC
19	*Amolops larutensis* (Boulenger, 1899)	X	X		LC
20	*Hylarana labialis* (Boulenger, 1887)	X	X	X	LC
21	*Hylarana erythraea* (Schlegel, 1837)	X	X		LC
22	*Odorrana hosii* (Boulenger, 1891)	X	X		LC
23	*Hylarana glandulosa* (Boulenger, 1889)		X		LC
24	*Pulchrana sundabarat* Chan, Abraham, Grismer, and Brown, 2020			X	LC
	Rhacophoridae				
25	*Nyctixalus pictus* (Peters, 1871)	X	X	X	NT
26	*Polypedates colletti* (Boulenger 1890)			X	LC
27	*Polypedates discantus* Rujirawan, Stuart and Aowphol, 2013	X			
28	*Polypedates leucomystax* (Gravenhorst, 1829)	X	X	X	LC
29	*Polypedates macrotis* (Boulenger 1891)			X	LC
30	*Rhacophorus pardalis* Gunther 1859			X	LC
31	*Zhangixalus prominanus* (Smith, 1924)	X		X	LC

IUCN Red List of Threatened Species: NE=Not Evaluated, DD=Data Deficient, LC=Least Concern, NT=Near Threatened, VU=Vulnerable, EN=Endangered, CR=Critically Endangered, EX=Extinct

CONCLUSION

Anurans possess a biphasic life cycle, which is vulnerable to environmental stressors, such as pollutions, anthropogenic activities, stochastic events, ecological or climatic changes on these microhabitats. Knowing microhabitat preference and the diversity and richness of species is crucial for anuran community conservation. There are several recommendations proposed for amphibian research and conservation practice in Ulu Gombak Forest Reserve. Consistent and long-term surveys can provide comprehensive data on the anuran population and ecology. It is possible to incorporate microhabitat preference and species detectability into conservation targets based on the species richness estimators. Long-term studies also eliminate seasonality, weather conditions and the skill of the investigator. When estimates of species density are required, a plot-based sampling is essential. Thus, the study area should have a permanent quadrat or trails. Different sampling techniques are suitable for different taxa and habitats and can reduce potential sampling biases. Therefore, using a wide range of techniques ensures that all possible niches are included. Finally, understanding patterns of biodiversity are vital to conservation management, and any decision on planning and development of an area, should be based on accumulated knowledge of the species groups that only come with more available data. Species lists are usually the basic data of biological inventory and are often employed when there are limited conservation resources. However, species lists still represent information that can be used to facilitate management authority of the area, until more ecological studies can be associated with the lists.

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