

Types of Leaves Preference by *Kalophrynus palmatissimus* in Two Forest Reserves

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Abstract- A collection of leaves was carried out at each captured area of *Kalophrynus palmatissimus* in Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan. *K. palmatissimus* is a leaf litter frog. Leaves or leaf litter provide microhabitat structures for leaf litter frogs. Leaves or leaf litter offer retreat sites for leaf litter frogs and shelters for their food sources (i.e. diversity of invertebrates). However, there have been little discussions about the types of leaves as the microhabitat structure of *K. palmatissimus*. The objective of this study was to investigate the types of leaves that were highly adapted by *K. palmatissimus* at both forest reserves. Thirty four and thirty one quadrats (2m × 2m) were established in AHFR and PFR respectively for a collection of leaves. A total of 53 and 85 leaves were recorded at AHFR and PFR respectively. Most of the leaves that were collected at both forest reserves were non-hairy/smooth leaves. The data collections in AHFR and PFR have significantly contribute to better understanding of types of leaves as the most suitable habitat and foraging sites for *K. palmatissimus*.

Index Terms- *Kalophrynus palmatissimus*, forest reserves, leaves, habitat, foraging site

INTRODUCTION

The morphology characteristics of leaves can be used to correctly assign the species of trees. Leaves can be collected almost year round, are easy to photograph and have well present shapes that make correct identification of tree species are possible [1]. In addition, the surface morphology of leaves can also be used to determine the presence of leaf litter frogs. For an example, leaf litter frogs prefer *Eucalyptus* plantations; the leaves of *Eucalyptus* are non-hairy/smooth types of leaves [3]. Non-hairy/smooth leaves refer to leaves with hairless surface of leaves. [5] suggested that dense vegetation of leaves such as *Shorea leprosula* (Red Meranti) and *Shorea macroptera* (Light Red Meranti) on the forest floor are the ideal microhabitat structures for breeding by certain species of leaf litter frogs. *Shorea leprosula* and *S. macroptera* are also non-hairy/smooth types of leaves.

Kalophrynus palmatissimus (also commonly known as Lowland Grains Frog) which is a leaf litter frog usually inhabits or habituates undisturbed lowland rainforests. [8] reported that *K. palmatissimus* was collected from forest floor of lowland dipterocarp forest at about 75 m above the sea level at Pasoh Forest Reserve (PFR), Negeri Sembilan. [9] in his study at Compartment 15, Ayer Hitam Forest Reserve (AHFR), Selangor mentioned that this species was recorded on the surface of forest litter at about 52 m above the sea level. As a leaf litter frog, *K. palmatissimus* prefers leaf litter as its microhabitat because it provides suitable breeding and forage sites. However, there have been little discussions about the preferable types of leaves for *K. palmatissimus* as their habitat and foraging sites. Therefore, the objective of this study was to identify the types of leaves that were highly adapted by *K. palmatissimus* at both Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan.

MATERIALS AND METHODS

Species Introduction

Kalophrynus palmatissimus is a leaf-litter frog species that can be found in forest litter on the forest floor of lowland forests [19]. This species is from the family Microhylidae. This species is endemic to Malaysia and is known to be present only in Pasoh Forest Reserve (PFR) at Negeri Sembilan, and Gombak Forest Reserve (GFR), FRIM, Templer's Park (Templer FR) [7] and Ayer Hitam Forest Reserve (AHFR) at Selangor [10]. Adult *K. palmatissimus* can be easily identified through its dorsal colour and a unique mark on its ventral. [8] reported that the dorsal colour of adult *K. palmatissimus* is light brown to reddish brown with darker brown blotch extending between eyes to posterior and breaking into patches at trunk.

Study Sites

The project was conducted at two study sites which are Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan from 12th November 2016 until 13th September 2017. The AHFR is recognized as a research, educational and development centre that contributes to the growth of knowledge and reference for research in tropical forest [14, 17]. This forest is rich with flora and fauna such as algae, herbs, fern, mammals, birds, reptiles, amphibians and fish [14, 17]. The AHFR is divided into six compartments and three compartments were studied here, which are Compartments 12, 13 and 15 (Figure 1).

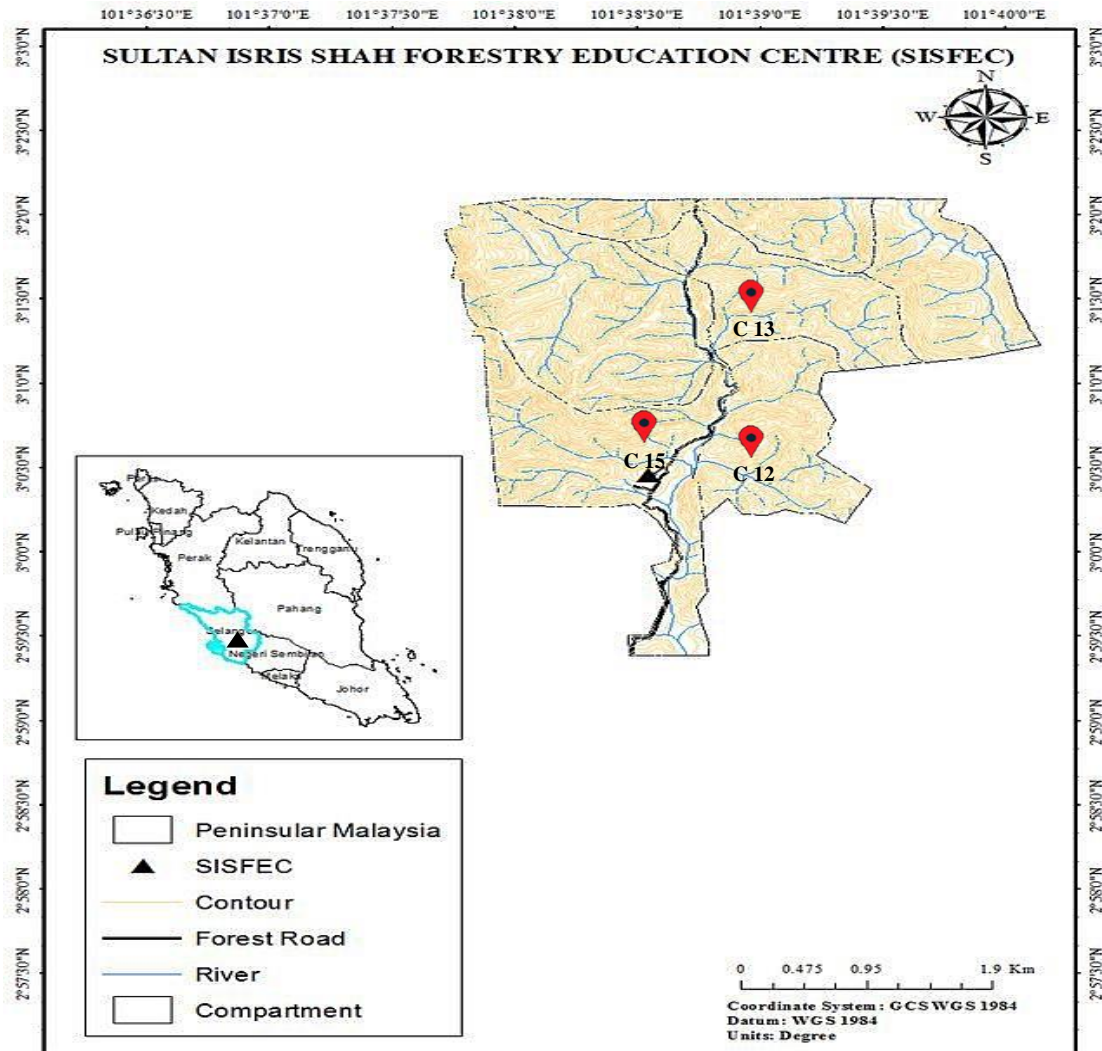


Figure 1: Location of Compartment 12 (03° 00' 792'' N, 100° 38' 821'' E), Compartment 13 (03° 00' 941'' N, 100° 38' 874'' E) and Compartment 15 (03° 00' 351'' N, 101° 38' 424'' E), Ayer Hitam Forest Reserve (AHFR), Selangor. (Source: [11])

Meanwhile, the PFR has been a center for local and international field research for Asian tropical forest since 1970s with a joint research project and collaboration among Japanese, British and Malaysian research teams [12]. According to [13], more than 1,000 tree species have been recorded in this forest and it is a world famous forest for its bird fauna, and is also a home to 500 species of ants. The three compartments of PFR which were studied here are Compartments 21, 22 and 32 (Figure 2).

PASOH FOREST RESERVE, NEGERI SEMBILAN (PFR)

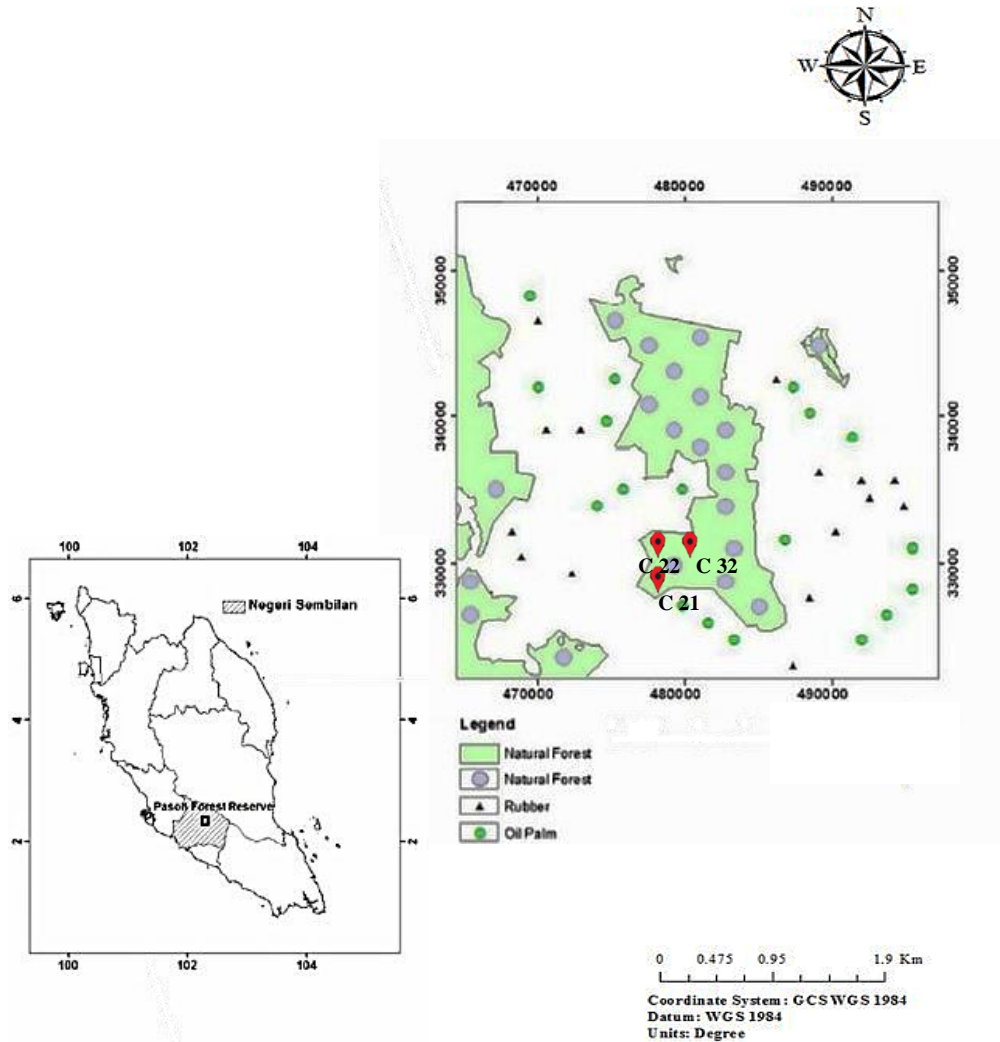


Figure 2: Location of Compartment 21 (02° 58' 137'' N, 102° 17' 567'' E), Compartment 22 (02° 58' 084'' N, 102° 17' 489'' E) and Compartment 32 (03° 00' 052'' N, 101° 42' 163'' E), Pasoh Forest Reserve (PFR), Negeri Sembilan. (Source: [18])

Leaves Collection

In this study, leaves were collected at each captured area of *Kalophrynus palmatissimus* based on the accessibility of the area. The leaves were collected in order to investigate the types of leaves that were highly selected by *K. palmatissimus* at both forest reserves. Thirty four and thirty one quadrats (2m × 2m) were established at each captured area of *K. palmatissimus* in Ayer Hitam Forest Reserve (AHFR) and Pasoh Forest Reserve (PFR) respectively. Most leaves were collected within the quadrats on the forest floor and some leaves were collected from the tree branches for identification purpose. The collected leaves were stored in individual plastic bags. All samples were identified by using reference book entitled ‘A Guide to the Common Plants of Ayer Hitam Forest, Selangor, Peninsular Malaysia’ [2].

RESULTS

Types of leaves recorded

Table 1 shows the leaves recorded in Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan. In total, 130 types of leaves were identified and recorded at both forest reserves, which comprise of 53 types of leaves (40.77 %) at AHFR and 85 types of leaves (65.38%) at PFR respectively. The total number of non-hairy/smooth leaves collected in AHFR was about one time higher than that of hairy leaves. In PFR, the total number of non-hairy/smooth leaves displayed about three times higher than that of hairy leaves. There were 34 (64.15 %) types of non-hairy/smooth leaves and 19 (35.85 %) hairy leaves at AHFR. Whereas, there were 64 (75.29 %) types of non-hairy/smooth leaves and 21 (24.71 %) hairy leaves in PFR. The highest number of tree family recorded was Dipterocarpaceae (31.48 %) while the least number of tree families recorded were Anisophylleaceae, Aquifoliaceae, Calophyllaceae, Celastraceae, Chrysobalanaceae, Clusiaceae, Connaraceae, Davalliaceae, Dilleniaceae, Elaeocarpaceae, Gleicheniaceae, Hanguanaceae, Ixonanthaceae, Lamiaceae, Lecythidaceae, Leguminosae, Marattiaceae, Monimiaceae, Olacaceae, Oleaceae, Pentaphylacaceae, Piperaceae, Plantaginaceae, Poaceae, Rhizophoraceae, Salicaceae, Sapindaceae, Selaginellaceae, Thymelaeaceae, Ulmaceae, and Violaceae (1.85 %). Nine mutual tree families recorded at both forest reserves, namely *Camptosperma auriculatum*, *Clidemia hirta*, *Elaeocarpus* sp., *Mallotus* sp., *Ochanostachys amentacea*, *Palaquium gutta*, *Shorea leprosula*, *Shorea macroptera*, and *Syzygium* sp. Some types of leaves recorded at captured area of *K. palmatissimus* in AHFR and PFR were shown in Figure 3, Figure 4 and Figure 5.

Table 1: Types of leaves recorded in Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan

No.	Family	Name of plants	AHFR	PFR	Morphology of leaves
1	Anacardiaceae	<i>Camptosperma auriculatum</i>	+	+	Non hairy/Smooth
2	Anacardiaceae	<i>Mangifera foetida</i>	-	+	Non hairy/Smooth
3	Anacardiaceae	<i>Parishia maingayi</i>	-	+	Non hairy/Smooth
4	Annonaceae	<i>Cyathocalyx havilandii</i>	-	+	Non hairy/Smooth
5	Annonaceae	<i>Enicosanthum fuscum</i>	-	+	Hairy
6	Annonaceae	<i>Fissistigma</i> sp.	+	-	Non hairy/Smooth
7	Annonaceae	<i>Goniothalamus</i> sp.	-	+	Non hairy/Smooth
8	Annonaceae	<i>Monocarpia marginalis</i>	-	+	Non hairy/Smooth
9	Annonaceae	<i>Polyalthia glauca</i>	-	+	Non hairy/Smooth
10	Annonaceae	<i>Polyalthia</i> sp.	-	+	Non hairy/Smooth
11	Annonaceae	<i>Popowia hirta</i>	-	+	hairy
12	Annonaceae	<i>Xylopi ferruginea</i>	+	-	Non hairy/Smooth
13	Apocynaceae	<i>Alstonia angustiloba</i>	+	-	Non hairy/Smooth
14	Apocynaceae	<i>Willughbeia</i> sp.	-	+	Non hairy/Smooth
15	Aquifoliaceae	<i>Ilex</i> sp.	-	+	Non hairy/Smooth
16	Arecaceae	<i>Calamus</i> sp.	+	-	Non hairy/Smooth
17	Arecaceae	<i>Iguanura wallichiana</i>	+	-	Hairy

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Table 1. (Continued)

18	Burseraceae	<i>Santiria denticulata</i>	-	+	hairy
19	Burseraceae	<i>Santiria</i> sp.	-	+	hairy
20	Calophyllaceae	<i>Mesua ferrea</i>	-	+	Non hairy/Smooth
21	Celastraceae	<i>Kokoona coriacea</i>	-	+	Non hairy/Smooth
22	Chrysobalanaceae	<i>Parinari costata</i>	-	+	hairy
23	Clusiaceae	<i>Garcinia</i> sp.	+	-	Non hairy/Smooth
24	Connaraceae	<i>Agelaea borneensis</i>	+	-	Hairy
25	Davalliaceae	<i>Davallia</i> sp.	+	-	Non hairy/Smooth
26	Dilleniaceae	<i>Tetracera indica</i>	+	-	Hairy
27	Dipterocarpaceae	<i>Dipterocarpus costulatus</i>	+	-	Non hairy/Smooth
28	Dipterocarpaceae	<i>Dipterocarpus crinitus</i>	-	+	Hairy
29	Dipterocarpaceae	<i>Dipterocarpus stellatus</i>	-	+	Non hairy/Smooth
30	Dipterocarpaceae	<i>Hopea nutans</i>	-	+	Non hairy/Smooth
31	Dipterocarpaceae	<i>Hopea odorata</i>	-	+	Non hairy/Smooth
32	Dipterocarpaceae	<i>Hopea</i> sp.	-	+	Non hairy/Smooth
33	Dipterocarpaceae	<i>Shorea dasyphylla</i>	-	+	hairy
34	Dipterocarpaceae	<i>Shorea ferruginea</i>	-	+	hairy
35	Dipterocarpaceae	<i>Shorea foxworthyi</i>	-	+	Non hairy/Smooth
36	Dipterocarpaceae	<i>Shorea leprosula</i>	+	+	hairy
37	Dipterocarpaceae	<i>Shorea macroptera</i>	+	+	Non hairy/Smooth
38	Dipterocarpaceae	<i>Shorea maxwelliana</i>	-	+	Non hairy/Smooth
39	Dipterocarpaceae	<i>Shorea multiflora</i>	-	+	Non hairy/Smooth
40	Dipterocarpaceae	<i>Shorea ovata</i>	-	+	Non hairy/Smooth
41	Dipterocarpaceae	<i>Shorea parvifolia</i>	-	-	Non hairy/Smooth
42	Dipterocarpaceae	<i>Shorea platycarpa</i>	+	-	hairy
43	Dipterocarpaceae	<i>Vatica micrantha</i>	-	+	Non hairy/Smooth
44	Ebenaceae	<i>Diospyros siamang</i>	-	+	Non hairy/Smooth
45	Ebenaceae	<i>Diospyros</i> sp.	-	+	Non hairy/Smooth
46	Elaeocarpaceae	<i>Elaeocarpus</i> sp.	+	+	Non hairy/Smooth
47	Euphorbiaceae	<i>Elateriospermum tapos</i>	-	+	Non hairy/Smooth
48	Euphorbiaceae	<i>Endospermum diadenum</i>	+	-	Hairy
49	Euphorbiaceae	<i>Mallotus penangensis</i>	-	+	Hairy
50	Euphorbiaceae	<i>Mallotus</i> sp.	+	+	Hairy
51	Euphorbiaceae	<i>Neoscortechinia philippinensis</i>	-	+	Non hairy/Smooth
52	Fabaceae	<i>Bauhinia integrifolia</i>	+	-	Non hairy/Smooth
53	Fabaceae	<i>Bauhinia unguolata</i>	+	-	Non hairy/Smooth
54	Fabaceae	<i>Spatholobus</i> sp.	-	+	hairy
55	Fagaceae	<i>Lithocarpus lucidus</i>	+	-	Non hairy/Smooth
56	Fagaceae	<i>Lithocarpus</i> sp.	-	+	Non hairy/Smooth
57	Gleicheniaceae	<i>Dicranopteris linearis</i>	+	-	Hairy
58	Hanguanaceae	<i>Hanguana malayana</i>	+	-	Non hairy/Smooth

59	Ixonanthaceae	<i>Ixonanthes reticulata</i>	+	-	Non hairy/Smooth
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Table 1. (Continued)

60	Lamiaceae	<i>Teijsmanniodendron coriacea</i>	-	+	Non hairy/Smooth
61	Lauraceae	<i>Actinodaphne</i> sp.	+	-	Non hairy/Smooth
62	Lauraceae	<i>Cinnamomum</i> sp.	-	+	Non hairy/Smooth
63	Lauraceae	<i>Cryptocarya griffithiana</i>	-	+	Hairy
64	Lauraceae	<i>Litsea castanea</i>	-	+	Non hairy/Smooth
65	Lauraceae	<i>Litsea grandis</i>	+	-	Non hairy/Smooth
66	Lauraceae	<i>Litsea</i> sp.	+	-	Non hairy/Smooth
67	Leguminosae	<i>Parkia singularis</i>	+	-	Non hairy/Smooth
68	Loganiaceae	<i>Norrisia maior</i>	-	+	Non hairy/Smooth
69	Loganiaceae	<i>Strychnos ignatii</i>	+	-	Non hairy/Smooth
70	Malvaceae	<i>Brownlowia</i> sp.	-	+	Non hairy/Smooth
71	Malvaceae	<i>Durio griffithii</i>	-	+	Non hairy/Smooth
72	Malvaceae	<i>Pentace laxiflora</i>	-	+	Non hairy/Smooth
73	Malvaceae	<i>Schoutenia accrescens</i>	-	+	hairy
74	Malvaceae	<i>Sterculia</i> sp.	+	-	hairy
75	Marattiaceae	<i>Ptisana salicina</i>	+	-	Non hairy/Smooth
76	Melastomataceae	<i>Clidemia hirta</i>	+	+	Hairy
77	Melastomataceae	<i>Memecylon</i> sp.	-	+	Non hairy/Smooth
78	Melastomataceae	<i>Phyllagathis hispida</i>	+	-	hairy
79	Melastomataceae	<i>Pternandra azurea</i>	-	+	hairy
80	Melastomataceae	<i>Pternandra echinata</i>	+	-	hairy
81	Meliaceae	<i>Aglaia</i> sp.	-	+	Hairy
82	Meliaceae	<i>Walsura</i> sp.	-	+	Non hairy/Smooth
83	Monimiaceae	<i>Kibara coriacea</i>	-	+	Non hairy/Smooth
84	Moraceae	<i>Artocarpus dadah</i>	-	+	Hairy
85	Moraceae	<i>Artocarpus rigidus</i>	-	+	Hairy
86	Moraceae	<i>Artocarpus scortechinii</i>	+	-	Hairy
87	Moraceae	<i>Artocarpus</i> sp.	+	-	Hairy
88	Moraceae	<i>Ficus</i> sp.	-	+	Non hairy/Smooth
89	Moraceae	<i>Streblus elongatus</i>	+	-	hairy
90	Myristicaceae	<i>Knema intermedia</i>	-	+	Non hairy/Smooth
91	Myristicaceae	<i>Knema laurina</i>	-	+	Non hairy/Smooth
92	Myrtaceae	<i>Syzygium polyanthum</i>	+	-	Non hairy/Smooth
93	Myrtaceae	<i>Syzygium</i> sp.	+	+	Non hairy/Smooth
94	Olacaceae	<i>Ochanostachys amentacea</i>	+	+	Non hairy/Smooth
95	Oleaceae	<i>Linociera</i> sp.	-	+	Non hairy/Smooth
96	Pentaphylacaceae	<i>Eurya</i> sp.	-	+	Non hairy/Smooth
97	Phyllanthaceae	<i>Cleistanthus</i> sp.	-	+	Non hairy/Smooth
98	Phyllanthaceae	<i>Glochidion</i> sp.	-	+	Non hairy/Smooth
99	Phyllanthaceae	<i>Phyllanthus</i> sp.	+	-	Non hairy/Smooth
100	Piperaceae	<i>Piper</i> sp.	+	-	Non hairy/Smooth

101	Plantaginaceae	<i>Brookea tomentosa</i>	-	+	Hairy
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Table 1. (Continued)

102	Poaceae	<i>Oplismenus burmannii</i>	+	-	Non hairy/Smooth
103	Polygalaceae	<i>Xanthophyllum amoenum</i>	-	+	Non hairy/Smooth
104	Polygalaceae	<i>Xanthophyllum</i> sp.	-	+	Non hairy/Smooth
105	Primulaceae	<i>Ardisia elliptica</i>	-	+	Non hairy/Smooth
106	Primulaceae	<i>Ardisia</i> sp.	-	+	Non hairy/Smooth
107	Rhizophoraceae	<i>Pellacalyx axillaris</i>	+	-	Non hairy/Smooth
108	Rubiaceae	<i>Anisophylla beccariana</i>	-	+	Non hairy/Smooth
109	Rubiaceae	<i>Canthium</i> sp.	-	+	Non hairy/Smooth
110	Rubiaceae	<i>Chassalia chartacea craib</i>	+	-	Non hairy/Smooth
111	Rubiaceae	<i>Gaertnera</i> sp.	-	+	Non hairy/Smooth
112	Rubiaceae	<i>Gaertnera vaginan</i>	-	+	Non hairy/Smooth
113	Rubiaceae	<i>Ixora javanica</i>	-	+	Non hairy/Smooth
114	Rubiaceae	<i>Ixora</i> sp.	+	-	Non hairy/Smooth
115	Rubiaceae	<i>Lasianthus</i> sp.	-	+	Non hairy/Smooth
116	Rubiaceae	<i>Porterandia anisophylla</i>	-	+	hairy
117	Rubiaceae	<i>Psychotria</i> sp.	-	+	Non hairy/Smooth
118	Rubiaceae	<i>Timonius wallichianus</i>	+	-	Non hairy/Smooth
119	Rubiaceae	<i>Uncaria</i> sp.	-	+	Non hairy/Smooth
120	Salicaceae	<i>Flacourtia rukam</i>	-	+	Non hairy/Smooth
121	Sapindaceae	<i>Nephelium</i> sp.	-	+	Non hairy/Smooth
122	Sapotaceae	<i>Barringtonia macrophylla</i>	+	-	Non hairy/Smooth
123	Sapotaceae	<i>Madhuca utilis</i>	+	-	Non hairy/Smooth
124	Sapotaceae	<i>Palaquium gutta</i>	+	+	Non hairy/Smooth
125	Sapotaceae	<i>Payena</i> sp.	-	+	Non hairy/Smooth
126	Sapotaceae	<i>Pouteria malaccensis</i>	+	-	hairy
127	Selaginellaceae	<i>Selaginella intermedia</i>	+	-	hairy
128	Thymelaeaceae	<i>Aquilaria microcarpa</i>	-	+	Non hairy/Smooth
129	Ulmaceae	<i>Gironniera nervosa</i>	+	-	Hairy
130	Violaceae	<i>Rinorea anguifera</i>	+	-	hairy
Total			53	85	

Note: + : Species recorded, - : None species recorded

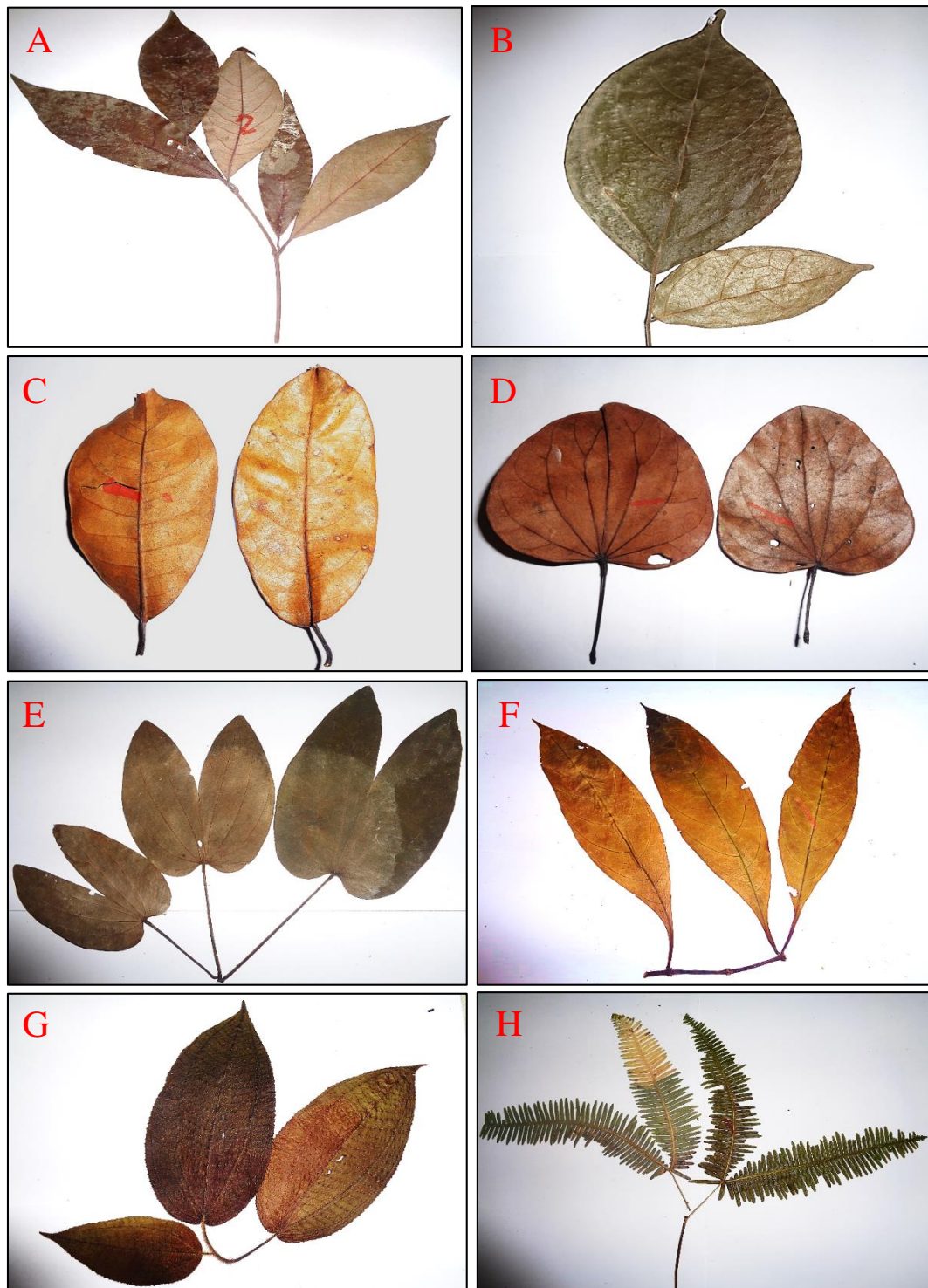


Figure 3: Examples of leaf collected. (A) *Actinodaphne* sp., (B) *Agelaea borneensis*, (C) *Artocarpus* sp., (D) *Bauhinia integrifolia*, (E) *Bauhinia unguolata*, (F) *Chassalia chartacea craib*, (G) *Clidemia hirta* and (H) *Dicranopteris linearis*



Figure 4: Examples of leaf collected. (I) *Elaeocarpus* sp., (J) *Fissistigma* sp., (K) *Gironniera nervosa*, (L) *Ixora* sp., (M) *Lithocarpus lucidus*, (N) *Mallotus* sp., (O) *Palaquium gutta* and (P) *Piper* sp.



Figure 5: Examples of leaf collected. (Q) *Phyllanthus* sp., (R) *Pternandra echinata*, (S) *Rinorea anguifera*, (T) *Selaginella intermedia*, (U) *Streblus elongatus*, (V) *Tetracera indica*, (W) *Timonius wallichianus* and (X) *Xylopia ferruginea*.

DISCUSSION

In this study, the non-hairy/smooth leaves were preferred by *Kalophrynus palmatissimus* than hairy leaves at Ayer Hitam Forest Reserve (AHFR), Selangor and Pasoh Forest Reserve (PFR), Negeri Sembilan. Most of the leaves that were collected at both forest reserves were non-hairy/smooth leaves. This view is supported by [3] who indicated that the leaf litter species of frogs like *Brachycephalus* sp., *Ischnocnema* sp. (aff. *parva*) 1, and *Ischnocnema* sp. (aff. *parva*) 2 are highly favoured leaves with smooth type of morphology as their breeding and reproduction habitats. This is because the smooth type of leaf morphology provides regular adaptations for habitat and to forage for food to ensure the development and survival of leaf litter frog like *K. palmatissimus*. [3] reported that leaf litter frog species primarily used non-hairy *Eucalyptus grandis* for breeding habitat requirement. According to [4], the anurans survival depend on their ability to reproduce. Therefore, the suitable microhabitats are very important for ground litter frogs to complete their life cycle. In the lower montane forest and immediate vicinity of Mt. Kalatungan, Bukidnon, Philippines, [20] reported that the microhabitat preference for *Megophrys stejnegeri* and *Polypedates leucomystax* is leaf litters. They also reported that *Staurois natator* prefer *Alocacia* sp., which has smooth leaf morphology as their microhabitat. According to [15], non-hairy fern leaves were found to provide sitting position for leaf litter frogs to rest on and hiding from predators.

There were nine similar types of leaves that were recorded at both AHFR and PFR which are *Camptosperma auriculatum*, *Clidemia hirta*, *Elaeocarpus* sp., *Mallotus* sp., *Ochanostachys amentacea*, *Palaquium gutta*, *Shorea leprosula*, *Shorea macroptera*, and *Syzygium* sp. Those collected nine types of leaves are common species that can be found in lowland dipterocarp forest [2]. Both AHFR and PFR are lowland dipterocarp forest. This suggests that those leaves are highly preferred by *K. palmatissimus* at AHFR and PFR as their most suitable breeding and foraging sites. [16] mentioned that *Limnonectes blythii* were recorded from lowland dipterocarp forest dominates by *Shorea leprosula* (meranti tembaga) in Beris Valley, Kedah.

CONCLUSION

It was suggested that *Kalophrynus palmatissimus* favoured non-hairy/smooth leaves as their most suitable microhabitat structure. Therefore, this preliminary information can be used as reference to search for the presence of *K. palmatissimus* and future studies to better understand the relationship between non-hairy/smooth leaves and *K. palmatissimus* should be conducted. In addition, this study provides a supportive justification to protect those described tree species at the two forest reserves, because protecting those tree species will indirectly protect *K. palmatissimus* and perhaps other anurans in Peninsular Malaysia.

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