Herpetofauna surveys at CFS ecological corridor (J-PL2: Panti Forest Reserve-Ulu Sedili Forest Reserve), Johor, Malaysia

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Abstract. Herpetological surveys were conducted at Panti Forest Reserve and Ulu Sedili Forest Reserve of Johor in March and April 2019. These forest reserves are identified as one of the designated primary linkages under the Central Forest Spine (CFS) Masterplan, named as J-PL2 or previously known as CFSII PL3. The objective of the study is to document updated list of herpetofauna species recorded at the J-PL2. During this study, one-hectare study plot was established at Panti Forest Reserve and Ulu Sedili Forest Reserve, respectively. Each study plot was equipped with 10 transect lines. A total of 25 pitfall traps were deployed at each study plot. These traps were set for five consecutive nights per session, with a total of two sampling sessions per site. In addition, active search was also conducted for a minimum of two hours at each site during every sampling session. As a result, a total of 30 individuals comprising of 13 species of herpetofauna were recorded at J-PL2. Panti Forest Reserve harbour highest number of herpetofauna with nine species (five families) followed by Ulu Sedili Forest Reserve with six species (five families). Amphibians was the most species captured in Panti Forest Reserve with six species, whilst the number of species recorded for both amphibians and reptiles at Ulu Sedili was similar with three species. Furthermore, five species of the herpetofauna representing by one amphibian and four reptiles are new additional recorded herpetofauna species when compared to a compilation of previously listed species at both forest reserves. *Pelobatrachus nasutus, Draco haematopogon* and *Naja sumatrana* are among the latest species recorded through this study. Referring to this information, hopefully the significance of J-PL2 as an important shelter for various herpetofauna species could be reflected and proper conservation actions must be undertaken to protect and sustain their population.

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1 Introduction

Malaysia has been endowed with dense tropical rainforests and high species richness. The rainforests provide plentiful diversity of habitats and ecosystems with remarkable numbers of biodiversity. However, the on-going loss and enormous forest conversion to agriculture, settlements, industrials, and other developments in Malaysia have caused habitat degradation, leading to forest fragmentation. The emergence of forest fragmentation creates concerns about conservation as the intrusions may impact and modify the natural species assemblages by breaking the habitats' continuity [1]. Eventually, this may lead to habitat destruction and biodiversity reduction, especially for forest-dependent species.

National Policy on Biological Diversity (NPBD) 2016-2025 has identified the crucial need for ecological connectivity to protect important habitats for wildlife population viability. Hence, the government has introduced the Central Forest Spine (CFS) initiative. Under the initiative, fragmented forest areas are targeted to create and re-establish a wider and contiguous range of forest complexes for wildlife. In total, there are 39 ecological corridors identified in Peninsular Malaysia [2]. The establishment of these corridors could safeguard the identified fragmented forest complexes. Hence, co-existence and benefit between development and conservation are expected to be balanced sustainably.

Panti Forest Reserve (FR) and Ulu Sedili FR are both located in the district of Kota Tinggi in Johor, West's Malaysia southernmost state. Both forest reserves were adjoining under a Central Forest Spine primary linkage namely J-PL2: Panti FR- Ulu Sedili FR or previously known as CFSII PL3. The J-PL2 is one out of three ecological corridors identified in the state of Johor. The corridor covers an area of 2,368ha and is known to support a rich array of species including enigmatic wildlife such as Asian elephant, Malayan tiger and Malayan sun bear. Securing this corridor is crucial as it is overlapping with a highly rich biodiversity forest, Endau-Kota Tinggi West Wildlife Reserve [2].

Previously, study on herpetofauna in Panti FR has been carried out by Leong [3], Leong [4], Yong [5], Norhayati el al. [6], Chan et al. [7] and Yang [8] while in Ulu Sedili FR by Leong [4]. Although the reports of herpetofauna at both forest reserves is available, the information is still considered insufficient and understudied especially for Ulu Sedili FR. Hence, this study aims to update the checklist of herpetofauna at J-PL2 which encompasses both Panti FR and Ulu Sedili FR. This updated information may supply essential information to decision-makers, especially the state or local authorities, to undertake further action. Thus, we might be able to better ameliorate the effects of large-scale habitat loss by securing the vital habitats for herpetofauna population.

2 Materials and Methods

2.1. Study sites

Surveys were conducted at two sites, each located in Panti FR (01°52'37.0" N; 103°48'11.4"E) and Ulu Sedili FR (01°52'38.7" N; 103°48'10.8" E). Panti FR mainly composed of lowland forest vegetation. The highest point in this reserve is Gunung Panti (481 m) and Gunung Panti Barat (513 m) in the central part of the reserve and Gunung Muntahak (634 m) in the northwestern region [7]. As for Ulu Sedili FR, it was gazetted as a Permanent Forest Reserve on 8 November 1951. The average elevation of the forest reserve is about 300 m above sea level and predominantly covered with lowland forest trees [9]. At both forest reserves, there

is the presence of arousing streams and tributaries arouse from several river networks in this corridor.

2.2 Trapping

The surveys were conducted twice for each site: 1) 11-16 March 2019 and 9-14 April 2019. At each site, a 1ha (100m x 100m) plot were constructed comprising a total 10 transect lines (A-J). The distance between each transect lines were 10m interval. Each survey sites equipped with a total of 25 pitfall traps (18L). A total of five pitfalls traps were deployed in between two transect lines (A-B; C-D; E-F; GH; I-J), at 20m interval each. These traps were opened for five consecutive nights for each survey. Apart from trapping, active night-searches at the smaller tributaries of the flowing rivers located nearby surveyed areas were also carried out with a minimum of two-hours per searching by eight persons. Specimens were caught by hand or with snake-tong and snake-hook. Required morphological measurements such as total length (TL) and snout-vent length (SVL) for all captured species were taken. Representative samples of each species collected were photographed prior to preservation. Liver samples were taken and stored in acetone. Specimen were next set in 10% formalin, then transferred into 70% denatured ethanol for storage. Voucher materials were deposited at the Zoology Branch Specimen Collections in Forest Research Institute of Malaysia (FRIM) for further reference.

3 Results and Discussion

A total of 13 species of reptiles and amphibians were identified. These comprised five species of reptiles from four families and eight species of anuran belonging to three families. The herpetofauna species recorded during this study at both Panti FR and Ulu Sedili FR are presented in Table 1 and the updated checklist of herpetofauna, compiled from both current and past studies were shown in Table 2.

Panti FR harbour higher number of herpetofauna species with two and six species of reptiles and amphibians, respectively. The high number of amphibians recorded may be influenced by the presence of the river system giving rise to numerous small, forest streams at Panti FR. This is supported by Grismer et al. [10] and Grismer et al. [11] which stated that forest stream typically supports a much higher diversity of frogs. The presence of other microhabitats in the Panti FR such as bedrock, shrubs that grow along the streamside, leaf litter, and rocky boulders may also provide opportunities for diverse anurans to inhabit the area. This is displayed during the study where most anurans recorded from this area were found on shrubs and rocky boulders, throughout active night-searches.

Among the anurans species recorded in Panti FR, Blyth's wart frog (*Limnonectes blythii*) and White-lipped frog (*Chalcorana labialis*) were the most abundance species, with the similar number of seven individuals documented. Species, *L. blythii* is mainly a forest frog that inhabits streams with rocks and sometimes can be found in puddles or wet grass of forest clearings at night [12]. Moreover, Vishnu and David [13] found that a shallow and slow-moving streams with a pH value above 5 were preferred microhabitat conditions for *L. blythii* when selecting the site for oviposition. In the meantime, *C. labialis* tends to occur in a shaded environment with clear shallow streams in lowland primary forests, adjacent secondary forests, and freshwater swamp forests [14,15]. During the study, the majority of *C. labialis* individuals are caught as its perch low down on streamside branches or fallen forest debris.

As for Ulu Sedili FR, only six species of herpetofauna comprised three species of reptiles and three species of amphibians were recorded. The number of reptile species presented in this area are slightly higher than in Panti FR. The recorded reptile species were Bell's anglehead lizard (*Gonocephalus bellii*), Peters's bow-fingered gecko (C*yrtodactylus consobrinus*) and Equatorial spitting cobra (*Naja sumatrana*). Both *G. belli* and *C. consobrinus* were caught at night as they perched on small tree branches along the trails. According to Das [16], these two species can be found occurs in lowland primary rainforest or mature secondary forests. Whereas the *N. sumatrana* is caught in the deployed pitfall trap. This venomous snake probably falls into the trap while slithering on the forest floor to forage for foods. According to Das [16], this carnivorous snake generally inhabits forested areas in the lowlands and mid-hills. It mainly devours rodents and frogs, but occasionally feeds on other snakes, lizards, and small mammals.

In this study, the yield of herpetofauna species at J-PL2 is considered low. The significant potential aspect of our low records may be largely attributed to the limited sampling period (five-traps night/session). Ibrahim et al [17] stated, herpetological surveys typically required longer periods due to the elusive and secretive behaviors of many snakes and lizards which tend to escape unnoticed or conceal themselves at the human attempt. Thus, cross-sectional survey tends to under-represent the actual herpetofauna diversity, especially in dense tropical forest [18]. Furthermore, Inger et al. [19] also mentioned the other factors that may be associated with the number of species recorded in the area which include area of coverage, sampling technique, weather, and types of microhabitats. Hence, continuous intensive surveys are needed to gain a better representation of herpetofauna diversity at J-PL2. The comprehensive information would facilitate to determine their ecological needs and allows for appropriate conservation measures to be designed by the authorities.

Despite the low diversity records, we were able to add five new records of herpetofauna species at J-PL2. Of these, one species is amphibian namely Malayan horned frog (*Pelobatrachus nasutus*), whilst the other four are reptile species known as Red-bearded Flying Dragon (*Draco haematopogon*), Bell's anglehead lizard (*Gonocephalus bellii*), Equatorial spitting cobra (*Naja sumatrana*) and Kuhl's gliding gecko (*Gekko kuhli*). This finding shows the number of herpetofauna at J-PL2 is still increasing and new records are potentially to be discovered with proper intensive surveys such as covering different sites in diverse forest settings (e.g., waterways, forest gradient), applying various sampling techniques (for instance: pitfall traps with drift fences, sound calls) and encompasses different seasonal cycles with extended sampling period.

Table 1. List of species recorded at Panti Forest Reserve and Ulu Sedili Forest Reserve, Johor

Family	Common Name	Scientific Name	IUCN	Panti FR	Ulu Sedili FR
i) Reptiles					
Agamidae	Red-bearded flying dragon	*Draco haematopogon*	LC	1[A]	
Agamidae	Bell's anglehead lizard	*Gonocephalus bellii*	LC		1[A]
Elapidae	Equatorial spitting cobra	*Naja sumatrana*	LC		1[P]
Gekkonidae	Peters's bow-fingered gecko	*Cyrtodactylus consobrinus*	LC		1[P]
Gekkonidae	Kuhl's gliding gecko	*Gekko kuhli*	LC	1[A]	
ii) Amphibians					
Dicroglossidae	Blyth's wart frog	*Limnonectes blythii*	NT	7[A]	
Dicroglossidae	Malayan giant frog	*Limnonectes malesianus*	NT	5[A]	
Megophryidae	Malayan horned frog	*Pelobatrachus nasutus*	LC		1[A]
Ranidae	White-lipped frog	*Chalcorana labialis*	LC	7[A]	1[A]
Ranidae	Common green frog	*Hylarana erythraea*	LC	1[A]	
Ranidae	Poisonous rock frog	*Odorrana hosii*	LC	1[A]	
Ranidae	Side-spotted Swamp Frog	*Pulchrana laterimaculata*	LC		1[A]
Ranidae	Spotted stream frog	*Pulchrana sundabarat*	LC	1[A]	
Total number of Species				**8**	**6**
Total number of Individuals				**24**	**6**
Total number of Families				**4**	**5**

IUCN: International Union for Conservation of Nature; LC= Least Concern; NT=Near Threatened
A: Individuals species recorded by active searching
P: Individuals species recorded by pitfall trapping

Table 2. A compilation of small mammals recorded in Panti Forest Reserve and Ulu Sedili Forest Reserve from previous and current studies.

No	Family	Common Name	Scientific Name	IUCN	A	B	C	D	E	F	G	Present Study, 2019
					PFR	PFR	USFR	PFR	PFR	PFR	PFR	J-PL2
i) Reptiles												
1	Agamidae	Armored tree dragon	*Acanthosaura armata*	LC					/	/		
2	Agamidae	Earless agamid	*Aphaniotis fusca*	LC	/			/	/		/	
3	Agamidae	Green crested lizard	*Bronchocela cristatella*	LC	/			/				
4	Agamidae	Oriental garden Lizard	*Calotes versicolor*	LC						/		
5	Agamidae	Dusky gliding lizard	*Draco formosus*	LC						/	/	
6	Agamidae	Red-bearded Flying Dragon	*Draco haematopogon*	LC								*
7	Agamidae	Black-bearded Flying Dragon	*Draco melanopogon*	LC	/			/	/			
8	Agamidae	Five-lined Flying Dragon	*Draco quinquefasciatus*	LC	/			/				
9	Agamidae	Common gliding lizard	*Draco sumatranus*	LC	/							
10	Agamidae	Common flying dragon	*Draco volans*	LC				/				
11	Agamidae	Bell's anglehead lizard	*Gonocephalus bellii*	LC								*
12	Agamidae	Giant forest dragon	*Gonocephalus grandis*	LC	/				/	/		
13	Colubridae	Malaya green whipsnake	*Ahaetulla mycterizans*	LC						/		
14	Colubridae	Gold-ringed cat snake	*Boiga melanota*	LC	/			/				
15	Colubridae	Lovi's reed snake	*Calamaria lovii*	LC	/			/				
16	Colubridae	Elegant bronzeback	*Dendrelaphis formosus*	LC	/			/				
17	Colubridae	Blueneck keelback	*Macropisthodon rhodomelas*	LC	/			/				
18	Colubridae	Half-keeled kukri snake	*Oligodon signatus*	LC	/			/				
19	Colubridae	Triangle keelback	*Xenochrophis trianguligerus*	LC	/			/				

20	Elapidae	Malayan krait	*Bungarus candidus*	LC					/	
21	Elapidae	Banded Malaysian coral snake	*Calliophis intestinalis*	LC	/	/				
22	Elapidae	Equatorial spitting cobra	*Naja sumatrana*	LC						*
23	Gekkonidae	Kendall's rock gecko	*Cnemaspis kendalii*	LC	/		/	/		
24	Gekkonidae	Peters's bow-fingered gecko	*Cyrtodactylus consobrinus*	LC				/		/
25	Gekkonidae	Taylor's Bow-fingered Gecko	*Cyrtodactylus quadrivirgatus*	LC			/			
26	Gekkonidae	Peninsular Bent-toed Gecko	*Cyrtodactylus semenanjungensis*	NT				/		
27	Gekkonidae	Four-clawed gecko	*Gehyra mutilata*	LC				/		
28	Gekkonidae	Spotted house gecko	*Gekko monarchus*	LC				/		
29	Gekkonidae	Smith's green-eyed gecko	*Gekko smithii*	LC	/	/		/		
30	Gekkonidae	Frilled gecko	*Hemidactylus craspedotus*	LC				/		
31	Gekkonidae	Common house gecko	*Hemidactylus frenatus*	LC				/		
32	Gekkonidae	Flat-tailed house gecko	*Hemidactylus platyurus*	LC				/		
33	Gekkonidae	Kuhl's gliding gecko	*Gekko kuhli*	LC						*
34	Geoemydidae	Asian leaf turtles	*Cyclemys dentata*	NT			/			
35	Pythonidae	Reticulated python	*Malayopython reticulatus*	LC	/	/				
36	Scincidae	Olive tree skink	*Dasia olivacea*	LC	/	/		/		
37	Scincidae	East Indian brown mabuya	*Eutropis multifasciata*	LC	/	/		/	/	
38	Scincidae	Nicobar island skink	*Eutropis rugifera*	LC	/	/				
39	Scincidae	Banded lipinia	*Lipinia vittigera*	LC				/		
40	Scincidae	Bowring's supple skink	*Lygosoma bowringii*	LC			/	/		
41	Varanidae	Common water monitor	*Varanus salvator*	LC	/	/				
42	Varanidae	Clouded monitor	*Varanus nebulosus*	NT	/	/				
43	Viperidae	Hagen's pit viper	*Trimeresurus hageni*	LC				/		
44	Viperidae	Sumatran pit viper	*Trimeresurus sumatranus*	LC			/			

ii) Amphibians

45	Bufonidae	Asian common toad	*Duttaphrynus melanostictus*	LC					/	/		
46	Bufonidae	Dwarf toad	*Ingerophrynus parvus*	LC					/	/		
47	Bufonidae	Swamp toad	*Ingerophrynus quadriporcatus*	LC							/	
48	Bufonidae	Java toad	*Phrynoidis asper*	LC					/	/		
49	Dicroglossidae	Asian grass frog	*Fejervarya limnocharis*	LC		/			/	/		
50	Dicroglossidae	Blyth's wart frog	*Limnonectes blythii*	NT		/	/		/	/	/	/
51	Dicroglossidae	Malayan giant frog	*Limnonectes malesianus*	NT		/			/	/		/
52	Dicroglossidae	Lesser swamp frog	*Limnonectes paramacrodon*	NT		/			/	/		
53	Dicroglossidae	Rhinoceros frog	*Limnonectes plicatellus*	LC		/						
54	Dicroglossidae	Flat-headed frog	*Limnonectes laticeps*	LC		/						
55	Dicroglossidae	Marten's oriental frog	*Occidozyga martensii*	LC						/		
56	Dicroglossidae	Common puddle frog	*Occidozyga laevis*	LC		/			/	/		
57	Dicroglossidae	Sumatran puddle frog	*Occidozyga sumatrana*	LC							/	
58	Megophryidae	Spotted litter frog	*Leptobrachium hendricksoni*	LC					/			
59	Megophryidae	Black-eyed litter frog	*Leptobrachium nigrops*	LC					/			
60	Megophryidae	Malayan horned frog	*Pelobatrachus nasutus*	LC								*
61	Microhylidae	Lowland grainy frog	*Kalophrynus palmatissimus*	EN					/	/		
62	Microhylidae	Black-spotted Sticky Frog	*Kalophrynus pleurostigma*	LC						/		
63	Microhylidae	Banded bullfrog	*Kaloula pulchra*	LC						/		
64	Microhylidae	Dark-sided Chorus Frog	*Microhyla heymonsi*	LC					/	/	/	
65	Microhylidae	Manthey's Narrow-mouthed Frog	*Microhyla mantheyi*	LC	/					/		
66	Microhylidae	Pengalengan rice frog	*Microhyla palmipes*	LC	/							
67	Microhylidae	False Ornate Narrow-mouthed Frog	*Micryletta inornata*	LC						/		
68	Ranidae	Nicobar frog	*Amnirana nicobariensis*	LC		/				/	/	
69	Ranidae	White-lipped frog	*Chalcorana labialis*	LC		/	/		/	/	/	/
70	Ranidae	Common green frog	*Hylarana erythraea*	LC		/			/	/		/
71	Ranidae	Poisonous rock frog	*Odorrana hosii*	LC					/	/	/	/

72	Ranidae	Banjaran frog	*Pulchrana banjarana*	NT					/		
73	Ranidae	Baram river frog	*Pulchrana baramica*	LC		/		/			
74	Ranidae	Rough-sided Frog	*Pulchrana glandulosa*	LC		/		/	/		
75	Ranidae	Side-spotted Swamp Frog	*Pulchrana laterimaculata*	LC		/			/	/	/
76	Ranidae	Spotted stream frog	*Pulchrana picturata*	LC				/	/		/
77	Ranidae	Variable-backed Frog	*Pulchrana signata*	LC		/					
78	Rhacophoridae	Frilled tree frog	*Kurixalus appendiculatus*	LC						/	
79	Rhacophoridae	Cinnamon frog	*Nyctixalus pictus*	NT					/		
80	Rhacophoridae	Collett's tree frog	*Polypedates colletti*	LC				/	/		
81	Rhacophoridae	Four-lined Tree Frog	*Polypedates leucomystax*	LC	/			/	/		
82	Rhacophoridae	Dark-eared Treefrog	*Polypedates macrotis*	LC	/			/	/		
83	Rhacophoridae	Inger's flying frog	*Rhacophorus gauni*	LC	/						
84	Rhacophoridae	Blue-legged Tree Frog	*Rhacophorus cyanopunctatus*	LC	/				/		
85	Rhacophoridae	Wallace's flying frog	*Rhacophorus nigropalmatus*	LC					/		
86	Rhacophoridae	Johore flying frog	*Rhacophorus prominanus*	LC	/						
87	Rhacophoridae	Reinwardt's flying frog	*Rhacophorus reinwardtii*	NT				/			
88	Rhacophoridae	Smooth tree frog	*Theloderma licin*	LC					/		

Note: A=Leong, 2004; B=Leong, 2005; C=Leong, 2005; D=Yong, 2006; E=Norhayati et al., 2009; F=Chan et al, 2010; G=Yang et al, 2016
PFR= Panti Forest Reserve; USFR=Ulu Sedili Forest Reserve
IUCN: International Union for Conservation of Nature; LC= Least Concern; NT=Near Threatened; EN=Endangered
(*): New additional distributional records

4 Conclusion

The results show that ecological corridor J-PL2 houses a variety of herpetofauna species, including forest-dwelling frog and reptile species that required intact and clean habitats to thrive and survive. This may indicate J-PL2 still holds pristine forests which is crucial to support the assemblages of their population. Hence, it is hoped that J-PL2 is conserved and protected from any disturbance by relevant authorities for the sake of herpetofauna continued survival and existence.

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