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Research Article

Biodiversity assesment in a Sarawak lowland dipterocarp rainforest of Niah National Park

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ABSTRACT

A transect survey was conducted from 2 – 6 December 2004 in Niah National Park to estimate species diversity and relative abundance of birds and mammals. This study was conducted in four forest line transects: Madu Trail (TR1), Sungai Tangap (TR2), Niah Great Cave (TR3), Bukit Kasut (TR4), and one river transect along the Niah River (RT). A total of 521 birds representing 59 species from 23 families were recorded. The Black-Nest Swiftlet (*Aerodramus maximus*) and the Mossy-Nest Swiftlet (*Aerodramus salanganus*) were the most common species in the park. The family Timaliidae (babblers), with nine species, was recorded as the most diverse family, whereas Strigidae (owls) and Hirundinidae (swallows) were the least diverse families with one species in each. A total of 29 mammalian individuals representing seven species from four families were recorded. The family Sciuridae (squirrels) with three species was recorded as the most diverse family, whereas Cynocephalidae (flying lemurs) and Muridae (rodents) were the least diverse families with one species and one individual each. TR1 was recorded with the highest Shannon-Weiner index (diversity index) of H' = 4.75 and H' = 2.20 for birds and mammals respectively. The lowest bird H' = 3.73 was recorded for TR2, whereas the lowest mammal H' = 0 was recorded for TR2 and RT. Although this study does not identify factors that contribute to different species diversity at each transect line, field observations suggest that vegetation and human activities were the major elements that contributed to the observations found at each transect in this study. Studies on the vegetation types and potential disturbances that influence the faunal diversity will provide useful insights in conservation and management planning of this park.

Keywords: Birds, mammals, Niah National Park, relative abundance, species diversity, transect

INTRODUCTION

Extended to an area of only 31.4 km sq (3,140 hectares), Niah National Park is one of Sarawak's smallest National Parks (Bennett, 1992). Its uniqueness for paleontology studies (e.g., Harrisson, 1958, Piper *et al*., 2007) and diverse ecology has attracted visitors, naturalists and scientists. The park is located 16 km inland, on

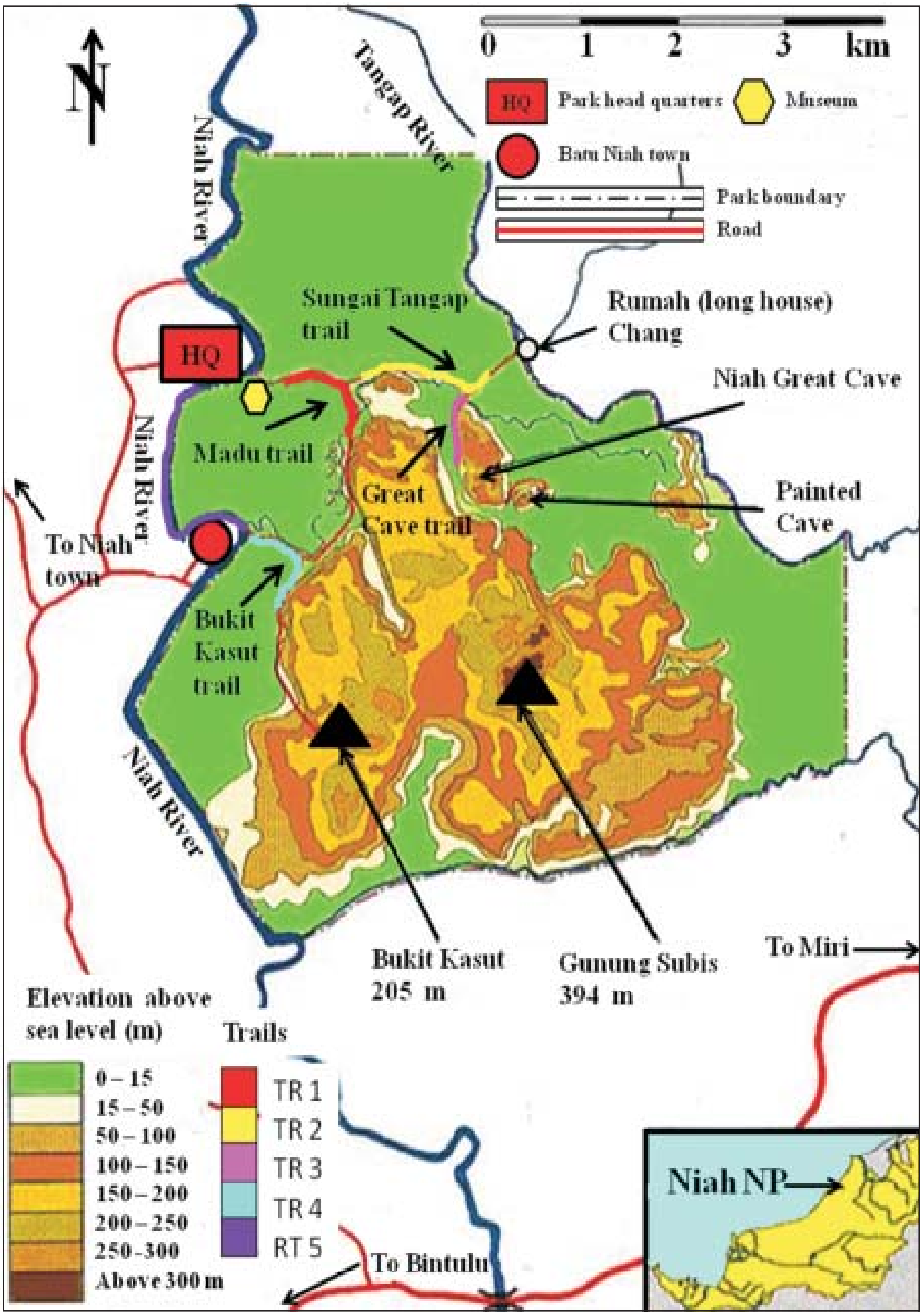

Figure 1: Map showing the locations of sampling areas in Niah National Park (adapted and modified from Hazebroek & Abang Morshidi 2000). All details and symbols were included inside the map. Transects were shaded with different colours as described in the map. Different colours of land cover refer to different elevations in the park.

the northern region of Sarawak (Hazebroek & Abang Morshidi, 2000). It is about 110 kilometres southwest of Miri and located near the Niah River, approximately 3.8 km from the small town of Batu Niah (Bransbury, 1993; Hazebroek & Abang Morshidi, 2000). Niah cave was first established as a National Historic Monument in 1958, and later as national park on 23 November, 1974. It was officially opened to the public on 1 January, 1975. Niah National Park has been proposed as a World Heritage Site by United Nations (UNESCO) owing to the important fact that it holds prehistoric human civilization remains (from 49,000 years ago) in Niah cave (Hazebroek & Abang Morshidi, 2000).

Limestone forest, mixed dipterocarp forest, peat swamp forest and regenerated forest are the main vegetations found in this park (Good, 1991; Anderson, 1996). About 60% to 70% of the park is dominated by Gunung Subis (394 m), which is a large and almost vertical limestone structure (Hazebroek & Abang Morshidi, 2000). In terms of the parks biodiversity, previous studies have documented approximately 190 species of birds, 64 species of mammals, 48 species of snakes and 22 species of frogs (Good, 1991). Niah cave serves as the main habitat for thousands of swiftlets and various species of bats (Medway, 1997). Black-Nest Swiftlets (*Aerodramus maximus*) and Mossy-Nest Swiftlets (*Aerodramus salanganus*) are the major occupants of this cave. These swiftlets also contribute as the major source of income for the local people (especially those in the Chang long-house inside the park; Figure 1) that collect swiftlets nests, which are in demand in the market for medical reasons.

Although the park harbours diverse wildlife, no studies have been conducted utilizing transect lines to survey, document, or update the current list of fauna with estimated relative abundance and diversity. This technique works best with diurnal animals and is usually biased towards highly social animals. However, there are also several advantages that have made this method a useful tool to measure species diversity. This includes the ability to provide a broader range of species than the trapping method due to the dependency on trapping method's limitation that it depends on trap numbers, bait types, position of traps and season (dry or monsoon). Therefore studies using transect surveys are able to provide a quick and reliable estimation of species diversity, especially to monitor the trend of faunal diversity in the park as a result of urbanization or disturbances in the surrounding areas.

Past logging operations that began in the 1960s have led to the emergence of town like Batu Niah that further explains the forest fragmentation found around Niah National Park. It is estimated that about 40% of Niah River water catchment areas (land cover areas) were transformed into a palm oil plantations in 2002. Only 22% of the forest catchment area from 1972 still remains in 2005 (Hansen, 2005). It was also noted that the native people from the long-house inside the park have started to cultivate inside the park boundary. Shifting cultivation and poaching were practised by the locals threatened the forest ecosystem, and thereby affecting wildlife (Hansen, 2005). In view of these threats, a study was conducted in five transects to document the species diversity, and relative abundance as an estimate of bird and mammal diversity in Niah National Park. This study also was aimed to facilitate park management by providing a list of fauna sighted along the walkways as a reflection of potential attractions. It is expected that this baseline data can be useful for future monitoring, management planning and conservation of wildlife in this park.

MATERIALS AND METHODS

Study Area

Transect line surveys were carried out at five different transect lines. Four of them were conducted along popular visitors trails: Madu Trail, Sungai Tangap Trail, Great Cave Trail and Bukit Kasut Trail in the forest, whereas the last one was along the Niah River, which flows along the national park boundary. The location and the range of each transect is shown in Figure 1.

Field Methodology

A transect line survey for data collection of birds and mammals was used without disruption on these faunas, as this involves only observations, rather than direct handling of the animals. The survey was conducted in 1 km distance for each transect line and 3.2 km distance for the river transect as illustrated in Figure 1. The presence of birds and mammals in each area was recorded based on direct and indirect observations. Direct observations were conducted by sighting the animals with binoculars whereas indirect observations were conducted based on the presence of signs such as vocalizations, footprints, faeces, feeding marks on fruits, nests and wallows (Mohd. Nor *et al*., 1992). Birds and mammals found along transects were identified using identification keys by Smythies (1981, 1998, 1999), Payne *et al.* (1985), Lekagul & Round (1991), Bond (1993), MacKinnon & Philipps (1993), Gregory-Smith (1995), Davison & Chew (1996), Harris *et al*. (1996), and Francis (1998). Individual bird and mammal surveys were recorded according to the species identifications. Observations were performed by several small groups that collected the data independently to reduce the double counting. Data was frequently compared between groups to avoid any miscalculation or misidentification. In some cases (mainly swiftlets), average record from all the groups was used as the final observation count. Thus, the data presented herein is the best estimate of faunal diversity.

Transects Lines

Surveys were conducted at four locations as following: transect line one (TR1), transect line two (TR2), transect line three (TR3) and transect line four (TR4). Surveys were conducted by groups of 8 to 10 people equipped with binoculars, field identification keys, and inventory lists. First, transects were measured and marked with coloured plastic-flagging tags at each 25 m interval as the observation point along transects. Survey hours were divided into three sessions: morning (from 0600 hours to 1000 hours), evening (1600 hours to 1800 hours), and at night (1930 hours to 2130 hours) to obtain the best estimation of both nocturnal and diurnal animals in the park. Observers walked at a speed of approximately 500 metres per hour and stopped for one minute at each 25 metre mark to observe and listen for any movement, calls, or signs of animals. This was repeated for five days at four different transects simultaneously by five different groups (including those in river transect). Each group was shuffled between transects to randomize observers and reduce observation errors. This method was useful to document diversity for a large area in a short time, as the length of the survey relies mainly on funding and manpower availabilty.

River Transect

Surveys along the Niah River were conducted by boat from Pangkalan Lobang dock to Bukit Kasut dock in a distance of about 3.2 km. The survey was conducted between 0630 hours to 0700 hours, 1200 hours to 1230 hours, and 1600 hours to 1635 hours. Boat speed was set at approximately 7.1 km per hour. The boat engine will be off to listen to the animals sound. Other surveys methods follow the description in transect line methods above.

Data Analysis

Observation counts in the transect line study were used to calculate the relative abundance of each species. Species diversity indices were calculated for birds and mammals for each line transect. The Shannon-Wiener Index and Evenness were calculated using the DIVERS program (Krebs, 1989), which has been modified (methods for data entry and retrieval has been changed) for ease of data input and output (Laman, 2001). Lastly, the diversity indices between transects were statistically compared using pairwise diversity comparisons following t-test method from Zar (1996).

RESULTS

Bird Species Diversity and Abundance

A total of 521 individuals of birds representing 59 species from 23 families were recorded (see Table 1). The family Timaliidae was recorded as the most diverse family with nine species, followed by Cuculidae with six species, and both Nectariniidae and Pycnonotidae with five species. According to Sarawak's legislation (1998), a total of 15 species from eight families are under Part I and Part II Wildlife Protection Ordinance 1998, which are protected in Sarawak. This study has recorded one species, *Anthracoceros malayanus* (family Bucerotidae; Black Hornbill) that is listed under Part I (Totally Protected Animals) as well as *Egretta garzetta* (family Ardeidae; Little Egret), *Loriculus galgalus* (family Psittacidae; Blue-crowned Hanging Parrot), *Ninox scutulata* (family Strigidae; Brown Hawk-owl), *Copsychus malabaricus* (family Turdidae; White-rumped Shama), all species of swiftlets (family Apodidae), all species of kingfishers (family Alcedinidae), and all species of woodpeckers (family Picidae) that are listed in Part II (Protected Animals) of Wildlife Protection Ordinance 1998. The avifauna of the park was dominated by the Black-Nest Swiftlet (*Aerodramus maximus*) with the highest relative abundance at each transect and was followed by Mossy-Nest Swiftlet (*Aerodramus salanganus*). The family Apodidae recorded the highest relative abundance with 32.1% (or 167 out of 521 individuals). Generally all birds, except for owls, are active during the day. The only nocturnal avian species observed was the Brown Hawk Owl.

Table 2 shows the Shannon-Weiner Index for diversity analysis of each transect. Species diversity index was highest at TR1 (4.75), followed by RT (4.26), TR4 (4.07), TR3 (4.03), and finally TR2 (3.73). Zar's *t*-test calculation at a = 0.05 indicates that there were significant differences in diversity indices between TR1 vs. TR2, TR1 vs. TR3, and TR1 vs. TR4. In contrast, the result indicates that there were no significant differences between TR2 vs. TR3, TR2 vs. TR4, and TR3 vs. TR4. The analysis did not include the comparison with the river transect as the observations for the river transect were set at 3.2 km whereas the rest of transects were calculated for 1 km range.

Mammal Species Diversity and Abundance

A total of 29 individuals of mammals representing seven species from four families were recorded (see Table 3). The mammals were recorded using observation and vocalization techniques for the following families: Cynocephalidae, Cercopithecidae, Sciuridae and Muridae. Following Sarawak's legislation (1998), only flying lemurs (family Cynocephalidae) were included in Part II of Wildlife Protection Ordinance. Only the Plaintain Squirrel (*Callosciurus notatus*) and Prevost's Squirrel (*Callosciurus prevostii*) from the family Sciuridae were recorded at RT (two individuals) and TR2 (one individual) respectively. Although this suggests a 100% relative abundance at each transect, they were represented by less than two individuals that may provide a biased estimation of the overall mammals in those transects. Highest relative abundance was followed by the Pig-Tailed Macaque (*Macaca nemestrina*) and the Plain Pigmy Squirrel (*Exilisciurus exilis*), with both at 22.2% for TR1 and TR3 respectively. In general, the highest relative abundance for mammals was dominated by the family Sciuridae with 65.5% (19 out of 29 individuals).

Table 4 shows the Shannon-Weiner Index for the diversity analysis of each transect. Species'

Table 1: Composition and relative abundance of avifauna recorded in Niah National Park. Total individuals captured and their associated relative abundance are showed according to transect lines (TR = Transect and RT = River Transect)

Family	Species and Common Name	Total	Transect 1	2	3	4	RT	Relative Abundance (%) TR1	TR2	TR3	TR4	RT
Ardeidae	*Egretta garzetta* (Little Egret)	3					3					6.0
Accipitridae	*Spilornis cheela* (Crested Serpent-eagle)	2	1	1				0.9	0.9			
Rallidae	*Amaurornis phoenicurus* (White-breasted Waterhen)	12	1	4		7		0.9	3.5		5.2	
Psittacidae	*Loriculus galgalus* (Blue-crowned Hanging Parrot)	5	3		2			2.8		1.8		
Cuculidae	*Cuculus micropterus* (Indian Cuckoo)	3		1	2				0.9	1.8		
	Cacomantis merulinus (Plaintive Cuckoo)	6	1	1	2	2		0.9	0.9	1.8	1.5	
	Surniculus lugubris (Drongo Cuckoo)	11	5	2		4		4.6	1.7		3.0	
	Phaenicophaeus chlorophaeus (Raffles's Malkoha)	3				1	2				0.8	4.0
	Phaenicophaeus sumatranus (Chestnut-bellied Malkoha)	1					1					2.0
	Centropus sinensis (Greater Coucal)	19	2	2	3	7	5	1.8	1.7	2.7	5.2	10.0
Strigidae	*Ninox scutulata* (Brown Hawk-owl)	1			1					0.9		
Apodidae	*Aerodramus maximus* (Black-nest Swiftlet)	103	13	32	23	29	6	11.9	27.8	20.4	21.6	12.0
	Aerodramus salanganus (Mossy-nest Swiftlet)	64	10	17	17	16	4	9.2	14.8	15.0	11.9	8.0
Alcedinidae	*Actenoides concretus* (Rufous-collared Kingfisher)	1					1					2.0
	Todirhamphus chloris (White-collared Kingfisher)	1					1					2.0
	Halcyon capensis (Stork-billed Kingfisher)	5	2				3	1.8				6.0
	Alcedo atthis (Common Kingfisher)	2					2					4.0
	Ceyx rufidorsus (Rufous-backed Kingfisher)	16	4	3	9			3.7	2.6	8.0		
Bucerotidae	*Anthracoceros malayanus* (Black Hornbill)	2			2					1.8		
Megalaimidae	*Megalaima rafflesii* (Red-crowned Barbet)	3	1		1	1		0.9		0.9	0.8	
	Megalaima mystacophanos (Red-throated Barbet)	5				5					3.7	
	Megalaima australis (Little Barbet)	20	7	8	4		1	6.4	7.0	3.5		2.0
Picidae	*Sasia abnormis* (Rufous Piculet)	1	1					0.9				
	Picus puniceus (Crimson-winged Woodpecker)	2	2					1.8				
Eurylaimidae	*Eurylaimus ochromalus* (Black-and-yellow Broadbill)	10	2	2	5	1		1.8	1.7	4.4	0.8	
Hirundinidae	*Hirundo tahitica* (Pacific Swallow)	1					1					2.0
Aegithinidae	*Aegithina tiphia* (Common Iora)	2					2					4.0
	Chloropsis cyanopogon (Lesser Green Leafbird)	6	1		1	4		0.9		0.9	3.0	
	Chloropsis cochinchinensis (Blue-winged Leafbird)	3		2	1				1.7	0.9		

Family	Species and Common Name	Total	Transect 1	2	3	4	RT	Relative Abundance (%) TR1	TR2	TR3	TR4	RT
Pycnonotidae	*Pycnonotus goiavier* (Yellow-vented Bulbul)	4					4					8.0
	Pycnonotus plumosus (Olive-winged Bulbul)	4			1	3				0.9	2.2	
	Pycnonotus brunneus (Red-eyed Bulbul)	12	2	4	3	2	1	1.8	3.5	2.7	1.5	2.0
	Alophoixus bres (Grey-cheeked Bulbul)	1	1					0.9				
	Alophoixus phaeocephalus (Yellow-bellied Bulbul)	2	2					1.8				
Turdidae	*Trichixes pyrropyga* (Rufous-tailed Shama)	1	1					0.9				
	Copsychus saularis (Magpie Robin)	6		1	1	2	2		0.9	0.9	1.5	4.0
	Copsychus malabaricus (White-rumped Shama)	12	2	4	2	4		1.8	3.5	1.8	3.0	
Timaliidae	*Trichastoma rostratum* (White-chested Babbler)	11	1	5		3	2	0.9	4.4		2.2	4.0
	Malacocincla malaccensis (Short-tailed Babbler)	1	1					0.9				
	Malacopteron magnum (Rufous-crowned Babbler)	5	5					4.6				
	Malacopteron cinereum (Scaly-crowned Babbler)	1	1					0.9				
	Malacopteron magnirostre (Moustached Babbler)	3		3					2.6			
	Napothera atrigularis (Black-throated Wren Babbler)	4	2			2		1.8			1.5	
	Macronous gularis (Striped Tit Babbler)	3	1			2		0.9			1.5	
	Macronous ptilosus (Fluffy-backed Tit Babbler)	1	1					0.9				
	Stachyris erythroptera (Chestnut-winged Babbler)	20	2	7	4	7		1.8	6.1	3.5	5.2	
Sylviidae	*Orthotomus sericeus* (Rufous-tailed Tailorbird)	27	6	7	6	8		5.5	6.1	5.3	6.0	
Muscicapidae	*Rhipidura perlata* (Spotted Fantail)	4	4					3.7				
Dicaeidae	*Prionochilus maculatus* (Yellow-breasted Flowerpecker)	26	5	4	7	9	1	4.6	3.5	6.2	6.7	2.0
	Dicaeum trigonostigma (Orange-bellied Flowerpecker)	1				1					0.8	
Nectariniidae	*Anthreptes malacensis* (Brown-throated Sunbird)	7		1	5	1			0.9	4.4	0.8	
	Hypogramma hypogrammicum (Purple-naped Sunbird)	3	2				1	1.8				2.0
	Nectarinia jugularis (Olive-backed Sunbird)	7			4	2	1			3.5	1.5	2.0
	Arachnothera longirostra (Little Spiderhunter)	19	4	2	5	7	1	3.7	1.7	4.4	5.2	2.0
	Arachnothera robusta (Long-billed Spiderhunter)	6	6					5.5				
Sturnidae	*Aplonis panayensis* (Asian Glossy Starling)	3					3					6.0
	Acridotheres tristis (Common Myna)	2					2					4.0
	Cracula religiosa (Hill Myna)	2	1		1			0.9		0.9		
Dicruridae	*Dicrurus paradiseus* (Greater Racket-tailed Drongo)	10	3	2	1	4		2.8	1.7	0.9	3.0	
	Total number of individuals	521	109	115	113	134	50					
	Total number of families	23	19	15	17	13	13					
	Total number of species	59	37	23	26	26						23

Table 2: Shannon - Weiner Index and evenness of avifauna (above), and comparison of diversity indices between two transects using the Zar *t*-test (below). The Zar *t*-test is calculated by comparing each transect line with other transect lines studied here. The river transect was not included for the Zar *t*-test, as explained in the results section (TR = Transect; RT = River Transect; α = 0.05)

	TR 1	**TR2**	**TR3**	**TR4**	**RT**
Number of individuals	109	115	113	134	50
Number of families	19	15	17	13	13
Number of species	37	23	26	26	23
Shannon-Weiner Index (*H'*)	4.75	3.73	4.03	4.07	4.26
Evenness	0.04	0.12	0.09	0.08	0.04

Transect	***t*-calculated**	***t*-critical**	**Significant/Not significant**
Transect 1 vs. Transect 2	22.07	1.96	Significant
Transect 1 vs. Transect 3	17.10	1.96	Significant
Transect 1 vs. Transect 4	17.56	1.96	Significant
Transect 2 vs. Transect 3	– 5.19	1.96	Not significant
Transect 2 vs. Transect 4	– 5.28	1.96	Not significant
Transect 3 vs. Transect 4	– 0.74	1.96	Not significant

diversity index was highest at TR1 (2.20) followed by TR3 (1.84), and TR4 (1.75). However, the result of the diversity index for mammals at TR2 and RT was zero. This is due to the small number of individuals at both line transects. The Zar *t*-test calculations at α = 0.05 showed that there was a significant difference between the diversity indices of TR1 vs. TR3, and TR1 vs. TR4. In contrast, results showed that there was no significant difference between TR3 vs. TR4.

DISCUSSION

Bird Species Diversity and Abundance

Results from this study showed that the avian family Apodidae had the highest relative abundance. This was probably due to high spotting chances compared to other animals, as they fly in a range and become detectable to the naked eye. The occurrence of limestone caves also explains this observation. Both the Black-Nest Swiftlet (*A. maximus*) and the Mossy-Nest Swiftlet (*A. salanganus*) were recorded with the highest relative abundance at all transects. According to Rahman & Abdullah (2002), abundance of swiftlets is influenced by the presence of caves and cliffs that serves as their major roosting site. Hazebroek & Abang Morshidi (2000) also reported that the Niah Great Cave is one of the largest limestone caves in Sarawak, with a high number of fauna occupying this habitat. In this cave, swiftlets were estimated to reach a total of 150,000 individuals. Three swiftlet species were found in the park: Black-Nest, Mossy-Nest and White-Bellied Swiftlets. Of these, Black-Nest Swiftlets are the most common found in Borneo and form the main population in the park (Hazebroek & Abang Morshidi, 2000). During this survey, most of the swiftlets were recorded in the morning and evening owing to the fact that they hunt and feed during the daytime. Swiftlets were observed on a regular day leaving their roosting cave as early as 0600 hours and returning as early as 1600 hours (also see Medway, 1997; Lim & Cranbrook, 2002).

Table 3: Composition and relative abundance of mammals recorded in Niah National Park. Total individuals captured and their associated relative abundance are showed according to transect lines (TR = Transect; RT = River Transect)

Family	**Species**		**Transect**					**Relative Abundance (%)**				
		Total	**1**	**2**	**3**	**4**	**RT**	**TR1**	**TR2**	**TR3**	**TR4**	**RT**
Cynocephalidae	*Cynocephalus variegatus* (Flying Lemur)	1				1					12.5	
Cercopithecidae	*Macaca fascicularis* (Long-tailed Macaque)	2	2					22.2				
	Macaca nemestrina (Pig-tailed Macaque)	1			1					11.1		
Sciuridae	*Callosciurus prevostii* (Prevost's Squirrel)	6	1	1	2	2		11.1	100.0	22.2	25.0	
	Callosciurus notatus (Plantain Squirrel)	13	3		4	4	2	33.3		44.4	50.0	100. 0
	Exilisciurus exilis (Plain Pigmy Squirrel)	5	2		2	1		22.2		22.2	12.5	
Muridae	*Sundamys muelleri* (Muller's Rat)	1	1					11.1				
	Total number of individuals	29	9	1	9	8	2					
	Total number of families	4	3	1	2	2	1					
	Total number of species	7	5	1	4	4	1					

Table 4. Shannon - Weiner Index and evenness of mammals (above), and comparison of diversity indices between two transects using the Zar *t*-test (below). The Zar *t*-test was calculated by comparing each transect line with other transect lines studied here. The river transect was not included for the Zar *t*-test, as explained in the results section (TR = Transect; RT = River Transect; *t*-critical is at 1.96 at $\alpha = 0.05$)

	TR1	**TR2**	**TR3**	**TR4**	**RT**
Number of individuals	9	1	9	8	2
Number of families	3	1	2	2	1
Number of species	5	1	4	4	1
Shannon-Weiner Index (*H'*)	2.20	0.00	1.84	1.75	0.00
Evenness	0.16	0.00	0.27	0.30	Infinite

Transect	***t*-calculated**	***t*-critical**	**Significant/Not significant**
Transect 1 vs. Transect 2	-	-	No comparison
Transect 1 vs. Transect 3	4.06	2.57	Significant
Transect 1 vs. Transect 4	4.48	2.57	Significant
Transect 2 vs. Transect 3	-	-	No comparison
Transect 2 vs. Transect 4	-	-	No comparison
Transect 3 vs. Transect 4	0.87	2.78	Not significant

Previous study by Rahman *et al*. (2004) at Fairy Cave and Wind Cave Bau, have also recorded Mossy-Nest Swiftlet with highest relative abundance: 18.2% (14 individuals). Similarly, Hassin (2004) also indicated that Mossy-Nest Swiftlet was the dominant species in Bau limestone forest with relative abundance of 25.74% (or 26 out of 101 individuals) when using mist-net techniques. Although the current study has reported lower swiftlet abundance compared to those in Bau limestone forests, it indicates nothing more than the difference in techniques used and number of species recorded in each study rather than the diversity of the site. Our study in Niah National park has recorded more than 500 individual of birds compared to those at Bau (Hassin, 2004) which recorded only 101 individuals through trapping techniques. This also indicates that the transect survey is able to cover a broader range of bird species in comparison to trapping techniques that depend on trap efficiency and positioning.

Babblers from the family Timaliidae were recorded with the highest number of species. This family was easily identified in the field compared to other families through their conspicuous calls. These species forage at both forest floor and under canopy (Strange & Jeyarajasingam, 1993). They feed on various types of food such as insects, larvae, and worms, and inhabit primary and secondary lowland forest. In Peninsular Malaysia, babblers alone contribute up to 25% of forest community species richness (Madoc, 1992). Cuckoo species from the family Cuculidae were recorded with the second highest number of species. These species were found mainly in open areas and river habitats. Sunbirds and spiderhunters of the family Nectariniidae were recorded with the third highest number of species. These birds were recorded in various types of habitats such as primary forest, secondary forest, gardens, plantations and peat swamp forest. These habitats provide this group of birds with a large range of food sources, microhabitats, and protection from predators.

TR1 was recorded with the highest diversity index followed by TR4. Both areas were categorized as less disturbed, and this may be the reason for their high species diversity. Generally, not many visitors or local commuters pass by this area. TR4 was not open to the public during this study. TR1 consisted of secondary forest, with patches of mixed dipterocarp forest. This type of forest provides variety of food sources such as seeds, fruits, small mammals, insects and larvae. Conversely, TR4 is situated in an area covered by secondary lowland forest, but surrounded by primary forest. This area is less disturbed and appropriate as foraging areas for birds. This study has recorded TR1 (4.75) and TR2 (3.73) diversity indices higher than those by Kon *et al*. (2004) which used mist-nets at similar transects (TR1 = 3.1 and TR2 = 3.15). Generally, the advantage of a wildlife survey compared to the mist-nets method is the ability to cover a larger sampling area, in both horizontal and vertical space. Transect surveys also enable the observer to cover all forest levels from above canopy, canopy, middle canopy, under canopy and forest floor levels with the aid of binoculars and animal calls. The mist-netting technique is more passive, selective, and is usually designed for capturing avifauna under canopy. Trapping techniques also depend on net position across flyway direction. This will influence the capture rate of the study. The transect survey technique is more general for broader coverage of species diversity.

A previous study by Rahman *et al*. (2004) at Bau limestone forest indicated that less disturbed areas have *H*' = 1.03, whereas disturbed areas have *H*' = 1.30. In comparison to our study, birds at Niah National Park were more diverse than those from Bau limestone forest. This was mainly due to the differences in level of disturbance, availability of food resources and forest vegetation in both study sites. Results from this study also indicated that the evenness index for all line transects were below 0.50. Low evenness index suggests that the number of individuals from each species were significantly different from each other in this study. This was mainly due to the large gap between high swiftlet count and any other species in this study which recorded observation rates of less than half that of the the swiftlet count.

Bird diversity indices showed significant differences in the following transect comparisons: TR1 vs. TR2, TR1 vs. TR3 and TR1 vs. TR4. This may be due to the differences in vegetation types and levels of disturbance at these transects. Secondary forest, with patches of primary mixed dipterocarp forest dominated the TR1 area. Vegetations in primary forest and lowland mixed dipterocarp forest provide a greater variety of fruit compared to those in secondary forests (Smythies & Davison, 1999). Fruits are an important source of food for the majority of bird species. Fewer visitors and reduced local activities, along with food source availability in TR1 were the major factors that resulted in significant differences between these transects. TR2 and TR4 were dominated by secondary forest, whereas TR3 was mainly dominated by limestone vegetation, which is known for lower biodiversity than any other forest types in Borneo (MacKinnon & Phillipps, 1993). Seasonal swamp forest that emerged during the rainy season also may have reduced foraging activities by the birds in TR2 areas throughout this study period.

In contrast, results do not show any significant difference in the following diversity indices comparisons; TR2 vs. TR3 and TR2 vs. TR4. Both, TR2 and TR3 can be categorized as disturbed areas, as there was a great amount of human activity, especially due to visitors and local sounds (e.g., walking, talking) that may have reduced bird activity around these areas. Both of these trails are popular trails that lead to the Niah Great Cave and the Long House inside the park. Both of these transects faced similar problems, as they were adjacent to each other in this study. Although fewer visitors and human activities were observed at TR4 than at TR2 and TR3, statistical analysis indicates that there were no significant differences between TR2 vs. TR4 and TR3 vs. TR4. This may be due to the similarity in secondary forest vegetation found in both TR2 and TR4 that subsequently supported similar bird species composition at both of the transects.

Although both TR3 and TR4 were observed with different vegetation types and levels of disturbance, and both were situated at a distance from each other, statistical analysis showed no significant difference between TR3 vs. TR4. However, after considering the park boundary, we found that TR4 was adjacent to the cultivated lands and logging camps, whereas TR3 was situated near limestone forest. These separate habitats may have resulted in a similar level of ecology and diversity constraint at both transects that could not be differentiated in statistical analyses.

Mammal Species Diversity and Abundance

Exilisciurus exilis and *C. notatus* from the family Sciuridae were common throughout the study. Results indicate that both species were recorded with the highest density and relative abundance. Squirrels are the small mammals that visitors most often encountered in Niah National Park (Hazebroek & Abang Morshidi, 2000). The availability of food sources, such as fruits, seeds, leaves, and other smaller animals might sustain their high population. Sciuridae can also adapt to various types of forest vegetation and is able to partition the space in trees within other species in the family. Plain Pigmy Squirrels (*E. exilis*) often forage on tree trunks, Plaintain Squirrels (*C. notatus*) forage on branches and on the ground, whereas Prevost's Squirrels (*C. prevostii*) forage in the canopies of high and big tree branches. Fungi that were found in all vegetation types on tree trunks, branches, twigs, left litter, soil and dead plant materials also serve as the major source of food for this family (Hazebroek & Abang Morshidi, 2000). Figs, especially *Ficus benjamina* were identified as an important food resource for all frugivorous animals in the park. This plant can be regarded as the 'keystone' species that promotes the diversification of other fauna in the park (*sensu* Marduka 2001).

The Long-Tailed Macaque and the Pig-Tailed Macaque were the only large mammals recorded and representative throughout the study. Most of the large mammals were shy and they usually hide when encountered with humans. Seasonal effect during monsoon season (e.g., seasonal swamp: Karim *et al*., 2004) and short study period may have influenced the low number of large mammals recorded in this study. Apart from this, hunting pressure by the locals also may have contributed to the reduction of large mammals recorded in the park (Mohd. Nor *et al*., 1992).

Only one individual of Prevost's Squirrel was recorded at TR2 and two individuals of Plantain Squirrel were recorded at RT in this study. This may be due to the condition of the area which can be categorized as disturbed, with high frequency of visitors and local activity along the transect. The seasonal swamp at TR2 also might have reduced the foraging range of any ground dwelling animal, especially the small mammals in this area. TR1 had the highest diversity index as recorded in birds. Lowland dipterocarp forest was the main factor that contributed to the richness of mammals' community in the park as it provided optimal food resources for diverse groups of animals (Hazebroek & Abang Morshidi, 2000; Karim *et al*., 2004). TR2 and RT were recorded with 0.0 diversity index with only one species in both of the survey sites (refer Ludwig & Reynolds, 1988).

Previous study by Karim *et al*. (2004) at Bau limestone area using trapping methods indicated that a total of 42 species from 17 families were recorded. Both Muridae and Sciuridae dominated that area with Muller's Rat

(*Sundamys muelleri*) as the most common species there. However current study only recorded 29 individuals representing seven species and four families in Niah National Park. A study by Nyaun *et al.* (2004) using trapping techniques (cage traps) at Madu Trail showed a higher value of diversity indices compared to those of similar sites in the study. This is mainly due to the baits that were used in traps that made it possible to attract shy animals into the traps. Hence, the probability of documenting small mammals (mostly shy) is higher using traps compared to direct observation, which depends on skill and chance of sighting mammals in the dense tropical rainforest. Therefore, differences in survey method may contribute to the variation between trapping and observation techniques, as traps were found more efficient in documenting, both volant and non-volant small mammals. Previous studies, using traps (e.g., mist-nets, harp traps, cage traps, camera traps) have documented new geographic records for the park and Sarawak (e.g., Hall *et al*., 2002; Abdullah 2003; Azlan & Sharma, 2006; Jayaraj *et al*., 2006; Anwarali *et al*., 2007).

A study at Tanjung Berlipat, Niah National Park (north to our study site), was recorded with a total of 35 species from 16 families of mammals. Tanjung Berlipat was reported to have less disturbed vegetation and reduced number of visitors. However, the small mammal species account compiled by the Niah National Park Management for Tanjung Berlipat does not provide details on the field methods and sampling effort used. This may represent a compilation of all other previous surveys performed in the park.

An analysis on small mammal diversity showed that there are significant differences between TR1 vs. TR3 and TR1 vs. TR4 diversity indices. This correlates with different forest vegetation and levels of human disturbance found at each transect. The level of disturbance was significant at TR4, as this transect is situated opposite Batu Niah town and exposed to vehicle sounds and boat engines along the nearby river. This may be the major factor that influences the mammals' species compositions in this area.

CONCLUSIONS AND RECOMMENDATIONS

Species diversity is a simple measure of community stability and persistence of the ecosystem in the face of disturbances (Hamilton, 2005). The transect line is a useful tool for rapid assessment of the diversity of birds and mammals in a tropical rainforest. However, this method is limited due to the behaviour of the animals, experience of the observer, and visibility of the target taxa in the dense tropical lowland forest. Increased survey period with more replicates to take account of seasonal and habitat differences will provide better estimates of the faunal diversity. This is also important to ensure the consistency of data in providing the best interpretation of diversity, density, and relative abundance of the studied faunas at a particular site. Wildlife surveys also require special skills to enable the observer to identify the birds and mammals from a distance, and possibly from their calls and footprints.

The faunal lists compiled in this transect survey can be improved by including trapping techniques that would enable the researcher to overcome some of the disabilities in transect surveys. The amount of line transects can be increased, so that at least 10% of the study is covered to provide a better estimation of diversity. The study should also be conducted away from the park walkways to reduce disturbance on the animals by park visitors when observations are conducted. As this survey was done during monsoon season, seasonal swamp might have influenced animals activity, especially ground dwelling mammals. Therefore, surveys during dry or fruiting season might increase the number of animals observed.

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