CONTRIBUTION OF REGENERATED FOREST IN CONSERVATION OF BATS IN PENINSULAR MALAYSIA

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MOHD-HANIF RMD, NUR-AIDA MT, ZAHIRUNISA AR, MOHD-RIDWAN AR & ABDULLAH MT. 2015. Contribution of regenerated forest in conservation of bats in Peninsular Malaysia. Surveys of bats were conducted at six regenerated forest sampling sites, namely, Sungai Dusun Forest Reserve (FR), Fraser Hill FR, Lata Bujang FR, Tasek Bera FR, Endau–Kluang FR and Endau–Kota Tinggi FR. A total of 289 individuals representing 35 species of bats were recorded. Endau–Kota Tinggi FR was the most diverse (Fisher's α = 9.95) while Endau–Kluang FR, the least diverse (Fisher's α = 3.17). Six species of bats, namely, *Dyacopterus spadiceus, Nycteris tragata, Rhinolophus sedulus, Kerivoula intermedia, K. pellucida* and *Myotis ridleyi* are listed as near threatened. Two species of bats, *Hipposideros ridleyi* and *Arielulus societatis*, are listed as vulnerable and facing high risk of extinction in the wild. The diversity of chiropterans in generated forest was high and was underestimated because of lack of information on those high flier species in and above canopy levels.

Keywords: Chiroptera, species diversity, species conservation, forest type

INTRODUCTION

Habitat disturbance is a major conservation issue. Despite having high diversity and significant ecological services and benefits on wild animals, tropical forests are being destroyed in every part of the world and continue to decline at alarming rates (Nakagawa et al. 2007). Therefore, scientific documentations are inevitably important to describe species diversity and their response to anthropogenic disturbances. Tropical rain forests are the epitome of richness for many taxonomic groups including bats. They are important in shaping the pattern and process of biological diversity (Wilson 1992). Bats help maintain the genetic diversity of tropical rainforest by cross pollinating many species of plants and dispersing the seeds of many others (Fujita & Tuttle 1991). On the other hand, insectivorous bats are major consumers of nocturnal-flying insects (Jones et al. 2002).

Bats are often termed as good biological indicator due to the fact that they are ubiquitous, diverse, abundant in the ecosystem and taxonomically well known. Being the second largest order of mammals in terms of species richness, they are relatively easy to sample using cost-effective techniques. Bats play a substantial role in controlling the population of insects as well as pollinating agents to certain plants. As bats are sensitive to changes within their habitat, they tend to reduce in population and will find new places to colonise; thus, they function as a measure of habitat integrity (Noss 1990, Blair 1999).

In the present assessment, six regenerated forests were chosen as sampling sites, namely, Sungai Dusun Forest Reserve (FR), Fraser Hill FR, Lata Bujang FR, Tasek Bera FR, Endau–Kluang FR and Endau–Kota Tinggi FR. To date, no detailed research on bat diversity in the selected sampling sites has been documented. Therefore, results obtained from this survey will be valuable to assist the Department of Wildlife

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and National Park (DWNP) for conservation and management decisions. The primary aim of this survey was to assess the species diversity and abundance of bats in six regenerated forests in Peninsular Malaysia and update the species distribution data. Comparison of species diversity and abundance between the six sampling sites was investigated to identify whether geographical distance and vegetation type influence taxonomic composition and diversity.

MATERIALS AND METHODS

Two four-bank harp traps and 10 mist nets were used to trap bats for three consecutive nights. This was reported to be the optimum effort in trapping chiropterans (Abdullah 2003, Hall et al. 2004). Harp traps were positioned across trail, forest opening and small streams. Traps were checked every two hours from 6.00 p.m. until midnight and at 6.30 a.m. Captured individuals were kept in cloth bags. Traps were repositioned to cover more areas and increase the chances of catching more individuals and species. Identification of bats was done following morphological descriptions by Payne et al. (2005) and Francis (2008). External morphology measurements of the specimens such as forearm length, ear length, head–body length, tibia length, hind foot length and tail length were measured using digital callipers and weighed using spring balance. Gender was identified and age was classified for each individual following Kunz (1988). Taxonomic classification was done according to Corbet and Hill (1992) as well as Wilson and Reeder (2005). Selected voucher specimens were collected and catalogued according to Abdullah et al. (2010).

Relative abundance of species was calculated by dividing total number of individual per species with total number of individuals caught. Diversity index used was Fisher's α that was calculated for each sampling site and habitat type. Species similarity was estimated using modified Morisita similarity coefficient indices. Diversity index was calculated using EstimateS version 8.2 (2009) and species similarity indexes were calculated using MultiVariate Statistical Package version 3.2 (2007). Surveys were carried out at six selected sites in Peninsular Malaysia (Figure 1). Description of the areas and their coordinates are listed in Table 1. Trapping was conducted during the dry season; however rainy days were recorded occasionally during sampling. The forests were between 20 and 35 years old based on estimation of tree diameter and height. Taxonomic list of bats was compared with previous studies that had been conducted in regenerated and primary forests of Peninsular Malaysia.

RESULTS

Generally, the surveys recorded 289 individuals of bat representing 35 species from six families. Of the total species caught, 7 species were frugivorous and the rest were insectivorous. Thirteen species were recorded as singletons. Taxonomic list of the captured species are shown in Table 2. The highest species composition was encountered in Endau–Kota Tinggi FR with 17 species. With only 6 species, Sungai Dusun FR recorded the least species composition between the study areas. In general, the highest number of captured individuals was recorded at Lata Bujang FR (87) and the least, at Sungai Dusun FR (11). *Rhinolophus trifoliatus* was found at all sampling areas. It was caught in both mist nets and harp traps. The fawn roundleaf bat, *Hipposideros cervinus*, was the most abundant species; a total of 75 individuals were caught at all sites. Photographs of selected species of bats caught in this study are shown in Appendix 1.

Species composition between the study areas were compared using modified Morisita coefficient index (Table 3). The comparison between Endau–Kluang FR (9 species) and Lata Bujang FR (11 species) gave the highest similarity value (0.647) with 4 shared species in common. The lowest similarity value (0.012) was between Lata Bujang FR (11 species) and Tasek Bera FR (11 species) with 2 shared species. Figure 2 shows species similarities at the six sampling sites. Statistically, the Fisher's analysis revealed that Endau–Kota Tinggi FR was the most diverse (α = 9.95) compared with the rest of the surveyed areas. Meanwhile Endau–Kluang FR was the least diverse (α = 3.17). The modified Morisita similarity coefficients indices ranged from 0 to 1 (0 means no similarity, while 1 means total similarity). Endau–Kluang FR (9 species) and Lata Bujang FR (11 species) with 4 shared species had the highest similarity value at 0.647 and the two sites form a cluster in the dendrogram (Figure 2). In contrast,

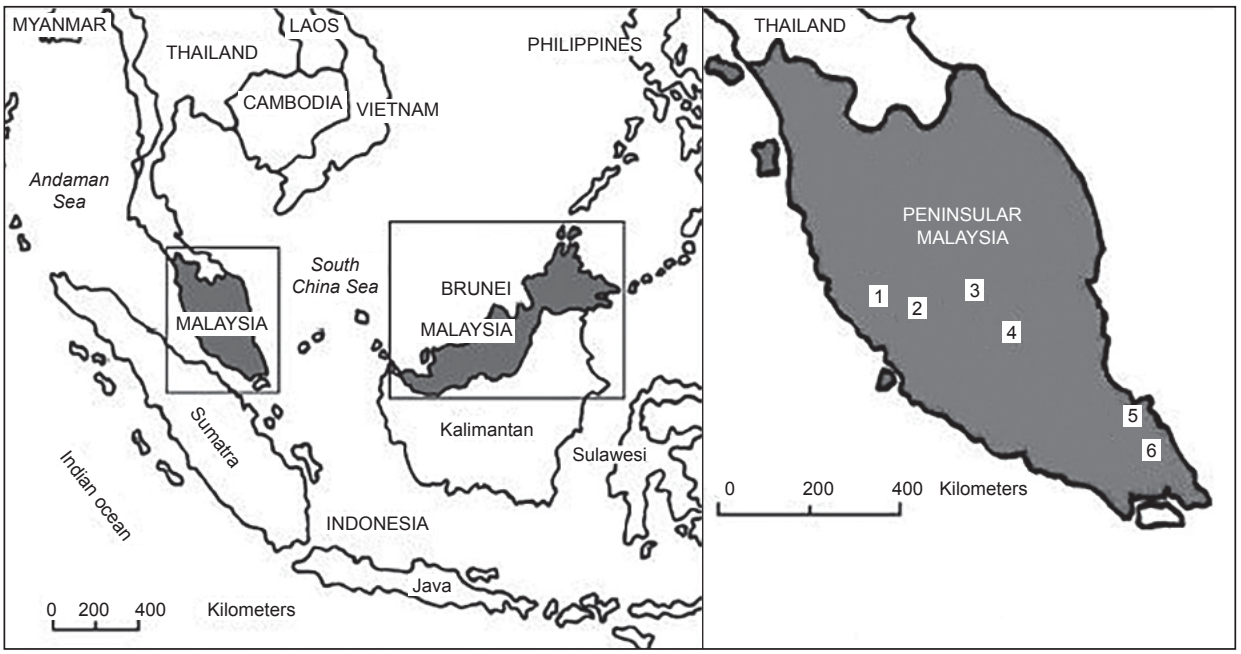

Figure 1 Map of Malaysia showing sampling areas; 1 = Sungai Dusun Forest Reserve, 2 = Fraser Hill Forest Reserve, 3 = Lata Bujang Forest Reserve, 4 = Tasek Bera Forest Reserve, 5 = Endau–Kluang Forest Reserve and 6 = Endau–Kota Tinggi Forest Reserve

Table 1 List of study areas, habitat type, date of study and location

Study area	Habitat	Date	Location
Endau–Kluang Forest Reserve, Johore	Mixed dipterocarp forest	27 Oct–1 Nov 2008	2° 28' N, 103° 30' E
Tasek Bera Forest Reserve, Pahang	Lowland dipterocarp forest	21–25 May 2009	3° 05' N, 102° 38' E
Fraser Hill Forest Reserve, Selangor	Secondary hilly lowland forest	26 July–2 Aug 2009	3° 37' N, 101° 44' E
Sungai Dusun Forest Reserve, Selangor	Mixed dipterocarp forest	27–30 Oct 2009	3° 40' N, 101° 20' E
Lata Bujang, Krau Forest Reserve, Pahang	Lowland dipterocarp forest	10–14 Nov 2009	3° 50' N, 102° 6' E
Endau–Kota Tinggi Forest Reserve, Johore	Mixed dipterocarp secondary forest	19–23 Apr 2010	2° 06' N, 103° 32' E

Lata Bujang FR (11 species) and Tasek Bera (11 species) had only 2 shared species and had the lowest similarity value at 0.012.

Table 4 shows the list of species recorded in regenerated and primary forests. Overall, 29 and 37% species of bats in Peninsular Malaysia were recorded in regenerated forest and primary forest respectively. Of the 57 species of bats recorded, 22 species occurred in both forests, 22 species were unique to primary forest and 13 were unique to regenerated forest (including 7 species of fruit bats). There were five near threatened species and three vulnerable species (IUCN 2013) that were unique to primary forest. Only one vulnerable species was unique to regenerated forest alone.

DISCUSSION

This study documented 35 species of bats representing approximately 29.6% of total species that could be found in Peninsular Malaysia. This

Table 2 Taxonomic list of species caught at six regenerated forest and number of individuals with relative abundance in parenthesis

Family, species	TB		SD		LB		EK		EKT		FH	
	N	M:F	N	M:F	N	M:F	N	M:F	N	M:F	N	M:F
Pteropodidae												
Cynopterus brachyotis	–	–	–	–	1 (1.2)	0:1	17 (33.3)	8:9	3 (6.5)	1:2	1 (1.4)	0:1
Cynopterus horsfieldii	–	–	–	–	–	–	1 (2.0)	1:0	–	–	2 (2.8)	0:2
Chironax melanochephala	–	–	1 (9.0)	0:1	–	–	1 (2.0)	0:1	–	–	9 (12.5)	1:8
Penthetor lucasi	–	–	–	–	–	–	–	–	–	–	1 (1.4)	0:1
Megaerops ecaudatus	–	–	–	–	1 (1.2)	1:0	–	–	1 (2.2)	0:1	–	–
Dyacopterus spadiceus	–	–	1 (9.0)	1:0	–	–	–	–	–		–	–
Balionycteris maculata	–	–	3 (27.3)	0:3	1 (1.2)	0:1	–	–	2 (4.3)	0:2	–	–
Nycteridae												
Nycteris tragata	–	–	–	–	1 (1.2)	1:0	–	–	2 (4.3)	0:2	–	–
Rhinolophidae												
Rhinolophus sedulus	–	–	–	–	–	–	–	–	6 (13.4)	2:5	–	–
Rhinolophus affinis	1 (4.5)	1:0	–	–	1 (1.2)	0:1	–	–	7 (15.2)	4:3	9 (12.5)	2:7
Rhinolophus trifoliatus	5 (22.7)	5:0	4 (36.4)	4:0	1 (1.2)	1:0	9 (17.6)	6:3	5 (10.9)	2:3	2 (2.8)	1:1
Rhinolophus stheno	–	–	–	–	9 (10.3)	4:5	–	–	–		–	–
Rhinolophus lepidus	–	–	–	–	5 (5.7)	3:2	–	–	3 (6.5)	2:1	–	–
Rhinolophus acuminatus	–	–	–	–	–	–	–	–	–		2 (2.8)	2:0
Rhinolophus luctus	–	–	1 (9.0)	1:0	–	–	–	–	–		–	–
Hipposideridae												
Hipposideros diadema	–	–	–	–	1 (1.2)	0:1	1 (2.0)	1:0	–	–	1 (1.4)	1:0
Hipposideros larvatus	–	–	–	–	–	–	–	–	1 (2.2)	1:0	4 (5.6)	1:3
Hipposideros cineraceus	–	–	–	–	–	–	–	–	–	–	1 (1.4)	1:0
Hipposideros bicolor	–	–	–	–	15 (17.2)	10:5	–	–	2 (4.3)	2:0	7 (9.7)	5:2
Hipposideros ridleyi	3 (13.6)	2:1	–	–	–	–	–	–	–	–	–	–
Hipposideros galeritus	–	–	–	–	–	–	–	–	2 (4.3)	1:1	–	–
Hipposideros cervinus	–	–	–	–	51 (58.6)	32:19	18 (35.3)	14:4	6 (13.4)	4:2	–	–

(continued)

Table 2 (continued)

Family, species	TB		SD		LB		EK		EKT		FH	
	N	M:F	N	M:F	N	M:F	N	M:F	N	M:F	N	M:F
Emballonuridae												
Emballonura monticola	–	–	–	–	–	–	–	–	1 (2.2)	1:0	–	–
Vespertilionidae												
Kerivoula papillosa	3 (13.6)	3:0	1 (9.0)	1:0	–	–	–	–	1 (2.2)	0:1	2 (2.8)	1:1
Kerivoula intermedia	1 (4.5)	0:1	–	–	–	–	–	–	2 (4.3)	2:0	–	–
Kerivoula hardwickii	–	–	–	–	–	–	2 (3.9)	1:1	–	–	–	–
Kerivoula pellucida	4 (18.2)	2:2	–	–	–	–	1 (2.0)	0:1	–	–	1 (1.4)	1:0
Myotis ridleyi	–	–	–	–	–	–	1 (2.0)	1:0	1 (2.2)	1:0	–	–
Myotis muricola	–	–	–	–	–	–	–	–	1 (2.2)	1:0	–	–
Murina suila	1 (4.5)	1:0	–	–	–	–	–	–	–	–	–	–
Tylonycteris robustula	1 (4.5)	0:1	–	–	–	–	–	–	–	–	28 (38.9)	8:20
Tylonycteris pachypus	1 (4.5)	1:0	–	–	–	–	–	–	–	–	–	–
Harpiachephalus harpia	–	–	–	–	–	–	–	–	–	–	1 (1.4)	0:1
Arielulus societatis	–	–	–	–	–	–	–	–	–	–	1 (1.4)	1:0
Glischropus tylopus	2 (9.1)	0:2	–	–	–	–	–	–	–	–	–	–
Total number of individuals	22		11		87		51		46		72	
Total number of family	3		3		4		4		6		4	
Total number of species	10		6		11		9		17		16	
Fisher's α	7.08		5.40		3.33		3.17		9.95		6.38	
Total male: female	15:7		7:4		52:35		32:19		23:23		25:47	

TB = Tasek Bera Forest Reserve, SD = Sungai Dusun Forest Reserve, LB = Lata Bujang Forest Reserve, EK = Endau–Kluang Forest Reserve, EKT = Endau–Kota Tinggi Forest Reserve, FH = Fraser Hill Forest Reserve; – = absent, N = number of individuals, M:F = propotion of male to female

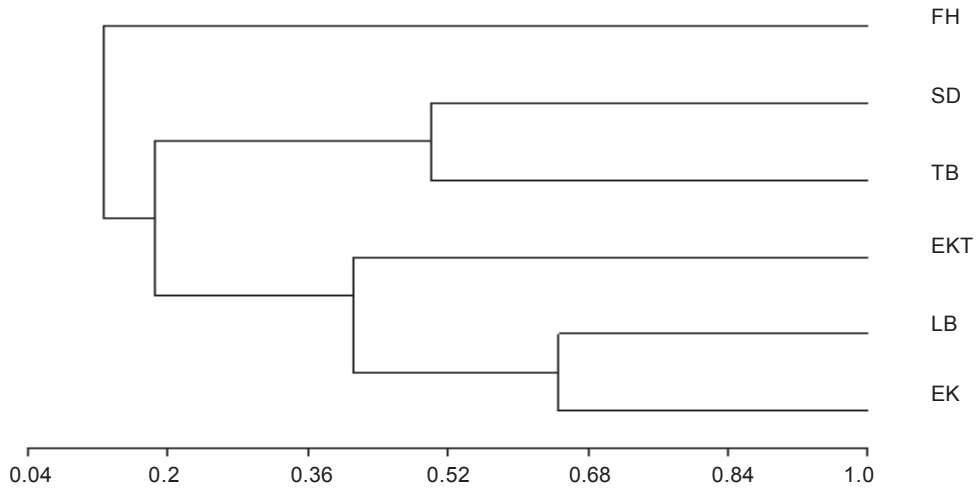

Figure 2 Dendrogram of species similarity for six regenerated forest (modified Morisita's similarity coefficient index); FH = Fraser Hill Forest Reserve, SD = Sungai Dusun Forest Reserve, TB = Tasek Bera Forest Reserve, EKT = Endau–Kota Tinggi Forest Reserve, LB = Lata Bujang Forest Reserve and EK = Endau–Kluang Forest Reserve

Table 3 Modified Morisita's similarity coefficient index of faunal resemblance for bats sample collected at six sampling sites

Sampling site	EK	TB	SD	LB	EKT	FH
EK	1					
TB	0.213	1				
SD	0.259	0.500	1			
LB	0.647	0.012	0.023	1		
EKT	0.463	0.296	0.308	0.359	1	
FH	0.056	0.212	0.109	0.064	0.189	1

EK = Endau–Kluang Forest Reserve, TB = Tasek Bera Forest Reserve, SD = Sungai Dusun Forest Reserve, LB = Lata Bujang Forest Reserve, EKT = Endau–Kota Tinggi Forest Reserve and FH = Fraser Hill Forest Reserve

number was considerably high for regenerated forests indicating that these areas were capable of holding a variety of bats species due to the suitability of habitat and roosting sites. Since trappings were conducted using ground level netting and harp traps, they might not reflect the actual number of species in the sampling areas. Vertical distribution of bats is closely related to their diet and foraging behaviour. For instance, the insectivorous bats commonly use understorey level for foraging, whereas fruit bats mainly use both understorey and canopy (Pereira et al. 2010). Referring to Figure 3, species accumulation at Sungai Dusun FR and Endau–Kluang FR plateaued starting from days 4 and 5 respectively. However, the pattern cannot be described as asymptote due to limited sampling days. Generally, a difference in weather condition, fruiting season and forest structure influenced the diversity of bats within the study areas. Heavy down pour affected the capture rate as the bats delayed their emergence. Besides reducing the vision of the bats, rain increases the energy cost of their flight. Replacement of traps could also affect the number of species caught (Kingston et al. 2003).

Table 4 Comparison of taxonomic list of regenerated forest bats (pooled data) with primary forest bats

Family, species	Regenerated forest (this study)	Primary forest* (Kingston et al. 2003)	IUCN 2013 status
Pteropodidae			
Cynopterus brachyotis	+	–	LC
Cynopterus horsfieldii	+	–	LC
Chironax melanochephalus	+	–	LC
Penthetor lucasi	+	–	LC
Megaerops ecaudatus	+	–	LC
Dyacopterus spadiceus	+	–	NT
Balionycteris maculata	+	–	LC
Nycteridae			
Nycteris tragata	+	+	NT
Megadermatidae			
Megaderma spasma	–	+	LC
Rhinolophidae			
Rhinolophus sedulus	+	+	NT
Rhinolophus affinis	+	+	LC
Rhinolophus trifoliatus	+	+	LC
Rhinolophus stheno	+	+	LC
Rhinolophus lepidus	+	+	LC
Rhinolophus acuminatus	+	–	LC
Rhinolophus luctus	+	+	LC
Rhinolophus macrotis	–	+	LC
Rhinolophus robinsoni	–	+	NT
Hipposideridae			
Hipposideros diadema	+	+	LC
Hipposideros larvatus	+	+	LC
Hipposideros cineraceus	+	+	LC
Hipposideros bicolor	+	+	LC
Hipposideros ridleyi	+	+	VU
Hipposideros galeritus	+	+	LC
Hipposideros cervinus	+	+	LC
Hipposideros doriae	–	+	NT
Hipposideros lylei	–	+	LC
Emballonuridae			
Emballonura monticola	+	+	LC
Vespertilionidae			
Kerivoula papillosa	+	+	LC
Kerivoula intermedia	+	+	NT
Kerivoula hardwickii	+	–	LC
Kerivoula pellucida	+	+	NT
Kerivoula minuta	–	+	NT
Kerivoula sp.	–	+	–
Myotis ridleyi	+	+	NT
Mytotis ater	–	+	LC
Myotis muricola	+	+	LC

(continued)

Table 4 (continued)

Family, species	Regenerated forest (this study)	Primary forest* (Kingston et al. 2003)	IUCN 2013 status
Myotis siligorensis	–	+	LC
Myotis horsfieldii	–	+	LC
Myotis hasseltii	–	+	LC
Murina suilla	+	+	LC
Murina rozendaali	–	+	VU
Murina aenea	–	+	VU
Murina cyclotis	–	+	LC
Tylonycteris robustula	+	–	LC
Tylonycteris pachypus	+	–	LC
Pipistrelus stenopterus	–	+	LC
Harpiachephalus harpia	+	–	–
Arielulus societatis	+	–	VU
Glischropus tylopus	+	+	LC
Hesperotenus blanfordi	–	+	–
Miniopterus medius	–	+	LC
Phoniscus atrox	–	+	NT
Phoniscus jagorii	–	+	LC
Mallosidae			
Mops mops	–	+	NT
Chaerephon johorensis	–	+	VU
Cheiromeles torquatus	–	+	LC
Total number of family	6	7	
Total number of species	35	44	
Total % of bats in Peninsular Malaysia	29	37	

*Kingston et al. (2003) recorded only insectivorous bat species at Kuala Lompat Research Station in Krau Wildlife Reserve, Pahang; LC = least concern, NT = near threatened, VU = vulnerable, + = present; – = absent

Of the 35 species of bats captured in this study, 6 are listed as near threatened. They are *Dyacopterus spadiceus, Nycteris tragata, Rhinolophus sedulus, Kerivoula intermedia, Kerivoula pellucida* and *Myotis ridleyi*. In Malaysia, only *D. spadiceus,* the rare Dayak fruit bat, has mammary tissue and lactating males have smaller nipples compared with females (Francis et al. 1994). *Dyacopterus spadiceus* was mainly recorded in hill and montane forests. It is rare in the lowland due to vertical stratification as this species predominantly forage in canopy and subcanopy (Kingston et al. 2006). Meanwhile, forest dwellers species such as *K. intermedia* and *K. pellucida* might be strongly affected by forest disturbance as they are dependent on forest for foraging and often found in the understorey of tall secondary forest (Payne et al. 2005). *Kerivoula intermedia* and *K. pellucida* were recorded as common bats in the understorey at Krau Wildlife Reserve (Kingston et al. 2006) and this suggested that the population in this study was possibly underestimated. Another two species of bats, i.e. *Hipposideros ridleyi* and *Arielulus societatis* are listed as vulnerable and considered to be facing high risk of extinction in the wild. The other 27 species of bats recorded in this study are listed as least concern by the International Union for Conservation of Nature (IUCN 2013). *Hipposideros bicolor* was trapped in three study sites with a total of 24 individuals.

Food selection by bats depends on where they feed. Some species eat a wide range of food. An insectivorous bat eats more than 30% of their body weight and nursing mothers eat more than 50% (Fenton 1983). Long-range bats fly high and make one capture attempt during each pass through a swarm of insect. Meanwhile, the short range species hunt in confined areas and make

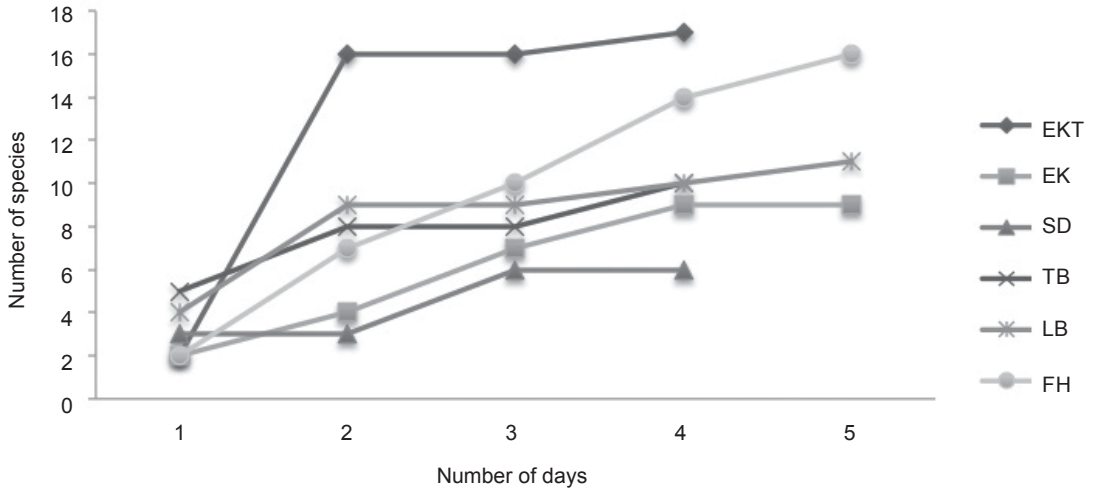

Figure 3 Species accumulation curve for six study sites; EKT = Endau–Kota Tinggi Forest Reserve, EK = Endau–Kluang Forest Reserve, SD = Sungai Dusun Forest Reserve, TB = Tasek Bera Forest Reserve, LB = Lata Bujang Forest Reserve and FH = Fraser Hill Forest Reserve

several attempts at capture on one pass through a patch of prey (Fenton 1983). In response to the loss of forest habitat, study of bats by Lane et al. (2006) in Singapore shows decline in the diversity of frugivores and insectivorous bats that may relate to urbanisation and destruction of roosting sites. Structuring of regenerated forest changes the diversity of bats species in the area. However, the regeneration of the forest can be replenished by pollinating bats to ensure a sustainable environment for both plants and the animal (Wunderle 1997). Therefore, it is important that diversity of bats be monitored in controlled period. Vulnerable bats are usually very site specific. They usually feed on some significant food source and roost on certain plants that are suitable to their behaviour. The presence of bats in the vulnerable category actually signifies that regenerated forests have potential to host these unique species over a period of time.

Bats are known to be biological indicators for forest types. Some species of bats could be a forest specialist and sensitive to environmental changes. However, diversity pattern observed in the current study compared with the study conducted in primary forest showed not much difference in species composition. This finding is supported by Christine et al. (2013) who reported that there was no significant difference between insectivorous bats species composition within a virgin jungle forest and an adjacent logged-over forest. This showed that regenerated forest could play significant roles in maintaining and conserving bats species.

We observed that the insectivorous bats species ranged from 3 to 14 species distributed from central to the south of Peninsular Malaysia (Table 2). A study of assemblage diversity of insectivorous bats in Peninsular Malaysia showed that species richness was lower in the north of Peninsular Malaysia compared with the south, with predicted richness from 9 to 16 species and 21 to 23 species respectively (Lim et al. 2014). Our study suggests that similar findings can be achieved with elongated sampling period. Size of forest fragment could also affect species diversity within an area. Smaller fragments (< 150 ha) are more variable in species composition than larger fragments or continuous forest (Struebig et al. 2008). The diversity level in forest fragments may also be induced by isolated karst outcrops that serve as population reservoirs for cave roosting bats (Struebig et al. 2009).

CONCLUSIONS

This survey provides new information and updates the current distribution of bats in six regenerated forest sampling sites in Peninsular Malaysia. Our study shows that regenerated forest can play a vital role in the conservation

of bats that are important in ecological services and maintenance of the forests. Knowing the current status of bat diversity is paramount in the conservation of bats. Our observations had underestimated the true diversity of species of chiropterans because sampling was done at about 2 m above the ground floor using mist nets and harp traps only. Bats in subcanopy and canopy levels were thus not trapped. Limestone forests which usually contain caves should be surveyed for habitat specialist bats in regenerated forests such as *Tadarida plicata* and *Cheiromeles torquatus* along with other cave-dwelling species that feed in open areas.

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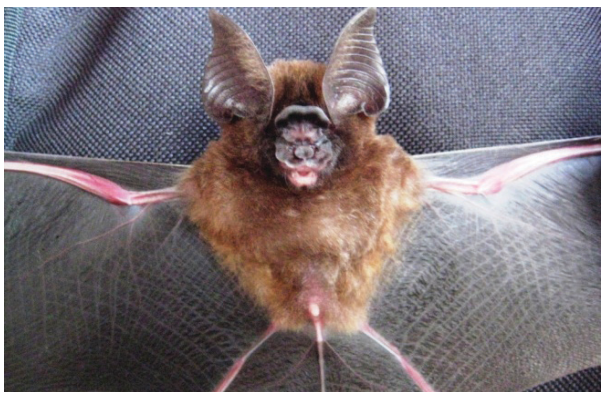
Nycteris tragata

Dyacopterus spadiceus



Hipposideros ridleyi

Megaerops ecaudatus

Cynopterus brachyotis

Rhinolophus trifoliatus

Appendix 1 Selected species of bats in regenerated forests observed in this study