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Insectivorous bat assemblage in the hill dipterocarp forest of Temengor Forest Reserve, Peninsular Malaysia

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Bat diversity in the hill forests of Peninsular Malaysia is often poorly studied due to reasons such as rough terrain and accessibility. Temengor is a 148 870 ha forest reserve that is well known for its rich biodiversity, but is constantly facing pressure from poaching, expansion of the timber industry and land development. In this study, we describe the insectivorous bat diversity of Temengor's hill dipterocarp forest. We captured 20 insectivorous bat species, most of which were forest specialists and compared our results to a previous study done in the lower regions of the Temengor forest. The species composition clearly shows that while cavernicolous bats dominated the lower regions, the hill regions were dominated by tree/foliage roosting species. These distinct species communities suggest that the large area of continuous forest in Temengor should be a conservation priority.

Key words: Insectivorous Bats, Diversity, Upper Hill Dipterocarp Forest, Temengor, Peninsular Malaysia.

INTRODUCTION

The majority of Malaysia's remaining forested areas are in the higher elevation covering the hill and upper hill forests. Unfortunately only a few studies (Fletcher et al. 2004) have been carried out to document the bat community diversity in these forests types in Peninsular Malaysia. Most previous studies on Malaysian bat communities were conducted in lowland forests (e.g. Francis 1990, Francis 1994, Zubaid 1993, Norsham et al. 2000, Kingston et al. 2003, Struebig 2008).

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Temengor Forest Reserve (148 870 ha) is one of the largest contiguous tropical rainforests still persisting in Peninsular Malaysia, and it is home to many endemic species of flora and fauna (Davison 1995). Despite its high biodiversity, it remains one of the least studied parts of the country. Only two bat surveys that have been conducted in Temengor. The first was carried out in 1910, without the use of modern trapping methods (Davison et al. 1995), and the second was by Francis (1995a) in the lowland and hill regions. Francis (1995b) documented two species of vespertilionid bats in the Temengor region that were not previously known from Peninsular Malaysia. These findings illustrate the potential of Temengor as a reserve for yet undiscovered biological diversity.

The objective of this study was to initiate the first rigorous documentation of the understorey insectivorous bat assemblage found in the hill dipterocarp forests of Temengor Forest Reserve. We focused on this particular bat assemblage because it is particularly vulnerable to disturbance and habitat fragmentation (Struebig et al. 2008). This is due to the fact that these bats need the forest not only for food but also for shelter (Findley 1993, Patriquin and Barclay 2003, Henderson et al. 2008).

MATERIALS AND METHODS

Temengor Forest Reserve (TFR) is located in northern Perak, Peninsular Malaysia. It lies contiguous to the Royal Belum Reserve, which adjoins the southern border of Thailand. This study was conducted within the 9765 ha Perak Integrated Timber Complex (PITC) timber concession forest (5°24’40"N to 5°34’15"N, 101°33’0"E to 101°39’30"E). This region has a tropical monsoon climate with an average temperature of 24.2–29.9°C and a high humidity level of 70–98%. Annual rainfall can reach up to 3000 mm per year. The drier season in the region is between February and July (Yap 2008).

The study area was located in Compartment 44, Block 5 of PITC and comprised 200 ha of pristine hill and upper hill dipterocarp forest. Whitmore (1990) defines hill dipterocarp forest as stretching from 300–650 m above sea level (asl) and upper hill dipterocarp forest as ranging from 650–1200 m asl. We conducted our study between 550–810 m asl, which places our study site between hill and upper hill forest. The presence of *Shorea curtisii* in hill dipterocarp forests generally distinguishes hill from upper hill dipterocarp forests (Whitmore 1990). Four of the most abundant tree species at our study site were *Shorea platyclados*, *Dipterocarpus costulatus*, *Koompassia malaccensis* and *Intsia palembanica* for trees more than 30 cm dbh (Azeyla, unpublished data).

Sampling was carried out twice between February and April in 2008 and again during the same time in 2009. Twenty-four 300 m transect lines were set up in the study area; transects were 200–500 m apart. Four-bank harp traps (approximately 2 m wide and 3 m tall) were used to capture insectivorous bats foraging in the understorey. The traps were set up on transects that were established one to two weeks prior to sampling. Harp traps were set approximately 1 m above ground level, with trees and undergrowth above and on either side of them. Each

night, nine traps on three transects (three traps on each transect) were set up. The traps were positioned 50–75 m apart and left in the same location for three consecutive nights. The traps were moved to the next three transect lines on the fourth day, and the process was repeated until all 24 transects had been sampled.

Captured bats were held in catch bags and identified using the identification key by Kingston et al. (2006), alternatively Francis (2008) can also be referred to. All bats were released after they were measured and banded.

A rarefied species accumulation curve was calculated for each trap night to determine if the site had been sampled adequately (Kingston 2006). Chao I species richness estimators (Chao 1984, Chao et al. 2006) were applied to estimate the overall species richness of the sampling site. This analysis was computed using Vegan: Community Ecology Package (Oksanen et al. 2009) in R (R Development Core Team 2009).

To better understand bat species composition across the entire altitudinal gradient of the Temengor region, we compared our findings to those of Francis (1995a). His study was conducted between 250–500 m asl. Although Francis (1995a) captured both frugivorous and insectivorous bats using harp trap and mist nets, we only took into account the species composition of insectivorous bats for comparison. Fruit bats were excluded in thus study because their occurrences are partially affected by fruiting season, and they have larger home ranges. We were more interested in looking at insectivorous bats, which are forest specialists and are more sedentary.

RESULTS

A total of 351 captures consisting of 20 insectivorous bat species (Table 1) were caught over 432 trap nights, including 29 recaptures. Most of the species caught were forest-dwelling species. Bats from the family Kerivoulinae (5 species) and Rhinolophidae (6 species) were most frequently caught. The single most abundant species was *Kerivoula papillosa*, which comprised 24% of the total captures. The results also show that 60% of the species caught were predominantly tree/foliage roosting species.

A rarefied species accumulation curve with 100 permutations shows a curve reaching an asymptote (Fig. 1), indicating that the bat assemblage in the area was adequately sampled. Extrapolated species richness using the Chao I index estimated a total of 21.5 ± 1.323 species. Thus to the degree of precision obtained, the Chao I index indicated an identical level of diversity to the actual number of species obtained.

DISCUSSION

Francis (1995a) captured 30 insectivorous bat species in 55 harp trap nights in the lowlands of Temengor. The lower regions of Temengor were mainly dominated by *Myotis horsfieldii*, *Hipposideros bicolor* sp. and *Rhinolophus affinis*. Although *R. affinis* and *H. bicolor* sp. were present in our study area, they were not particularly

Table 1. Bat families and species caught in Temengor Forest Reserve, Perak and their conservation status (IUCN, 2010). Species classification and day roost is according to Kingston *et al*. (2006). [HF = Hill forest (this study). LF = Lowland forest (Francis 1995a). IUCN status: VU - Vulnerable, NT - Near threatened, LC - Least Concern, DD – Data Deficient. Day roost; C - Cave, B - Boulders/Crevices, T - Trees/Foliage, unk – unknown]

FAMILY	*SPECIES*	*No. of Individuals*		*IUCN*	*Day*
		HF	*L F*	*status*	*roost*
Hipposideridae	*Hipposideros bicolor* sp. *	2	44	LC	C/B
	Hipposideros diadema	1	6	LC	C/B
	Hipposideros galeritus	0	2	LC	C/B
	Hipposideros cineraceus	1	2	LC	C/B
	Hipposideros sabanus	2	0	NT	T
Rhinolophidae	*Rhinolophus stheno*	9	1	LC	C/B/T
	Rhinolophus lepidus	25	21	LC	C/B
	Rhinolophus acuminatus	3	0	LC	T/F
	Rhinolophus trifoliatus	46	6	LC	T
	Rhinolophus affinis	19	42	LC	C/B
	Rhinolophus luctus	1	0	LC	C/B/T
	Rhinolophus megaphyllus	0	8	LC	
Nycteridae	*Nycteris tragata*	4	0	NT	T
Vespertilionidae	*Murina suilla*	2	2	LC	T
Sub-family	*Murina cyclotis*	17	4	LC	T
Murininae	*Murina aenea*	0	1	VU	T
	Murina rozendaali	8	0	VU	T
	Harpiocephalus mordax	0	2	DD	unk
Vespertilionidae	*Kerivoula papillosa*	85	27	LC	T
Sub-family	*Kerivoula hardwickii*	40	6	LC	T
Kerivoulinae	*Kerivoula pellucida*	22	4	NT	T
	Kerivoula intermedia/K. minuta	43	33	NT	T
	Phoniscus atrox	3	1	NT	T
Vespertilionidae	*Glischropus tylopus*	18	0	LC	T
Sub-family	*Tylonycteris robustula*	0	1	LC	T
Vespertilioninae	*Tylonycteris pachypus*	0	8	LC	T
	Myotis ridleyi	0	3	NT	C
	Myotis muricola	0	4	LC	C/T
	Myotis montivagus	0	1	LC	unk
	Myotis horsfieldii	0	45	LC	C/B
	Myotis hermani	0	1	DD	unk
Vespertilionidae Sub-family Miniopterinae	*Miniopterus schreibersii*	0	1	NT	C

* *Hipposideros bicolor* 131 and *H. bicolor* 142 are morphologically cryptic but acoustically divergent species that have different maximum echolocation frequency (Kingston et al. 2001). To assist field identification, they were classified based on the forearm length found in Kingston et al. (2006). However in this table both *H. bicolor* 131 and *H. bicolor* 142 species were categorized as *H. bicolor* sp. for easy comparison with Francis (1995a).

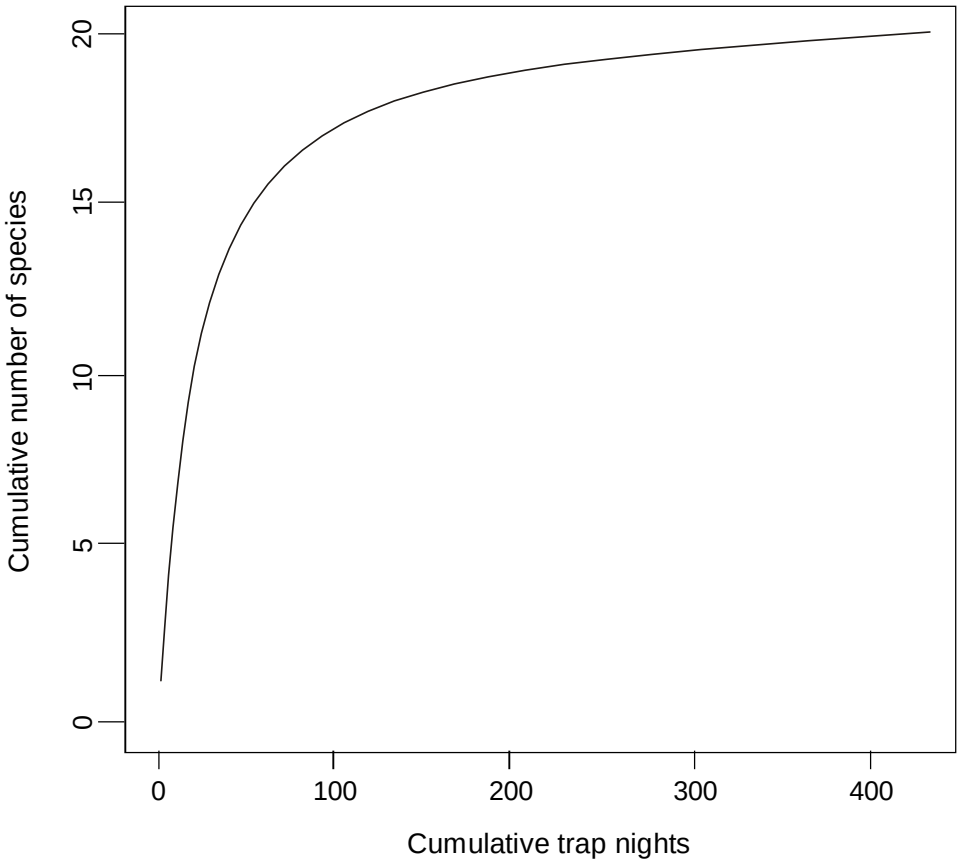

Figure1. Species accumulation curve using rarefaction method according to cumulative trap nights (9 traps x 48 nights) at Temengor Forest Reserve, Perak.

abundant, and *M. horsfieldii* was not captured. According to Kingston *et al*. (2006), *M. horsfieldii* dwells primarily in lowland and hill forests, which explains its absence from the upper hill regions.

Our study instead showed a high abundance of *Kerivoula papillosa*, a forest specialist that inhabits primary forests of all altitudes. This species is quite particular in its roosting ecology, preferring to roost in the hollows of small standing trees that are < 20 m in height and 4–15 cm diameters at breast height (Kingston et al. 2006). *Rhinolophus trifoliatus*, the second-most abundant species in our study, is also a forest specialist and is known to roost below leaves (Kingston et al. 2006). These specialized roosting requirements may be an important factor in determining the abundance of these species in these dipterocarp forests.

The species *Hipposideros diadema*, *H. cineraceus* and *R. luctus* were infrequently trapped. These species might not have been captured as often as other species due to their specific habitat requirements, such as cave roosts, or due to insufficient trapping effort (Mohd. Azlan et al. 2005, Anwarali Khan et al. 2008).

Nevertheless, their rarity in our study may also be a reflection of the true abundances of these species (Francis 1995a, Kingston et al. 2003).

Among the bat species caught in hill forest of TFR, five species are classified as near threatened (NT), and one as Vulnerable (VU) (IUCN 2010) (Table 1). All of these listed species are primarily tree/foliage roosting species. Although we obtained relatively high captures of some threatened species, such as *K. intermedia*, very few individuals of other threatened species, such as *Phoniscus atrox* and *Murina rozendaali* were captured. It is possible that these species require a very specific habitat or that their numbers are diminishing; either way, very little information is currently available about their ecological roles and requirements that would allow us to determine the reason for their infrequent capture in this study. Acquiring such information through future field studies will be essential for their conservation.

Our findings indicate that bat species compositions vary substantially across the natural elevation gradients within a single contiguous tropical forest reserve. The hill dipterocarp forest of the Temengor Forest Reserve is clearly dominated by tree/foliage roosting species; whereas the lower regions were dominated mainly by cavernicolous species. Forest specialists such as *K. papillosa* and *R. trifoliatus* are forest dependent species, thereby restricting their occurrence to the areas surrounding viable roosts (Struebig et al. 2009). Any disturbance such as logging may be a potential threat to these species that are adapted to living in dense primary forests. Although cavernicolous species from the Hipposideridae and Rhinolophidae families usually roost in large colonies in caves, they were captured in low abundance in this study. This suggests that they may be caves in the surrounding area, or they may alternatively be roosting in smaller colonies in boulders found in the study area. This can only be confirmed by radio-tracking some of the individuals. These roosting ecology characteristics are important factors that determine both local abundances and commonness, which may also influence individual species' vulnerability to human activities (Sheema 2006).

Although the Temengor Forest Reserve is part of a protected reserve, it faces constant pressure from poaching, expansion of the timber industry, road building and development (Davison 1995). However, understanding differences in bat species assemblages at different elevations and under different environmental conditions will undoubtedly increase our knowledge of bat habitat requirements. This knowledge will, in turn, help form practical predictions about the long-term consequences of human-induced environmental changes (Fukami and Wardel 2005) and determine how reserves and protected areas should be planned.

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