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Bat Survey of Mount Penrisen and Notes on the Rare *Kerivoula minuta*, *Kerivoula intermedia* and *Hipposideros coxi* in Sarawak, Borneo

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Abstract: In this effort to capture the rare *Hipposideros coxi* that was described from this area, eight mist-nets and three harp-traps were deployed on various locations in the resort for a total of two trapping nights on Mount Penrisen. We recorded 68 individuals from 12 species during the 19 trap-nights including a male *Kerivoula minuta* which is a new record for Sarawak. In addition to previous sampling, we had recorded 15 species of bats from two field works on Mount Penrisen. These represent a new distributional records for Mount Penrisen. Comparison with surveys done by several authors at highland areas revealed that higher bat species diversity was observed on Mount Penrisen in terms of number of species. These represent a new distributional records for Mount Penrisen. The targeted species, *H. coxi* which is endemic to Borneo, was not caught in this survey. Extensive bat surveys should be carried out in the vicinity of the mountain covering much more habitats that are found there. The usage of ultrasonic bat detectors should be incorporated as there is no literature of such method has been employed in the area and microchiropterans of the area are still inadequately documented.

Key words: Highland bat diversity, *Hipposideros coxi*, *Kerivoula intermedia*, *Kerivoula minuta*

INTRODUCTION

In our search for the elusive insect bat, *Hipposideros coxi* that was described from this area, an intensive sampling was conducted to document bats diversity at Mount Penrisen. Previously only two species of bats were listed from the area (Payne *et al.*, 1998). The most recent study by Jayaraj *et al.* (2005) revealed a total of eight species of megachiropterans only existing in the vicinity of the resort in which most netting sites were situated at banana plots scattered around the resort. Thus in this survey the objective is to capture microchiropterans from the area, as there were no microchiropterans caught during the previous sampling by Jayaraj *et al.* (2005).

During this survey, we were also targeting for *Hipposideros coxi* as Mount Penrisen is the type locality where these species was found, in order to get the paratypes. *H. coxi* was first described by Shelford (1901) from Mount Penrisen at elevation of 1280 m (Corbet and Hill, 1992). It was previously known only from southwest of Sarawak in between from Bako to Mount Penrisen

(Payne *et al.*, 1998). It is clearly distinguished from other species of its genus by the great specialization of its noseleaf, which in the degree of its complexity is approached by no other species of the group (Hill, 1963).

Another interesting species is the *Kerivoula minuta* which is the smallest bat in Borneo (Payne *et al.*, 1998) and is considered one of the smallest bat in the world. Its distribution ranges from south Thailand, Peninsular Malaysia and Sabah (Corbet and Hill, 1992). It lives in the understorey of dipterocarp forest (Payne *et al.*, 1998). *K. intermedia* is similar to *K. minuta* and overlaps in forearm length but the skull of *K. minuta* is comparably smaller and body lighter with lighter body (Payne *et al.*, 1998). It occurs in tall and secondary forest. Its distribution ranges from Peninsular Malaysia, Sabah and Kalimantan (Payne *et al.*, 1998).

MATERIALS AND METHODS

The survey was conducted on the 8 to 10th May 2005 at Mount Penrisen, Padawan. Mount Penrisen, locally known as Borneo Heights, is located along Jalan

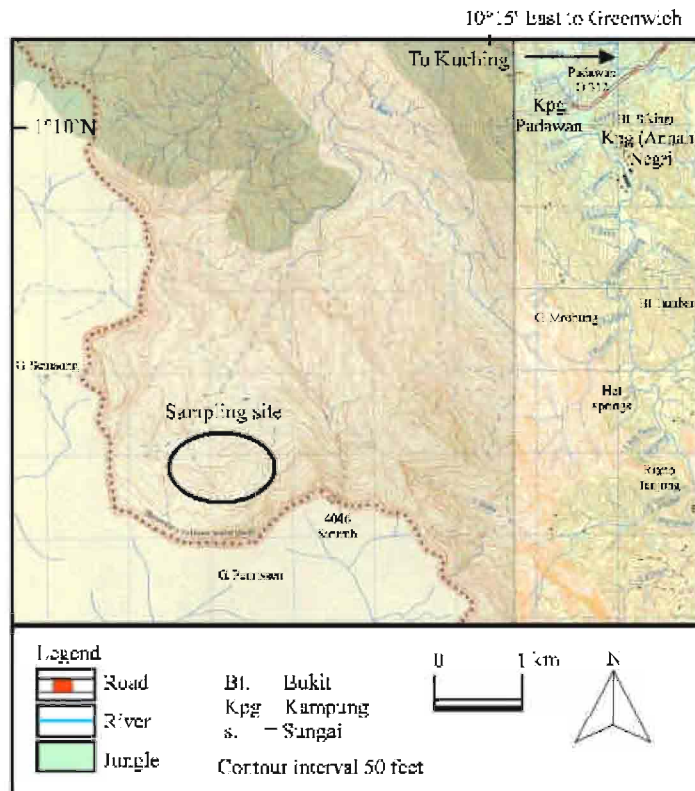


Fig. 1: Location of sampling site at Mount Penrisen. The west side of the map is the Sarawak-Kalimantan border. The sampling station is about an hour walk from the border

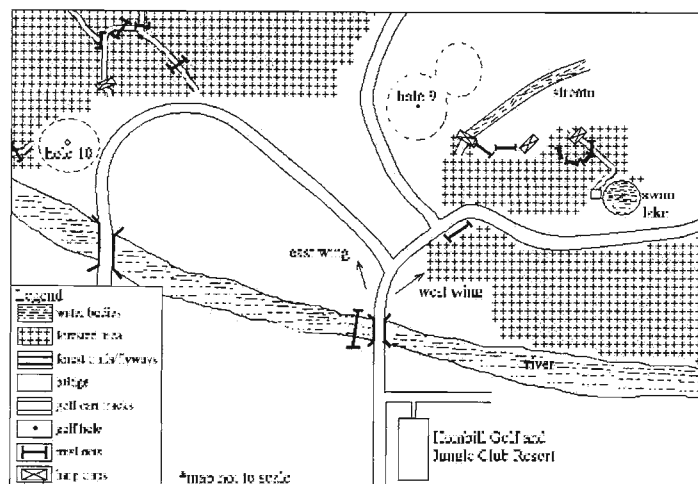


Fig. 2: Sketch map (not to scale) illustrating the locations of the nets on the vicinity of the sampling area. The first harp-trap was deployed at a creek near hole nine. The second harp-trap was deployed on the fringe between hole nine and bush patches and the third in the same bush patches between hole nine and Swan Lake on the first night. The first mist-net was set up at a river just before entering the golf course. Two mist-nets were used as wing for harp-trap 1 and 2 where as the rest were deployed at strategic locations at the west wing on the golf course that are presumed as flyways for the bats

Borneo Heights, Padawan, Sarawak. Our sampling station was near the Hornbill Golf and Jungle Club Resort, about 70 km south of Kuching and about 1000 m above sea level (a.s.l) in primary tropical rainforest. This remote mountain hideaway is located between forest-clad plateaus near the Sarawak-Kalimantan border (Fig. 1). The habitat occurring in the vicinity of the sampling area is described as regenerated forest. The highland climate, with moderate temperatures ranging from 18 to 28°C adds to the uniqueness of the flora and fauna in the area (Jayaraj *et al.*, 2005).

Eight mist-nets and three harp-traps were deployed on various locations around in the golf resort for a total of two trapping nights. The first harp-trap was deployed at a creek, the second on the fringe between hole nine and bush patches and the third in the same bush patches between hole nine and a lake called Swan Lake on the first night. The second harp-trap was subsequently moved to the edge of the golf course near hole ten on the second night.

The first mist-net was set up at a river just before entering the golf course. Two mist-nets were used in wing-like formation to direct insect bats into the direction of the harp-traps 1 and 2. The rest of the nets were deployed at strategic locations at the west wing on the golf course that are presumed as flyways for the bats. Eight mist-nets were set up at the vicinity of the forest patches area that interspaced the golf course for the first day.

All eight mist-nets were removed from original locations and five mist-nets were deployed at the fringe of east wing on the golf course near hole ten on the second night. Four of them were placed along forested patches near the flyways, in a patch of dense forest. Figure 2 (is a sketch map not to scale) illustrating the locations of the nets on the vicinity of the sampling area.

Bats were identified using identification keys from Payne *et al.* (1998). Weighing was done using Pesola spring balance while all standard body measurements were measured using a digital caliper (Mitutoyo Corporation) following Nargosen and Peterson (1980).

Upon examination, bats were marked using ear-notching technique and subsequently released. Selected museum vouchers were then euthanised using chloroform, dissected exposing the stomach and intestine for better preservation and further preserved in 75% ethanol. Selection criteria were based on number of individuals of a particular species caught, the availability of representatives of a particular species from the area and the age of the individuals. Age of bats was determined by the degree of ossification of epiphyseal-diaphyseal on the third, fourth and fifth metacarpals (Kunz, 1988).

RESULTS AND DISCUSSION

Sixty-eight individuals from 12 species were caught during the whole course of 19 trap-nights including a male *Kerivoula minuta* which is a new record for Sarawak (Table 1). One recapture was recorded which was an adult female *C. brachyotis* on 9 May 2005 morning. Table 4 lists out the external morphological measurements of bats from the area accumulated from this study.

The standard morphological measurements and skull measurements recorded from *K. minuta* and additional information about *K. intermedia* regarding the morphological and skull measurements from this study and previous sampling at Tawau Hill conducted by M.T. Abdullah (unpublished data) are shown in Table 2.

We also include the morphological and skull measurements of male, female and description by Payne *et al.* (1998) for added information as the original description made by Shelford was only based on a female (Table 3).

We also spotted a common palm civet (*Paradoxurus hermaphroditus*) near hole 10 on the second day.

In addition with previous sampling conducted by Jayaraj *et al.* (2005), we report of 15 species of bats were recorded from two field works at Mount Penrisen and in

Table 1: List of species of bats, individuals caught and comparison with previous data

Suborder family species	This study	Compiled by Jayaraj <i>et al.</i> (2005)	Payne <i>et al.</i> (1998)
MEGACHIROPTERA			
PTEROPODIDAE			
<i>Cynopterus brachyotis</i>	36	14	Na
<i>Cynopterus horsfieldi</i>	Nc	1	Na
<i>Penthetor lucasi</i>	4	4	Na
<i>Megaerops ecaudatus</i>	Nc	4	Na
<i>Dyacopterus spadiceus</i>	1	Nc	Na
<i>Balionycteris maculata</i>	1	Nc	Na
<i>Aethalops alecto</i>	2	2	Na
<i>Eonycteris spelaea</i>	5	1	Na
<i>Eonycteris major</i>	Nc	3	Na
<i>Macroglossus minimus</i>	16	9	Na
MICROCHIROPTERA			
RHINOLOPHIDAE			
<i>Rhinolophus borneensis</i>	1	Nc	Na
<i>Rhinolophus affinis</i>	1	Nc	Na
EMBALLONURIDAE			
<i>Taphozous longimanus</i>	Nc	Nc	R
HIPPOSIDERIDAE			
<i>Hipposideros cervinus</i>	1	Nc	Na
<i>Hipposideros coxi</i>	Nc	Nc	R
Vespertilionidae			
<i>Kerivoula intermedia</i>	1	Nc	Na
<i>Kerivoula minuta</i>	1	Nc	Na
No. of individuals	70	38	Na
No. of species	12	8	2
Net-night	12	15	
Trap-night	6	2	

*Nc = Not caught, Na = Not available, R = Recorded

Table 2: The skull measurements of *K. minuta* and *K. intermedia*

	<i>K. minuta</i>		<i>K. intermedia</i>		
	This study	Payne <i>et al.</i> (1998)	This study	*Previous sampling	Payne <i>et al.</i> (1998)
	Female	Na	Female	Male	Na
Morphological measurements					
Forearm	27.5	25-29.5	30.7	27.87	26.5-31
Ear length	10.92	Na	12.85	10	9-11.5
Tibia length	13.06	Na	13.87	14.11	Na
Tail length	34.97	8-10	40.6	33.0	37-41
Wingspan	207	Na	225	188	Na
Weight	2.3	1.9-2.3	4	3	2.9-4.2
Skull measurements					
GL	11.67	Na	12.14	12.91	Na
CBL	11.03	10.0-11.1	11.70	12.46	11.1-11.8
CCL	10.86	Na	11.53	11.30	Na
IOB	2.94	Na	3.05	2.99	Na
MT	4.44	4.1-4.6	4.73	4.72	4.6-5.0
M-M	4.65	Na	45.17	4.89	Na
C-C	2.92	Na	3.10	3.05	Na

*Previous sampling at Tawau Hill, Sabah conducted by M.T. Abdullah (unpublished data), Description of skull measurements are as follow: GL = Greatest Length; CBL = Condylbasal Length; CCL = Condyllocanine Length; IOB = Interorbital Breadth; MT = Maxillary Toothrow; M-M = Molar-Molar Width; C-C = Canine-Canine width; Na = data not available

Table 3: *Hipposideros coxi* morphological measurements from sample obtained from Bau and Payne *et al.* (1998)

	Male	Female	Payne <i>et al.</i> (1998)
Morphological measurements			
Forearm	53.0	53.6	53.0-55
Ear length	22.1	28.3	Na
Tibia length	20.1	20.2	Na
Tail length	31.0	35.2	Na
Wingspan	308	296	Na
Weight	9	10	15.5-20
Skull measurements			
GL	19.55	20.39	Na
IOB	3.14	3.16	Na
CCL	19.05	18.96	Na
CBL	19.17	19.76	Na
MT	6.61	6.88	Na
C-C	4.45	4.08	Na
M-M	6.75	6.95	Na

*Na = data not available

addition to Payne *et al.* (1998) there are now 17 species of bats in the area. The number of species accumulated from the area currently represents approximately 16% of the total chiropteran fauna known to occur in Borneo. Several lowland species were also caught in this area such as *Balionycteris maculata* which was known to occur in lowland dipterocarp, heath and riverine forests (Yasuma, 1996).

Highland bat diversity surveys are very much lacking in most areas in Borneo especially Sarawak. Comparison with surveys done by several authors at highland areas revealed that higher bat species diversity was observed at Mount Penrisen in terms of number of species. Tuen *et al.* (2002) recorded eight species of bats during their survey at Crocker Range. In addition to Payne *et al.* (1998), 13 species has been recorded so far at Crocker Range. Eight species has been recorded from Mount Murud (Tuen *et al.*, 2004). Salleh *et al.* (1999) recorded a

total of five species of bats from Kelabit Highlands whereas Mohd. Azlan *et al.* (2003) chiropteran survey at Kayan Menterang National Park, East Kalimantan recorded 11 species of bats from 3 families. Although low compared to Mulu National Park which recorded 27 species of bats, Mount Penrisen might be understudied as there are many areas and different habitat that should be sampled, especially microchiropterans as only a total of seven species of these entomophagous species have been recorded from the area.

We also observed that the usage of harp-traps and mist-nets would also influence the capture rates. Mohd. Azlan *et al.* (2003) noted that the bat diversity and abundance surveys may be affected various factors including variation in sampling method, duration of study, types of capture method employed and type and structure of forest. He noted that the sole usage of mist-nets in particular would affect the capturing of microchiropterans. Similar to Mohd Azlan *et al.* (2003), Tuen *et al.* (2004) also captured only megachiropterans during their survey.

The *K. minuta* was caught in the third harp-trap deployed at bush patches between hole nine and Swan Lake. Previously this species was reported from localities throughout Sabah (Payne *et al.*, 1998). A survey on bats of Sangulirang limestone formation in East Kalimantan by Struebig and Suyanto (2005) also reports that this species occur in East Kalimantan. We suggest a more extensive survey targeting on this species to record more information about their ecology in Borneo as it is listed as near threatened in IUCN Red List (Struebig and Suyanto, 2005; IUCN, 2004). After examining the specimen, we found out that the tail length of the specimen contradicts with description from Payne *et al.* (1998).

Table 4: External morphological measurements of bats from Mount Penrisen accumulated from this study

Species	N	Ear length (mm)	Forearm length (mm)	Tibia length (mm)	Weight (g)	Wingspan (mm)	Tail length (mm)
<i>Cynopterus brachyotis</i>	36	14.50 (12.69-16.9)	60.0 (53.7-64.5)	21.93 (20.3-28.4)	30.4 (20.0-43.0)	337.9 (310.0-368.0)	12.80 (9.62-19.69)
<i>Penthetor lucasi</i>	4	15.42 (13.9-18.2)	63.5 (62.0-65.3)	29.60 (27.9-29.0)	37.3 (30.0-44.0)	337.0 (316.0-356.0)	13.40 (10.4-14.9)
<i>Dyacopterus spadiceus</i>	1	16.2	76.6	29.6	72.0	380	20.8
<i>Balionycteris maculata</i>	1	10.6	43.26	14.53	13	268	None
<i>Aethalops alecto</i>	2	12.2 (12.1-12.3)	44.7 (44.6-44.8)	16.3 (16.2-16.4)	15.0 (14.0-16.0)	266.5 (262.0-271.0)	None
<i>Eonycteris spelæa</i>	5	16.4 (13.4-18.6)	64.3 (54.9-71.6)	29.1 (22.6-32.1)	45.0 (26.0-60.0)	349.0 (306.0-70.0)	15.08 (13.06-17.16)
<i>Macroglossus minimus</i>	16	12.7 (10.47-14.13)	40.4 (37.51-44.06)	17.4 (14.9-17.6)	14.6 (10.0-19.0)	258.0 (233.0-277.0)	None
<i>Rhinolophus borneensis</i>	1	19.0	43.2	21.1	8.0	286.0	18.8
<i>Rhinolophus affinis</i>	1	19.4	50.4	23.8	12.0	293.0	20.1
<i>Hipposideros cervinus</i>	1	13.8	49.6	18.6	10.0	264.0	24.8
<i>Kerivoula intermedia</i>	1	12.9	30.7	13.9	4.0	225.0	40.6
<i>Kerivoula minuta</i>	1	10.9	27.5	13.1	2.3	207.0	34.9

*Values in parentheses indicate the minimum and maximum values recorded from bats of the species

A similar species to *K. minuta*, *K. intermedia* was also caught in this study. The bat was caught in the third harp-trap also. The Sungai Bebar Biodiversity Expedition caught this species in the peat swamp forest at Sungai Bebar, Pekan in Pahang (Chiew, 2005; Shukor *et al.*, 2005). Payne *et al.* (1998) stated that the habitat of this species is in understorey of dipterocarp forest.

The targeted species, *H. coxi* was not caught in this study. Payne *et al.* (1998) stated that the distribution of this species is only known from the southwest Sarawak from Bako and Mount Penrisen. Jub *et al.* (2003) netted this species during a scientific expedition at Bau limestone area. Thus we report the distribution *H. coxi* now includes Bau limestone area.

CONCLUSIONS

Extensive bat surveys should be carried out in the vicinity of the mountain covering much more habitats around Mount Penrisen. The usage of ultrasonic bat detectors should be incorporated as there is no literature of such method has been employed in the area and microchiropterans of the area are still inadequately documented. Several authors (Kingston *et al.*, 1999; Fenton *et al.*, 1987) do provide a good example on the utilization of this method.

The validation in carrying out such surveys is that this area is the type locality of one of the endemic species of Borneo, *H. coxi* (Koopman, 1989) and individuals from this area are of valuable significance in terms of genetic material and conservation of the species. It is also evident that in-terms of bat species diversity, there are several species that are evidently rare, example include *K. minuta* which occur in this area.

The protection of the flora and fauna at vicinity is being facilitated by the existence of a golf resort where the management ideally should keep the forest area around the golf course intact to give the visitors a sort of exotic experience.

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