Notes on roundleaf bats (Hipposideridae) at selected forest reserves of Central Forest Spine (CFS) landscapes in Peninsular Malaysia

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Abstract. Surveys on Roundleaf bats (Hipposideridae) were conducted at 18 forest reserves in nine CFS ecological corridor networks namely Pedu, Bukit Saiong, Kenderong, Bintang Hijau, Sungai Betis, Sungai Brok, Tembat, Tanum, Sungai Yu, Ulu Jelai, Bukit Bujang, Angsi, Berembun, Labis Timur, Mersing, Lenggor Tengah, Panti and Ulu Sedili FRs. This study mainly aims to record the presence of Hipposideridae at the selected forest reserves. The surveys started from February 2018 until August 2020. A total of three harp traps were set up in each forest reserve, except for Ulu Jelai, Tembat and Berembun FRs with six harp traps. Overall, 67 individuals comprising seven species from genus Hipposideros were recorded in this study. Hipposideros bicolore was the most widely distributed species recorded in nine forest reserves whereas, Hipposideros larvatus is the most abundance species recorded in this study with 25 individuals. Kenderong and Bintang Hijau FRs recorded the highest number of Hipposideridae species in this study, both with four species. The presence of Hipposiderids in this study might be associated with their suitable roosting and foraging areas as well as availability of food sources. Therefore, this information gives an early insight on Hipposideridae distribution and habitat requirement at the forest reserves in CFS ecological corridor landscapes that stakeholders need to consider in establishing the corridors. More sampling efforts need to put in this study, covering more areas in the forest reserves with longer sampling periods and more number of traps used in order to really identify critical corridors for bat conservations.

1. Introduction
There are 21 species of Roundleaf bat (Hipposideridae) in Peninsular Malaysia that consists of three genera namely Hipposideros (18 spp.), Aselliscus (1 sp.) and Coelops (2 spp.) [1-3]. This family varies in size from small (forearm length 34mm and 4g weight) to moderately large species (forearm length over 100mm and 60-70g weight) [4]. Generally, insectivorous bats are essential biological control agent for some of the significant insect pest populations not only in the forest but also in the agriculture habitats [5]. Hipposideridae mainly consumes insects such as moths and beetles [6].
Besides, insectivorous bats populations are also important indicators of biodiversity and ecosystem health and respond to a range of stressors related to environmental change [7]. For instance, their sensitivity toward accumulations of pesticides and other toxins, and changes in their abundance or activity may reflect differences in arthropod prey species populations as well as the loss of forests [7].

However, habitat loss is known to be significant threats to Malaysian bats [2]. The forest-interior insectivorous bats like Hipposideridae are particularly vulnerable to forest loss and degradation [8]. Therefore, Central Forest Spine (CFS) initiative was introduced to safeguard fauna and flora by restoring connectivity of the fragmented forests through the establishment of 37 identified ecological corridors across eight states in Peninsular Malaysia [9].

Currently, there are lacks of information on Hipposideridae that have been documented from the forest reserves, especially in CFS ecological corridor networks. Thus, this study mainly aims to record the presence of Hipposideridae at selected forest reserves in CFS ecological corridor networks. It is very crucial to document this information to support stakeholders with the right information on Hipposideridae species, including their distribution and habitat requirement that needs to be considered in establishing corridors at CFS landscapes. Proper forested or stream corridors are crucial for bats as the landscapes provide suitable areas for bats to commute and forage [10].

2. Methodology

2.1 Sampling sites

This study was conducted at 18 forest reserves across nine CFS ecological corridors (Figure 1). The active trapping has been conducted in 21 sampling sites. A brief description of the sampling sites, coordinates, sampling periods and habitat type are listed in Table 1 and Table 2.

Figure 1. Location of sampling sites at selected forest reserves in CFS ecological corridors landscapes.
Table 1. List of sampling sites and coordinates.

| No. | State | CFS Linkage | Sampling sites | Coordinate          |
|-----|-------|-------------|----------------|---------------------|
| 1   | Kedah | CFSI SL7    | Pedu FR        | 06'10'52.9" N      |
|     |       |             |                | 100'50'37.3" E     |
|     |       |             | Bukit Saiong FR| 06'06'09.2" N      |
|     |       |             |                | 100'51'29.1" E     |
| 2   | Perak | CFSI PL8    | Kenderong FR   | 05'29'52.7" N      |
|     |       |             |                | 101'02'45.1" E     |
|     |       |             | Bintang Hijau FR| 05'29'42.4" N      |
|     |       |             |                | 101'02'15.4" E     |
| 3   | Kelantan | CFSI PL3 | Sungai Betis FR| 04'44'41.8" N      |
|     |       |             |                | 101'39'23.5" E     |
|     |       |             | Sungai Brok FR | 04'40'26.5" N      |
|     |       |             |                | 101'38'34.7" E     |
| 4   | Terengganu | CFSI PL7 | Tembat FR (1)  | 05'01'19.8" N      |
|     |       |             |                | 102'32'00.1" E     |
|     |       |             | Tembat FR (2)  | 05'00'51.9" N      |
|     |       |             |                | 102'32'09.0" E     |
| 5   | Pahang | CFSI PL1    | Tanum FR       | 04'34'21.0" N      |
|     |       |             |                | 101'59'01.8" E     |
|     |       |             | Sungai Yu FR   | 04'33'31.3" N      |
|     |       |             |                | 101'58'36.3" E     |
|     |       |             | Ulu Jelai FR (1)| 04'33'31.7" N      |
|     |       |             |                | 101'59'09.1" E     |
| 6   |       | CFSI PL6    | Ulu Jelai FR (2)| 04'25'10.4" N      |
|     |       |             |                | 101'36'29.8" E     |
|     |       |             | Bukit Bujang FR| 04'24'46.9" N      |
|     |       |             |                | 101'36'16.4" E     |
| 7   | Negeri Sembilan | CFSII SL7 | Angsi FR      | 02'43'24.7" N      |
|     |       |             |                | 102'04'13.4" E     |
|     |       |             | Berembun FR (1)| 02'44'03.8" N      |
|     |       |             |                | 102'02'44.3" E     |
|     |       |             | Berembun FR (2)| 02'43'31.1" N      |
|     |       |             |                | 102'02'38.3" E     |
| 8   | Johor | CFSII PL1   | Labis Timur FR | 02'26'44.3" N      |
|     |       |             |                | 103'32'18.6" E     |
|     |       |             | Mersing FR     | 02'16'58.3" N      |
|     |       |             |                | 103'37'36.6" E     |
|     |       |             | Lenggor Tengah FR| 02'16'22.0" N     |
|     |       |             |                | 103'37'33.8" E     |
| 9   |       | CFSII PL3   | Panti FR       | 01'52'37.0" N      |
|     |       |             |                | 103'48'11.4" E     |
|     |       |             | Ulu Sedili FR  | 1'52'38.7" N       |
|     |       |             |                | 103'48'10.8" E     |

Table 2. Brief description of the habitat types for each sampling sites.

| No. | Sampling sites | Habitat Type                      |
|-----|----------------|-----------------------------------|
| 1   | Pedu FR        | LDF, SF, FWR, FWCCC, FWFA         |
| 2   | Bukit Saiong FR| LDF, SF, FWR, FWS, FWCCC, FWHA, FWRC |
| 3   | Kenderong FR   | LDF, SF, FWS, FWCO, FWHA, FWBP    |
| 4   | Bintang Hijau FR| LDF, SF, FWR, FWCCC, FWHA, FWRC   |
| 5   | Sungai Betis FR| LDF, SF, FWHA, FWCCC, FWDV        |
| 6   | Sungai Brok FR | LDF, SF, FW, FWCCC, FWHA          |
| 7   | Tembat FR (1)  | LDF, SF, FWS, FWCO, FWHA,         |
| 8   | Tembat FR (2)  | LDF, SF, FWS, FWCCC, FWHA, FWFDL  |
| 9   | Tanum FR       | LDF, SF, FWS, FWCCC, FWHA, FWLA   |
| 10  | Sungai Yu FR   | LDF, SF, FWR, FWCCC, FWHA, FWLA   |
| 11  | Ulu Jelai FR (1)| LDF, SF, FWCCC, FWHA, FWDV      |
| 12  | Ulu Jelai FR (2)| LDF, SF, FWCCC, FWHA, FWFDL, FWRC |
| 13  | Bukit Bujang FR| LDF, SF, FWCCC, FWCO, FWHA, FWDV  |
| 14  | Angsi FR       | LDF, SF, FWCCC, FWCO, FWHA, FWDL  |
| 15  | Berembun FR (1)| LDF, SF, FWCCC, FWCO, FWHA       |
However, through the compilation with previous publications, Labis Timur FR and Panti FR shown the highest number of species recorded with seven species respectively [14-22].

During this study, there is no Hipposiderids has been caught at respective forest reserves namely Angsi FR, Mersing FR, Labis Timur FR and Panti FR. However, previous studies had recorded the presence of these insectivorous bats from these forest reserves [14,16-19,21,22]. This is probably due to differences in trap placements, sampling periods, sampling coverage and season.

**Hipposideros bicolor**

This species was the most widely distributed in nine forest reserves namely Kenderong FR, Bintang Hijau FR, Tembat FR, Tanum FR, Sungai Yu FR, Ulu Jelai FR, Berembun FR, Lenggor Tengah FR and Ulu Sedili FR with 12 individuals cumulatively (Table 3). Among the forest reserves, these species were mostly captured in Tembat FR, Sungai Yu FR and Lenggor Tengah FR, each of which had two individuals. The presence of this species in the forest reserves might be associated with the hilly areas and limestone karst or river with rock crevices which provide suitable roosting sites for this

| 16 | Berembun FR (2) | LDF, SF, FWS, FWCC, FWHA, FWRC, FWDV |
| 17 | Labis Timur FR | LDF, SF, FWR, FWCC, FWFA |
| 18 | Mersing FR | LDF, SF, FWCC, FWCO, FWHA |
| 19 | Lenggor Tengah FR | LDF, SF, FWCC, FWCO, FWFA, FWFDL |
| 20 | Panti FR | LDF, SF, FWR, FWCC, FWHA |
| 21 | Ulu Sedili FR | LDF, SF, FWR, FWCC, FWHA, FWFDL |

Notes: LDF – Lowland dipterocarp forest; SF – Secondary forest; FWR – Forest with river; FWS – Forest with stream; FWCC – Forest with closed canopy closure; FWCO – Forest with canopy opening; FWHA – Forest with hill area; FWFA – Forest with flat area; FWDV – Forest with dense vegetation; FWFDL – Forest with fallen dead log; FWLA – Forest with limestone area; FWRC – Forest with rock crevices; FWBP – Forest with bertam tree patches.

2.2 Field methods

Sampling was carried out in 1ha plots respectively from February 2018 until August 2020. Each plot was sampled twice. All forest reserves have one plot and three sets of four-bank harp traps were deployed within the plot. However, there are three forest reserves namely Tembat FR, Ulu Jelai FR and Berembun FR that have two plots. Therefore, six sets of four-bank harp traps were deployed respectively. Harp traps were randomly set up at the areas that have the potential to be the bats’ flyway and also nearby river or stream. The harp traps were opened for five consecutive nights during each sampling session. The traps were checked at least five times a day at 0630 hours, 1930 hours, 2030 hours, 2130 hours and 2230 hours. Captured individuals were identified following identification keys by Francis [4], Francis [11], Kingston et al. [2] and Phillipps & Phillipps [3]. Standard measurements were taken from each individual, namely forearm length (FA), tail length (T), ear length (E), and live weight (g).

3. Results and Discussions

A total of 67 individuals comprising seven species from genus Hipposideros were recorded in 14 forest reserves. Harp trap shown to be the most effective method to trap insectivorous bats because it return less echoes and harder to be detected [12]. Occasionally, there are some incidents that insectivorous bats were caught by mist net such as Rhinolophus trifoliatus [13]. Besides, placement of harp trap is important since Hipposideridae is the most common bats that forage in the forest understory [3]. Thus, a study using harp traps is the best to capture Hipposideridae.

Kenderong FR and Bintang Hijau FR recorded the highest number of species captured, both with four species respectively namely *Hipposideros bicolor*, *H. larvatus*, *H. pomona*, *H. armiger* (only at Kenderong FR) and *H. galeritus* (only at Bintang Hijau FR). However, through the compilation with previous publications, Labis Timur FR and Panti FR showed the highest number of species recorded with seven species respectively [14-22].

This species was the most widely distributed in nine forest reserves namely Kenderong FR, Bintang Hijau FR, Tembat FR, Tanum FR, Sungai Yu FR, Ulu Jelai FR, Berembun FR, Lenggor Tengah FR and Ulu Sedili FR with 12 individuals cumulatively (Table 3). Among the forest reserves, these species were mostly captured in Tembat FR, Sungai Yu FR and Lenggor Tengah FR, each of which had two individuals. The presence of this species in the forest reserves might be associated with the hilly areas and limestone karst or river with rock crevices which provide suitable roosting sites for this
species [2]. At the same time, the abundance of insects in the forest reserves especially on the fallen dead logs might also be the contributing factors to this finding as this species feed on insects [6,23]. This species is also known to be widely distributed in all states of Peninsular Malaysia [24]. Also, to date, there are some records on *H. bicolor* in Bintang Hijau FR [20], Gunung Angsi FR [14,16,21], Labis FR [16] and Panti FR [16,17,22]. Thus, this species is the first record for Kenderong FR, Tembat FR, Tanum FR, Sungai Yu FR, Ulu Jelai FR, Berembun FR, Lenggor Tengah FR and Ulu Sedili FR.

**Hipposideros diadema**

A total of 10 individuals for this species was captured namely at Sungai Betis FR, Sungai Brok FR, Pedu FR, Bukit Saiong FR, Ulu Sedili FR, Tembat FR, Tanum FR and Sungai Yu FR (Table 3). It was mostly captured in Bukit Saiong FR and Sungai Brok FR, both with two individuals respectively. The occurrence of this species in the forest reserves might be due to the presence of rock crevices along the river or limestone karst located nearby the study plots, providing roosting areas for this species [2]. It is also common in both primary and secondary forests in all elevations [2]. To date, this species has been found in Bintang Hijau FR [20], Endau Kluang Wildlife Reserve; Labis FR and Mersing FR [19], Labis FR [16] and Panti FR [16-18,22]. Therefore, this species is considered as the first record for Sungai Betis FR, Sungai Brok FR, Pedu FR, Bukit Saiong FR, Ulu Sedili FR, Tembat FR, Tanum FR and Sungai Yu FR.

**Hipposideros cervinus**

Thirteen individuals captured in six forest reserves namely Bukit Saiong FR, Ulu Jelai FR, Bukit Bujang FR, Berembun FR, Lenggor Tengah FR and Ulu Sedili FR (Table 3). This species were mostly trapped in Ulu Jelai FR with six individuals. The abundance of this species in the Ulu Jelai FR might be due to the hilly and dense forest, providing suitable foraging areas for this species. Previous studies had also captured *H. cervinus* in the sites with hilly and dense forest with relative humid conditions [25]. Apart from that, the presence of large rock crevices in the plot also contributes to this finding as it serves as roosting areas for this species [2]. This species usually can be found in both primary lowland and hill forests [2,26]. However, this species is also recorded at the regenerated forest in Peninsular Malaysia [27]. Up until now, this species has been recorded in Tembat FR [15], Gunung Angsi FR [14,16,21], Berembun FR [14,21], Labis FR [16], Endau Kluang Wildlife Reserve; Labis and Mersing FRs [19] and Panti FR [16,17,22]. Hence, this species is the first record for Bukit Saiong FR, Ulu Jelai FR, Bukit Bujang FR, Lenggor Tengah FR and Ulu Sedili FR.

**Hipposideros larvatus**

This species is the most abundant species recorded in this study with 25 individuals cumulatively. This species was recorded in four forest reserves that are Kenderong FR, Bintang Hijau FR, Tanum FR and Sungai Yu FR (Table 3). This species was mostly caught in Kenderong FR with 11 individuals that might be associated with the high abundance of insects such as Orthoptera, Coleoptera and Lepidoptera found at the stream and open areas with shrubs located nearby the study plot, providing food sources for this species [5]. Apart from that, many studies also found this species in the forests with boulders, limestone caves, streams and waterfall [25]. Currently, this species has been documented in Bintang Hijau FR [20], Gunung Angsi FR [14,16,21], Labis FR [16] and Panti FR [16,17,22]. Therefore, this species is the first record for Kenderong FR, Tanum FR and Sungai Yu FR.

**Hipposideros pomona**

This species was recorded in two forest reserves, namely Kenderong FR (4 inds) and Bintang Hijau FR (1 ind) (Table 3). The presence of this species might be related to the high abundance of insects at the stream located nearby the study plots which provides food sources for this species. This is also
supported by previous studies that had captured this species in the forest with stream or small waterfall [25]. It was also known to be found in the northern region of Peninsular Malaysia, including Kelantan [4,25,28]. This study is the first record of this species in Kenderong FR and Bintang Hijau FR.

*Hipposideros armiger*

This species was only recorded in Kenderong FR with one individual (Table 3). This finding might be associated with the presence of bertam tree patches in the plot and rock crevices at the nearby stream that provide roosting areas for this species [2]. Apart from that, the presence of this species might be related to the high abundance of insects such as Coleoptera in the forest reserve [29]. Currently, no record on this species at Kenderong FR, except for Bintang Hijau FR based on the previous record by Department of Wildlife and National Parks, DWNP (1992) [20]. Therefore, this species can be considered as the first record for Kenderong FR.

*Hipposideros galeritus*

This species was recorded in only one forest reserve, namely Bintang Hijau FR with one individual (Table 3). The species was recorded in the forest reserve might be associated with the presence of rock crevices nearby the study plot, providing a roosting area for this species [2,25]. Based on the previous study, this species was recorded in Gunung Angsi FR [14,16], Berembun FR [14], Labis FR [16] and Gunung Panti FR [16]. Thus, this is the first record of this species in Bintang Hijau FR.

### Table 3. List of Hipposideridae species recorded in this study for each sampling sites.

| No. | Scientific Name | Common Name | Forest Reserves (No. of Individual) | Total |
|-----|----------------|-------------|------------------------------------|-------|
| 1   | *Hipposideros armiger* | Great Roundleaf Bat | A 1 B 1 C 1 D 1 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 1 |
| 2   | *Hipposideros bicolor* | Bicolored Roundleaf Bat | A 1 B 2 C 1 D 1 E 2 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 2 N 1 O 1 P 1 Q 1 R 1 S 2 T 1 U 1 | 12 |
| 3   | *Hipposideros cervinus* | Fawn Roundleaf Bat | A 1 B 2 C 1 D 1 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 13 |
| 4   | *Hipposideros diadema* | Diadem Roundleaf Bat | A 1 B 1 C 1 D 1 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 10 |
| 5   | *Hipposideros galeritus* | Cantor's Roundleaf Bat | A 1 B 1 C 1 D 1 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 1 |
| 6   | *Hipposideros larvatus* | Intermediate Roundleaf Bat | A 1 B 4 C 9 D 4 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 25 |
| 7   | *Hipposideros pomona* | Pomona Roundleaf Bat | A 1 B 4 C 1 D 1 E 1 F 1 G 1 H 1 I 1 J 1 K 1 L 1 M 1 N 1 O 1 P 1 Q 1 R 1 S 1 T 1 U 1 | 5 |

**Total No. of Species**: 1 2 4 4 1 1 0 2 3 3 0 2 1 0 1 1 2 0 0 0 3 7

**Total No. of Individual (Captured only)**: 1 3 17 12 1 2 0 3 3 7 0 7 2 0 1 1 4 0 0 0 3 67

Notes: A – Pedu FR; B – Bukit Saiong FR; C – Kenderong FR; D – Bintang Hijau FR; E – Sungai Betis FR; F – Sungai Brok FR; G – Tembat FR (1); H – Tembat FR(2); I – Tanum FR; J – Sungai Yu FR; K – Ulu Jelai FR(1); L – Ulu Jelai FR(2); M – Bukit Bujang FR; N – Angsi FR; O – Berembun FR(1); P – Berembun FR(2); Q – Lenggor Tengah FR; R – Mersing FR; S – Labis Timur FR; T – Panti FR; U – Ulu Sedili FR
4. Conclusion
In conclusion, a total of 67 individuals consisting of seven species from genus Hipposideros were recorded in 14 forest reserves. Kenderong FR and Bintang Hijau FR recorded the highest species richness of Hipposideridae in this study. *H. bicolor* is the most widely distributed species, whereas *H. larvatus* is the most abundant species recorded in this study. The presence of Hipposideridae in this study might be depending on the roosting and foraging areas as well as food availability. There are also first records of roundleaf bat species for the forest reserves in this study. Therefore, more efforts need to be put in this study by using more sampling efforts, more number of traps, different trap placements and covering more areas of the forest reserves in order to document Hipposideridae that can truly represent the forest reserves in CFS ecological corridor networks. At the same time, the information gathered can be used to identify critical or essential corridors for Hipposideridae and also other bat species conservations in CFS ecological corridor landscapes.

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