Notes on small mammals diversity at Perlis State Parks, Wang Kelian, Perlis, Malaysia

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Abstract. Three surveys were conducted to document diversity on small mammals at Perlis State Park, Wang Kelian, Perlis, Malaysia from 2019 until 2020. For each survey, a total of 50 cage traps, 10 mist-nets and two four-bank harp traps were set up for three-trapping nights along a 500 m transect line to sample small mammals. The opportunistic observation was also applying to record the incidence of small mammals. In total, 17 species of small mammals were documented during these surveys. Of these, seven species are volant small mammals, and ten species are non-volant small mammals. The family with the most diverse species was Pteropodidae with five species and Cynopterus brachyotis being the most dominant species (n = 46). Interestingly, these surveys report new distributional records for three small mammal species in Perlis State Park, though several studies have been conducted previously. This information demonstrates that there may be more species yet to be recorded from this study site. Comparing the species similarity between our study site and several state parks in Peninsular Malaysia shows that Perlis State Parks also holds a relatively high diversity of small mammals. Therefore, adequate conservation measures such as recognizing this state park as an important conservation area are needed to ensure valuable small mammals’ sustainability.

1. Introduction

Small mammals can be referred to as any mammal whose individual live weight not exceeds 5 kg at an adult stage [1]. It can be grouped into volant and non-volant. Chiroptera and Rodentia are among orders with a majority of species diversity for small mammals. The Chiroptera is the second most diverse mammalian group, comprising approximately more than 40% of the total mammalian fauna, while there were at least 50 species of rodents recorded in Peninsular Malaysia [2, 3, 4, 5, 6, 7, 8, 9]. The small mammals play many essential ecological roles such as in prey and predation, seed dispersal, biological indicator, decomposer and pollinator to ensure a good balance of an ecosystem [10, 11].

Perlis State Park is located in Perlis, the most northern state in Peninsular Malaysia. It situated on the western border of Perlis and Thailand within the Nakawan range, the longest continuous limestone hills in Malaysia [12]. It is the first established protected area in the northern region of Peninsular Malaysia and created a cross-frontier protected area with Thalebaan National Park in Satun, Thailand.
The state park was established in 1996 and occupied of 5,015 ha comprising of two forest reserve areas which are Mata Ayer Forest Reserve (2,156 ha) and Wang Mu Forest Reserve (2,859 ha) [14]. The state park is a semi deciduous forest, meaning the plants that shed their leaves for a short time when old leaves fall, and new leaves begin to develop [15, 16]. The state park also possesses many ecotourism attractions such as Wang Burma Cave I, Wang Burma Cave II and hiking trails to Gunung Perlis (733 metres), the highest hill in Perlis [16, 17].

Previously, there were several records of small mammals from this state park have been gathered by Jayaraj et al. [17], Sharma [18], PERHILITAN [19], Shukor et al. [20] and Shukor et al. [21]. Cumulatively, a total of 72 species of small mammals were reported. The number of small mammal species recorded indicates this state park being inhibited by numerous small mammal populations. However, Jayaraj et al. [17] mentioned that the mammalian species of this state park is still underestimated and additional surveys are required to estimate overall mammalian diversity in this state park. Therefore, we have carried out surveys to entail constructing an updated checklist of small mammals in this state park. Later, this enhanced information could strengthen this state park’s significance as a protected area and further highlight it as one of vital reservoir for conserving valuable small mammals.

2. Methodology

2.1 Study Site
Three survey sessions for small mammals were conducted from 2019 until 2020: i) 15 to 18 August 2019 during Perlis State Park Biological Diversity Scientific Expedition organized by Perlis Forestry Department, ii) 28 to 31 January 2020 and iii) 10 to 13 February 2020. In each survey, trapping is carried out along a 500 m transect line between Putera Denmark Trail and the hiking trail leading to Gunung Perlis. The survey site is a lowland forest (below 500 m a.s.l) and predominantly with secondary forest vegetation.

2.2 Small Mammal Sampling
A 500 m transect line was equipped with a total of 50 collapsible cage traps (42 x 17 x 17 cm), baited with oil palm to capture non-volant small mammal. All collapsible cage traps were deployed on the ground at 10 m interval and left open for three consecutive nights, and checked twice daily at 0700 hours and 1600 hours. The cumulative trapping efforts for non-volant small mammals were 450 trap nights.

For Chiroptera, a total of 10 mist nets (12 m x 2 m with 36 mm mesh) and two harp traps (four banks) were set up for three consecutive nights during the respective survey. These nets and harp traps were set randomly between transects and left open throughout during each survey session. Nets and harp traps were checked twice daily, at 0630 hours and in between 1930 hours until 2030 hours. The cumulative trapping efforts were 90-net nights and 18-trap nights for the mist nets and harp traps, respectively.

Apart from trapping, opportunistic observation for nocturnal and diurnal small mammals was also performed whenever possible. The observation was aided with Nikon binoculars (16X55) and Bushnell binoculars (10X42).

All captured individuals were safely secured in cloth bags. Live weight and required morphological measurements were taken for identification purposes. The measures taken for non-volant small mammal includes ear (E), hind foot (HF), tail (TL) and head body (HB). Meanwhile, measurement of forearms (FA), ear (E) and tail (T) were taken for bats. After the identification processes, representatives of all captured species were photographed, tissue (preserved temporarily in 95% ethanol) and deposited at the Zoology Branch Specimen Collections in Forest Research Institute Malaysia (FRIM) for further references. The identification of recorded small mammals was made following keys by Francis [9], Kingston et al. [22] and Phillipps & Phillips [23].
2.3 Statistical Analysis
Relative abundance of each volant and non-volant small mammal was calculated by dividing the total individual of a species with total individuals of all species captured. The results of relative abundance were tabulated into the checklist provided in the study. Similarity Analysis were carried out based on Bray-Curtis model to illustrates the similarity of small mammal diversity exists between Perlis State Park with other state parks in the country such as Gunung Stong State Park of Kelantan, Selangor State Park and Royal Belum State Park in Perak.

3. Results and Discussion
Respectively, eight and 71 individuals of non-volant and volant small mammals were caught during these surveys. Of these captured individuals, there were five species of non-volant small mammals under four families (Muridae, Sciuridae, Tupaiidae and Viverridae) and six species of volant small mammals from three families (Hipposideridae, Pteropodidae and Rhinolophidae). Moreover, our opportunistic observations also recorded an additional six species of small mammals. Overall, 17 species of small mammals were documented throughout these surveys with three new distributional records for Perlis State Park (Table 1).

The chiropteran was the majority of small mammals recorded. Pteropodidae was the most diverse family, consisting of five species: *Megaerops ecaudatus*, *Pteropus vampyrus*, *Rousettus amplexicaudatus*, *Rousettus leschenaultii* and *Cynopterus brachyotis*. The emergent of fruiting trees might favour the high presences of pteropodids as all species of pteropodids are mainly phytophagous, consumes fruit, floral resources (nectar and pollen), or leaves with insects forming a small component of its diet [24, 25, 26, 27, 28, 29, 30].

The short-nosed fruit bat (*C. brachyotis*) was the most dominant small mammal, with 46 individuals captured, followed by *R. amplexicaudatus* (10 individuals) and *R. leschenaultii* (nine individuals). Despite plentiful food resources, the high number of *C. brachyotis* captured may be influenced by its distributional ranges and adaptation. According to Hall et al. [31], *C. brachyotis* is Southeast Asia's common and widespread frugivorous bats. It is well adapted to anthropogenic conditions and inhibits wide ranges of habitats, including primary forest, disturbed forest, mangrove, cultivated areas, orchards, gardens and urban areas [9].

In comparison, Jayaraj et al. [17] also reported a high yield of diverse insectivore bats (26 species) in Perlis State Park. This contrasts with our surveys where only two species of insectivore bats, namely *Hipposideros diadema* and *Rhinolophus affinis* were caught. We notice the surveys site possess an abundance of invertebrates that typically devours by insectivorous bats such as beetles, mosquitoes, bugs and moths [32]. Therefore, food resources are not utmost contributing factor for low records of insectivorous bats as we assume their nutrient requirements are sufficiently available. The significant potential aspect of our little records probably due to the limiting number of trapping nights and the number of harp traps used as compared to the Jayaraj et al. [17] study.

Furthermore, lack of preferable roosting sites such as rock crevices, large tree hollows and cave within the harp trap placement and rainy condition during most of the surveys periods also may adding factors to low number of insectivorous bats accounted. According to Cristian et al. [33], on rainy days, insectivorous bats will reduce their daily activities since echolocation calls imposed by raindrops that could cause the bats to lose orientation or detected as prey.

As for non-volant small mammals, only eight individuals were caught comprising five species known as *Leopoldamys sabanus*, *Maxonomys rajah*, *Petinomys vordermanni*, *Tupaia glis* and *Paradoxurus hermaproditus*. Unlike other captured non-volant small mammals, the *P. vordermanni* are found netted at mist net deployed at the adjacent trail towards Gunung Perlis instead in the collapsible cage. According to Fokidis & Risch [34], *P. vordermanni* tends to forage on trees and live mostly in trees holes with an average of 6 m above the ground, but the number can be much higher or lower depending on the location. Thus, this may explain the capture of *P. vordermanni* in our 3 metre-height mist net. In addition, *L. sabanus* was the most captured non-volant small mammal with three individuals. According to Lim [35], this giant bodied and long-tailed rat is a common, generalist species in local assemblages of small mammals presented throughout the Sunda region of Southeast Asia. Moreover, this rat can also move in different matrix structure of logged and unlogged forest [36].
In these surveys, we speculate our low captures of non-volant small mammals may not only contribute by inadequate trapping effort but also probably cause by placement of traps. During the surveys, the trapping efforts were focused on single habitat (terrestrial) as the collapsible cage traps were deployed on the forest floor. Therefore, the traps were aimed to captured ground-dwelling small mammals, thus may not represent the actual species diversity of non-volant small mammals that inhabits the area, especially the arboreal species such as flying squirrels.

Through our opportunistic observations, there were six species of small mammal spotted. Five species are non-volant small mammals: Callosciurus caniceps, Ratufa bicolor, Sundasciurus tenuis, Paguma larvata and Nycticebus coucang. Another observed species was the volant Pteropus vampyrus. The civet and squirrels were encountered at Putera Denmark Trail. An individual, N. coucang, was spotted at night while climbing between tree branches of flowering trees situated in the open car park inside the state park. According to Francis [9], N. coucang is an arboreal, primarily solitary and occurs mainly in tall and secondary forests, sometimes in gardens and plantations. On the other hand, the P. vampyrus was spotted at night while flying to forage on fruiting trees located behind the chalet inside of the Perlis State Park.

Although we consider our trapping efforts are insufficient, but our surveys succeed in documenting the presence of new distributional records involving three small mammals species, which in turn provides an additional list of small mammals to the previous studies by Jayaraj et al. [17], Sharma [18], PERHILITAN [19], Shukor et al. [20] and Shukor et al. [21]. These species include the captured Rousettus amplexicaudatus and Petinomys vordermanni, as well as the observed Pteropus vampyrus. This finding may show the possibilities of more species of small mammals yet to be discovered in this area. Hence, we support Jayaraj et al. [17] who mentioned that more regular surveys encompassing wider areas, increased trapping effort, and multiple approaches may facilitate a more comprehensive representation of small mammals in this state park.

In addition, we also carried out a comparison on the similarity of small mammals species composition in Perlis State Park with three other state parks, namely Gunung Stong State Park, Selangor State Park and Royal Belum State Park (Figure 1). The information of small mammals in Gunung Stong State Park were gathered from Shukor et al. [37], Mariana et al. [38] and Jayaraj et al. [39]. Meanwhile, for Selangor State Park the data were compiled from Kaviarasu et al. [11], Lim et al. [40], Lim et al. [41], Nor et al. [42], William-Dee et al. [43] and Sing et al. [44] whilst, small mammals information collected for Royal Belum State Park were from Ratnam et al. [45], Francis [46], Nur Aida et al. [47] and Shahfiz et al. [48]. The Bray-Curtis similarity coefficient indices ranged from 0 to 1 is applied (0 = no similarity, 1 = total similarity). Based on the generated Unweighted Pair-Group Method using Arithmetic averages (UPGMA) dendogram of similarity, Perlis State Park is grouped with Selangor State Park and Gunung Stong State Park at similarity composition value of 82.7% and 81.9% respectively. The composition of small mammal in Perlis State Park is almost 78.3% of similarity with Royal Belum State Park.
Figure 1. Dendogram of small mammals species similarity between Perlis State Park and Royal Belum State Park, Gunung Stong State Park and Selangor State Park.

Perlis State Park is the smallest comparable to Selangor State Park, Gunung Stong State Park and Royal Belum State Park. However, it holds more than half diversity of small mammals in compared to these much larger comparative state parks. This may point out the relevancy of this state park of being gazetted as protected area as it may serve as a critical viable habitat for variety of small mammals in Perlis.

Here, we also represent in Table 1 the latest conservation status (IUCN Red List of Threatened Species) and protection status (Wildlife Conservation Act 2010) of reported small mammals in Perlis State Parks compiled from this current surveys and previous studies [17, 18, 19, 20, 21]. Out of all 75 species of small mammals documented, six small mammals were considered threatened species. These include two endangered species, namely *Nycticebus coucang* and *Pteromyscus pulverulentus* and the remaining four were vulnerable species such as *Maxomys rajah* and *Petinomys vordermanni*. Moreover, there were 11 and eight species of small mammals were categorized as Totally Protected and Protected, respectively, under the Wildlife Conservation Act 2010. This information further shows up the importance of this state park as a vital area for the in-situ conservation of precious small mammals.
Table 1. A compilation of small mammals recorded in Perlis State Park from current and previous studies.

| No | Family             | Common Name         | Scientific Name       | Shama et al. (1992) | DWNP et al. (1993) | Shukor et al. (2002) | Jayaraj et al. (2013) | Present study (2021) | IUCN | WCA 2010 |
|----|--------------------|---------------------|-----------------------|---------------------|---------------------|----------------------|----------------------|----------------------|------|----------|
| 1  | Cynocephalidae     | Sunda Flying Lemur  | Galeopterus variegatus | /                   | /                   |                      |                      |                      | LC  | TP  |
| 2  | Erinaceidae        | Moonrat             | Echinosorex gymnura   | /                   | /                   |                      |                      |                      | LC  | TP  |
| 3  | Felidae            | Leopard Cat         | Prionailurus bengalensis | /                   |                      |                      |                      |                      | LC  | TP  |
| 4  | Herpestidae        | Crab-eating Mongoose| Herpestes urva        | /                   |                      |                      |                      |                      | LC  | TP  |
| 5  | Hipposideridae     | Great Roundleaf Bat | Hipposideros armiger  | /                   |                      |                      |                      |                      | LC  |      |
| 6  | Hipposideridae     | Bicolored Roundleaf Bat | Hipposideros bicolor | /                   | /                   |                      |                      |                      | LC  |      |
| 7  | Hipposideridae     | Fawn Roundleaf Bat  | Hipposideros cervinus | /                   | /                   |                      |                      |                      | LC  |      |
| 8  | Hipposideridae     | Diadem Roundleaf Bat| Hipposideros diadema  | /                   | /                   | 1                    |                      |                      | LC  |      |
| 9  | Hipposideridae     | Least Roundleaf     | Hipposideros doriae   | /                   | /                   |                      |                      |                      | LC  |      |
| 10 | Hipposideridae     | Dayak Roundleaf Bat | Hipposideros phacoenum | /                   | /                   |                      |                      |                      | LC  |      |
| 11 | Hipposideridae     | Cantor's Roundleaf Bat| Hipposideros galiatus | /                   | /                   |                      |                      |                      | LC  |      |
| 12 | Hipposideridae     | Intermediate Roundleaf Bat | Hipposideros larvatus | /                   | /                   |                      |                      |                      | LC  |      |
| 13 | Hystricidae        | Common Porcupine    | Hystrix brachyura     | /                   | /                   |                      |                      |                      | LC  |      |
| 14 | Lorisidae          | Greater Slow Loris  | Nycticebus coucang    | /                   | /                   | Observed             |                      |                      | EN  | TP  |
| 15 | Megadermatidae     | Lesser False Vampire| Megaderma spasma      | /                   | /                   |                      |                      |                      | LC  |      |
| 16 | Muridae            | Bower's Rat         | Berylmys bowersi      | /                   | /                   |                      |                      |                      | LC  |      |
| 17 | Muridae            | Pencil-Tailed Tree Mouse| Chiropodomys gliroides | /                   | /                   |                      |                      |                      | LC  |      |
| 18 | Muridae            | Long-Tailed Giant Rat| Leopoldamys sabanus   | /                   | /                   | 3                    |                      |                      | LC  |      |
| 19 | Muridae            | Brown Spiny Rat     | Maxomys rajah         | /                   | /                   | /                    | 1                    |                      | VU  |      |
| 20 | Muridae            | Red Spiny Rat       | Maxomys surifer       | /                   | /                   |                      |                      |                      | LC  |      |
| 21 | Muridae            | Whitehead's Rat     | Maxomys whiteheadi    | /                   | /                   | /                    |                      |                      | VU  |      |
| 22 | Muridae            | Asian House Rat     | Mus musculus          | /                   | /                   |                      |                      |                      | LC  |      |
| 23 | Muridae            | Chestnut White-bellied Rat| Niviventer fulvescens | /                   | /                   |                      |                      |                      | LC  |      |
| 24 | Muridae            | House Rat           | Rattus rattus         | /                   | /                   |                      |                      |                      | LC  |      |
| 25 | Muridae            | Malaysian Field Rat | Rattus tiomanicus     | /                   | /                   |                      |                      |                      | LC  |      |
| 26 | Muridae            | Muller's Rat        | Sundamys muelleri     | /                   | /                   |                      |                      |                      | LC  |      |
| 27 | Nycteridae         | Hollow-Faced Bat    | Nycteris tragata      | /                   | /                   |                      |                      |                      | NT  |      |
| No. | Order        | Family      | Genus and Species                        | Status | Ref. |
|-----|--------------|-------------|------------------------------------------|--------|------|
| 28  | Pteropodidae | Pteropodidae| *Balionycteris maculata*                 |        |      |
| 29  | Pteropodidae | Pteropodidae| *Cynopterus brachyotis*                  |        |      |
| 30  | Pteropodidae | Pteropodidae| *Cynopterus horsfieldii*                 |        |      |
| 31  | Pteropodidae | Pteropodidae| *Cynopterus sphinx*                      |        |      |
| 32  | Pteropodidae | Pteropodidae| *Eonycteris spelaea*                     |        |      |
| 33  | Pteropodidae | Pteropodidae| *Macroglossus minimus*                   |        |      |
| 34  | Pteropodidae | Pteropodidae| *Macroglossus sobrini*                   |        |      |
| 35  | Pteropodidae | Pteropodidae| *Megaerops ecaudatus*                    | 2      |      |
| 36  | Pteropodidae | Pteropodidae| *Pteropus vampyrus*                      |        |      |
| 37  | Pteropodidae | Pteropodidae| *Rousettus amplexicaudatus*              | 10     |      |
| 38  | Pteropodidae | Pteropodidae| *Rousettus leschenaultii*                | 9      |      |
| 39  | Rhinolophidae| Rhinolophidae| *Rhinolophus affinis*                    |        |      |
| 40  | Rhinolophidae| Rhinolophidae| *Rhinolophus chiwkwueae*                |        |      |
| 41  | Rhinolophidae| Rhinolophidae| *Rhinolophus coelophyllus*              |        |      |
| 42  | Rhinolophidae| Rhinolophidae| *Rhinolophus macrotis*                   |        |      |
| 43  | Rhinolophidae| Rhinolophidae| *Rhinolophus malayanus*                  |        |      |
| 44  | Rhinolophidae| Rhinolophidae| *Rhinolophus robinsoni*                  |        |      |
| 45  | Rhinolophidae| Rhinolophidae| *Rhinolophus stheno*                     |        |      |
| 46  | Rhinolophidae| Rhinolophidae| *Rhinolophus trifoliatu*                 |        |      |
| 47  | Rhinolophidae| Rhinolophidae| *Rhinolophus lepidus*                    |        |      |
| 48  | Sciuridae    | Sciuridae   | *Callosciurus notatus*                   |        |      |
| 49  | Sciuridae    | Sciuridae   | *Callosciurus prevostii*                 |        |      |
| 50  | Sciuridae    | Sciuridae   | *Callosciurus caniceps*                  |        |      |
| 51  | Sciuridae    | Sciuridae   | *Lariscus insignis*                      |        |      |
| 52  | Sciuridae    | Sciuridae   | *Petarurista petarurista*                |        |      |
| 53  | Sciuridae    | Sciuridae   | *Petinomys vordermannii*                 | 1      |      |
| 54  | Sciuridae    | Sciuridae   | *Pteromyscus pulverulentus*              |        |      |
| 55  | Sciuridae    | Sciuridae   | *Ratufa affinis*                        |        |      |
| 56  | Sciuridae    | Sciuridae   | *Ratufa bicolor*                        |        |      |
| 57  | Sciuridae    | Sciuridae   | *Sundasciurus lowii*                     |        |      |
| 58  | Sciuridae    | Sciuridae   | *Sundasciurus tenuis*                    |        |      |
| Family          | Species                          | Scientific Name          | Status  |
|-----------------|---------------------------------|--------------------------|---------|
| Soricidae       | Southeast Asian Shrew           | Crocidura fuliginosa     | LC      |
| Tragulidae      | Lesser Oriental Chevrotain      | Togul cus kanchil        | LC      |
| Tupaiidae       | Common Treeshrew                | Tupaia glis              | 2 LC    |
| Tupaiidae       | Lesser Treeshrew                | Tupaia minor             | LC      |
| Vespertilionida | Hardwicke's Woolly Bat          | Kerivoula hardwickii     | LC      |
| Vespertilionida | Small Woolly Bat                | Kerivoula intermedia     | NT      |
| Vespertilionida | Papillose Woolly Bat            | Kerivoula papillosa      | LC      |
| Vespertilionida | Clear-Winged Woolly Bat         | Kerivoula pellucida      | NT      |
| Vespertilionida | Bronzed Tube-Nosed Bat          | Murina aenea             | LC      |
| Vespertilionida | Lesser Tube-Nosed Bat           | Murina suilla            | LC      |
| Vespertilionida | Burmese Whiskered Myotis        | Myotis montivagus        | DD      |
| Vespertilionida | Small-Toothed Myotis            | Myotis siligorensis      | LC      |
| Vespertilionida | Myotis peninsularis             |                         |         |
| Vespertilionida | Narrow-Winged Pipistrelle       | Pipistrellus stenopterus | LC      |
| Vespertilionida | Greater Bamboo Bat              | Tylonycteris robustula   | LC      |
| Viverridae      | Masked Palm Civet               | Paguma larvata           | LC      |
| Viverridae      | Common Palm Civet               | Paradoxurus hermaphroditus| LC      |

**Total number of individuals:** 79

**Total Number of Species:** 25 20 15 49 17

**Total Number of Family:** 14 12 9 11 8

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*a* International Union for Conservation of Nature Red List of Threatened Species  
*b* Wildlife Conservation Act 2010  
*c* Not Evaluated  
*d* Data Deficient  
*e* Least Concern  
*f* Near Threatened  
*g* Vulnerable  
*h* Endangered  
*i* Protected  
*j* Totally Protected  
*k* New additional distributional records
4. Conclusion
The identified diversity of small mammals gives an insight into this state park as a crucial habitat for a variety of small mammals. Therefore, recognizing and securing this state park as a vital protected area is needed to conserve and ensure the survival of its small mammal population. However, we believe more efforts are required to fully document the small mammal diversity in this Perlis State Park. Thus, we recommend: i) carry out a more intense study covering different sites in diverse forest settings (e.g., waterways, forest gradient, vertical stratification); ii) apply various sampling technique (e.g., camera trapping, different baits) with extended sampling period.

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