

Research Article

The Non-Volant Terrestrial Small Mammals at Ulu Muda Forest Reserve, Kedah, Malaysia

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Abstract

An eight days survey of non-volant small mammals was conducted at the Ulu Muda Forest Reserve in the state of Kedah, Malaysia. To sample the small mammals, we placed 100 cage traps and 50 bucket pitfall traps randomly along the existing man-made trails in four sampling sites within the study area. Total trapping effort for the cage traps was 796 trap nights, while the total trapping effort for the bucket pitfall traps was 400 trap nights. Overall, 24 non-volant small mammal individuals represented by seven species from the Family Muridae were captured. The Red spiny rat, *Maxomys surifer*, was the most dominant species accounting for 42% of the total individuals captured. We also caught the Chestnut white-bellied rat (*Niviventer fulvescens*) which is a new record for the study area. Although sampling was conducted only briefly, our study has demonstrated that Ulu Muda Forest Reserve still holds a high diversity of forest rat species, some of which are of international or regional conservation concern. Increasing the sampling effort, i.e., by surveying more areas over a longer period, would likely increase the possibility of capturing more small mammal species in this area.

Keywords: Rats, Ulu Muda Forest Reserve, species diversity, *Niviventer fulvescens*.

Introduction

Ulu Muda is recognized as the largest lowland dipterocarp rainforest in the northern part of Peninsular Malaysia (Bashir Ali, 2014). The geology of Ulu Muda is composed of hills of 300 meters (m) with moderately high peaks and lowland area of less than 200m above sea level, and this area covers 162,931 hectares (Suksuwan, 2008). In addition to providing important habitats for many wildlife species, the Ulu Muda area plays an important role as a water catchment for Muda Lake, Peru Lake and Ahning Lake. In terms of forest types, Ulu Muda is covered by hill dipterocarp, and limestone vegetation (Marden et al., 2013). This location is also unique for having many natural saltlicks that are an important

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source of essential minerals for large mammal species (Stevens, 1968; Matsubayashi et al., 2007; Bashir Ali, 2014). Based on camera trapping methods, the World Wide Fund for Nature recorded 31 species of mammals at saltlick sites in Ulu Muda (Bashir Ali, 2014).

Since over 10 years ago, the Ulu Muda Forest Reserve has recorded approximately 112 mammalian species which account for 50% of mammalian species found throughout Peninsular Malaysia (DWNP, 1993; WWF-Malaysia, 2002; Mariana et al., 2005; Sharma et al., 2005; Shukor et al., 2005; DWNP, 2010). The animals reported here include charismatic species such as the Asian elephant (*Elephas maximus*), Malayan tapir (*Tapirus indicus*) and Sambar deer (*Rusa unicolor*). Additionally, the Hairy-nosed otter (*Lutra sumatrana*), which is an endangered otter species usually found in a peat swamp forest, has also been recorded in Ulu Muda (Hubback, 1932; Bashir Ali, 2014; Salahshour, 2016).

Although efforts to gazette Ulu Muda as a protected area started since 1930, the official gazettement of this area has yet to be made to date (Elagupillay, 1987; Stevens, 1968; DWNP, 1989; MOCAT, 1996; Bernama, 2009). While Ulu Muda's large mammalian faunal has been extensively investigated in the past, few studies concerning small mammals have been conducted (Shukor et al., 2005; Sharma et al., 2005; Bashir Ali, 2014). This has created a gap in the latest information about Ulu Muda's overall faunal diversity.

In this study, we conducted a survey focusing on the non-volant small mammal fauna of Ulu Muda Forest Reserve. Non-volant small mammals refer to any non-flying mammals whose adult live weight in the wild do not exceed five kilogrammes (kg; Hayward & Phillipson, 1979; Barnett & Dutton, 1995) such as rats, shrews, gymnures and treeshrews. The latest small mammal survey using camera trapping in Ulu Muda by (Bashir Ali, 2014) recorded only two non-volant species of rodent, i.e., the Long-tailed giant rat (*Leopoldamys sabanus*) and Malayan porcupine (*Hystrix brachyura*). Camera trapping method is not ideal for studying small mammals because species identity is not easily known from the photographs captured (Bernard et al., 2013). Thus, we conducted a survey of the small mammals using live-cage traps and bucket pitfall traps with the main aim to provide an updated checklist of the non-volant small mammal community in Ulu Muda Forest Reserve. We also gathered information concerning their distribution, regional or local conservation status and morphological characteristics to enrich the scientific data for this animal group.

Methodology

Study area

Ulu Muda consists of seven permanent reserve forests (PRF) namely Bukit Keramat Forest Reserve (FR), Padang Terap FR, Pedu FR, Chebar Besar FR, Chebar Kecil FR, Bukit Saiong FR and Ulu Muda FR (Bashir Ali, 2014). In this study, we surveyed the distribution of non-volant small mammals in Ulu Muda Forest Reserve (UMFR) with GPS coordinate N 6° 07.536 E 100° 58.146 (Figure 1). Four sampling sites were selected in this study (1) base camp (N 06° 06.888' E 100° 57.787'), (2) Labua (N 06° 06.833' E 100° 57.784'), (3) Gua Labu (N 06° 07.026' E 100° 58.114') and (4) Sira Panas (N 06° 06.482' E 100° 57.509'). These sites are located near the Muda River and covered by secondary forests with an elevation range between 100m to 150m. Sampling was conducted from 6th to 14th December, 2019. Sira Panas is one of the many natural saltlicks in Ulu Muda Forest Reserve. Other natural saltlicks around this forest reserve that are known to us are Sira Bongor and Sira Air Hangat.

Taxon sampling

One hundred cage traps with size of 28cm x 15cm x 12cm each were set up at all sampling sites (25 cage traps at each site) along the existing man-made trails. All cage traps were baited with either cut ripe banana coated with peanut butter, oil palm kernels, salted or fresh fishes. In addition, 50 buckets (height = 25cm, top diameter = 21cm with 10 small holes at the bottom to allow water

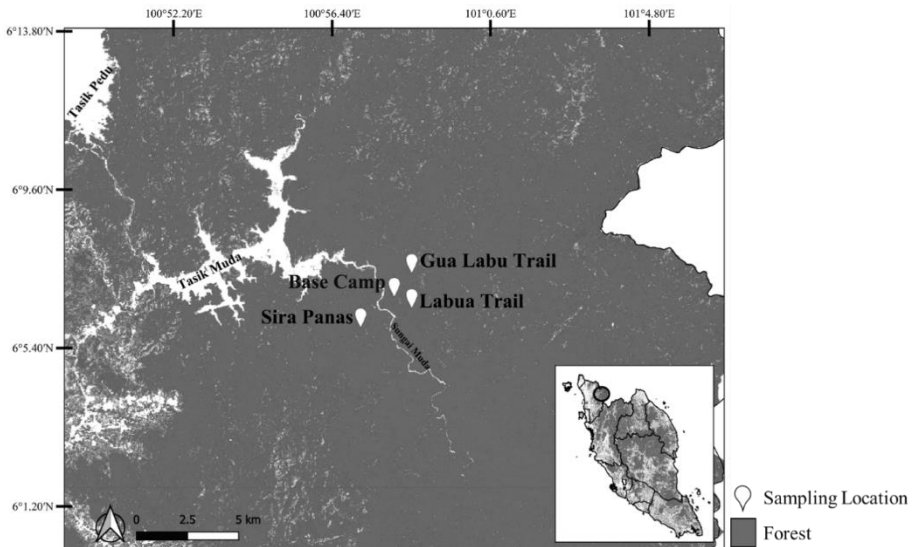


Figure 1. Map showing the four sampling sites, namely Gua Labu trail, Labua trail, base camp, and Sira Panas in the Ulu Muda Forest Reserve.

drainage) were buried without bait where their openings were the same level as the forest floor. Both cage traps and buckets were deployed between 10 to 50m apart from each other. All traps were active for eight consecutive days and nights and were checked for animals trapped once a day in the morning between 7:00 hrs - 11:00 hrs. All traps were re-baited with new baits during the daily check. The identity of the trapped animals was determined using several field guide books i.e., Francis (2008), Aplin et al. (2003) and Herbreteau et al. (2011). All trapped animals were euthanized using Zoletil® 50 following the standards widely used by field researchers (Rivas et al., 2015; Ishak et al., 2018). All tissue samples from the liver were collected and preserved in 90% ethanol for DNA analysis. All samples were labeled and preserved in 70% ethanol as wet specimens (Tingga et al., 2012) and were stored in the Museum of Zoology, Universiti Malaya.

Data analyses

We analyzed the diversity indices of rats using Paleontological Statistics software (PAST) version 3.26 (Hammer et al., 2001). The diversity indices include Simpson diversity index ($1-D$), Shannon-Wiener diversity index (H), Buzas and Gibson's evenness (E) and Margalef's richness index (D_{Mg}) (Mohd-Taib et al., 2019; Tu et al., 2020). We compared the results of our survey with earlier records based on studies conducted in 2008 by Mariana et al. (2008) in the same locality (see Table 1).

To construct the species accumulation curve, the cumulative number of species from all the sampling sites were calculated using PAST software. The cumulative number of species was used against the sampling efforts which is given by the sampling days, to draw the accumulation curve. The rarefaction curve of the total individuals non-volant small mammals captured from Ulu Muda Forest Reserve, Kedah was also constructed using the same software, to access the species richness from the sampling results.

Results and Discussion

A total of seven species of murid rodents have been recorded in Ulu Muda Forest Reserve during our survey based on an overall of 24 small mammal individuals caught. We did not capture other groups of rodents as recorded by Bashir Ali (2014) using the same sampling methods as our survey. This is most likely due to the brief period of our survey (8 days only). Nevertheless, we have sighted several arboreal species from the genus Tupaiidae or Sciuridae, although we could not confirm the species identity. The most frequently caught species in

this survey was the Red spiny rat (*Maxomys surifer*) followed by Whitehead's spiny rat (*Maxomys whiteheadi*) with 10 and 6 individuals caught, respectively (Table 1). *M. surifer* is one of the common murids found in the lowland dipterocarp forest (Francis, 2008). This species is quite similar to *M. whiteheadi* (Figure 2) based on its morphology, especially the bicolored tail. *M. whiteheadi* is also the only captured species listed as Vulnerable by the IUCN Red List (IUCN, 2020; refer Appendix 1 for other species status). During this survey, we were unsuccessful in trapping Rajah spiny rat (*Maxomys rajah*). This might be due to its habitat, which possibly occurs in a drier area than the *M. surifer*. These two species are rarely found in the same locality (Francis, 2008). Two singleton species were represented by Muller's giant Sunda rat (*Sundamys muelleri*) and Indomalayan Pencil-tailed tree mouse (*Chiropodomys gliroides*). Two individuals of *Niviventer* species were also captured, which are Dark-tailed tree rat (*Niviventer cremoriventer*) and Chestnut white-bellied rat (*N. fulvescens*). The latter is a new record in Ulu Muda Forest Reserve.

Table 1. Taxonomic list and comparison with previous survey of non-volant small mammals collected from a survey at Ulu Muda Forest Reserve in Kedah state.

| Family | | |
|---------------------------------|---------------|-----------------------|
| Species | In this study | Mariana et al. (2008) |
| Muridae | | |
| <i>Maxomys surifer</i> | 10 | 1 |
| <i>Maxomys whiteheadi</i> | 6 | 7 |
| <i>Maxomys rajah</i> | 0 | 2 |
| <i>Niviventer cremoriventer</i> | 2 | 0 |
| <i>Niviventer fulvescens</i> | 2 | 0 |
| <i>Rattus tiomanicus</i> | 2 | 0 |
| <i>Sundamys muelleri</i> | 1 | 6 |
| <i>Chiropodomys gliroides</i> | 1 | 0 |
| <i>Leopoldamys sabanus</i> | 0 | 4 |
| Tupaiaidae | | |
| <i>Tupaia glis</i> | 0 | 1 |
| Total individuals | 24 | 21 |
| Total families | 1 | 2 |
| Total species | 7 | 6 |

There are three species of *Niviventer* that can be found in Peninsular Malaysia consisting of *N. cremoriventer*, *N. cameroni* and *N. fulvescens* (Figure 2). Out of three, only *N. cameroni* has a distinct distribution where it lived at an elevation of more than 1000m and was recorded in Cameron Highlands, Pahang (Francis, 2008). The other two species of *Niviventer* are distributed in forests throughout Peninsular Malaysia (Francis, 2008).

Based on our observation, except the body sizes and length of tails, their morphologies are quite similar to the *M. whiteheadi* and by coincidence they shared the same habitat. This might lead to species misidentification, especially with the juvenile *N. fulvescens*.

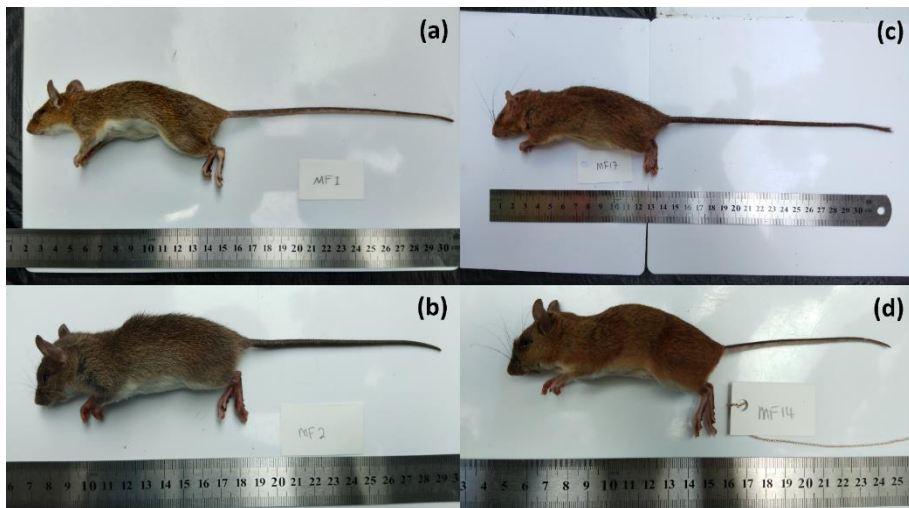


Figure 2. Photos of rats collected: a) *Niviventer fulvescens*, b) *Rattus tiomanicus*, c) *Niviventer cremoriventer* d) *Maxomys whiteheadi*

As compared with the previous study by Mariana et al. (2008), our results have shown slight changes in murid abundance as in Table 1. For example, Mariana et al. (2008) managed to trap six individuals of *S. muelleri* while we only found a single individual of this species which was commonly present near water sources such as streams and rivers. Same goes with the Long-tailed giant rat (*Leopoldamys sabanus*) and Common treeshrew (*Tupaia glis*) which are known to be common and widely distributed species. We did not expect to get the same result as Mariana et al. (2008), but to see the changes in diversity at the same locality. The absence of some species may be due to disturbance in the sampling sites that chase away most of the small mammals. The assumption is based on scattered animal dung especially in Labua and Sira Panas indicating the presence of medium to large mammals. Besides that, our sampling efforts are quite low as we divided the cage and pitfall traps to each sampling site. The disturbance and possible food scarcity for small mammals may force the animals to go deeper into the forests and our coverage is not enough to cover them.

Our results showed rather moderate (Simpson's diversity index) and low values of diversity indices (Table 2), indicating a moderate species richness of small

mammals in the sampling sites and the number of individuals is not distributed evenly between the captured species. This could be seen based on the highest and lowest number of captured species. Based on our observation, there is no deforestation or new development in our study sites. The nearby nature lodge (Earth Lodge) is the only eco-tourism provider in the forest (Bashir Ali, 2014) and during our trip, no tourists were spotted there, except for our research team and MNS staff.

Table 2. The species diversity of non-volant small mammals analyzed in this study.

| Sample analyses | This study |
|--|------------|
| No. of species | 7 |
| No. of individuals | 24 |
| Simpson diversity index ($1-D$) | 0.740 |
| Shannon-Wiener diversity index (H) | 1.597 |
| Buzas and Gibson's evenness (E) | 0.706 |
| Margalef's richness index (D_{Mg}) | 1.888 |

The species accumulation curve was constructed to depict the dependence of the cumulative number of species captured from the sampling sites on a variable representing sampling effort which is sampling days (Figure 3).

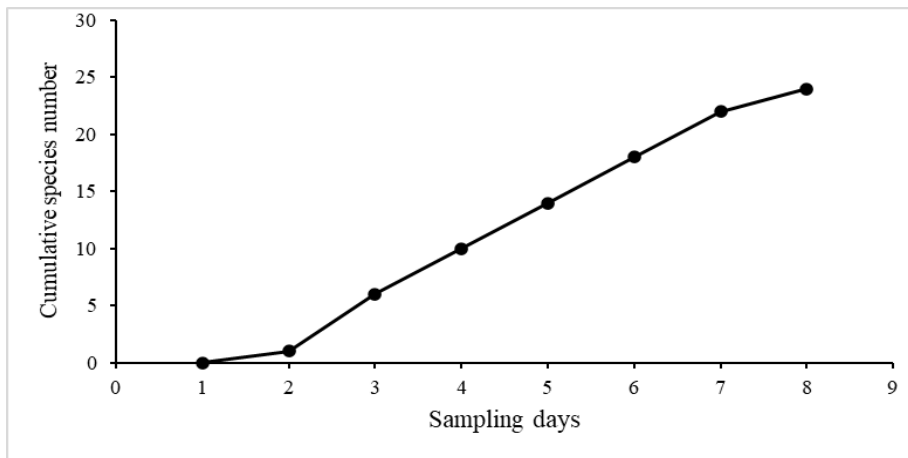


Figure 3. Species accumulation curve showing the cumulative species number against the sampling days (8 days of sampling period) from Ulu Muda Forest Reserve, Kedah.

The figure also shows that the curve almost achieves the horizontal asymptote of the species richness. Extended period of samplings at Ulu Muda Forest Reserve, Kedah would increase the species richness of the non-volant small

mammals captured and the species accumulation curve will probably achieve asymptote.

According to Colwell (2009), rarefaction curves are useful for comparing species richness among populations in the inventoried or not inventoried sampling sites with inadequate effort. Therefore, the rarefaction curve was constructed based on the species richness against the cumulative number of species (Figure 4). The figure shows the accumulation curve has almost reached asymptote.

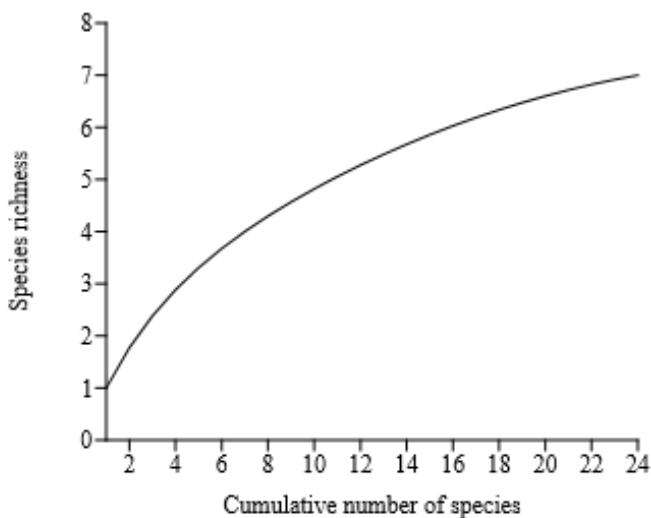


Figure 4. Rarefaction curve of the total individuals' non-volant small mammals captured from Ulu Muda Forest Reserve, Kedah.

Based on Colwell et al. (2012), the rarefaction curve is usually used to estimate the complete richness of the samples by visualizing it as the asymptote of the accumulation curve. In this study, it can be said that the sampling efforts are suitable and enough to estimate the total richness of the collected samples. However, any additional sampling efforts are still needed to increase species richness of non-volant small mammals captured from the sampling sites so that the accumulation curve can reach asymptote.

Conclusion

The few numbers of individuals and low number of non-volant small mammal species caught were most likely due to our short sampling duration, sampling efforts and less abundance of them in our sampling sites. However, this survey provides an updated checklist on the species occurrence at Ulu Muda Forest Reserve. Future surveys should be conducted over a longer period using a larger number of traps (increase sampling efforts) to get better results.

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Appendix 1. Taxonomic list and descriptive statistical measurements of non-volant small mammals collected from a survey at Ulu Muda Forest Reserve in Kedah state. Sample size is noted as (n) and its mean \pm standard deviation and range (in parenthesis) were displayed too. All measurements are in millimeters (mm) and weight in grams (g). Sexes and ages, ranging from juvenile to adult are combined.

| Family | Species | Common name | n/sex | Head and body length (HB) | Tail length (TL) | Hind foot length without claw (HF) | Ear length (E) | Weight (W) | IUC N Stat us |
|---------|---------------------------------|--------------------------------------|-----------|---------------------------------|---------------------------------|------------------------------------|-----------------------------|--------------------------------|---------------|
| Muridae | <i>Maxomys surifer</i> | Red spiny rat | 5M, 5F | 164.0 \pm 19.0 (140 - 199) | 173.4 \pm 19.0 (149 - 206) | 37.6 \pm 1.6 (36 - 41) | 23.5 \pm 2.6 (21 - 28) | 107.6 \pm 41.0 (50 - 182) | LC |
| | <i>Maxomys whiteheadi</i> | Whitehead's spiny rat | 5M, 1F | 110.5 \pm 6.6 (101 - 119) | 105.5 \pm 6.0 (100 - 116) | 26.4 \pm 1.9 (25 - 30) | 16.4 \pm 0.9 (15 - 18) | 37.5 \pm 7.2 (29 - 50) | VU |
| | <i>Niviventer cremoriventer</i> | Dark-tailed tree rat | 2M | 124.0 \pm 24.0 (107 - 141) | 176.5 \pm 312 (154 - 199) | 25.5 \pm 0.7 (25 - 26) | 18.3 \pm 1.1 (18 - 19) | 51.0 \pm 24.0 (34 - 68) | LC |
| | <i>Niviventer fulvescens</i> | Chestnut white-bellied rat | 1M, 1F | 140 | 166.0 \pm 12.7 (157 - 175) | 23.5 \pm 3.5 (21 - 26) | 19.0 \pm 1.4 (18 - 20) | 67.0 \pm 18.4 (54 - 80) | LC |
| | <i>Rattus tiomanicus</i> | Malayan field rat | 2M | 138.5 \pm 34.6 (114 - 163) | 136.0 \pm 32.5 (113 - 159) | 31.0 \pm 2.8 (29 - 33) | 17.5 \pm 2.1 (16 - 19) | 67.5 \pm 37.5 (41 - 94) | LC |
| | <i>Sundamys muelleri</i> | Muller's giant Sunda rat | 1F | 212 | 267 | 46 | 23 | 307 | LC |
| | <i>Chiropodomys gliroides</i> | Indomalayan Pencil-tailed tree mouse | 1N/A | N/A | 160 | 20 | N/A | N/A | LC |
| | | Total individuals | 24 | | | | | | |

*M=male, F=female, N/A=Not Available, VU=Vulnerable, LC=Least Concern