Presence of moonrat (*Echinosorex gymnura*) at selected forest reserves in Central Forest Spine (CFS) landscape of Peninsular Malaysia

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Abstract. Surveys on moonrat were conducted at 13 sites under 11 fragmented forest reserves of five CFS ecological corridors located in the states of Negeri Sembilan, Johor, Terengganu, Pahang and Kelantan. The surveys were conducted between February 2018 to September 2019. Not much information on moonrat is documented at these forest reserves. Therefore, the study aims to document the presence of moonrat within CFS landscape in Peninsular Malaysia. A total of 100 collapsible cage traps were deployed at each surveyed site. Cumulatively, a total of eight individuals of moonrat were recorded from six forest reserves. Tanum FR and Ulu Jelai FR located in Pahang, harbour highest number of individual of moonrat, respectively with two individuals in each forest reserve. Forest conditions such as canopy closure, vegetation density and food resources may affect the presence of moonrat. Based on the information, further conservation measures can be strategized in order to conserve these fragmented forest reserves of CFS ecological corridor as a habitat for this mammal.

1. Introduction
Moonrat, *Echinosorex gymnura* (Raffles, 1822) is a mammal species under the family Erinaceidae [1, 2]. Moonrat has body weighs of 870-1100 g, head-body lengths of 30-40cm, and tail lengths of 21-29 cm [1, 2]. The distribution of moonrat ranging from peninsular Myanmar, Thailand and Malaysia to Sumatra and Borneo [2]. In Peninsular Malaysia, the moonrat typically seems to be in black and colour, with the face covered by white fur and marked by three prominent black patches [2, 3]. Meanwhile, the endemic Borneo subspecies *Echinosorex gymnura alba* generally appears white with only a sparse scattering of black hairs [1]. This terrestrial mammal recorded inhibits lowland primary, secondary rainforest, swamp forest, sometimes mangrove and plantation at an elevation of up to 900m above sea level and prefers to occur in damp areas and near streams [2]. It is primarily active at night, and during the day, it usually rests in hollow rotting tree trunks on the ground, under tree roots or in-ground cavities [2]. The species devours mainly on terrestrial and aquatic invertebrates such as beetles, spiders, earthworms, millipedes and crustaceans [2, 4]. The IUCN Red List of Threatened Species has classified moonrat as Least Concern [5]. However, the population may probably decline due to the loss of intact forests [2].
Previously, Brozovic et al. [6] have studied the effects of forest degradation on the moonrat population in Sabah. The results of their study indicate canopy closure and forest quality positively associated with moonrat occurrence, where moonrat strongly depends on high-quality lowland forest. In Peninsular Malaysia, there are several published studies reported on the occurrence of moonrat such as [7-13]. However, the detail information on moonrat such as biology and ecology, can be considered low and scarce especially at fragmented forests of Central Forest Spine (CFS) landscape.

Central Forest Spine is an important initiative that introduces to re-create the connectivity among fragmented forests in Peninsular Malaysia. The objective of CFS is to maintain contiguous forest network of forest complex via ecological corridors [14]. The emergence of forest fragmentation due to ongoing activities such as land clearing and conversion of vegetation from one type to another creates concerns to conservation. The intrusions may impact and modify the natural species assemblages that may lead to habitat destruction and biodiversity reduction, especially for forest-dependent species [15]. Currently, there are 37 CFS ecological corridors identified which consists of 17 primary linkages (PL) and 20 secondary linkages (SL).

This study aims to document the presence of moonrat within CFS landscape in Peninsular Malaysia. Therefore, the importance of forest reserves under CFS ecological corridor in providing vital habitats and resources for moonrat to survive can be highlighted. Later, effective conservation actions can be taken to preserve and conserve this little known species.

2. Methodology

2.1. Study Areas

Surveys of moonrat have been conducted in 13 sites from 11 forest reserves (FR) at five states, namely Negeri Sembilan, Johor, Terengganu, Pahang and Kelantan (Table 1). These forest reserves are identified as fragmented forests in five Central Forest Spine (CFS) ecological corridors of Peninsular Malaysia. Each forest reserve consists of one survey site except for Berembun FR and Tembat FR (respectively with two survey sites in each forest reserve). All survey sites are considered lowland forest (below 300m a.s.l), predominantly consists of secondary vegetation and located at least 500m far from the main road. The location of these surveys was as shown in Figure 1.

| Ecological Corridor | Forest Reserves | Location |
|---------------------|-----------------|----------|
| CFSII-SL7: Angsi FR - Berembun FR, Negeri Sembilan | Angsi FR | 02°43'24.7" N 102°04'13.4" E |
|                     | Berembun FR     | 02°44'03.8" N 102°02'44.3" E |
| CFSII PL1: Labis FR - Mersing FR - Lenggor FR, Johor | Lenggor FR | 02°16'22.0" N 103°37'33.8" E |
|                     | Mersing FR      | 02°16'58.3" N 103°37'36.6" E |
|                     | Labis FR        | 02°26'44.3" N 103°32'18.2" E |
| CFSI PL7: Taman Negara – Tembat FR (Greater Taman Negara), Terengganu | Tembat FR (i) | 05°01'19.8" N 102°32'00.1" E |
|                     | Tembat FR (ii)  | 05°00' 51.9"N 102°32'09.0" E |
Figure 1. Location of survey sites in selected forest reserves of CFS ecological corridors in Peninsular Malaysia.

2.2. Trapping
A 1-ha plot (100m x 100m) was established in each survey site comprised a total of 10 transect lines (A-J), with a distance of 100 metres individually. The interval between each transect lines was 10m apart as shown in Figure 2.

A total of 100 collapsible cage traps (42 x 17 x 17 cm), baited with oil palm were set up in each plot to capture moonrat. Each transect line equipped with a total of ten collapsible cage traps, which deployed on the ground at 10m interval as in Figure 2. These traps were opened for five consecutive nights and checked twice daily at 0700 hours and 1600 hours. All captured individuals were transferred to cloth bags. Live weight and required morphological measurements were taken. The measurements taken were ear (E), hindfoot (HF), tail (TL) and head body (HB). The samples were identified based on Phillipps and Phillipps [1] and Francis [16]. Trapping session were conducted twice for each survey sites between February 2018 until September 2019.
3. Results and Discussion

A total of eight individuals of moonrat were captured from six forest reserves (Table 2). Tanum FR and Ulu Jelai FR located in Pahang, harbour highest number of individual of moonrat recorded, respectively with two individuals in each forest reserve. The other four forest reserves that have documented the presence of moonrat were Angsi FR, Mersing FR, Tembat FR and Sg. Betis FR with one individual captured, respectively (Table 2).

The presence of moonrat may be influenced by the conditions of the forest reserves. According to Brozovic et al. [6], canopy closure and forest quality positively associated with moonrat occurrence. They found that moonrat was sensitive to habitat destruction such as forest opening resulted from logging activities and required good quality forest. In this context, good quality forest allied to the forest with high canopy closure and associated with the incidence of forest-dependent mammals [6, 15, 17] and dense understorey vegetation as this condition usually support small mammals occurrence [18]. Therefore, the presence of moonrat in several forest reserves such as Angsi FR, Tembat FR, Sg. Betis FR and Jelai FR may be contributed by these factors as there is still dense distribution of secondary vegetation and low canopy openness present in these study sites. Moreover, there are no disturbances such as human encroachment or land conversion activities detected at these locations during our surveys.

Moreover, the presence of tree cavities such as hollow rotting tree trunks, under roots or burrows is likely another factor to associate with the presence of moonrat. Survey sites at Tanum FR, Sg. Betis FR, Tembat FR and Angsi FR were among areas that have a higher number of abandoned hollow logs based on our observation. Several studies mentioned that moonrat requires these conditions for it to roosts during the day [2, 4]. Our records of capturing moonrat in the collapsible cage traps deployed on the forest floors also may indicates this mammal is terrestrial species as mentioned by few studies [1, 2, 6].

Besides, the favourable microclimate for sustaining moist conditions which tend to be offered by denser forest such as representative in Angsi FR, Tembat FR and Jelai FR also may be influenced the presence of moonrat, as this species prefers to inhabits in moist areas [1, 2]. Moreover, Ewers et al. [19] stated that forests with well develop canopy structures and dense vegetation supports higher biomass

**Figure 2.** Illustration of plot and traps set up in each survey site. A total of 10 transect lines (A-J) were constructed with a total length of 100m each. The interval of each transect line was 10m apart. Each survey site are occupied with 100 collapsible cage traps.
density and invertebrates diversity. Therefore, the availability of invertebrates as food resources for moonrat also potentially influenced its occurrence.

Although moonrat was primarily feed on invertebrates; however, our surveys used palm oil fruit as bait to trap. The captured individuals in this study indicates that the moonrat is occasionally consumes plant derivatives. According to Gould [4], moonrat was observed with an intense orange stain on the fur of its head presuming the mammal consume oil palm fruits. Moreover, Lim [7] also has conducted a study on food habits of moonrat and stated that moonrat feeds on other fruits such as bananas and apples in captivity. Details study on food preference for moonrat should be revised since the last information considerably are out-dated.

Interestingly, all records of moonrat in this study were found at sites with presence of stream. The association between presences of moonrat and waterbody such as stream is still arguable. According to Lim [7], presences of streams might provide additional food resource for moonrat in the form of aquatic insects. Moreover, Francis [2] concluded that the moonrat is preferable to damp areas and its swimming ability help to prey on aquatic insects [4]. However, Brozovic et al. [6] concluded that the waterbody is not a prerequisite for moonrat occurrence if terrestrial invertebrates are sufficiently available to support their nutrients requirements. Therefore, we support Brozovic et al. [6] that further research is required to evaluate true dependency of moonrat on waterways.

Table 2. Number of individual moonrats recorded in the surveyed sites of selected forest reserves.

| Forest Reserves | Surveyed sites | Number of individual recorded |
|-----------------|----------------|------------------------------|
| Angsi FR        | Angsi FR       | 1                            |
| Berembun FR     | Berembun FR (i) | 1                            |
| Labis FR        | Labis FR       | 1                            |
| Mersing FR      | Mersing FR     | 1                            |
| Lenggor FR      | Lenggor FR     | 1                            |
| Tembat FR       | Tembat FR (i)  | 1                            |
| Tembat FR       | Tembat FR (ii) | 1                            |
| Tanum FR        | Tanum FR       | 2                            |
| Sg. Yu FR       | Sg. Yu FR      | 2                            |
| Ulu Jelai FR    | Ulu Jelai FR   | 2                            |
| Sg. Betis FR    | Sg. Betis FR   | 1                            |
| Sg. Brok FR     | Sg. Brok FR    | 1                            |
| **Total number of individual recorded** | **8** |

4. Conclusion

In our study, we found the results on the presence of moonrat at the selected forest reserves of CFS ecological corridors may not be sufficient to predict main factors of moonrat occurrence in CFS landscape. It is may be due to low sampling efforts and the absence of distribution modelling analysis. Thus, we recommend to (1) carry out more intense study covering different sites in diverse forest settings (e.g., waterways, forest gradient); (2) more sampling efforts by applying various method (e.g., camera trapping, different baits) and extended sampling period (3) conduct more study encompassing different seasonal periods (4) carry out further analysis (e.g., distribution/occupancy modelling).

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