Activity pattern of *Scotophilus kuhlii* at agriculture and urban landscape area in Tasik Chini and Universiti Kebangsaan Malaysia

F A Ahmad-Bakri¹, N A Abd-Rahman², Z A M Ahmad², Maryati M¹* and M F Abu-Bakar¹

¹Universiti Tun Hussein Onn Malaysia, Kampus Pagoh, Hab Pendidikan Tinggi Pagoh, KM 1 Jalan Panchor, 84600 Panchor, Johor, Malaysia
²Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
* Corresponding author: maryati@uthm.edu.my

Abstract. The ecology of *Scotophilus kuhlii* is poorly known. Thus, this study was done to determine the activity pattern of the bats. Radio tracking was done for ten bats (five males and five females) in September and October 2014. The tracking was done after the transmitter were glued behind bats below their scapula. From this study, the mean home range size of *S. kuhlii* in agriculture (0.68km²) was higher than that in urban landscape (0.37km²). The overlapping between males and females bats home ranges showed that this occurs due to existence of many food resources in the region. This is an important ecological information so that the conservation effort can be done accordingly. This is due to different species may differ in their responses to environmental factors such as habitat fragmentation.

1. Introduction

Bats are unique in the animal kingdom as they are the only mammals to have evolved flight ability. The interest on studying bats in Malaysia arose as more ecological benefits provided by this flying mammal have been discovered important either to the environment as well as in maintaining a balanced ecosystem. Bats provide several ecosystem services and hence reflect the status of the plant populations on which they feed and pollinate [1].

According to the Malaysian Bat Conservation Research Unit, 34 species in Malaysia are now listed on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of threatened and endangered species while many other species are declining. The declining of many bat species occur as Malaysia aggressively going through uncontrolled development in twentieth century which results to habitat loss mainly caused by fragmentation and deforestation [2].

The locations chosen for this study were around Tasik Chini and also inside UKM. Tasik Chini was chosen as it comprises of heavy agricultural activity such as oil palm while UKM situated in urban landscape. However, both sites have their own untouched forest that may contains foods for the target species, *Scotophilus kuhlii*.
Scotophilus kuhlii is a bat species of the Vespertilionidae family that is very widespread throughout Southeast Asia. It was selected in this study because it is a very highly adaptable species where it can be found in primary and secondary habitats, and in both rural and urban areas. It roosts communally in hollow trees, but the species has adapted well to urbanisation and frequently roosts in large numbers in attics or abandoned buildings in colonies of several hundred individuals. In South Asia, disturbance to roosting sites might represent a local threat to some populations. In northeast Luzon (Philippines), it is eaten as an aphrodisiac. Although it is a widespread species, it is highly gregarious and is frequently associated with human settlements [3], little is known of its ecology or biology.

This study was conducted to determine the activity pattern of Scotophilus kuhlii at agriculture and urban landscape area. By doing so, the documentation about their activity pattern in the study area could be useful to produce a database for bats conservation.

2. Methodology

This project was done for seven days monthly for each site in Tasik Chini and UKM from September 2014 to October 2014. The number of total days for the sampling recorded was 28. Throughout the sampling, mist netting and telemetry were employed to fulfil the objectives of the study.

2.1 Sampling site

This study was conducted at two different sites which is Tasik Chini and Universiti Kebangsaan Malaysia (UKM) (Figure 1). The first site is located in Pekan district which is about 100km from Kuantan. Tasik Chini area consists of oil palm, rubber, mining, agriculture and settlement areas where the forested area had been declining due to agricultural activity. The second site was in and around UKM campus and colleges. UKM is situated in Bangi, Selangor which is about 35 km south of Kuala Lumpur. UKM is surrounded by tropical forest but the area is now shrunk in size due to expansion of the campus. The site was categorised as agricultural (Tasik Chini) and urban landscape (UKM).

2.1.1 Location of the study site

Two different sites were chosen for Tasik Chini and UKM respectively. For Tasik Chini, the mist netting was done at Sekolah Kebangsaan Chini 2 and Sekolah Kebangsaan Chini 3 & 5 buildings. For the sampling in UKM, the study was held at Kolej Dato’ Onn and Rumah Haiwan buildings.

2.2 Mist-netting of the bats.

Mist netting was also employed to catch bats. The mist nets (2.5 m x 9 m x 4 m) were placed randomly across flyways such as trails or forest gaps. The nets were left open from 1800 till 2100 throughout the five days of sampling. For each individual bat captured, the body mass, forearm length, whole body length, tail length, ear size, sex and reproductive status were recorded. The recorded data were to make sure that no same individuals were caught. Identification were done with reference to [3]. Aluminium tags were fitted to allow identification of recaptured individuals and prevent repeated tracking of same individuals.

2.3 Radio tracking

To locate roosts and determine their home range, each captured bat was glued with radio transmitter on their back below the scapula using surgical glue (Skin-Bond). These transmitters were the smallest available, weighing 0.45 grams, and had an active life of up to two weeks. The bat was held for at least two hours and as soon as the glue dried, the bat was released. Each individual of radio-collared bats were tracked every hour using a hand-held Yagi antenna attached to a portable receiver (RHO) continuously for seven days. The fixes of each animal were recorded by following the strongest signal detected by the receiver where the methods of homing in will apply to get to an accurate fix location of the individuals. Each bat was tracked from the time of its emergence from its roost and during foraging and they were tracked until dawn in many
instances. For each data point, tracker location were recorded based on global positioning system coordinate (GPS, Garmin Ltd) [4].

Figure 1. Map showing study sites in Tasik Chini and UKM Forest Reserve.

2.4 Data analysis

2.4.1 Movement patterns of S. kuhlii Ecological Software Solutions BIOTAS was used to generate the location fixes of the tracked animals to determine their movement patterns. Average daily movement were calculated to determine range of movement every day in their home range for each individual. Animal movements were measured by measuring the straight line distance between consecutive locations [5]. Daily movement rate of an individual were calculated by total daily distances moved each day divided by the total active period for that individual on that particular day [6].
3. Results

3.1 Capture data
The sampling was carried out for two consecutive months, September and October 2014 in both Chini (agriculture landscape) and UKM (urban landscape). A total of 10 individuals of *S. kuhlii* were used throughout the study. However, the bats were divided to two different landscape, five bats for each landscape. From the captured individuals in agriculture landscape, two were males and another three bats were females. While in urban landscape, three males and two females were captured and used in the study. The individuals were identified by their transmitter frequencies which were 151.349 (AF1), 151.388 (AF2), 151.591 (AM1), 151.630 (UF2), 151.510 (UM3), 151.67(AF3), 151.705 (AM2), 151.75 (UF1), 151.990 (UM1) and 151.790 (UM2) (Table 1).

Table 1. Home range sizes based on MCP and Kernel (95% and 50% Kernel) for *Scotophilus kuhlii* radio-tracked at agricultural and urban area.

| Bats individual | Home Range based on Minimum Convex Polygon (km²) | Home Range based on Kernel technique (km²) |
|-----------------|-----------------------------------------------|------------------------------------------|
|                 |                                           | 95% Kernel   | 50% Kernel   |
| AF1             | 0.2                                         | 26.3         | 5.3          |
| AF2             | 0.3                                         | 28.9         | 8.1          |
| AM1             | 0.2                                         | 29.8         | 10.9         |
| AF3             | 1.2                                         | 0.8          | 0.09         |
| AM2             | 1.5                                         | 1.3          | 0.01         |
| UF1             | 0.03                                        | 0.3          | 0.09         |
| UM1             | 0.1                                         | 0.5          | 0.09         |
| UM2             | 0.03                                        | 0.4          | 0.7          |
| UM3             | 0.9                                         | 0.6          | 0.06         |
| UF2             | 0.7                                         | 0.9          | 0.1          |

A= agriculture U=urban F=female M=male

3.2 Activity pattern and overlapping home range of *S. kuhlii* based on Minimum Convex Polygon
By plotting the locations and home ranges on a map, the territories of the bats were observed. The territory of bats in UKM urban area changed a little over the course of the study, in both location and size. The territories of bats in Rumah Haiwan (urban landscape) heavily overlapped for most of the study, even down to the exact trees they were using for day roosts.

Using radio tracking, the activity pattern of an individual bat was determined and recorded. Figure 2 and 3 show the overlap of the bat through the Minimum Convex Polygon techniques. Based on this overlap, there were some individuals that moved in the same area with other individual bats. For example, four individual bats from KDO residential experience overlapping of home ranges. The same situation also applied to the two individuals which were caught in Rumah Haiwan UKM.
Figure 2. Overlapping home ranges of five individuals *S. kuhlisi* at agricultural landscape area.

Figure 3. Overlapping home ranges of five individuals *S. kuhlisi* at urban landscape area.

4. Discussion
Rate ranges overlap in individual bats can provide information on the social interactions between bats [7]. The home ranges overlap will occur due to the high number of population in the region. Decreased degree
levels of overlap may occur in species that will defend the territory and the area of disturbance by the same species [8]. Overlap rate may occur higher among male and female bats during breeding season [7]. Review by [8] states that home ranges overlap usually occurs due to the existence of food resources in the region. This statement is also supported by several field and laboratory studies related to mammals and birds specified by [9]. Most of the dwelling bats ranges overlap occurs in areas of the field that have a light source such as the lights on the tree.

The open-matrix prevents the mobility of animals between forest elements in fragmented environments because they have experienced abrupt changes in forest environment under terrestrial, ecological, and biotic conditions [10]. Moreover, as animals travel through the landscape they become important such as in dispersal of seeds. In an attempt to preserve the ecosystem, restricted movements may cause damage to key ecological processes [11]. The peak activity time for bats usually is around dusk and early morning. The active period of the bats out of their nest is about 19:30h according to the individual bats recorded.

Bats leave their nesting area in a fairly short time period of about 10 minutes [12]. Bats are most likely to travel at night [13]. This situation is designed to prevent excessive heating during daytime in case of movement [14]. Some studies conclude that nocturnal bats travel to escape predators including birds and competition [15]. Therefore, bats hunt for food at night since the number of insects during the day is typically smaller than at night [16].

Micro-climatic conditions and the suitability of nesting sites can also affect bats' habitat range and movement patterns [17]. When the local atmosphere rains, the bats would not venture out and they would sit in the nest until the weather turns better. This situation could make flying and traveling to other areas difficult for the individuals. The study by [18] reported that when the local temperature was too high between 33 °C to 35 °C, bats would fly away from their nesting spot. This may be because the bats need to reduce the energy they need [19]. This finding is also confirmed by [20] study confirming that bats may move when the micro-climate is too high. There are bats that choose to nest in the building area and move from one building to another to maintain the appropriate body temperature [20]. This situation could be attributed to bats in the CGAT which chose the building as their nesting site.

The availability of food sources is a factor that might also influence the home range and the movement patterns of individual bats [21]. Most individuals that are being tracked would not go out for too long in search of food. This situation may be due to the availability of convenient food around this campus.

Based on previous habitat selection studies, bats are more likely to reside in areas with large insect numbers [22]. The lamp posts around the road draw insects to occupy the pole and make it easy for bats to find food. A research carried out in Switzerland against *Pipistrellus pipistrellus* bats suggests that one of the reasons for this population trend is the presence of insects that are found below the side lights and are a food source for this species [23]. The bats in UKM, for instance, do not move too far and have very small home range because they do not have to travel far to get food.

Gender factors and reproductive status could influence home ranges and bats' movement patterns [24]. Through tracking, it is found that female bats are more likely to move farther than males and have a wider range of habitats. For example, Female KDO individuals 2 have a higher range of occupancy and higher movement distance than other male bats. According to [4], non-breeding female bats migrate in search for food over long distances. This is to meet the needs of life especially food sources. Female bats would also be more likely to travel long distances to obtain more food sources than male bats due to the need for energy resources during breeding [25]. This also supported by [26] that males bats forage 700m higher than that of females bats. The two sexes also forage in different elevation.

During the breeding season, the male bats would also often go a long way to find their mate. Studies by [27] agree that the species *Barbastella barbastellus* stringent roosting habits may cause their home ranges to be bigger during pregnancies. The females usually travel together and form a small maternity colonies.
Their habit are frequently switching their roost thus would travel more. This is supported by [28] which stated that pregnant bats often change their nesting sites. This may be due to the need to find suitable nesting sites [29] to facilitate the process of giving birth.

5. Conclusion
This study is important in order to determine habitat utilization by *S. kuhlii* in the fragmented Tasik Chini Biosphere Reserve and UKM Forest Reserve as this species is associated with human habitation. The findings would be useful in contributing towards the conservation of *S. kuhlii*. More comprehensive information is needed for site management purposes. Hopefully this study would provide more information on habitat use by *S. kuhlii* and impact of land alteration towards *S. kuhlii* in the Tasik Chini Biosphere Reserve and UKM Forest Reserve.

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