Journal of Academia Vol. 10, Issue 2 (2022) 10 – 27

THE ABUNDANCE OF FRUIT BATS IN UITM KUALA PILAH AND ITS MORPHOMETRIC ANALYSIS.

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Abstract

There are currently few records of anthropogenic effects on bat composition, particularly in Malaysia. The objectives of this study are to determine the abundance and growth rate of bats at UiTM Negeri Sembilan Kampus Kuala Pilah (UiTMCNS). Mist nets with 2.5 x 9 x 4cm in size were set up at five checkpoints for sample collection, followed by species identification and morphological measurement of each sample. A total of 13 individuals of *Cynopterus brachyotis* and 9 individuals of *Macroglossus minimu*s were collected from 4 checkpoints (checkpoint 1, 2, 3 and 5), with non-individual of bat was collected from checkpoint 4. The number of *C. brachyotis* and *M. minimus* were recorded at checkpoint; 1 (6, 4) individual, 2 (3, 2) individuals, 3 (3, 1) individuals and 5 (1, 2) individuals, respectively. Both *C. brachyotis* and *M. minimus* are classified as fruit bats. The Length-Weight Regressions (LWRs) of both species caught shows positive allometric growth as the 'b' value is more than 3. The parabolic form of LWRs for this study is W=24.384L4.853. The result of LWRs analysis prove that the study area is still suitable to become the fruit bat's habitat. This research will help to increase data on bats composition in Negeri Sembilan, especially UiTMCNS. The data also can be used as a guideline for future researchers and important for conservation planning of the species in Negeri Sembilan.

Keywords: Composition; regression; growth, *C. brachyotis*, *M. minimus*

Article History:- Received: 7 September 2021; Revised: 2 March 2022; Accepted: 25 August 2022; Published: 31 October 2022
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Introduction

Bats consist second largest of order in mammal populations. Bats are charismatic, ecologically important creatures that make up nearly half of all mammal species in tropical forests and 20% of all mammal species globally (Medellín *et al.,* 2000). According Simmons and Cirranello (2020), there are more than 1400 known species of bats. Bats are mammals of the order Chiroptera (Haave-Audet *et al.,* 2021) and one of the largest monophyletic clades in mammals (Lei and Dong, 2016). Bats are dominant in the tropic areas. About 18 bats families including the vesper bats (family Vespertilionidae), horseshoe bats (family Molossidae) and horseshoe (family Rhinolophidae) were found in the temperate zone (Kurta *et al.,* 2020). Bats contains up to 40% of diversity in the island's terrestrial mammal (Payne *et al.,* 1985). The most abundance of bat is the long-fingered bat and it is highly distributed in the Afrotrophic area including Palearctic, Indomalayan, Australasian, and ecozones (Simmons, 2005).

Southeast Asia has variety of bats and it is considered as high species richness compared to other places (Francis, 2008) with more than 140 species (Elias, 2021). Almost 45 species were recorded in rainforest of Malaysia and 51 species in Kuala Lompat Research Station in the Krau Wildlife Reserve are insectivorous bat species (Kingston *et al*. 2003). According to Munian *et al.* (2020), the diversity of mammals is quite high due to high number of different species recorded, with 66 species (15%) of 440 species of mammals are endemic to Malaysia. Other than that, over 70 species of bats were found in 620 km^2 of undisturbed forest of Malaysia (Lane *et al.,* 2006). Due to that, the checklist of bats species presents in this country including their distributions across the region are very important as a reference in developing suitable conservation planning such as Wildlife Management Plan (Francis *et al.,* 2010). The abundance of bats is affected by the amount of fruiting plants and the temperature, which can induce changes in network metrics and have a detrimental impact on the network structure (Laurindo *et al.,* 2017). According to Méndez *et al.* (2022), the abiotic environment are predominantly associated with dispersal-related frugivore traits or alternatively, human impact. Fruit features (colour and nutritional content) exhibited larger influence on seed distribution than distance from forest fragments in native species plantings; in addition, plantings with fleshy-fruited pioneers attract more frugivorous birds (and seed dispersal) than plantings with wind-dispersed species (Camargo *et al.,* 2020).

The morphological features of species are highly essential to notice during the identifications process, and various studies on morphological studies have been done because bat species have different morphologies in terms of shape and size (Shahab *et al.,* 2020). The New World leaf-nosed bats (Chiroptera: Phyllostomidae) has short wings and broad in size that confer slow, with small in body size (Stockwell, 2001) and high frequency echolocation calls which all of these are important adaptations to hunt in dense forest (Kingston *et al.,* 2003). Other than that, there are species with stronger bites, normally it from insectivorous and frugivorous with shorter sizes of rostrum and mandible, higher skull and more muscle developed in their body. According to Albernaz *et al.* (2021), wide variation in the occurrence, morphology, and physiology of this gland in mammals, particularly bats, with this variation being related not only to the number of regions and fluctuations in their functioning throughout the year.

Bats' early life experiences have long-term effects on a variety of characteristics, including adult size, reproductive success, adult metabolic rate, ageing rate, and survival (Pigeon *et al.,* 2017). Compensatory growth and catch-up growth have been reported in wild populations (Bize *et al.,* 2006). However, it is sometimes difficult to establish whether catch-up growth or compensating growth happened, as the words have been used interchangeably in numerous research (Hector and Nakagawa, 2012). Furthermore, growth is rarely linear, with growth rate frequently being size dependent (e.g., growth rate reduces as bat grows larger), which might lead to the false detection of compensatory growth (Nicieza and Álvarez, 2008). Most bat species rely on life history traits such as high adult survival (related with longer lifespan) and low reproductive rates that showed slow population growth rates (Claireau *et al.,* 2021).

Bats has important ecological roles in seed dispersal, arthropod suppression, prey and predation, distribution and nutrients cycling (Kasso and Balakrishnan, 2013). In the other hand, bat serves as bioindicators in the ecosystem health because of their sensitivity towards the environment, climate change, water loss and noise pollution (Wanger *et al.,* 2014). According to Kasso and Balakrishnan (2013), bats play main ecological services via facilitating the reproductive success and the recruitment of new seedlings. Bats play a crucial part in our environment and at least 31 Malaysian plant species, including durian, petai, mango, banana, guava, jackfruit, and papaya, rely on Old World fruit bats (Megachiroptera) for pollination (Mohd Nasir *et al.,* 2021). Pollinator abundance has been shown to have a direct influence on durian tree fruiting performance (MacInnis and Forrest, 2019). Bats contribute to the structure and function of forests, as well as having a direct impact on forest integrity and regeneration (Martins *et al.,* 2017).

Mist net is one type of trap that has been used to catch different types of bats. For examples, Bakar and Faudzi (2019) has managed to collect several species of bats including 15 individuals from three species belonging to the Pteropodidae and Vespertilionidae families using mist net, with *Cynopterus brachyotis* was the most often captured bat, followed by *Scotophillus kuhlii* and *Macroglossus minimus*. Due to less study on bat species in this area, this study was conducted to determine the abundance and growth rate of bats at UiTM Kuala Pilah Campus. The data of bat samples collected was analyzed by using PAST 3.26 Software and Minitab 17.

Methods

Sampling sites determination

This study was carried out at UiTM Negeri Sembilan Kampus Kuala Pilah (UiTMCNS) at latitude: 2.793247 longitude: 102.218954. Kuala Pilah is one of the seven districts in Negeri Sembilan. Kuala Pilah positioned withinside the crucial a part of Negeri Sembilan among Bahau and Seremban, additionally recognized as small city with an area of 109,039.58 hectares. The sampling site of checkpoint 1 is located at open areas and nearby with fruit trees (Calamansi lime trees). Checkpoint 2 is located nearby Seri Pilah 2 college residence, checkpoint 3 is located nearby campus building and checkpoint 4 is in primary forest with dense trees but without any fruit trees nearby. Meanwhile, checkpoint 5 is located at abandon field nearby the parking lots in the campus area (Figure 1a-e).

Setting up the mist net

Mist netting is often used as a device to determine or indicate species that are present in a sampling area (Zamora-Marín *et al.,* 2021). The mist nets were set up through the modification from Mist Net Interaction, Sampling Effort and Species of Bats Captured by Larsen (2007). The mist nets with the hole size diameter about ±4cm were prepared in this sampling. Firstly, about two net poles with 12 meters height were prepared. Then, the first pole was embedded into the soil and followed by the second pole with distance of six meters. The non-bonded rope on the upper part of the net was tied at the top of the pole, while the non-bonded rope on lower part was tied at the bottom of the pole. The traps were left one whole night. The assumption that the first six hours of the night are when numerous species are at their most active, the continuous monitoring should be applied (Trevelin *et al.,* 2017). However, to limit the number of bats killed, appropriate ethical processes and guidelines should be implemented (Russo *et al.,* 2017).

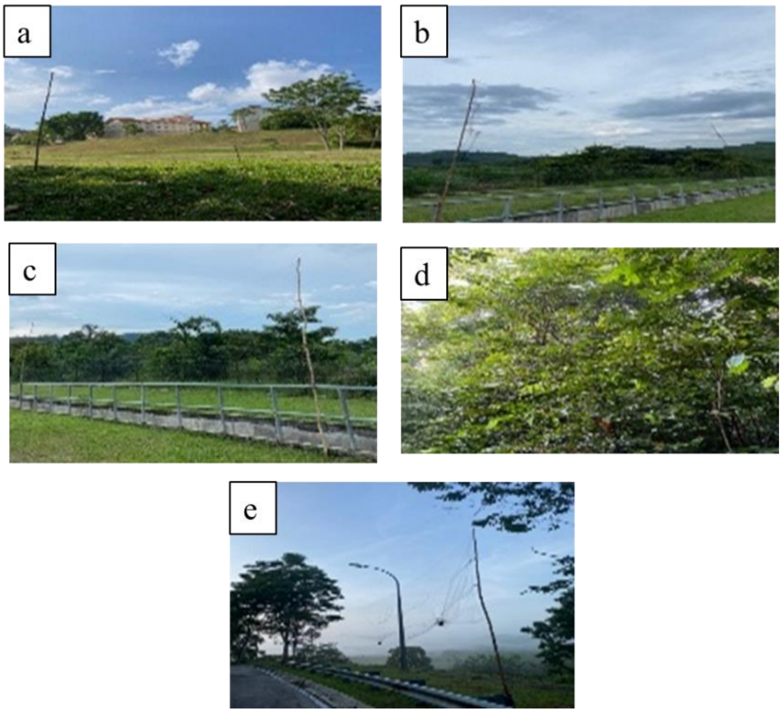

Figure 1. The sampling sites; a) Coordinate 1; b) Coordinate 2; c) Coordinate 3; d) Coordinate 4; and e) Coordinate 5

Sample collections

The sampling activities were conducted for six days from 8th April 2021 until 13th April 2021. The samples of bats were collected and put into the sacks that contained chloroformed wool. The Capture-Recapture Method was conducted to avoid the observation and measurement on the same individual

(Oyler-McCance *et al.,* 2018). After all the individuals had been thoroughly recorded, most of the species were tagged and released back into their natural environment. No individuals were found dead during the sampling.

Species identification and morphometric measurement

The sample of bats were examined and identified based on their morphological characteristics (Hornok *et al.,* 2021). The morphological parts that were observed are ear, wingspan, foot, thumb, tail, forearm, hind-leg, calcar, and wing chord (Khajeh *et al.,* 2021). For morphometric observation, the length (in mm) and width (in mm) of similar morphological parts were measured using measuring tape (Figure 2a-b).

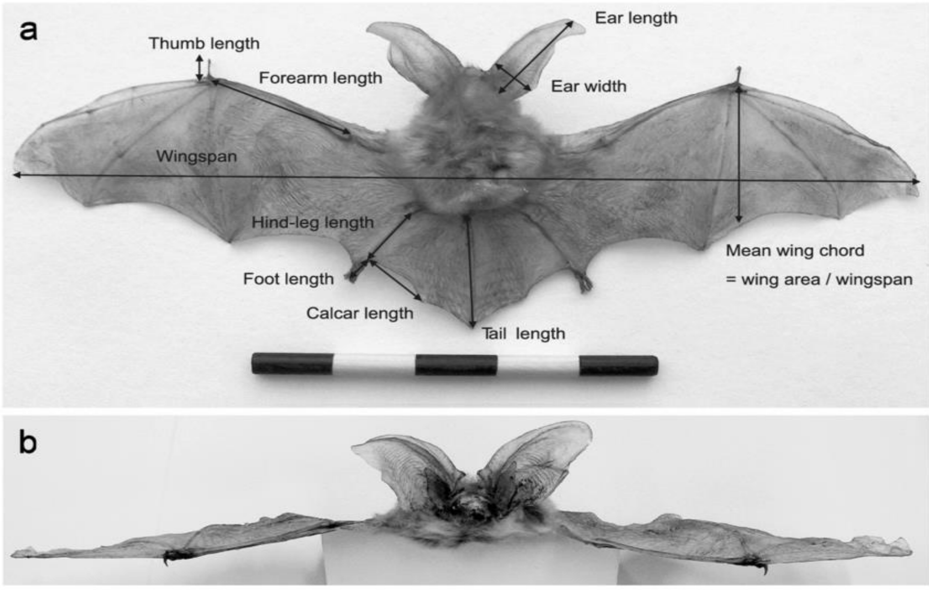

Figure 2. The morphometric measurement of bat (Marinello and Bernard, 2014)

Statistical analysis

PAST 3.26 Software was used for calculating diversity indices such as (Shannon-Wiener Index, Margalef Index, and Evenness Index). The other software, Minitab 17 was used to analyzed the correlation-coefficient and length-weight regression analysis (LWR).

A. Shannon-Wiener Index (*H'*)

According to Daly *et al.* (2018), Shannon's diversity index is used to identify community diversity which is the changes in community structure that reflecting the existence or absence of ecological pressures, while Sun and Ren (2021) explain that the Shannon–Weiner index is used to represent the disarray and uncertainty of individual species. Higher variety is reflected by higher levels of uncertainty. Based on Kiernan (2021), the diversity index gives the probability that two individuals randomly selected will belong to the same species.

The formula used is:

$$H' = -\sum [(pi) \times \ln (pi)]$$

Where:

H'=Shannon-Wiener Index, *pi = ni/N*
pi=Proportional abundance of the species i
ni= total number of individual of species i
N=Total number of individuals of all species

B. Margalef Index (*R'*)

The Margalef index is used to measure species richness and it is highly sensitive to sample size although it tries to compensate for sampling effects (McCarthy and Magurran, 2004).

The formula used is:

$$E = (S - 1) / \ln N$$

Where:

S=Total number of genera
N=Total number of individuals in the sample
ln=Natural logarithm

C. Evenness Index (*E'*)

The evenness index (E) describes the individuals number between species in a community. The ecology will be better balanced if individuals are dispersed across species more equitably (Ulfah *et al.,* 2019). However, evenness is the most fuzzy concept as constituent of species diversity that is independent from species richness (Hill, 1973).

The formula used is:

$$E = \frac{H'}{H_{maks}}$$

Where:

E=Evenness index
H'=Diversity index
H_{max}=ln *S*,
S=Number of species found

Result and Discussion

Composition of bats species at UiTM Negeri Sembilan Kampus Kuala Pilah (UiTMCNS)

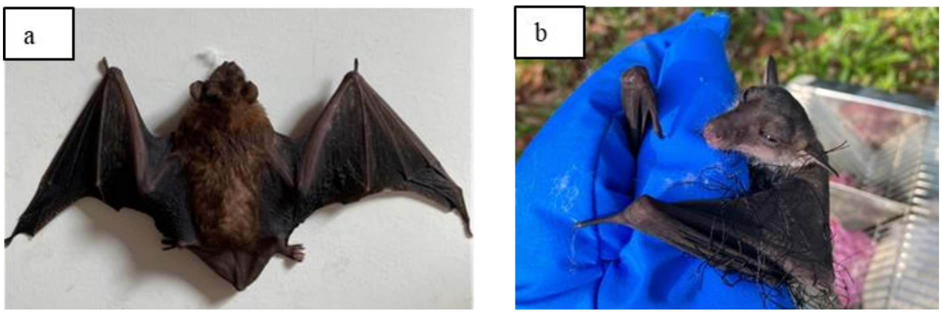

Figure 3. The pictures of bats; a) *Cynopterus brachyotis*, and b) *Macroglossus minimus*

In this study, two species of bats including *Cynopterus brachyotis* and *Macroglossus minimus* were discovered and recorded (Figure 3a-b). According to Gannon *et al.* (2004), bats species study focusing on species richness in large area and the type of the habitat can be conducted by using some useful tools. This study was conducted by using sets of mist net to sample bats that exist in UiTMCNS. Based on Table 1, the dominant bat samples were recorded at checkpoint 1, followed by checkpoint 2, checkpoint 3 and checkpoint 5. At checkpoint 4, no individual of bat was caught probably due to its location inside the primary forest with dense trees without any fruit tree nearby. According to Mohd Top *et al.* (2021), *C. brachyotis* is a common bat that may be found in a wide range of environments, including disturbed areas, orchards, and plantations.

Table 1. The composition of bats collected at five checkpoints

Species/checkpoint	C1	C2	C3	C4	C5	Total
Cynopterus brachyotis	6	3	3	0	1	13
Macroglossus minimus	4	2	1	0	2	9
Total	**10**	**5**	**4**	**0**	**3**	**22**

*C1= Checkpoint 1 ; C2= Checkpoint 2; C3= Checkpoint 3; C4= Checkpoint 4; and C5= Checkpoint 5

In addition, the results were contradicted with this research expectations that the bat species richness, diversity and abundance observed in dense forest sites are greater than in the open area. This is because the bats seek out a variety of daytime retreats at trees. These bats use trees to roost and build the nests for themselves (Fontaine *et al.,* 2021). The highest individual number of bats was collected at C1 with 10 individuals (45.45%). The C1 was located at open areas nearby calamansi lime tree, and it could be considered as obsolete land. This finding was supported by Berge (2020) who was mentioned that a bat species preferred open, less complex habitats such as fields or open area especially for foraging. From observation on the mist net hanging at this coordinate, most of the bats were trapped on the top of the net. As a result, installing the net higher may improve the probability of trapping more bats, as would be predicted, the majority of bats fly higher than the deployed nets. This statement can be supported by O'Mara *et al.* (2021) and Gomes *et al.* (2015), which bats reach high altitudes, both this uplift and bat high-altitude ascents are very predictable, and the bats prefer to forage high in open air. So, the net is suitable to be used as a tool in this study as it is strength, more durable, replicable construction, and versatile maneuverability in upper strata, an elevated mist-net frame is a viable alternative or supplement to existing elevated mist-netting using poles, ropes, and pulleys (Holbech, 2020).

In contrast with Francis (2008) and Monadjem *et al.* (2013), the bats foraging is near the ground and among vegetation, compared than in the open air. Narrow-space forages and open-space bats responded to forest edges differently, with open-space bats having higher counts at edges (Estrada *et al.,* 2010). Presley and Willig (2022) state that a number of variables, such as habitat loss and fragmentation have an impact on the local bat community, for example increase in habitat availability will increase the species diversity of bats. Other than that, bats were significantly more abundant in fruit plantations such as banana plants because the ability of banana plantations to support bat diversity as a source of food (Alpízar *et al.,* 2020). This claim also was supported by Ashraf and Habjoka (2013), *C. brachyotis* or fruit bat dominance because of available fruit trees in the forest area such as rambutan trees, banana trees, and other fruits that can serve as potential roosting and foraging areas. It also had been supported by Reinegger *et al.* (2021), the majority fruit species were consumed by animals, including bats, and fruit production was generally low but highly variable across tree replicates.

In checkpoint 2, about five individuals (22.72%) of bats from both families were listed in Table 1. This checkpoint was located at Seri Pilah 2 college residence. This checkpoint located at higher elevation level because the college area is higher than the other areas in UiTMCNS. According to O'Mara *et al.* (2021), several bat species have been spotted hundreds to thousands of meters above the ground and bats using wind and geography, take advantage of these locations to reach high altitudes while reducing airspeeds. Other than that, about four individuals (18.2%) of bats from two families were listed at checkpoint 3. The sampling location is at students' car park of Faculty Applied Science. This area is considered as disturbed because its development had just been completed a month before the sampling activities is started. The number of samples was considered as low compared to checkpoint 1 and 2. According to García-Morales *et al.* (2013), bat species richness is higher in well-preserved landscapes than in human-altered landscapes. Furthermore, the claims can also be supported by Afelt *et al.* (2018) that the modification of environments leads to habitat disturbance, habitat loss and changes in the biodiversity. In addition, it can be supported by Law and Blakey (2021) who indicated that population of bats influenced by the forest disturbances.

No bat species found at checkpoint 4 which is forest area of UiTMCNS. According to Roberts (2006), *M. minimus* and *C. brachyotis* are not endemic and are most common in disturbed, open habitats, and agricultural areas and are usually absent from primary forest when other forest fruit bats are present. While *Ptenochirus jagori* is most common in primary and secondary forest and present at low densities in heterogeneous anthropogenic habitats, however non individual of this species found in UiTMCNS even in the forest area. Similar to this study, in other Asian country such as Philippine islands, *C. brachyotis* and *M. minimus* are also found where *P. jagori* appears to be absent. Based on Mohd Nasir *et al.* (2021), in comparisons of bat species richness and evenness in primary forest, secondary forest, and urban forest, 396 bats from 33 species were reported in primary forest, 608 bats from 31 species were found in secondary forest, and 222 bats from 11 species were recorded in the urban forest. Contradict to the statement, no individual of bat was collected in forest area in UiTMCNS. It is likely because they have other options to continue living such as habitats that are close to fruit trees and, they prefer to forage in open areas. Other than that, no bats caught are marked with a marker after the first catch is made. This indicates that each sample captured was a different sample and no data repetition occurred.

In this study, the importance of the hole size of the net plays a significant role in capturing bats of various sizes, from the smallest to the largest. Based on observation, there was damage to the net where several large holes were found during sample collection activities, expected that the size of the net is small, and the larger size of bats was trapped in the net. The black 16 mm mesh, 12 x 2.5 m nylon mist net and 38 mm mesh, 12 x 2.7 m were used in previous study by Lavery *et al.* (2021). Therefore, variety net sizes should be used to increase the possibility to catch the bats in the future to ensure that more bats species of different sizes can be trapped. According to Ferreira *et al.* (2021), selecting the best mist-net type for a bat survey should take into consideration on its effectiveness, durability, and endurance. The technology, mode of application, cost, and ability to emit ultrasound across the frequency spectrum differ amongst lures. There is currently no published test on which devices are more successful based on the broadcast calls and/or target species, while some researchers are working on it and expect to publish it in the future (Burke *et al.,* 2021). As studied by Pérez-Torres *et al.* (2020), a "cone trap" is a device that enables for the targeted capture of certain groups of bats in caves. It is light, easy to operate by one person, affordable, portable, and modular.

Diversity indices

PAST 3.26 software was used to analyzed and evaluate the study's findings (Shannon-Wiener Index, Evenness Index, and Margalef Index). Diversity indices incorporated both species richness and evenness into a single value. The value of this index varies from 0 to 1, giving the probability that two individuals selected randomly from a population will belong to the same species or different species (Okpiliya, 2012). However, the analysis of diversity, richness, and evenness unable to be done for checkpoint 4 due to no samples collected during the sampling activities (Table 2).

The highest diversity of bats shown by Shannon-Wiener indices with H'= 0.673 is at checkpoint 1 and checkpoint 2, followed by checkpoint 5 (H'= 0.6365) and checkpoint 3 (H'= 0.5623). According to Rahman (2010), the higher value of the index denotes higher diversity of the species. So, the findings have shown that highest and similar diversity index in the checkpoint 1 and checkpoint 2. Both checkpoints are considered as favourable habitat for survival of the bat species. In some cases, a given value of a diversity index may result from various combinations of species richness and evenness, or the same diversity index value can be obtained for a community with low evenness (Okpiliya, 2012).

While the highest Evenness Index (E') is shown by checkpoint 1 and checkpoint 2 with the same value of E'= 0.9801, followed by checkpoint 5 (E'=0.9449) and checkpoint 3 (E'=0.8774). This finding can be supported by Siebert *et al.* (2021) which explained that the abandon area has substantially less species diversity than the protected area. The abandoned field's low species evenness suggests that a few disturbance-tolerant species dominate, which is a common result of human-caused environmental degradation (Wittebolle *et al.,* 2009). However, the proportional contributions of species richness, evenness, and composition to spectral reflectance, as well as variables that might bias species diversity estimates from afar, a combination of species richness and evenness are not always a good indicator for species (Wang *et al.,* 2018). For example, when species richness increases but evenness is low due to small number of species.

The diversity analysis index values of Shannon-Wiener (H') and Evenness Index (E') in the checkpoint 1 are 0.673 and 0.980 respectively. Followed by checkpoint 2, the values of Shannon-Wiener (H') and Evenness Index (E') are 0.673 and 0.980 respectively. Compared to other checkpoints, the index value is lower but both checkpoints were not the highest in richness because the number of different kinds of organisms present in that area is low. This study was collected 22 individuals of bats from two species which are *C. brachyotis* and *M. minimus*. However, the diversity depends not only on richness, but also on evenness. The richness at checkpoint 5 is higher because the number of different species present in the area, which is more species it would be greater richness. Checkpoint 5 caught two species found that consist of one species of *C. brachyotis* and two species of *M. minimus* which represents 33.33% and 66.66% respectively. Meanwhile the species evenness is the relative abundance of the different species in an area. The more similar abundance, the more evenness.

Table 2. The diversity analysis of bats collected at five checkpoints

Indices/Checkpoint	**1**	**2**	**3**	**4**	**5**
Shannon-Wiener Index (*H'*)	0.673	0.673	0.562	No value	0.637
Evenness Index (*E'*)	0.980	0.980	0.877	No value	0.945
Margalef Index (*R'*)	0.434	0.621	0.721	No value	0.910

Morphometric measurement

External morphology is commonly used to identify bats as well as to study flight and foraging behavior, typically relying on simple length and area measurements (Schmieder *et al.,* 2015). Identification of morphometric measurements based on various indicators such as weight, ear length, ear width, wingspan, foot, thumb, tail, forearm, hind-leg, and calcar-length has been made (Dharmayanti *et al.,* 2021). Despite the importance of bats in ecosystem dynamics, there is currently no conceptual framework for functional investigations that rely on the assessment of bat features. Body size is likely one of the most useful characteristics in bats such as biophysical features of wings (e.g. naked and highly vascularized membranes), and it's also one of the easiest to quantify (Castillo-Figueroa *et al.,* 2022). Species of *M. minimus* is a small fruit bats with the weight range between 13.0-19.0 g of females' adult body masses and forelimbs length is in range of 3.83-4.33 cm. For adults' males, their weight is in range of 12.5-18.0 g, with 39.1-42.6 mm in length of forelimbs (Kofron, 2007). Based on Table 3, the highest and lowest weight of bats individual was recorded on *C. brachyotis* with 57.0 g and 21.0 g, respectively. According to Ahmad Ruzman (2016), the weight of *C. brachyotis* species was up to 32g for mature adult. Since this study discovered the same species of bats weighing more than 32g, it is possible that some of the bats were pregnant at the time of capture.

Both *C. brachyotis* and *M. minimus* are quite easy to be identified and differentiated based on its morphological character, such as the shape of the nose. *C. brachyotis* has a short nose, while long nose for *M. minimus*. Both samples were collected in the same mist net of checkpoint 1. Indirectly, this checkpoint consists of the highest diversity of species compared to the other checkpoints. According to Turcios-Casco *et al.* (2020), the length of the forearm, metacarpals, and digits can be used to differentiate juveniles from adults, but the length of the forearm is the most used character. But it was contradicted to the findings by Community (2021) which explain that once bat is an adult, there are no reliable morphological indicator of age.

The morphology of the wing, body and tail are the factors to detect the growth of bats, as the size is directly proportional to the growth of bats (Schmieder *et al.*, 2015). Based on Table 3, the length of tail is from 6 mm and 38 mm is the longest measurement, the range value for *C. brachyotis* and *M. minimus* are 32 mm and 31 mm, respectively. According to Muscarella and Fleming (2007), because of their higher mobility, little bats with low wing loading and low aspect ratio can possibly graze both in the understory and canopy of forests. Larger species with high wing loads and aspect ratio, on the other hand, are less manoeuvrable and prefer to forage in the canopy.

Table 3. The morphometric measurements of bats caught in UiTMCNS

Character/species	*C. brachyotis*	*M. minimus*
Weight (g)	21-57	21-41
Ear length (mm)	15-26	13-20
Ear width (mm)	6-15	5-10
Wingspan (mm)	272-450	271-420
Foot (mm)	10-18	10-16
Thumb (mm)	9-28	8-25
Tail (mm)	6-38	7-38
Forearm (mm)	50-65	45-60
Hind-leg (mm)	22-34	20-32
Calcar-length (mm)	11-112	8-83

The shortest wingspan is shown by *M. minimus* (271 mm) and the longest is 450 mm (*C. brachyotis*). According to Beilke *et al.* (2021), the length increases of the wingspan generally associated with fast, efficient, and agile flight. Significantly, the larger wingspan area will increase the speed of flight by bats. According to Crane *et al.* (2020), there are 430 species with available wing morphology data (wingspan, wing area, wing loading, relative wing loading, or aspect ratio), accounting for approximately 27.8 percent of all bat species worldwide. The geographic biases raise several concerns about using a global approach to meta-analysis of wing morphology data and bat populations face a variety of threats between regions (Frick *et al.,* 2020). According to Cheney *et al.,* (2014), both the movement dynamics and structure of the Cynopterans bat hindlimb influence wing form. The effects will be stronger near the hindlimb and body and lessen as you go away from them, with little to no influence in the hand-wing.

Although *C. brachyotis* belongs to Megachiroptera suborder, they are not necessarily having long wingspan, this species normally having a wingspan of ~370 cm or 1.7 m in length and it is considered relatively small (McNab, 1989). Hence, the highest length and the area of the wingspan for the *C. brachyotis* species are ~40cm and ~230 cm^2 respectively (Elangovan *et al.,* 2007). As stated by Bradford (2018), one of the adorable long-tongued fruit bats, which is *M. minimus* has wingspan about 25.40 cm. According to Table 3, the length of the wingspan reaches 38.0 cm. This can be said because the types of food sources, weather and habitat conditions are different compared to the studies that have been done by other researchers. These factors can also be linked to the growth of each available bat. It is reasonable if this study finds that the bat wingspan length differs from other studies.

Based on the data, the range forearm length for the *C. brachyotis* is 320 mm while 310 mm for *M. minimus*. However, the longer size of forearm of *C. brachotis* was recorded by Holbech (2020) with 6.54 cm. Srinivasulu *et al.* (2010) was gathered specimen from the South Asia including *C. brachyotis* and *M. minimus* having length of forearm ranging 64.0-79.0 mm, length of head and body 76.0-113.0 mm, length of hind foot 12.6-18.0 mm, length of tail 4.5- 19.0 mm and length of ear 17.5-24.0 mm. The maximum foot size of *C. brachyotis* in this study is 18 mm, while 16 mm of *M. minimus*. Based on Zakaria *et al.* (2020), the value of hind foot measurement for *C. brachyotis* is 11 mm but no sample of *M. minimus* had been collected.

Between two species of bat, *C. brachyotis* has round shape and small ear with range 11 mm compared to the nectar bat, *M. minimus* with 8 mm. Importantly, bats with the large ears use for passive listening and prey detection, whereas bats with small ears normally fly faster in uncluttered habitats (Gardiner *et al.,* 2011, Håkansson *et al.,* 2017). Therefore, length of the ear size is associated to the composition of preys consumed, which may affect the ability of each species to regulate group of arthropods (Potter *et* *al.,* 2018). Furthermore, the bats excel at navigating their environment via echolocation, their unique navigation mechanism. It turns out, however, that fruit-eating bats can use their smell sense to supplement their echolocation system and find a tasty reward like a banana (Jaramillo, 2022). Meanwhile, insectivorous bats are known to use echolocation primarily to identify and hunt their prey, as opposed to other bats which use eyesight and olfaction (Ripperger *et al.,* 2019). As studied by Giacomini *et al.* (2021), for prey identification and pursuit of quickly moving prey, insectivorous bats have evolved to employ echolocation as their primary sensory mechanism.

Length-weight regression analysis (LWRs) of bats

Table 4 shows the length-weight regression analysis of bats in UiTMCNS. Length-weight analysis is a useful analysis in estimate the average weight and length of bat samples (Adaka *et al.,* 2015; Hilborn and Walters, 2001). According to Ricker and Smith (1975), the relationship of length (L) and weight (W) is denoted as $W=aL^b$, where the value of *b* is the most important because it provides information of bat growth pattern. The biological significance of the parameter 'b' (also known as the allometry coefficient) is that it indicates the rate of weight gain relative to length growth or the rate at which weight rises for a given length increase. In this study, we combined all species for LWRs analysis because these results contribute to the knowledge of bat diversity in UiTMCNS where type of species had no previous length-weight regressions. A total of 22 individuals from two different species were studied. Table 4 shows the estimated length-weight relationship parameters, including regression parameters a and b, as well as the coefficient of determination (r^2).

Table 4. The length-weight regression analysis of bats in UiTMCNS

Parameter	Values
r^2	0.719
a	24.384
b	4.853
$b > 3$	Bat heavier positive allometric growth (optimum condition for growth)

The constant value, *a*, could clarify body shape of individual, meanwhile the value of *b* exponent portrays very important information of bats growth capability to predict the healthy level of the bats (Froese, 2006). When the value of *b* is more than 3.0, the bat grows following the positive allometric pattern. Based on a result, the *b* value is greater than 3 with 4.853 which indicates that there is a substantial positive relationship between the weight and length of the bats in UiTMCNS (Table 4). It shows the positive allometric growth with indication that the bats become heavier as bat length increases. However, if *b* is less than 3 (negative allometric), weight will decrease as bat length increases (Atama *et al.,* 2013). Based on Isa *et al.* (2010), the length-weight relationship is considered as significantly difference with $p<0.001$ and the growth exponents, *b*, varied from 2.665 to 4.106 (positive allometric growth).

Positive allometric patterns have been observed based on the data above. Literally, UiTMCNS area was optimum condition for the growth of bats (b>3= positive allometric growth) (Figure 4). It has potential to influence the bat distribution also the activity as pollinator and seed disperser since only fruit bats trapped. Then, the weather also became one of the factors as the bats were less abundance in rainy day than sunny day. Other than that, crop factors that distributed in the campus area are also important for the life of bats such as fruit trees and large trees for them to perch and sleep during the day. Fruit bats was found in the campus area due to the presence of the Calamansi tree. Similar factor was previously discussed by Noormi *et al*. (2018) which explained that the *M. minimus* was attracted by Golden Yellow Trumpet-shaped flowers presence around the UiTM Kuala Pilah. The level of environmental disturbance in this area also does not have a significant impact on the growth of bats, as only a few areas had been disturbed such as the installation of solar systems in parking lots. According to Cunto and Bernard (2012), bat responses to the disturbances studied showed no clear pattern, ranging from no influence on species richness between fragments to increased abundances in the surrounding matrices.

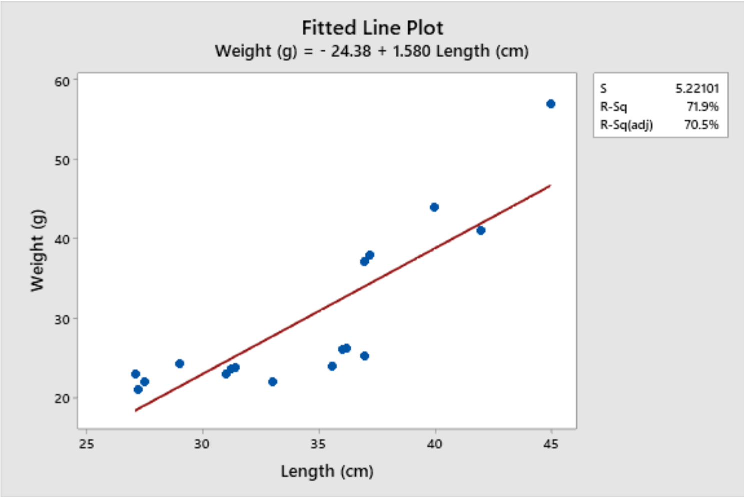

Figure 4 The length-weight regression analysis of bats in UiTM Kuala Pilah.

Conclusion

As a conclusion, the abundance of bat found to be higher at open area compared to forest area. However, only two species able to be captured and recorded, and both are categorized as fruit bats (*Cynopterus brachyotis* and *Macroglossus minimus*). Both *C. brachyotis* and *M. minimus* were recorded at open area, while non are found in the forest at all, be proof that bats especially fruit bats prefer to live in open area with the presence of fruit trees. The presence of fruit trees contributes to the presence of fruit bat species because there is a source of food for them to survive. The lack of successfully captured species indicates that the UiTM Negeri Sembilan Kampus Kuala Pilah environment may not be suitable as a habitat for bats other than fruit bats. Other than that, higher diversity does not guarantee more richness and evenness of the species in the same area. It is depending on the condition of the habitat with the source availability required by the bat's species. However, the growth rate of bats is positive allometric and it proves that the environment of UiTM Negeri Sembilan Kampus Kuala Pilah is still suitable to be inhabited by bats from fruit bats species. Further study should be conducted to increase human understanding on diversity, abundance, and distribution of bats, especially in Negeri Sembilan district. Indirectly, the data can be used as a reference to determine the direct anthropogenic impacts towards bats species, followed by conservation planning to protect the species.

Acknowledgement/Funding

Authors would like to acknowledge Universiti Teknologi MARA Negeri Sembilan Kampus Kuala Pilah for providing equipments and facilities for conducting this research activity.

Author Contribution

Mohd Fakhrudin Nokin was conducted the research by collecting and identifying the samples, while Nur Hasyimah Ramli run the analysis. Both authors involved in writing the paper.

Conflict of Interest

Author declares no conflict of interest.

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