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# Diversity Pattern of Bats at Two Contrasting Habitat Types along Kerian River, Perak, Malaysia

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**Abstrak:** Penilaian kepelbagaian kelawar di Malaysia di dua jenis habitat berbeza (hutan sekunder dan ladang kelapa sawit) telah dijalankan di Sungai Kerian antara bulan Februari 2009 dan Februari 2010. Tiga ratus dua puluh sembilan individu kelawar daripada 13 spesis dan 4 famili telah direkodkan dengan menggunakan 10 jaring kabut. Spesies kelawar yang paling kerap ditangkap di hutan sekunder ialah *Cynopterus brachyotis* (n=75), diikuti oleh *Macroglossus minimus* (n=10), sementara itu di ladang kelapa sawit, spesies kelawar yang paling kerap ditangkap adalah *Cynopterus brachyotis* (n=109), diikuti oleh *Cynopterus horsefieldi* (n=76). Kejayaan tangkapan adalah sama untuk kedua-dua jenis habitat. Keseluruhan tangkapan malam untuk kedua-dua jenis habitat adalah 5460. Ladang kelapa sawit menunjukkan kelimpahan yang lebih tinggi dan berbeza secara signifikan daripada hutan sekunder, dengan jumlah kelimpahan 209 dan 120 masing-masing (Mann-Whitney *U*-test = 31.5, $p<0.05$). Keputusan kajian ini menunjukkan tiada perbezaan yang signifikan dalam kekayaan spesies antara kedua-dua kawasan. Walau bagaimanapun, kemasukan spesies yang berkait dengan kawasan terganggu di hutan sekunder adalah petunjuk kepada kesan negatif ke atas hutan dan kepelbagaian haiwan di kawasan ini. Pengurus hutan perlu mempertimbangkan beberapa langkah yang sensitif terhadap fragmentasi hutan sebelum membuat sebarang keputusan tentang pengurusan hutan.

**Kata kunci:** Hutan Sekunder, Ladang Kelapa Sawit, Kepelbagaian, Kelimpahan Spesies

**Abstract:** We present an assessment of the diversity of Malaysian bats at two contrasting habitat types (secondary forest and oil palm plantation) along the Kerian River surveyed between February 2009 and February 2010. Three hundred and twenty nine individual bats from 13 species representing 4 families were recorded using 10 mist nets. The most commonly caught bat in the secondary forest was *Cynopterus brachyotis* (n=75), followed by *Macroglossus minimus* (n=10). Meanwhile, in the oil palm plantation, the most commonly caught bat was *Cynopterus brachyotis* (n=109), followed by *Cynopterus horsfieldi* (n=76). The netting efforts were equal for both habitat types. The total sampling nights for each habitat type was 5460. The oil palm plantation had a greater bat abundance that was significantly different from that of the secondary forest, with 209 and 120 individuals, respectively (Mann-Whitney *U*-test = 31.5, $p<0.05$). Our results suggest that there is no significant difference in species richness between the two sites. However, the invasion by disturbance-associated species of the secondary forest is indicative of negative effects on the forest and animal diversity in this area. Forest managers should consider multiple measures of forest fragmentation sensitivity before making any forest management decisions.

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**Keywords:** Secondary Forest, Oil Palm Plantation, Diversity, Species Abundance

## INTRODUCTION

Bats play important roles as pollinators, seed dispersers and forest insect regulators (Kingston *et al*. 2006; Francis 2008; Price 2000). At least 31 Malaysian plant species, including favourites such as *Durio zibethinus* (durian), *Parkia spp*. (*petai*), *Mangifera indica* (mango), *Musa acuminata* (banana), *Psidium guajava* (guava), *Artocarpus heterophyllus* (jackfruit) and *Carica papaya* (papaya) (Kingston *et al.* 2006), rely on Old World fruit bats (Megachiroptera) for pollination. One species of bat, *Eonycteris spelaea*, a long-tongued fruit bat, has been found to be an important pollinator of durians (Price 2000). The insect-eating bats (Microchiroptera) are just as important. Every night, an insectivorous bat needs to eat at least half its body weight in insects. This can be equivalent to 600 mosquito-sized insects in just an hour, and large bat colonies can consume over 2000 tonnes of insects per year (Kingston *et al.* 2006). Fortunately, Southeast Asia has a very wide variety of bat with high species richness compared to other places (Francis 2008). However, the occurrence of bats varies with location, habitat type and the landscape cover of the area. The forest cover, patch size and patch density were found to be frequently associated with the abundance of bat species (Gorresen & Willig 2004). The bats species in Southeast Asia, however, face serious habitat loss caused by fragmentation and deforestation (Sodhi & Brook 2006). Forest disturbance is known to cause drastic changes in the number of animal species, including mammals (Yap & Ong 1990; Lynam & Billick 1999; Nakagawa *et al*. 2006; Charles & Ang 2010). The species richness of small mammals declines in response to forest fragmentation (Vargas & Simonetti 2004). Rhim and Lee (2007) also reported that the species abundance of small mammals was significantly different between fragmented and unfragmented forest areas in South Korea. According to Danielsen and Heegaard (1995), the proportion of dominant bat species increased and the overall bat species richness decreased by 38%–50% as the result of logging at their study site. They found that the conversion of forest habitat to plantation at their study site also caused the species richness of bats to decline between 13%–25% and caused changes in the bat community structure (Danielsen & Heegaard 1995). It is important to know the ecology and distribution of bats before making any effort to conserve them. Understanding the spatial distribution of a certain species within its habitat is important for interpreting ecological processes and plays a vital role in planning conservational management (Meyer *et al.* 2008). There have been many studies comparing the population distributions and other aspects of the ecology of Malaysian small mammals in different habitat types (Stevens 1968; Harrison 1962; Zubaid & Khairul 1997; Nakagawa *et al*. 2006). However, to the best of our knowledge, there is still no study on riparian habitats in Peninsular Malaysia. Although this study did not concentrate on all of the different habitat types throughout the Kerian River basin, but rather on two different habitat types, each occurring at a different riparian zone (upper stream and middle stream), this study does offer an important contribution to the understanding of bat species composition in riparian habitats. This information may contribute to the Department of Wildlife's animal database and can assist the Department in the management and conservation of wildlife. This study also provides data for authorities with respect to land use planning and development. We report the findings of our study along the Kerian River in Perak, Malaysia.

## MATERIALS AND METHODS

The Kerian River is situated in the northern part of Peninsular Malaysia and lies at 5º 09' N to 5º 21' N and 100º 36.5' E to 100º 46.8' E. It is also located between the border of the states Kedah and Perak. Land use such as forested areas, paddy fields, oil palm plantations, orchards and settlement areas can be found distributed along the Kerian River basin (Amelia *et al.* 2006). The existing environment of the Kerian River has been heavily developed into agricultural lands. The area is divided into two categories: non-agricultural and agricultural lands. The major crops are rubber, rice (Kerian Rice Irrigation Schemes) and oil palm. During this study, the sampling was concentrated at two contrasting habitat types, a secondary forest and an oil palm plantation. The secondary forest was situated in the upper stream, and the oil palm platination was located in the middle stream. Figure 1 shows the sampling location along the Kerian River basin during the study.

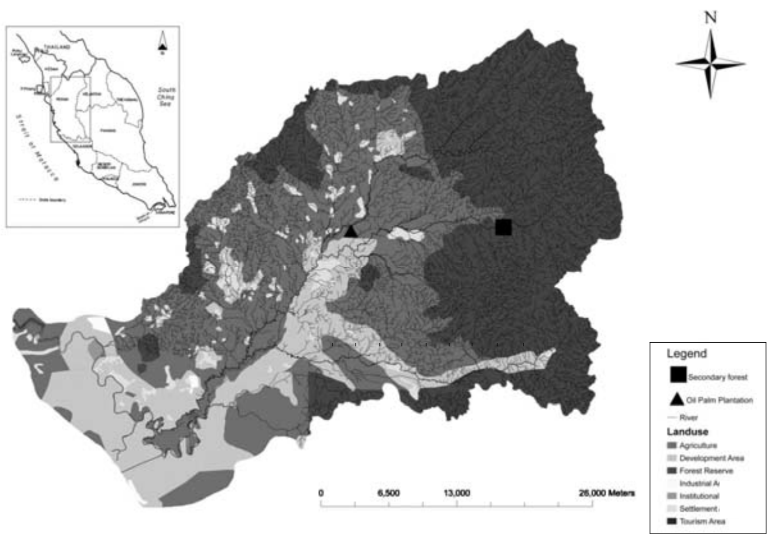


Figure 1: The study areas along Kerian River, Perak, Malaysia.

**Table 1:** Number of individuals and relative abundance of bats captured at both habitat types along the Kerian River between February 2009 and February 2010.

| No. species | Secondary forest | Relative abundance (%) | Oil palm plantation | Relative abundance (%) |
|---|---|---|---|---|
| Pteropodidae | | | | |
| *1. Balionycteris maculata* | 3 | 2.5 | 0 | 0 |
| *2. Chironax melanocephalus* | 5 | 4.17 | 0 | 0 |
| *3. Cynopterus brachyotis* | 75 | 62.5 | 109 | 52.15 |
| *4. Cynopterus horsfieldi* | 8 | 6.67 | 76 | 36.36 |
| *5. Cynopterus sphinx* | 0 | 0 | 10 | 4.78 |
| *6. Eonycteris spelaea* | 9 | 7.5 | 9 | 4.31 |
| *7. Macroglossus minimus* | 10 | 8.33 | 0 | 0 |
| *8. Macroglossus sobrinus* | 7 | 5.83 | 0 | 0 |
| *9. Rousettus amplexicaudatus* | 0 | 0 | 1 | 0.48 |
| Hipposideridae | | | | |
| *10. Hipposideros armiger* | 1 | 0.83 | 0 | 0 |
| *11. Hipposideros diadema* | 2 | 1.67 | 0 | 0 |
| Megadermatidae | | | | |
| *12. Megaderma lyra* | 0 | 0 | 1 | 0.48 |
| Vespertilionidae | | | | |
| *13. Scotophilus kuhlii* | 0 | 0 | 3 | 1.44 |
| Total records | 120 | 100 | 209 | 100 |
| Number of species | 9 | | 7 | |
| Number of families | 2 | | 2 | |
| Net/trap-hour | 5460 | | 5460 | |
| Bats/effort (net/trap-hour) | 0.022 | | 0.038 | |
| Shannon-Weiner Index, H' | 1.374 | | 1.100 | |
| Evenness, J | 0.625 | | 0.565 | |

The secondary forest was located at Sungai Bayor, Pekan Rantau Panjang, Perak (100º 43.60’ E and 5º 57.50’ N). The secondary forest that exists in this upper stream area resulted from logging activities 20 years ago and is now dominated by secondary vegetation. Plant species found include *mahang* (*Macaranga spp*.), bamboo (*Bambusa spp*.), rattan (*Calamus spp*.), *jelutong* (*Dyera costulata*), *mengkirai* (*Trema spp*.), *resam* (family Gleicheniaceae), *senduduk* (*melastoma spp*.) and shrubs. The area has been fragmented into cultivated areas, including rubber plantations and fruit orchards, such as banana, durian and pineapple orchards, which are owned by nearby villagers. Local villagers generate income from forest products such as *Parkia sp.* (petai). Nearby rivers are popular recreational places for local people mainly from Perak and Kedah. Both Gunung Inas Forest Reserve and Bukit Hijau Forest Reserve are approximately 50 km from the study sites.

The oil palm plantation is situated in the District of Selama, Perak (5º 58.18' N and 100º 24.26' E). It is located close to the main road about 10 km from the town of Selama. In addition to the oil palm plantation, there are also rubber plantations in this area.

Each night, 10 mist nets (9 x 4 m) were deployed in each habitat type (secondary forest and oil palm plantation) for 4 consecutive days between February 2009 and February 2010. The mist nets were placed randomly in these areas. The mist nets were opened at 1830 hours every evening and closed at 0830 hours every morning during the study period. The captured bats were placed in cloth bags to be weighed using an electronic scale. Species identification relied on specific physical measurements. Therefore, the forearm, ear, body and tail were measured to the nearest millimetre (mm), and the weight in grams (g) recorded. In addition, the sex (female or male), reproductive condition and age (adult or juvenile) were determined. The stage of pregnancy of female bats was also determined. Bats caught were identified using Medway (1983), Khan (1992), Payne *et al.* (1998), Kingston *et al*. (2006) and Francis (2008). They were then released immediately after identification. Nights with heavy rain, high winds or a full moon were avoided. The species diversity, species richness and the abundance of bats in each habitat type were determined. The Shannon-Wiener Index was used to determine the species diversity of each site. The monthly differences in species diversity, species richness and abundance between the two habitat types were compared using the Mann-Whitney *U*-Test (non-parametric test) using SPSS version 15.0.

## RESULTS

A total of 329 individuals comprising 13 species and 4 families were captured in both habitat types. The oil palm plantation showed a higher abundance compared to the secondary forest, with 209 and 120 individuals, respectively; the abundance was significantly different between the 2 habitats (Mann-Whitney *U*-test = 31.5, $p<0.05$). The most commonly caught bat in the secondary forest was *Cynopterus brachyotis* (n=75, or 62.5% of total captures), followed by *Macroglossus minimus* (n=10, or 8.33% of total captures), while in the oil palm plantation, the most commonly caught bat was *C. brachyotis* (n=109, or 52.15% of total captures), followed by *Cynopterus horsfieldi* (n=76, or 36.36% of total captures) (Table 1). The total numbers of Megachiroptera (frugivorous bats) and Microchiroptera (insectivorous bats) caught in the secondary forest were 117 and 3 individuals, respectively. In the oil palm plantation, 205 Megachiroptera and 4 Microchiroptera were recorded. The secondary forest had a higher number of species richness, with nine species and two families, the Pteropodidae and Hipposideridae, whereas the oil palm plantation had seven species and three families, the Pteropodidae, Megadermatidae and Vespertilionidae. Out of the nine species from the secondary forest, six species were captured only in the secondary forest (i.e., they were not captured in the oil palm plantation). These species were *Balionycteris maculata*, *Chironax melanocephalus*, *M. minimus*, *Macroglossus sobrinus*, *Hipposideros armiger* and *Hipposideros diadema*.

Evidently, all of these species still depend on the secondary forest habitat in this area to survive despite having been disturbed. However, the monthly species diversity index (Mann-Whitney *U*-test = 55, $p>0.05$) and the species richness (Mann-Whitney *U*-test = 60.5, $p>0.05$) for the secondary forest and oil palm plantation were not significantly different. The niche breadth value for each species was also very low. *Eonycteris spelaea*, *C. brachyotis* and *C. horsfieldi* showed the highest niche breadths of 2.00, 1.93 and 1.21, respectively. The other species had niche breadths of 1.00.

## DISCUSSION

In this study, *C. brachyotis* was the dominant species in both habitat types. The occurrence of this species has also been recorded in other studies conducted elsewhere. In the oil palm plantation, *C. brachyotis* and *C. horsfieldi* dominate this area (Heidemann & Heaney 1989). *C. brachyotis* and *C. horsfieldi* were both listed by Francis (2008) as common species in disturbed areas. They are highly adapted to their environments to take advantage of many available shelters. Usually, these species will select any cavity as their roosting site (Khan 1992), including caves, trees, rock shelters, hollow trees, drains and culverts. A study conducted in Bario, Kelabit Highlands, Sarawak (Rahman *et al.* 1995), recorded *C. brachyotis* proportions up to 84% of the total catch of bats in this area. According to Francis (2008), this species occurs in almost all habitat types including lower montane forest, dipterocarp forest, gardens, mangroves and strand vegetation. They are also commonly found in orchards, oil palm plantations and open areas (Medway 1983) and are reported to roost in small groups in trees and under oil palm fronds (Francis 2008). Almost all species that were found in the oil palm plantation can be classified as common species in disturbed areas. The conversion of forest into an agricultural area clearly affected the overall species presence and the abundance of bats.

The high abundance of bats in the oil palm plantation could be due to the lack of shelter or roosting sites in adjacent areas, as this plantation is one of the very few isolated vegetated patches left due to land clearing. Bats migrate to this area for food sources and to shelter from hot temperatures, as food sources and seasons are two important factors controlling the migration of bats (Popa-Lisseanu & Voigt 2009). Oil palm plantations situated along riparian area, such as Kerian River, attract more bats (Fleming & Eby 2003), which use them as stopovers when foraging for food and water (Fukui *et al.* 2006). A previous study on bat diversity in eastern Madagascar found that plantations and agricultural areas provide suitable habitats for many bat species (Randrianandrianina *et al.* 2006). The wide trails in oil palm plantations could act as conduits of movement between the bats' roosting and foraging sites. Other studies also reported high bat activities in riparian areas compared to other habitat types (Ford *et al.* 2005; Rogers *et al.* 2006; Davidson-Watts *et al*. 2006; Sullivan & Sullivan 2006). Furmankiewicz and Kucharska (2009) suggested that rivers are migration flyways for bats that travel for long and short distances.

In the secondary forest, almost all bat species that occur in this area were forest-dependent species except for *C. brachyotis* and *C. horsfieldi*. *C. brachyotis* and *M. minimus* were the most commonly caught bats in this area. The presence of banana plantations close to the secondary forest invited *M. minimus*, which feeds on the nectar of banana fruits (Francis 2008), to this area, aiding in the pollination of these plants. Winkelmann *et al.* (2003) provide more evidence supporting this conclusion with their findings that the activity hotspots of *M. minimus* were associated with flowering bananas, which is the primary food resource of this species.

Hodgkison and Balding (2004) found that the local assemblages of fruit bats are related to the availability of food in a lowland Malaysian rain forest. Harvey *et al.* (2006) demonstrated that the species richness of bats in their study area was positively correlated with tree species richness. Although many studies have shown that logging activities affect the species richness, abundance and composition of many species, selective logging as in the Kerian River basin is not expected to drastically reduce food availability or nesting sites (Syakirah *et al*. 2000). As the forest re-grows, the effects of fragmentation are expected to lessen compared to those produced by agricultural clearing. The flush of new growth in the gaps created may in fact increase the availability of food. Logging normally involves the removal of tall trees, thus threatening the survival of certain species. Common species may be able to thrive better in logged forest than rare species do (Syakirah *et al.* 2000; Rhim & Lee 2007; Bernard *et al.* 2009). Only species with specialised food or habitat requirements would be seriously affected. The presence of Gunung Inas Forest Reserve and Bukit Hijau Forest Reserve, the primary forest close to this area, could also provide the habitat needs for forest-dependent species in this area. Although some species, such as *C. brachyotis* and *C. horsfieldi*, are able to make use of new habitats, most remain dependent on the neighbouring patches of primary forest and cannot survive without them. Nevertheless, the tolerance level of species towards the disturbance actually depends on the varying abilities of species to thrive in disturbed habitats (Lynam & Billick 1999).

In this study, insectivorous bat species represented the lowest proportion of the bats captured from both habitat types. Other similar studies demonstrated low capture of insectivorous bats due to edge effects. Laurence *et al*. (2002) stated that the insectivorous animals in tropical forests including birds and bats avoid forest edges. In a fragmented tropical landscape in Mexico, 85% of bats captured were frugivorous, compared to only 15% insectivorous bats (Galindo-González & Sosa 2003). The insectivorous bats were suspected to increase in number when the edge effect is reduced. Thus, if there are no precaution acts implemented, most of the Kerian River basin will be disturbed, and the bats species will become endangered as their habitats are lost.

## CONCLUSION

In conclusion, although the secondary forest had a higher species richness than the oil palm plantation, there was no significant difference in species richness between the two habitat types. However, the species abundance between these habitat types was significantly different. Forest managers in the Kerian River basin should consider multiple measures of forest fragmentation sensitivity before making any forest management decisions.

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