2

LITERATURE REVIEW.

2.1 The tropical forest of Peninsular Malaysia

Southeast Asia has been identified as one of the world's biodiversity hotspots based on both plant and animal diversity (Myers *et al*., 2000). Nearly 500 species of mammals are currently recognized in mainland Southeast Asia (Francis, 2008). Since 1992, more than 50 new species of small mammals including bats, rodents, and insectivores, have been described in Southeast Asia due to its restricted geography (Wilson & Reeder, 2005). Unfortunately, most of this diversity is now been threatened by habitat loss due to rapid development and agricultural activities, therefore urgent conservation actions are desperately needed. Malaysia is divided into two parts; Peninsular Malaysia which cover 131,700 km^2 consist of the Malay Peninsula and southern of Thailand Peninsula; and East Malaysia which occupying 198,300 km^2 of northern Borneo. Peninsular Malaysia is a subdivision of Southeast Asia mainland whereas the provinces of Sabah and Sarawak are situated in Borneo, the third largest island in the world. Over the past century, Malaysia had lost half of its forest cover and most of the remaining forests are located in mountainous regions with little agricultural value or in isolated protected areas. Since independence in 1957, large areas of productive lowland forest in Malaysia have been converted into oil palm and rubber plantations through government agricultural development schemes. In addition to habitat loss and fragmentation, increased demand on wild meat and high-priced body parts for some wild animals have reduced populations of many animal especially large mammals (Hubback, 1932; Aiken & Leigh, 1992).

Tropical rainforest is the most complex terrestrial ecosystem with its impressive appearance of vegetation that have huge tree crown and holds an important reservoirs for earth's biodiversity (Sodhi *et al*., 2004). Tropical forest supplies a resources needed by their flora and fauna such as shelter, refuge, food, and breeding ground for species survival (Zamri & Zakaria, 2002). Almost entire Southeast Asia is considered as biodiversity hotspot because it contains high number of endemic species that are threatened by the loss of original habitats (Myers *et al*., 2000). The high species richness and endemism in Southeast Asia is linked to its complex geological history (Sodhi *et al*., 2004). Most of the research is actively being carried out in the Neotropics due to better resources and funding, it is the tropical regions in the Paleontropics that need the most attention for research due to its rich biodiversity and increased risk of habitat destruction and species extinction.

The interest in rainforests is much deeper ever since the naturalist discovered the importance of these ecosystems as natural laboratories for various scientific disciplines and their fundamental role in global balance, concerning their function in climate stabilisation as major carbon storage, global water balance, and prevention from soil erosion (Wallace, 1869; Whitemore, 1984; Linsenmair, 1997; Canadell & Noble, 2001). The increasing interest in species richness and the community composition of tropical forests during the last decade is mainly due to the threatening rate of their disturbance and disappearance. The conversion of natural habitat to the other land uses is the major driving force of biodiversity loss (Brooks *et al*., 2002).

Most of Southeast Asia was under forest cover 8000 years ago, but large-scale deforestation in the region begun during the 1800s as a result of agricultural expansion needed by local and global demands. Planting of perennial crops for export, including rubber (*Hevea brasiliensis*), oil palm (*Elaeis guineensis*) and coconut (*Cocos nucifera*), also accounted for 20-30% of the total cultivated land-area of the region.

Habitat edges have long been considered to have important effects on the abundance and diversity of certain kinds of flora and fauna. Habitat edges can have both positive and negative impacts on wildlife (Alvarez *et al*., 1988; Harris, 1988; Yahner, 1988). Some species may increase in abundance as the edge habitat increases the vegetation complexity and allow access to two or more habitat types, that providing a combination of shelter cover and food than that available in either habitat alone (Yoakum & Dasmann, 1969). Murcia (1995) reported some species prefer to inhabit the forest interior and avoid the forest edges due to altered microclimate, vegetation structure and risk of predators near the edges. Meanwhile, Temple & Cary (1988) reported the nesting success of many songbirds may decrease as the relative amount of edge to interior habitat increases, this due to increased access to nests by predators and nest parasites.

Few studies have focused on the impacts of ede effects on non-Volant small mammals in tropical habitats (Laurance, 1994; Goosem, 2000; Asquith & Mejia-Chang, 2005; Fuentes-Montemayor *et a*l., 2009). Bider (1968) reported higher diversity of mammals along forest-field edges than in either habitat alone and higher activity levels for forest mammals in the first 50 m from the forest edge than further in the interior. Other study has indicated that edges habitat may be used as travel routes by mammals (Gates, 1991). The avifauna of forest interior contains higher species diversity than in forest edge. This is probably due to higher canopy cover and high number of tall and big trees (Zakaria *et al*., 2014). In the Atlantic Forest or Cerrado located in Brazil, Stevens

& Husband (1998) recorded increasing diversity as a function of the distance from the edge. Pardini (2004) found significantly richer small mammal community in edge habitats in comparison with the interior of mature forest and conclude that arboreal species are more affected by edge effects.

The response can vary amongst species from preference to avoidance (Murcia, 1995). Some species negatively affected, others benefit from this change and increase in abundance. Many small mammal species are able to deal with changing habitat (Wells *et al*., 2004). In Malaysia, species richness of the forest-interior group of bats was reduced by fragmentation, and correlated negatively with fragment size (Struebig *et al*., 2008). This pattern was driven by the loss of forest-roosting species, those that roost in foliage and tree cavities, tend to forage within close proximity of their roosts, and avoid the forest edge (Shariff, 2003; Fletcher, 2006).

2.2 Oil palm plantation

Agricultural expansion is one of the major drivers of tropical biodiversity loss worldwide (Foley *et al*., 2005). Oil palm (*Elaeis guineensis*) originates from West Africa where it grows in the wild but later was developed as agricultural crop. Oil palm is a monoecious crop as it bears both male and female flowers on the same tree. Each tree can produces compact bunches weighing between 10 to 25 kilograms with 1000 to 3000 fruit per bunch. Generally, the fruit is almost dark black and the colour turns to orange red when ripe. Each fruit consists of hard kernel (seed) enclosed in a shell (endocarp) which is surrounded by a fleshy mesocarp. Usually oil palm tree will start bearing fruits after 30 months of field planting and will continue producing fruits for next 20 to 30 years.

Over the past few decades, the oil palm plantation has become one of the most rapidly expanding crops in the world (Clay, 2004; Koh & Wilcove, 2007). The rapid growth of the oil palm industry was contributed by its diverse uses, which include food additives, cosmetics, industrial lubricant and biodiesel (Corley & Tinker, 2003; Clay, 2004). The rising global demand of palm oil is likely to accelerate the forest conversion into oil palm plantation especially in the tropical countries (Koh, 2007). Due to the favourable climate, fertile soils and low labour costs, Indonesia and Malaysia are the two of the most cost-efficient countries in the world for oil palm agriculture. These two countries currently lead the world in oil palm production, accounting 80.5% of worldwide oil palm cultivated area (FAO, 2014).

Malaysia and Indonesia are located in tropical region and both countries are listed as world's biodiversity hotspots contain high concentrations of endemic species but undergoing rapid deforestation (Sodhi *et al*., 2004; Koh, 2007). Rapid expansion of oil palm agriculture in these countries had raised serious concern about its potential

impacts on the biodiversity in this region. Despite the importance of this crop and increasing global concern for environmental change, surprisingly little research has focused on the actual impacts on biodiversity due to forest conversion to oil palm plantation (Turner *et al*., 2008; Foster *et al*., 2011). Previously studies indicated that generally conversion of natural ecosystems to agricultural landscapes had severe negative impact on global biodiversity (Sodhi *et al*., 2004; 2010) with losses of species. Oil palm plantations are always associated with reduction in species richness and species diversity (Turner *et al*., 2011).

Previous studies have been done in Malaysia on various fauna such as beetles (Chung *et al*., 2000), ants (Bruhl & Eltz, 2010), small mammals (Bernard *et al*,. 2009), birds (Koh & Wilcove, 2008), and frogs (Faruk *et al*., 2012) showed that oil palm plantations supports extremely low numbers and diversity of fauna compared with natural forest. The endangered species such as Sumatran rhino (*Dicerorhinus sumatrensis*), tiger (*Panthera tigris*) and Orang utan (*Pongo pygmaeus*) tend to be the most sensitive as they are the most affected species due to expansion of oil palm plantations. Only common mammal species with least conservation concern such as wild pigs (*Sus scrofa*), leopard cats (*Prionailurus bengalensis*), and common palm civets (*Paradoxurus hermaphroditus*) are able to survive within the oil palm monoculture (Koh *et al*., 2007; Maddox *et al*., 2007; Rajaratnam *et al*., 2007). A key reason for the lower biodiversity value of oil palm monocultures is the absence of the major components of forest vegetation, including forest trees, lianas and epiphytic plants (Danielsen *et al*., 1995; Fitzherbert *et al*., 2008).

2.3 Volant small mammals

Volant small mammal refers to small mammals that have flying ability such as bats. Bats belong to order Chiroptera, the second largest mammalian order after Rodentia (Vaughan *et al*., 2000). There are two suborders of bats; Megachiroptera or megabats and Microchiroptera or microbats. Small and furry, bats are the only mammals to have achieved powered flight. Malaysia is an important country for bat conservation within Southeast Asia (Kingston *et al*., 2006). Simmons (2005) recorded 125 species from Peninsular Malaysia, 94 from Sabah and 76 from Sarawak. This accounted for 40% of overall Malaysia mammals (Kingston *et al*., 2006). According to Faisal-Ali *et al*. (2008) there are at least 20 species of Old World fruit bats, belonging to the family Pteropodidae, and 105 species of insectivorous bats of following seven families; Rhinolophidae (19 species), Hipposideridae (20 species), Megadermatidae (2 species), Emballonuridae (5 species), Nycteridae (1 species), Molossidae (4 species), and Vespertilionidae (54 species).

Tropical region supports the highest diversity of bat fauna known (Kunz, 1982) and are among the most species rich and ecologically diverse of all mammals (Kingston, 2009). Bats can be found in various habitats type. The reasons for their success are mainly due to their variety in foraging strategies and the tendency to exhibit a variety of roosting behaviour (Ganon & Willig, 1995). The morphology of a species influence flight maneuverability and echolocation frequency which tends to influence the feeding habits. Based on their feeding habits, bats are playing important roles as pollinators, seed dispersers and forest insect regulators (Prize, 2000; Kingston, 2006; Francis, 2008). Fruit bats share long evolutionary history with many of their food plants as seed dispersers and pollinators in a lowland Malaysian rainforest (Hodgkison *et al*., 2003).

Many species of bats have very specific roosting requirements. A good roosting site provides adequate protection for bats to rest and reproduce (Tan *et al*., 1999). Protection from predators and suitable temperature are important for maternity roosts. Therefore, humidity, sun light and height above the ground are always being considered before a roost is selected (Sedgeley & O'Donnell, 1999; Sedgeley, 2001). Fallen trees, caves, foliage, rock crevices, hollow trees, and man-made structure such as house are some of the common places for bat roost. This speciality displayed by bats shows that they are very sensitive and vulnerable to any changes in habitat.

Chiroptera is the largest mammalian order in Peninsular Malaysia. The most recent estimate of this group in Malaysia is 125 species (Simmons, 2005). Krau Wildlife Reserve in Pahang is the most extensively studied site for bat diversity in Peninsular Malaysia with 69 species was recorded. This study reported that Krau holds the highest diversity of bats known for a single site in the world (Kingston *et al*., 2006). Many bat surveys studies have been conducted in Malaysia (Francis, 1994; Zubaid, 1993; Norsham *et al*., 2000; Kingston *et al*., 2003; Struebig, 2008). Joann *et al*. (2011) conducted study on insectivorous bat assemblage in the hill dipterocarp forest and discovered cave-dweller bats dominated the lower region while tree/foliage roosting species occupied the hill region. Struebig *et al*. (2008) study the impacts of fragmentation on insectivorous bat species that vary in dependence forest in Peninsular Malaysia found that small fragments forest were more variable in species composition cavity/foliage-roosting bats, but not for that of cave-roosting or edge/open space foraging species than larger fragments or continuous forest of. Study of roosting ecology of fruit bats in Peninsular Malaysia (*Cynnopterus*) was conducted by Campbell *et al*. (2006).

2.4 Non-volant small mammals

Non-volant small mammal refers to small mammals that do not have flying ability. These include Muridae (rats and mice), Sciuridae (squirrels), Tupaiidae (tree shrews) and Erinaceidae (moon rat) families. These groups of animals play key roles in tropical forest ecosystems and important seed consumers and as prey items to larger predators such as snake, eagle and big cat. In Southeast Asia, Francis (2008) listed over 470 species of land mammals, while Khan (1992) documented 205 species comprising 32 families and 11 groups of mammals in Peninsular Malaysia. DWNP (2010) have listed 222 species of mammals in Peninsular Malaysia. According to IUCN Red List of Threatened Species, of these, seven are considered endangered while ten are vulnerable species. This value is probably underestimates since all species facing pressures such as poaching, habitat fragmentation and commercial exploitation.

Small mammals play an important role for the rain forest ecosystem, they act as a seed dispersal, pollination, insect pest control and become prey items by larger carnivores (Cathew & Goldingay, 1997; Shanahan & Compton, 2000; Yasuda *et al*., 2005; van der Meer *et al*., 2008). Some studies on small mammals communities (terrestrial and arboreal) have been conducted in Borneo (Wells *et al*., 2004; 2007; Nakagawa *et al*., 2006; Bernard *et al*., 2009) but less similar studies have been carried out in the Peninsular Malaysia (Yasuda *et al*., 2003). Therefore, little is known about the relationship between small mammal communities and their rainforest habitat in Peninsular Malaysia.