



**Faculty of Resource Science and Technology**

**DIVERSITY OF BATS AT THE FOREST EDGE OF TWO GOLF COURSES IN  
SARAWAK, BORNEO**

**LIM YANG PING (23874)**

**Bachelor of Science with Honours  
(Animal Resource Science and Management)  
2012**

**DIVERSITY OF BATS AT THE FOREST EDGE OF TWO GOLF COURSES IN  
SARAWAK, BORNEO**

**LIM YANG PING (23874)**

This project is submitted in partial fulfilment of the requirement for the degree of  
Bachelor of Science with Honours  
(Animal Resource Science and Management)

Faculty of Resource Science and Technology  
Universiti Malaysia Sarawak  
2012

## **Declaration**

I hereby declare that the thesis is based on my original work except for citation which has been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degrees at UNIMAS or any other institution of higher learning.

---

Lim Yang Ping  
Animal Resource Science and Management Program  
Department of Zoology  
Faculty of Resource Science and Technology  
Universiti Malaysia Sarawak

## **Acknowledgements**

First of all, I would like to thank Damai Golf and Country Club, and Sarawak Club Golf Resort for their permission to conduct the research in their golf courses. Heartiest thanks to my supervisor Professor Dr. Andrew Alek Tuen, and co-supervisor, Professor Dr. Mohd Tajuddin Abdullah for their guidance, knowledge and skill sharing, advices and patience during the preparation of my Final Year Project. A lot of thanks to my mentor, Dr. Yuzine Esa, and all the lecturers of Faculty of Resource Science and Technology, especially lecturers from Department of Zoology for sharing their invaluable knowledge and experiences which broaden my vision. Special thanks to all Zoology Department laboratory assistants, especially Mr. Isa bin Sait, Mr. Nasron bin Ahmad, IBEC laboratory assistants, Mr. Mohd Hasri Al-Hafiz bin Haba and Miss Rahah binti Mohd Yakup for all their kindness, help, providing facilities and equipments, guidance during my sampling periods. Nevertheless, compassion from all postgraduates, especially help from Mary ak Buloh Balang, Lyhmer Jack, and Mohd Isham Mohd Azhar during sampling are appreciated. Last but not least, thanks to my colleagues for their encouragement and company.

## Table of Contents

|   |     |
|---|-----|
| Acknowledgements.....   | I   |
| Table of Contents.....  | II  |
| List of Tables and Figures .....  | III |
| Abstract.....   | 1   |
| 1.0 Introduction .....  | 2   |
| 1.1 Objective .....   | 4   |
| 2.0 Literature Review .....   | 5   |
| 2.1 Comparison of Bat Studies Done in Temperate Regions versus<br>Tropical Regions..... | 5   |
| 2.2 Development of Golf Courses Worldwide.....  | 12  |
| 2.3 The Effect of Golf Course Development on Biodiversity.....                          | 12  |
| 3.0 Materials and Methods .....   | 15  |
| 3.1 Study Areas .....   | 15  |
| 3.2 Sampling Methodologies.....   | 18  |
| 3.3 Species Identification .....  | 18  |
| 3.4 Statistical Analysis .....  | 20  |
| 3.4.1 Simpson Index.....  | 20  |
| 3.4.2 Shannon Index.....  | 21  |
| 3.4.3 Zar t-test.....   | 22  |
| 3.4.5 Chi-square test.....  | 24  |
| 4.0 Result .....  | 26  |
| 5.0 Discussion.....   | 31  |
| 5.1 Comparing Bat Diversity between Both Sampling Areas.....                            | 31  |
| 5.2 Comparing Bat Species Recorded between Adjacent Forests and Current<br>Study.....   | 34  |
| 6.0 Conclusion.....   | 39  |
| 7.0 References .....  | 40  |
| Appendices.....   | 45  |

## List of Tables and Figures

|                   |   |    |
|-------------------|---|----|
| <b>Figure 1:</b>  | Damai Golf and Country Club.....  | 15 |
| <b>Figure 2:</b>  | Sarawak Club Golf Resort.....   | 16 |
| <b>Figure 3:</b>  | Damai Golf and Country Club located at foothill of Mount Santubong.....   | 16 |
| <b>Figure 4:</b>  | Rocky outcrop beside golf course.....   | 16 |
| <b>Figure 5:</b>  | Conifer trees beside golf course.....   | 17 |
| <b>Figure 6:</b>  | Long coarse grass beside golf course.....   | 17 |
| <b>Figure 7:</b>  | Secondary forest at forest edge of golf course.....   | 17 |
| <b>Figure 8:</b>  | Rubber tree and fig tree found in secondary forest.....   | 18 |
| <b>Figure 9:</b>  | Harp trap set in Damai Golf and Country Club.....   | 19 |
| <b>Figure 10:</b> | Harp trap set in Sarawak Club Golf Resort.....  | 19 |
| <b>Figure 11:</b> | Cumulative graph of number of species and individuals captured against days in Damai Golf and Country Club (March 2011 & February 2012) ..... | 27 |
| <b>Figure 12:</b> | Cumulative graph of number of species and individuals captured against days in Sarawak Club Golf Resort (March 2011 & February 2012).....     | 28 |
| <b>Table 1:</b>   | List of bats species recorded in Sarawak Club Golf Resort and Damai Golf and Country Club during March 2011 and February 2012.....            | 26 |
| <b>Table 2:</b>   | Comparison of diversity and capture rate of bat species recorded in study areas.....  | 29 |
| <b>Table 3:</b>   | Reproductive status of <i>Cynopterus brachyotis</i> in study areas during February 2012.....  | 30 |
| <b>Table 4:</b>   | Comparison of species captured and capture rate between Tuen <i>et al.</i> (2000) and current study (2011 & 2012).....                        | 34 |
| <b>Table 5:</b>   | Comparison of species captured and capture rate between previous studies done in UNIMAS area and current study (2011 & 2012).....             | 36 |

# Diversity of Bats at Forest Edges of Different Golf Courses in Sarawak, Borneo

Lim Yang Ping

Animal Resource Science and Management Programme  
Faculty of Resource Science and Technology  
Universiti Malaysia Sarawak

## ABSTRACT

A total of six sampling nights was conducted in each of two selected golf courses, which were Sarawak Club Golf Resort and Damai Golf and Country Club to determine and compare the bat diversity. Twenty mist nets and two harp traps were set up in the forest edges of golf courses from March 15<sup>th</sup> - 18<sup>th</sup> 2011 in Sarawak Club Golf Resort and March 22<sup>th</sup> - 25<sup>th</sup>, 2011 in Damai Golf and Country Club. Sampling was conducted again at both study sites from February 8<sup>th</sup> - 11<sup>th</sup>, 2012 in Damai Golf and Country Club and February 14<sup>th</sup> - 17<sup>th</sup>, 2012 in Sarawak Club Golf Resort. A total of three bat species with 126 individuals were captured in Damai Golf and Country Club and three bats species with 34 individuals were captured in Sarawak Golf Course Resort. Species recorded from Sarawak Golf Course Resort were *Cynopterus brachyotis*, *Balionycteris maculata* and *Tylonycteris pachypus* while species recorded from Damai Golf and Country Club were *Cynopterus brachyotis*, *Hipposideros galeritus* and *Hipposideros cervinus*. The highest capture rate from both sampling sites was *Cynopterus brachyotis*. Statistical analyses used were Simpson Index, Shannon Index, Zar t-test, and Chi-square test. Bat species diversity for both sampling sites is low and there is no significant difference in bat diversity between Sarawak Golf Course Resort and Damai Golf and Country Club. It is suggested that golf course is not a suitable habitat for bats in Kuching and Samarahan Divisions.

Key words: Bats, golf courses, forest edges, diversity, comparison

## ABSTRAK

Sejumlah enam malam pensampelan telah dijalankan dalam setiap daripada dua padang golf yang dipilih, iaitu Sarawak Club Golf Resort dan Damai Golf and Country Club untuk menentu dan membanding kepelbagaian kelawar. Dua puluh jaring kabut dan dua perangkap harp telah dipasang dalam pinggir hutan padang golf dari 15 hingga 18 March 2011 dalam Sarawak Club Golf Resort dan 22 hingga 25 March 2011 dalam Damai Golf and Country Club. Pensampelan telah dijalankan lagi di kedua-dua tempat kajian dari 8 hingga 11 Februari 2012 dalam Damai Golf and Country Club dan 14 hingga 17 February 2012 dalam Sarawak Club Golf Resort. Sejumlah tiga spesis dengan 126 individu telah ditangkap dalam Damai Golf and Country Club dan tiga spesis dengan 34 individu telah ditangkap dalam Sarawak Golf Course Resort. Spesis yang dicatat dari Sarawak Golf Course Resort ialah *Cynopterus brachyotis*, *Balionycteris maculata* dan *Tylonycteris pachypus* manakala spesis yang dicatat dari Damai Golf and Country Club ialah *Cynopterus brachyotis*, *Hipposideros galeritus* dan *Hipposideros cervinus*. Kadar penangkapan yang tertinggi dari kedua-dua tempat pensampelan ialah *Cynopterus brachyotis*. Analisis statistik yang digunakan ialah Index Simpson, Index Shannon, ujian-t, dan ujian Chi-square. Kepelbagaian kelawar untuk kedua-dua tempat pensampelan adalah rendah dan tidak ada perbezaan kepelbagaian yang nyata antara Sarawak Golf Course Resort dan Damai Golf and Country Club. Adalah dicadangkan bahawa padang golf bukan habitat yang sesuai untuk kelawar dalam Bahagian Kuching dan Samarahan.

Kata kunci: Kelawar, padang golf, pinggir hutan, kepelbagaian, perbandingan

## 1.0 Introduction

Bats are volant small mammals and it can be divided into two suborders, which are Megachiroptera and Microchiroptera (Tweedie, 1978). Megachiroptera are fruit bats and they are often larger than insect bats. They feed on fruits or nectar. Fruit bats locate fruiting trees by using their excellent sense of smell and color vision (Adams, 2003). Microchiropterans are insect bats which usually have smaller size than Megachiropterans. Insect bats are carnivores and they feed on insects. They use echolocation to navigate in dark (Francis, 2001) and also to detect their prey distance. Bats occur worldwide except for polar regions and some oceanic island (Harvey *et al.*, 2011). Megachiropterans can be only found in Old World such as Africa, India, Australia and Indonesia (Adams, 2003; Tuttle, 2005). Microchiropterans are highly diverse in appearance and they are distributed worldwide except Antarctica (Adams, 2003; Tuttle, 2005).

There are total of 18 families in Order Chiroptera (Simmons, 2005) with more than 1300 species worldwide (Harvey *et al.*, 2011). Bats are most abundant in tropics (Harvey *et al.*, 2011) and temperate region have less bats species although temperate region cover much more area than tropics. According to Fukuda *et al.* (2009), Southeast Asia is a hotspot for bat. Indonesia has the greatest number of bat species with total number of 175, while Malaysia has 112 species of bats with 11 of them are endemic species (Mickleburgh *et al.*, 2002). Borneo has eight families of Order Chiroptera (Payne & Francis, 2007) with 96 species (Struebig *et al.*, 2010). Temperate regions such as Great Britain consists of two families of Order Chiroptera with 15 species (Richardson, 1985), three species in New Zealand (Hutson *et al.*, 2001), four families with 47 species in United States and one family representing 20 species in Canada (Harvey *et al.*, 2011). Borneo has 746 337 km<sup>2</sup> (MacKinnon *et al.*, 1996) while United States

has 9 826 275 km<sup>2</sup> (CIA, 2011). Bat species in United States and Canada make less than 5% of species worldwide (Harvey *et al.*, 2011), even less than total of bat species in Southeast Asia.

Naturally bats roost in caves and within the forest trees (Francis, 2001). Assemblage of bats in an area depends on availability of food sources, forest structure and roosting sites (Kunz & Lumsden, 2003). Bats have its intrinsic conservation value. They play an important role in ecosystem as pollinators and seed dispersals (Struebig *et al.*, 2007) especially among the oceanic islands. For example, fruit bats, *Eonycteris spelaea* is a major pollinator durian, *Durio zibethinus* (Bumrungsri *et al.*, 2009). Other than that, insect bat control the population of insects and play role in recolonisation of disturbed areas by fruit bats (Tuen *et al.*, 2002). Thus, bats need to be conserved by retaining their habitat requirement or other ways in order to maintain the ecosystem dynamic.

The percentage of natural forests worldwide is being reduced due to land development activities. Golf courses are increasingly occupying land worldwide (Sorace & Visentin, 2007) for the fulfillment of human needs. Constructing a golf course needs a huge landscape for playing area and deforestation will occur in playing area and areas earmarked for other related structures. However, non-play areas are usually left and kept as natural habitat for wildlife. Smart *et al.* (1993) stated that golf courses are developed to be as natural as possible. Conservation value of golf courses is enhanced by preserving and increasing the amount of natural patches, and decreasing the amount of managed turf grass (Sorace & Visentin, 2007). Habitat such as ponds and streams are also being created to preserve the wildlife diversity. The wildlife diversity in golf courses will increase if the wildlife habitats are managed well (Dodson, 2000). Nonetheless, there is no declaration that it has positive impact on bat diversity.

In Borneo, Fukuda *et al.* (2009) stated that anthropogenic changes of forest can greatly affect the diversity, abundance, and feeding behavior of bats. A large number of this island's bat species depend on forests for food and shelter where deforestation can therefore have major impacts by reducing foraging habitats and roosting sites (Struebig *et al.*, 2010). Habitat alteration and loss is the major threats to bats in Borneo (Struebig *et al.*, 2010). Therefore, building a golf course that alter large land area and reduce roosting sites and food sources of bats might reduce the bat diversity.

There are only a few studies done about wildlife diversity in golf courses in Borneo especially on bat diversity. Since there are two contrasting viewpoint and poor understanding of bat diversity around golf course area, this study is important to determine the value of golf course on bat communities in Borneo. The data can reflect the suitability of golf courses for habitat of bats.

## **1.1 Objective**

- 1.** To determine and compare the diversity of bats at forest edge of two golf courses in Kuching and Samarahan Divisions.

## **2.0 Literature Review**

### **2.1 Comparison of Bat Studies Done in Temperate Regions versus Tropical Regions**

Temperate regions include countries that are not located on equator such as Great Britain, Europe, Russia, North America, Northern Mexico in North Temperate Zone while South Temperate Zone are including southern Australia, New Zealand, Southern South America and South Africa.

In eastern Ontario of Canada, a study on the effect of fragmented forest on bat diversity was conducted (Ethier & Fahrig, 2011). The study site was located in a rural area where dominated by agriculture land with mixed deciduous trees. Four sampling days was done in each of the 22 landscapes with acoustic method and seven species of bats were recorded. Their study showed that there is a positive effect on fragmented forest to the diversity and abundance of temperate bats because fragmented forest has more heterogeneity in landscape pattern and suitable for bats to survive.

Bogan *et al.* (1998) had done a three-year study on bat populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico during summer. Mist nets and harp traps were used to capture bats for 50 nights at Bandelier National Monument and 56 nights at Los Alamos National Laboratory. Before releasing them, a miniature radio transmitter was attached to some of the bats' body for roosting studies such as the general structure and elevation of roosting sites (Bogan *et al.*, 1998). A total of 1532 individuals representing 15 species were recorded. They found out the bats roosting sites are in between snags, rock crevices, cliffs, building, trees and caves. Besides that, they stated that presence of suitable habitat determine the diversity of temperate bats.

Driessche *et al.* (1999) had studied the habitat selection by bats in temperate old-growth forests, Clayoquot Sound, British Columbia from year 1996 until 1998. The study done over three summers by using 753 mist nets managed to record 118 individuals of bats representing six species (Driessche *et al.*, 1999). Besides that, one species of bat was detected and identified by using ultrasonic detectors (Driessche *et al.*, 1999). They stated that flying and foraging bats are more likely to roost in tall, open forests at lower elevations rather than in dense forests.

Effect of elevation on bat species richness and activities was investigated by using acoustic method in shrublands of central Crete (Greece) during spring and autumn (Georgiakakis *et al.*, 2010). Detection of bats was based on the D-980 ultrasound detector and species was identified using software. Thirteen species were recorded and they concluded that bats activity was not significantly affected by elevation (Georgiakakis *et al.*, 2010). Other than that, they also stated that bat species richness and bat activities were higher in spring than in autumn but air temperature had no significant effect. Georgiakakis *et al.*, (2010) stated that the main factors that affect the bat diversity were food sources and roost availability.

These studies of bat diversity in temperate regions showed that bats can adapt well with the alteration of forest structure as long as their food source and roosting sites are retained.

Tropical regions include countries that are located on or near the equator such as Southeast Asia. These countries are known to harbor a high diversity of bats. In Philippine, a study about bat diversity in Mount Isarog Natural Park (MINP) of southeastern Luzon was done to compare with result collected in year 1988 (Sedlock *et al.*, 2008). Harps traps, tunnel

traps and mist nets were used to capture bats and a total of 26 bat species were recorded where nine species of them were new record for MINP (Sedlock *et al.*, 2008). Combination of using mist nets, harp traps and tunnel traps resulted in more complete data of bats and less biased (Sedlock *et al.*, 2008). They also stated that four species that recorded during year 1988 were not being collected and this might be due to sampling error and seasonal difference of sampling period.

In Central Sulawesi of Indonesia, Graf (2010) studied the diversity and habitat use by understory bats in forest and agro forestry systems around village of Toro, western boundary of Lore Lindu National Park. Bats were surveyed by using mist nets in four habitat types which were natural forest, selectively logged forest, agroforestry systems with a diverse layer of shade trees remaining from the formerly logged natural forest and agroforestry systems with a homogeneous shade tree layer consisting of only one planted tree species. A total of 13 species with 195 individuals were recorded in 8,592 net-meter-hours. Graf (2010) stated that abundance of *C. brachyotis* decrease with the increasing of canopy closure. He also mentioned that abundances and species richness were greater in the understorey of agroforestry systems than in forests.

In Peninsular Malaysia, Nur Juliani *et al.* (in press) had studied the diversity of Malaysian bats at secondary forest and oil palm plantation along Kerian River, Perak between February 2009 and February 2010 using ten mist nets at each vegetation type. A total of 329 individuals with 14 species were captured in both site and secondary forest has more species captured than oil palm (Nur Juliani *et al.*, in press). They stated that all species found in oil palm plantation is belongs to common species that can be found in disturbed forest such as *C. brachyotis*.

In Borneo, Abdullah *et al.* (1997) studied the abundance, diversity and distributional of bats in disturbed habitats of Kalimantan Barat, Indonesia. Selected sampling sites were drained peat soil forest with plantation, secondary peat soil forest and coconut-banana plantation area. Secondary peat soil forest had thicker shrub cover compared to other two sites (Abdullah *et al.*, 1997). A total of 180 bats with six species were recorded in three habitats after 36 trapping night (Abdullah *et al.*, 1997). They found that coconut-banana plantation was abundant and diverse with bat species. *C. brachyotis* was the highest captured rate species (Abdullah *et al.*, 1997). Recapture rate was low and they suggested that it is due to the abundance of food sources in sampling sites which lead to the wide spread dispersal of bats.

Mohd-Azlan *et al.* (2003) had studied the diversity, relative abundance and conservation of Chiropterans in Kayan Menterang National Park, East Kalimantan, Indonesia, which is a primary mixed dipterocarp forest. Studies were done in disturbed and undisturbed areas where disturbed areas were including fruit orchards and cleared land (Mohd-Azlan *et al.*, 2003). A total of 11 species with 168 individuals were recorded where 124 of them were captured from undisturbed areas (Mohd-Azlan *et al.*, 2003).

In Sabah, a field survey was conducted by Ketol *et al.* (2009) in Gunung Silam to inventory the diversity of mammals. The study sites were surrounded by agricultural lands planted with jackfruit, banana and oil palm. Three mist nets were set in banana plot in lowland and another three mist nets were set in primary forest at higher elevation. A total of four bats species were recorded where three species of fruit bats were captured in banana plot and a species of insect bat was captured in primary forest (Ketol *et al.*, 2009). Fruit bats were only captured at area where their food sources are available (Ketol *et al.*, 2009).

Mahyudin *et al.* (2010) had done small mammal trappings in Maliau Basin Conservation Area, Sabah by using mist nets and harp traps. After 708 of trapping nights, three bats species was managed to be recorded. They stated that factors like disturbance from construction works and lack of food sources in study sites affect the number of animals detected.

Benda (2010) studied bat diversity from western Sabah (North Borneo, East Malaysia). Three study sites were selected which were Gunung Emas, Sapulut and Batu Punggul by using mist net, and hand collecting. There were four vegetation types which are montane forest in Gunung Emas, primary lowland forest in Batu Punggul, secondary forest and anthropogenic habitats in Sapulut (Benda, 2010). A total of 16 species was recorded where Gunung Emas had the least bat species and Batu Punggul had the highest bat diversity while Sapulut had the highest bat abundance.

In Sarawak, Wilson *et al.* (2006) had done a small mammal survey in Planted Forest Zone of Bintulu, Sarawak. Two study sites, which were secondary forest and *Acacia mangium* plantation, were used for the study. The secondary forest were belongs to kerangas forest and freshwater swamp whereas *Acacia mangium* plantation represents highly disturbed vegetation. Twenty two species of bats were recorded from both forests while only three species were captured from *Acacia mangium* plantation.

Fukuda *et al.* (2009) had studied bat diversity in the vegetation mosaic around a lowland dipterocarp forest of Lambir Hills National Park (LHNP), Sarawak. Their aim was to investigate the anthropogenic effects on bats by studying their diversity and feeding habits in four different vegetation types such as primary forests, secondary forests, orchards and oil palm plantation. A total of 495 individuals representing 28 species were captured. Species of

bats captured in oil palms and orchards were relatively lower than in the primary and secondary forests. They stated that orchards and oil palm plantation may be inadequate habitats for both insect and fruit bats (Fukuda *et al.*, 2009).

A field survey of small mammals was done by Wiantoro *et al.* (2009) in Ba' Kelalan, Lapo Bunga Camp and Church Camp in Mount Murud, Sarawak, to compare with the data collected in year 2003 and 2007 (Tuen *et al.*, 2003; Faisal *et al.*, 2007) and determine the latest diversity of small mammals. A total of five bats species with 12 individuals were recorded and *Pipistrellus javanicus* was a new record within the captured bat species (Wiantoro *et al.*, 2009). However, the bat diversity is lower compared to the previous studies (Tuen *et al.*, 2003; Faisal *et al.*, 2007) as the forest become fragmented and disturbed due to logging activities (Wiantoro *et al.*, 2009).

Rahman *et al.* (2010) had studied diversity of bats in two protected limestone areas, which were Niah National Park (NP) and Wind Cave Nature Reserve (NR) in Sarawak from November 2007 until April 2009. Eight to 12 mist nets and three harp traps were used and a total of 1520 individuals representing 36 species were recorded, where nine species of them were new records for both areas (Rahman *et al.*, 2010). They stated that several bats species such as *Cheiromeles torquatus*, *Eonycteris spelaea*, *Rousettus amplexicaudatus*, *Rousettus spinalatus* and *Coelops robinsoni* were declining in numbers because of human disturbances such as guano mining, ecotourism and bird nest collecting.

Jayaraj *et al.* (2011) had studied comparative distribution and diversity of bats from eight selected localities in Sarawak, which were Tubau camp at Bintulu, Batang Ai National Park, Bako National Park, Mount Penrisen in Padawan, Kubah National Park, Similajau

National Park, Lambir Hills National Park and Mount Murud in Limbang and Miri Divisions. Result of 20 mist nets and one to four harp traps in at least three consecutive nights, a total of 45 species of bats with 806 individuals were captured (Jayaraj *et al.*, 2011). From the study, Bako National Park in which the study was conducted in five vegetation types had the highest bat species and Tubau camp, which was isolated and disturbed, had the lowest bat species (Jayaraj *et al.*, 2011).

These studies in tropical forest of Southeast Asia reveal that reduction of food sources and alteration of forest structure decreased bat diversity.

Mount Santubong is the adjacent habitat of Damai Golf and Country Club. Diversity of small mammals was studied in Mount Santubong in year 1997 between May and October at three different altitudes, which were <100m above sea level (a.s.l.), 450m a.s.l. and >800m a.s.l. in two different sites, which were disturbed and undisturbed areas (Tuen *et al.*, 2000). Sampling was conducted for 20 days using ten mist nets at each site. A total of four bat species with 35 individuals were recorded. The result showed that abundance of bats is more at the middle altitude compare to low and high altitude. *Penthetor lucasi* is the most captured bats and *C. brachyotis* is more abundant in lower altitude.

Universiti Malaysia Sarawak (UNIMAS) is adjacent area of Sarawak Club Golf Resort. Studies about diversity of small mammals in peat swamp forest and secondary forest were done. In year 2010, Mohd Rais *et al.* (2010) had updated and compared the small mammals' diversity at both sites which were done by Hamdan (2004), Abdullah *et al.* (2006), Abang Abdillah (2008), and Jelani (2008). The study was conducted for six days from July till August with the use of ten mist nets and three harp traps at each site. A total of three species

of bats were captured in peat swamp forest with *Balionycteris maculata* as the most abundant species (Mohd Rais *et al.*, 2010). Whereas two species of bats were recorded at secondary forest within the same sampling period and *C. brachyotis* was the most abundant species (Mohd Rais *et al.*, 2010). They stated that species diversity of bats had decreased compared to previous studies due to the changing habitat (Mohd Rais *et al.*, 2010).

## **2.2 Development of Golf Courses Worldwide**

Golf originated from Scotland and it is evolved from the Dutch game “het kolven” (Beard, 1982; Astor, 1991). The Old Course in St. Andrew is believed to be the first golf course in the world, it was established in the 15<sup>th</sup> century. In year 1997, there were 25,000 golf courses worldwide and United State had approximately 15,000 golf courses (Terman, 1997). During the year 2005, in Europe, there were 5,200 golf courses and over 31,500 golf courses worldwide (Tanner & Gange, 2005; Sorace & Visentin, 2007). More recently, there are approximately 32,000 of golf courses worldwide (World Golf Foundation, 2010). Malaysia has almost 200 golf courses where ten of them are located in Sarawak and Kuching consists of six golf courses.

## **2.3 The Effect of Golf Course Development on Biodiversity**

In Italy, golf courses are located in lowland and hilly territories where the habitat types include turf grass, forest, uncultivated area and wetland. There rows of tree and bushes in forest and turf grass in uncultivated area. The number of native trees in golf courses is low and mostly planted with introduced tree species for aesthetic purpose (Tanner & Gange, 2005). However, golf courses provide greater habitat range than adjacent farmland and bird species favor the diversification of habitat (Tanner & Gange, 2005).

Several studies on wildlife in golf course have been done before in temperate countries. In Italy, Sorace and Visentin (2007) had done a study on avian diversity on 23 golf courses and surrounding landscape. Their major aim is to investigate whether the proportion of natural patches positively affected the richness of species and the number of species of conservation concern or sensitive to habitat fragmentation. Their result showed that golf course with higher forested area has higher avian diversity.

A study has been done by Terman (1997) at Prairie Dunes Country Club and natural area, Sand Hill State Park in Kansas to compare the diversity of birds. After their three years study, they found that golf course has higher density of birds compared to natural area.

Tanner and Gange (2005) had done their research on effect of golf course to biodiversity of birds and some insects on nine golf courses and nine adjacent habitats in UK. Their objectives were to determine whether golf courses have higher diversity compared to farmland and also to examine whether biodiversity will increase with the increasing of golf course age. Their result showed that golf courses have higher diversity compare to farmland and bird diversity increases with the increasing of the age of the golf course (Tanner & Gange, 2005). These studies showed there are positive effect of golf course to bird's and insect diversity.

In Malaysia, so far there are only a few studies done on wildlife diversity in golf courses. In Sarawak, Buluh Balang (2010) studied on the diversity and feeding guilds of birds in different types of habitat at Sarawak Club Golf Resort of Kota Samarahan. Forty two bird species were observed where two species were frugivore and 13 species were insectivore (Buluh Balang, 2010). She stated that forest patches in golf courses provide roosting site and

foraging area for birds (Buluh Balang, 2010). Bats are insectivore and frugivore too. Thus, these factors may also attract bats to enter the golf course for their needs.

Jayaraj *et al.* (2005) studied bat diversity near Hornbill Golf and Jungle Club Resort in the highland area of Mount Penrissen, Sarawak from 27 to 29 January 2005 to compare the data recorded with other highland biodiversity. Ten mist nets and one harp trap were used to capture bats in two trapping nights and a total of 38 individuals of bats representing eight species of fruit bats were captured in mist nets (Jayaraj *et al.*, 2005). They stated that bat diversity tends to be reduced with the increase of elevation except for the species that endemic to the montane forests such as *Aethalops alecto* and *Megaerops ecaudatus* (Jayaraj *et al.*, 2005).

After one year, another study was carried out by Jayaraj *et al.* (2006) in Mount Penrissen, Sarawak around golf course. Eight mist nets and three harp traps were set in the golf course for two trapping nights and they managed to capture 12 species with 68 individuals (Jayaraj *et al.*, 2006). They managed to capture the rare *Kerivoula minuta*, *Kerivoula intermedia* and *Hipposideros coxi*. Compare to the research done in year 2005, a total of 15 species were recorded and new bats species distribution record of Mount Penrissen area was established (Jayaraj *et al.*, 2006). They stated that Mount Penrissen might be understudied because there are other areas and habitats that are not sampled (Jayaraj *et al.*, 2006).

### 3.0 Materials and Methods

#### 3.1 Study Areas

The study was conducted at two different golf courses, which are Damai Golf and Country Club and Sarawak Club Golf Resort. The distance between the two golf courses are around 32 km. Both golf courses are disturbed areas but still retain forest patches in between the playing areas. Yellow marks in figures 1 and 2 are the sampling sites in this survey. In first sampling period during March 2011, sampling was done in sites A and B in Damai Golf and Country Club (Figure 1) and in sites A and B of Sarawak Club Golf Resort (Figure 2). In second sampling period (February 2012), sampling was done in sites A and C in first sampling day for Damai Golf and Country Club. Mist nets from site C were relocated to site B during and after second sampling day. For Sarawak Club Golf Resort, sampling was only done in site B during second sampling period.



**Figure 1:** Damai Golf and Country Club (Google Earth, Imagery date: 3/8/2003)



**Figure 2:** Sarawak Club Golf Resort (Google Earth, Imagery date: 26/9/2006)

Damai Golf and Country Club (N01 °44'41", E110 °18'17") is the first Arnold Palmer-designed course in Malaysia and established in April 1996. It is located at the foothill of Mount Santubong (Figure 3), hugging the beaches, rocky outcrops of the South China Sea (Figure 4), surrounded by mountain ridges.



**Figure 3:** Damai Golf and Country Club located at foothill of Mount Santubong (Photo adopted from Panoramio, 2008)



**Figure 4:** Rocky outcrop beside golf course (Photo adopted from Open Fairways Asia, 2011)

The place is windy and conifer trees and long coarse grass can be found at the forest edges of golf course beside the shoreline (figures 5 & 6).



**Figure 5:** Conifer trees beside golf course (Photo adopted from Panoramio, 2007)



**Figure 6:** Long coarse grass beside golf course (Photo taken by LYP)

Sarawak Club Golf Resort is located next to UNIMAS and Kampung Sebayor (N01 28'30", E110 25'49"). Sarawak Club Golf Resort has approximately 5839 meters of length with full length hole par 72 course (Buluh Balang, 2010). According to Buluh Balang (2010), Sarawak Club Golf Resort consists of four existing different habitats which are peat swamp forest, mangrove forest, streams and ponds. Forest edges belong to peat swamp forest and also secondary forest with rubber tree plantation and fig trees at the other site of golf course (figures 7 & 8).



**Figure 7:** Secondary forest at forest edge of golf course (Photo taken by LYP)



**Figure 8:** Rubber tree and fig tree found in secondary forest (Photo taken by LYP)

### 3.2 Sampling Methodologies

Sampling was conducted from 15<sup>th</sup> to March 18<sup>th</sup>, 2011 (three nights) in Sarawak Club Golf Resort and 22<sup>th</sup> to March 25<sup>th</sup>, 2011 (three nights) in Damai Golf and Country Club. Second sampling was conducted after nearly one year, which was during 8<sup>th</sup> to February 11<sup>th</sup>, 2012 (three nights) in Damai Golf and Country Club and February 14<sup>th</sup> until February 17<sup>th</sup>, 2012 (three nights) in Sarawak Club Golf Resort. Each sampling was started from the night of first sampling day until the morning of fourth sampling day, which resulted with a total of six sampling nights in each golf course.

Twenty mist nets with four shelves (2.5 m × 9 m × 36 mm mesh) and two four-bank harp traps were set up in forest edges of each golf course (figures 1 & 2). Mist nets which are made of black nylon were used because the black color made it less visible to bats. Harp trap are made from fishing lines that will avoid the reflection of echolocation by insect bats, and increase the capture rate. They were set between the gaps of two trees and across a trail that is probably the flying trails of bats (figures 9 & 10).