Faculty of Resource Science and Technology

Species Diversity, Species Similarity and Shared Species of Understorey Birds at Mount Jagoi and Mount Singai, Bau, Sarawak

Cheng Poh Leng

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

Species Diversity, Species Similarity and Shared Species of Understorey Birds at Mount Jagoi and Mount Singai, Bau, Sarawak

Cheng Poh Leng

23283

The Final Year Project is submitted in partial fulfilment of requirement for degree of

Bachelor of Science with Honours

(Animal Resource Science and Management Programme)

Faculty of Resource Science and Technology

Universiti Malaysia Sarawak

2012

ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to my supervisor, Mr. Charlie Justin Mergie Laman as well as my co-supervisor, Prof. Dr. Mustafa Abdul Rahman for their guidances in completing this project on the topic Species Diversity, Species Similarity and Shared Species of Understorey Birds at Mount Jagoi and Mount Singai, Bau, Sarawak. I am grateful to Luisa Duya Anak Setia for allowing me to reanalyse the bird data of Mount Singai.

Besides, I would like to thanks to Prof. Dr. Andrew Alek Tuen, Assoc. Prof. Dr. Alexander Kiew Sayok and Assoc. Prof. Dr. Gabriel Tonga Noweg for helping and giving me the opportunity to conduct this study at Mount Jagoi. I would like to acknowledge the Faculty Resource Science and Technology and Institute of Biodiversity and Environment Conservation (IBEC) for providing necessary financial support and sampling tools to facilitate this study.

Thanks to staff, Mr. Nasron Ahmad, Miss Rahah binti Mohd. Yakub and Mr. Mohd. Hasri Al-Hafiz b. Haba; postgraduate students, Mary ak Buloh Balang, Bong Hsien Huon, Ik Wadell ak Ik @ Pahon, Veronica ak Juti and Kishen Bunya; my colleagues and friends, Tay Guan Khoon, Tham Chook Yan, Nur Shakirah bt. Kamarul Zaman, Frances Hii Dai Sze, Puvaneswari a/p Puvanasundram, Elizabeth Lendai Anak John Herbert, Nur Mukminah bt. Naharuddin, Nurshilawati bt. Abdul Latip, Adi Shabrani bin Mohd. Ridzuan, and those I have no mentioned here, for their supports and encouragements. Finally, I would like to thanks the local community of Mount Jagoi who willing to help throughout the sampling periods.

DECLARATION

No portion of the work referred to in dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

CHENG POH LENG

Animal Resource Science and Management Programme

Faculty of Resource Science and Technology

Universiti Malaysia Sarawak

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

Glossaries

Singleton Species which are represented by a single individual in the sample.

Doubleton Species which are represented by two individuals in the sample.

Uniques Species which occur in only one sample.

Duplicates Species which occur in two samples.

Species Diversity, Species Similarity and Shared Species of Understorey Birds at Mount Jagoi and Mount Singai, Bau, Sarawak

Cheng Poh Leng

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

ABSTRACT

Birds are useful in indicating the forest's vegetation and they are important for environmental monitoring. This study focuses on the understory bird community at Mount Jagoi and Mount Singai in Bau, Sarawak in terms of species diversity, species similarity and shared species. Birds at Mount Jagoi were captured by mist-netting from 8th to 12th August, 2011, 8th to 12th November, 2011, and 2nd to 6th February, 2012. A total of 298 individuals comprising 53 species from 22 families were recorded at Mount Jagoi; while there were 127 individuals comprising 26 species from 12 families were documented at Mount Singai. The most dominant species in both areas was Little Spiderhunter (*Arachnothera longirostra*); while the dominant families recorded were Pycnonotidae and Timaliidae. The results showed that bird community at Mount Jagoi was richer and significantly more diverse than Mount Singai, but they were having high similarity of bird's composition. Mount Jagoi and Mount Singai shared 19 bird species based on available data, where more than 70% of bird species at Mount Singai are present at Mount Jagoi. This may be resulted from similar habitat and food sources at both areas. The prediction analyses showed that 32 species should be shared between the two mountains; and for further survey of 300 individuals, 10 new species should be discovered at both mountains.

Key words: bird community, species diversity, species similarity, shared species

ABSTRAK

Burung adalah berguna untuk menentukan jenis hutan dan ia penting untuk mengawasi persekitaran. Kajian ini menumpu kepada komuniti burung di Gunung Jagoi dan Gunung Singai di Bau, Sarawak dari segi kepelbagaian, persamaan dan perkongsian spesis. Burung di Gunung Jagoi ditangkap dengan menggunakan jaring dari 8 hingga 12 Ogos, 2011, 8 hingga 12 November, 2011, and 2 hingga 6 Februari, 2012. Sebanyak 298 individu dari 53 spesis dan 22 keluarga direkodkan di Gunung Jagoi; dan sebanyak 127 individu dari 26 spesis dan 12 keluarga telah direkodkan di Gunung Singai. Spesis yang paling dominan ialah Little Spiderhunter (Arachnothera longirostra); family yang dominan ialah Pycnonotidae dan Timaliidae. Ia didapati bahawa komuniti burung di Gunung Jagoi adalah lebih kaya dan lebih pelbagai berbanding dengan Gunung Singai, tetapi kedua-dua gunung mempunyai persamaan yang tinggi dari segi komposisi burung. Gunung Jagoi dan Gunung Singai mempunyai 19 spesis burung yang sama, di mana lebih daripada 70% spesis di Gunung Singai didapati wujud di Gunung Jagoi. Ia mungkin disebabkan oleh habitat dan sumber makanan yang lebih kurang sama di kedua-dua kawasan. Analisis menganggarkan bahawa kedua-dua gunung tersebut sepatutnya mempunyai 32 spesis yang sama; bagi 300 individu kajian seterusnya, 10 spesis yang baru dianggarkan akan diperoleh di kedua-dua gunung ini.

Kata kunci: komuniti burung, kepelbagaian spesis, persamaan spesis, perkongsian spesis

1.0 INTRODUCTION AND OBJECTIVE

Clout and Hay (1989) stated that birds are one of the significant indicators on forest types. Some bird species such as New Zealand pigeon (*Hemiphaga novaeseelandiae*) are actually selective browsers on certain plants and the presence of this bird is useful to indicate the forest's vegetation. Birds are also important for environmental monitoring since they ecologically function as predator, seed dispersers, pollinators and control of insect population.

According to Gill and Donsker (2011), there are around 10,448 of bird species found in the world and they have been classified into 40 orders, 233 families and 2233 genera. A total of 622 bird species including migratory birds and 39 endemic species have been recorded in Borneo (Smythies, 1999). It has been updated to 633 species with 50 endemic species recorded in Borneo (Myers, 2009), which covered about six per cent of world's bird species. Since birds' diversity study can be used as a tool to conserve the global diversity (Campbell and Reece, 2002), the birds' diversity study had become crucial right now due to current threat to biodiversity.

Mount Jagoi, with its highest peak at 352m is located in Bau district, about 39km southwest of Kuching City, Sarawak, Malaysia. Bung Jagoi village is situated close to the top of Mount Jagoi. There is only one family staying in the village at this moment. Numerous orchards, farm land, plantations and rubber gardens are situated at the foot of the mountain. There is mature secondary forest near the top of the mountain with a number of fruit trees such as durian (*Durio zibethinus*) and cempedak (*Artocarpus integer*) along the trail to the peak of Mount Jagoi which are possibly visited by forest mammals or birds.

Approximately 20 kilometres northeast of Mount Jagoi is Mount Singai, which is higher at 562m. It is a pilgrimage site where the Catholic Memorial and Pilgrimage Centre (CMPC) is situated near to the mountain slope. There were also the traditional Bidayuh longhouses located at the mountain since 40 years ago. Several human settlements dotted the foot hill such as Kampung Tanjong Bowang and Kampung Atas. The foot hill is comprised of orchard and secondary regrowth. Small waterfall can be found at lowland which is less than 100m elevation. Along the way up to the mountain, the vegetation is lush with plenty of palms, ferns, bamboos and fruit trees such as durian.

Since the two mountains are located relatively a short distance apart in geographical scale, i.e. a mere 20km, one would expect the bird diversity of Mount Jagoi and Mount Singai to be similar.

The main objective of this study is to survey the understorey bird communities at Mount Jagoi. The secondary objective is to compare the understorey bird between Mount Jagoi and Mount Singai in terms of species diversity, species similarity and shared species. Thus the hypothesis is,

H_o: There is no significant difference on species diversity between Mount Jagoi and Mount Singai.

H_A: There is significant difference on species diversity between Mount Jagoi and Mount Singai.

2.0 LITERATURE REVIEW

2.1 Related Previous Studies

2.1.1Related Studies near Mount Jagoi

There is no recorded scientific survey that had been done in Mount Jagoi. Setia (2011) conducted a preliminary study on the bird diversity at Mount Singai from 13th to 18th September, 2010, and 3rd to 8th December, 2010; 26 bird species were captured by setting up 30 mist nets. Little Spiderhunter (*Arachnothera longirostra)* was the dominant species in this study. Rufous-collared Kingfisher (*Actenoides concretus*), Green Broadbill (*Calyptomena viridis*) and Short-tailed Babbler (*Malacocincla malaccensis*) which are classified as near threatened species, were caught during this study. Shannon diversity index showed there was no significant difference of bird diversity at both elevations. According to Setia (2011), the birds are probably adapted to human presence. However, there was high species similarity between both elevations and the areas studied calculated using Chao-Jaccard-Estimate Abundance-based and Chao-Sorensen-Estimate Abundance-based in EstimateS program.

A bird's study was conducted by Ng (2006) in three different fallows of varying ages in Kampung Serasot, Bau, Sarawak which is about 5km away to the east of Mount Jagoi. Little Spiderhunter was the only similar species for three plots and this species was also the most dominant species of five and 20 year plots. She found out that there was no significant different of bird diversities between five year plot, 20 year plot and 30 year plot using Shannon diversity index. However the bird species was dissimilar in term of composition in each site and it was mainly caused by different vegetation in each site.

A study of understory bird of limestone area near Fairy Cave, Bau, Sarawak was conducted by Rostina (2004) for six days. Fairy Cave is about 9km to the northwest of Mount Jagoi. A total of 33 species from 101 individuals were mist netted at areas outside the cave and farm land of ethnic Bidayuh's village. The dominant species captured was Mossy-nest Swiflet (*Aerodramus salangana*) as the study area is near to Fairy Cave and Little Spiderhunter was the second dominant at these study areas. Shannon index showed the species diversity at farm land was higher compared to the area outside Fairy Cave.

These studies have some similar characteristics where the study sites were near to human settlement. Although vegetation types are different, the Little Spiderhunter was still the most abundant species in those study areas. This information is important as it shows that the species diversity and composition within an area is depending mainly on availability of food sources and followed by vegetation types.

2.1.2 Other Related Studies

A study on bird diversity was carried out by Buloh *et al.* (2008) from 16^{th} to 23^{rd} August 2008 in Gunung Sewa, Kampung Giam, Padawan using mist-netting. The study site is about 27km from Mount Jagoi in the south-eastern direction. This study was aimed to determine the abundance and diversity of bird species between the orchard and the limestone forests. A total of 27 species and 14 families were recorded. Out of 27 species captured at Gunung Sewa, eight species were captured in orchard while 10 species were captured in limestone forest. At the same time, nine species can be found in both sites. Little Spiderhunter was the most abundant species with 20 individuals captured during the sampling period. Buloh *et al.* (2008)

stated that there was significant difference in species diversity between orchard area and limestone area.

In August 2009, Leow *et al.* (2009) conducted another study in Padawan at Gunung Regu, Kampung Temurang to determine the abundance and diversity of bird species between scree forest and limestone forest (doline). A total number of 117 individuals comprising of 34 species from 14 families were caught during six days sampling period. Two endemic species were caught, namely Bornean Blue-flycatcher (*Cyornis superbus*) and Yellow-rumped Flowerpecker (*Prionochilus xanthopygius*). This study concluded that there was a significant difference in species diversity between the scree forest and the doline.

Bird diversity study at Mount Serapi, Kubah National Park, Matang, Sarawak and nearby area which is about 29km northeast of Mount Jagoi were conducted during the period of June 1994 to April 1996 (Gregory-Smith, 1997). A total of 125 species were recorded at Mount Serapi, comprising 15 species of sub-montane or hill-slope by observation and mist-netting. Four endemic species which are Rufous-fronted Babbler (*Malacopteron magnum*), Chesnut-crested Yuhina (*Yuhina everetti*), Yellow-rumped Flycatcher (*Ficedula zanthopygia*) and Dusky Munia (*Lonchura fuscans*) found at Mount Serapi.

A study on bird's diversity at different elevation of Mount Serapi at Kubah National Park, Sarawak was carried out by Razali (2007). Samplings were done within 27th to 1st August, 2006, and 2nd to 6th December, 2006. The results shown that there were 58 bird species from 19 families had being captured. At the same time, Little Spiderhunter was the most abundant species at Mount Serapi followed by Red-eyed Bulbul (*Pycnonotus brunneus*). Analyses showed that the species diversity at Mount Serapi was no significant different between elevations but different in terms of species composition.

A study on diversity and abundance of bird at primary and secondary forest at Kubah National Park was conducted by Fauzi (2007) during August and December 2006 for four days each. Forty one species were caught and Little Spiderhunter was the most abundant species recorded during this study. Besides, the composition of bird communities was different between primary and secondary forest. Moreover, there was significant different of bird diversity between dry season and wet season.

2.2 Species Richness Estimation

Species richness estimation is the basic and tremendously useful method to measure the diversity if the study area is delimited in space and time (Magurran, 1988). However, its accuracy is influenced by three main factors which are the number of individual sampled, relative abundance distribution and sampling effort (Gotelli and Colwell, 2001). Non-parametric estimator of species richness are widely used compared to parametric estimator as it avoids making assumptions about species discovery rates and gives better approach for species richness estimation (Colwell and Coddington, 1994; Magurran, 2004). Some of the examples of non-parametric estimators are Chao estimators and Jackknife estimators.

2.2.1 Chao1 and Chao2 Richness Estimators

Chao1 is a simple estimator developed by Chao (1984). Singletons and doubletons are used in estimating the species richness as they carry most of the information of unseen species (Chao, 1984). Since the Chao1 estimator is subject to availability of abundance data, it was modified by Chao (1987) known as Chao2 estimator which taking accounts the frequencies of uniques and duplicates in incidence data. However, there is a loophole in both estimators where the estimators will breaks down when doubletons in abundance data or duplicates in incidence data is absent. Hence, these estimators are revised and developed to a bias-corrected formulation (Chao, 2005).

2.2.2 Abundance-based and Incidence-based Coverage Estimators

Abundance-based Coverage Estimator (ACE) was proposed by Chao and Lee (1992). Species richness is estimated through separating the observed species into two groups which are rare and abundant groups. The rare groups are important for the estimation of the number of unseen species. A cut-off points (10 individuals) obtained from empirical evidence is suggested where the rare groups are represented by species with one up to 10 individuals, and the abundant groups are represented by species with more than 10 individuals (Chao *et al.*, 1993). Incidence-based Coverage Estimators (ICE) was proposed later by Lee and Chao (1994). It requires incidence data and is concentrated on species observed in less than 10 samples (Magurran, 2004).

Coefficient of variation (CV) is an important approach for both ACE and ICE to measure the degree of heterogeneity among species detection probabilities for rare species (Chao *et al.*, 2000). The larger the CV, the greater the degree of heterogeneity among species detection probabilities.

2.2.3 Jackknife estimators

Jackknife estimators are originally used for capture-recapture study to estimation the population size; it is subsequently modified to first-order Jackknife and second-order Jackknife for species richness estimation used (Burnham and Overton, 1979; Smith and van Belle, 1984). Both estimators have been designed for both the abundance and incidence data to meet the ecologists and statisticians' need. First-order Jackknife uses only singletons or uniques to estimate the species richness. Unlike the first-order Jackknife, the second-order Jackknife is similar with Chao2 estimator where it includes the singletons and doubletons or uniques and duplicates for the species richness estimation.

2.2.4 Bootstrap Estimator

Bootstrap method is an alternative method of measuring species richness from quadrat samples by obtaining results from simulation on computer (Krebs, 1999). It is a popular method to estimate the accuracy of ecological indices via confidence interval or standard error (Dixon, 2001). Although this estimator and its variance were developed originally for quadrate sampling, the procedure can be used for other type of sampling (Chao, 2005). After a sufficient number of bootstrap estimates are computed, their average is taken as the final estimate (Chao, 2005).

2.2.5 Rarefaction

Rarefaction method was proposed by Sanders (1968) and it had been discussed by Krebs (1999) and Magurran (2004). It standardizes different samples sizes from different communities to produce a smooth species accumulation curves (Krebs, 1999; Magurran, 2004). The comparison of species richness can be made where the larger community is rarefied down to the smaller community with either sample-based or individual-based data (Colwell, 2009b; Gotelli and Entsminger, 2011).There are some limitations on the use of rarefaction where the communities should be taxonomically similar, same sampling methods and the assumption of individuals are randomly dispersed in the community (Krebs, 1999; Magurran, 2004).

2.3 Species Diversity Estimation

Species diversity can be separated into two distinct categories which are species richness and species evenness. Simpson's index and Shannon's index are the most commonly used indices to measure the species diversity where these indices cover both species richness and evenness (Colwell, 2009a).

2.3.1 Simpson's Index

Simpson's index is the first nonparametric diversity measure proposed where it emphasizes the most abundant species rather than species richness (Magurran, 2004). It is measured by using the proportion of individuals in each species to estimate the diversity of extremely large community. It ranges from 0 (low diversity) to almost 1.

2.3.2 Shannon's Index

The most popular and widely used diversity index is Shannon's index. It focuses more on rare species and tends to highlight the richness of a community by obtaining the information such as the number of species and the number of individuals in each species (Krebs, 1999; Mouillot and Lepretre, 1999; Magurran, 2004). The value of Shannon index is normally fell within 1.5 to 3.5.

2.4 Shared Species Estimation

The number of shared species can be used as a measure of similarity between two communities. However, the observed number of shared species is usually treated as the real number of shared species in particular community; but there might have some undiscovered shared species in the incomplete survey (Chao *et al.*, 2000). Thus, Chao *et al.* (2000, 2006) had developed shared species approach which uses the concept of sample coverage to estimate the shared species between two communities.

2.5 Species Similarity Estimation

Species similarity and dissimilarity estimators are used to compare the species composition and diversity within two or more study sites using quantitative data (Magurran, 2004). Jaccard index and Sorensen index which measure the species similarity based on incidence or abundance data are the most widely used indices (Magurran, 2004; Chao *et al.*, 2005).

2.5.1 Jaccard Index and Sorensen Index

Jaccard index and Sorensen index are closely related to each other. Classis Jaccard index and Classic Sorensen index are basically computed using incidence data from two communities (Magurran, 2004). The range is from zero (no similarity) to one (complete similarity). The values of both indices will small if the richness of one community is much larger than another one; it truly expresses the differences of species composition between the communities (Jost *et al.*, 2011). However, both indices usually biased downward estimation when the sampling is incomplete due to their sensitivity to sample size and species richness (Chao *et al.*, 2005). Chao *et al.* (2006) adjusted these two indices to reduce the bias that effected by dominant species and the ignorant of rare species.

2.5.2 Morisita-Horn Index

Morisita-Horn index is one of the widely used and satisfactory similarity estimators. The value of modified Morisita index is from zero (no similarity) to about one (complete similarity). It is abundance-based similarity index where it focuses on the differences of relative abundances of each species in two communities; and this resulted to the ignorance of rare species (Jost *et al.*, 2011). In fact, this estimator is influenced by species richness and sample size (Wolda, 1981).

2.6 Species Prediction

Species prediction is necessary in assisting the management and conservation of biological communities. According to Shen *et al.* (2003), there are two types of approaches which used to predict the number of new species; one approach is extrapolation and another one is based on statistical sampling model. It is important to forecast the number of new species that probably appear in the future survey because complete species inventories are almost unachievable goal (Boneh *et al.*, 1998; Shen *et al.*, 2003).

Several predictors were formulated through different aspects including Efron and Thisted (1976), Boneh *et al.* (1998), Solow and Polasky (1999) and Shen *et al.* (2003). Keating *et al.* (1998) compared 11 predictors and developed some recommendation on how to choose the best predictors for different studies. Recently, Shen *et al.* (2003) found out Solow and Polasky's methods and predictor proposed by Shen *et al.* (2003) were among the more stable and accurate approaches.

2.7 Programs to Estimate Species Diversity, Species Similarity and Shared Species

With the advance technology for analysis procedures, species diversity, similarity and shared species estimation can be computed from developed software tools such as PAST (Hammer *et al.*, 2001), EstimateS (Colwell, 2009b), or SPADE (Chao and Shen, 2010).

2.7.1 EstimateS Program

EstimateS (Statistical Estimation of Species Richness and Shared Species from Samples) software was developed by Colwell (2009b). Colwell (2009b) stated that more than 60,000 users in more than 100 countries have downloaded EstimateS and 237 publications recognized that cited EstimateS. Its computing features are more focus on numerous biodiversity functions, estimators, and indices based on biotic sampling data. The common species diversity and similarity estimators such as Simpson index, Shannon index, Jaccard index and Sorensen index can be calculated from this software. Researchers such as De Silva and Medellin (2001), Raman and Sukumar (2002), and Sekercioglu (2002) had used it to estimate bird diversity.

A case study of Mexican land birds was carried out by De Silva and Medellin (2001). They compare bird species assemblages within six study areas and seven biological stations in Mexico mainland; using EstimateS software to estimate the species diversity. They found out that seven families and two genera of land birds are widely spread in Mexico mainland.

Raman and Sukumar (2002) studied that responses of tropical rainforest birds to abandoned plantations, edges and logged forest in the Western Ghats, India. By using EstimateS to calculate species diversity and similarity, they concluded that bird communities were more similar within sites with more similar in tree species composition. Besides, the results shown the rare, large-bodied birds were affected by habitat alternation.

Sekercioglu (2002) used EstimateS to estimate species richness and similarity to study the effects of forestry practices on four vegetation structure and bird community in Kibale National Park, Uganda. Through the analyzed results, forest-dependent birds occur mostly in unlogged native forest and followed by selectively logged forest at low intensity. The results shown the abundance and species richness of birds were highest in unlogged or lightly logged forests.

2.7.2 SPADE Program

SPADE (Species Prediction and Diversity Estimation) program is introduced by Chao and Shen (2010) to provide various biodiversity estimations based on different kinds of sample data obtained from one to multiple communities. It contains the estimators for species richness, shared species richness in two communities, prediction the number of new species, diversity and similarity indices, multi-community diversity measure and also genetic analysis on allele similarity and differentiation. SPADE is recently used by researchers such as MacGregor-Fors and Schondube (2011) to conduct statistical analysis of bird studies.

MacGregor-Fors and Schondube (2011) surveyed the tropical dry forests and agricultural areas used by neotropical bird communities in the Pacific coast of Jalisco, Mexico. SPADE was used to determine the sufficiency of survey effort on the bird communities in their study sites. They observed the tropical dry forests had the highest species richness and evenness. Cattle pastures habitat and cropfields had low species richness and evenness values compared to tropical dry forests. In the end of this survey, it shown that the bird community structure, diversity and composition were different between tropical dry forest and agricultural habitats.

2.7.3 Similarity and Difference between Programs Used

EstimateS and SPADE are using the same formulation of estimators to compute the data in which the way these programs present the data analysed is different. EstimateS computes the data by showing the accumulated or value for each sample while SPADE gives the exact results of estimators. Analysed data from EstimateS has to be transferred into Microsoft Excel, a graphing application to visualize the data. Some estimators are only available in certain software such as species prediction estimators are only accessible in SPADE but not EstimateS. Therefore, these programs have their own advantages and give options to researchers to choose the best way to present and explain their findings. Table 1 below shows the comparison of those programs.

Table 1. Comparison of EstimateS and SPADE programs.

Programs / Particulars	EstimateS	SPADE
Formulation	Same	Same
Output	Value is provided for each sample, Accumulated value	Exact value
Graph application	Available, Need to export to Microsoft Excel	Not available
Species richness indices	Yes	Yes
Diversity indices	Yes	Yes
Significant test	No	No
Shared species estimators	Yes	Yes
Species similarity indices	Yes	Yes
Species prediction	No	Yes

3.0 MATERIALS AND METHODS

3.1 Study Sites

This study was conducted in Mount Jagoi which is located at Bau district, Sarawak (Figure 1). Field works were carried out at four study sites, namely Site A (N01º20.807' E110º02.383', approximately 69m above sea level), Site B (N01°21.182' E110°02.057', approximately 239m above sea level), Site C (N01°21.938' E110°02.395', approximately 103m above sea level) and Site D (N01°21.551' E110°02.277', approximately 340m above sea level). Site A and Site B are located near to Kampung Duyoh, Site C is located near to Kampung Serasot and Site D is located near to the summit of Mount Jagoi.

Figure 1. Location of study sites at Mount Jagoi, Bau district, Sarawak. (Google Earth, 2012)

At Mount Singai, four study sites were conducted together with Setia (2011). Those study sites were Site A (N01°30.478' E110°10.477', approximately 96m above sea level), Site B (N01°30.351' E110°10.547', approximately 151m above sea level), Site C (N01°30.177'