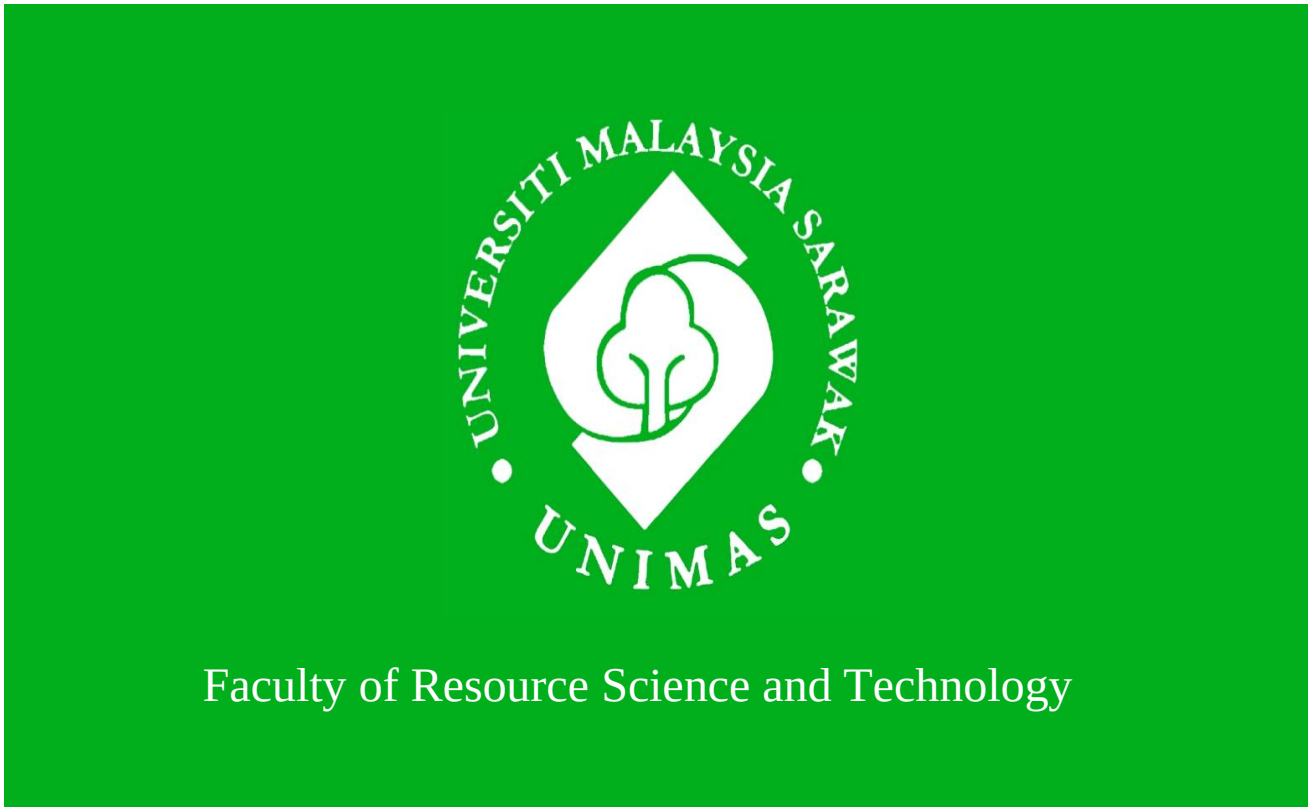

MODELLING DISTRIBUTION OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) OF SEVERAL DIVISION IN SARAWAK BY USING SECONDARY DATA

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Bachelor of Science with Honours
(Animal Resource Science and Management)
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This project is submitted in partial fulfillment of the requirements for a
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DECLARATION

I hereby to declare that no portion of the work referred to in this dissertation have been submitted in support of an application for another degree or qualification to this university or any other institution of higher learning.

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LIST OF ABBREVIATION

HDF	High dipterocarp forest
MDF	Mix dipterocarp forest
GIS	Geographical Information System
GPS	Global Positioning System
SFRC	Sarawak Forestry Research Centre
ARSC	Agriculture Research Centre Semongok
FRST	Faculty Resource Science Technology
AIC	Akaike's Information Criteria
GLM	Generalised Linear Model
MAXENT	Maximum Entropy
nsp	Number of species
hab	Habitat type
dis	Disturbance effect
sea	Seasonal effect
rain	Rainfall distribution
ind	Number of individual

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Modelling Distribution of Fruit Flies (Diptera: Tephritidae) of several Division in Sarawak by using Secondary Data

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ABSTRACT

This study was conducted to identify the distribution of Tephritidae fruit flies in Kuching until Sarikei division in Sarawak by relate the distribution of fruit flies to the environmental variables such as habitat type, disturbance effect, seasonal effect, and rainfall distribution. A total of 118 occasions and 13 species were recorded between year 2003 and 2011. The data collection was transformed into responding variables and predictive variables and analysed using the R-project software. All of the variables were analysed by using Generalised Linear Model (GLM). The Akaike's Information Criteria (AIC) value showed that all of predictive variables effect distribution of fruit flies. Futher analyses had been done for six species of Genus *Bactrocera* which are *B. papayae*, *B. dorsalis*, *B. umbrosa*, *B. cucurbitae*, *B. carambolae* and *B. tau*. Result showed seasonal effect and rainfall distribution affected distribution of *B. umbrosa* with AIC value (579.609), *B. cucurbitae* (766.405) and *B. tau* (255.891). Besides that, *B. carambolae* and *B. dorsalis* showed lowest AIC value in disturbance effect with value *B. carambolae* (344.174) and *B. dorsalis* (570.158). Meanwhile, habitat type, disturbance effect, seasonal effect and rainfall distribution were affected distribution *B. papayae* (1210.676). The result from this study hopefully can aid in pest management especially in Southern part of Sarawak.

Key: *Tephritidae fruit flies, Modelling, Southern Sarawak, AIC values, GLM*

ABSTRAK

Kajian ini dijalankan bagi mengkaji taburan lalat buah Tephritid (Dipetra: Tephritidae)di bahagian Kuching sehingga Sarikei negeri Sarawak dengan mengkaji taburan lalat buah dan pemboleh ubah alam sekitar iaitu jenis habitat, kesan gangguan, kesan musim dan taburan hujan. Sebanyak 118 peristiwa dan 13 spesis telah dikumpul dari tahun 2003 sehingga 2011. Koleksi data ditukar kepada pemboleh ubah berkadaran dan pemboleh ubah prediktif. Ramalan bagi pemboleh ubah yang paling mempengaruhi taburan lalat buah ditentukan menggunakan perisian R-project. Kesemua pemboleh ubah telah di analisis menggunakan "Generelized Linear Model" (GLM). Nilai "Akaike's Information Criteria" (AIC) yang dihasilkan menunjukkan bahawa kesan musim dan taburan hujan mempengaruhi taburan bagi lalat buah. Analisis bagi nilai AIC diteruskan bagi enam spesis iaitu B. papayae, B. dorsalis, B. umbrosa, B. cucurbitae, B. carambolae **dan** ***B. tau. Hasil dari nilai AIC menunjukkan kesan musim dan taburan hujan mempengaruhi taburan B. umbrosa (579.609), B. cucurbitae (766.405) dan B. tau (255.891). Selain itu, terdapat dua spesis manghasilkan nilai AIC paling rendah bagi pemboleh uabah kesan gangguan iaitu B. carambolae (344.174) dan B. dorsalis (570. 158). Disamping itu, jenis habitat, kesan gangguan, kesan musim dan taburan hujan mempengaruhi taburan B.papayae (1210.676). Hasil daripada kajian ini yang menunjukkan taburan lalat buah di selatan Sarawak di harap dapat membantu di dalam proses pengurusan haiwan perosak.***

Kata kunci: lalat buah Tephritid, Permodelan, Sarawak selatan, nilai AIC, GLM

1.0 INTRODUCTION

Documentation of Tephritidae was carried out from October 2011 to May 2012. The objectives of the study were to compile the data of fruit fly (Diptera : Tephritidae) in certain division of Sarawak thus knowing current status of this family in Sarawak. Second, this study aimed in mapping the current distribution of Tephritidae by using secondary data. Besides that, this project aimed in identifies the environmental variables which favorable in affecting the distribution of fruit flies and be able to assist in the management plan of fruit flies in Sarawak.

According to Korneyer (1999), there are six subfamilies under Tephritidae which are Dacinae, Trypetinae, Tephritinae, Phytalmiinae, Tachiniscinae and Blepharoneurinae. Besides that, a number of 52 species under subfamily Dacinae have been recorded in Malaysia (Tan, 2004). Furthermore, a recent study done by Ferrar (2010) stated that Tephritidae is known as the origin fruit fly from Asia Pacific.

Life cycle of fruit fly is started when eggs are laid by the female in host fruit and this cycle continues until the larvae were evolved (Ferrar, 2010). According to Tan (2004), after the larvae matured it will thickened its skin to form pupa before changing to an adult and the adult of fruit fly emerged within 7-14 days. Based on Tobin (1990), the life cycle of fruit fly is completed once mating between mature and the fresh fruit is infested. Hill and Abang (2010) noted that larvae of Tephritidae family are phytophagous and live inside the developing fruits while the pupa stage take place inside the soil.

Fruit fly is widely known pest. According to Steek (2006), *Bactrocera dorsalis* is a phytophagous pest which usually attacks commercial fruits such as citrus, mango, peach and plum, other than that this species also help in pollination of coffee, chili and pepper. For example, the melon fly, *B. cucurbitae* breeding sites includes cucumber, melons, squash and pumpkin. This species also attacks the flower, stem and roots of plants (Steek, 2006).

Even though fruit fly is famously known as pest it also played an important role as the important member food cycle in particular population for example in the amphibian food cycle. In addition, fruit flies also have a variety role in ecology.

Table 1: List of fruit fly belonging to species subfamily Dacinae recorded in Malaysia (Ferrar, 2010)

Species name	Common name	Host fruit range
Bactrocera carambolae	Carambola fruit fly	Different families
Bactrocera cucurbitae	Melon fly	Cucurbitae ,other families
Bactrocera papayae	Papaya fruit fly	Different families
Bactrocera latifrons	Solanum fruit fly	Solanaceae, other families
Bactrocera dorsalis	Oriental fruit fly	Different families

This study used secondary data obtained from the UNIMAS Zoological Museum, Museum of Sarawak, Agricultural Research Centre Semengok (ARCS) and previous study. All of the data were analysed using Software program R-project (The R Foundation) by performing the Generalised Linear Model (GLM) that will be combined together to form predictive mapping of Tephritidae in Sarawak by analyzing the Akaike's Information Criterion (AIC) value.

There is a need to study the distribution of Family Tephritidae in Sarawak. Nevertheless, the previous studies Ismail (2007) and Hashim (2009) only covered the diversity and behavioral aspect only. Furthermore, there are insufficient data determinig distributions of this family in Sarawak.

2.0 LITERATURE REVIEW

2.1 Geographical review

According to Smythies (1960), Sarawak is situated at the north-west coast of Borneo covered with 48,300 square miles in area. Forest type in Sarawak are tropical evergreen type and the Dipterocarpacaeae family has monopoly most of the forest in Sarawak with about 300 species recorded (Smythies, 1960).

Benders-Hyde (2002) stated that tropical rainforest are mostly dominated by tree Dipterocarpacae family. Tropical rainforest can be divided into two parts which are high dipterocarp forest (HDF) and mixed dipterocarp forest (MDF). These trees are the habitat for many animals to get their food. Here, there are variety of relationships between animal and animal or animal and plant. Besides, some animal and insects also play a vital role in pollinating rainforest plant (Park, 1992).

Limestone forest is well known for the richness of calcium carbonate. Usually, there is 95% of calcium carbonate in limestone. There are estimates of 600 species of insect on limestone at hills of Sarawak. Frankham *et al.* (1952) pointed out that limestone at Sarawak supply great range of plant habitat.

Secondary forest is a forest that has already being disturbed by human activity and abandonment result from clearing of natural forest for shifting cultivation. According to research done by Caro and Girling (2010), fruit fly has the same species richness with moth, grasshopper, scavenger flies, and orchid bees in secondary forest.

2.2 Family review

Leong (1988) conducted study on seasonal fluctuation of *Dacus dorsalis* complex from May 1986 to June 1988. The study site was at guava orchard at Stapok Peat Experimental Station, Kuching and carambola orchard at Sg. Pinang, Bau. He managed to catch high percentage of *Dacus dorsalis* males while only little percentage of *D. umbrosa* and *D. cucurbitae*. This study concluded that, the major pest for guava and colembola was *D. dorsalis*.

Leong (1995) later on studied the biological control of fruit flies in Thailand and Malaysia. They found that from August 1991 to September 1993, 20 species of fruit flies were detected in Sarawak. From 1086 host fruits, only 122 fruits collected were detected with fruit fly. Result from this study indicated that *B. papayae* possessed the greatest diversity among others species.

Another study done by Vijaysegaran (1996) was on distribution of species under the genus *Bactrocera*. The data compiled from White and Elson-Harriss (1992) resulted on two species of *Bactrocera* namely *B. umbrosa* and *B. latiforns*. *B. umbrosa* attacked breadfruit and jackfruit while *B. latifrons* attack chili, tomato, and solanaceous crops.

Moreover, a study done by Drew (2004) showed that, Dacinae sub family is endemic to IndoMalayan rainforest which included Indonesia, Thailand, Malaysia and Papua New Guinea and the genus *Bactrocera* is endemic to South East Asia. Similar environment and tropical rainforest are the factors which contribute to the similar endemic species (Chua, 2010).

According to Ismail (2007), the most abundance species collected from Kota Samarahan was *B. dorsalis*. This study managed to capture 402 numbers of individuals, and followed by the *B. umbrosa* with 69 individuals. A number of 18 individuals of species *B. cucurbitae* and four individuals of *B. albistrigata* were also captured.

Another study done by Hashim (2009) on the relationship between colour preference of traps and the distribution of Tephritidae in Kota Samarahan, Sarawak were also conducted. The study sites included Kampung Tanjung Bundong, Kampung Muara Tuang, Kampung Meranek and IADA Samarahan. This study also resulted on the abundance of *B. dorsalis* in Samarahan area.

However, Cheng *et al*. (2010) did not find any record on fruit fly from the Arboratum forest in UNIMAS campus. A study by Chua (2010) found a new species of Tephritidae, namely, *Dacus (Callantra)* that is detected at Southern Thailand, Indonesia, Peninsular Malaysia and Sarawak.

2.3 Modeling review

A study done by Leyequien *et al.* (2007) related to the capturing of fugitive by applying remote sensing to terrestrial animal distribution and diversity. This paper revealed the uses of remote sensing in assessing the terrestrial fauna diversity which deal with mammals, birds, reptiles and invertebrates. The data analysis is done by using GIS to predict the species distribution.

Nakato and Ayanlade (2009) had study on mapping the distribution of tsetse flies in Eastern Uganda, Nigeria. This study shows how GIS and remote sensing computed data on land use and land cover uses. Besides that, this study aimed to build a tsetse control programme by using environmental data and remote sensing software. Result from this study showed that the decreasing habitat for tsetse flies at eastern Uganda is due to land clearance for development.

A study on predicting species distribution from checklist data using site –occupancy models by Kery *et al.* (2010). This study emphasized on the species distribution of order Odonata in Switzerland by using secondary data. This study had made comparison with the conventional distribution model in which the result showed that there is wrong estimation in this model. They concluded that, conventional distribution model is not modelling species distribution per species but more to distribution of apparent

Site – occupancy model is a "method used to estimate detection probabilities of individual animals (and hence abundance) at each site are frequently expensive of time and effort" (Mackenzie, 2002). In other hand, the detection animal will be recorded as presence and the undetected animal refer as absence but there are negative biased when the undetected species actually presence during the sampling time (Mackenzie, 2002). Further more, Crossland *et al.*

(2005) stated that the site occupancy model will estimate the number of sites occupied by the species in an area and number of individuals present in an area.

According to Pearson (2007), a modeling technique uses combined information between environmental variables and known species occurrence records to identify environmental conditions. The environmental variables employed in the species distribution modeling were including temperature and precipitation. These variables were used to describe the abiotic environment.

A study by Phillips *et al*. (2006) was emphasised on the using of Maximum Entropy (MAXENT) in model the species distribution of Neotropical mammals which were *Bradypus variegates* and *Microryzomys minutus* by using the presence data. The environmental variables used for this study were climate, elevation and the potential vegetation. The study showed that, MAXENT model prediction is constant and have very well topographic data.

3.0 MATERIAL AND METHOD

3.1 Study Site: Kuching until Sarikei division

This study covered several part Sarawak including Samarahan Bau, Siburan, Tebedu, Simunjan, Padawan, Lundu, Sri Aman and Sarikei. Figure 1 shows map of Kuching, Samarhan, Sri Aman, Betong and Sarikei division (www.sarawak.gov.my). Samarahan division consists of Kota Samarahan, Serian, Simunjan, and Asajaya, while Bau, Lundu and Siburan were under the Kuching division.

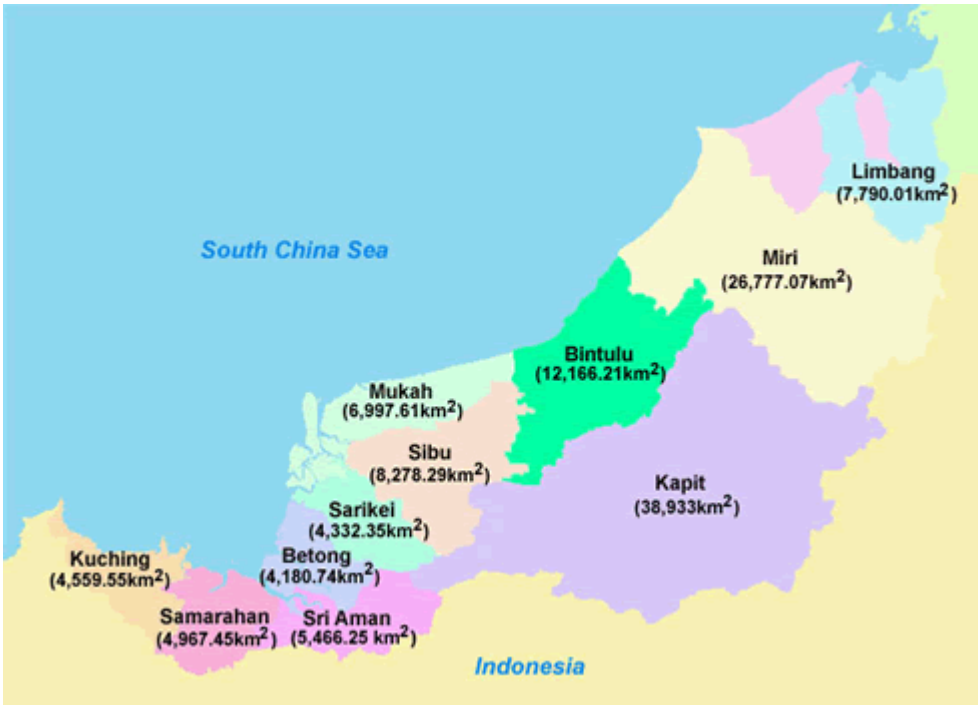

Figure 1: Map of Kuching until Sarikei division

3.2 Data Collection

The study was conducted by collecting the secondary data of family: Tephritidae of Southern part of Sarawak. The data for this study was collected from UNIMAS Zoological Museum, Agricultural Resource Centre Semongok (ARSC), published journal and previous studies of

final year student projects (FRST). The extracted data were then fitted in a table. By using the Microsoft Excel programme the list of Tephritidae was recorded and presented based on locality, Global Positioning System (GPS) reading, number of sample in occasion, number of individuals, number of species, habitat type, disturbance effect, seasonal effect, and rainfall distribution.

3.3 Data analysis

The data analysis was done by performing the R-project software and Tinn-R text editor (Appendix 3). The analysis were run by comparing the responding variables (occasion, number of sample in occasion, number of individuals and number of species) with the predictive variables (habitat type, disturbance effect, seasonal effect, rainfall distribution). The result was produced by analysing the value using the Generalised Linear Model (GLM), which then evaluated the Akaike's Information Criteria (AIC) values. The mapping of every locality was also conducted by comparing with the predictive variable.

3.3.1 Variables

Variables used for this study were responding variables and predictive variables. The responding variable of this study were the number of occasions, number of individuals, and number of species. For the predictive variables, the habitat type, disturbance effect, seasonal effect and rainfall distribution data were used. All of these variables were collected and categorised according their characteristic as shown in Table 2.

3.3.2 R- Software

R software is a software used to analyse environmental variable and diversity data. According to Seefeld and Linder (2007), R is a designation application to do calculation, manipulate data and result in graphical display of data. R software is so flexible which it can complete most of data analysis tasks. Besides, the software also easily to apply as it do not have any license restriction, thus it can be downloaded freely from R project web site which is http://www.r-project.org/.

3.3.3 Generalised Linear Model

According to Gill (2000), Generalized Linear Model (GLM) is a method which results in producing the model parameter estimator. In this study, GLM is used to synthesize the responding variable (number of species) and the predicting variable (habitat type, disturbance effect, seasonal effect, and rainfall distribution.

According to Luikko (2007), the lowest AIC value shows the best models to be used. Therefore, in this study variables with the lowest value was the major variable which effecting the distribution of Tephritidae in Southern Sarawak. The AIC is formulated as shown bellow:

$$AIC=2k - 2\ln(L)$$

K= number is the number of parameters in the statistical model

L= maximized value of the likelihood function for estimated model.

Table 2: The predictive variables and its values

Predictive variables	Maximum and minimum value
Habitat type:	
Limestone area	1
Urban area	2
Rural area	3
Shrub area	4
Secondary forest	5
Peat swamp area	6
Mixed dipterocarp forest	7
Kerangas forest	8
Disturbance effect:	
Disturbed	1
Mild	2
Less	3
Seasonal effect:	
Southwest monsoon seasonal	1
Northeast monsoon seasonal	2
Rainfall distribution:	
Low	1
High	2

4.0 RESULTS AND DISCUSSION

4.1 Species Composition

A total of 118 localities were recorded in this study which covered the lower division of Sarawak. The sites include Samarahan, Siburan, Bau, Lundu, Simunjan, Serian, Padawan, Tebedu, Sri Aman and Sarikei. The data collection was successfully compiled the number of species and individuals at this division from year 2003 until 2011 (Table 3) represented by *B. papayae*, *B. cucurbitae*, *B. umbrosa*, *B.carambolae*, *B. dorsalis*, *B. caudata*, *B. tau*, *B. albistragata*, *B. nigrotibialis* , *B. apicalis*, *B. vultus*, *B. alrifacies* and *D. langicornis*

Table 3 shows the species recorded and the number of individuals for every species. Numbers of individuals of B. papayae were the highest with 70,809 individuals. The second highest number of individuals recorded was *B. caudata* with 8,157 individuals. *B.curcubitae* was the third highest species with number individual of 4,457. Besides, species with low number of individuals recorded included *B. alrifacies* and *B. apicalis*, with 28 individuals each while *B. vultus* recorded with 22 individuals.

Table 3: The species recorded and number of individuals detected

Species	Number of individuals
B. papayae	70809
B. cucurbitae	4457
B. umbrosa	1100
B. carambolae	1084
B. caudata	8157
B. tau	279
B. albistragata	774
B. dorsalis	3539
B. nigrotibialis	499
B. vultus	22
B. alrifacies	28
B. apicalis	28
D. langicornis	31

Figure 2 shows the number of species recorded from different localities in several division of Sarawak. The highest number of species recorded was from Lundu with 11 species which are *B. papayae*, *B. carambolae*, *B. cucurbitae*, *B. umbrosa*, *B. nigrotibialis*, *B.albistragata*, *B. tau*, *B.caudata*, *D. longicornis*, *B. vultus* and *B. alrifacies*. Kota Samarahan shows the least number in species captured from years 2003 until 2011. There were only four species of Tephritidae recorded, namely *B. dorsalis*, *B. cucurbitae*, *B.albistragata* and *B. umbrosa*.

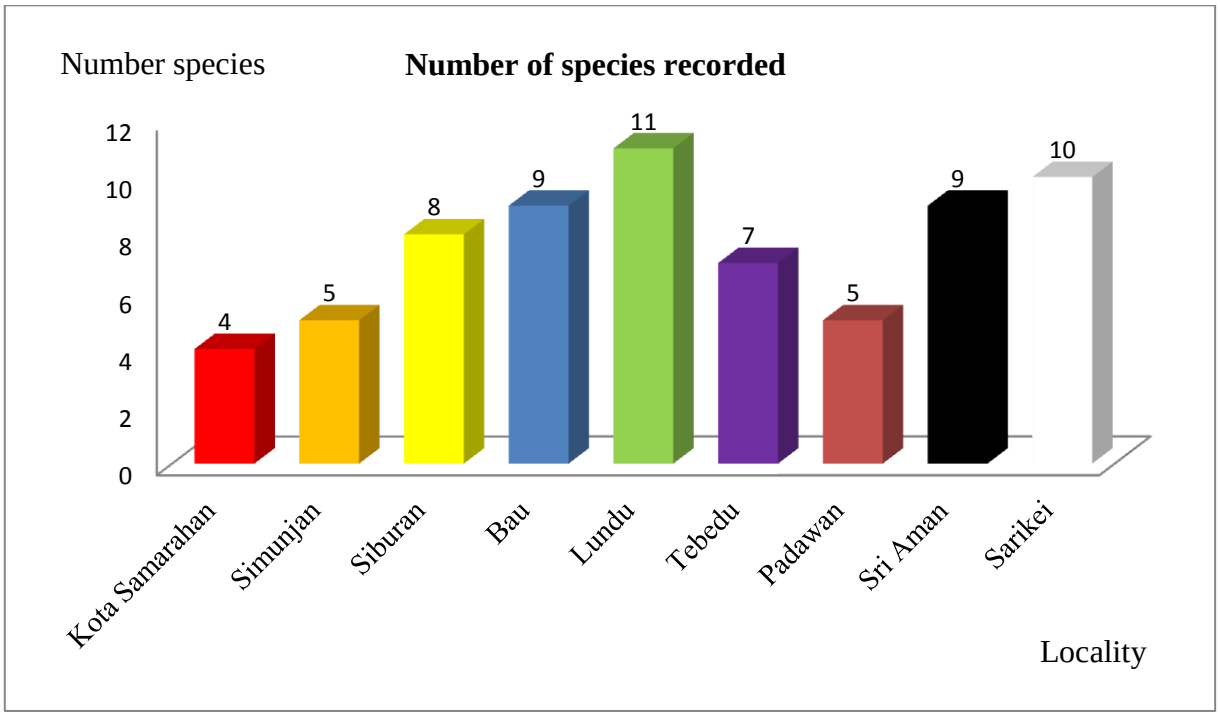

Figure 2: The number of species recorded in locality