DIVERSITY, STRATIFICATION AND TEMPORAL DYNAMICS OF GEOMETRID MOTHs (LEPIDOPTERA: GEOMETRIDAE) IN KUBAH LOWLAND MIXED DIPTEROCARP FOREST, SARAWAK

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DIVERSITY, STRATIFICATION AND TEMPORAL DYNAMICS OF GEOMETRID MOTHS (LEPIDOPTERA: GEOMETRIDAe) IN KUBAH LOWLAND MIXED DIPTEROCARP FOREST, SARAWAK

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A thesis submitted in fulfillment of the requirement for the Degree of Master of Science (Entomology)

Faculty of Resource Science and Technology
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2012
DECLARATION

I declare that, except as acknowledged in the text, the work presented in the thesis is entirely my own work and has not been submitted, either in part or in whole, for a degree at this or any other university.

______________________
(Irene Christianus)

Date:
Dedicated to my beloved parents, supervisor, family and friends
Foremost, I am extremely grateful to my supervisor, Professor Dr. Fatimah Abang, for giving me the confidence to explore my research interests. I am intellectually indebted for her inexhaustible advice and guidance throughout my postgraduate study. I would have been lost without her.

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Abstract

The diversity and stratification of the geometrid moths was investigated in a mixed dipterocarp forest, Kubah National Park, Sarawak. Modified Pennsylvanian light traps illuminated with a 160 Watt mercury vapour lamp were used to sample moths in the understorey (1 m) and canopy (32 m) strata. From a total of 336 samples, 916 individuals representing 173 species of geometrid moths were recorded. A total of 149 species and 675 individuals of geometrids were sampled in the understorey while 100 species and 241 individuals in the canopy stratum. Overall, species diversity of geometrid moth in Kubah mixed dipterocarp forest was found to be considerably high ($\alpha = 63.09 \pm 3.41$) for a single moth family and fell in the range of previously reported diversity score in Bornean rain forests. Results from the present study unequivocally showed that both understorey ($\alpha = 59.17 \pm 3.66$) and canopy ($\alpha = 64.09 \pm 6.7$) strata did not differ significantly in terms of diversity, however species richness and abundance tend to be numerically high in the understorey stratum. Kubah lowland mixed dipterocarp forest was characterised by the dominance of Ennominae and the presence of the least diverse Bornean geometrid subfamily Oenochrominae. A unimodal pattern with a peak of abundance in the understorey stratum was detected in Ennominae and ground specialists were represented from the tribes Hypochrosini, Boarmiini and Baptini. Markedly, data from the present study revealed that geometrid moth populations fluctuate through time, particularly the subfamily Ennominae and Geometrinae. Yet, the fluctuations in geometrid moth populations in response to meteorological factors and moonlight illumination were insignificant.

Keywords: moths, Geometridae, diversity, stratification, temporal, Sarawak.
Kepelbagaian, Stratifikasi dan Dinamik Masa Kupu-kupu Geometrid
(Lepidoptera:Geometridae) di Hutan Tanah Rendah Dipterokarp Campuran Kubah, Sarawak.

Abstrak

Kajian kepelbagaian dan stratifikasi kupu-kupu geometrid telah dijalankan di hutan tanah rendah dipterokarp campuran, Kubah National Park, Sarawak. Perangkap cahaya Pennsylvania yang telah diubahsuai diterangi dengan lampu raksa 160 Watt digunakan untuk menangkap kupu-kupu di paras permukaan tanah (1 m) dan kanopi (32 m) hutan. Daripada sejumlah 336 sampel, 916 individu yang mewakili 173 spesies kupu-kupu geometrid telah direkodkan. Sebanyak 149 spesies dan 675 individu kupu-kupu geometrid telah direkod di paras permukaan tanah sementara 100 spesies dan 241 individu direkod di kanopi. Secara keseluruhan, indeks kepelbagaian spesies kupu-kupu geometrid di hutan campuran dipterokarp Kubah yang direkodkan adalah cukup tinggi (α = 63.09 ± 3.41) bagi sebuah famili kupu-kupu dan jatuh dalam skor indeks kepelbagaian yang pernah dilaporkan di hutan hujan Borneo sebelum ini. Hasil daripada kajian ini juga menunjukkan bahawa kedua-dua sampel dari atas permukaan tanah (α = 59.17 ± 3.66) dan kanopi (α = 64.09 ± 6.7) tidak berbeza secara signifikan dari segi indeks kepelbagaian spesies Namun kekayaan dan kelimpahan spesies cenderung lebih tinggi di atas paras permukaan tanah. Hasil daripada kajian juga mendapati hutan tanah rendah dipterokarp campuran ini didominasi oleh subfamili Ennominae dan kehadiran Oenochrominae iaitu subfamili yang mempunyai jumlah spesies paling sedikit di Borneo. Pola taburan unimodal dengan kemuncak kelimpahan spesies di permukaan tanah diwakili oleh Ennominae dan beberapa spesies dari suku Hypochrosini, Boarmiini dan Baptini menunjukkan kecenderungan untuk berada di
paras permukaan tanah. Data yang diperolehi juga menunjukkan bahawa taburan kekayaan
dan kelimpahan kupu-kupu geometrid berubah-ubah mengikut masa. Namun, perubahan
kekayaan dan kelimpahan kupu-kupu geometrid tidak berkaitan secara signifikan dengan
taburan hujan dan juga cahaya bulan.

Kata kunci: kupu-kupu, Geometridae, kepelbagaian, stratifikasi, masa, Sarawak.
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ABBREVIATIONS

a.s.l.     above sea level
ca         approximately
e.g.      for examples
ft         feet
i.e.       that is
km         Kilometer
m          Meter
MDF        Mixed Dipterocarp Forest
mm         millimeter
Mt         Mount
spp.       Species
sq.        Square
UNIMAS     Universiti Malaysia Sarawak
vs         versus
W          Watt
°C         degree Celcius
α          alpha
CHAPTER ONE

General Introduction

1.1 Research Overview

The magnitude of the entomofauna diversity in tropical forest canopies remains largely unknown and has been the subject of much controversy among entomologists and ecologists (Basset et al., 2003a). Erwin (1982) estimated that the global number of insect species was at around 30 million and tropical forest canopies were pointed as being a repository of extremely high biodiversity. However, Erwin’s theory was highly disputed by most entomologists claiming that the estimated figure was far too high. Nevertheless, Erwin’s work was immensely useful in endorsing scientific interest on the canopy of tropical forests as what he called the ‘last biotic frontier’ in the entomological study.

Tropical rainforest is noted for high diversity of flora and fauna compared to the forest in the temperate region. Ecologically, it often includes a structurally complex dimension, both vertically and horizontally. The architecture of the vegetation has an important influence on the co-existing animal biodiversity due to the structure of leaves, flowers, plants and branches of trees that have greatly influence the composition of the associated arthropod communities from the top to the bottom of the canopy (Stork et al., 1997). Basset (1992) mentioned that the estimation of absolute population size often involves stratified sampling of the insect population. Vertical stratification represents the distribution of organisms along the vertical plane (Basset et al., 2003b). Typically, observers were usually limited to ground level, with few opportunities to study canopy organisms directly. However, the increase availability forms of access into the tallest rainforest trees has enabled researchers to study the structure
and ecology of these communities, the extent to which they vary in space and time, and their interactions with host plants. Moreover, the development of single rope techniques in rainforest environments by Perry (1978) has produced interesting sampling opportunities for tropical entomologists, which, at present, remain under-exploited.

In tropical rainforest, insects account for a major proportion of arthropod diversity and within the insects, the herbivores dominate in terms of species numbers (Basset et al., 2001). Apart from the Coleoptera, Lepidoptera is among the most species-rich of phytophagous insects. Interest in using Lepidoptera as bioindicators of environmental quality has blossomed in recent years. Lepidoptera are often termed as indicator taxa because they are critical to the functioning of many ecosystems, with species having functional roles as selective herbivores, pollinators and prey for migratory passerines and small mammals (Summerville et al., 2004). Summerville et al. (2004) also mentioned that although butterflies have been advocated as indicator taxa in tropical forests, they account for only 15% of lepidopteran species diversity worldwide.

Tropical forests, however, are rich in moth species and several studies suggest that certain moth assemblages show promise as indicators of overall lepidopteran biodiversity and forest composition (e.g. Kitching et al., 2000). In addition, macromoths are also rich in species and they have direct response to vegetation (Barlow and Woiwod, 1990). During their early stage (larvae), they are herbivores, which mainly consume leaves of trees. Some macromoths are host specific and restricted to certain habitats while others are polyphagous and widespread generalists (Chey, 2000).
Since sampling effort is necessarily limited in any field study, investigations have to be restricted either to guilds or taxonomic units. Many previous studies have restricted investigations to taxonomic units such as certain groups of Lepidoptera or Coleoptera (e.g. Schulze et al., 2001; Beck et al., 2002; Charles and Basset, 2005).

In this study, geometrid moths which are one of the highly dependent group of insects was chosen as a target group because it is one of the most species-rich families of moths. Geometrids have been frequently targeted as model organisms for diversity studies in the tropical rainforests (e.g. Intachat et al., 1999; Intachat and Holloway, 2000; Brehm, 2006; Hilt et al., 2006). Over 1000 species occur on Borneo (Holloway, 1997) and tropical geometrid communities are taxonomically quite well known compared to most other large groups of herbivorous insects in the tropics.

Furthermore, moths are usually sampled during the most mobile, adult phase of their life history by light-trapping method. The vast majority of the macro- as well as micromoth species are nocturnal in their behaviour and their response to the light provides a very convenient method of sampling by using ultraviolet or mercury vapour light trap (Holloway, 1985). Light-trapping method is also practical in monitoring general temporal trends of insect abundance (Kato et al., 1995). However, samples obtained from the light trap catches often include many heterochthonous taxa or ‘tourist’ (e.g. Chey et al., 1997) and thus moth assemblages collected are not purely represent the biotope where sample is made (Kato et al., 1995). This may be true for certain moth assemblages such as the Sphingidae and Noctuidae which are known for their powerful flight ability. Nevertheless, bias can be minimised by
choosing a group that has low mobility and thus high habitat fidelity (Holloway, 1984). Therefore, moths from the family Geometridae are such a group (Intachat et al., 1997).

Since vertical stratification is an optimal sampling methodology, geometrid moths were sampled vertically, from the understorey (1 m) up to the canopy (32 m) of Kubah mixed dipterocarp forest. Of all the forest types in Sarawak, mixed dipterocarp forest is the richest, estimated to contain over 2000 tree species, and the most extensive (Hazebroek and Abang Kashim, 2000). The structure of mixed dipterocarp forests is unique, with a multi-layered forest canopy structure. The high canopy reaches a height of 40 m, with emergent trees occasionally exceeding 70 m (Whitemore, 1984). It is estimated that, a century ago, mixed dipterocarp forest covered about 80% of Sarawak’s land surface (Hazebroek and Abang Kashim, 2000). At present, small areas of mixed dipterocarp forest are protected in Kubah National Park. Pristine habitats including mixed dipterocarp forest which cover most of the Borneo lowland have been threatened with deforestation and fragmentation. Thus, an understanding of these threatened ecosystems and assessment of the faunal diversity is inevitably essential to their preservation.

In Sarawak, macromoth diversity has been intensively accomplished by Holloway (1984), encompassing from various lowland and montane areas, ranging in altitudes from 50 to 2360 m a.s.l. In Borneo, few studies on the geometrid moth diversity in various vegetation types and altitude have been studied (e.g. Beck et al., 2002; Beck et al., 2006; Beck and Chey, 2008). As documented by Beck and Chey (2008), a marked peak of geometrid moth diversity was at ca 650 a.s.l. However, at present, information on the macromoths composition in Kubah National Park is still lacking. The scarcity of scientific documentation on macromoths
diversity in Kubah mixed dipterocarp forest would therefore make the present study valuable for generating baseline data on the selected moth communities.

Previous studies on faunal vertical stratification was documented for a wide range of taxa including mammals (e.g. Francis, 1994; Bernard, 2001; Hodgkinson et al., 2004), avifauna (e.g. Vasquez et al., 2009) and entomofauna (e.g. De Vries et al., 1997; Abang and Karim, 2005). All these studies highlight the importance to take into account both the understorey and canopy stratum in assessing the faunal diversity in a stratified rainforest or otherwise some fauna would be merely subsampled and thus underestimated. Additionally, the analysis of vertical stratification patterns of the macromoths, geometrid moths in this case, could underpin the knowledge of their segregation along the multi-layered forest habitats (Schulze et al., 2001) and thus help to understand how high species richness can be maintained in such ecosystems (Brehm, 2006).

It appears to be plausible that there is an equal segregation of mobile flying insects in the understorey and canopy of a rainforest because the direct flight distance between the two strata (less than 40 m) can be covered even by a small insect (Brehm, 2006). Nonetheless, there is evidence that some herbivorous insects, for instance butterflies and moths, have a height preference within tropical forests that reflects the occurrence of their host-plants or other resources (e.g. De Vries et al., 1997; Schulze et al., 2001). A study by Intachat and Holloway (2000) on geometroid moths’ stratification in Pasoh Forest Reserve gave an insight into geometrid vertical distribution in the tropical rainforests. Results from the study revealed that there was no consistent significant difference in species richness, abundance and