FOREST SPILL OVER EFFECTS OF BUTTERFLY COMMUNITY INTO DIFFERENT AGRICULTURE LANDSCAPES

SATHIYARUBINI A/P SATIMURTY

FH 2019 42

FOREST SPILL OVER EFFECTS OF BUTTERFLY COMMUNITY INTO DIFFERENT AGRICULTURE LANDSCAPES

By

SATHIYARUBINI A/P SATIMURTY

A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry Universiti Putra Malaysia

2019

DEDICATION

For my beloved family:

SATIMURTY A/L KANNAN

MALLIKA A/P RAMASAMY

Also my siblings

To all my friends,

Thank you for your encouragements supports

And the sacrifices that all of you have given.

Thank you for everything

ABSTRACT

Forest conversion into agricultural land has become a major concern in South East Asia due to its negative impact on overall biodiversity specifically insects. Insects may adapt and survive under human dominated landscapes as seen in some species of butterflies (Insecta:Lepidoptera). However, most butterfly species experience population decline as a result of land use changes. The present study was conducted to investigate forest spillover effect of butterfly community into different agricultural landscapes namely rubber plantation, oil palm plantation and fruit orchard. The study was conducted at Kampung Ulu Sepri, Kampung Empangan Batu and Kampung Batang Sepri located in Pedas, Negeri Sembilan. Butterfly sampling was conducted using active and passive sampling. in all study sites (a total of 90 sampling points). For active sampling, butterflies were observed based on point count method using binocular and camera for 10 minutes at each point. Meanwhile, for passive sampling, butterfly trap with fruit bait were placed at two meter above ground for all sampling points. Habitat quality characteristics between agricultural landscape were also assessed by measuring canopy openness and closure, vegetative structure, air temperature, relative humidity and proximity to forest between different agricultural landscape. In overall, a total of 1608 Lepidoptera individual belonging to 61 species and 5 families were recorded. The results recorded the highest butterfly abundance in oil palm with 600 individuals followed by rubber plantations and fruit orchard with 585 and 423 individuals, respectively. For butterfly species richness, rubber plantation represent the highest species recorded with 24 species followed by orchard and oil palm with 22 and 15 butterfly species, respectively. Greater butterfly abundance and species richness in monoculture plantations compared to polyculture landscapes indicates spillover of butterfly community into adjacent agricultural landscapes. This study provide evidence of butterfly spill over from forest into agricultural lands. Therefore, agricultural management in monoculture plantations should emphasize on biodiversity friendly management systems by reducing agrochemical applications to help maintain butterfly resilience in human dominated landscape.

ABSTRAK

Penukaran hutan ke tanah pertanian telah menjadi kebimbangan utama di Asia Tenggara kerana kesan negatif terhadap keanekaragaman biodiversiti secara keseluruhannya serangga. Serangga boleh menyesuaikan diri dan bertahan di bawah landskap yang dikuasai oleh manusia seperti yang dilihat dalam beberapa spesies rama-rama (Insekta: Lepidoptera). Walau bagaimanapun, kebanyakan spesies rama-rama mengalami penurunan akibat perubahan penggunaan tanah. Kajian ini dijalankan untuk menyiasat kesan limpahan spesies rama-rama hutan ke landskap pertanian yang berbeza iaitu ladang getah, ladang kelapa sawit dan dusun buah. Kajian ini dijalankan di Kampung Ulu Sepri, Kampung Empangan Batu dan Kampung Batang Sepri yang terletak di Pedas, Negeri Sembilan. Rakaman rama-rama dilakukan menggunakan persampelan aktif dan pasif di semua tapak kajian (sejumlah 90 titik pensampelan). Untuk pensampelan aktif, rama-rama diperhatikan berdasarkan kaedah kiraan titik menggunakan binokular dan kamera selama 10 minit pada setiap titik. Sementara itu, untuk pensampelan pasif, perangkap rama-rama dengan umpan buah ditempatkan pada dua meter di atas tanah untuk semua titik pensampelan. Ciri-ciri kualiti habitat antara landskap pertanian juga dinilai dengan mengukur keterbukaan dan penutupan kanopi, struktur vegetatif, suhu udara, kelembapan relatif dan jarak dekat antara landskap pertanian yang berlainan. Secara keseluruhan, sejumlah 1608 individu Lepidoptera yang terdiri daripada 61 spesies dan 5 keluarga direkodkan. Hasilnya mencatat kelebihan rama-rama tertinggi di kelapa sawit dengan 600 individu diikuti oleh ladang getah dan kebun buah dengan masing-masing 585 dan 423 individu. Bagi kekayaan spesies rama-rama, ladang getah mewakili spesies tertinggi yang direkodkan dengan 24 spesies diikuti oleh kebun buah dan kelapa sawit dengan 22 spesies dan 15 spesies rama-rama. Kelimpahan rama-rama yang lebih besar dan kekayaan spesies di ladang monokultur berbanding dengan landskap polikultur menunjukkan limpahan rama-rama ke dalam landskap pertanian bersebelahan. Kajian ini memberikan bukti limpahan rama-rama dari hutan ke tanah pertanian. Oleh itu, pengurusan pertanian di ladang monokultur harus memberi penekanan kepada sistem pengurusan mesra biodiversiti dengan mengurangkan aplikasi agrokimia untuk membantu mengekalkan daya tahan rama-rama dalam landskap yang dikuasai manusia.

ACKNOWLEDGEMENTS

First of all, I would like to take this utmost opportunity to express my sincere gratitude to my supervisor Dr. Norhisham Razi, who always gives supports and guidance throughout my study. He also patient and understanding supervisor. My sincere thanks is also extended to Dr. Badrul Azhar Md. Shariff for his advices and guidance.

I would also like to thank to my examiner, Dr. Nazre Salleh for his inspiring comments and suggestions for this project. My greatest appreciation also goes to the people that have been involved directly or indirectly in making this research project paper success. They are residents of Kampung Sungai Lalah, Kampung Empangan Batu, and Kampung Batang Sepri, Negeri Sembilan for their assistance and kindness in giving information. Their cooperation and assistance during the field survey had been very helpful to me.

Finally, thanks to my beloved parents and siblings. Appreciation and gratitude are also expressed to my friends and colleagues for their help and constructive suggestion through this study, especially to Intan Farha, Nur Afifah, Nurul Iffah, Mohd Mizan, Lijan John, Syafiq and many others. Last but not least to those whose names are not mentioned, I wish to express my special thanks for their helps in one way or another during this project.

APPROVAL SHEET

I certify that this research project report entitled "Forest Spill Over Effects Of Butterfly Community Into Different Agriculture Landscapes" by Sathiyarubini a/p Satimurty has been examined and approved as a partial fulfillment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

____

Dr. Norhisham Razi

Faculty of Forestry

University Putra Malaysia

(Supervisor)

____

Prof Dr Mohamed Zakaria Bin Hussin

Dean

Faculty of Foresty

University Putra Malaysia

Date: 21 June 2019

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVATIONS

ANNOVA	Analysis of Variance
KKK	Kuala Lumpur Kepong Berhad Company
HSD	Honestly Significant Difference
FAO	Food and Agriculture Organization of United States

CHAPTER 1

INTRODUCTION

1.1 General Background

Rapid decrease of tropical forest cover has received much attention in recent decades (FAO, 2012).Across the world, conversion of natural habitats to agriculture landscapes has resulted in the loss of biodiversity (Millenium Ecosystem Assesment, 2005).Sutrisno said in their study forest loss happens concurrently with the loss of tropical biodiversity which stems from forest clear cutting for monoculture plantations (Houlihan,Harrision & Cheyne 2013). In Southeast Asia, major forest loss is mainly caused by the expansion of oil palm, *Elaeis guineensis* Jacq plantations as mentioned by McMorrow (Lucey & Hills 2012). Massive agricultural expansions has led to forest degradation and biodiversity losses which affect ecosystem services. Moreover, biodiversity of agricultural land such as oil palm plantation is relatively lower compared to tropical forest (Fitzherbert et al ., 2008)

Insects occupy various types of ecosystem and play a vital role in ecosystem stability as pollinators, decomposers and plant propagation (Ghazanfar et al., 2016). Due to this, they provide important role as biological indicator for habitat quality as they respond quickly to environmental changes. Insects such as Lepidopterans comprise of highly diverse taxon and has receive reasonable attention worldwide (Ghazoul, 2002). Lepidoptera (butterflies) are the second largest order of arthropods and are most easily identified (Inuoye, 2001; Erhardt 1984; Kremen, 1994). Thomas (2005) added that butterflies are probably the best known taxonomically and ecologically throughout the world making them particularly useful for biodiversity survey. Butterflies can be categorized based on feeding guilds such as, nectar feeders and fruit feeders. Butterflies can be found in a wide range of habitat ranging from undisturbed areas such as tropical forests into urban parks. Butterflies sensitivity to environmental changes due to their physiological characteristics as most species require certain habitat quality (i.e temperature, relative humidity, floristic compositions and vegetation cover) and diverse food resources , which is mostly met under natural forest conditions (Bonebreak et al., 2010).

Butterflies are important pollinators for wild plant and crops. They depends on vegetations as foraging resources and refuge for reproduction and survival. Other than pollinators, butterflies also provide important function in ecosystem restoration as food source to birds, reptiles and amphibians (Ghazanfar et al., 2016). Conversion of natural forest area into monoculture plantations significantly affects insect biodiversity specifically butterflies. Agricultural intensification as seen in monoculture systems are most likely to support lower insect community compared to polyculture due to lower vegetation structural complexity and floristic diversity (Matson et al.1997; Ghazali et al.,2016). Polyculture systems provide the opportunity of a biodiversity friendly agriculture practices that support both agricultural production and biodiversity conservation specifically insects (Asmah et al., 2016).

1.2 Problem Statement

Agricultural expansion adjacent to forest area may lead to over dispersion of certain butterfly species into human dominated landscape leading to population decline. Due to this, the current study was carried out to investigate spillover effects of butterfly community in different agricultural landscapes. In addition, butterflies may become adaptive under environmental changes, so it is essential to distinguish suitable species as indicator for habitat disturbance. This study is important to highlight relevant butterfly species for conservation and habitat restoration effort. Agricultural management such as monoculture practice is not biodiversity friendly due to single crop management. Poor landscape complexity due to lower plant diversity limits butterfly persistency under environmental changes. However, butterfly species dispersal to human dominated landscape occurs due to forest loss. This study is important to highlight the importance of conservation effort in human dominated landscape especially agricultural areas by increasing habitat heterogeneity through plant diversity that promote the survival of diverse butterfly species and their abundance.

1.3 Significance of study

Agricultural practices which are widely practiced worldwide, requires sustainable approach to priorities conservation effort by being biodiversity friendly in both monoculture and polyculture systems. Butterfly (Lepidoptera) are good indicators because they respond quickly to environmental disturbance that affect habitat quality such as plant diversity and agrochemical applications. Thus, this study is essential to highlight how modified habitats influence butterfly diversity and abundance (Rickets et al., 2001).

1.4 Research Objective

The core objective of this research was to investigate spillover of butterfly community from natural forest into different agricultural landscapes between monoculture and polyculture systems. Different agricultural landscapes between oil palm plantation, rubber plantation and orchard may maintain different butterfly community. The specific objectives were to; (i) compare butterfly species richness and abundance between different agricultural landscapes based on proximity to the forest, and (ii) determine the relationship of microclimatic condition and vegetation structure with butterfly species richness and abundance.

1.5 Research Questions

Two research questions were posed to meet the objectives of this research. (i) What are the key habitat quality which supports the butterfly abundance and diversity between agricultural landscapes? And (ii) Do butterfly abundance and diversity varies between agricultural management and proximity to forest?

REFERENCES

Ahmed, R., Hoque, A. T. M. R., & Hossain, M. K. (2008). Allelopathic effects of Leucaena leucocephala leaf litter on some forest and agricultural crops grown in nursery. *Journal of Forest Research* 19,298–302.

Altieri, M.A., Nicholls, C.I., 2004. Effects of agroforestry systems on the ecology and management of insect pest populations. Ecological Engineering for Pest Management: Advances in Habitat Manipulation for Arthropods. *Journal of Asia Pacific Entomology*, 19, 143–155.

Ashraf, M., Zulki, R., Sanusi, R., Tohiran, K. A., & Terhem, R. (2018). Alley-cropping system can boost arthropod biodiversity and ecosystem functions in oil palm plantations. *Journal of Agriculture Ecosystems and Environment,* 260, 19–26.

Ashton, L. A., Barlow, H. S., & Nakamura, A. (2015). Diversity in tropical ecosystems : the species richness and turnover of moths in Malaysian rainforests, *Journal of Insect Conservation and Diversity* 8, 132–142.

Asmah, S., Ghazali, A., Syafiq, M., Yahya, M. S., Peng, T. L., Norhisham, A. R., Lindenmayer, D. B. (2016). Effects of polyculture and monoculture farming in oil palm smallholdings on tropical fruit-feeding butterfly diversity. *Journal of Agriculture and forest entomology, 5,*1-11.

Azhar, B., Leong, C., & Zakaria, M. (2014). Effects of monoculture and polyculture practices in oil palm smallholdings on tropical farmland birds. *Journal of Basic and Applied Ecology*, *15*(4), 336–346.

Aguirre-Gutiérrez, J., WallisDeVries, M. F., Marshall, L., van't Zelfde, M., Villalobos-Arámbula, A. R., Boekelo, B., & Biesmeijer, J. C. (2017). Butterflies show different functional and species diversity in relationship to vegetation structure and land use. *Journal of Global Ecology and Biogeography*, 26(10), 1126-1137.

Azhar, B., Saadun, N., & Leong, C. (2015). Promoting landscape heterogeneity to improve the biodiversity benefits of certified palm oil production : Evidence from Peninsular Malaysia. *Journal of Global Ecology and Conservation*, *3*, 553–561.

Azhar, B., Saadun, N., Prideaux, M., & Lindenmayer, D. B. (2017). The global palm oil sector must change to save biodiversity and improve food security in the tropics. *Journal of Environmental Management*, *203*, 457–466.

Bazelet, C. S., & Samways, M. J. (2011). Identifying grasshopper bioindicators for habitat quality assessment of ecological networks. *Journal of Ecological Indicators*, *11*(5), 1259-1269.

Benedick, S., White, T. A., Searle, J. B., Hamer, K. C., Mustaffa, N., Khen, C. V., Al, E. T. Impacts of habitat fragmentation on genetic diversity in a tropical forest butterfly on Borneo, (2007) *Journal of Tropical Ecology,* 22, 623–634.

Bonebrake, T.C., Ponisio, L.C., Boggs, C.L., Ehrlich, P.R., 2010. More than just indicators: a review of tropical butterfly ecology and conservation. *Journal of Biological Conservation,* 143, 1831–1841.

Blau, W.S. (1980). The effect of environmental disturbance on a tropical butterfly population. *Journal of Ecology*, 61, 1005–1012

Basset, Y., Charles, E., Hammond, D.S. & Brown, V.K. (2001). Short-term effects of canopy openness on insect herbivores in a rainforest in Guyana. *Journal of Applied Ecology* 38, 1045–1058.

Bowman, D.M.J.S., Woinarski, J.C.Z., Sands, D.P.A., Wells, A. & McShane, V.J. (1990) Slash-and-burn agriculture in the wet coastal lowlands of Papua New Guinea: response of birds, butterflies and reptiles. *Journal of Biogeography*, 17, 227–239

Blagodatsky, S., Xu, J., Cadisch, G., 2016. Carbon balance of rubber (Hevea brasiliensis) a review of uncertainties at plot, landscape and production level. *Agriculture Ecosystem Environment*, 221, 8–19.

Chakravarty, S., Ghosh, S. K., & Suresh, C. P. (2011). Deforestation : Causes,Effects and Control Strategies, *Journal of Global Perspectives on Sustainable Forest Management*, 12, 3–29.

Cavarzerel, V., Moraes, G. P., Roper, J. J., Silveira, L. F., & Donatelli, R. J. (2013). Recommendations for monitoring avian populations with point counts: a case study in southeastern Brazil. *Papéis Avulsos de Zoologia,* 53(32), 439-449.

Collinge, S. K. (1996). Ecological consequences of habitat fragmentation: implications for landscape architecture and planning. *Journal of Landscape and Urban Planning* 36, 59–77

Corbett, A. & Rosenheim, J.A. (1996). Impact of a natural enemy overwintering refuge and its interaction with the surrounding landscape. *Ecol. Entomol*., 21, 155–164

Devries, P.J., Walla, T.R., 2001. Species diversity and community structure in neotropical fruit-feeding butterflies. *Biol. J. Linn. Soc.* 74, 1–15.

Estrada, A., R. Coates-Estrada,A. A.Dadda, and P. Cammarano. 1998. Dung and carrion beetles in tropical rain forest fragments and agricultural habitats at Los Tuxtlas, Mexico. *Journal of Tropical Ecology* 14: 577–593.

Erhardt, A. (1985) Diurnal Lepidoptera: Sensitive Indicators of Cultivated and Abandoned Grassland. *Journal of Applied Ecology*, 22, 849-861.

Fitzherbert, E., Gardner, T., Davenport, T.R.B., Caro, T., 2006. Butterfly species richness and abundance in the Katavi ecosystem of western Tanzania. *Journal of Ecology*, 44, 353–362.

Fayle, T. M., E. C. Turner,J.L. Snaddon,V.K. Chey,A.Y.C. Chung, P. Eggleton, and W. A. Foster. 2010. Oil palm expansion into rain forest greatly reduces ant biodiversity in canopy, epiphytes and leaf- litter. *Journal of Basic Application Ecology*, 11: 337–345.

FAO, 2012. Global forest land-use change 1990–2005. FAO Forestry Paper 169

Fox, J., Castella, J., 2013. Expansion of rubber (Hevea brasiliensis) in Mainland Southeast Asia: what are the prospects for smallholders? *Journal of Peasant Studies* 40, 37–41.

Fermon, H., Waltert, M., Vane-Wright, R.I. & Mühlenberg, M. (2005) Forest use and vertical stratification in fruit- feeding butterflies of Sulawesi, Indonesia: impacts for conservation. *Biodiversity and Conservation*, 12, 1–18

Ghazali, A., Asmah, S., Syafiq, M., Yahya, M. S., Aziz, N., Tan, L. P., & Azhar, B. (2016). Effects of monoculture and polyculture farming in oil palm smallholdings on terrestrial arthropod diversity. *Journal of Asia-Pacific Entomology*, 19(2), 415–421.

Ghazanfar, M., Malik, M. F., Hussain, M., Iqbal, R., & Younas, M. (2016). Butterflies and their contribution in ecosystem: A review. *Journal of Entomology and Zoology Studies*, 4(2), 115-118.

Garcia-Ulloa, J., Sloan, S., Pacheco, P., Ghazoul, J., Koh, L.P., 2012. Lowering environmental costs of oil-palm expansion in Colombia. *Journal of Conservation* 5, 366–375

Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., et al., (2013).Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Journal of Science*, 339, 1608–1611.

Gabriel, D., Sait, S.M., Kunin, W.E. & Benton, T.G. (2013) Food production vs. biodiversity: comparing organic and conventional agriculture. *Journal of Applied Ecology*, 50, 355–364.

Ghazoul, J., L. P. Koh, And R. A. Butler. 2010. A Redd light for wildlife- friendly farming. *Journal of Conservation Biology* 24: 644–645.

Houlihan, P. R., Harrison, M. E., & Cheyne, S. M. (2013).Impacts of forest gaps on butterfly diversity in a Bornean peat-swamp forest. *Journal of Asia-Pacific Entomology,* 16(1), 67–73.

Harvey, C.A., Gonzalez, J., Somarriba, E., 2006. Dung beetle and terrestrial mammal diver- sity in forests, indigenous agroforestry systems and plantain monocultures in Talamanca, Costa Rica. *Journal of Biodiversity Conservation* 15, 555–585.

Hall, L.S., Krausman, P.R., Morrison, M.L., 1997. The habitat concept and a plea for standard terminology. *Wildl. Soc. Bull*. 25, 173–182.

Horner-Devine, M. C.; Daily, G. C.; Ehrlich, P. R.; Boggs, C. L. 2003. Countryside biogeography of tropical butterflies. *Journal of Conservation Biology*: 17 (1): 168-177.

Holloway, J. D. 1984. Notes on the butterflies of the Gunung Mulu National Park. *Journal of Sarawak Museum* 30:89–131

Inuoye, D.W. (2001) Role of Pollinator in Encyclopedia of Biodiversity, Volume 4. *Academy Press*, 732-730

Johnson, M. D. (2007). Measuring habitat quality: a review. *The Condor*, 109(3), 489-504.

Kalkman VJ, Clausnitzer V, Dijkstra KDB, Orr AG, Paulson D, et al.(2008) Global diversity of dragonflies (Odonata) in freshwater. *Journal of Hydrobiologia* 595: 351– 363.

Kirton, L. G. (2014). A naturalist's guide to the butterfly of peninsular Malaysia, Singapore and Thailand. Oxford, John Beaufoy Publishing, 1-176.

Koh, L. P. (2007). Impacts of land use change on south-east Asian forest butterflies: A Review. *Journal of Applied Ecology*, 44(4), 703-713.

Kunte, K. (2000). Butterflies of Peninsular India, Hyderabad. India: Universities Press Limited.

Kingsolver, J. G., Ragland, G. J. and Diamond, S. E. (2009). Evolution in a constant environment: thermal fluctuations and thermal sensitivity of laboratory and field populations of Manduca sexta. *Journal of Evolution* 63, 537-541.

Koh, L.P. & Sodhi, N.S. (2004) Importance of reserves, fragments and parks for butterfly conservation in a tropical urban landscape. *Journal of Ecological Applications*, 14(6), 1695–1708.

Kremen, C., Niles, J. O., Dalton, M. G., Daily, G. C., Ehrlich, P. R., Fay, J. P., Grewal, D. & Guillery, R. P. (2000) Crop polination from native bees at risk from agricultural intensification. *Journal of Science* 288, 1828–1832

Lucey, J. M., & Hill, J. K. (2012). Spillover of Insects from Rain Forest into Adjacent Oil Palm Plantations, *Journal of Biotropica*, 44(3), 368–377.

Lucey, J. M., Tawatao, N., Senior, M. J. M., Vun, C., Benedick, S., Hamer, K. C.,Hill, J. K. (2014). Tropical forest fragments contribute to species richness in adjacent oil palm plantations. *Journal of Biological Conservation*, *169*, 268–276.

Lawton, J. H., D. E. Bignell, B. Bolton, G. F. Bloemers, P. Eggleton, P. M. Hammond, M. Hodda, R. D. Holt, T. B. Larsen, N. A. Mawdsley, N. E. Stork, D. S. Srivastava, and A. D. Watt. 1998. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Journal of Nature* 391:72–76.

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997). Agricultural intensification and ecosystem properties. *Science*, 277, 504–509.

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis: http://www.maweb.org

P. Horak. 1996. Great tits, Parus major, trade health for reproduction. Proc. R. Soc. Lond. *Journal of Biology*, 263:1443–1447.

Pivnick KA, McNeil JN. 1985. Effect of nectar concentration on butterfly feeding: measured feeding rates for *Thymelicus lineola* (Lepidoptera: Hesperiidae) and a general feeding model for adult Lepidoptera. *Journal of Oecologia* 66:226-37.

Perfecto, I., Snelling, R., 1995. Biodiversity and the transformation of a tropical agro ecosystem: ants in coffee plantations. *Ecol. Appl*. 5, 1084–1097.

Rubene, D., Schroeder, M., & Ranius, T. (2015). Diversity patterns of wild bees and wasps in managed boreal forests : Effects of spatial structure, local habitat and surrounding landscape*. Journal of Biological Conservation*, *184*, 201–208.

Rice, R.A., Greenberg, R., 2000. Cacao cultivation and the conservation of biological diversity. *Journal of Ecology*, 29, 167–173

Reynolds, R. T., Scott, J. M., & Nussbaum, R. A. (1980). A variable circular-plot method for estimating bird numbers. *Condor*, 82(3), 309-313.

Rosin, Z. M., Myczko, Ł., Skórka, P., Lenda, M., Moroń, D., Sparks, T. H., & Tryjanowski, P. (2012). Butterfly responses to environmental factors in fragmented calcareous grasslands. *Journal of Insect Conservation*, 16(3), 321-329.

Rickets, T.H., Daily, G.C. and Fay, J.P. (200l) Countryside Biogeography of Moths in a Fragmented Landscape: Biodiversity in Native and Agricultural Habitats. *Journal of Conservation Biology*, 15, 378-388

Rosenzweig,M. L. 2003. Reconciliation ecology and the future of species diversity. *Oryx* 37: 194–205.

Sachs, J. D., Baillie, J. E., Sutherland, W. J., Armsworth, P. R., Ash, N., Beddington, J., et al. (2009). *Biodiversity conservation and the millennium development goals*. 325(5947), 1502–1503.

Turner, E. C., Snaddon, J. L., Fayle, T. M. & Foster, W. A. 2008 Oil palm research in context: identifying the need for biodiversity assessment. *Journal of Basic and Applied Ecology*, 12 (3), 145-198.

Thomas, A.W., Thomas, G.M., 1994. Sampling strategies for estimating moth species diversity using a light trap in a northeastern soft- wood forest. *Journal of Lepidoptera Society* 48, 85–105

Willott, S. J., Lim, D. C., Compton, S. G., & Sutton, S. L. (2000). Effects of Selective Logging on the Butterflies of a Bornean Rainforest, *14*(4), 1055–1065.

Wahlberg, N.; Leneveu, J.; Kodandaramaiah, U.; Peña, C.; Nylin, S.; Freitas; A. V. L.; Brower, A. V. Z. 2009. Nymphalid butterflies diversify following near demise at the Cretaceous/Tertiary boundary. *Proceedings of the Royal Society* B 276 (1677): 4295-4302.

Walker, M. & Jones, T. H. 2001. Relative roles of top-down and bottom-up forces in terrestrial tritrophic plant–insect herbivore– natural enemy systems. *Oikos* 93:177–187.

Weerakoon, B. M. B., Bandara, A. M. R. S., & Ranawana, K. B. (2015). Impact of canopy cover on butterfly abundance and diversity in intermediate zone forest of Sri Lanka. *Journal of Tropical Forestry and Environment*, 5(1), 41-46 41.

Yang, F., Hui, C., Men, X., Zhang, Y., & Fan, L. (2016). Agriculture Ecosystems and Environment Early eclosion of overwintering cotton bollworm moths from warming temperatures accentuates yield loss in wheat. “*Agriculture, Ecosystems and Environment,*” 217, 89–98.

Yahya, M. S., Syafiq, M., Amal, A. A., Asmah, S., & Azhar, B. (2017). Switching from monoculture to polyculture farming benefits birds in oil palm production landscapes. *Journal of Ecology and Evolution*, 7, 6314–6325.

Zhang, J.F., 1994. Discovery of primitive fossil earwigs (Insecta) from the Late Jurassic of Laiyang, Shandong and its significance. *Acta Palaeontologica Sinica*, 33, 229-245