COMPARING TERRESTRIAL INSECT DIVERSITY USING PITFALL TRAP UNDER DIFFERENT AGRICULTURAL LANDSCAPES

REXIE MEEKENDDEY MADIS

COMPARING TERRESTRIAL INSECT DIVERSITY USING PITFALL TRAP UNDER DIFFERENT AGRICULTURAL LANDSCAPES

By

REXIE MEEKENDDEY MADIS

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

2018

DEDICATION

For my beloved family:

Richard Madis Araji

Evelyn Hong Teo Yong

Also my siblings

To all my friends,

Thank you for your encouragements supports from start to end of my research and the sacrifices that you’re helping me.

Last but not least,

I dedicated this dissertation to Norhisham Ahmad Razi

Who has encouraged me, helped and give so much support during conducting this research and in my study.

Thank you for everything.

ABSTRACT

Forest conversion for agricultural expansion is among the major driver of biodiversity losses worldwide. Agricultural land use, however, may have different impacts on overall biodiversity especially insects. Understanding landscape heterogeneity between monoculture and polyculture systems can improve conservation of insect biodiversity in agricultural plantations. The present study compared terrestrial insect abundance and order richness between polyculture orchard, monoculture rubber and monoculture oil palm plantations. The study was carried out in Kampung Sungai Lalah, Pedas, Negeri Sembilan from January to February 2018. Terrestrial insects were sampled using pitfall traps at all agricultural landscapes (total sampling point = 45). In overall, the study recorded 2555 individuals belonging to 10 insect orders. Polyculture orchard recorded greater insect abundance and order richness followed by monoculture oil palm and monoculture rubber plantations. Polyculture orchard also showed greater vegetation cover and relative humidity. In addition, Dermaptera and Homoptera were also recorded in polyculture orchard and monoculture oil palm plantations. The findings from this study indicate that polyculture systems can support greater insect abundance and diversity due to complex vegetation structure and higher humidity. Local diversity of plants and insects also represent improved ecosystem services such as decomposition rates. The findings suggest that agricultural management should prioritize polyculture systems to improve insects conservation and ecosystems services.

ABSTRAK

Pembukaan hutan untuk pertanian adalah penyebab utama kemerosotan biodiversiti di muka bumi ini. Penggunaan pertanian mempunyai impak terhadap biodiversiti terutamanya serangga. Pemahaman mengenai kualiti landskap antara sistem monokultur dan polikultur boleh meningkatkan penjagaan terhadap biodiversiti serangga pada penanaman pertanian. Kajian ini membandingkan kepelbagaian dan kekayaan order serangga darat antara polikultur kebun, monokultur getah dan monokultur ladang kelapa sawit. Penyelidikan dibuat di Kampung Sungai Lalah, Pedas, Negeri Sembilan daripada Januari ke Febuari 2018. Serangga darat diambil sampel menggunakan perangkap lubang pada semua landskap pertanian (jumlah sampel = 45). Keseluruhannya, kajian ini merekodkan 2555 bilangan serangga daripada 10 kekayaan order. Polikultur kebun merekodkan kepelbagaian dan kekayaan order serangga yang paling baik dan diikuti oleh monokultur kelapa sawit dan monokultur getah. Polikultur kebun juga menunjukkan vegetasi dan kelembapan relatif yang paling baik. Sebagai tambahan, Dermaptera dan Homoptera direkodkan di polikultur kebun dan monokultur ladang kelapa sawit. Penyelidikan ini menunjukkan sistem polikultur boleh menyokong kepelbagaian serangga dengan struktur vegetasi yang pelbagai dan kelembapan yang tinggi. Tumbuhan tempatan dan serangga membantu perkhidmatan ekosistem seperti penghuraian. Kajian ini menyarankan pengurusan pertanian seharusnya mengutamakan sistem polikultur untuk meningkatkan konservasi serangga dan perkhidmatan ekosistem.

ACKNOWLEDGEMENTS

Thanks to God for His merciful for giving me strength to do my research and accomplish this project with successfully. First and foremost, I would like to extend my gratitude to all the parties who support me, especially my supervisor, Dr Norhisham Ahmad Razi for his continues guidance, constructive suggestion and precious advice regarding my project throughout the period of my research. His invaluable help have contributed to the success of my research.

Great appreciation to the people has been involved to my research project paper to success. They are residents of Kampung Sungai Lalah, Negeri Sembilan for assistance in giving information about the study site.

Last but not least, my deepest gratitude goes to my family members and friend especially to Megat, Amalina, Aziati, Fatin and Najihah for their support throughout the research. Thanks to all of you.

APPROVAL SHEET

I certify that this research project report entitled "Comparing Terrestrial Insect Diversity Using Pitfall Trap Under Different Agricultural Landscapes" by Rexie Meekenddey Madis 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, Univeristi Putra Malaysia.

Dr. Norhisham Razi
Faculty of Forestry
Universiti Putra Malaysia
(Supervisor)

Prof. Dr. Mohamed Zakaria Bin Hussin
Dean
Faculty of Forestry
Universiti Putra Malaysia

Date: May 2018

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
FAO	Food and Agriculture Organization of the United Nations
HSD	Tukey's Honestly Significant Difference

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Tropical deforestation continues to rise at an alarming rate worldwide (FAO 2015). However, the net loss of forest area has reduced between 2000 to 2010 due to increase global effort in reforestation and afforestation (Achard et al., 2002). The major drivers of tropical deforestation are mainly due to forest conversion into agricultural land use for agricultural products. Agricultural products such as palm oil ensures food security and is a potential source of renewable energy (Sunderland et al., 2017). In Malaysia alone, at least 1,040,000 ha of forest were converted to oil palm from 1990 to 2005 (Wilcove & Koh, 2010). Due to this, tropical forest conversion into oil palm plantations has become one of the major concerns for biodiversity declines. However, agricultural management and practices can be improved to ensure biodiversity conservation as suggested by (Foster et al., 2011) In the study, they suggested that agricultural landscape must contain forest reserves as these ecosystem can conserve forest community and maintain ecosystem functioning. Besides that, retaining forest remnants can provide refuge for forest-dependent species that would not be able to survive in agricultural landscape (Edwards et al., 2010).

Previous studies has shown that the decline in local biodiversity are mainly due to intensification of agricultural management as seen in monoculture systems

(Bengtsson et al., 2005). Local species diversity may increased with environmental friendly farming practices but this is highly dependent on the surrounding area of the landscape (Weibull et al., 2003) The ecological process within an ecosystem may influence local species assemblages due to interactions between different environmental variables (Tscharntke et al. 2005). Land use effects are represented by two categories; landscape and habitat heterogeneity (Weibull et al., 2003), which is influenced by the presence of natural habitat (Schmidt, 2005). Thus, difference in local species assemblages is mostly influenced by the local environment factor at the landscape level (Schweiger et al 2005).

Tropical rain forest provides refuge for various insect communities. Forest degradation from logging activities and conversion into agriculture land are among the major factor that contributes to population decline of tropical insect species (Sodhi et al. 2010). Insects perform various ecological functions in ecosystem services that include pollination, predation and decomposition (Zhang et al., 2007). Thus, forest degradation may interrupt ecosystem services due to loss of important forest insect species (Didham et al 1996). However, there are insect species that dominate agricultural habitats due to its open area characteristics (Liow et al., 2001).

Even though, habitat heterogeneity in agricultural land is lower compared to forest area, agricultural land still support few insect communities for nesting and food resources.. Insects can become an important ecological indicator to measure biodiversity friendly practices in agricultural landscapes as seen in many terrestrial insect community such as beetles (Coleoptera), ants (Hymenoptera), termites (Isoptera) and grasshopper (Orthoptera) species (Bruhl & Eltz, 2010; Bazelet & Samways). Terrestrial insect adaptation to their surrounding depends on the environmental variables such as microclimate, soil characteristics and the type of vegetation (Fattorini and Salvati 1999). Some beetle species also depends on flouristic composition as they feed on plant leaves and nectar (Cooter 1991). Terrestrial insects is an important agent for ecosystem services as they can improve soil characteristics through soil mixing that support better nutrient cycling for plant growth as seen in dung beetles (Davis & Philips, 2005) termites (Donovan et al., 2001) and ground-dwelling ants (Bruhl & Eltz, 2010).

1.1 Problem Statement

Land conversion from tropical forest area into agriculture landscape has caused a significant loss of insect biodiversity specifically terrestrial insect community (Groc et al., 2017). In spite of their importance to improved soil stability, to investigate the effects of land used changes on terrestrial insect is still scarce. Terrestrial insect community can become an important ecological indicator to compare agricultural management and practices that has the potential to support biodiversity conservation.

1.2 Justification

Terrestrial insects represent an ideal model organism to assess different agricultural systems that is biodiversity friendly. Greater habitat heterogeneity is clearly illustrated in polyculture systems due to complex vegetation structure compared to monoculture systems (Ghazali et al., 2016). However, different monoculture plantations such as oil palm and rubber plantations may support different terrestrial insect community. The present study will provide more information regarding terrestrial insect community between monoculture and polyculture systems. The results will highlight the importance of terrestrial insect for ecosystems services in agricultural landscapes.

1.3 Research Objectives

The present study set out to determine terrestrial insect species composition and distribution between three different agricultural landscapes. .The specific objective is to compare terrestrial insect species richness and abundance between monoculture (oil palm and rubber plantations) and polyculture (fruit orchard) systems. To achieve this, the present study ask the following questions; (i) Is there any changes in terrestrial insect community between monoculture and polyculture systems and (ii) how changes in vegetation structure influence terrestrial insect species richness and abundance.

REFERENCES

Achard, F., Eva H. D., Stibig, H. J., Mayaux, P., Gallego, J., Richards, T., & Malingreau, J. P.(2002) Determination of deforestation rates of the world's humid tropical forests. *Science*, 297, 999–1002.

Arimoro, F. O., & Ikomi, R. B. (2009). Ecological integrity of upper Warri River, Niger Delta using aquatic insects as bioindicators. *Ecological Indicators*, 9(3), 455–461.

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

Baars, M. A. (1979). Catches in pitfall traps in relation to mean densities of carabid beetles. *Oecologia*, 41: 25– 46.

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

Bengtsson, J., Ahnström, J. & Weibull, A.C. (2005). The effects of organic agriculture on biodiversity and abundance: a meta-analysis. J. *Applied Ecology*, 42, 261–269.

Brühl, C. a., & Eltz, T. (2009). Fuelling the biodiversity crisis: species loss of ground-dwelling forest ants in oil palm plantations in Sabah, Malaysia (Borneo). *Biodiversity and Conservation*, 19(2), 519–529.

Bujan, J., & Kaspari, M. (2017). Nutrition modi fi es critical thermal maximum of a dominant canopy ant. *Journal of Insect Physiology*, 102,1–6.

Carignan, V. & Villard, M. A. (2001). Selecting Indicator Species To Monitor Ecological Integrity: A Review. Computing. Vienna: R Foundation for Statistical Computing.

Chen, J., Qin, Z., Li, Z., Cheng, F., & Liang, B. (2014). Landscape and Urban Planning Influence of canopy structural characteristics on cooling and humidifying effects of Populus tomentosa community on calm sunny summer days. *Landscape and Urban Planning*, 127, 75–82.

Cooter, R. D. (1991). Economic Theories of Legal Liability. *Journal of Economic Perspectives*, 5 (3): 11-30.

Crowder, D. W., & Carri, Y. (2009). Comparing the refuge strategy for managing the evolution of insect resistance under different reproductive strategies. *Journal of Theoretical Biology*, 261, 423–430.

Davis, A. L. V., & Philips, T. K. (2005). Effect of Deforestation on a Southwest Ghana Dung Beetle Assemblage (Coleoptera: Scarabaeidae) at the Periphery of Ankasa Conservation Area. *Environmental Entomology*, 34(5), 1081–1088.

Didham, R. K., Stork, N. E., & Davis, A. J. (1996). Insects in fragmented forests : a functional approach. *Trends in Ecology & Evulation*, 11(6); 255-260.

Donovan, S.E., Eggleton, P., Dubbin, W., Batchelder, M. & Dibog, L. (2001) The effect of a soil-feeding termite Cubi- termes fungifaber (Isoptera: Termitidae) on soil properties: termites may be an important source of soil microhabitat heterogeneity in tropical forests. *Pedobiologia*, 45, 1–11.

Edwards, D. P., Hodgson, J. a., Hamer, K. C., Mitchell, S. L., Ahmad, A. H., Cornell, S. J., & Wilcove, D. S. (2010). Wildlife-friendly oil palm plantations fail to protect biodiversity effectively. *Conservation Letters*, 3(4), 236–242.

Ewers, R. M., & Didham, R. K. (2006). Confounding factors in the detection of species responses to habitat fragmentation. *Biological Reviews of the Cambridge Philosophical Society*, 81(1), 117–142.

Eyre, M. D., Rushton, S. P., Luff, M. L. & Telfer, M. G. (2005). Investigating the relationships between the distribution of British ground beetle species (Coleoptera, Carabidae) and temperature, precipitation and altitude. *Journal of Biogeography*: 45 (6), 973-983.

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution and Systematics,* 34, 487–515.

FAO, (2006). Global Forest Resource Assessment: Main Report. Rome: Food and Agriculture Organization of the United Nations.

FAO, (2007). Global Forest Resource Assessment: Main Report. Rome: Food and Agriculture Organization of the United Nations.

FAO, (2015). Global Forest Resource Assessment: Main Report. Rome: Food and Agriculture Organization of the United Nations.

Fattorini, S., & Salvati L. (1999). Population features of Kestrels Falco tinnunculus in urban, suburban and rural areas in Central Italy. *Acta Ornithologica*, 34 (1): 54-58.

Foster, W. a, Snaddon, J. L., Turner, E. C., Fayle, T. M., Cockerill, T. D., Ellwood, M. D. F., Yusah, K. M. (2011). Establishing the evidence base for maintaining biodiversity and ecosystem function in the oil palm landscapes of South East Asia. Philosophical Transactions of the Royal Society of London. Series B, *Biological Sciences*, 366(1582), 3277–3291.

French, V., Oxbrough, A., Irwin, S., Kelly, T. C., Smiddy, P., & Halloran, J. O. (2012). Forest Ecology and Management Can mixed species stands enhance arthropod diversity in plantation forests ? *Forest Ecology And Management*, 270, 11–18.

Fuente, M.A.S. and Marquis, R.J. (1999). The role of ant-tended extrafloral nectaries in the protection and benefit of a Neotropical rainforest tree. *Oecologia*, 118, 192-202.

Geno, L. and Geno, B. (2001). Polyculture Production: Principles, Benefits and Risks of Multiple Cropping LandManagement Systems for Australia,RIRDC Publication 01/34.

Geno, L. (1976). Ecological agriculture: The environmentally appropriate alternative, *Alternatives*, (5),53–63.

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.

Groc, S., Delabie, J. H. C., Fernandez, F., Petitclerc, F., Corbara, B., Leponce, M., Dejean, A. (2017). Litter-dwelling ants as bioindicators to gauge the sustainability of small arboreal monocultures embedded in the Amazonian rainforest. *Ecological Indicators*, 82, 43–49.

Gullan, P.J. and Cranston, P.S. (2005) Insects: An Outline of Entomology. 3rd Edition, Blackwell Publishing Ltd., Hoboken, 505 p.

Hanski, I. & Rybicki, J. (2013). Species–area relationships and extinctions caused by habitatloss and fragmentation. *Ecology Letters*, 16; 27–38.

Harvey, C., González & Villalobos, J. (2007). Agroforestry systems conserve species-rich but modified assemblages of tropical birds and bats. *Biodiversity and Conservation*, 16(8), 2257-2292.

Hodkinson, I. D., & Jackson, J. K. (2005). Terrestrial and Aquatic Invertebrates as Bioindicators for Environmental Monitoring, with Particular Reference to Mountain Ecosystems: *Environmental Management*, Vol. 35, no. 5, 649-666.

Hölldobler, E. O. Wilson (1990). The Ants Springer. *Evolutionary Biology*, 5; 169-171.

Holt, E. A. & Miller, S. W. (2010) Bioindicators: Using Organisms to Measure Environmental Impacts. *Nature Education Knowledge,* 3(10):8

Holway, D. A., & Suarez, A. V. (2005). Homogenization of ant communities in mediterranean California : The effects of urbanization and invasion. *Biological Conservation*, 127; 319-326.

Horak, J., Peltanova, A., Podavkova, A., Safarova, L., Bogusch, P., Romportl, D., & Zasadil, P. (2013). Agriculture, Ecosystems and Environment Biodiversity responses to land use in traditional fruit orchards of a rural agricultural landscape. *Agriculture, Ecosystems and Environment*, 178, 71–77.

Kimberling, D. N., Karr, J. R., & Fore, L. S. (2001). Measuring human disturbance using terrestrial invertebrates in the shrub – steppe of eastern Washington (USA). *Ecological Indicators*, 1(2):63-81.

Koh, L. P. (2008). Can oil palm plantations be made more hospitable for forest butterflies and birds? *Applied Ecology*, 45; 1002–1009.

Koivula M. (2011) Useful model organisms, indicators, or both? Ground beetles (Coleoptera, Carabidae) reflecting environmental conditions. *ZooKeys*, 100: 287-317.

Liow, L. H., Sodhi, N. S. & Elmqvist, T. (2001). Bee diversity along a disturbance gradient in tropical lowland forests of South-East Asia. *Journal of Applied Ecology*, 38:180–192.

Martin, K. (2016). Effects of rubber cultivation on biodiversity in the Mekong Region. Hohenheim University.

McGeoch, M. A. (1998). The selection, testing and application of terrestrial insects as bioindicators. *Cambridge Journals: Practice and Research*,73; 181-201.

Meyfroidt, P., & Lambin, E. F. (2011). Global forest transition: prospects for an end to deforestation. Annual Review of Environment and Resources 36, 343–371.

Nair, P. (1993). An introduction to agroforestry. Kluwer Academic Publishers.

Pant, M., Negi, G. C. S., & Kumar, P. (2017). Macrofauna contributes to organic matter decomposition and soil quality in Himalayan agroecosystems, India. *Applied Soil Ecology*, 120, 20–29.

Peerawat, M., Blaud, A., Trap, J., Chevallier, T., Alonso, P., Gay, F., Brauman, A. (2018). Rubber plantation ageing controls soil biodiversity after land conversion from cassava. *Agriculture, Ecosystems and Environment*, 257, 92–102.

Peterson, H. Strand, T., Lamb, B., Thistle, H., & Allwine, E. (2009). A simple model for simulation of insect pheromone dispersion within forest canopies. *Ecological Modelling*, 220, 640–656.

R Development Core Team, (2011). R: A Language and Environment for Statistical. *Open Journal of Ecology*, Vol.3 No7.

Schelt, T. I. M. V. A. N., & Villa, J. (2017). Enhancing biodiversity in traditional fruit orchards. Wageningen University.

Schmidt M. (2005). The heat repeat protein blm10 regulates the yeast proteasome by capping the core particle. *Nature Structural & Molecular Biology,*12(4):294-303.

Schweiger, H. F., & Peschl, G. M. (2005). Reliability analysis in geotechnics with the random set finite element method. *Georisk Assessment and Management of Risk for Engineered Systems and Geohazards*, 32, 422–435.

Sodhi, N. S., Posa, M. R. C., Lee, T. M., Bickford, D., Koh, L. P., & Brook, B. W. (2010). The state and conservation of Southeast Asian biodiversity. *Biodiversity and Conservation*, 19(2), 317–328.

Sunderland, K. D. (1996). Ecology And Behavior Of Ground Beetles, *European Journal of Entomology*, 41: 23-56.

Sunderland, T., Abdoulaye, R., Ahammad, R., Asaha, S., Baudron, F., Deakin, E., Vianen, J. Van. (2017). Forest Policy and Economics A methodological approach for assessing cross-site landscape change : Understanding socio-ecological systems. *Forest Policy and Economics*, 84, 83–91.

Thomas, R. S., Glen, D. M., & Symondson, W. O. C. (2008). Prey detection through olfaction by the soil-dwelling larvae of the carabid predator *Pterostichus melanarius*, *Soil biology & biochemistry*, 40, 207–216.

Tscharntke, T., Tylianakis, J., Rand, T., Didham, R., Fahrig, L., Batáry, P., Bengtsson, J., Clough, Y., Crist, T., Dormann, C., Ewers, R., Fründ, J., Holt, R., Holzschuh, A., Klein, A., Kleijn, D., Kremen, C., Landis, D., Laurance, W., Lindenmayer, D., Scherber, C., Sodhi, N., Steffan-Dewenter, I., Thies, C., van der Putten, W. and Westphal, C. (2018). Landscape moderation of biodiversity patterns and processes - eight hypotheses. *Biology Review*, 87, pp. 661–685

Utomo, B., Prawoto, A. A., Bonnet, S., Bangviwat, A., Gheewala, S. H. (2016). Environmental performance of cocoa production from monoculture and agroforestry systems in Indonesia. *Cleaner Production*, 134, 583-591

WATSON, D.M. (2002). A conceptual framework for studying species composition in fragments, islands and other patchy ecosystems. *Journal of Biogeography*, 29, 823–834.

Weibull, A., & Östman, Ö. (2003). Basic and Applied Ecology Species composition in agroecosystems : The effect of landscape , habitat , and farm management, *Journal of Applied Ecology, 361*, 349–361.

Wilcove, D. S., & Koh, L. P. (2010). Addressing the threats to biodiversity from oil-palm agriculture. *Biodiversity and Conservation*, 19(4), 999–1007.

Zhang, W., Ricketts, T. H., Kremen, C., Carney, K., & Swinton, S. M. (2007). Ecosystem services and dis-services to agriculture. *Ecological Economics*, 64(2), 253–260.