UNIVERSITI PUTRA MALAYSIA

ASSEMBLAGES OF NOCTURNAL BIRDS IN OIL PALM SMALLHOLDINGS IN SELANGOR, MALAYSIA

MUHAMMAD SYAFIQ BIN YAHYA

FH 2017 12

ASSEMBLAGES OF NOCTURNAL BIRDS IN OIL PALM SMALLHOLDINGS IN SELANGOR, MALAYSIA

By

MUHAMMAD SYAFIQ BIN YAHYA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

March 2017

This thesis is dedicated to my parents

and

Sharifah Nur Atikah

For their endless love, support and encouragement

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

ASSEMBLAGES OF NOCTURNAL BIRDS IN OIL PALM SMALLHOLDINGS IN SELANGOR, MALAYSIA

By

MUHAMMAD SYAFIQ YAHYA

MARCH 2017

Chairman : Puan Chong Leong, PhD
Faculty : Forestry

Over the last several decades, a large tract of forests in the tropics had been converted into oil palm cultivations (either plantations or smallholdings). The expansion of such cultivation is recognized as one of the major causes of a rapid decline in fauna biodiversity in the tropics. In contrast to large-scale plantations, oil palm smallholdings may support greater levels of biodiversity through the implementation of intercropping practices. To date, the assemblages of nocturnal birds and their response toward environmental factors in oil palm smallholdings still remain unclear. Hence, this study estimated the density of nocturnal bird species as well as examined the effects of local-level and landscape-level variables on the composition of nocturnal bird species in oil palm smallholdings in Peninsular Malaysia. A total of 1,408 individuals of 11 nocturnal bird species (i.e. nine owl and two nightjar species) were recorded from 90 sampling points spaced more than 800 m apart. The density of Spotted Wood Owl (*Strix seloputo*) was seven individuals per 100 ha, followed by Sunda Scops Owl (*Otus lempiji*) with 15 individuals for every 100 ha, Common Barn Owl (*Tyto alba*) with five individuals per 100 ha and Large-tailed Nightjar (*Caprimulgus macrurus*) with seven to eight individuals for every 10 ha. Biota and/or Environment Matching Analyses (BEST) indicated four predictor variables, i.e. three local variables (crop richness, widths of roads and trenches) and one landscape variables (distance to the nearest road) significantly influenced the community assemblages of nocturnal bird species in the smallholdings. Generalized Linear Models (GLMs) indicated seven predictor variables (i.e. four local variables; height of oil palms, number of oil palms, width of the roads and trenches, and three landscape variables; number of settlements per 100 meter radius, distance to the nearest forest and settlement) significantly influenced the abundances of certain nocturnal species. this study demonstrated that the composition and abundance of nocturnal birds in oil palm smallholdings were influenced by both local and landscape-level variables. This not only improved our understanding on habitat preference of the little known nocturnal birds in Malaysia but also supports that habitat complexity in cultivated areas may aid in biodiversity conservation, at least for nocturnal birds.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

HIMPUNAN BURUNG MALAM DI KEBUN KECIL KELAPA SAWIT DI SELANGOR, MALAYSIA

Oleh

MUHAMMAD SYAFIQ YAHYA

MAC 2017

Pengerusi : Puan Chong Leong, PhD
Fakulti : Perhutanan

Sejak beberapa dekad yang lalu, sebahagian besar hutan di kawasan tropika telah ditukar kepada tanaman kelapa sawit (sama ada dalam bentuk ladang atau kebun kecil). Pertambahan tanaman ini secara mendada telah dikenalpasti sebagai salah satu punca utama penurunan secara kritikal biodiversiti fauna di kawasan tropika. Berbeza dengan ladang berskala besar, kebun kecil kelapa sawit dapat menyokong tahap biodiversiti yang lebih tinggi melalui pelaksanaan amalan selingan. Sehingga kini, respon burung malam dengan faktor persekitaran di kawasan kebun kelapa sawit masih lagi tidak jelas. Sehubungan itu, kajian ini telah menganggarkan kepadatan spesies burung malam dan juga meninjau kesan-kesan pembolehubah peringkat tempatan dan peringkat landskap kepada komposisi spesies burung malam di kebun kelapa sawit di Semenanjung Malaysia. Sejumlah 1,408 individu daripada 11 spesies burung malam (iaitu daripada sembilan spesies burung hantu dan dua spesies burung tukang) telah dicatatkan dari 90 titik persampelan yang dijarakkan lebih daripada 800 m. Kepadatan Burung Hantu Carik Kafan (*Strix seloputo*) telah dianggarkan sebanyak tujuh individu setiap 100 hektar. Ini diikuti dengan Burung Pungguk Celapuk Reban (*Otus lempiji*) sebanyak 15 individu bagi setiap 100 hektar, Burung Hantu Jelapang (*Tyto alba*) sebanyak lima individu setiap 100 hektar dan Burung Tukang Malas (*Caprimulgus macrurus*) sebanyak tujuh hingga lapan individu bagi setiap 10 hektar. Analisa *Biota and/or Environment Matching Analyses* (BEST) menunjukkan empat pembolehubah peramal, iaitu tiga pembolehubah tempatan (kekayaan tanaman, lebar jalan dan parit) dan satu pembolehubah landskap (jarak ke jalan utama yang terdekat) mempengaruhi secara ketara ke atas komuniti burung malam di kebun kecil. Analisa *Generalized Linear Model* (GLM) pula menunjukkan tujuh pembolehubah peramal (iaitu empat pembolehubah tempatan; ketinggian kelapa sawit, bilangan kelapa sawit, lebar jalan dan parit, dan tiga pembolehubah landskap; bilangan penempatan bagi setiap 100 m radius, jarak hutan dan penempatan terdekat) dengan ketara mempengaruhi kelimpahan spesies burung malam tertentu. Kajian ini menunjukkan bahawa komposisi dan kelimpahan burung malam di kebun kelapa sawit dipengaruhi oleh kedua-dua pembolehubah tempatan dan

landskap. Ini bukan sahaja mempertingkatkan pemahaman kita terhadap pemilihan habitat burung malam yang kurang diketahui di Malaysia tetapi juga menyokong bahawa habitat kawasan tanaman yang kompleks boleh membantu dalam pemuliharaan biodiversiti, iaitu sekurang-kurangnya untuk burung malam.

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest appreciation to my supervisor, Dr. Puan Chong Leong for his intellectual guidance, patience, and endless encouragement. My gratitude also goes to my co-supervisor, Dr. Badrul Azhar for his valuable advices and guidance throughout this study. It is such a blessing to have them in my supervisor committee and without their guidance and persistent help, this study would not have been possible.

I wish to express my sincere gratitude to my thesis examination committee for their constructive comments and suggestions which improved the clarity and rigourousness of the presentation of my thesis.

Finally, I would like to thank everyone who involved and assisted in this study especially to Sharifah Nur Atikah Syed Hassan, Muhamad Syafiq Che Shaffine, Amal Ghazali Nasron, Siti Asmah Muslim, Syafiq Abd Razak, Nor Laili Ibrahim, Sasidhran Selvadurai, Nur Fatin Adila Md Rashid, Raja Nazrin Raja Ahmad, Diau Ya Bing and Muhammad Ekhzarizal Mohamed Eusop. Besides that, I am grateful to have the permission given by land owners to conduct this study in their smallholdings.

I certify that a Thesis Examination Committee has met on **17 March 2017** to conduct the final examination of Muhammad Syafiq Yahya on his thesis entitled "**Assemblages of Nocturnal Birds in Oil Palm Smallholdings in Selangor, Malaysia**" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Ahmad Ainuddin Nuruddin, PhD
Professor
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Mohamed Zakaria Hussin, PhD
Professor
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Mustafa Abdul Rahman, PhD
Professor
Faculty of Natural Science and Sustainability
University College Sabah Foundation
(External Examiner)

ROBIAH YUNUS, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the supervisory Committee were as follows:

Puan Chong Leong, PhD
Senior Lecturer
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Badrul Azhar Md Sharif, PhD
Senior Lecturer
Faculty of Forestry
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotation, illustrations and citation have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: _____ Date: _____

Name and Matric No.: Muhammad Syafiq Bin Yahya (GS37640)

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature : _____

Name of Chairman
of Supervisory
Committee : Dr. Puan Chong Leong

Signature : _____

Name of member
of Supervisory
Committee : Dr. Badrul Azhar Bin Md Sharif

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BEST	Biota and/or Environment Matching analyses
CBO	Common Barn Owl
CDS	Conventional Distance Sampling
DF	Distance to the nearest forest patch
DR	Distance to the nearest main road
DS	Distance to the nearest house
FAO	Food and Agriculture Organization of the United Nations
FDS	Forest Department Sarawak
GLMs	Generalized Linear Models
HP	Average height of oil palms
IT	Informatics Theoretic
IUCN	International Union for Conservation of Nature Red List
LTN	Large-tailed Nightjar
MNS	Malaysian Nature Society
MPOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Council
NC	Number crop species
NP	Number of oil palms
NS	Number of human settlements
PERHILITAN	Department of Wildlife and National Parks
RL	Relative likelihoods
RSPO	Roundtable on Sustainable Palm Oil
SIMPER	Similarity Percentages test
SSO	Sunda Scops Owl
SWD	Sabah Wildlife Department

SWO	Spotted Wood Owl
USD	United State Dollar
WR	Average width of roads
WT	Average width of trenches

CHAPTER 1

INTRODUCTION

1.1 General Background

Originally from West and Central Africa, oil palms (*Elaeis guineensis*) have been planted on a vast scale throughout many developing countries in humid tropical regions (Corley & Tinker, 2003; Wakker *et al*., 2004; Fitzherbert *et al.*, 2008; Koh & Wilcove, 2007; 2008; Tan *et al.,* 2009). Triacylglycerol ('palm oil') derived from oil palms is a main ingredient for a huge variety of edible, cosmetic and industrial products in the market (Pearce, 2008), as well as biofuel (Koh & Ghazoul, 2008) and it has become a major component of the national economy in many developing countries (e.g., Brazil, Malaysia and Indonesia) (Shuit *et al*., 2009; Koh & Wilcove, 2008). In Southeast Asia, millions of hectares of forested land have been converted to oil palm cultivation over the last few decades (Koh & Wilcove, 2007; Groom *et al*., 2008).

Malaysia and Indonesia are the leading countries in the global palm oil trade (Poku, 2002; FAO, 2015). By 2005, the two countries accounted for about 83% of the world's palm oil production and dominated 89% of the global exports of palm oil (Brown *et al*., 2005). Currently, Malaysia alone contributes about 39% of global palm oil production and 44% of the world exports (MPOC, 2012). By year 2012, oil palm cultivation makes up 77% of the total agricultural areas in Malaysia covering about 15% of the total land area of the country (MPOB, 2012). In Malaysia, there are two main types of oil palm management, namely plantations and smallholdings. Plantations involve industrial scale monoculture planting systems of typically more than 500 ha per estate, which are managed mostly by privately owned, listed companies or government linked corporations. On the other hand, smallholdings are owned by local farmers who practice small-scale agriculture involving intercropping with other cultivated plants, within an area sometimes as little as 5 ha (Ismail *et al.,* 2003; Azhar *et al.,* 2011, Jambari *et al*., 2012).

Undeniably, the existence of this monoculture landscape has altered the biological communities that were present before cultivation was established. Yet, in spite of rigorous agricultural management, even homogeneously structured, large-scale oil palm plantations have been shown to serve as

habitats for some fauna species (Azhar *et al.,* 2011; Jambari *et al*., 2012). Despite the number of species found in oil palm cultivation being far below that those in natural forests, oil palm cultivation supports certain species of birds (Koh, 2008a; Azhar *et al.,* 2011; Jambari *et al*., 2012; Azhar *et al*., 2014a), mammals (Azhar et al., 2014b) and insects (Krooss & Schaefer, 1998; Koh, 2008a; Turner & Foster, 2008; Wickramasinghe *et al*., 2004). Such findings indicate the possibility of cultivated areas functioning either as a main or a complementary habitat for species which are able to adapt to such an environment.

Nocturnal birds such as owls were found out to be associated with this complementary habitat and seem to have benefited from such open landscape. In Malaysia, there are three major families of nocturnal birds, i.e. owls (from the family of Strigidae and Tytonidae), Nightjars (from the family of Caprimulgidae), and frogmouths (from the family of Podargidae). In terms of protection status, most nocturnal bird species in Malaysia have been listed as totally protected. Nocturnal birds are listed under second schedule in Section 3 of the Wildlife Conservation Act 2010 under the jurisdiction of the Department of Wildlife and National Parks (PERHILITAN) for Peninsular Malaysia, second schedule in Section 2 of the Wildlife Conservation Enactment 1997 under the jurisdiction of the Sabah Wildlife Department (SWD) for Sabah and first Schedule in Section 2(1) under the Sarawak Wildlife Protection Ordinance 1998 under the jurisdiction of the Forest Department Sarawak (FDS) for Sarawak.

1.2 Problem Statement

Habitat features of the oil palm agro-ecosystem give its nocturnal avifauna special interest. An abundant year-round oil-rich crop can attract many rodents: squirrels by day are replaced by high population densities of various native rats as well as shrews and tree-shrews by night (Wood, 1968; Medway, 1983). Opportunities for predatory birds, however, are constrained by the scarcity of nest sites (oil palms containing no cavities suitable for hole-nesting owls), the continuous canopy of palm fronds (that may interfere with typical foraging methods), and risks from management practices such as rodent poisoning.

Previous studies in Malaysian oil palm plantations have suggested that Common Barn-owls (*Tyto alba*) may provide biological control of rats in oil palm plantations (Lenton, 1984; Hafidzi *et al*., 2003; Puan et al., 2012; Puan, 2013). Besides Common Barn-owl, oil palm plantations routinely serve as a habitat for several other owls, i.e. Spotted Wood-owl (*Strix seluputo*) and Sunda Scops-owl (*Otus lempiji*) (Puan, 2013), and a study conducted in oil palm smallholdings in Malaysia recorded several nocturnal bird species that are more typically associated with forest habitats (i.e. Brown Wood-owl (*Strix leptogrammica*) and Dusky Eagle-owl (*Bubo coromandus*) (Atikah *et al*., 2013).

This inevitably raises questions about nocturnal avian community structure, the relative importance of predators and insectivores, the significance of oil palm as supplemental habitat for otherwise forest-dependent species, and the effects of landscape scale differences such as distance from forest. Other than food availability (Atikah *et al*., 2013), local-level and landscape-level habitat structure are expected to influence the composition of nocturnal birds

particularly in smallholdings that practiced intercropping. Both local-level and landscape-level structure found in smallholdings are different from those of large-scale plantations. Hence, this study examined the effects of local-level and landscape-level variables on the composition and abundances of nocturnal bird species in oil palm smallholdings in Peninsular Malaysia. Species composition and their response to the surrounding environmental factors including local-level or landscapes-level variables are important to both management and conservation of nocturnal birds in Malaysia.

1.3 Objectives

The main objective of this study was to assess the assemblages of nocturnal birds in oil palm smallholdings in Peninsular Malaysia. The specific objectives of this study were:-

(1) To determine the density of nocturnal birds in the oil palm smallholdings using distance sampling, and

(2) To examine the influence of local-level and landscape-level variables on the community assemblage and the abundances on nocturnal birds at species level.

REFERENCES

Abbitt, R.J., Scott, J.M. & Wilcove, D.S. (2000). The geography of vulnerability: incorporating species geography and human development patterns into conservation planning. *Biological Conservation,* 96(2): 169-175.

Abidin, C.M.R.Z, Hafidzi, M.N., Hamid, N.H. & Hasber. S. (2016). Propagation of Barn owls in an Oil Palm Plantation of Sabah: FGV's Experience. Proceedings of 9th International Conference on Plant Protection in The Tropics (9th ICPPT), Kuching Sarawak, Malaysia, pp. 237.

Ahmad, F. (2001). Sustainable agriculture system in Malaysia. In *Regional Workshop on Integrated Plant Nutrition System (IPNS), Development in Rural Poverty Alleviation, United Nations Conference Complex,* Bangkok, Thailand, pp. 18-20.

Aikanathan, S., Chenayah, S. & Sasekumar, A. (2011). Sustainable agriculture: a case study on the palm oil industry. *Malaysian Journal of Science*, 30(1): 66-75.

Alldredge, M.W., Simons, T.R. & Pollock, K.H. (2007). A field evaluation of distance measurement error in auditory avian point count surveys. *The Journal of Wildlife Management,* 71(8): 2759-2766.

Atikah, S.N., Puan, C.L. & Azhar, B. (2013). Preliminary estimation of nocturnal bird density in oil palm agroecosystem, in: Lai, F.S., Halis, R., Bakar, S.N.A., Ramachandran, S., Puan, C.L. (Eds.), Proceedings of the International Forestry Graduate Students Conference. Faculty of Forestry, Universiti Putra Malaysia, Serdang, pp. 50–53.

Arnold, G.W. (1983). The influence of ditch and hedgerow structure, length of hedgerows, and area of woodland and garden on bird numbers on farmland. *Journal of applied Ecology*, 20: 731-750.

Azhar, B., Lindenmayer, D.B., Wood, J., Fischer, J., Manning, A., McElhinny, C. & Zakaria, M. (2011). The conservation value of oil palm plantation estates, smallholdings and logged peat swamp forest for birds. *Forest Ecology and Management,* 262(12): 2306-2315.

Azhar, B., Lindenmayer, D., Wood, J., Fischer, J., Manning, A., McElhinny, C. & Zakaria, M. (2012). Contribution of illegal hunting, culling of pest species, road accidents and feral dogs to biodiversity loss in established oil-palm landscapes. *Wildlife Research,* 40: 1-9.

Azhar, B., Lindenmayer, D. B., Wood, J., Fischer, J., Manning, A., Mcelhinny, C. & Zakaria, M. (2013). The influence of agricultural

system, stand structural complexity and landscape context on foraging birds in oil palm landscapes. *Ibis*, 155(2): 297-312.

Azhar, B., Puan, C.L., Zakaria, M., Hassan, N. & Arif, M. (2014a). Effects of monoculture and polyculture practices in oil palm smallholdings on tropical farmland birds. *Basic and Applied Ecology*, 15: 336-346.

Azhar, B., Lindenmayer, D.B., Wood, J., Fischer, J. & Zakaria, M. (2014b). Ecological impacts of oil palm agriculture on forest mammals in plantation estates and smallholdings. *Biodiversity and Conservation*, 23: 1175-1191.

Azhar, B., Puan, C.L., Aziz, N., Sainuddin, M., Adila, N., Samsuddin, S., Asmah, S., Syafiq, M., Syafiq, A.R., Hafizuddin, A., Hawa, A. & Jamian, S. (2015a). Effects of in situ habitat quality and landscape characteristics in the oil palm agricultural matrix on tropical understory birds, fruit bats and butterflies. *Biodiversity and Conservation*, 24(12): 3125-3144.

Azhar, B., Saadun, N., Puan, C.L., Kamarudin, N., Aziz, N., Nurhidayu, S. & Fischer, J. (2015b). Promoting landscape heterogeneity to improve the biodiversity benefits of certified palm oil production: Evidence from Peninsular Malaysia. *Global Ecology and Conservation*, 3: 553-561.

Basri, M.W. (2010). Overview of the Malaysian oil palm industry 2009. Malaysian Palm Oil Board. http://econ.mpob.gov.my/economy/Overview_2009.pdf (accessed 20 May 2015).

Benton, T.G., Vickery, J.A. & Wilson, J.D. (2003). Farmland biodiversity: is habitat heterogeneity the key?. *Trends in Ecology & Evolution*, 18: 182-188.

Bogner, H.E. & Baldassarre, G.A. (2002). The effectiveness of call-response surveys for detecting Least Bitterns. *The Journal of wildlife management*, 66: 976-984.

Brown, E. (2005). *Cruel Oil. How palm oil harms health, rainforest and wildlife*. Center of Science in the Public Interest. Washington D.C., pp. 11-26.

Buckland, S.T. (2006). Point-transect surveys for songbirds: robust methodologies. *The Auk*, 123(2): 345-357.

Buskirk, W.H. & McDonald, J.L. (1995). Comparison of point count sampling regimes for monitoring forest birds. *Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, US Department of Agriculture*, pp. 25-34.

Clarke, K.R. & Ainsworth, M. (1993). A method of linking multivariate community. *Marine ecology progress series*, 92: 205-219.

Corley, R.H.V. & Tinker P.B.H. (2003). *The oil palm. Fourth edition*. Blackwell Science Ltd, Oxford.

Conway, C.J. & Gibbs, J.P. (2005). Effectiveness of call-broadcast surveys for monitoring marsh birds. *The Auk*, 122(1): 26-35.

Danielsen, F., Beukema, H., Burgess, N.D., Parish, F., Bruhl, C.A., Donald, P.F., Murdiyarso, D., Phalen, B., Reijnders, L., Struebig, M. & Fitzherbert, E.B. (2009). Biofuel plantations on forested lands: double jeopardy for biodiversity and climate. *Conservation Biology,* 23: 348–358.

Delport, W., Kemp, A.C. & Ferguson, J.W.H. (2002). Vocal identification of individual African Wood Owls *Strix woodfordii*: a technique to monitor long-term adult turnover and residency. *Ibis*, *144*(1): 30-39.

Donald, P.F., Green, R.E. & Heath, M.F. (2001). Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London B: Biological Sciences*, 268 (1462): 25-29.

Dragonetti, M. (2007). Individuality in scops owl *Otus scops* vocalisations. *Bioacoustics*, *16*(2): 147-172.

Fayle, T.M., Turner, E.C., Snaddon, J.L., Chey, V.K., Chung, A.Y., Eggleton, P. & Foster, W.A. (2010). Oil palm expansion into rain forest greatly reduces ant biodiversity in canopy, epiphytes and leaf-litter. *Basic and Applied Ecology*, 11(4): 337-345.

Fitzherbert, E.B., Struebig, M.J., Morel, A., Danielsen, F., Brühl, C.A., Donald, P.F. & Phalan, B. (2008). How will oil palm expansion affect biodiversity?. *Trends in ecology & evolution*, 23(10): 538-545.

Food and Agriculture Organization of the United Nations, FAO, (2015). Food and Agriculture Organization of the United Nations Statistics Division from: http://faostat3.fao.org/compare/E (accessed January 3, 2015).

Foster, W.A., Snaddon, J.L., Turner, E.C., Fayle, T.M., Cockerill, T.D., Ellwood, M.F., Broad, G.B., Chung, A.Y.C., Eggleton, P., Khen, C.V. & 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 B: Biological Sciences*, 366: 3277-3291.

Fuller, M.R. & Mosher, J.A. (1981). Methods of detecting and counting raptors: a review.

Fuller, R. J. (Ed.). (2012). *Birds and Habitat: relationships in changing landscapes.* Cambridge University Press.

Gerhardt, R.P. (1991). Response of Mottled Owls to Broadcast of Conspecific Call *Journal of Field Ornithology,* 62: 239-244.

Ghazali, A., Asmah, S., Syafiq, M., Yahya, M.S., Aziz, N., Tan, L.P., Norhisham, A.R., Puan, C.L., Turner, E.C. & 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.

Goosem, M. (2007). Fragmentation impacts caused by roads through rainforests. *Current Science*, 93(11): 1587-1595.

Green, R.E., Cornell, S.J., Scharlemann, J.P.W. & Balmford, A. (2005). Farming and the fate of wild nature. *Journal of Science,* 307: 550-555.

Groom, M.J., Gray, E.M. & Townsend, P.A. (2008). Biofuels and biodiversity: principles for creating better policies for biofuel production. *Conservation biology*, *22*(3): 602-609.

Hafidzi, M.N. & Naim, M. (2003). The use of the Barn Owl, *Tyto alba* to suppress rat damage in rice fields in Malaysia. *Aciar Monograph,* 96: 274-276.

Najmi-Hanis Z., Puan, C.L., Zakaria, M. & Azhar, B., (2016). Home range and activity patterns of Sunda Scops-owl in Peninsular Malaysia. *Raffles Bulletin of Zoology*, 64: 28–32.

Hassall, M., Jones, D.T., Taiti S., Latipi Z., Sutton S.L. & Mohammed M. (2006). Biodiversity and abundance of terrestrial isopods along a gradient of disturbance in Sabah, East Malaysia. *European Journal of Soil Biology*. 42: S197-S207.

Haselmayer, J. & Quinn, J.S. (2000). A comparison of point counts and sound recording as bird survey methods in Amazonian southeast Peru. *The Condor*, *102*(4): 887-893.

Hausleitner, D. & Bio, R.P. (2006). Inventory Methods for Owl Surveys. Standards for Components of British Columbia's Biodiversity No. 42. Ecosystem Branch of the Ministry of Environment for the Resources Information Standards.

Hill, E.F. & Mendenhall, V.M. (1980). Secondary poisoning of barn owls with famphur, an organophosphate insecticide. *The Journal of Wildlife Management*. 44(3): 676-681.

Hegdal, P.L. & Colvin, B.A. (1988). Potential hazard to eastern screech-owls and other raptors of brodifacoum bait used for vole control in orchards.*Environmental toxicology and chemistry*, *7*(3): 245-260.

Holzschuh, A., Steffan-Dewenter, I., Kleijn, D. & Tscharntke, T. (2007). Diversity of flower-visiting bees in cereal fields: effects of farming system, landscape composition and regional context. *Journal of Applied Ecology*, 44: 41-49.

Ismail, A., Simeh, M.A. & Noor, M.M. (2003). The production cost of oil palm fresh fruit bunches: the case of independent smallholders in Johor. *Oil Palm Industry Economic Journal*, 3(1): 1-7.

Jambari A., Azhar B., Ibrahim N.L., Jamian S., Hussin A., Puan C.L. & Zakaria M. (2012). Avian biodiversity and Conservation in Malaysian oil palm production areas. *Journal of Oil Palm Research,* 24: 1277-1286.

Jones, M.J., Linsley, M.D. & Marsden, S.J. (1995). Population sizes, status and habitat associations of the restricted-range bird species of Sumba, Indonesia. *Bird Conservation International*, *5*(01): 21-52.

Kay, B.J., Twigg, L.E., Korn, T.J. & Nicol, H.I. (1994). The use of artifical perches to increase predation on house mice (*Mus domesticus*) by raptors. *Wildlife Research*, 21(1): 95-105.

Kemp, A., Kemp M. & Thong-aree, S. (2009). Surveys of nocturnal birds at Bala rainforest, southern Thailand. *Forktail*, 25: 117-124.

King, B. (2002). Species limits in the Brown Boobook *Ninox scutulata* complex. *Bulletin of the British Ornithologists' Club,* 122(4): 250-257.

Koh, L.P. & Wilcove, D.S. (2007). Cashing in palm oil for conservation. *Nature*, 448(7157): 993-994.

Koh, L.P. & Ghazoul, J. (2008). Biofuels, biodiversity, and people: understanding the conflicts and finding opportunities. *Biology Conservation*, 141: 2450-2460

Koh, L.P. & Wilcove, D.S. (2008). Is oil palm agriculture really destroying tropical biodiversity?. *Conservation letters,* 1(2): 60-64.

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

Koh, L.P. (2008b). Birds defend oil palms from herbivorous insects. *Ecological Applications,* 18(4): 821-825.

König, C., Weick, F. & Becking, J.H. (1999). Owls*: a guide to the owls of the world* (Vol. 12). Christopher Helm Publishers Incorporated.

Kujawa, K. (1997). Relationships between the structure of mid-field woods and their breeding bird communities. *Acta Ornitologica*, *32*, 175-184.

Krooss, S. & Schaefer, M. (1998). The effect of different farming systems on epigeic arthropods: a five-year study on the rove beetle fauna (Coleoptera: Staphylinidae) of winter wheat. Agriculture, ecosystems & environment, 69(2): 121-133.

Lack D. (1954). *The Natural Regulation of Animal Numbers*, Clarendon Press, Oxford.

Laiolo, P. (2002). Effects of habitat structure, floral composition and diversity on a forest bird community in north-western Italy. *Folia Zoologica*, *51*(2), 121-128.

Legare, M.L., Eddleman, W.R., Buckley, P.A. & Kelly, C. (1999). The effectiveness of tape playback in estimating Black Rail density. *The Journal of wildlife management,* 63(1): 116-125.

Lenton, G.M. (1984). The feeding and breeding ecology of Barn Owls Tyto alba in peninsular Malaysia. *Ibis*, *126*(4), 551-575.

Mack, Y.P. & Quang, P.X. (1998). Kernel methods in line and point transect sampling. *Biometrics,* 54: 606-619.

Maddox, T., Priatna, D., Gemita, E. & Salampessy, A. (2007). The conservation of tigers and other wildlife in oil palm plantations. *ZSL Conservation Report,* No.7. London: The Zoological Society of London.

Malaysia Palm Oil Board, MPOB (2012). Oil Palm and the Environment. Retrieved from: http://www.mpob.gov.my/en/home (accessed May 27, 2014).

Medway, L.G. (1983). *The Wild Mammals of Malaya (Peninsular Malaysia) and Singapore* (Second edition), Oxford University Press.

Mendenhall, V.M. & Pank, L.F. (1980). Secondary poisoning of owls by anticoagulant rodenticides. *Wildlife Society Bulletin*, 8: 311-315.

Malaysian Palm Oil Council, MPOC (2012). The oil palm trees. Malaysian Palm Oil Council. Retrieved from http://www.mpoc.org.my/The_Oil_Palm_Tree.aspx (accessed 20 April 2015).

Malaysian Nature Society, MNS (2005). A Checklist of the Birds of Malaysia – Conservation Publication No.2. Malaysian Nature Society - Birds Conservation Council, Kuala Lumpur.

Michel, V.T., Jiménez-Franco, M.V., Naef-Daenzer, B. & Grüebler, M.U. (2016). Intraguild predator drives forest edge avoidance of a mesopredator. *Ecosphere*, *7*(3) doi:10.1002/ecs2.1229.

Naim, M., Hafidzi, M. N., Azhar, K. & Jalila, A. (2010). Growth performance of nestling barn owls, Tyto Alba javanica in rat baiting area in Malaysia. *ARPN Journal Agriculture Biological Science*, 5: 1-13.

Newton, I., Kavanagh, R., Olsen, J. & Taylors, I. (2012). Ecology and conservation of Owls: proceedings of the Owls 2000 Conferences, Canberra, Australia. CSIRO Publishing, Canberra.

Newton, I. (2004). The recent declines of farmland bird populations in Britain: an appraisal of causal factors and conservation actions. *Ibis*, 146(4): 579-600.

Nichols, J. D., Hines, J. E., Sauer, J. R., Fallon, F. W., Fallon, J. E. & Heglund, P. J. (2000). A double-observer approach for estimating detection probability and abundance from point counts. *The Auk*, 117(2): 393-408.

Norris, K. (2008). Agriculture and biodiversity conservation: opportunity knocks. *Conservation letters*, *1*(1): 2-11.

Padoa-Schioppa, E., Baietto, M., Massa, R. & Bottoni, L. (2006). Bird communities as bioindicators: the focal species concept in agricultural landscapes. *Ecological indicators*, *6*(1): 83-93.

Pearce, F. (2008). The Gurdian. The slippery business of palm oil. . Retrieved from http://www.theguardian. com/environment/2008/nov/06/1 (accessed 20 January 2015).

Puan, C.L. & Zakaria, M. (2007). Perception of visitors towards the role of zoos: a Malaysian perspective. *International Zoo Yearbook*, 41(1): 226-232.

Puan, C.L., Goldizen, A.W., Zakaria, M., Hafidzi, M.N. & Baxter, G.S. (2011). Absence of differential predation on rats by Malaysian barn owls in oil palm plantations. *Journal of Raptor Research*, *45*(1): 71-78

Puan, C.L., Baxter, G.S., Goldizen, A.W., Zakaria, M. & Hafidzi, M.N. (2012). Barn owl predatory behavior and response to prey abundance: towards an ecologically-based agricultural practice. *Ornis Mongolia,* 1: 63-66.

Puan, C.L. (2013). *Integrating Ecology into Rodents Pest Management in Oil Palm Agroecosystem*. University Putra Malaysia Press, Serdang.

Puan, C.L., Yong, D.L., Azhar, B., Phua, M.H. & Lim, K.C. (2015). Ecological correlations of nocturnal bird assemblages in Malaysian Borneo. *Forktail*, 31: 82–86.

Poku, K. (2002). Small-scale Palm Oil Processing in Africa. FAO Agricultural Services Bulletin 148. Retrieved from: http://www.fao.org. (accessed 25 July 2015)

Ralph, C.J. & Sauer, J.R. (1995). Monitoring bird populations by point counts. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, New York.

Robson, C. & Allen, R. (2000). A field guide to the birds of South-East Asia. New Holland. London.

Rundlöf, M., Bengtsson, J. & Smith, H.G. (2008). Local and landscape effects of organic farming on butterfly species richness and abundance. *Journal of Applied Ecology*, 45: 813-820.

Sachs, J.D., Baillie, J.E.M. & Sutherland, W.J. (2009) Biodiversity conservation and the millennium development goals. *Science*, 325: 1502–1503.

Salim, H., Noor, H.M., Hamid, N.H., Omar, D., Kasim, A. & Abidin, C.M.R.Z. (2014). Secondary poisoning of captive Barn Owls, *Tyto alba javanica* through feeding with rats poisoned with chlorophacinone and bromadiolone. *Journal of Oil Palm Research*, 26: 62-72.

Salim, H., Noor, H.M., Tajudin, R., Hamid, N.H., Omar, D., Kasim, A. & Abidin, C.M.R.Z. (2016). Effects of rodenticide on growth of nestling barn owl, *Tyto alba javanica* in oil palm plantations. *Journal of Oil Palm Research*, *28*(1), 16-25.

Savilaakso, S., Garcia, C., Garcia-Ulloa, J., Ghazoul, J., Groom, M., Guariguata, M.R., Laumonier, Y., Nasi, R., Petrokofsky, G., Snaddon, J. & Zrust, M. (2014). Systematic review of effects on biodiversity from oil palm production. *Environmental Evidence*, 3: 1-21.

Sheng, H.L. & Xu, H.F. (1992). *Field Research Methods for Mammals*. Beijing:
China Forestry Press.

Shuit, S.H., Tan, K.T., Lee, K.T. & Kamaruddin A.H. (2009). Oil palm biomass as a sustainable energy source: A Malaysian case study. *Energy*, 34: 1225-1235.

Sutherland, W.J. (Ed.). (2006). *Ecological census techniques: a handbook*. Cambridge University Press.

Syafiq, M., Atiqah, A.R.N., Ghazali, A., Asmah, S., Yahya, M.S., Aziz, N., Puan. C.L. & Azhar, B., (2016). Responses of tropical fruit bats to monoculture and polyculture farming in oil palm smallholdings. *Acta Oecologica*, 74: 11–18.

Takats, D.L. & Holroyd, G. (1998). Owl Broadcast Surveys in the Foothills Model Forest, Alberta, Canada. Manitoba: Department of Renewable Resources Canada.

Takats, D.L., Francis, C.M., Holroyd, G.L., Duncan, J.R., Mazur, K.M., Cannings, R.J., Harris, W. & Holt, D. (2001). Guidelines for nocturnal owl monitoring in North America. Edmonton: Beaverhill Bird Conservatory and Bird Studies Canada.

Tan, K.T., Lee, K.T., Mohamed, A.R. & Bhatia S. (2009). Palm oil: addressing issues and towards sustainable development. *Renewable and Sustainable Energy Reviews,* 13(2): 420-427.

Tilman, D., Cassman, K.G., Matson P.A., Naylor R. & Polasky S. (2002). Agricultural sustainability and intensive production practices. *Nature, 418*: 671–677.

Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., Bishop, J.R.B., Marques, T.A. & Burnham, K. P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*, *47*(1): 5-14.

Turner, E.C. & Foster, W.A. (2008). The impact of forest conversion to oil palm on arthropod abundance and biomass in Sabah, Malaysia. *Journal of Tropical Ecology,* 25: 23-30.

Venable, N.J. (1985). *Night Birds, Owls*. Cooperative Extension Service, West Virginia University.

Vandermeer, J. & Perfecto, I. (2007). The agricultural matrix and a future paradigm for conservation. *Conservation biology*, *21*(1): 274-277.

Wakker, E., Watch, S. & Rozario, J. D., (2004). Greasy Palms: the Social and Ecological Impacts of Large-scale Oil Palm Plantation Development in Southeast Asia. AIDEnvironment, Amsterdam.

Wells, D.R. (1999). The Birds of the Thai-Malay Peninsula: Non-passerines, Volume 1. Academic Press, London.

Wickramasinghe, L.P., Harris, S., Jones, G. & Vaughanm J.N. (2004). Abundance and species richness of nocturnal insects on organic and conventional farms: effects of agricultural intensification on bat foraging. *Conservation Biology*, 18(5): 1283-1292.

Wildlife Conservation Act. (2010). *Laws of Malaysia* (*Act 716)*. Percetakan Nasional Malaysia Berhad. Kuala Lumpur.

Wildlife Conservation Enanctment. (1997). Laws *of Sabah*. Percetakan Nasional Malaysia Berhad.

Wildlife Protection Ordincance. (1998). *Laws of Sarawak* (Chapter 26). Percetakan Nasional Malaysia Berhad.

Wood, B.J. (1968). Pests of Oil Palms in Malaysia and Their Control. Incorporated Society of Planters, Kuala Lumpur.

Wood, B.J., Corley, R.H.V. & Goh, K.H. (1973). Studies on the effect of pest damage on oil palm yield, in: Wastie, R.L., Earp, E.A. (Eds.), *Advances in Oil Palm Cultivation*. Incorporated Society of Planters, Kuala Lumpur, pp. 360–374.

Wood, B.J. & Fee, C.G. (2003). A critical review of the development of rat control in Malaysian agriculture since the 1960s. *Crop Protection,* 22(3): 445-461.

Yaap, B., Struebig, M.J., Paoli, G. & Koh, L.P. (2009). Mitigating the biodiversity impacts of oil palm development. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 5, 19.Venable, N. J., (1985). Night Birds: Owls. *Furtherance of Acts of Congress of May 8 and June 30*, 1914. West Virginia.

Zakaria, M., Chong, L.P. & Yusuf, M.E. (2005). Comparison of species composition in three forest types: Towards using bird as indicator of forest ecosystem health. *Journal of biological sciences*, *5*(6): 734-737.