UNIVERSITI PUTRA MALAYSIA

AVIAN BIODIVERSITY PARAMETERS IN RICE FIELDS IN KUALA SELANGOR, MALAYSIA

NUR AMIRA MOHD HANAFI

FH 2018 3

AVIAN BIODIVERSITY PARAMETERS IN RICE FIELDS IN KUALA SELANGOR, MALAYSIA

By

NUR AMIRA MOHD HANAFI

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

January 2018

COPYRIGHT

Dedication

This piece of work is dedicated to my beloved father Mohd Hanafi and my lovely mother Nor Ana and to all my siblings. Your unconditional love has made me stronger throughout my study, Thanks.

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

AVIAN BIODIVERSITY PARAMETERS IN RICE FIELDS IN KUALA SELANGOR, MALAYSIA

By

NUR AMIRA MOHD HANAFI

January 2018

Chair : Badrul Azhar Md Sharif, PhD
Faculty : Forestry

Rice is one of the main staple food for most of Southeast Asian countries and it is one of the traditional crops in Malaysia and its neighbouring countries. Not only that, rice fields are common agricultural landscape of Southeast Asia that inhabited by various species of birds. This is because flooded rice fields provide similar environmental conditions to certain natural wetland habitats in terms of flooding condition, water depth and landscape features. Declination of wetland areas also one of the reasons birds are attracted to rice fields. These birds would provide ecosystem services that improve agricultural yields with minimum use of agrochemicals such as pesticides.

Until now, there are quite a number of scientific studies that have investigated the status and ecology of birds in the rice fields of Malaysia. Thus, this study is the first to quantify avian biodiversity in rice production landscapes during three farming stages in Peninsular Malaysia. More specific, it determined bird abundance, species richness, and composition in rice field landscapes, and compared these during different stages of rice growing.

This study was conducted at the rice fields in Kuala Selangor district. A total of 60 sampling points were randomly established in three locations, from which 3,447 individual birds of 46 species and 26 families were recorded. Water and land birds were counted in rice fields using the point-count method. There was a significant difference in bird abundance between the three different stages of rice growing. In bird species richness, the results showed significant difference during the various stages of rice growing.

The growing stage supported greater bird abundance and more diverse species composition compared to the pre-harvest and post-harvest stages. Rice-growing provides temporary habitats to different bird species in the managed aquatic landscape. This implies the presence of abundant food, such as small fish and amphibians. In conclusion, the evidence from this study suggests that biodiversity-friendly agricultural practices should be implemented to improve habitat quality for birds in rice production landscapes. Apart from being agricultural landscapes, rice fields also can be managed more as an off-reserve strategy in order to protect the waterbird diversity.

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

BIODIVERSITI BURUNG DI DALAM LANSKAP SAWAH PADI DI KUALA SELANGOR, MALAYSIA

Oleh

NUR AMIRA MOHD HANAFI

Januari 2018

Pengerusi : Badrul Azhar Md Sharif, PhD
Fakulti : Perhutanan

Beras adalah salah satu makanan ruji utama bagi kebanyakan negara di Asia Tenggara dan ia merupakan salah satu tanaman tradisional di Malaysia dan negara-negara jiran. Bukan itu sahaja, sawah padi juga merupakan landskap pertanian yang biasa di Asia Tenggara yang menampung kepelbagaian spesies burung. Ini kerana, keadaan sawah padi yang dibanjiri air dapat menyediakan keadaan tertentu yang menyerupai dengan habitat semulajadi tanah lembap seperti keadaan air yang bertakung, kedalaman air dan kepelbagaian ciri landskap. Kemerosotan kawasan tanah lembap juga merupakan salah satu daripada punca, burung-burung air tertarik kepada sawah padi. Burung-burung ini secara tidak langsung membantu menyediakan perkhidmatan ekosistem yang dapat meningkatkan hasil pertanian dengan penggunaan agrokimia secara minimum.

Sehingga kini, terdapat beberapa kajian saintifik yang telah menyelidik tentang status terkini burung-burung di sawah padi di Malaysia. Oleh yang demikian, kajian ini digunakan untuk mengukur biodiversiti burung dalam landskap penanaman padi semasa berada di tiga peringkat pertumbuhan padi di Semenanjung Malaysia. Secara spesifik lagi, ia adalah untuk menentukan kelimpahan burung, kekayaan spesies, dan juga komposisi di dalam landskap sawah padi, dan membuat perbandingan di antara ketiga-tiganya semasa kitaran pertumbuhan padi di setiap peringkat pertumbuhan yang berlainan.

Kajian ini telah dijalankan di sawah padi di daerah Kuala Selangor. Sebanyak 60 titik persampelan telah dipilih secara rawak di tiga lokasi berlainan, di mana sebanyak 3,447 individu burung daripada 46 spesies dan 26 keluarga telah direkodkan. Burung air dan burung telah dikira di sawah padi menggunakan kaedah bilang titik. Terdapat perbezaan yang signifikan dalam jumlah kelimpahan burung di

antara ketiga-tiga peringkat penanaman padi. Manakala dalam kekayaan spesis burung , keputusan data menunjukkan perbezaan yang signifikan dalam pelbagai peringkat penanaman padi

Dalam peringkat awal tumbesaran padi, ia dilihat menyokong kelimpahan burung yang lebih banyak dan komposisi spesies yang lebih pelbagai berbanding dengan peringkat pra-tuai dan lepas tuai. Pertumbuhan padi pada peringkat awal membantu menyediakan habitat sementara kepada spesis burung yang berbeza dalam landskap akuatik yang terurus. Ini menunjukkan bahawa terdapat kehadiran makanan yang banyak, seperti ikan kecil dan amfibia. Sebagai kesimpulannya, bukti daripada kajian ini menunjukkan bahawa amalan pertanian mesra-biodiversiti perlu dilaksanakan untuk meningkatkan kualiti habitat untuk burung dalam landskap pengeluaran padi. Selain daripada menjadi landskap pertanian, sawah padi juga boleh diuruskan dengan lebih baik sebagai salah satu strategi rezab-luaran untuk melindungi kepelbagaian burung ai

ACKNOWLEDGEMENTS

Alhamdulillah, all praise to Allah S.W.T, The Most Merciful, who gave me strength to finish writing this thesis. First and foremost, I would like to extend my gratitude towards my supervisor, Dr. Badrul Azhar Md Sharif, who without any doubt giving me a lot of knowledge, ideas, guidance, helpful comment and patience on the whole process of making this thesis successful. A big thanks to the Faculty of Forestry, Universiti Putra Malaysia for giving me opportunity to do the study.

A grateful thanks to the local community in Tanjung Karang, Sekinchan and Sungai Besar for their endless cooperation and helps given throughout the study. Not forgetting, my friends for their encouragement and helps and being supportive that enable me to complete this journey.

Finally, I would like to express my deepest love and gratitude for my family especially my mother, Nor Ana Haji Ali and my father, Mohd Hanafi Hassan for their unwavering support, emotional motivation and love that I received from them. Lastly, to everyone who involve directly and indirectly to complete this thesis. Thank you.

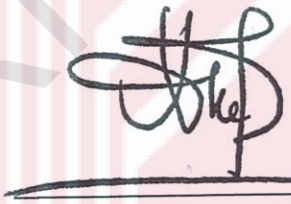
I certify that a Thesis Examination Committee has met on 19 January 2018 to conduct the final examination of Nur Amira binti Mohd Hanafi on her thesis entitled "Avian Biodiversity Parameters in Rice Fields in Kuala Selangor, Malaysia" in accordance with the Universities and University Colleges Act 1971 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:

Mohamad Azani bin Alias, PhD
Associate Professor
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

Hafidzi bin Mohd Noor, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Shahrul Anuar Mohd Sah, PhD
Professor
Universiti Sains Malaysia
Malaysia
(External Examiner)



NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 26 April 2018

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

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

Tengku Rinalfi Putra Tengku Azizan, PhD
Senior Lecturer
Faculty of Veterinary Medicine
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:

- x this thesis is my original work;
- x quotations, illustrations and citations have been duly referenced;
- x this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- x 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;
- x written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the 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 (Research) Rules 2012;
- x 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.: __Nur Amira Binti Mohd Hanafi (GS 42662)__

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 are stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to:

Signature: _____

Name of Chairman
Of Supervisory Committee : Dr. Badrul Azhar Md. Shariff

Signature: _____

Name of Member
Of Supervisory Committee : Dr. Tengku Rinalfi Putra Tengku Azizan

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GRiSP	Global Rice Science Partnership
MADA	Lembaga Kemajuan Pertanian Muda
FAO	Food and Agriculture Organization
IWMI	International Water Management Institute
DDT	Dithio dimethyl trichloroethane
BHC	Benzene hexachloride
DDE	1,1 , bis-4-chlorphenyl)- 2,2 dichlorethylene
ANOVA	One Way Analysis of Variance
MDS	Multi-Dimensional Scaling
ANOSIM	Analyses of Similarity

CHAPTER 1

INTRODUCTION

1.1 Background Study

Over the past century, continuous agricultural expansion has changed most natural habitats, including wetlands. The loss and degradation of natural wetlands have negatively affected water birds (Ma et al. 2010). However, the creation of artificial wetland area is viewed as valuable measure as it can provide new habitat for bird communities (Zedler, 2003; Ismail, 2012). Artificial wetlands are those that are created or extensively modified by humans; for example, salt ponds, and reservoir and rice fields. Moreover, Ramsar Convention (1971) has categorized rice field as a type of man-made wetlands and is considered an important habitat in agricultural ecosystem (Ramsar Convention Secretariat, 2013). Therefore Czech and Parsons (2002), stated that rice fields are among the most important artificial wetland habitats for water birds worldwide.

Rice fields occupy more of the world's land than any other wetland crop, covering over 1.5 million km^2 (FAO, 2004). This is because rice is the primary source of calories for over half of the world's human population (Donald, 2004). It is grown mostly in humid coastal lowlands and deltas, where the soil holds water well. In the Indochinese region, *Oryza sativa* was domesticated independently for the local varieties and widespread to China, India and Indonesia. Rice is produced in many ways, ranging from dry fields (50% of all rice production) through seasonally flooded fields to deep permanent inundation (Donald, 2004). However, all rice plants share common features and go through three main stages of growth that is vegetative, reproductive, and ripening before the seed can be harvested (Global Rice Science Partnership (GRiSP), 2013).

Rice plants can be categorized into two group varieties- the short-variation varieties which mature in 105-120 days and the long-duration varieties which mature in 150 days (GRiSP, 2013). The short-duration varieties usually planted in tropical environment, spends about 45-60 days in the vegetative phase, 30 days in reproductive phase, and another 30 days in the ripening phase. The growth duration of the rice plant is 3 - 6 months, depending on the variety and the environment under which it is grown. During this time, rice completes two distinct growth phases that is vegetative and reproductive. The vegetative phase includes germination, early seedling growth, and tillering meanwhile, the reproductive phase is the time before and after heading that is panicle exsertion in rice plants (Bambaradeniya and Amerasinghe, 2003). Ripening period is the time after the heading is complete.

Most classifications of rice environments are based on hydrological characteristics. Irrigated lowland rice is grown in bunded fields need to have sufficient water available during entire growing season, with controlled shallow water depth between 5 to 10 cm for one or more crops a year (Bambaradeniya and Amerasinghe, 2003). Rain-fed lowland environments which are mainly dependent on the duration of the rainfall for at least part of the cropping season to water depths that exceed 100 cm for no more than 10 days. In both irrigated and rain-fed lowlands, fields are predominantly puddled, and plants are transplanted, direct seeding on wet or dry soil is also widely practiced and has largely replaced transplanted irrigated rice in South East Asia (Halwart and Gupta, 2004).

In South East Asia, where agriculture is a major source of livelihood, Malaysia is one of the rice producers that contribute to the percentage of world total milled rice production. Rice (*Oryza sativa*) is the third most important crop after oil palm and the rubber in regards of economic importance in Malaysia (Mohd Ekhwan et al. 2013) and is mainly produced in four states in northern Peninsular Malaysia – Kedah, Perak, Perlis and Penang. In the 1950′s, 73% of the land in Peninsular Malaysia was forested, but more than half of this land has now been lost by conversion to agriculture and another quarter has been logged (Rainforest Conservation Fund, 2014). According to Ministry of Agriculture (2010), the total area of Malaysia's agricultural traditional landscapes that characterized by rice fields are 673 745 ha. Rice cultivation has great impact on birds, as birds can be directly influenced by the land use, habitat quality and food supply (McCafee, 2011).

1.2 Problem Statement

In Malaysia, there are quite a number of scientific studies of birds in the rice fields while in other producing countris the studies of birds in rice fields mostly focused on water birds and some on farmland birds (Amano et al. 2008; Fujioka, 2010; Elphick, 2008). Not only that, along Peninsular Malaysia's west and east coasts, there is a presence of wetland and wide coastal plains that provide migration routes for both sides of land mass (Malaysia Birding, 2011). In Peninsular Malaysia, most rice fields are found at the downstream zone of major rivers and close to coastal areas (MADA, 2014). Here, rice is planted mainly in two seasons in a year, with several growing stages in one season (Toriman et al. 2013).

There are three main stages including direct seedlings or transplanting, growing and harvesting activities, creating temporary wetlands with inundated water> 10 cm level (Nur Munira et al. 2014a). As part for the agricultural intensification to increase food production, the pesticides are used intensively to protect the paddy plants from algae, weeds, insects and diseases (Ahmed, 2001). The use of insecticides, herbicides and fungicides in the rice fields might cause direct and indirect impacts towards birds that associate with rice fields (Parsons, 2010). This can be illustrated briefly by data from the Ebro delta that conducted by Martinez-Vilalta (1996) shown massive declines of bird numbers coincident with peaks of indiscriminate pesticide use in the 1970s.

Malaysian rice fields are surrounded by many different habitats such as secondary forest, shrub land and streams. The connection between these habitats has provided various organism including birds, reptiles and fishes with food and shelter (Katoh et al. 2009). This in turn attracts different kind of bird species including farmland bird and raptors.The most common bird in rice fields are Egrets, Herons, Bitterns and Common Myna (Nur Munirah et al. 2014a; Maeda, 2001; Paliwal and Bhandarkar, 2014; Fujioka, 2010; Acosta et al. 2010). In general, rice fields provide suitable habitat for foraging, breeding activities and shelter for various kind of birds (Takahashi and Ohkawara, 2007; Wood et al. 2010).

To date, studies that have correlated water bird with rice field habitats and farming management practices was carried out only in certain periods, such as the non-growing season (Amano, 2008; Elphick, 2004). Several studies in fact have revealed that, the abundance of water bird species also varied among each stage of rice growing cycle. Recent study by Nam et al. (2015) in the South Korea stated that the shorebirds, herons, and waterfowl species that were observed mainly used flooded fields before rice transplanting, during rice growing and post-harvest respectively. Another example of this, is the study carried out by Nachuha (2009) in which, the abundance of individual species (most common ones) have higher abundances recorded on ploughed fields (36 individuals) and fields with rice (38 individuals).

In Malaysia, a considerable amount of literature has been published regarding birds in rice fields. As an example, a recent study conducted in northern Peninsular Malaysia by Nur Munirah et al. (2014a) recorded 67 bird species in the rice field. This shows the number of bird species that use rice fields is relatively high. Another factor that influences the bird diversity and abundance in the rice fields is the migratory season (Robson, 2005). Migrants usually arrive in Peninsular Malaysia in very large numbers from September to March every year (Jeyarajasingam and Pearson, 2012). Hence, it is crucially important to determine the population structure of the water birds in terms of ecological and the effects of disturbances in rice fields on the water birds for improved management and conservation.

1.3 Research Objectives

The research objectives of this study are as follows:

1. To determine and compare bird species composition in three rice farming stages; growing stage, pre-harvest stage and post-harvest stage.

2. To compare bird abundance and species richness in three rice farming stages.

1.4 Research Hypotheses

1. Families with diverse species composition are predicted to be highest in the growing stage compared to pre-harvest and post-harvest stage.

2. Bird abundance species are estimated to be high during pre-harvest stage and lowest during the post-harvest stage.

3. Bird species richness is expected to be highest in pre-harvest stage compared to growing and post-harvest stage.

REFERENCES

Abdullah, A. R., Bajet, C. M., Matin, M. A., Nhan, D. D. & Sulaiman, A. H. 1997. Ecotoxicology of pesticides in the tropical paddy field ecosystem. *Environ. Toxicol. Chem.* 16(1), 59-70.

Abdullah, S. A. & Nakagoshi, N. 2007. Forest fragmentation and its correlation to human land use change in the state of Selangor, Peninsular Malaysia. *Forest Ecology and Management* 241, 39-48.

Acosta, M., Mugica, L., Blanco, D., Lopez-Lanus, B., Dias, R.A., Doodnath, L.W. & Hurtado, J. 2010. Birds of rice fields in the Americas. *Waterbirds* 33, 105-122.

Ahmed, F. E. 2001. Analyses of pesticides and their metabolites in foods and drinks. *Trends in Analysis Chemistry* 20(11): 649-661.

Amano, T., Kusumoto, Y., Tokuoka, Y., Yamada, S., Eun-Yong, K. & Yamamoto, S. 2008. Spatial and temporal variations in the use of rice-paddy dominated landscapes by birds in Japan. *Biological Conservation* 141, 1704-1716.

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

Bambaradeniya, C.N.B. & Amerasinghe, F.P. 2003. Biodiversity associated with the rice field agroecosystem in Asian countries: A brief review. Working Paper 63. Colombo, Sri Lanka: International Water Management Institute.

Bancroft, M. C., Gawlik, D. E & Rutchey, K. 2002. Distribution of wading birds relative to vegetation and water depth in the northern Everglades of Florida, USA. *Waterbirds* 25, 265-277.

Beerens, J. M., Gawlik, D. E., Herring, G. & Cook, M. I. 2011. Dynamic habitat selection by two wading bird species with divergent foraging strategies in a seasonally fluctuating wetlands. *The American Ornithologist Union* 128(4): 651-662.

Bewick, V., Cheek, L. & Ball, J. 2004. Statistics review 9: One-way analysis of variance. *Critical Care* 8, 130-136.

Bibby, C. J., Burgess, N. D., Hill, D. A. & Mustoe, S. H. 2000. *Bird Census Techniques* (2nd ed.). London, Academic Press, 302p.

Bibby, C., Jones, M. & Marsden, S. 2000. *Expedition Field Techniques: Bird Surveys.* BirdLife International, Cambridge, United Kingdom.

Bird, J.A., Pettygrove, G.S. & Eadie, J.M. 2000. The impact of waterfowl foraging on the decomposition of rice straw: mutual benefits for rice growers and waterfowl. *Journal of Applied Ecology* 37, 728-741.

Birdlife International. 2008. State of the world's birds. Indicator for our changing world. (Birdlife International Cambridge, U.K.). http://www.issuu.com/birdlifeinternational/docs/sowb2008_en?e=1693724/1227002. [04 December 2016].

BirdLife International. (2012). Birds occur in all major habitat types, with forest being particularly important. Presented as part of the BirdLife State of the world's birds website. http://americas.birdlife.org/datazone/sowb/casestudy/172. [12 December 2016]

Bright, J. A., Morris, A. J. & Winspear, R. 2008. A review of indirect effects of pesticides on birds and mitigating land-management practices. Royal Society for the Protection of Birds, The Lodge, UK.

Boatman, N. D., Brickle, N. W., Hart, J. D., Milsom, T. P., Morris, A. J., Murray, A. W. A., Murray, K. A. & Robertson, P. A. 2004. Evidence for the indirect effects of pesticides on farmland birds. *Ibis* 146 (Suppl. 2), 131-143.

Burger, J. 1985. Habitat selection in temperate marsh-nesting birds. *In: Habitat selection in birds*, Cody, M. L. (Eds.). Pp. 253-81. Orlando, FL: Academic Press.

Campbell, N. A., Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A. & Minorsky, P. V. 2008. *Biology* (8th ed.). United States of America: Pearson Education, Inc.

Capistrano, A. D. & Marten, G. G. 1986. Agriculture in Southeast Asia. In Gerald G. Marten (ed.), Traditional Agriculture in Southeast Asia, p. 6-19. Westview Press.

Chamberlain, D. E., Fuller, R. J., Bunce, R. G. H., Duckworth, J. C. & Shrubb, M. J. 2000. Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. *J. Appl. Ecol.* 37, 71-788.

Clark, K. E., Zhao, Y., & Kane, C. M. 2009. Organochlorine pesticides, PCBs, dioxins, and metals in postterm peregrine falcon (Falco peregrinus) eggs from the Mid-Atlantic States, 1993–1999. *Archives of environmental contamination and toxicology*, 57(1), 174-184.

Clarke, K.R. & Warwick, R.M. 2001. *Change in marine communities: an approach to statistical analysis and interpretation* (2nd edition). Plymouth: PRIMER-E.

Clarkson, B. R., Ausseil, A. E. & Gerbeaux, P. 2013. Wetlands ecosystem services. In Dymond JR ed. Ecosystem services in New Zealand - Condition and trends. Manaaki Whenua Press, Lincoln, New Zealand.

Collazo, J. A., O'Harra, D. A. & Kelly, C. A. 2002. Accessible habitat for shorebirds: factors influencing its availibility and conservation implications. *Waterbirds* 25(Suppl. 2), 13-24.

Colwell, M. A. & Taft, O. W. 2000. Waterbird communities in managed wetlands of varying water depth. *Waterbirds* 23: 45-55.

Colwell, M. A. 2010. Shorebird ecology, conservation, and management. *University of California Press*.

Cox, G. W. (2010). *Bird Migration and Global Change*. United States of America: Island Press.

Czech, H.A. & Parsons, K.C. 2002. Agricultural wetlands and waterbirds: a review. *Waterbirds* 25, 56-65.

Darnell, T. & Smith, E. H. 2004. Avian use of natural and created salt marsh in Texas, USA. *Waterbirds* 27: 355-361.

Day, J.H. & Colwell, M.A. 1998. Waterbird communities in rice fields subjected to different post-harvest treatments. *Colonial Waterbirds* 21, 185-197.

Dimalexis, A. & Pyrovetsi, M. 1997. Effect of water level fluctuations on wading bird foraging habitat use at an irrigation reservoir, Lake Kerkini, Greece. *Colonial Waterbirds* 20, 244-252.

Donald, P. F., Green, R. E. & Heath, M. F. 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. *Proc. Royal. Soc. Lond. B* 268, 25-29.

Donald, P.F. 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology* 18, 17-37.

Elphick, C. S. & Oring, L. W. 1998. Winter management of Californian rice fields for waterbirds. *Journal of Applied Ecology* 35, 95-108.

Elphick, C.S. 2004. Assessing conservation trade-offs: identifying the effects of flooding rice fields for waterbirds on non-target bird species. *Biological Conservation* 117, 105-110.

Elphick, C.S. 2008. Landscape effects on waterbird densities in California rice fields: taxonomic differences, scale-dependence, and conservation implications. *Waterbirds* 31, 62-69.

Elphick, C. S., Baicich, P., Parsons, K. C., Fasola, M. & Mugica, L. 2010. The future for research on waterbirds in rice fields. *Waterbirds*, 33(sp1), 231-243.

Fasola, M. & Ruiz, X. 1997. Rice farming and waterbird: integrated management in an artificial landscape. In: Farming and Birds in Europe (D. J. Pain and M. W. Pienkowski, Eds.) pp. 210–235. Academic Press, London, UK.

Food and Agriculture Organization (FAO). 2004. FAO Statistical Databases. Available online at http://www.fao.org.

Fujioka, M., Armacost, Jr. J. W., Yoshida, H. & Maeda, T. 2001. Value of fallow farmlands as summer habitats for waterbirds in a Japanese rural area. Ecological Research 16, 555-567.

Fujioka, M., Lee, S.D., Kurechi, M. & Yoshida, H. 2010. Bird use of rice fields in Korea and Japan. *Waterbirds* 33, 8-29.

Froneman, A., Mangnall, M.J., Little, R.M. & Crowe, T.M. 2001. Waterbird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. *Biodiversity and Conservation* 10, 251-270.

Garbach, K., Milder, J. C., Montenegro, M., Karp, D. S. & DeClerck, F. A. J. 2014. Biodiversity and ecosystem services in agroecosystems. *Encyclopedia of Agriculture and Food Systems*, Vol 2, 20 p.

Gaston, K. J., Blackburn, T. M. & Goldewijk, K. K. 2003. Habitat conversion and global avian biodiversity loss. *Proc. R. Soc. Lond. B.* 270, 1293-1300.

Gawlik, D. E. 2002. The effects of prey availability on the numerical response of wading birds. *Ecological Monographs* 72, 329-346.

Gray, L., Cheshire, G. & Mattison, C. 2010. *Animals.* China: Igloo Books Ltd.

Green, A.J. & Elmberg, J. 2014. Ecosystem services provided by waterbirds. *Biological Reviews* 89, 105-122.

Greene, T. 2012. Birds: incomplete counts - line transect counts. Department of

Conservation *Te Papa Atawhai.* *http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/im-toolbox-birds-incomplete-line-transect-counts.pdf* [13 February 2017].

Gregory, R. D. 2000. Development of breeding bird monitoring in the United Kingdom and its principles elsewhere. *The Ring*, 22, 35-44.

Gregory, R. D. & Baillie, S. R. 1998. Large-scale habitat use of some declining British birds. *J. Appl. Ecol.* 35, 785-799.

Gregory, R. D., Gibbons, D. W. & Donald, P. F. 2004. Bird census and survey techniques. In *Bird Ecology and Conservation; a Handbook of Techniques*, ed. Sutherland, W. J., Newton, I., Green, R. E. Oxford, Oxford University Press, pp. 17-56.

Global Rice Science Partnership (GRiSP). 2013. Rice almanac, 4th edition. Los Banos (Philippines): International Rice Research Institute. 283 p.

Groenigen, J. W. V., Burns, E. G., Eadie, J. M., Horwath, W. R. & Kessel, C. V. 2003. Effects of foraging waterfowl in winter flooded rice fields on weed stress and residue decomposition. *Agriculture, Ecosystems and Enviroment* 95, 289-296.

Groombridge, B. & Jenkins, M. D. 2002. World atlas of biodiversity: earth's living resources in the 21st century. University of California Press, California, USA.

Halwart, M. & Gupta, M. V. (eds.). 2004. Culture of fish in rice fields. FAO and The World Fish Center, 83 p.

Harmsworth, G. 2002. Coordinated monitoring of New Zealand wetlands Phase 2, Goal 2: Maori environmental performance indicators for wetlands condition and trend. A Ministry for the Environment SMF Project - 5105. Landcare Research Contract Report LC0102/099, Palmerston North, New Zealand. 65 p.

Hattori, A. & Mae, S. 2001. Habitat use and diversity of waterbirds in a coastal lagoon around Lake Biwa, Japan. *Ecological Research* 16, 543-553.

Herman, T., Murchie, E. H. & Asgar, A. W. 2015. Rice production and climate change : A case study of Malaysian rice. *Pertanika J. Trop. Agric. Sci.* 38(3), 321-328.

Hohman, W.L., Moore, J.L., Stark, T.M., Weisbrich, G.A. & Coon, R.A. 1994. Breeding waterbird use of Louisiana rice fields in relation to planting practices. *Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies* 48, 31-37.

Holm, T. E. & Clausen, P. 2006. Effects of water level management on autumn staging waterbird and macrophyte diversity in three Danish coastal lagoons. *Biodiversity and Conservation* 15, 4399-4423.

Horgan, F.G., Stuart, A.M. & Kudavidanage, E.P. 2014. Impact of invasive apple snails on the functioning and services of natural and managed wetlands. *Acta Oecologica* 54, 90-100.

Ibáñez C., Curcó A., Riera X, Ripoll I. & Sánchez C. 2010. Influence on birds of rice field management practices during the growing season: a review and an experiment. *Waterbirds* 33(Special Publication 1), 167–180.

Ikuta, K., & Yamaguchi, M. 2005. The present state of carp fisheries and aquaculture in Japan. *Bull. Fish. Res. Agency Suppl.* 2, 55-58.

Isenring, R. 2010. Pesticide reduce biodiversity. A review in International year of biodiversity. *Pesticides News* 88, p4-7.

Ismail, A., Rahman, F. & Zulkifli, Z. 2012. Status, composition and diversity of avifauna in the artificial Putrajaya wetlands and comparison with its two neighboring habitats. *Tropical Natural History* 12, 137-145.

Jeyarajasingam, A. & Pearson, A. 2012. *A field guide to the birds of Peninsular Malaysia and Singapore*. United States: Oxford University Press Inc., New York.

Katoh, K., Sakai, S. & Takahashi, T. 2009. Factors maintaining species diversity in Satoyama, a traditional agricultural landscape of Japan. *Biological Conservation* 142, 1930-1936.

King, S., Elphick, C. S., Guadagnin, D., Taft, O. & Amano, T. 2010. Effects of landscape features on waterbird use of rice fields. *Waterbirds*, 33(sp1), 151-159.

Khush, G. S. 1997. Origin, dispersal, cultivation and variation of rice. *Plant Molecular Biology* 35, 25-34.

Kumalasari, N. R. & Bergmeier, E. 2014. Effects of surrounding crop and semi-natural vegetation on the plant diversity of paddy fields. *Agriculture & Food Security* 3:15.

Lantz, S. 2008. The effects of water depth and vegetation on wading bird foraging habitat selection and foraging success in the Everglades. Postgraduate thesis, Master of Science, Faculty of The Charles E. Schmidt College of Science, Florida Atlantic University. 77p.

Lantz, S., Gawlik, D. E. & Cook, M. I. 2011. The effects of water depth and emergent vegetation on foraging success and habitat selection of wading birds in the Everglades. *Waterbirds* 34(4), 439-447.

Lansdown, R.V. & Rajanathan, R. 1993. Some aspects of the ecology of *Ixobrychus* bitterns nesting in Malaysia ricefields. *Colonial Waterbirds* 16, 98-101.

Lawler , S. P. & Dritz, D. A. 2005. Straw and winter flooding benefit mosquitoes and other insects in a rice agroecosystem. *Ecological Applications* 15, 2025-2059.

Longgoni, V., Rubolini, D. & Bogliani, G. 2007. Delayed reproduction among Great Bitterns *Botaurus stellaris* breeding in ricefields. *Bird Study* 54, 275-279.

Ma, Z., Cai, Y., Li, B., & Chen, J. 2010. Managing wetland habitats for waterbirds: An International Perspective. *Wetlands* 30, 15-27.

Maclean, J. L., Dawe, D. C., Hardy, B. & Hettel, G. P. 2002. *Rice Almanac: Source book for the most important economic activity of Earth*. CABI Publishing, Wallingford, UK.

MADA (Lembaga Kemajuan Pertanian Muda). 2014. Sejarah penanaman padi di Semenanjung Malaysia. http://ppkh2kepalabatas.wordpress.com/2014/08/20/sejarah-penanaman-padi-di-semenanjung-malaysia/. [10 February 2016].

Mader, S. S. (2004). *Biology.* New York: McGraw-Hill Companies, Inc.

Maeda, T. 2001. Patterns of bird abundance and habitat use in rice fields of the Kanto Plain, central Japan. *Ecological Research* 16, 569-585.

Mandan, J. K., Patil, V. Bhave, S. 2014. Birds associated with paddy fields in Ratanagiri, Maharashtra. *Indian Forester*, 140 (10), 993-997.

Masero, J.A., Santiago-Quesada, F., Sanchez-Guzman, J.M., Lopes, R.J., Villegas, A., Abad-Gomez, J.M., Encarnacao, V., Corbacho, C. & Moran, R. 2006. Long lengths of stay, large numbers, and trends of the Black-tailed Godwit *Limosa limosa* in the rice fields during spring migration. *Birds Conservation International* 1, 1-13.

Malaysia Birding. 2011. Birding in Malaysia. http://www.malaysiabirding.org/section.php?sid=10&pb=Tier. [29 November 2016].

Marten, G. G. 1990. Small-scale agriculture in Southeast Asia. In M. A. Altieri and S. Hecht (eds.), Agroecology and small farm development, p. 177-194. CRC Press.

Martinez-Vilalta, A. 1996. The rice fields of the Ebro Delta. *Management of Mediterranean Wetlands, Ministerio de Medio Ambiente, Madrid, Spain* Vol4: 173-186.

McAfee, A. (2011). *Birds of Universiti Sultan Zainal Abidin.* Terengganu: Pusat Penerbitan Universiti Sultan Zainal Abidin.

Mehmet Ali, T. and Yusuf, A. (2010). Ecological Importance of Birds. In: 2nd International Symposium on Sustainable Development, June 8-9 2010, Sarajevo.

Ministry of Agriculture. 2010. Malaysian plantations. http://www.moa.gov.my/c/document_library/get_file?uuid=d0e%200be21-75aa-4812-969-32a5e68ec7a8andgroupId=10136 [22 November 2016]

Mitra, A., Chatterjee, C. & Mandal, F. B. 2011. Synthetic chemical pesticides and their effects on birds. *Res. J Environ. Toxicol.* 5, 81-96.

Molles, M. C. 2005. *Ecology Concepts And Applications.* (6th ed.). New York: McGraw-Hill Companies, Inc.

Mohd Ekhwan, T., Er, A.C., Lee, Q.Y., Sharifah Mastura, S.A., Fuad, M.J., Mazlin, M., Rahmah, E., Mohammad Barzani, G., Yusop, Z., Norazlina, A.A., Habibah, A. & Hamzah, J. 2013. Paddy production and climate change variation in Selangor, Malaysia. *Asian Social Science* 9, 1-8.

Mohd Suhaimi, H. I. 2010. Cultural and religious festivals: The Malaysian experience. *Journal of Southeast Asian Studies*, 15(1).

Nachuha, S. 2009. Is waterbird distribution within rice paddies of eastern Uganda affected by the different stages of rice growing? Pp. 44-49. In: Harebottle, D. M., Craig, A. J. F.K., Anderson, M. D., Rakotomanana, H., and Muchai, M. (eds). Proceedings of the 12th Pan-African Ornithological Congress, 2008. Cape Town, Animal Demography Unit. (ISBN: 978-0-7992-2361-3).

Najim, M. M. M., Lee, T. S., Haque, M. A. & Esham, M. 2007. Sustainability of rice production: A Malaysian perspective. *The Journal of Agricultural Sciences,*

3(1): 12p.

Nam, H., Choi, Y., Choi, S. & Yoo, J. 2015. Distribution of waterbirds in rice fields and their use of foraging habitats. *Waterbirds* 38, 173-183.

Natuhara, Y. 2013. Ecosystem services by paddy fields as substitutes of natural wetlands in Japan. *Ecol. Eng.* 10p. http://dx.doi.org/10.1016/j.ecoleng.2012.04.026.

Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A. G. & Kaltenborn, B. P. (Eds). 2009. The environmental food crisis - The environment's role in averting future crises. A UNEP rapid responses assessment. United Nations Environment Programme, GRID-Arendal, www.grida.no.

Newton, I. 1995. The contribution of some recent research on birds to ecological understanding. *Journal of Animal Ecology* 64, 675-696.

Newton, I. 2004. The recent declines of farmland birds populations in Britain. An appraisal of causal factors and conservation actions. *Ibis* 146, 579-600.

Nor Atiqah, N. & Rosli, R. 2015. The relationship between morphological characteristics and foraging behavior in four selected species of shorebirds and waterbirds utilizing tropical mudflats. *The Scientific World Journal*. 7 p.

Nur Munirah, A., Nurul Salmi, A.L., Shahrul Anuar, M.S., Mohd Abdul Muin, M.A., Amirrudin, A. & NurJuliani, S. 2014a. Diversity and temporal distribution of birds in rice-growing landscape, Northern Peninsular Malaysia. *Sains Malaysiana* 43, 513-520.

Nur Munirah, A., Nurul Salmi, A.L. & Muhd Hakim, S. 2014b. Use of rice fields by raptors in northern Peninsular Malaysia. *Ela Journal* 3, 5-14.

Ntiamoa-Baidu, Y., Piersma, T., Wiersma, P., Poot, M., Battley, P. & Gordon, C. 1998. Water depth selection, daily feeding routines and diets of waterbirds in coastal lagoons in Ghana. *Ibis* 140, 89-103.

Nyman, J.A. & Chabreck, R.H. 1995. Fire in coastal marshes: history and recent concerns. *Proceedings of the Annual Tall Timbers Fire Ecology Conference* 19, 134-141.

O' Connor, R. J., Dunn, E., Johnson, D. H., Jones, S. L., Petit, D., Pollock, K., Smith, C. R., Trapp, J. L. & Welling, E. 2000. A programmatic review of the North American Breeding Bird Survey. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD. https://www.pwrc.usgs.gov/bbs/bbsreview/bbsfinal.pdf [13 February 2017]

Parsons, K.C., Mineau, P. & Renfrew, R.B. 2010. Effects of pesticide use in rice fields on birds. *Waterbirds* 33, 193-218.

Paliwal, G.T. & Bhandarkar, S.V. 2014. Observation on the biodiversity conservation of birds in paddy agro ecosystems in different crop stages. *International Journal of Current Microbiology and Applied Sciences* 3, 1161-1165.

Pearlstine, E.V., Mazzotti, F.J. & Kelly, M.H. 2006. Relative distribution and abundance of wintering raptors in agricultural and wetland landscapes of South Florida. *Journal of Raptor Research* 40, 81-85.

Pierluissi, S. & King, S. L. 2008. Relative nest density, nest success, and site occupancy of King Rails in southwestern Louisiana rice fields. *Waterbirds* 31, 530-540.

Pierluissi, S. 2010. Breeding waterbirds in rice fields: a global review. *Waterbirds* 33, 123-132.

Post, W. 1998. Reproduction of least bitterns in a managed wetland. *Colonial Waterbirds* 21: 268-273.

Rainforest Conservation Fund. 2014. Case studies in tropical deforestation Southeast Asia. 3) Peninsular Malaysia and Malaysian Borneo (Sabah and Sarawak). http://www.rainforestconservation.org/rainforest-primer/4-case-studies-in-tropical-deforestation/c-south-and-southeast-asia/3-peninsular-malaysia-and-malaysian-borneo-sabah-and-sarawak/. [04 December 2016].

Ramsar Convention Secretariat. 2013. *The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar Iran, 1971).* 6th ed. Ramsar Convention Secretariat, Gland, Switzerland.

Reece, J. B., Meyers, N., Urry, L. A., Cain, M. L.,Wasserman, S. A., Minorsky, P. V., Jackson, R. B. & Cooke, B. 2015. *Campbell Biology : Australia and New Zealand Version.* Pearson Australia Group Pty Ltd.

Robson, C. 2005. *Field Guide to the birds of South-East Asia*. UK: New Holland Publisher Ltd.

Scherr, S.J. & McNeely, J.A. 2008. Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 363, 477-494.

Sodhi, N. S., Koh, L. P., Brook. B. W. & Ng, P. K. L. 2004. Southeast Asian biodiversity: an impending disaster. *Trends in Ecology and Evolution* 19(12): 1-7.

Suhaimi, O., Abdul Razak, H., Ibni Hajar, R., Ayob., A.H., Wan, C.C., Muhd Radzali, M., Aminuddin, Y., Abu Hassan, D. & Mohd Isa, O. 2006. *Baseline information Felcra Seberang Perak rice estate production*. Malaysia: MARDI.

Sulai, P., Nurhidayu, S., Aziz, N., Zakaria, M., Barclay, H. & Azhar, B. 2015. Effects of water quality in oil palm production landscapes on tropical waterbirds in Peninsular Malaysia. *Ecological Research* 30, 941-949.

Sundar, K. S. G. and Subramanya, S. (2010). Bird use of rice fields in the Indian Subcontinent. *Waterbirds* 33 (Special Publication 1): 44-70.

Sutherland, W. J. 2006. *Ecological Census Techniques - a handbook (2nd Edition).* Cambridge University Press, New York.

Stafford, J.D., Kaminski, R.M. & Reinecke, K.J. 2010. Avian foods, foraging and habitat conservation in world rice fields. *Waterbirds* 33, 133-150.

Strong, A. M., Bancroft, G. T. & Jewell, S. D. 1997. Hydrological constraints on Tricolored Heron and Snowy Egret resource use. *Condor* 99, 894-905.

Swinton, S. M., Lupi, F. Robertson, G. P. & Hamilton, S. K. 2007. Ecosystem services and agriculture: cultivating agricultural ecosystems for diverse benefits.

Ecological Economics 64, 245-252.

Takahashi, M. & Ohkawara, K. 2007. Breeding behaviour and reproductive success of Grey-headed Lapwing *Vanellus cinereus* on farmland in central Japan. *Ornithological Science* 6, 1-9.

Taylor, S. L. & Pallord, K. S. 2008. Evaluation of two methods to estimate and monitor bird population. *PLoS ONE*, 3(8): 30-47.

Toriman, M. E., Er, A. C., Lee, Q. Y., Sharifah Mastura, S. A., Fuad, M. J., Mazlin, M., Rahmah, E., Gasim, M. B., Yusop, Z., Norazlina, A. Z., Habibah, A. & Hamzah, J. 2013. Paddy production and climate change variation in Selangor, Malaysia. *Asian Social Science*, 9(14): 55-62.

Tourenq, C., Benhamou, S., Sadoul, N., Sandoz, A., Mesleard, F., Martin, J. L., & Hafner, H. 2004. Spatial relationships between tree-nesting heron colonies and rice fields in the Camargue, France. Auk 121, 192-202.

Townsend, S.E., Pearlstine, E.V., Mazzotti, F.J. & Deren, C.W. 2006. Wading birds, shorebirds, and waterfowl in rice fields within the Everglades agriculture area. *Florida Field Naturalist* 34, 9-20.

Volpato, G. H., Lopes, E. V., Mendonca, L. B., Roberto, B., Bisheimer, M. V., Serafini, P. P. & Anjos, L. D. 2009. The use of the point count method for bird survey in the Atlantic forest. *Zoologia* 26(1), 74-78.

Wall, B. 2008. Organochlorine pesticide contamination and its potential effects on eggshell characteristics of Dickcissels (*Spiza americana*). *2007-2008*, p11.

Watson, D. M. 2003. The 'standardized search': an improved way to conduct bird surveys. *Austral Ecology*, *28*(5), 515-525.

Weller, M. W. 1999. *Wetland Birds: Habitat resources and conservation implications*. Cambridge University Press, New York.

Wood, C., Qiao, Y., Li, P., Ding, P., Lu, B. and Xi, Y. 2010. Implications of rice agriculture foe wild birds in China. *Waterbirds* 33, 30-43.

Zakaria, M., Rajpar, M.N. & Sajap, S.A. 2009. Species diversity and feeding guilds of birds in Paya Indah Wetland Reserve, Peninsular Malaysia. *International Journal of Zoological Research* 5, 86-100.

Zedler, J.B. 2003. Wetlands at your service: reducing impacts of agriculture at the watershed scale. *Frontiers in Ecology and the Environment* 1, 65-72.

Zedler, J. B. 2006. Why wetlands so valuable? Arboretum Leaflet 10. Madison, WI, University of Wisconsin-Madison.