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HABITAT MODELING OF NON-MIGRATORY WATERFOWL IN PAYA INDAH WETLAND, MALAYSIA

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HABITAT MODELING OF NON-MIGRATORY WATERFOWL IN PAYA INDAH WETLAND, MALAYSIA

By

ABDOLLAH SALARI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

For my family, who have always supported my passion for nature based activities whether it be hunting or wildlife conservation

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Doctor of Philosophy

HABITAT MODELING OF NON-MIGRATORY WATERFOWL IN PAYA INDAH WETLAND, MALAYSIA

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October 2014

Chairman : Professor Mohamed Zakaria Hussin, PhD
Faculty : Forestry

Waterfowl are the most conspicuous components of freshwater wetlands ecosystem and their presence or absence may indicate the ecological conditions of the wetlands. Paya Indah Wetlands (PIW) reserve is one of Malaysia's premier ecotourism parks, covering approximately 3100 hectares in the State of Selangor. Lesser Whistling Duck (LWD) (*Dendrocygna javanica)* and cotton pygmy goose (CPG) (*Nettapus coromandelianus)* are the two only non-migratory waterfowl species from among the approximately 122 bird species which exist in the area. Both species have small populations in the area and are supposed to be recluse. Understanding species-habitat relationships and processes and mechanisms of which habitat balance species density are central themes of our study.We demonstrate how modern technology and field survey can be used to develop ecological baseline data including landuse/landcover, water depth, water quality, water-level fluctuation, and normalized difference vegetation index (NDVI). Landuse/landcover classifications were applied by visual interpretation. NDVI was extracted based on red and near infra-red 2 bands. The Topo to Raster method was used for interpolation of water depths. Water-quality index and water-level fluctuation of lakes were interpolated across lakes using the inverse-distance weighted method. Qualitative and quantitative accuracy assessment of our classification was promising and clearly illustrated that World View-2 imagery can yield fast and reasonably precise identification of ecosystem characteristics for ecological baseline data. On other part of the study we monitored both waterfowl species in PIW by Point-Count methods. We marked 48 observation points in our study site. We determined ducks location based on the standpoint location, distance to ducks and initial bearing. We demonstrate how a use-availability design can be applied to fit habitat suitability for LWD and CPG by MaxEnt. We fit 10 a priori models based on biological relevant combinations of explanatory variables and ranked them based on AICc for both species. The results of the top models show that water depth and water-level fluctuation play a vital role in determining the quality and quantity of habitats for lesser whistling duck and cotton pygmy goose. The influence of NDVI and proportion of spike rush and water lily indicated that the quantity and quality of those particular vegetation types increased suitability of a particular habitat. On the last part of the study, we worked on hypothesis that distribution and density-based models should reveal environmental conditions which functionally relate to distribution and density. We applied Resource Selection Functions (RSF) to understand habitat selection of LWD and CPG by employing binomial generalized linear models for presence/absent data and zero-altered negative binomial for count data. The results show that LWD and CPG prefer similar habitats. Fine scale measures of habitat quality influenced habitat selection and species distribution most, while a combination of anthropogenic activities and habitat quality were the best predictors of selection at a density level. Our habitat suitability models identified important areas and selection models enlighten habitats that need more attention. Furthermore, density model provides progressively more information for conservation. Our modeling approaches provide a baseline explanation of waterfowl habitat selection which could be extrapolated to Malaysia and even South East Asia.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PERMODELAN HABITAT UNTUK BURUNG-BURUNG AIR BUKAN HIJRAH DI PAYA INDAH WETLAND, MALAYSIA

Oleh

ABDOLLAH SALARI

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Burung air adalah komponen yang paling mudah dilihat di ekosistem tanah lembap air tawar dan kehadiran atau ketidak hadiran mereka mungkin menunjukkan keadaan ekologi tanah lembap. Paya Indah Wetlands (PIW) adalah salah satu taman ekopelancongan utama Malaysia, meliputi kira-kira 3100 hektar dalam Negeri Selangor. Belibis (*Dendrocygna javanica*) dan Itik Kapas (*Nettapus coromandelianus*) adalah dua spesies burung air yang tidak berhijrah dari kira-kira 122 spesies burung yang wujud di kawasan itu. Kedua-dua spesies ini merupakan populasi kecil di kawasan itu dan agak menyendiri. Memahami hubungan habitat-spesies dan proses dan mekanisme keseimbangan antara kepadatan spesies dan habitat adalah tema utama kajian kami. Kami menunjukkan bagaimana teknologi moden dan survei lapangan boleh digunakan untuk membangunkan data asas ekologi termasuk gunatanah/litupantanah, kedalaman air, kualiti air, turun naik paras air, dan indeks perbezaan normal tumbuhan (NDVI). Pengelasan gunatanah/litupantanah telah diaplikasikan melalui pentafsiran imej visual. NDVI telah dikenal pasti berdasarkan band 2 infra merah dan hampir infra-merah. Kaedah ”Topo to Raster” telah digunakan untuk menentukan kedalaman air. Purata tahunan indeks kualiti air dan tahap turun naik air tahunan di seluruh tasik telah ditentukan menggunakan kaedah songsang-jarak berwajaran. Klasifikasi penilaian ketepatan kualitatif dan kuantitatif adalah baik dan jelas menggambarkan bahawa imej World View 2 boleh dihasilkan dengan pantas dan pengenalan yang agak tepat kepada ciri-ciri ekosistem sebagai data asas ekologi. Oleh itu, kami memantau dua spesies burung air bukan hijrah di PIW menggunakan kaedah Kira-Titik. Berdasarkan kepada keluasan tasik, masa dan kemudahan logistic, kami menanda 48 titik pemerhatian (daripada 288 titik rawak sedia ada) di kawasan kajian kami. Kami menentukan taburan itik berdasarkan kedudukan titik, jarak kepada itik dan bering asal untuk pemodelan MaxEnt dan menunjukkan bagaimana penggunaan reka bentuk ketersediaan boleh digunakan untuk membangunkan taburan spesies dan pemodelan pemilihan habitat untuk belibis dan itik kapas menggunakan MAXENT algorithem. Kami memasukkan 10

model keutamaan berdasarkan pemboleh ubah daripada kombinasi berkait biologi dan disusun kedudukan mereka berdasarkan AICc untuk kedua-dua spesies. Keputusan model terbaik menunjukkan bahawa kedalaman air dan perubahan-paras air memainkan peranan penting dalam menentukan kualiti dan kuantiti habitat itik belibis dan itik kapas. Pengaruh NDVI dan kadar rumpai dan teratai mempengaruhi kuantiti dan kualiti jenis tumbuhan tertentu dalam meningkatkan kesesuaian sesuatu habitat. Pada bahagian akhir kajian, kami mengkaji hipotesis model berasaskan taburan dan densiti yang sepatutnya menunjukkan keadaan alam sekitar yang berkaitan dengan fungsi taburan dan densiti. Kami menggunakan fungsi pemilihan sumber untuk memahami penggunaan habitat oleh LWD dan CPG dengan menggunakan model binomial linear umum untuk data kehadiran/ketidakhadiran dan binomial negatif sifar diubahsuai untuk data titik. Keputusan menunjukkan bahawa LWD dan CPG memilih habitat yang sama. Pengukuran skala halus kualiti habitat lebih mempengaruhi pemilihan habitat dan taburan spesies, manakala gabungan aktiviti antropogenik dan kualiti habitat adalah yang penentu terbaik pemilihan di peringkat densiti. Model taburan spesies kami mengenal pasti kawasan penting dan model pemilihan menekankan aspek habitat yang memerlukan perhatian yang lebih. Tambahan pula, model densiti memberi maklumat lebih baik secara beransur-ansur, pemahaman yang lebih baik terhadap proses, dan akhirnya menyediakan alat untuk pengurusan dan pemuliharaan. Pendekatan model kami memberikan penerangan asas pemilihan dan keutamaan habitat burung air yang boleh digunapakai di Malaysia dan malahan juga Asia Tenggara.

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I certify that a Thesis Examination Committee has met on 8 October 2014 to conduct the final examination of Abdollah Salari on his thesis entitled "Habitat Modeling of Non-Migratory Waterfowl in Paya Indah Wetland, 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 Doctor of Philosophy.

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DECLARIATION

Declaration by the student

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LIST OF ABBREVATIONS AND SYMBOLS

%	Percentage
^{0}C	Degree Celsius
Temp	Temperature
RH	Relative Humidity
cm	Centimetre
m	Meter
ha	Hectare
PIW	Paya Indah Wetlands
LWD	Lesser whistling Duck
CPG	Cotton Pygmy Goose
WQI	Water Quality Index
Prop	Proportion
Spik	Spikerush
Dep	Depth
LLF	Lake-Level Fluctuation
Hum	Human
SE	Standard Error
NDVI	Normalize Difference Vegetation Index
CV	Coefficient of variation
RSF	Resource Selection Function
GLM	Generalized Linear Model
ZANB	Zero Altered Negative Binomial

CHAPTER 1

INTRODUCTION

1.1 General background

Birds are one of the most thoroughly studied groups of species in ecology; this is no doubt due the intense curiosity and wonder surrounding these species (Gill, 1995; Walters, 2003). In particular, people have historically had a deep desire to understand the behavior of birds. Ancient Egyptians were some of the earliest recovered natural historians of birds (Bleeker, 1964; Velde, 1980). Birds were often the subjects of their paintings and other art, and important elements of their religion were based on the natural history of birds. For example, Egyptians frequently depicted an individual‘s soul as a bird. Furthermore, hunting has been a traditional pastime and source of revenue for many years. Hunters in general are interested in ways to maintain or increase wildlife populations and birds were common target due to their availability and variety. These interests later provided strong support for birds and their habitat conservation and management. For instance, waterfowl hunters are recognized as traditional conservationist in North America (Enck, Swift, & Decker, 1993). Today there are numerous organizations in the world devoted to recreational hunting and management, such as Ducks Unlimited in North America, which highly Support waterfowl conservation issues. They provide funding and expertise to enhance waterfowl management.

Modern ecological studies of birds have moved beyond simple interest and desire to understand this group of species to necessity. Today bird studies mainly revolve around addressing the conservation and management issues facing these species. A large number of studies have been conducted on attempting to understand how birds choose their habitat, how they are influenced by landuse/lancover changes (Meager, Schlacher, & Nielsen, 2012; Sanza, Traba, Morales, Rivera, & Delgado, 2012, p. ndan). Researchers have also begun to explore the potential influence of Climate change on bird populations (Cobben et al., 2012). To understand habitat requirements of birds and successfully manage these species, researchers are dependent on standardized collection techniques.

Obviously, these days there are advanced technological instruments to study birds (Berthold & Terrill, 1991). Radio tracking is one of the most straightforward and commonly-used methods (Marion & Shamis, 1977; Sargeant, 1984). To overcome the difficulty of locating the bird in the field, radio receivers have been placed in earth-orbiting satellites(Alerstam, 1996). Most commonly the ARGOS satellites have been used for this task. Recently, birds have been fitted with Global Positioning System (GPS) devices (von Hunerbein, Hamann, Ruter, & Wiltschko, 2000). These devices are capable of recording fine-scale data and offer large numbers of existing software to analyze the data.

Even though these advanced technologies can provide us large amounts of fine-scale data, there are some critical limitations associated with their application (Pennycuick, Fast, Ballerstadt, & Rattenborg, 2012; Wells, Washburn, Millspaugh, Ryan, & Hubbard, 2003; White et al., 2013). These limitations are especially restrictive when attempting to conduct research with limited funding. Capturing enough individuals from a small population for tagging, and concerns about the effect of carrying transmitters combined with extremely expense of these new technologies forced us to conduct our study based on traditional observation which was the most affordable and reliable method in our study area.

Comparisons of bird-habitat relationships across different regions require the use of standardized collection techniques. Bird counting is by far one of the simplest standardized approaches to monitoring birds (Thompson & La Sorte, 2008). Even though it has its own limitations, it is still one of the best methods available for bird studies (C John Ralph, Droege, & Sauer, 1995). Point count methodology is applicable in all seasons, climates, and circumstances. Hence, fixed radius point count was implemented in our study (Leal, Martins, Palmeirim, & Granadeiro, 2011; R. A. McKinney & Paton, 2009). To analyze habitat suitability with MaxEnt we estimated locations of birds. Hence, given standpoint location, distance to bird and initial bearing were used to estimate the location of ducks (Kamil & Cheng, 2001; Murray, Gates, & Spinola, 2011).

Species-habitat relationships have become an increasing priority in the field of conservation and management these days(Boyce & McDonald, 1999). The keys to managing rare species are 1) recognize those habitats available to the species, assessed likelihood of being selected and habitat prefrence, and 2) find why species are more abundant in some of those habitats. Thus, recognizing and maintaining high quality habitats and enhance poor quality habitat would be vital elements in conservation of rare or endangered species. Assessing species distribution alone may result in management actions to which animals cannot respond. Rather, one must understand both habitat selection and abundance/density and how they relate to resources when assessing habitat quality, to manage rare or endangered populations. From a management perspective, making a link between selection and abundance/density will ultimately result in better management decisions that have the greatest chance of achieving species management goals, such as long-term population persistence.

1.2 Problem Statement

Birds are an important component of wetland ecosystem and often exhibit distinct relationship with their habitats (Seymour & Simmons, 2008). The habitat loss and degradation caused the decline of waterbirds all around the world (Mitsch & Gosselink, 2000; M. P. Ward, Semel, & Herkert, 2010). Knowledge about habitat selection and characteristics of them can empower conservation activities by revealing environmental conditions that are functionally related to both species distribution and density.

Wetland areas are both ecologically and economically important. The economic value of the ecosystem services provided by lakes and wetlands on a world scale is immense because these ecosystems support high biodiversity and in turn high ecological and conservation values (Costanza et al., 1997; Fromm, 2000; Wainger & Mazzotta, 2011). There are only 39 sites (16,942 km^2 or 0.004% of the total region area) in Southeast Asia designated as RAMSAR wetlands (http://ramsar.wetlands.org) indicating that more conservation attention should be given to non-forest habitats (Tantipisanuh & Gale, 2013). Malaysian wetlands are facing an overwhelming pressure from rapid development and urbanization (Asmawi, 2007). Anthropogenic activities have altered the wetland habitats in a variety of ways that consequently cause threats to most waterfowl (Dahlgren & Korschgen, 1992; Fox & Madsen, 1997; Pease, Rose, & Butler, 2005; Väänänen, 2001). The environmental problems in tropical wetlands highlight the need for restoration and preventative management (Hasmadi, Pakhriazad, & Norlida, 2011; MacAlister & Mahaxay, 2009). Furthermore, the conservation value of waterfowl management is hindered by the lack of available information on which to base and justify any management activities. Hence, quantifying attributes which affect waterfowl ecosystems could be valuable for further ecological research and restoration programs.

Lesser whistling Duck (LWD) (*Dendrocygna javanica)* and Cotton Pygmy Goose (CPG) (*Nettapus coromandelianus*) are both native to most areas of south Asia, east Asia and southeast Asia, including Malaysia (IUCN, 2013b). population of LWD shows decreasing trend in recent years (IUCN, 2013a). In general, information about waterfowl ecology in Malaysia is scarce. Waterfowl habitat characteristics have not been measured and modeled fine-scale in Malaysia. Particularly, our understanding about factors affecting distribution and abundance/density of LWD and CPG are poor where further decline may cause extinction of them in the Paya Indah Wetlands (PIW).

To demonstrate application of spatially explicit habitat selection modeling for LWD and CPG, we used World View 2 for quantifying habitat and MaxEnt algorithm for distribution modeling in our research. In following chapters we work on the hypothesis that habitat selection and density based models should reveal environmental conditions, which functionally relate to distribution and density of both species in PIW. Distribution models can enlighten management, but abundance/density models provide more information and improve our understanding of ecological processes leading ultimately to better management and conservation. Our distribution models represent a sound benchmark for the ecology of LWD and CPG and can provide a powerful tool to help identify areas for habitat restoration and conservation enhancement. Two-stage habitat-selection modeling provides a powerful tool for describing habitats where the processes determining distribution and abundance might be influenced by different factors. Hence, these results provide more useful information to research-base management and prioritizing conservation efforts for waterfowl in PIW.

1.3 Research Objectives

Wildlife biologists realize that measurable objectives must be set for all researches and studies so that they can be evaluated. Also, they should be developed with a desired objective in mind.

The research objectives of this study were as follows:

1. To quantify habitat characteristics which may affect habitat selection of lesser whistling duck and cotton pygmy goose
2. To predict species distributions and model resource selection functions of those species and compare selection/density models for revealing factors which functionally related to both species population

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