UNIVERSITI PUTRA MALAYSIA

EFFECTS OF CATTLE GRAZING ON AVIAN BIODIVERSITY AND UNDERGROWTH VEGETATION COVER IN OIL PALM AGRICULTURE

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By

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Expansion of oil palm agriculture in the tropics is driven by its economic success. However, it may cause biodiversity loss if such expansion is permitted without considering environmental protection. Mitigation efforts such as incorporating bio-control agents may reduce this negative impact. Integrating cattle in oil palm plantation to control weeds is expected to improve biodiversity in this agro-ecosystem. While reducing the need for chemical herbicides, it also provides additional food security, ecosystem services, and habitat heterogeneity. Point transect sampling method was used to survey palm oil plantation birds in 45 oil palm plantations which were divided into systematically, un-systematically cattle grazed and control plantations (without cattle grazing). Bird species richness was found increased with size of grazing area, but decreased with number of cattle. Bird abundance was positively related with the systematic grazing system, but was also negatively influenced by number of cattle. Oil palm plantations with systematic or non-systematic cattle grazing had more diverse bird species composition than those without cattle grazing. The bird species composition was determined by four attributes, including the number of cattle, selective weeding frequency, age of oil palm stand, and palm height. Cattle grazing also had a significant positive effect on the height and extent of undergrowth in oil palm plantations, while still suppressing weeds. Therefore, targeted (i.e. systematic rotational) cattle grazing system was concluded can improve bird diversity in the plantations. Therefore, cattle integration with oil palm agriculture for weeds control should be promoted as one step to realize the environmental sustainability goal. It was recommended that a cattle grazing is an excellent way for oil palm stakeholders to improve sustainability and

biodiversity in plantations by maintaining constant, manageable undergrowth while reducing their reliance on chemical herbicides.

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

KESAN RAGUTAN LEMBU TERHADAP BIODIVERSITI BURUNG DAN LITUPAN RUMPUT DALAM KAWASAN SAWIT

Oleh

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Pertambahan keluasan tanaman sawit di kawasan tropika didorong oleh potensi ekonominya. Walau bagaimanapun, ia boleh menyebabkan kehilangan biodiversiti sekiranya pengembangan ini berlaku tanpa mengambil kira aspek pemuliharaan alam sekitar. Usaha mitigasi seperti penggunaan agen kawalan biologi mungkin dapat mengurangkan kesan negatif ini. Mengintegrasikan lembu untuk mengawal rumpai di ladang sawit diharapkan dapat meningkatkan biodiversiti dalam ekosistem-pertanian ini. Di samping mengurangkan keperluan racun kimia, ia juga dapat meningkatkan keselamatan makanan, khidmat ekosistem, dan kepelbagaian habitat. Kaedah pensampelan transek titik telah digunakan untuk meninjau burung ladang di 45 buah ladang sawit yang dikategorikan kepada melaksanakan integrasi lembu secara sistematik, tidak sistematik dan ladang kawalan (tanpa integrasi lembu). Kepelbagaian spesies burung didapati meningkat dengan luasnya kawasan ragutan, tetapi menurun dengan bertambahnya bilangan lembu. Jumlah keseluruhan burung dipengaruhi secara positif oleh sistem ragutan yang sistematik, tetapi dipengaruhi secara negatif oleh jumlah lembu. Ladang sawit yang mengamalkan integrasi lembu yang sistematik atau tidak sistematik mempunyai komposisi spesies burung yang lebih tinggi daripada ladang tanpa ragutan lembu. Komposisi spesies burung ditentukan oleh empat faktor iaitu; bilangan lembu, kekerapan kawalan rumpai secara selektif, umur sawit, dan ketinggian sawit. Ragutan lembu juga mempunyai kesan positif yang signifikan ke atas ketinggian dan litupan rumpai di ladang sawit, dalam masa yang sama mengawal pertumbuhan rumpai. Dapat disimpulkan bahawa ragutan lembu (secara bergilir yang sistematik) boleh meningkatkan kepelbagaian burung di ladang sawit. Oleh itu, integrasi lembu dengan sawit

bagi mengawal rumpai perlu dipromosikan sebagai satu langkah untuk merealisasikan matlamat kemapanan alam sekitar. Oleh yang demikian, adalah disyorkan kepada pihak yang berkepentingan dalam industri sawit bahawa, kaedah ragutan lembu adalah cara yang sangat baik untuk meningkatkan kelestarian dan biodiversiti di dalam ladang serta dapat mengawal rumpai dan mengurangkan kebergantungan kepada racun kimia.

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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:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	Percentage
&	And
|r|	R Modules
=	Equality
±	Plus -Minus
am	Before Midday
ANOSIM	Analysis Of Similarity
ANOVA	Analysis Of Variances
BACI	'Before-After-Control-Impact'
BIOENV	Biota And / Or Environment Matching Analysis
cm	Centimeter
CO_2	Carbon Dioxide
df	Degree of freedom
e.g.	Example
F	F- Statistic
FAO	Food and Agriculture Organization
FELCRA	Federal Land Consolidation and Rehabilitation
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunch
GHG	Greenhouse Gas
GLMs	Generalized Linear Models
GMO	Genetically Modified Organisms
GPS	Global Position System
GRS	Geographic Resource Solution
ha	Hectare
HCVF	High Conservation Value Forest
IPM	Integrated Pest Management
IUCN	The International Union for Conservation of
IWM	Integrated Weed Management
km	Kilometer
LU	Livestock Unit
m	Meter
m^2	Meter square
MPOB	Malaysian Palm Oil Board
MSPO	Malaysian Sustainable Palm Oil
Mt	Metric tonne
NGO	Non-Governmental Organization
P	Probability
PRI	Indonesian Established Perkebunan Inti Rayat
R^2	R Squared
RISDA	Rubber Industry Smallholders' Development
RM	Ringgit Malaysia

RSPO	Roundtable on Sustainable Palm Oil
SE	Standard Error
SIMPER	Similarity Percentage
t	Tonne
TAC	Targeted Area Concentration
TFA	Trans-Fatty Acids
VSNI	Victim Support Northern Ireland

CHAPTER 1

INTRODUCTION

1.1 General Review

Oil palm (*Elaeis guinensis*) is currently the most important oil-producing crop in the world (Verheye, 2010; Geibler *et al.,* 2010; Rutherford *et al.,* 2011). In the present study, it is identified as the most economical and sustainable source of food and biofuel in the world (Lam *et al.,* 2009). This conclusion is based on its production capability, where the average yield of oil palm per hectare is the highest compared to other crops that produce oil. Oil palm produced 3.8 tonnes of oil per hectare which is 9.3, 7.6 and 5.8 times higher than soybean, rapeseed and sunflower crops respectively (Teoh, 2010). This results from its physiological potential where the high photosynthetic rate of oil palm has increased its oxygen emission and carbon dioxide absorption rates to ten times more effective than in soybean (Basiron, 2007).

The projection on the world's production of oil and fat for 2017 indicated that 90% of the demand would be fulfilled by palm oil, soybean, rapeseed and sunflower where each vegetable oil will contribute 38%, 29%, 13% and 10% respectively (MPOB, 2017). While the projected volume for this same period was 64.15 million tonnes, where Indonesia and Malaysia were expected to contribute 85% of the total palm oil produced (MPOB, 2017). The demand for palm oil in the world's vegetable oil market is driven by its versatility usage (Teoh, 2010; Ng *et al.,* 2012), economic advantages (Lam *et al.,* 2009) and health concern on other vegetable oil sources, especially on trans-fatty acids (TFA) and genetically modified organisms (GMO) issues (Teoh, 2010).

Palm oil production has contributed significantly to the economy of the countries involved and also helped the poor community in those countries to survive. For example, the government of Malaysia established Federal Land Development Authority (FELDA) in 1956 and the government of Indonesian established Perkebunan Inti Rayat (PRI) in 1978 to resettle the poor and landless people (Basiron, 2007; Teoh, 2010). Under the FELDA scheme alone, a total of 112,635 settlers in 317 land schemes have benefited more than one million individuals (Fredericks, 2012).

Unfortunately, the vast potential of oil palm has been tainted by several improper allegations such as the driver of world biodiversity loss, deforestation, climate change and environmental pollution due to pesticide

and fertiliser usage (Wilcove & Koh, 2010; Oosterveer, 2015; Hensen *et al.,* 2015). Conversion of natural forests to oil palm plantations is claimed to be a major threat to conservation biodiversity effort especially in South East Asia and resulted in the reduction of most animal taxa in both species richness and abundance (Foster *et al.,* 2011).

Taking responsibility, oil palm stakeholders have developed and promoted several eco-friendly practices in oil palm management. Approaches such as zero-burning, conservation of wildlife and habitat, waste minimisation and Integrated Pest Management (IPM) have been widely adopted by oil palm plantations (Basiron, 2008; Tan *et al.,* 2009). The government of Malaysia also imposed a ban on open burning in agriculture since 1998 (Noor, 2003) to curb recurrent haze problem. Zero-burning technique, for example, was well-accepted because it is not only good for the environment (Verheye, 2010) but also gives a positive result on cash flow and economic return (Noor, 2003). By investing in environmentally-friendly practices in the good governance of oil palm, this industry can contribute more in development and social improvement (Sayer *et al.,* 2012).

There is growing interest in using livestock for weed control in oil palm plantations as suggested in IPM practice (Ayob & Kabul, 2009). Government agencies encourage this practice not only for controlling weed naturally but also to meet the local market demand for red meat (Awaludin, 2000). Livestock including cattle, buffaloes, and goats are being integrated with oil palm cultivation. This practice has reduced the dependency on herbicides which indirectly might help in maintaining farmland biodiversity (Awaludin & Masurni, 2004).

With the inception of the Roundtable on Sustainable Palm Oil (RSPO) scheme in 2008 at the international level and the Malaysian Sustainable Palm Oil (MSPO) in 2013 at the national level, oil palm growers in Malaysia are required to certify their plantations (Kumaran, 2017). The principles and criteria in both certification schemes have demanded that oil palm growers use biological agents to control pest organisms (RSPO, 2005; Kuntom *et al.,* 2015). This measure will minimise the use of herbicides. It is an important effort because continuous application of herbicides in agriculture can harm both the environment and human health (Stoleson *et al.,* 2011; Sutyarso & Kanedi, 2014).

1.2 Problem Statement

Agrochemicals such as pesticides, herbicides, and fertilisers are the main source of pollutants in agricultural landscapes (Krebs *et al.,* 1999; O'Connor & Shrubb, 1986; Wilson *et al.,* 2009). Even though agrochemicals have been linked to the eradication of non-target wildlife and beneficial species (Boatman *et al.,* 2004; Capinera, 2010; Christin *et al.,* 2003; Freemark & Boutin, 1995; Mañosa *et al.,* 2001; Relyea, 2005; Ouellet *et al.,* 1997), these chemicals are still widely used by farmers and agribusiness enterprises in developing countries to control pests and weeds. In order to suppress competing weeds, oil palm stakeholders have spent tens of millions of dollars annually on pesticides. However, it has adverse side effects on the ecosystem and human health in the long-run. Agro-chemicals not only contaminate soils and water quality (Margni *et al.,* 2002; Pimentel & Edwards, 1982) but can cause severe illnesses to human beings (e.g. cancer) (Alavanja *et al.,* 2003; Matthews, 2006; Settimi *et al.,* 2003). Thus, agriculture stakeholders should explore new ecological-friendly methods to reduce dependency on these chemicals (e.g. zero-burning technique is one of the ecological-friendly practices implemented by palm oil stakeholders).

For many years, livestock farming has been integrated with oil palm cultivation in Malaysia in order to meet local meat consumption demand (Devendra, 2007; Devendra & Thomas, 2002; Latiff & Mamat, 2002; Payne, 1985). For example, in the Economic Transformation Program (ETP) under Entry Point Project 5 (EPP-5) which started in 2013, the Malaysian government has distributed a total of 2,500 cattle to oil palm plantation companies to encourage livestock in order to increase the country's level of meat self-sufficiency (PEMANDU, 2017). However, palm oil stakeholders have failed to understand their potential in weed management and its biodiversity-friendly aspect. Until now, the purpose of using the cattle as an agent to control the weeds seems to be unsuccessful. More importantly, there is lack empirical evidence that supports any sustainable management practices in oil palm areas. Previous studies have suggested the retention of forest patches is important in biodiversity conservation in agricultural areas (Koh, 2008; Edwards *et al.,* 2010; Azhar *et al.,* 2011), but few have emphasised the importance of sustainable practices in these areas (Donald, 2004; Azhar *et al.,* 2012; Jambari *et al.,* 2012). This leads to the need for conservation scientists and palm oil stakeholders to collaborate to study the potential benefits of targeted grazing in order to control the weeds as well as conserve the farmland biodiversity.

1.3 Justification

This study provides a new approach to implementing the innovative practice to control weeds and rodent populations. In accordance with the Malaysian Sustainable Palm Oil (MSPO) and Roundtable on Sustainable Palm Oil (RSPO) principles and criteria, the findings demonstrate that such ecological-friendly methods (i.e. targeted grazing) can enhance farmland biodiversity in oil palm plantations. Research that focuses on the ecological aspects of such integration system between cattle farming and oil palm agriculture is limited. Thus, this study offers a new perspective in improving the system of managing farmland.

Oil palm plantations should only be expanded through sustainable approaches. Some suggested mitigations are still debated for their partiality, reasonable impact and economic viability. Promoting an environmentally-friendly farming system has a direct positive impact on the improvement of the oil palm plantation landscape, and every sector could participate. Therefore, Malaysian government has made mandatory for oil palm growers in this country either from plantations or smallholders sector to embrace with certification such as Malaysian Sustainable Palm Oil (MSPO) by 2019 (Sivanandam, 2017). This effort believed able to handle negative concern on palm oil especially from customers in European Union and marketability palm oil produced in this country will be increased,

Since biodiversity of birds is a reliable bio-indicator to evaluate the impact of livestock grazing on oil plantations (Robbins *et al.,* 1986), it was used in this study. In this study, a bird survey was conducted following point count method. Two treatments were applied to test the hypothesis, namely cattle grazed plantation following a systematic approach and non-systematic approach. Oil palm plantation with no cattle integration activity depended solely on chemical herbicide for controlling weeds.

1.4 Objectives

This study was conducted with the following objectives:

i. To compare the oil palm plantation bird species diversity between grazed and non-grazed plantations.
ii. To examine the relationship between different grazing practices on the farmland and the bird composition.
iii. To determine the effects of cattle grazing on the ground cover by comparing between grazed and non-grazed plantations.

1.5 Research Questions and Hypotheses

i. How do the vegetation structure, cattle's stocking density and chemical weeding costs differ between different grazing systems (i.e. systematic grazing, unsystematic grazing, and control)? It was hypothesised that the vegetation structure would be different following different weed management practices.

ii. What is the effect of cattle grazing on bird biodiversity with respect to different cattle grazing management? It was hypothesised that systematically managed cattle integration with oil palm plantations would increase bird species diversity and abundance.

iii. What oil palm plantation bird species contribute the most to the bird community composition in systematically and non-systematically managed plantations using livestock as well as control plantations? It was hypothesised that bird species that dominated those systems will be different which indicates that individual species have specific tolerance to agricultural practices.

iv. Does oil palm plantation bird species composition differ between systematically, non-systematically managed farmland and control plantations? It was hypothesised that bird composition in cattle grazed plantations would be significantly more diverse than un-grazed (control) plantations. It was also predicted that bird species composition in control plantations characterised by intensified herbicide spraying frequency was the least diverse.

v. What is the effect of cattle grazing on ground vegetation in grazing management? It was hypothesised that systematically managed cattle integration with oil palm plantations would improve weed control.

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