EVALUATION OF RAT OCCURRENCE IN OIL PALM PLANTATIONS USING GIS AND REMOTE SENSING TECHNIQUES

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ABSTRAK

PENILAIAN KEHADIRAN TIKUS DI LADANG KELAPA SAWIT DENGAN MENGGUNAKAN TEKNIK GIS DAN PENDERIAAN JAUH

Kerosakan yang disebabkan oleh tikus di ladang kelapa sawit membawa kerugian ekonomi. Dalam kajian ini, faktor-faktor yang mempengaruhi kewujudan tikus telah dikaji dengan menggunakan teknik GIS. 255 ekor tikus telah ditangkap dengan menggunakan perangkap dan kebanyakannya adalah *Rattus rattus diardii*. Di ladang kelapa sawit, species tikus adalah *R. r. diardii, R. argentiventer*, dan *Maxomys whiteheadi*. Di hutan pula, species tikus adalah *R. r. diardii, M. whiteheadi*, dan *M. surifer.* Data tangkapan tikus digabungkan dengan beberapa faktor. Faktor yang mempengaruhi kehadiran tikus telah dikenalpasti melibatkan umur pokok, jarak dari jalan, jarak dari kilang pemprosesan, dan indeks vegetasi NDVI. Persamaan logistik binomial dan multinomial telah dibangunkan untuk meramal taburan tikus di ladang kelapa sawit. Kajian ini teah mengenalpasti kawasan yang tinggi, sederhana, dan rendah kehadiran tikus. Kawasan tanam semula merupakan kawasan yang paling tinggi kehadiran tikus (Kadar tangkapan 25.35%, Kehadiran tikus di 95.31% lokasi). Sarang burung hantu boleh diletakkan di kawasan tersebut, dan kehadiran tikus di ladang kelapa sawit boleh ditangani dengan lebih berkesan.

ABSTRACT

Rat damage in oil palm plantation brings significant economic losses. In this study, factors that influence rat occurrence were investigated using live trapping and GIS-based multicriteria analysis. 255 rats, mostly Rattus rattus diardii *were captured using live trapping from nearly two thousands trap-night efforts. In oil palm plantation, rat species captured is* R. r. diardii, R. argentiventer, Maxomys whiteheadi. *In forest, rat species captured is* R. r. diardii, M. whiteheadi, and M. surifer.*Rat capture data was examined using several spatial factors. Factors that influence rat occurrence are found to be palm age, distance from road, distance from mill, and Normalized Difference Vegetation Index (NDVI) value. Binomial and multinomial logistic regression models were developed for prediction of rat occurrence in oil palm plantation. This study identified high, medium, and low rat occurrence area in oil palm plantation; highest rat occurrence (25.35% success rate, 95.31% points with rat) was recorded in replanting area. Identification of high rat occurrence area allow effective placement of barn owl nest box, for addressing rat problems in resource saving and environmental friendly way.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GIS	Geographic information system
RISDA	Rubber Industry Smallholders Development Authority
NDVI	Normalized Difference Vegetation Index
FFB	Fresh fruit bunch
IPM	Integrated Pest Management
USEPA	United States Environmental Protection Agency
BOP	Barn owl programmes
DOA	Department of Agriculture
FELDA	Federal Land Development Authority
FASSB	FELDA Agricultural Services Sdn. Bhd.
THC	Tetracycline hydrochloride
MPOB	Malaysian Palm Oil Board
PHVA	Population and habitat viability assessment
MCA	Multicriteria analysis
USGS	United States Geological Survey
DEM	Digital elevation model
OBC	Object-based Classification
MCP	Minimum Convex Polygon

LIST OF SYMBOLS

g	Gram
ha	Hectares
X^2	Chi-square
R^2	R-square
m	Meter
m^2	meter square
P	Probability
P(Y)	Probability of rat occurrence
p	significance level
K^	Kappa statistic

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

The oil palm industry is threatened by the persistence of pest problems, such as the red palm weevil, the rhinoceros beetle and rats (RISDA, 2010). Rat damage in oil palm plantation brings significant economic losses up to RM9700/ha/year, resulting from physical damage to oil palm fresh fruit bunch and the cost of rat control practices involved (Hafidzi & Saayon, 2001). Many plantations relied on rodenticide to control rat. The drawback of rodenticide use is it also consumed by non-target animals such as palm civets or cause secondary poisoning in predators that prey on rat (Naim *et al.*, 2010).

A widely employed environmentally safe approach in controlling rat is by relying on the natural predator, the barn owl (*Tyto alba*) (Hafidzi & Saayon, 2001). Natural propagation of the barn owl by way of provisioning artificial nest boxes started in the oil palm plantation in Malaysia in the 1980's (Duckett & Karuppiah, 1989; Smal, 1989). By and large the placement of the nest boxes in the oil palm plantation was largely random and not based on factors that influence rat density and distribution. As a consequence the nest boxes failed to attract barn owls and achieve optimum occupancy rates. From the point of sustainable agriculture perspective this is wastage of resource allocation and compromises on the effectiveness of the system. To successfully manage rat problem in plantation, it is important to know what are the factors that influence rat occurrence. However, the spatial aspect of rat occurrence has not been sufficiently studied.

Geographic information system (GIS) is suitable in habitat assessment of small mammals, such as foxes (Gerrard *et al.*, 2001), squirrels (Menzel *et al.,* 2006; Pereira & Itami, 1991) and urban rat (Traweger & Slotta-Bachmayr, 2005). In this study, the occurrence of rat and the spatial assessment that influence this in oil palm plantation in Sabah was investigated.

1.1 Research objectives

1. To develop a spatial model of rat occurrence in oil palm plantations using GIS and remote sensing techniques.
2. To estimate rat occurrence in monoculture plantation and plantation adjacent to forest.

1.2 Problem statements

Despite various studies done on oil palm pest, none of them focus on examining the occurrence of rat using GIS and remote sensing techniques (Darus & Wahid, 2000; Deoras *et al.,* 1972; Liau, 1990; Wood, 1976). Although the barn owl has been introduced for decades, allocation of their nest box is still based on trial and error. The success of the use of the barn owl in controlling rodent pests might rely on deeper ecological settings of the rodents, which in turn influence the function of the owl as a predator. Through this study, the spatial distribution of rats in oil palm plantations and factors that influence it were examined.

1.3 Justification

This study was conducted to support sustainable development of oil palm industry, especially on the using of biological control method. It will bring us more understanding on rat and allow us to deal with rat problem through strategic placement of barn owl nest box. This study will provide an alternative to placement of nest boxes for the barn owl allowing the possibility to further enhance the use of biological control of rat pests in the oil palm plantations.

CHAPTER 2

LITERATURE REVIEW

2.1 Rats and their habitat

2.1.1 Background

In order to effectively handle rat problems, we need more understanding in their behavior and habitat. Rat makes up about 30% of the world mammalian species (Wilson & Reeder, 2005).They are highly adaptive creature and are well distributed all over the world. *Rattus rattus* for example, has a world-wide range and includes subantarctic islands (Pye *et al*., 1999; Schwarz, 1960). Another common species, *R.norvegicus* has a more northernly distribution (Schwarz, 1960), and dominates cities in temperate regions (Cavia *et al.*, 2009). Subspecies *R. r. diardii* is found in Sabah and the taxonomy is as follows (Payne *et al*., 1998):

phyllum	: chordata
class	: mammalia
order	: rodentia
suborder	: sciurognathi
family	: muridae
subfamily	: murinae
subspecies	: *Rattus rattus diardii*
common name	: black rat or house rat

It was reported that rat feed on nuts, plant leaves, stems, seeds, grass and insects (Horskins *et al.*, 1998). A pair of mature rat can produce up to 2000 offspring per year and their infants reach maturity in three to four months (Payne *et al*, 1998; RISDA, 2010). Innes and Skipworth (1983) studied *R.rattus* in New Zealand and found that *R.rattus* has stable home range with irregular shape, appear in different area in different nights, but stayed within their home range.

2.1.2 Rat in oil palm plantation

Rat is a problem in oil palm plantation, either newly planted or matured (RISDA, 2010). They are prevalent in oil palm plantations due to its favorable environment for breeding and taking refuge from predators (Hafidzi, 1995). The most widespread rat species found in oil palm of Peninsular Malaysia is the Malaysian wood rat (*R. tiomanicus*), the Malayan black rat (*R. r. diardii*), and ricefield rat (*R. argentiventer*) (Hafidzi & Saayon, 2001). Their main differences are listed in Table 2.1.

Eighty percent of *R.rattus* diet consists of plant matter (McDonald *et al.*, 1997). They are considered pest in oil palm plantation where they damage the oil palm fruit's bunches and cause stunted growth in both matured and young oil palm seedlings (Hafidzi & Saayon, 2001; Heru *et al.,* 2000). Study of 5372 rat in oil palm plantation showed that 96% of the stomach content is oil palm fruit (Wood & Liau, 1984). The abundance of rat has been found to have direct relationship to crop damage (Brown *et al.,* 2006).

Table 2.1 : Main differences of ***R. r. diardii, R. argentiventer,*** **and** ***R. tiomanicus***

	R. r. diardii	*R. argentiventer*	*R. tiomanicus*
Wt (g)	100-200	85-180	78-125
HB (mm)	122-219	140-210	140-188
T (mm)	121-220	130-192	120-181
T/HB	>100%	<100%	75-120%
HF (mm)	32-39	32-36	28-35
Skull: cbl	33.8-42.9	35.1-39.7	34.3-36.9
Skull: io	5.8-7.4	5.6-6.6	5.9-6.5
Skull: mt	6.2-7.0	7.0-7.1	6.0-6.8
Upperparts	Finely grizzled olive-brown	Pale brown with brown speckling	Finely grizzled olive-brown
Underparts	paler, buffy brown with grey bases	Wholly silvery-grey	Pale grey with buffy white tips/White

Tail	Brownish	Brownish	Dark brownish
Female mammae	10	12	10
Ridge on feet	No	No	Yes
Black guard hair on rump	Yes	No	Whole body
Distinct feature	Big body size	Mostly subterranean, attack young oil palm	Good climbers, dominant (in Peninsular Malaysia)
			

Wt: weight
HB: length of head and body
T: length of tail
HF: length of hinge feet
cbl: condylobasal length
io: interorbital breadth
mt: metatarsal

Source: A Field Guide to the Mammals of Borneo (Payne *et al.,* 1998)

Newly planted oil palm is vulnerable to rat attacks; rat eat the young tissue which leads to stunted growth and death of the young oil palm (Padilla *et al.,* 1995; RISDA, 2010). In matured oil palm plantations, rat eat fresh fruit of oil palm. Rat also eat oil palm florescence when their population exceeds carrying capacity (RISDA, 2010). Their high adaptability had caused their population to exceed the carrying capacity in oil palm plantation (Hafidzi, 1993; Hafidzi, 1995). It was reported that estimated damage from rat activities can reach 3 ton/ha/year or RM1200/ha/year (Hafidzi & Saayon, 2001). The damage is even more critical in seriously attacked oil palm plantation (RISDA, 2010).

2.1.3 Rat control methods

Rat can be controlled using chemical, physical, or biological control method (RISDA, 2010). The cost of rat control varied with method used and it falls between RM30-RM70/hectare/year (RISDA, 2010).

i. Chemical control

Chemical control by means of rodenticide can be found in various formulations with different active ingredients (RISDA, 2010). There are more than 50 registered formulations of rodenticide registered in Malaysia alone (RISDA, 2010).

Wood (1976, 1984, 1988) suggested a six months interval baiting, while Ho (1996) recommended baiting when rat damage exceeds 5% of the fresh fruit bunch (FFB) (RISDA, 2010). In practice, some plantation modified the system suggested. For example, FELDA oil palm plantation do baiting three times a year, while another oil palm plantation, PERMAI, do baiting when damage exceeds 10% of FFB.

The drawback of rodenticide is rat will develop resistance to them over time after extended usages. There are two types of rodenticide, the first generation anticoagulants and the second generation anticoagulants. The latter was introduced when rat have developed resistance to the former (RISDA, 2010). Currently, the most widely employed first generation rodenticide in Malaysia is warfarin (Naim, 2009). Study also showed that using of rodenticide can only provide short term solution. A study done in 17 farms in United Kingdom showed that rat population can return to 50% of pre-treatment population in just one year (Cowan *et al.,* 2003).

Rodenticide has other drawbacks. Rat has high annual mortality rate and short lifespan, but with an extraordinary high reproductive potential (r-selected life strategy). Thus, the reduction of population by means of rodenticide can only provide short-term effect (Witmer, 2007). In oil palm plantation where food availability is high, rodenticide can be ineffective against rat (Leung & Clark, 2005). Leung & Clark (2005) investigated the effectiveness of baiting in a pig farm in Australia by using several types of commonly applied rodenticide. They concluded