ECOLOGY AND CONTROL OF THE GREATER BANDICOOT RAT (*Bandicota Indica* Bechstein*)* IN RICE FIELD, JITRA, KEDAH, MALAYSIA

By

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

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Chair : Hafidzi Mohd Noor, PhD
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For the safety and security of food, a science-based pest rodent management strategy is crucial. However, after 80 years of introduced in Malaysia, there were limited information obtained regarding rodent pest status in especially the greater bandicoot rat species, which put farmers at disadvantage especially with the increasing encounter of the species recently. This thesis conferring basic information upon their population abundance in the rice field, and identify the key habitat structure that affects rodent pest populations by investigating the relationships of rodent pest populations with habitat characteristics. The greater bandicoot rat (*Bandicota indica*), the rice field rat (*Rattus argentiventer*), and the black rat (*Rattus rattus*), were found to coexist in the rice fields of Kedah, Northern Peninsular Malaysia. The greater bandicoot rat population was found to adapt similar strategy with the rice field rat by synchronizing their breeding season with monsoonal season. Although the species responded well with protein-based bait, their stomach content was consisting of plant materials (±60%). Aside from that the rodent abundance in the rice fields was positively correlated with bund height and width, rice growing stages, and rice planting seasons (Mallows CP=526.30, Adjusted R^2=16.54). However, rodent abundance was negatively related with the distance between active burrows to residential areas (Mallows CP=706.87; Adjusted R^2= 4.10). The greater bandicoot rats were thought to reproduce underground and rarely respond to traps during the major rice planting season (monsoonal season). The efficacy of *B. indica* towards first and secondary anti- coagulant rodenticide was evaluated and there was no sign of resistance of the species during the study. Therefore, we recommend local farmers to conduct rodent control from the end of wet season until the beginning of the supplementary season (dry planting season) as it coincides with the emergence of juvenile generations bred during previous wet seasons. Authorities should conduct vigilant monitoring to avoid any new invasion to nearby states.

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

EKOLOGI DAN KAWALAN TIKUS WIROK EKOR PENDEK (*Bandicota Indica* Bechstein) DI SAWAH PADI, JITRA, KEDAH, MALAYSIA

Oleh

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Demi menjaga keselamatan dan bekalan makananan tempatan, strategi pengurusan tikus perosak berasaskan sains adalah penting. Walaubagaimanapun, maklumat mengenai status perosak tikus terutamanya spesies wirok ekor pendek adalah terhad walaupun sepsis ini telah wujud di Malaysia sejak 80 tahun dahulu. Oleh sebab itu, tesis ini membincangkan maklumat asas tentang kelimpahan populasi mereka di sawah, dan mengenal pasti struktur habitat utama yang mempengaruhi populasi perosak tikus. Tikus wirok ekor pendek (*Bandicota indica*), tikus sawah (*Rattus argentiventer*), dan tikus hitam (*Rattus rattus*), didapati hidup bersama di kawasan sawah di Kedah, Utara Semenanjung Malaysia. Populasi tikus wirok ekor pendek didapati menyesuaikan strategi pembiakan mereka seperti tikus sawah dengan menyegerakkan musim pembiakan mereka dengan musim tengkujuh.Walaupun spesies bertindak balas dengan baik dengan umpan berasaskan protein, kandungan perut mereka terdiri daripada bahan tumbuhan (±60%). Selain itu, kelimpahan tikus di sawah berkorelasi positif dengan ketinggian dan lebar batas, peringkat penanaman padi, dan musim menanam padi (Mallows CP=526.30, R^2 Terlaras=16.54). Walau bagaimanapun, kelimpahan tikus berkait negatif dengan jarak antara lubang tikus yang aktif ke kawasan kediaman (Mallows CP=706.87; R^2 Terlaras = 4.10). Keberkesanan penggunaakn racun tikus antikoagulan pertama dan kedua telah dinilai dan didapati tiada tanda-tanda rintangan oleh spesies ini semasa kajian. Oleh itu, kami mengesyorkan para petani tempatan menjalankan kawalan tikus dari akhir musim hujan sehingga awal musim tambahan (musim tanaman kering) kerana ia bertepatan dengan kemunculan generasi juvana yang dibiakkan pada musim hujan sebelum ini. Pihak berkuasa juga perlu menjalankan kerja-kerja pemantauan untuk mengelakkan spisis ini dari menceroboh negeri-negeri lain.

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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 Doctor of Philosophy in Wildlife Ecology and Management. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
˚	Degree
˚C	Degree Celsius
=	Equal sign
g	Gram
Ha	Hectare
Kg	Kilogram
Km	Kilometer
<	Less than
M	Mean
m	Meter
>	More than
N	North
Ppm	Part per million
P	p-value
%	Percentage
±	Plus-minus
SD	Standard deviation
Sp.	Species
Spp.	Subspecies
w/w	Weight by weight

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most ancient cereal crops cultivated in human civilization, estimated at around 130 million years ago and thought to have originally grown in the ancient landmass Gondwanaland (Dogara and Jumare, 2014). Rice ranked second as the highest produced grain worldwide after maize (FAO, 2013) and is mostly consumed by Asian population. Most rice was cultivated for consumption within the country as only 4% of the world's rice production is traded internationally. Paddy field is mostly grown in Asia, West Africa, North America, Central and East Africa, South and Central America, Australia, and the United States of America (Muthayya et al.,2014; Mohidem et al., 2022).

Malaysia is an upper- middle-income country that has transformed from an exporter of raw materials into a multi- sector economy and focused on exporting electronics, oil and gas, and palm oil (The World Factbook, 2021). Agriculture is not the main economic trust, hence Malaysia imported most of her food requirements as most of Malaysia's arable lands were cultivated under oil palm. Although Malaysia aims to achieve at about 65-70% of the local consumption in rice production (Arshad et al. 2011), Rajamoorthy (2015) anticipated the government will become a net importer until 2030 if she decides to stop enhancing national rice production. This is simply because demand for rice will continue to increase with crop production keep falling behind. It will affect the livelihood of rice farmers and jeopardizing the food security status as rice stockpile keep diminishing.

The minimal national target of self-sufficiency in rice production can be achieved by conducting mitigation measures that can be implemented is to manage pest and diseases of the rice crop. Major insect pests such as brown plant hopper and stem borer are also listed by FAO (2002) as constraints in paddy production. Rodents, on the other hand, are the most destructive vertebrate pest since they consume paddy crop at every stage of the development from seeds dispersal/sowing to harvesting; damaging the stalks at the milking, booting and the ripened ready to harvest paddy plants (Singleton et al, 2004). Rodent outbreaks can cause potentially large yield loss in every planting season (Brown et al., 2017; Singleton et al., 2021,). Rodents were accounted for an estimated annual loss of RM43 million (based on a conservative annual 5% loss) (Lam, 1985). Rodents are prolific, producing several large litters a year; if left unchecked can become a plague.

The rice field rat, *Rattus argentiventer* is a common local pest species here in Asia and causes significant rice loss in the fields. Other rodent pest identified in Malaysia includes the roof rat (*rattus rattus*), the wood rat (*rattus tiomanicus*), the brown rat (*Rattus norvengicus*), the field rat (*rattus rattus diardii*) and the ricefield mouse (*Mus caroli*) (Lim, 2005). Most of them identified as nuisances in agriculture lands, however, the brown rat, roof rats are exceptionally notorious in urban area as well. They are also possessing high health risk to humans (Paramasvaran et al., 2009,2013).

The Greater bandicoot rats on the other hands, are not native to Malaysia, but has been introduced to the northern part of peninsular Malaysia as well as Java, Indonesia and Taiwan (Marshall, 1997). It was firstly recorded as pests in Malaysia in 1966 (Lam,1985). Believed to have originated from Central Asia, but the molar fossil records infer that *B. indica* sparsely inhabited the eastern part of the Oriental Region in the Middle and Late Pleistocene (Kawamura et. al 2019). Over time they greatly increased in numbers and their distribution expanded to the western part of the region in association with human activities during the Holocene period.The bandicoot rats are generally large and are the largest among rodent pest species. An adult can weigh up to 1kg with head tail to length nearly 30cm. Being omnivorous, they feed on a wide range of food making them a versatile pest on many agricultural crops. They have been documented feeding on wheat, sorghum, rice, peanut, sugarcane in South Asian countries i.e., India, Pakistan, and Bangladesh (Parshad & Jindal, 1991; Chakraborthy,1992; Khalequzzaman & Hossain, 1998; Hossain & Khalequzzaman, 2002; Borah & Bora, 2012; Birah, et.al., 2013; Borah &Mallick, 2016;)

The bandicoot rats were identified as generalists; however, they were found to prefer high fiber diet (Gong, et.al., 2011). A refined study by Hossain and Khalequzzaman, (2000) on food preferences of bandicoot rat in India suggested that; the they prefer powdered rice and wheat, compared to broken or whole of the same crop. The preferences towards fibrous crops resulted their existence in wheat fields (Singal and Pasahan,1993; Sheikher and Malhi, 1983), sugarcane (Tariq et.al., 2017), sorghum, ground nuts, potato (Hussain, et.al.,2016, Chakraborty & Chakraborty,1999) legumes (San and Sein, 2019) fodder crops (Siddique and Arshad, 2003) and even in poultry farms (Mehmood, et.al., 2011).As a pest, bandicoot rat invasions are feared for several reasons; they are large in size (Aplin et al, 2003; Musser & Brothers, 1994) and naturally the rate of consumption relative to that of R. argentiventer may lead to the displacement of the latter. They are adaptable in various landscape (Nurul et al, 2011; Pachero, 2019; Mehmood et al., 2011; Rao, 1980), high reproductive rate (Lam 1985; Thitipramote et al., 2009), disease carrier (Arankalle et al., 2001; Boge et al., 2021; Khairojanan et al, 2020; Raut et al, 2003; Sofizadeh et al., 2016) and capability on causing devastating damages whether towards crops, storage products and infrastructures (Phukon &Borah, 2019; Poche at al.,2019; Rao & Singh, 1983; Srihadra & Srihari, 1980,1983). All these criteria allow Bandicoot sp to have the potential for expansion beyond its present geographical distribution limits and will pose unknown challenges to rodent management program in Malaysia.

In Malaysia, some study reported their occurrences alongside human settlements (Nurul, et al 2011) and hypothesized their diet may related to human consumptions. Other report by Lim (2005) concluded that the bandicoot rats may also consumes other resources than agriculture crops such as mollusks, river crabs and earthworm to survive. However, there is limited information on the population status, a lack of information on their ecology, and an absence of comprehensive study on them, although they have been introduced for more than a decade in Malaysia. Therefore, this study aims to comprehend the least studied local invasive rodent pest, yet one of the largest rodent species in the rice field of the northern states of Peninsular Malaysia; the greater bandicoot rat, Bandicota indica in rice field Jitra, Kedah.

OBJECTIVE

Overall objective:

The overall objective of this study is to understand the ecology of *Bandicota indica* in paddy field, population abundance, their preferred habitat and practical control method that can be conducted by local farmers to keep the rodent population in check.

Specific objectives:

1. To monitor population abundance of *B. indica* and the rodent species composition using trapping index throughout rice plant growth stages in the rice field in Jitra, Kedah.

2. To determine the bait preferences and diet of *B. indica* for a comprehension of the diet profile throughout the rice plant growth stages.

3. To investigate for any new invasion in Perak by evaluating differences in burrow entrances sizes between Kedah and Perak states.

4. To evaluate any correlation of rodent burrowing activities with stand- level and landscape-level environmental parameters using Generalized Linear Mixed Model (GLMMs).

5. To determine rodenticide efficacy on *B. indica* of chlorophacinone and flucoumafen using choice and no choice feeding test.

6. To determine rodenticide efficacy on *B. indica* of chlorophacinone and flucoumafen in the field assessment.

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