Faculty of Resource Science and Technology

Rodents and The Associated Parasites from Different Habitat Types in Sarawak

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Rodents are the most successful mammalian order and are well distributed globally, including Sarawak. However, habitat destruction and alteration may influence the rodents' population structures and distributions. Rodents can serve as hosts for medically concerning parasites that might act as vectors for zoonotic diseases. This has highlighted the importance of understanding the distribution and diversity of rodents in different habitat types and the parasites they carry. This study is intended to: 1) study the distribution and diversity of rodents in different habitat types in Sarawak; 2) determine the parasite prevalence and habitat preference of rodents in different habitat types in Sarawak; and 3) discover the host-parasite relationship between rodents and their parasites in Sarawak. Samplings were conducted between November 2018 and December 2019, which resulted in 241 individuals of rodents captured, comprising eight species. Of this, 78 individuals were captured from urban areas, followed by oil palm plantations (72 individuals), rural areas (65 individuals), and forest areas (26 individuals). Statistical analysis showed that the forest areas have the most diverse rodent' species among all habitats (H'= 1.91, $p<0.05$), followed by oil palm plantations (H'=0.93), urban (H'=0.66) and rural areas (H'=0.40). A total of 236 rodents were then examined for parasites, and 218 of them were found to be infected with at least one parasite. A total of 41 species of parasites were recovered in this study, and the rodent community was mainly dominated by ectoparasites (77.12%), followed by endoparasites (61.44%), and hemoparasites (30.51%). From the habitat viewpoint, overall parasite prevalence was highest in forest areas (100%). A significant difference between habitat types was detected in the prevalence of hemoparasites and endoparasites (both $p<0.001$) believed to be influenced by humidity and temperature as well as other factors. This study also discovered 129 host-parasite interactions between 41 parasite species and eight murid rodents. Goodness-of-fit

indicates (m2XY=183.3784, p= 0.035, nperm=1000) resulted significant congruence between the host and parasite distance matrices. Meanwhile, bipartite analysis indicates a low level of specialization for all parasites, or, in other words, parasites in this study are not host-specific based on bipartite analysis. These results provide information on the structure of rodents as well as the population of their parasites in Sarawak. This study also depicts Borneo's present parasite infection status and rodent-parasite relationship, which may help in deeper research on parasite and host relationships as well as be part of the effort in forecasting human health risk in this region.

Keywords: Habitat gradient, host-parasites interaction, parasite, rodents, zoonoses.

Roden dan Parasitnya dari Pelbagai Jenis Habitat di Sarawak

ABSTRAK

Tikus merupakan sejenis mamalia yang paling berjaya dan tersebar luas di seluruh dunia, termasuk di Sarawak. Walau bagaimanapun, kemusnahan dan perubahan habitat boleh menjejaskan struktur dan kepelbagaian populasi tikus. Tikus boleh berperanan sebagai tuan rumah untuk parasit yang berkaitan dengan perubatan dan boleh bertindak sebagai vektor untuk penyakit zoonotik. Ini membuktikan kepentingan untuk memahami penyebaran dan kepelbagaian tikus dalam habitat yang berbeza dan parasit yang mereka bawa. Kajian ini bertujuan untuk: 1) mengkaji penyebaran dan kepelbagaian tikus dalam habitat yang berbeza di Sarawak; 2) menentukan kelaziman parasit dan keutamaan habitat tikus di pelbagai jenis habitat di Sarawak dan 3) mengkaji hubungan tuan rumah-parasit antara tikus dan parasit di Sarawak. Pengumpulan sampel telah dijalankan antara November 2018 dan Disember 2019, dimana 241 individu tikus telah ditangkap terdiri daripada lapan spesies. Sebanyak 78 ekor tikus dari jumlah tersebut ditangkap dari kawasan bandar, diikuti oleh ladang kelapa sawit (72 ekor), kawasan perkampungan (65 ekor), dan kawasan hutan (26 ekor). Analisis statistik menunjukkan bahawa kawasan hutan mempunyai spesies tikus dengan kepelbagaian paling tinggi di antara semua habitat (H'=1.91, p<0.05), diikuti oleh ladang kelapa sawit (H'=0.93), bandar (H`=0.66) dan kawasan perkampungan (H'=0.40). Sebanyak 236 tikus kemudian diperiksa untuk jangkitan parasit, dan 218 daripada tikus ini telah dijangkiti oleh sekurang-kurangnya satu parasit. Sebanyak 41 spesies parasit telah diperoleh dari kajian ini, dan komuniti tikus ini didominasi oleh ektoparasit (77.12%), diikuti oleh endoparasit (61.44%), dan hemoparasit (30.51%). Dari sudut pandang habitat, penyebaran parasit secara keseluruhan adalah tertinggi di kawasan hutan (100%). Perbezaan yang ketara antara jenis habitat ditemui dalam kelaziman hemoparasit dan

endoparasit (kedua p<0.001) yang diyakini dipengaruhi oleh kelembapan dan suhu serta faktor-faktor lain. Kajian ini juga mendapati 129 interaksi tuan rumah dan parasit antara 41 spesies parasit dan lapan tikus Murid. Indikator kesesuaian yang baik (m2XY = 183.3784, p = 0.035, nperm = 1000) menghasilkan kongruen yang ketara antara matriks jarak tuan rumah dan parasit. Sementara itu, analisis bipartit menunjukkan tahap pengkhususan yang rendah untuk semua parasit, atau, dengan kata lain, parasit dalam kajian ini tidak spesifik kepada tuan rumah berdasarkan analisis bipartit. Hasil ini telah memberikan maklumat tentang struktur tikus serta populasi parasit mereka di Sarawak. Kajian ini juga menggambarkan status jangkitan parasit Borneo yang sedia ada dan hubungan tikus dan parasit, yang boleh membantu dalam penyelidikan yang lebih mendalam mengenai hubungan parasit dan tuan rumah serta menjadi sebahagian daripada usaha dalam meramalkan risiko kesihatan manusia di rantau ini.

Kata kunci: *Kecerunan habitat, interaksi perumah-parasit, parasit, tikus, zoonosis.*

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LIST OF ABBREVIATIONS

CA	Correspondence analysis
cm	centimetre
DI	Desa Ilmu
EDTA	Ethylenediamine tetraacetic acid
FA	Forest areas
KB	Kampung Baru
KNP	Kubah National Park
KSM	Kampung Sebat Melayu
LC	Least Concern
m	meter
NaCl	sodium chloride
NNP	Niah National Park
OP	Oil palm plantation
PCA	Principle Components Analysis
PDI	Paired Difference Index
PJ	Petrajaya
RA	Rural areas
SJOP	Sadong Jaya Oil Palm Plantation
UA	Urban areas
UNIMAS	Universiti Malaysia Sarawak
VU	Vulnerable
WOP	Wilmar Oil Palm Plantation

CHAPTER 1

INTRODUCTION

1.1 Study Background

Rodent is a diverse group of mammals that exploit a wide range of habitats (Yihune & Bekele, 2012). They make up an important group in the forest, cultivated land and towns, extending from the shore to mountain top and from the ground to the forest (Paramasvaran et al., 2013). They covered nearly every continent in the world except Antarctica and certain oceanic islands (Bonnefoy et al., 2008). They include 29 families, 468 genera, and over 2052 species worldwide (Ardianyah & Mahrun, 2022). A total of 66 species of them are listed in Borneo that belonging to three families, Sciuridae, Muridae and Hystricidae (Phillipps & Phillipps, 2018). Among those families, Muridae is the most medically concerning group and the most successful family in the mammalian order with a global distribution (Telmadarraiy et al., 2007).

Their broad distribution has been the main concern on human health risk. The growth of economy and agriculture in Malaysia has forced Malaysia to experience rapid deforestation and habitat degradation (Madinah et al., 2014). Sarawak is not exempted to be part in this development since forests were reduced by 0.62% annually (Kamlun et al., 2012). Rodent was the one that most affected by these activities as they are response quickly to environmental changes owing to their short lifespan and prolific reproduction capabilities. (Wan et al., 2022). The increased of the habitat destruction and the human population in Sarawak may lead to near extinction of some conservation important species and increase exposure of either direct or indirect transmission of diseases by the rodents. Yet, rodents are good ecological engineer in natural habitat and it also medically important as it is vector for

various zoonotic diseases (Rabiee et al., 2018). Eventhough their population response quickly to the environmental changes, some of them are highly adaptable to the unpredictable environment combined with other factors that favour the parasitic growth (Chuluun et al., 2005; Premaalatha et al., 2017). Therefore, information on distribution, diversity and abundance of rodents are crucial for conservation purposes and to aid in disease survelance.

A large proportion of the disease from rodent was led by the parasitic infections based on Rabiee et al. (2018). Rodents are hosts to an impressive diversity of parasites because they are able to provide a favourable habitat for many species of parasites on an individual (Madinah et al., 2014; Nadchatram, 2008; Nava et al., 2003). Parasites are often associated with harmful diseases.

Apart from parasite diversity, there is a paucity of information on the host-parasite relationship between rodent and parasites in Sarawak. The information on factors affecting rodent and parasite relationship is important in understanding disease emergence and transmission and the roles of parasites in host adaptation process. Even though the investigation of host–parasite associations might be dreary with given the generally low parasite prevalence and infestation rates, there is still a desire to make up an inference on prevalence and host-specificity patterns (Wells et al., 2013). This underline the need of a study on of the host-parasite relationship between rodents and the associated parasites in Sarawak as well as to understand the disease transmission by the rodent, specifically from the family Muridae. This study provides an information that aid authorities in improving their management on health risk management as well as educate and create awareness among communities on the potential reservoirs of infectious diseases in this region. This study documents the distribution of rodent as a potential zoonotic disease reservoir and its diversity

of parasite in contrasting habitats in Sarawak. The relationship and host specificity between host and parasite that provide crucial information on the health risk status of human interactions with rodent was also being discussed herein.

1.2 Problem Statement

Land-used intensification is the main causes in structuring rodent population (Morand et al., 2019; Palmeirim et al., 2020; Zhang et al., 2016). Massive habitat alterations may cause disappearing of native species and may increase the interaction between human and rodent. Most of the previous studies conducted in Malaysia were focused on species diversity of rodents in forest and human settlement, rarely combined the oil palm plantation.

Forecasting zoonotic disease reservoir is a stressing public health priority (Han et al., 2015). Parasites study is always being important in the medical field. There are many parasite species have been reported in Malaysia and some of them were medically concerning species due to their association of disease transmission to human. A large proportion of them have contributed in zoonoses worldwide. The studies on parasite infections of small mammals in Peninsular Malaysia from contrasting habitats ranging from forested to urban areas have been conducted over the years (Madinah et al., 2011; Paramasvaran et al., 2009; Priscilla et al., 2015; Zain, 2008). In addition, the studies of rodent parasites in Malaysia have focused on arthropods or ectoparasites (Adrus et al., 2011; Chuluun et al., 2005; Hafidzi et al., 2007; Madinah et al., 2011; Madinah et al., 2013; Mariana et al., 2011; Mariana et al., 2005, 2008; Mariana et al., 2007; Mustapha et al., 2019; Ng et al., 2017; Paramasvaran et al., 2009; Razali et al., 2018). Although the parasites of rodents were studied substantially in Malaysia, these studies rarely include population from agricultural areas, particularly from oil palm plantations as the largest growing crop in Malaysia. Moreover, the parasite diversity in

Sarawak is seldom addressed. Consequently, there is a lack of information regarding the ecology of rodent parasites in Sarawak.

There are poor of information regarding the distribution rodents and its parasite from the different habitats in Sarawak. The host parasite interaction in Sarawak also still poorly understood. Thus, this study contribute to the information regarding the current status of parasites and its host infection in Borneo. The expansion and urbanisation have resulted in a serious ecological changes that have irreversibly altered the composition and structure of terrestrial rodents as well as their parasite populations. Since, Sarawak is facing rapid development, the effect of this development needs to be taken into action and attention.

1.3 Objectives

Thus, the objectives of this study were:

i. To study the distribution and diversity of rodent in different habitat types in Sarawak

ii. To determine the prevalence of parasites and habitat preference on rats in different habitat types in Sarawak

iii. To discover the host-parasite relationship between rodent and their parasites in Sarawak

1.4 Hypothesis

The hypothesis tested are:

i. H_O: There is no significant difference in host distributions in different habitat types in Sarawak

   H_A: There is a significant difference in host distributions in different habitat types in Sarawak. (Chapter 4).

ii. H_O: There is no significant difference of rodent parasite in contrasting habitats in Sarawak

   H_A: There is a significant difference of rodent parasite in contrasting habitats in Sarawak (Chapter 5).

1.5 Chapter Summary

This thesis is divided into six chapters. First chapter comprises of the general introduction and objectives of this research study. Second chapter reviews the previous studies and information relevant to this research study. Chapter 3 looks into the finding of rodents distributions and species diversity in different habitat types in Sarawak. Chapter 4 provides and discusses the result of the rodent parasites diversity in different habitat types in Sarawak and compares the results between habitats. Chapter 5 discusses the host-parasite relationship emphasize to rodent and their parasites in Sarawak. Chapter 6 summaries the results of this research study with recommendation for forthcoming research on parasite of rodents. Lastly, Chapter 7 comprises the overall conclusion of this study and recommendation for future parasite studies.

CHAPTER 2

LITERATURE REVIEWS

2.1 Taxonomy of rodent

The classical rodent classification divided into three suborders which are Sciuromorpha (resembling squirrels), Myomorpha (resembling mice), and Hystricomorpha (resembling porcupines) originate from Brandt (1855). This classification relies on the examination of the jaw and skull structure, as well as the positioning of the masticatory muscles. Another classification was made by Tullberg (1899) who combined the mandibular conformation and Brandtian zygomasseteric criteria. Hence, this classification divided into two major group namely Sciurognathi and Hystricognathi. Rodent authorities (Landry, 1999; Wood, 1985) strongly advise against using Brandtian descriptions as argument rise on the descriptive meaning of the terms do not strictly agree with the morphologies of included members, which leads to confusion. However, the suborders Sciuromorpha, Myomopha, and Hystricomorpha have strong evidence supporting their classification as monophyletic taxa. Meanwhile, the evidence for classifying Castorimorpha and Anomaluromorpha is less convincing (Donnelly, 2015).

The suborders Sciuromorpha and Hystricomorpha each consist of one family, namely Sciuridae (squirrel family) and Hystricidae (porcupine family), respectively (Tripathi, 2014). On the other hand, the suborder Myomorpha is further divided into five families namely Dipodidae (birch mice), Platacanthomydae (dormice), Spalacidae/Rhizomydae (bamboo rats), Cricetidae (hamsters), and Muridae (voles, rats, mice, gerbils, etc.) (Tripathi, 2014).

Malaysian rodents consist of squirrels (Sciuridae), porcupines (Hystricidae), rats and mice (Muridae).

2.2 Rodent as important host to zoonotic diseases

Rodents are small mammals from order Rodentia that are characterised by their dentition that consist of a pair of incisors in both upper and lower jaws. According to Nieri-Bastos et al. (2004) and Madinah et al. (2013), Rodentia is the most species-rich order among mammalian (Meltesen et al., 2023). They are divided into three major families which are Sciuridae (squirrels), Muridae (rats) and Hystricidae (porcupines) (Hawkey, 2017). Several studies have stated that family Muridae are known as the largest family among the other mammalian families (Hamdan et al., 2016; Wilson & Reeder, 2005). Approximately 27 species of Muridae, 36 species of Sciuridae and three species of Hystricidae have been recorded in Borneo (Phillipps & Phillipps, 2018) specifically.

Despite being an essential part of natural communities, they also could cause damage to human-made structures, food resources and increase health risk by being a highly potential vector of diseases. Telmadarraiy et al. (2007) highlighted that Muridae is the most medically important family of rodent. Hence, this study has been conducted with a specific focus on Muridae, commonly referred to as rats and mice. Based on a study by Sengupta (2013), rodent grow rapidly and attain sexual maturity as early as the sixth week. They are able to deliver litters from one to 13 pups per pregnancy (Chahoud & Paumgartten, 2009) with an average gestation period of 22 days (Berman, 2020).

According to Johnson and Horn (2008), the distribution of rodents is influenced by several environmental factors which includes the habitat exploitation by human. These have been supported by Yihune and Bekele (2012) since the distribution of rodent in their study

were affected by vegetation, food availability and human impact. Their incredible adaptation to various lifestyles and environments (Rabiee et al., 2018) enables them to thrive in the new human-made habitats such as residential areas and plantation areas. The combination of a short reproductive cycle and big litters per pregnancy will lead to a rapid growth in their population. This, in turn, can result in an increase in zoonotic diseases that can infect the human community (Hafidzi et al., 2007). Therefore, the information of this significant host of transmissible zoonotic diseases could not be neglected.

2.3 Rodents parasites

Rodents are notorious hosts to numbers of zoonotic diseases that serve a genuine risk to human health (Luis et al., 2013; Meerburg et al., 2009; Morand et al., 2015). Many cases have been reported on zoonotic disease transmitted to human by the rodent such as toxoplasmosis, plague, hymenolepiasis, and others (Tijjani et al., 2020). Rodent-borne diseases are a huge issue that cannot be simply deal with due to the fluctuating occurrence rates and their correlation with the fast expansion of industrial and agricultural sectors, as well as global climate change (Rabiee et al., 2018). Rabiee et al. (2018) has been gathering diseases data from worldwide and found about 70 diseases were known as rodent-borne disease. In addition, study by Rabiee et al. (2018) proved that 50% of the rodent-borne disease were caused by parasitic infection, followed by bacterial and viral infections.

Three main classes of parasites that have been noted to directly cause disease in humans are protozoa, ectoparasites and helminth (Castro & Olson, 1996). Generally, parasites utilise host as their both nutrient bank and habitat for shelter, but transmission to another host has sometimes been crucial for the development and survival (Moore, 2010). Transmission of parasite falls into those general categories: the transmission of propagules (direct transmission), transmission by living vectors (usually by hematophagous insect), and