UNIVERSITI PUTRA MALAYSIA

DIVERSITY OF ORCHIDS IN GUNUNG JERAI, KEDAH, MALAYSIA

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FS 2016 82

DIVERSITY OF ORCHIDS IN GUNUNG JERAI, KEDAH, MALAYSIA

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

November 2016

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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November 2016

Chairman : Professor Rusea Go, PhD
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As one of the isolated mountains in Malaysia, Gunung Jerai, Kedah served beautiful scenery to visitors and potentially to be developed as an eco-tourism park in Kedah. Activities such as amenity forests, camping sites and outdoor sports can cause destruction to natural habitat. Geologically, the formation involved granites as the core and quartzite covers the outer layer of the mountain. This indicates the establishment of hill heath forest vegetation, mostly on the summit region and lowland dipterocarp forest vegetation at lower region. The uniqueness of its vegetation attracts botanists and collectors to do series of plant collection since 1845. Orchid's collection has started since 1924 by Ridley and continued by others until today. Although it has been collected for almost 100 years, there is no intensive study on the diversity of orchids in Gunung Jerai, Kedah. They just produced checklists based on the species collected. Therefore, this study is needed to reveal the current orchid diversity within this area towards a proper scientific documentation apart from adding new information to the existing data. The construction of taxonomic keys is essential as reference for future studies especially in the similar type of habitats. Another objective is to propose a conservation plan for the orchids through conservation assessments especially for rare and endemic species. As to complete the sampling works, the whole mountain is divided into five zones with fourteen accessible trails. Ten metres width belt-transects are plotted along each trail. As a result, a total of 136 species are collected from five subfamilies which represented by 65 genera in Orchidaceae. From the total collection, there are 57.0 % epiphytic orchids, 34.0 % terrestrial orchids, 7.0 % lithophytic orchids and only 2.0 % are saprophytic orchids. The domination of Epidendroideae subfamily in all zones shows that it has high adaptation ability in all different types of habitat. Although sampling is done within only 0.3 % from the total area of 85.6 km^2, 24 new records to Kedah are documented including three new records to Malaysia, namely *Coelogyne chrysotropis*, *Liparis geophila* and *Pteroceras teres*. In addition, two new species are listed and yet to be described from genera *Corybas* and *Zeuxine*. Out of fives zones, Zone 3 harbours the most species richness (88 species) and obtained the highest Simpson's Index of Diversity (1- D = 0.890). Sorenson's Similarity Coefficient shows there is close relation between Zone 2 and 3 as they have the highest value (C_s = 0.382) . Meanwhile, there is 67.0 % dissimilarity of

species distribution between sunrise area and sunset area. As for conservation, there are 21 species categorized as vulnerable species. Then, through Species Rarity Rank, Zone 3 has the highest priority to be conserved (R_T = 38). From the overall results, obviously Gunung Jerai possesses majority of habitat-specific species with 71 species (52.0 %) are determined as unique species. Thus, status of the forest needs to be changed from Rank 2 to Rank 1 to protect species and their natural habitat. Besides that, strong enforcement from Department of Forestry also needed to prohibit illegal poaching activities that can cause species extinction in wild.

Keywords: Conservation, Diversity, Gunung Jerai, Orchidaceae

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

KEPELBAGAIAN ORKID DI GUNUNG JERAI, KEDAH, MALAYSIA

Oleh

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November 2016

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Sebagai salah satu gunung terpinggir di Malaysia, Gunung Jerai mempunyai pemandangan yang indah untuk para pelancong dan berpotensi untuk dibangunkan sebagai kawasan eko-pelancongan di Kedah. Aktiviti seperti hutan lipur, tapak perkhemahan dan sukan lasak boleh mengakibatkan kemusnahan habitat semulajadi. Secara geologinya, teras gunung ini adalah berasaskan batu granit dan di bahagian permukaannya diselaputi oleh batu quartz. Hal ini mengakibatkan pembentukan hutan kerangas bukit di kawasan puncak dan hutan tanah pamah di bahagian yang lebih rendah. Keunikan kepelbagaian tumbuhan telah menarik perhatian pakar tumbuhan untuk mengumpul koleksi sampel sejak tahun 1845. Pengumpulan orkid telah bermula sejak tahun 1924 oleh Ridley dan diikuti oleh yang lain-lain sehingga hari ini. Walaupun telah dieksplorasi untuk hampir 100 tahun, masih tiada kajian intensif tentang kepelbagaian orkid di Gunung Jerai, Kedah. Hanya senarai spesis yang terkumpul telah dihasilkan. Oleh itu, kajian ini diperlukan untuk mendedahkan status kepelbagaian orkid di kawasan Gunung Jerai bagi penyediaan dokumentasi saintifik dan penambahan maklumat baru untuk data yang sedia ada. Selain itu, kunci taksonomi perlu disediakan untuk rujukan kajian pada masa hadapan terutamanya untuk jenis habitat yang sama. Tujuan lain ialah untuk mencadangkan pelan konservasi bagi spesis orkid melalui penilaian konservasi terutama bagi spesis endemik dan terancam. Kawasan gunung ini telah dibahagikan kepada lima zon yg diwakili 14 trek secara keseluruhannya. Transek jalur berkelebaran sebanyak sepuluh meter telah ditetapkan sepanjang trek. Hasilnya, sebanyak 136 spesis daripada lima subfamili dalam *Orchidaceae* yang diwakili daripada 65 *genera* telah dikumpul. Daripada koleksi keseluruhan, terdapat 57.0 % orkid epifit, 34.0 % orkid tanah, 7.0 % orkid *lithophytic* dan 2.0 % orkid *saprophytic*. Dominasi oleh subfamili *Epidendroideae* di semua zon menunjukkan ianya mempunyai kebolehan adaptasi yang tinggi di semua jenis habitat. Walaupun hanya meliputi 0.3 % daripada kawasan keseluruhan (85.6 km^2), terdapat 24 spesis rekod baru untuk Kedah, termasuk tiga rekod baru bagi Malaysia, iaitu *Coelogyne chrysotropis*, *Liparis geophila* dan *Pteroceras teres*. Selain itu, dua spesis dikenalpasti sebagai spesis baru daripada genus *Corybas* dan *Zeuxine*. Daripada lima zon, Zon 3 mempunyai bilangan spesis tertinggi (88 spesis) dan memperolehi kepelbagaian tertinggi (1-D = 0.890). Nilai Persamaan Sorenson menunjukkan Zon 2 dan 3 mempunyai nilai

persamaan yang paling tinggi antara semua (C_s = 0.382). Manakala, terdapat 67.0 % perbezaan spesis di antara kawasan matahari terbit dan kawasan matahari terbenam. Bagi konservasi spesis, terdapat 21 spesis dikategorikan sebagai *vulnerable species*. Kemudian, *Species Rarity Rank* menunjukkan Zon 3 mempunyai keutamaan untuk pemuliharaan berbanding yang lain (R_T = 38). Peratusan menunjukkan majoriti spesis di Gunung Jerai memerlukan spesifik habitat untuk hidup dengan jumlah sebanyak 71 spesis unik. Oleh itu, status hutan di Gunung Jerai perlu ditukar daripada Rank 2 kepada Rank 1 untuk melindungi spesis dan juga habitat semulajadinya. Selain itu, penguatkuasaan yang kuat daripada Jabatan Perhutanan juga perlu untuk menghalang aktiviti pengumpulan haram yang boleh mengakibatkan kepupusan spesis liar.

Kata kunci: Gunung Jerai, Kepelbagaian, Konservasi, *Orchidaceae*

ACKNOWLEDGEMENT

This thesis becomes a reality with the kind and support from many individuals. I would like to extend my sincere thanks to all of them.

First and foremost, I would like to thank Allah for His wisdom and blessings that give me continuous strength, peace of mind and in good health through out to finish this project. I would like to express my gratitude towards my parents and family members, their endless support and encouragement to pursue my studies. Next, I would like to acknowledge my supervisor, Prof. Dr. Rusea Go, for her timeless cares, advices, expertise and experiences. Thanks for being not only a good supervisor, but, a great leader, a loving mother, and a cheerful friend. I am also grateful to my co-supervisor, Dr. Syaizwan Zahmir Zulkifli for being an aspiring advisor. I would like to show my gratitude to Dr. Amirrudin Ahmad from Universiti Malaysia Terengganu (UMT) for his consultancies.

My special gratitude to Faculty of Science, especially the Transportation Unit, Encik Khairul, Encik Nor Azlan, Encik Amir, to Department of Biology, Prof. Dr. Ahmad Ismail (Head of Department), all lecturers and staffs, especially, Encik Azizul Aziz and Puan Farah Kamaluddin, for their assistance in preparation of materials needed and companion during sampling. Many thanks to Jabatan Perhutanan Semenanjung Malaysia (JPSM) and Jabatan Perhutanan Negeri Kedah (JPNK) for the official approval of entering their Permanent Forest Reserved Gunung Jerai, Kedah.

Thanks to staff of Pejabat Perhutanan Daerah Kedah Tengah, Encik Khairuddin Perdan, Encik Mazlan, and Encik Anuar Ali for their full cooperation during sampling. Besides, I would like to thank to all guides, Maftac team, Penjejak Gunung team, Encik Nazri and Encik Anuar Halim and friends, for their kindness in helping us to access the trails. Last but not least, I would like to appreciate my dear friends, Farah Alia Nordin, Micheal Charles Rajaram, Mohd Akmal Mohd Raffi, Nor ‘Izzati Shaipudin, Siti Fatimah Md. Isa, Suhaima Mohammad Suki, Vaniellie Justine Terrence, Vhenosha Annathurai and Wong Wee Nee, who had gone through ups and downs together sharing their knowledge and willingness as companion during the many fieldworks done during this study.

I certify that a Thesis Examination Committee has met on 30 November 2016 to conduct the final examination of Nur Adilah binti Auyob on his thesis entitled "Diversity of Orchids in Gunung Jerai, Kedah, 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 Master of Science.

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20 Examples of wild species exploitation from Gunung Jerai, Kedah such as **(A)** and **(B)** *Anoectochilus* species; **(C)** *Paphiopedilum callosum* var. *sublavae* and **(D)** *Crepidium callophyllum* by local collectors. This illegal poaching activitiy by local collectors can caused species population in Gunung Jerai to be degraded and having high risks of extinction in wild. 152

LIST OF ABBREVIATIONS

a.s.l.	Above sea level
AD	Anno Domini
CAM	Crassulacean Acid Metabolism
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CP	Coelogyne Peak
CR	Critically Endangered
C_s	Sorenson's Similarity Coefficient
D	Simpson's Index
DD	Data Deficient
DNA	Deoxyribonucleic acid
E	East
EN	Endangered
EW	Extinct in Wild
EX	Extinct
FSC	Forest Stewardship Council
GPS	Global Positioning System
H.L.	Hutan Lipur
ha	Hectare (s)
HCVF	High Conservation Value Forest
HSK	Hutan Simpan Kekal
ICBN	International Code of Botanical Nomenclature
IOSPE	Internet Orchid Species Photo Encyclopedia
IUCN	International Union for Conservation of Nature
JPBDK	Jabatan Pembangunan Bandar dan Desa Negeri Kedah
JPNK	Jabatan Perhutanan Negeri Kedah
JPSM	Jabatan Perhutanan Semenanjung Malaysia
km^2	Kilometre square
KSAS	Kawasan Sensitif Alam Sekitar
LC	Least Concern
m	Metre (s)
MADA	Lembaga Kemajuan Pertanian Muda
mm	Millimetre (s)
N	North
NatGeo	National Geographic
NE	Not Evaluated
NT	Near Threatened
PAST	Paleontological Statistics
pH	Power of hydrogen
PM	Puteri Mandi
PT	Permatang
PTS	Padang Tok Sheikh
PVC	Polyvinyl chloride
RG	Regency
RM	Ringgit Malaysia
RS	Roadsides
R_T	Species Rarity Rank
SB	Sungai Badak

SBP	Sungai Batu Pahat
SK	Singkir
SOF	Swiss Orchid Foundation
SP	Seri Perigi
sp.	Species
S_T	Species Vulnerability Rank
ST	Sungai Teroi
TM	TM Tower
TP	Tupah
TTH	Titi Hayun
UPM	Universiti Putra Malaysia
VU	Vulnerable
WCSP	World Checklist of Selected Plant Families
WWF	World Wildlife Fund

LIST OF SYMBOLS

º	Degree
ºC	Degree Celcius
%	Percentage (s)
≤	Less than or equal to
≥	More than or equal to
<	Less than
>	More than

CHAPTER 1

INTRODUCTION

1.1 General

Malaysia is one of the mega diversity countries in the world. The humid and dry climate in tropical region supported the survival of many species of plants including orchids. Orchidaceae or also known as orchids are the most species-rich family among flowering plants. It consists of about 20000 to 35000 species worldwide (SOF, 2015). Peninsular Malaysia has about 905 species that are represented from 143 genera (Rusea *et al*., 2014). In addition, orchids renown spectacular floral diversity and sensitive towards their surrounding environment. Thus, any environmental change in natural habitat can lead to species degradation.

One of the major factors that can cause environmental changes is human activities such as illegal poaching and unsustainable development. Rapid development in Malaysia has threatened its biodiversity of flora and fauna. In Malaysia, about 18.23 million ha is the forested areas (JPSM, 2014). Though 27.0 % are gazetted as permanent preserved forests, still, the risk of species extinction is concerned (JPSM, 2014). Hence, diversity study is needed for accumulation of qualitative and quantitative data that involve species richness and species abundance in a particular area. This includes species checklists and diversity analysis that can improve the existing databases, for future conservation plans especially on vulnerable and endangered species.

1.2 Problem Statement

As one of the well-known highland in Malaysia, Gunung Jerai, Kedah has common issue where the species is being threatened by poaching activities and disturbance of natural habitat. According to Dressler (1981), Gunung Jerai is one of the hotspot for orchid's collection because it harbours one-third from the total genera known in Peninsular Malaysia and it attracts many botanists and collectors (Jutta & Faridah, 2006). Thus, this mountain becomes a potential area to be developed as an eco-tourism park in Kedah due to its topographical features and uniqueness of its vegetation (Amir *et al*., 2009). Until now, several areas have been opened to public for jungle trekking, camping sites, resort, and other outdoor activities. Those activities may lead to orchid's natural habitat destruction such as forest floor damages, landslides, and rubbishes. When trails are too exposed to human access, this also will increase illegal poaching activities, which will cause species degradation and extinction in the wild.

Orchids are known to be very sensitive towards environmental changes. The species distribution depends on humidity, sun exposure and type of surrounding vegetation.

Most species survive in high humidity condition, but several species are resistant towards low humidity condition. Other than humidity level, sun exposure is important because it relates to orchid's pollinators.

As a conical isolated mountain, Gunung Jerai comprises of hill heath forest vegetation and lowland dipterocarp forest vegetation. In conclusion, the specificity towards abiotic (environment) and biotic (pollinators) factors may cause the differences of their species distribution and makes orchids can be as the environmental bio indicator (Wahizatul *et al*., 2011). Basically, only series of species checklists are produced by previous collectors without any species abundance documentation (Holttum, 1972; WWF, 1977; Seidenfaden & Wood, 1992; Jutta & Faridah, 2006). Therefore, there is no proper scientific documentation produced so far to evaluate actual species diversity and status of availability in this area.

1.3 Objectives

Hence, the purposes of this study are:

1.3.1 To measure the orchids diversity in Gunung Jerai, Kedah.
1.3.2 To construct the taxonomic keys based on the species collected and can be as reference for the future studies especially in a similar type of habitat.
1.3.3 To propose conservation plans based on the IUCN Redlist criteria and CITES appendices.

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