COMPARISON OF DIVERSITY OF NEPENTHACEAE, ORCHIDACEAE AND ZINGIBERACEAE IN DISTURBED AND UNDISTURBED FORESTS IN JOHOR

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ABSTRACT

This study focused on the diversity of plants belonging to Nepenthaceae, Orchidaceae and Zingiberaceae occurring within the Belumut Forest-Eco Park, Mo'akil Permanent Reserve Forest and Soga-Perdana Permanent Reserve Forest. These three forest areas each have patches with varying degree of disturbance categorized as undisturbed, disturbed and recovered forest, respectively. The objectives of the study were, to compare the diversity of Nepenthaceae, Orchidaceae and Zingiberaceae family in the forest of varying degree of disturbances, to create and update a check list of plants belonging to the three study areas, and to determine the effect of disturbances on the diversity of the three families within the study areas. The sampling and data collection was done using line transect method (100 metre-long and 6 metre-wide). Specimens were tagged, GPS coordinates were taken, elevation plant description and habitat notes were documented. Belumut Forest-Eco Park and Mo'akil Permanent Reserve Forest recorded eight species of plants from only two families (three Orchidaceae species and five Zingiberaceae species for Belumut F-EP and two Nepenthaceae, two Orchidaceae and four Zingiberaceae for Mo'akil PRF). Soga-Perdana Permanent Reserve Forest recorded the lowest number of species with six species from all three families (one Nepenthaceae, one Orchidaceae and four Zingiberaceae species). Among the twenty species of plants recorded (three Nepenthaceae, five Orchidaceae and 12 Zingiberaceae species), two were endemic in Peninsular Malaysia which were Scaphochlamys johorensis collected from the Belumut Forest-Eco Park and S. endauensis collected from Mo'akil Permanent Reserve Forest. The Mo'akil Permanent Reserve Forest was the most diverse among the three study areas, showing that even with a smaller forest patch size, the number of individuals per species present will affect the diversity of an area. The Belumut Forest-Eco Park showed less diversity than the Mo'akil Permanent Reserve Forest due to S. johorensis being more numerous than all the other species within the study area.



ABSTRAK

Kajian ini dijalankan tertumpu kepada kepelbagaian diversity species tumbuhan dari keluarga Nepenthaceae, Orchidaceae dan Zingiberaceae di Taman Eko-Rimba Belumut, Hutan Simpan Kekal Mo'akil dan Hutan Simpan Kekal Soga-Perdana. Ketiga-tiga hutan ini mempunyai Kawasan dengan tahap gangguan yang berbeza yang masing-masing dikategorikan sebagai hutan tidak terganggu, terganggu dan pulih. Objektif kajian adalah, untuk membandingkan kepelbagaian Nepenthaceae, Orchidaceae dan Zingiberaceae dalam hutan dengan tahap gangguan yang berbeza-beza, disamping membuat dan mengemaskini senarai semak tumbuhan kepunyaan tiga kawasan kajian dan menentukan kesan gangguan terhadap kepelbagaian tiga keluarga dalam kawasan kajian. Persampelan dan pengumpulan data dilakukan dengan menggunakan kaedah transek garis (panjang 100-meter dan lebar 6 meter). Spesimen telah ditag, koordinat serta GPS telah diambil, penerangan tumbuhan, ketinggian dan nota habitat telah direkodkan. Taman Eko-Rimba Belumut dan Hutan Simpan Kekal Mo'akil merekodkan lapan spesies tumbuhan daripada dua keluarga sahaja (tiga spesies Orchidaceae dan lima spesies Zingiberaceae untuk Belumut F-EP dan dua Nepenthaceae, dua Orchidaceae dan empat Zingiberaceae untuk Mo'akil PRF). Hutan Simpan Kekal Soga-Perdana mencatatkan bilangan spesies terendah dengan enam spesies daripada ketiga-tiga keluarga (satu Nepenthaceae, satu Orchidaceae dan empat spesies Zingiberaceae). Antara dua puluh spesies tumbuhan yang direkodkan (tiga Nepenthaceae, lima Orchidaceae dan 12 spesies Zingiberaceae) dua daripadanya adalah endemik di Semenanjung Malaysia iaitu Scaphochlamys johorensis yang hanya dikutip dari Taman Eko-Rimba Belumut dan S. endauensis yang dikutip dari Mo' akil Hutan Simpan Kekal. Hutan Simpan Kekal Mo'akil mempunyai diversity yang tertinggi di antara tiga kawasan kajian, yang menunjukkan walaupun dengan saiz hutan yang lebih kecil, bilangan individu tumbuhan bagi setiap spesies yang berada di habitat akan mempengaruhi kepelbagaian sesuatu kawasan. Taman Eko-Rimba Belumut menunjukkan



kurang kepelbagaian berbanding Hutan Simpan Kekal Mo'akil, kerana *S. johorensis* mempunyai bilangan individu tumbuhan yang lebih banyak daripada semua spesies lain dalam kawasan kajian.

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LIST OF SYMBOLS AND ABBREVIATIONS

Σ	-	(sum) of $P_i^2(\frac{n}{N})^2$
Asl	-	above sea level
CITES	-	The Convention of International Trade in Endangered Species
F-EP	-	Forest-Eco Park
Н	-	Shannon Diversity Index value
IUCN	-	International Union of Conservation of Nature
km	-	kilometre
m	-	metre
PRF	-	Permanent Reserve Forest
S	-	number of species
sp	-	species
ssp	-	species of unknown genera



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CHAPTER 1

INTRODUCTION

1.1 Background of study

Malaysia, a country located in the middle of Southeast Asia is blessed with a high diversity of flora and fauna, due to its location near the equator, where the climate is stable all year round and the sun rays are the strongest. Being situated in the middle of a floristic zone known as the Malesian ecoregion or within the Indo-Malayan realm, it shares many of the genera and even species of flora throughout the region which spans from the Western Ghats (India) in the west to New Caledonia in the east (Soepadmo, 1998). Out of the many families of plants present in the Malesian ecoregion, the plants belonging to the families of Nepenthaceae, Zingiberaceae and Orchidaceae have long been studied because of their diversity as well as medicinal and ornamental uses. Many of these studies focus on determining new species and new medicines. But on occasion new species may be discovered within previously studied sites and at new sites. The chances of finding new species are high, especially in isolated areas. In a study done in the forest of a mountain that had not been studied before in the north of Johor, a new species of Zingiberaceae was discovered but it has not yet been named. This proves that there are still emerging new species being found to this day (Kiew, Saw, & Rafidah, 2007).

In recent years the forest areas around Malaysia are facing the threat of land use change and deforestation at an alarming rate (Besi *et al.*, 2019). Deforestation causes forests to be fragmented into smaller pieces which are usually surrounded by developed land. Within these forests, the disturbances can severely affect the plant assemblages



(Sani, 1998). The difference of species that respond to change will vary with diversity and distribution based on the tolerance of the species to disturbances.

The three focused families of plants for this study were families belonging to the Nepenthaceae, Orchidaceae and Zingiberaceae, locally known as the Asian pitcher plants, orchids and gingers respectively. The Nepenthaceae family belongs to the order, Caryophyllales. A large family of plants that includes the *Dianthus* family (Caryophyllaceae), cactus family (Cactaceae) and four other carnivorous plant families which are Droseraceae, Drosophyllaceae, Dioncophyllaceae and Ancistrocladaceae (Heubl, Bringmann & Meimberg., 2006). The Orchidaceae family or the orchid family belongs to the order, Asparagales which is a monophyletic order. Other families found within this order are Asparagaceae or the asparagus family, Iridaceae or the iris family and Amaryllidaceae, which is the family containing the genus *Allium* or onions (Pires *et al.,* 2006). The ginger family or Zingiberaceae is a well-known and studied family of plants consisting of eight families which are mainly distributed in the tropics with some species being found as far north as Japan and Southern Australia (Kress, 1990).



Among the three plant families, of Nepenthaceae, Orchidaceae and Zingiberaceae, the families of Nepenthaceae and Orchidaceae are the most popular among plant hobbyists. Nepenthes are carnivorous plants with unique modified leaves used to trap their prey, which come in a wide array of shapes and sizes. Thus, the popularity of Nepenthes has resulted in the overexploitation of them in their natural habitat coupled with habitat destruction which may lead many rare species to extinction (Susanti & Kencanawati, 2018). Orchidaceae is another family of plants which are often overexploited. These species are often over harvested, causing the populations of these orchid species, especially the rare ones to face extinction. This is because the number of reproductively active plants is removed from the habitat location (Mondragon, 2009). Generally, orchids are considered highly evolved plants with most of them having beautiful inflorescence and some attractive foliage. Due to this, the dealing and selling of orchid plants and their cut flowers have become a multimillion-dollar industry in many countries around the world (Thammasiri, Khasim & Hedge., 2020). This is a major contributing factor of why many species have become endangered and even locally extinct like the commonly seen Paphiopedilum fairrieanum in Northeast India (Thammasiri et al., 2020). Unlike the other two families which are facing severe exploitation due to their popularity, Zingiberaceae have recently gained popularity as an ornamental species. They are good garden plants and suitable for tropical landscaping purposes. Many ginger species such as gingers in the *Hedychium* genus have large showy and fragrant flowers, and are hardy to lower temperatures making them popular garden plants (Sarangthem, Talukdar & Thongam., 2013). The three families of Nepenthaceae, Orchidaceae and Zingiberaceae are often used as the main focus for phytotourism, especially for *Nepenthes* (Setiawan, 2017).

Aside from being used for ornamental purposes, the genera in the families of Nepenthaceae, Orchidaceae and Zingiberaceae have been known to be used in traditional and modern medicines. New studies are being carried out on the species of *Nepenthes* and orchids, which were previously thought not to be useful in the pharmacology industry. Currently, the only areas where the studies are being done on these species are in Indochina and Thailand (Likhitwitayawuid et al., 1998, Thao et al., 2016 & Sanusi et al., 2017). Orchids on the other hand, have been used in traditional medicines for centuries. However, only now they are being tested and studied for their chemical properties. A study on *Habenaria edgeworthiiform* proves that it has immense pharmaceutical potential. For example, it is used in Indian Ayurvedic medicines to treat a variety of disorders such as intestinal disorders and tuberculosis (Thammasiri et al., 2020). Gingers, on the other hand, have been known to have medicinal and commercial value since the spice trade era. Commonly used ginger genera, such as Elingera elatior (torch ginger), Curcuma longa and Zingiber officionale are a source of flavouring. Many different species of Curcuma are also known to have medicinal values and are widely studied by the countries where the various species are found. For example, the previously unknown species of *Curcuma* from northern Thailand are used by the indigenous peoples to treat snake bites (Chaveerach et al., 2008).

Plant checklists, which are created by conducting a taxonomic survey have become helpful in identifying species, their distribution and conservation status. They are also used to determine the former diversity within a location by looking at the number of species present or which species had survived from disturbances in their habitat (Nesbitt *et al.*, 2010). These checklists play a role in the composition of data that can be drawn by the ethnobotany, ethnopharmacology and food industry to determine new medicines or food products (Nesbitt *et al.*, 2010). Fragmented forests are often ignored by scientists, due to the often-low diversity of species within these forest patches since they are less likely to harbour rare species or species that are often associated with large forest patches (Minguia-Rosas *et al.*, 2014). Logging and land use change are the main causes of fragmentation, which will lead to the loss of species (Cronk, & Fuller, 2014). This also means the loss of potential future medicines and commercial uses, since plants belonging to Zingiberaceae and Orchidaceae have been used by the indigenous people for centuries because of their medicinal properties (Chaveerach *et al.*, 2008 & Nesbitt *et al.*, 2010). A study on the diversity of Nepenthaceae, Orchidaceae and Zingiberaceae has not been carried out at the Mo'akil Permanent Reserve Forest (PRF) and Soga-Perdana PRF. Therefore, there is still a lot of potential to ascertain the diversity of species belonging to the three families.

Disturbed forests are forests which have undergone changes to their structure either from anthropogenic sources or natural sources such as storms and fires, while recovered forests are formerly disturbed forests where the succession of species has occurred (Congdon & Herbohn, 1993). The comparison of the diversity between disturbed and undisturbed forests is a good way to determine how disturbances affect the diversity of flora and fauna within a certain area or habitat. Different forest types and species will react differently to the disturbances with significant variation (Kumar & Shahabuddin, 2005).

Studies done by comparing the species richness within both the disturbed and undisturbed forest fragments have shown the distinct structural patterns that vary based on the degree of disturbances (Cravalho, Braga & Nascimento., 2016). Aside from that, forest structures within a certain area can vary based on the topography, elevation and soil type (Sham, 1998). In areas below 300 metres in elevation, there are lowland forests which are distinguished based on their soil type and location. These include fresh water swamps, peat swamps near riverine areas, mangrove swamps and beach forests next to the sea and lowland dipterocarp forests which grow inland where conditions are suitable (Sham, 1998).

The chosen study areas were all within the three districts in central Johor, namely Kluang, Batu Pahat and Muar, the Belumut Forest-Eco Park in Kluang, Mo'akil



Permanent Reserve Forest (*Hutan Simpan Kekal Mo'akil*) located between Batu Pahat and Muar and Soga-Perdana Permanent Reserve Forest (*Hutan Simpan Kekal Soga-Perdana*) in Batu Pahat District. Figure 1.1 below shows the location of these three areas in Johor.



Figure 1.1: Location of the three chosen study areas within Johor

Among the three sites, the Belumut Forest-Eco Park (F-EP) area located within the Kluang Permanent Reserve Forest (PRF) is the largest. The Kluang PRF in its entirety, covers an area of 16264 hectares (Anon, 2011) where certain zones were logged about 40 years ago (Anon, 2019). A few historical botanical surveys were conducted here during the late 1800's (Burkhill, 1927). A recent survey for a preliminary checklist of plants within the entirety of the Kluang PRF which included the Belumut Forest-Eco Park and Mount Belumut only showed one species of Zingiberaceae (*Scaphochlamys johorensis*) and while no species of *Nepenthes* or orchids were mentioned or documented among the 75 families, 218 genera and 390 species of documented plants (Fitri & Latiff, 2018). The site is quite hilly with steep slopes, with some 45° angle gradient and the forest floor is dominated by palms in the genera of *Licuala*. The highest point of this area is the summit of Mt Belumut which is 1035 metres asl (JPSM, 2016).

This study only focused on the lowland forest from 180 m and below which is within lowland rainforests. The Mo'akil PRF study area has scarce information on the events that have occurred there. The only information available is that certain areas within the study area were logged about 5 to 40 years ago (Anon, 2019) and the current size of the study area is unclear but it could exceed 6000 ha making it the second largest among the three study areas. The topography of the area is hilly and steep, with many valleys and small areas of swampy land which floods during heavy rains. The highest point within the study area is Mo'akil Hill which is around 500 metres asl but the study was conducted from 215 metres asl and below. The forest floor varies within this site depending on the soil conditions and the slope and it has a high diversity of herbaceous plants as reported by a survey done in September 2019. The Soga-Perdana PRF is located 3 km from Penggaram City within Batu Pahat District (JPSM, 2016). The study area contains the Soga-Perdana Forest-Eco Park which takes up about 49.3 ha of the main Permanent Reserve Forest which is around 500 ha (JPNJ, 2012). The topography and the flora of this study area are similar to those in the Mo'akil PRF study area. The highest elevation of this study area is 250 metres asl but this study only focuses on areas below 180 metres asl and also on within the area of the Soga-Perdana Forest-Eco Park (JPNJ, 2012). The history of the study area is not documented but according to Sivarajah, (2018) and Anon (2020) the area was partially cleared in certain zones during the 1920's for rubber plantations, then



during the 1980's a housing development company had cleared the rubber plantations and certain areas within the Permanent Reserve Forest leaving areas which are dominated by stands of *Acacia* trees and *Dicanopteris* ferns.

1.2 Problem statement

Taxonomic surveys on plants are often done to compare the diversity or the presence of species temporally and between locations. Comparative studies of virgin undisturbed forests as well as recovered and logged forests were done on orchid diversity, showing a correlation between anthropogenic disturbances and the diversity of species (Besi *et al.*, 2019). Therefore, comparative studies can be applied to plants of other families which may show a different diversity trend compared to orchids. The studies also help clarify the relative important process that influence the diversity of the focused plant families Nepenthaceae, Orchidaceae and Zingiberaceae (Roberts & Gilliam, 1995).

The three areas within Johor have had preliminary studies done on the diversity of plants but none of them had recorded sufficient data on various species of the Nepenthaceae, Orchidaceae and Zingiberaceae families. The preliminary checklist for the Kluang Permanent Reserve Forest where the Belumut F-EP is located only had one species of ginger documented (Fitri & Latiff, 2018) while the Soga-Perdana Forest-Eco Park preliminary checklist had only documented two genera of ginger (JPNJ, 2012). The Mo'akil PRF does not have a preliminary checklist within the current location but in the 1800's a checklist was done in a part of the Mo'akil PRF. However, the area of the survey has been extensively cleared for agriculture and there is no checklist done to date (Anon, 2019).



1.3 Scope

The study of the diversity of *Nepenthes*, orchids and gingers was conducted at the Belumut F-EP recreational forest which is located within the Kluang PRF in Kluang, the Soga-Perdana PRF in Batu Pahat and the Mo'akil PRF in Sri Medan which is in between Muar and Batu Pahat. These three study areas were chosen due to their accessibility, proximity

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