# INTEGRATIVE CONSERVATION MANAGEMENT OF BORNEAN ORANG UTAN (*Pongo pygmaeus*) IN MALAYSIA

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# INTEGRATIVE CONSERVATION MANAGEMENT OF BORNEAN ORANG UTAN (*Pongo pygmaeus*) IN MALAYSIA

**by**

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*"Unless someone like you cares a whole awful lot,*
*Nothing is going to get better. It's not."*

— *Dr. Seuss,* The Lorax

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ° | Degree |
| ‘ | Minute |
| “ | Second |
| °C | Degree Celsius |
| % | Percentage |
| cm | Centimeter |
| km | Kilometer |
| M | Meter |
| mL | Milliliter |
| IUCN | International Union for Conservation of Nature |
| ANOVA | Analysis of Variance |
| SPSS | Statistical Package for the Social Sciences |
| BMOUI | Bukit Merah Orang Utan Island |
| SORC | Sepilok Orang utan Rehabilitation Centre |
| SNR | Semenggoh Nature Reserve |
| UAV | Unmanned Aerial Vehicle |
| DCA | Department of Civil Aviation |
| SFC | Sarawak Forestry Corporation |
| DBH | Diameter at Breast Height |
| SWD | Sabah Wildlife Department |
| DWNP | Department of Wildlife and National Park |
| MyTQA | Malaysia Tourism Quality Award |
| SaBC | Sabah Biodiversity Centre |

**PENGURUSAN PEMULIHARAAN BERSEPADU ORANG UTAN BORNEO (*Pongo pygmaeus*) DI MALAYSIA**

## ABSTRAK

Pengurusan pemuliharaan orang utan yang baik sangat penting, memandangkan haiwan ini telah dikelaskan dalam haiwan terancam kritikal (CR) oleh IUCN sejak tahun 2016. Tesis ini merangkumi empat elemen dalam pemuliharaan iaitu kajian perilaku orang utan, ekologi sarang orang utan, interaksi manusia- hidupan liar dan pembolehlaksanaan teknologi. Objektif pertama tesis ini ialah untuk menentukan perbezaan perilaku orang utan dan penggunaan ruang berdasarkan ketiadaan pelawat dan sebaliknya dan arah pandangan ketika adanya pelawat, secara fokal. Kedua, tesis ini bertujuan untuk menentukan kriteria sarang pilihan orang utan secara ekologi (kawasan, kelas, posisi, diameter pokok di paras dada, dan spesies serta tinggi pokok) di Sepilok Orangutan Rehabilitation Centre (SORC) dan Semenggoh Nature Reserve (SNR). Kepelbagaian struktur pokok sarang diukur secara kuantitatif (kelas, posisi, panjang, lebar, kedalaman sarang) di SORC dan SNR menggunakan dron yang diinterasi dengan perisian terbuka. Seterusnya, tesis ini menilai pembolehlaksaan dron dan kamera termal dalam merekodkan bilangan orang utan pada waktu malam di SORC dan SNR. Tesis ini juga merangkumi elemen interaksi manusia dan hidupan liar dengan menilai perbezaan kefahaman dan kesedaran pelawat sebelum dan selepas lawatan ke SNR, SORC dan Zoo Taiping menerusi borang soal selidik dan penilaian skala Likert. Elemen ini juga dinilai dengan menemuramah pekerja di SORC, SNR dan Zoo Taiping tentang nilai motivasi bekerja di pusat pemuliharaan orang utan. Dalam bab yang pertama, tesis ini menjumpai sepuluh perilaku orang utan iaitu

"Berehat", "Diberi Makan", "Manipulasi bahan semulajadi", "Manipulasi objek", "Lokomotif", "Sosial Positif" "Bergayut" "Mempamerkan diri", "Sosial Negatif" dan "Tiada Kelihatan:. Di SNR, lebih signifikan tingginya perilaku "Diberi makan" ketika adanya pelawat ($\chi$2= df= 1, P = 0.0001), dan "Manipulasi Objek" ($\chi$2=.3152, df= 1, P= 0.0120) serta "Mempamerkan diri" ($\chi$2 = 10.3300, df = 1, P = 0.0013). Sebaliknya ketika ketiadaan pelawat , lebih signifikan perilaku "Manipulasi Bahan Semulajadi"($\chi$2 = 9.1067, df = 1, P = 0.0025) dan "Lokomotif" ($\chi$2 = 6.0410 , Df = 1, P = 0.0140) Analisis statistik juga mencatatkan orang utan lebih banyak "Diberi Makan" ($\chi$2 = 11.5903, df = 1, p = 0.0007) ketika kebradaan at, dan "Bergayut" ketika ketiadaan pelawat ($\chi$2 = 7.3539, df= 1, p 0.0067). Selain itu, perbezaan signifikan didapati di kesemua pusat pemuliharaan orang utan dalam kajian penggunaan ruang dan arah penglihatan orang utan. Tesis ini menjajarkan had kemasukan pelawat dan penambahan alat pengkayaan kemahiran untuk mengelakkan habituasi orang utan. Untuk bab kajian kedua, tesis ini mendapati tiada perbezaan signifikan dalam parameter sarang (seperti tinggi, diameter di paras dada, korelasi tinggi sarang dengan tinggi pokok, apabila kajian dilakukan dengan berjalan kaki. Tiada korelasi signifikan tree (N = 14, Spearman correlation = 0.4581. df =1. p = 0.0966) antara tinggi sarang dengan sarang pokok apabila diukur dengan cara konvensional (berjalan kaki). Walau bagaimanapun, terdapat korelasi signifikan antara tinggi sarang dengan tinggi pokok apabila diukur ketika persampelan dengan menggunakan dron ( N =56, Spearman correlation = 0.8865. df =1. P =<0.0001). Dron hanya boleh mengambil gambar sarang dari jarak yang boleh dipantau, namun teknologi lebih canggih dijangka akan lebih mudah didapati pada masa akan datang..Tesis ini juga merekodkan orang utan dalam sarang pada waktu malam. Kajian pada waktu malam ini memerlukan pengesahan secara manual secara berjalan kaki,

uan secara pantas terbukti boleh dilakukan pada waktu malam. Akhir sekali, kajian soal selidik dalam elemen interaksi manusia dan hidupan liar membuktikan perbezaan signifikan lepada pelawat selepas lawatan, yang merangkumi empat aspek iaitu "Pengetahuan Am" tentang orang utan, "Motivasi dan Minat terhadap Pemuliharaan", "Pengurusan Pusat Pemuliharaan" dan "Pendapat tentang Pusat Pemuliharaan". Nilai motivasi yang direkod melalui temuramah dengan pekerja di pusat pemuliharaan adalah "Pemuliharaan", "Pendapatan", "Kemajuan peribadi", "Persekitaran" dan "Kemanusiaan". Penghasilan tesis ini mencakupi kerjasama dan kepercayaan yang yang jitu antara pengkaji, badan bukan kerajaan, agensi kerajaan dan syarikat persendirian. Adalah dicadangkan bahawa kerjasama ini dikekalkan demi kelestarian usaha pemuliharaan orang utan di Malaysia.

**INTEGRATIVE CONSERVATION MANAGEMENT OF BORNEAN ORANG UTAN (*Pongo pygmaeus*) IN MALAYSIA**

## ABSTRACT

Conservation management of orang utan in Malaysia is a very crucial issue since Bornean orang utan is categorized to Critically Endangered (CR) status by IUCN since 2016. This thesis encompassed four elements of conservation which are behavior of the orang utan, nesting ecology of the orang utan, the human-wildlife interaction and technology feasibility. The objectives of the thesis were firstly, to determine the difference between behavioral pattern, and space use based on absence and presence of visitors, and also visual direction during presence of visitors, by using focal sampling at SORC, SNR and Taiping Zoo. Secondly, this thesis aimed to determine the nesting site preference (nesting site, classes, position, tree species used for nesting, tree height, and DBH) by orang utans in SORC and SNR The variation of nest structure quantitatively (length, depth, width and temperature factor) in SORC and SNR are studied by utilizing Unmanned Aerial Vehicle (UAV) integrated with open-resource software. Next, this thesis aimed to evaluate the feasibility of UAV and thermal camera in capturing orang utan images at nocturnal condition at SORC and SNR. This thesis also aimed to evaluate the difference at entry exit level regarding effect of presentation of information and communication at the centre to visitors perception and knowledge about orang utan conservation at SORC, SNR and Taiping Zoo by using questionnaire method and to evaluate the difference motivation among the workforce at SORC, SNR and Taiping Zoo by using interview and thematic qualitative analysis. For the first working chapter, there were ten behavioural pattern that were observed by using focal

samplings, such as “Resting”, “Feeding”, “Manipulating Browse”, “Object Manipulating", "Locomotion”, “Social Positive”, “Hanging”, “Exhibiting”, “Social Negative "and “Out of Sight”. There was no significant difference observed at Taiping Zoo.). Orang utan at SNR spent significantly more time ―Feeding‖ during presence of visitors than during absence ($\chi 2$= df= 1, P = 0.0001). Similarly, significantly more time spent for “Object manipulating” ($\chi 2$=.3152, df= 1, P= 0.0120) and “Exhibiting” ($\chi 2$ = 10.3300, df = 1, P = 0.0013). On contrary, the orang utans at SNR spent more time doing “Manipulating browse” ($\chi 2$ = 9.1067, df = 1, P = 0.0025) and “Locomotion” ($\chi 2$ = 6.0410, Df = 1, P = 0.0140) during absence of visitors, and showed significant difference between the variables). Statistical analysis showed that there was significant difference between time spent on “Feeding” during absence (score means= 23.5000) with presence of visitors (Score means = 37.5000); ($\chi 2$ = 11.5903, df= 1, p = 0.0007). There was also a significant difference between absence (Score means = 35.7000) and presence of visitors (Score means = 25.300) for time spent to do ―Hanging‖ ($\chi 2$ = 7.3539, df= 1, p 0.0067). In addition, this chapter also comprised the space use and the visual direction of the orang utan. All of the centre also showed significant difference of space use based on visitors/ presence and absence, also the visual direction of the orang utan during presence of the visitors. It is recommended that the centres limit the number of the visitors, and provide husbandry or environmental enrichment to avoid habituation of the orang utan. However, this thesis found non- significant value of nesting parameters were obtained during the sampling, such as height and Diameter at Breast Height (DBH) of the nesting tree, nest class, nest position and frequency of tree species based on nesting and non- nesting site during on ground tracking. This chapter contains images and recorded the nest width and depth of the orang utan nests, There was no correlation

between nest height with tree (N = 14, Spearman correlation = 0.4581. df =1. p = 0.0966) when observed during ground observation. However there was a correlation between nest height and tree height from the data obtained during UAV sampling height (N=56, Spearman correlation = 0.8865. df =1. P =<0.0001). Data scarcity is a limitation for this chapter, and although by far only observable nests could be recorded, the UAV tech can is rapidly progressing, there might be a possibility that these constraints might be addressed in future studies. This thesis also managed to record orang utan by using thermal camera mounted on UAV. Similarly, the sampling required ground truthing to validate the findings but rapid monitoring could be made possible in nocturnal condition. Finally, human wildlife interaction was highlighted in two chapters, which were questionnaires for the visitors and the interviews for the workforce at the centre. "General Knowledge of the Orang utan", "Motivation and Interest of Conservation", "Management of Centre" and Perception of the centre‖ was evaluated in each centre based on Likert Scale questions. The following chapter recorded five motivation value of the workforce at the centres. These motivation values were "Conservation", "Monetary", "Personal Advancement", "Environment/ Surrounding", and "Humanistic". This thesis was made of strong collaboration among the stakeholders such as researchers, non-governmental organizations, authorized governmental bodies and companies. It is recommended that this collaboration would be sustained for a better future of orang utan conservation management in Malaysia.

# CHAPTER 1

# INTRODUCTION

## 1.1 Great Apes and Bornean Orang Utans

The hominids, or "Hominidae" is a family in the order Primates that comprises the great ape genera *Pan, Pongo, Homo* and *Gorilla* (Williamson et al., 2013). Unfortunately, fast and dramatic growth of global civilization and urbanization have affected the existence of the majority of species in this family of hominids, with the exception of humans (Roos et al., 2013).

Generally, *Pongo* (orang utans) is the only genus of great apes that exists in Southeast Asia and they appear in two regions, which are Borneo and Sumatra (Delgado Jr & Van Schaik, 2000). Orang utans can be distinguished into three different species, which are the Bornean orang utans (*Pongo pygmaeus*, Linnaeus 1760), Sumatran orang utans (*Pongo abelii*; Van Bemmel, 1968) and Tapanuli orang utan (*Pongo tapanuliensis*); (Nater et al., 2017). All three species can be found in Indonesia, while only the Bornean orang utan can be found in east Malaysia (Sabah and Sarawak) (Atmoko & Rifki, 2012; Meijaard, Wich, Ancrenaz, & Marshall, 2012; Nowak, 2017; Wich et al., 2008).

The Bornean orang utan is listed as Critically Endangered (CR) in the IUCN Red List (IUCN, 2016). Major threats to orang utan populations include destruction and fragmentation of habitat, poaching and illegal pet trade (Abram et al., 2015; Alamgir et al., 2019; Pandong et al., 2019). Efforts to mitigate the population decline are implemented in Malaysia through policies and laws. Locally, Bornean orang utan is protected and listed under Totally Protected Species in Act 716, Wildlife

Conservation Act (2010) (Act, 2010). This effort was initiated in 1961 by the Sabah Deputy Conservator of Forests, P. F. Burgess. In Sabah, orang utan is protected under Schedule 1 of the Sabah Wildlife Conservation Enactment 1997. This law prohibited any hunting or shooting activities of the orang utan under any circumstances in Sabah (Sabah Wildlife Department, 2020). After a year, the Sabah Orang Utan Rehabilitation Centre was established to save the local orang utans (Kuze et al., 2012). In Sarawak, the orang utan is protected under three ordinances which are Forests Ordinance, Wild Life Protection Ordinance, 1998 and subsidiary regulations National Parks and Nature Reserves Ordinance, 1998 (Forestry Department Sarawak, 2013).

Orang utans in Malaysia can still be found in protected areas in Sabah and Sarawak, and also are kept in rehabilitation centres that train confiscated orang utans before they can be reintroduced back to their native habitat. The rehabilitation program is a necessary prequel to reintroduce these orang utans back into the wild (Grundmann, 2006; Russon, 2002). Usually, the release of rehabilitated orang utans in Sabah occurs in Tabin Wildlife Reserve (Robins et al., 2013). Orang utans are also conserved ex situ or in other zoos or centers, in order to provide education tools for people who are not able to go to Malaysian Borneo to watch these great apes. Tourism based on conservation efforts of orang utans could encourage economic profits in a community (Russell & Ankenman, 1996), and most importantly sustain wildlife populations. Welfare of these orang utans should be prioritized while promoting wildlife-based tourism as outlined by international guidelines (Macfie & Williamson, 2010).

## 1.2 Background and Knowledge Gaps of the Study

This thesis covers four elements that are related to the conservation management of Bornean orang utans. The first element was behavioural assessments of the orang utan related to the visitor, secondly ecology of the orang utan conservation sites, thirdly is the human-wildlife interaction, and finally feasibility of monitoring technology. These elements were reflected through the five working chapters in the thesis.

Firstly, the element of behaviour of the orang utan was assessed in comparison with presence and absence of the visitors. Orang utans that are held in captivity or in rehabilitation centres may be affected by management practices and behaviour and number of visitors who visit these centres. This study is important as visitor effect toward captive wildlife could impact behaviour and health of captive species in general (Nickerson, 2016; Wells, 2005). When threatened species are affected, backlash against the centre management could happen if these negative impacts are not sufficiently controlled, such as allowing visitors to physically interact and touch the exhibited species, which can lead to disease transmission, injuries and in the long run, unwanted behavioural change (Muehlenbein et al., 2010). Space use in captivity is another important factor that needs to be monitored and regulated.

This first working chapter also touched on space use and visual direction of the orang utan at the conservation sites. It is important to indicate how visitor presence and absence causes difference of space use in orang utan, as housing management and husbandry of captive orang utans affects breeding success and safety for animals and visitors (Hebert & Bard, 2000). Presence of trees as natural setting for the orang utan encourages the natural behaviour such as climbing or swaying (Choo et al., 2011). In

additional to that study, eyes morphology and visual direction plays vital role in animal‘s communication method (Kaplan & Rogers, 2002). Previous studies showed abundant studies on communication of orang utan by using vocalisation (Hardus et al., 2009; Wich et al., 2009) and sociality (Galdikas, 1985a, 1985b) had been studied, but limited studies on facial or visual pattern of the orang utan. With high number of visitors coming to the centres twice daily, this study intended to see if the orang utan showed any differences of eye gazing pattern combined with body postures by the visitor‘s presence at the feeding platform.

Secondly, this thesis touched on understanding the nesting ecology and forest profile in rehab is important to evaluate the parameters related to the preference of building nests in orang utans. Previously, most of the studies on nests involved the nest counts and type of nesting tree preferred. Nest building is a skill generally acquired through observational learning of the mother‘s or other adults‘ nesting practices (Russon, 2009; Russon et al., 2007; Samson & Hunt, 2014; van Casteren et al., 2012). Other great ape which is chimpanzee build nest for daily living, too. Samson (2012) determined that chimpanzee‘s nest structure is more complex if it is built on the higher position of a tree, due to higher wind turbulence. Nest variation provides fascinating input on great apes‘ behavioral ecology, as part of great apes‘ mechanism of shelter for anti-predation , improving sleep quality and resembling their ability to problem-solving (Fruth et al., 2018; Prasetyo et al., 2009; Stewart et al., 2018). Orang utan master the skill of nest building may have similar importance to other skills, such as climbing, foraging and being able to identify their natural predators, for survival in the wild (Fruth & Hohmann, 1994; Samson, 2012; Stewart et al., 2018). Both orang utans (Prasetyo et al., 2009), gorilla (Brugiere & Sakom, 2001; Casimir, 1979) and

chimpanzee (Stewart et al., 2018) build nest on the ground, but the smaller frequency is conducted by the orang utan due to predator factor.

Hence, nesting site preferences was studied by relating the distribution of trees species, the height of tree and DBH of trees in the area with nest and area without nest in the rehabilitation centre. This second working chapter assesses parameters such as tree height, nest height and Diameter at Breast Height (DBH) of nesting trees. Past methods included measuring the nest parameters by manual observation, which could be done from the ground or climbing the tree.

This second working chapter also combined the third element of feasibility of technology in conservation management of orang utan. In order to ease these manual assessment methods for nesting ecology, in this chapter a novel method in nest measurement by using ImageJ and Unmanned Aerial vehicle (UAV) was tested. This technique was expected to minimize the use of human labour and climbing, which subsequently reduces the risk and time.

The element of feasibility of drone technology was also tested in a nocturnal condition. Chapter 6 evaluated a novel method of assessing orang utan presence in sleeping locations by using a UAV attached with a thermal camera at night while flying over the forest canopy. Orang utans are known as diurnal wildlife, so there is little information on their behaviour and condition during the night. Monitoring orang utans during night time is an issue due to safety (forest density, trespassers and poachers) and cost and maintenance (lack workforce, large areas to cover). Thus, the outcome of this research is important to create more affordable technology in the future, especially to count orang utan in their nest and monitor the orang utans in their habitat during night time.

Another element in this study touches on the human integration in orang utan conservation efforts. Chapter 7 and Chapter 8 in this thesis elaborate about this perspective, which is separated by awareness of visitors about orang utan conservation, and motivation of the workforce to work in orang utan conservation. Humans play a vital role in ensuring environmental and biodiversity sustainability. It is also important to consider the social part as conservation requires maintaining economic stability and conducting education. Hence, it is important to measure how effective conservation centres serve as education tool to raise awareness among the visitors.

Chapter 8 evaluated the motivation of workforce at the conservation centres. This study is important as every level of workforce contributes towards translating a centre‘s objective and direction. Challenges such as extra hours of working and limited salary are usually faced by the workforce at the conservation sites. The surroundings could be uncertain too, with dense forest that requires physical strength to patrol and risk of safety and disease transmission from orang utans to humans (Hayward, 1999). Another perspective is that these conservation sites also allow the public to visit daily, thus it is vital to discover the motivation since the visitors‘ interactions and the quality of customer care need to be considered in the marketing strategies of the conservation sites. Motivation value is related to attitude and their expression (Campbell-Smith et al., 2018), and described as universal and intangible (Rokeach, 1973). Hence, understanding the motivation value is important to create comprehensive ideas for the centres‘ managers to design responsibilities and job scopes of the workforce, also to sustain a healthy and enthused working environment.

Some novelties are compiled in this thesis. Firstly, this study focuses on Bornean orang utans (*Pongo pygmaeus*) in Malaysia in three local orang utan conservation centres, which were Sepilok Orang utan Rehabilitation Centre (SORC)

in Sabah, Semenggoh Nature Reserve (SNR) in Sarawak, and Taiping Zoo and Night Safari in Perak. SORC is one of the earliest rehabilitation centres for orang utans in Malaysia, while SNR practices conservation of semi-wild orang utans, and Taiping Zoo houses captive orang utans and provide an important education tool and breeding platform for the orang utan. Secondly, this thesis assessed the feasibility of technology advancements in measuring orang utan nest parameters by using UAV and the user-friendly, open-access software ImageJ, thermal cameras to monitor orang utans at SORC and SNR. Thirdly, a chapter evaluated the effectiveness of information and communication at the conservation sites, that highlights environmental education (EE), since these centres should be acting to act as important education tool to visitors. Fourth, the qualitative analysis that evaluated the motivation values of the workforce at the centres could be used to relate with the attitude of the workers, and consequently improve management of the centres.

The objectives of this study were:

1. To determine the difference between behavioural patterns, space use and visual direction of captive orang utans based on absence and presence of visitors by using focal sampling at SORC, SNR and Taiping Zoo.
2. To determine the nesting site preference (nesting site, tree species used for nesting, tree height, and DBH) by orang utans in SORC and SNR.
3. To quantitatively determine the variation of nest structure (nest length, depth, width, and temperature) in SORC and SNR by utilizing an Unmanned Aerial Vehicle (UAV) integrated with open-source software as analysing tools in diurnal condition.

4. To evaluate the feasibility of UAV and thermal camera in capturing orang utan images and counting orang utan in their nest at nocturnal condition at SORC and SNR.
5. To evaluate the difference of visitors‘ knowledge about orang utan conservation before entering and after exiting a centre (SORC, SNR and Taiping Zoo), pertaining to the presentation of information and communication at the centre by using pre-, post-questionnaire method.
6. To determine the motivation value of the workforce at SORC, SNR and Taiping Zoo by using open-ended interviews and thematic qualitative analysis.

## 1.3 Problem Statements and Hypotheses

This study was conducted to answer the problem statements below:

1. Does the behavioural pattern, space use and visual direction of orang utans different between absence and presence of visitors?

   $H_0$: There is no significant difference of the behavioural pattern, space use and visual direction of orang utans between absence and presence of visitors.

   $H_a$: There is a significant difference of the behavioural pattern, space use and visual direction of orang utans between absence and presence of visitors.

2. Are the tree parameters (such as tree height, tree species and tree DBH) different in nesting sites of orang utans, compared to non- nesting sites of the orang utan?

   $H_0$: There is no significant difference in the tree parameters (such as tree height, tree DBH and tree species) between nesting sites with non-nesting sites of the orang utans.

   $H_a$: There are significant differences in the tree parameters (such as tree height, tree DBH and tree species) between nesting sites with non-nesting sites of the orang utans.

3. Does nest structure have significantly different attributes based on images from UAV?

   $H_0$: There is no significant difference of nest structure based on nest length, width, and depth of nest

   $H_a$: There is significant difference of nest structure quantitatively based on nest length, width, and depth of nest.

4. Is there any difference of success rate in capturing orang utan images during nocturnal condition by using UAV and thermal camera?

   $H_0$: There is no success rate in capturing orang utan images during nocturnal condition by using UAV and thermal camera?

   $H_a$: There is a success rate in capturing orang utan images during nocturnal condition by using UAV and thermal camera.

5. Does the presentation of information and communication at the centre bring different effect to visitors‘ perception and knowledge about orang utan, prior entry and after exit from the center?

   $H_0$: There is no significant difference of effect of presentation of information and communication at the centre to visitors‘ perception and knowledge about orang utan conservation, prior entry and after exit from the centre.

   $H_a$: There is a significant difference of effect of presentation of information and communication at the centre to visitors‘ perception and knowledge about orang utan conservation prior entry and after exit from the centre.

6. Is there any difference of motivation value among the workforce in performing their job, based on the conservation sites?

Since this topic explored on qualitative research which does not involve any hypothesis testing, the motivation of the workforce is explored by interpreting responses of the workforce into a number of themes based on some previous literature.

## 1.4 Thesis Structure

Generally, this thesis will have eight chapters which cover all topics of the studies (Table 1.1). Chapter Four to Eight are written as stand-alone manuscript. There are repetitions in the information that might appear in certain portion of each chapter.

Table 1.1: The thesis structure

| | |
|---|---|
| **Chapter 1** | This chapter would cover the general view of great apes including orang utans. The topics covered the introduction of the orang utan, the problem statements and hypotheses, the aims of the studies and the thesis structures. |
| **Chapter 2** | This chapter consists of the literature review of taxonomy, morphology, general behaviour, habitat phenology, conservation status and threats, conservation measures of orang utans, conservation drones, sustainable oil palm, and education program regarding orang utan. |
| **Chapter 3** | This chapter would thoroughly describe the location background of SORC, SNR and Taiping Zoo and basic methodology applied in the study |
| **Chapter 4** | This chapter mainly the effect of visitors on behaviour pattern, space use and visual direction of the orang utan at Taiping Zoo, SORC and SNR. |

| | |
|---|---|
| **Chapter 5** | This chapter covers the topic of nesting site preferences by orang utans, evaluated by forest profile, ground tracking and UAV. This chapter consisted introduction of nesting behaviour, previous study on nesting sites preferences by orang utans, the methodology used to carry out the study, findings of the study, the discussion and conclusion. |
| **Chapter 6** | This chapter evaluates the feasibility of UAV and thermal camera in capturing orang utan images at nocturnal condition at SORC and SNR. |
| **Chapter 7** | This chapter relates on the difference at entry exit level regarding effect of presentation of information and communication at the centre to visitors perception and knowledge about orang utan conservation at SORC, SNR and Taiping Zoo by using questionnaire method. |
| **Chapter 8** | This chapter would focus on the difference of motivation among the workforce at SORC, SNR and Taiping Zoo by using interview and thematic qualitative analysis |
| **Chapter 9** | This chapter summarize the whole finding throughout the study and put emphasis on several recommendations regarding a better conservation and management effort of the orang utan. |

# CHAPTER 2

# GENERAL LITERATURE REVIEW

## 2.1 General Background of Bornean Orang Utan

Orang utans are one of the four great apes of the world, and the only great ape in Asia and outside of Africa. In the Pleistocene, orang utans could be found in many areas of Asia, including today‘s Java, Sumatra, Borneo, Vietnam, the subtropical regions of Southern China, Burma and Northeast India (Delgado Jr & Van Schaik, 2000). Those populations of orang utans collapsed, probably due to ecological factors such as geographical structural shift by continental drift during multiple ice ages/ warmer periods, rising global mean temperature and anthropogenic factors such as hunting (Campbell-Smith et al., 2018). Today, orang utans can only be found on the islands of Borneo and Sumatra (Ancrenaz et al., 2016; Nowak, 2017; Singleton, 2017). Historically, the orang utan was first described as Simia satyrus (von Linné, 1767), which was later classified into two different species, the Bornean orang utan (Pongo pygmaeus) and Sumatran orang utan (Pongo abelii) in the late 1980s. In October 2017, Nater et. al. (2017) described a third species of orang utan, the Tapanuli orang utan (Pongo tapanuliensis). Both Sumatran and Tapanuli orang utans are found on the Sumatran island, with *P. tapanuliensis* exclusively found in the Tapanuli province. Bornean orang utans are found in both Malaysia and Kalimantan (but not Brunei), with three subspecies in the Northeastern region (*P. pygmaeus morio*), the Western (*P. pygmaeus pygmaeus*) and the Southern (*P. pygmaeus wurmbii*) parts of Borneo (IUCN, 2016).

Our limited understanding on charismatic megafauna such as orang utans, especially on their life histories, ecology, behaviour and threats, presents many puzzles left to be explored (Goossens et al., 2009). Orang utans are Critically Endangered keystone species of the tropical lowland forest of South-East Asia (IUCN, 2016), and knowledge about their vulnerability and adaptability to threats and how their populations could survive and thrive could inform important decision making processes for conservation efforts. This literature review highlights variations in orang utan biology according to species based on geographic factors and takes a closer look at the Bornean orang utan especially in the Malaysian part of Borneo.

Striking a balance between human population growth, development, and nature conservation is one of the main challenges to effectively manage wildlife and ecosystems (Mutalib, Fadzly, & Foo, 2013). Human activities, such as land clearings and fragmentation of habitats, cause a rapid decline in wild orang utan populations, currently pushing them to the brink of extinction. Often orang utans are killed during land clearing and forest logging activities (Campbell-Smith, Simanjorang, Leader-Williams, & Linkie, 2010; Felton, Engström, Felton, & Knott, 2003; Johnson, Knott, Pamungkas, Pasaribu, & Marshall, 2005; Nantha & Tisdell, 2009). They are also poached for food and body parts and sold into the illegal pet trade (Marshall et al., 2006) Rapid development of urban and agricultural areas, such as land expansion for timber and oil palm plantations has been causing human-primate conflicts that further endanger wild orang utans (Gaveau et al., 2009; Meijaard et al., 2011; Meijaard et al., 2012; Nantha & Tisdell, 2009). In Kalimantan, orang utans are mainly killed due to security concerns derived from such conflicts, and as a food resource for some non-Muslim communities (Marshall et al., 2006; Meijaard et al., 2011; Nijman, Spaan, Rode-Margono, & Nekaris, 2015).

## 2.2 Taxonomy and Morphology of Orang Utans

From the early years of Orang utan discovery, studies on this megafauna provide information on human-wildlife interaction, adaptation and life histories, evolution and other science disciplines. Goossens et al (2009) raise the issue of systematic documentation for variability of orang utan species in different islands, or even at the same island. This is due to that the findings of orang utan species and subspecies in late 1990s centuries that required more explanation, leading to more necessity for better protection of orang utan. Groves (2001) argued that differences between orang utans species could not be solely dependent on morphology explanation. There are scarce information regarding genetic characteristics and comparison between species from all geographic population, thus there are still needs for more studies on orang utan_s taxonomy. Figure 2.1 showed the taxonomy structure of the orang utan.

**Kingdom** Animalia

**Phylum** Chordata

**Class** Mammalia

**Orde**r Primate

**Family** Hominidae

**Genus** Pongo

**Species** *Pongo abelii* (Lesson, 1827) *Pongo pygmaeus* (Linnaeus, 1760; Groves, 1971)

**Subspecies** *P. p. morio* (Owen, 1837) *P. p. pygmaeus* (Linnaeus, 1760) *P. p. wurmbii (Tiedemann, 1808) Pongo tapanuliensis* (Nater et al., 2017)

Figure 2.1: The taxonomy of orang utans (IUCN, 2016; Williamson et al., 2013)

Morphology of orang utan are generally shared between the three species such as presence of flanges for adult male, moustache, large body covered with fur, throat pouch, absence of tail and beard. These features are special features in addition to the usual features of animals such as eyes, mouth, nose, a pair of hand and leg. Both male and female orang utans have beards (Ancrenaz et al., 2016; Nater et al., 2017; Singleton, 2017).

All orang utan species typically show highly sexual dimorphic characteristics. This sexual dimorphism could be explained by three factors such as female choice, defence against predator, partitioning of diet (Mitani, 1985). Female orang utans prefer large bodied males that can fight with other males. In additional, researchers found that stronger males could crack fruit, such as the development of flanges in mature males (Uchida, 1996). On average,, males can weigh up to 90 kg, while adult females

orang utans could weigh 40 kg (Rodman, 1984). Flanges are cheek pads made of fibrous tissue (Delgado Jr & Van Schaik, 2000; Winkler, 1989), an obvious physical feature as a sign of dominance in social interaction of orang utan (Kuze, Malim, & Kohshima, 2005; Uchida, 1996) Nonetheless, male orang utans without flanges are still capable in producing offspring.

Orang utan takes the slowest time to grow up and reproduce, as compare to other mammals (van Noordwijk et al., 2018). Morphologically, there are some differences between the three species that could be seen in terms of few aspects. Differences could be derived from few aspects such as hair colour, hair structures, facial hair, cheek pads or flanges, throat pouch and others (Table 2.1, Plate 2.1).

Bornean, Sumatran and Tapanuli orang utans have apparent external characteristics such as hair colour, body size, hair structure and cheek pads as well as throat pouch (Nowak, 2017; Roos et al., 2013). These apparent characteristics are said to be either passed genetically or affected by the other factors such as diet, hormonal factor, behavioral changes, as well as environmental factor such as the altitude of orang utan‘s habitat (Courtenay, Groves, & Andrews, 1988).

Table 2.1: The morphology difference between Bornean and Sumatran orang utans compiled from different literatures (Ancrenaz et al., 2016; Nater et al., 2017; Nowak, 2017; Singleton, 2017)

| **Orang utan species/ properties** | ***Pongo pygmaeus*** | ***Pongo abelii*** | ***Pongo tapanuliensis*** |
|---|---|---|---|
| **Hair colour** | Red to deep maroon or blackish brown | Rusty red or light cinnamon | More cinnamon pelage than Bornean orang utan |
| **Hair structure** | Coarse long hair | Longer, denser and softer hair | Thicker and frizzier hair compared to *P. Abelii* |
| **Facial hair** | Short, scruffy and less pronounced beard | Long beard | Prominent moustache, female have beard resemble *P. abelii* |
| **Cheek pads (flanges)** | Larger check pads either naked or covered with short, shiny, bristly hairs | Prominent cheek pads covered with light thickly, silky hairs | Dominant male have flat flanges covered in downy hair, older male flanges resemble *P. pygmaeus* male |
| **Throat pouch** | Very large and pendulous | Noticeable but smaller than Bornean orang utan‘s | NA |
| **Body Size** | Large | Thin | Similar to linear body of *P. abelii* |
| **Weight** | Male~87kg meanwhile Female~37kg (However, captive orang utan tend to obesity) | | Up to hundred kilos in male, 40kg in female |
| **Height** | Male~970mm meanwhile female~780mm | | Male:1.5m , female:1.1m |

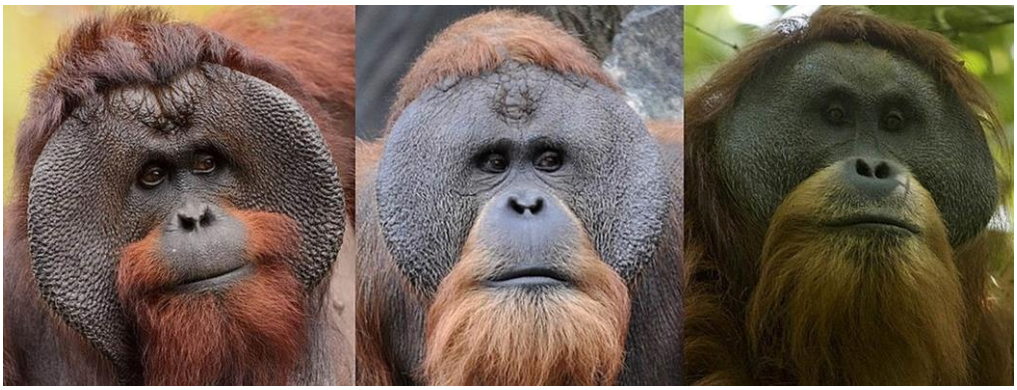

Plate 2.1: Photo of from left, Bornean orang utan, Sumatran orang utan, and Tapanuli orang utan (Laman & Commons, 2017)

Kuze et al. (2005) also discussed about other morphology characteristics in Bornean orang utan in Malaysia and captive centres in Japan. The study shows that a significant number of infants have lighter colour skin especially around the eyes and mouth and erect hair; as compared to adult Bornean orang utans who are found to have darker skin and thicker hair. During infancy phase, both female and male Bornean orang utans possessed white eyelids, but those eyelids of male orang utan would turn into black at earlier age than female orang utans.

## 2.3 Historical Life Distribution

There are many arguments revolving around the definition of subspecies of the Bornean orang utan *P. pygmaeus* (Mailund, Dutheil, Hobolth, Lunter, & Schierup, 2011; Warren et al., 2001; Zhang, Ryder, & Zhang, 2001), but most literature agrees on three subspecies according to geographic distribution in Borneo.. Geological timeline of orang utan population shows the population of Pongo population as early as Miocene/Pliocene era in South or East Asia, however the number changed due to climatic ecosystem due to onset of Asian monsoon system and initiation of El Nino

(Delgado Jr & Van Schaik, 2000; Goossens et al., 2009). This condition caused an irregular mass of fruiting cycle in Asian forest. Reaching to Pleistocene era, Pongo genus was found in Java, Borneo, Sunda Shelf, Sumatra, southern China, and Mainland of Southeast Asia (Delgado Jr & Van Schaik, 2000; Spehar et al., 2018). During this era, a climate shift phenomenon occurred in the form of cycling glacial, leading to cooler and drier temperature. With the lowered temperature and cooler climatic condition, large forest cover collapsed and caused fragmentation of forest habitat. Concurrently, several Pongo spp. occurred across Southern China, and food source became dispersed. Due to this stressful condition and necessity to survive, behaviour of Pleistocene orang utan changed, leading to sociality characteristic of modern orang utan that is highly dispersed.

Evidence also showed that hunting of the orang utan has been existed since this era. During the Halocene years, forest ecosystem has expanded and sea level has risen up, causing some of the Pongo species extinct, especially at Peninsular Malaysia (Goossens et al., 2009). Pongo genus in the Peninsular extinct, compared to other smaller primates such as gibbons and macaques due to reasons such as food specification, and capabilities to withstand extreme seasonality.

## 2.4 Life History and General Behaviour of the Orang Utan

In general, orang utans are known to be naturally solitary and elusive as primarily after they have become adult, male orang utans would choose to be alone. Flanged males would typically only involve in social behaviour during sexual consortship (Atmoko & Van Hooff, 2004; Banes et al, 2015; Schiirmann, 1982). Wild males do not care for their offspring, but infants will stay close with their mothers until

the age of 9 years. Generally, when female orang utans associate with their offspring, they would avoid male orang utans.

Adult male orang utans usually will not encounter each other, or else it will cause aggressiveness and fights among each other. There are some records of female orang utans travelling together, especially when age differences are minor(Galdikas, 1985a; SA Wich, Utami-Atmoko, Setia, Djoyosudharmo, & Geurts, 2006) As mother orang utan carry and care for their the infants, infants will stay close with their mother to learn about basic living skills such as building nests, finding food, avoiding predators, climbing and swaying in trees and others. Mothers will also actively protect the infant from predators and other orang utans (Miller & Nadler, 1981).

Typically, orang utans depend on living in trees, which is related to the protection against predators but Bornean orang utans seem to be more terrestrial than the other species (Ancrenaz et al., 2014). In general, orang utans are the biggest arboreal mammals spending most of their time foraging for food in trees. A study at Tanjung Puting showed that this diurnal mammals spent 60% of their time in the tree foraging for food (Galdikas, 1988).

Orang utans are well adapted to the arboreal lifestyle even building tree nests. These nests are built for sleeping during day and night (Ancrenaz, Calaque, & Lackman-Ancrenaz, 2004). Nests are built every day, but orang utans also reuse and improve old nests. Life on trees also encourages orang utans to perform tool use, such as using big leaves as head covers during rainy days, or using twigs to scratch their back (Galdikas, 1982; Game, Meijaard, Sheil, & McDonald-Madden, 2014). There are also records of orang utans using tools to stimulate their genitals in Ketambe, and Bornean orang utans use a handful of leaves to wipe their chins (Felton et al., 2003). The aforementioned literature also show the orang utan possess culture and learn

through imitation and recorded behaviours are passed on through generations of orang utans (Russon, 2003; Van Schaik et al., 2016). The more a behaviour is imitated, it means that the behaviour has reached cultural status in a population. For example, leaf carrying, throat scrape, nest smacks and others (van Noordwijk, van Schaik, & Wich, 2006). These innovations found in rehabilitation centres, usually caused from subsistence, comfort and social communication (van Noordwijk et al., 2006).

## 2.5 Habitat Phenology of Bornean and Sumatran Orang Utans

The habitats of orang utans in Sumatra and Bornean are similar but vary in certain aspects. Forest productivity and fruit availability is higher in P. abelii's habitat compared to all subspecies of Bornean orang utan (Van Schaik 2009) generally due to younger volcanic content in Sumatran soils that supports higher plant productivity.

Food availability is more stable and higher in Sumatra and Sumatran orang utans have a lower variation in fruit intake than the Bornean orang utan (Russon et al 2009 (Kuze et al., 2012)). Bornean orang utans primarily depend on fruit sources during fruit masting season and rely more on non-fruit fall back as compared to Sumatran species. It seems that the female Bornean orang utan‘s conception rate is positively related to fruit availability (Russon, 2009).

The altitudinal range of orang utans in Sumatra is 500 m higher than in Bornean (Djojosuharnio and Van Schaik, 1999). Also, Sumatra is home to tigers that play important ecological roles as predators and that cannot be found in Borneo, which may explain less strict arborealism in Bornean orang utans.

## 2.6 Conservation Status and Threats

Globally, habitat of wildlife populations is plummeting at a worrying rate. More than a quarter of all animal populations worldwide is threatened with extinction (IUCN, 2016) due to natural factors and anthropogenic factors.

Historically, orang utan populations and Pongo species have suffered and became locally extinct due to extreme weather and seasonality (Delgado Jr & Van Schaik, 2000). It is important to highlight anthropogenic threats, as population growth and resource consumption have increased, wildlife population are threatened, causing rampant loss to biodiversity and environmental health (Hoffmann et al., 2010; Rowcliffe, Milner-Gulland, & Cowlishaw, 2005). This section discusses the threats to orang utan habitats and populations although the points may not be limited to this species per se.

Fossils of orang utan remains, such as teeth, have commonly been found in prehistoric sites in Vietnam, Thailand, China, and Borneo suggesting that orang utans formerly existed in those areas. Some species of orang utans have become extinct in some regions of Southeast Asia due to forest clearance and hunting activities (Delgado Jr & Van Schaik, 2000) and reasons further discussed below.

All three species of orang utans are currently listed as Critically Endangered according to the IUCN Red List (Ancrenaz et al., 2016; Nowak, 2017; Singleton, 2017). Populations of the Bornean orang utan started to show a major decline in the 1950s, with estimated more than of its population were lost within 60 years afterwards (Ancrenaz et al., 2016). It is also estimated that their numbers will be continue to plummet until 2025.

### 2.6.1 Habitat Loss

Habitat loss and fragmentation may be the major factor leading to declining numbers of orang utans. Habitat loss can cause further secondary effects that threaten orang utans, such as allowing access to the forest and opening ways for the illegal pet trade, poaching or killing, and human-orang utan conflicts (Tanalgo & Hughes, 2018; M. C. Wilson et al., 2016; Wu, 2013). Habitat loss and fragmentation arises from logging (e.g.: timber, illegally and legally), forest conversion (e.g: urban areas and development, agricultural farms, especially oil palms plantation), or forest fires and road building (Alamgir et al., 2019; Gaveau et al., 2009; Imai, Furukawa, Tsujino, Kitamura, & Yumoto, 2018; Serge A Wich et al., 2008; M. C. Wilson et al., 2016). Miettinen (2016) reports that deforestation of peatland forests that are important orang utan habitat in Peninsular Malaysia, Borneo and Sumatra has been converted over the past 30 years since 1990. Peat swamp is an important ecosystem in tropical Southeast Asia, as it is refuge to endemic species of terrestrial flora, mammals, fish and others (Alamgir et al., 2019; Yule, 2010) and is a vital habitat for orang utans. Between 2000 and 2010, 25% of peat swamp habitat was lost on Borneo, and almost half (41.3%) in Sumatra (Miettinen, Shi, & Liew, 2011). The steep decline of peat swamp forest has been due to several reasons such as establishment of oil palm plantations, repetitive selected logging, or road and railway construction (Alamgir et al., 2019; Kaur, 1998; Miettinen et al., 2011; Phillips, 1998). Peat swamp is anaerobic, highly acidic and highly sensitive to forest fires, often leading prolonged severe fires resulting in haze and air pollution (Alamgir et al., 2019; Yule, 2010) which is contributing the ongoing climate crisis.